SEDAR

Southeast Data, Assessment, and Review

SEDAR Grouper Assessment Review

SEDAR Supplement 1

Final Report

June 2007

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Section I

Evaluation Panel Report

March 12 - 16, 2007

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1. Introduction

1.1. 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.

1.2. SEDAR Grouper Assessment Review Overview and Need

The SEDAR Steering Committee determined that additional scrutiny should be devoted to recent grouper assessments.

A basic tenet of each SEDAR assessment is that all previous assessment decisions and assumptions are up for debate, and that each decision and assumption included in the current assessment is to be specifically evaluated and judged on scientific merit. Participants are clearly instructed that any decisions made in previous assessments are to be thoroughly evaluated in light of current knowledge. There is no requirement or expectation that decisions made regarding one assessment should be consistent with those in prior assessments, and, in fact, justifications based solely on past decisions are explicitly discouraged. As a result, SEDAR participants are compelled to continually improve assessment quality and it is acknowledged within the Southeast fisheries management community that SEDAR has improved assessment methods, data evaluation techniques, and awareness of critical data collection program characteristics.

One consequence of continually evaluating all prior decisions and striving to improve methods is that current assessments may develop solutions to data deficiencies and analytical challenges that differ from solutions applied in previous assessments. Previous SEDAR assessments have faced post-approval criticism brought on by technological advancements and improved understanding of data sources stemming from later assessments, and the accepted solution has been to apply the most up to date methods to each problem at the next available opportunity. For example, updates to SEDAR 1 and 2 assessments included model configurations and data treatments developed through subsequent assessments.

A similar situation arose recently when the findings of assessments for Gulf of Mexico and South Atlantic gag grouper were compared with those for Gulf of Mexico red grouper. Although many of the same datasets were included in the assessments for gag and red grouper in the Gulf of Mexico, the two species are exploited by similar fisheries, and there is potential overlap in the species range, the SEDAR 10 (gag) and SEDAR 12 (red grouper) assessments differed in key areas including data time series, discard mortality rates, estimation of natural mortality, and analysis of fishery-dependent catchability. Similar differences are also noted within the SEDAR 10 assessments for South Atlantic gag grouper and Gulf of Mexico gag grouper. It should be noted that the assessments prepared during SEDAR 10 and SEDAR 12 were judged separately on their individual merits and found adequate and acceptable by independent scientific review panels. In addition, the SEDAR 10 assessment of Gulf of Mexico gag grouper was also reviewed and deemed acceptable by the Gulf of Mexico Fishery Management Science and Statistics Committee. Nonetheless, the SEDAR Steering Committee determined that additional scrutiny should be devoted to recent grouper assessments.

This special review project is convened by request of the SEDAR Steering Committee to evaluate key decisions of the SEDAR 10 and SEDAR 12 stock assessments. The Steering Committee determined that additional evaluation should be devoted to these issues to ensure confidence in both the assessment process and assessment findings. The Steering Committee recognizes the inherent challenge in

balancing demands to scientists to prepare each assessment with the best available data and most up to date methods with constituents' expectations that similar fisheries should receive similar analytical treatments. By initiating this project, the SEDAR Steering Committee intends to ensure every effort is made to verify that all decisions are scientifically sound and adequately scrutinized within the assessment process.

The SEDAR Grouper Assessment Review will be carried out in two steps. First, an evaluation panel of experts knowledgeable in the fisheries and the SEDAR 10 and 12 stock assessments will be convened to review the assessment findings and recommendations in light of current knowledge. This group will prepare a report including recommendations for subsequent assessment analyses if justified. Second, a SEDAR review panel will be convened to independently review the findings and recommendations of the evaluation panel as well as any additional assessment analyses prepared as a result of the evaluation panel findings.

1.3. Workshop Time and Place

The SEDAR Grouper Assessment Review Evaluation Workshop was held March 19 - 22, 2007, in Miami, FL.

1.4. Terms of Reference

1. Review SEDAR 10 and SEDAR 12 assessment reports, relevant supporting documents, and recommendations, along with any additional research available since the SEDAR assessments, regarding the following specific topics:

    A. The length of the time series to be used for the base cases in each assessment (Gulf gag, Atlantic gag and Gulf red grouper).
    B. The treatment of the catchability coefficient for fishery-dependent indices of abundance in each assessment.
    C. The estimation of the number and size composition of discarded fish, as well as the fraction of the discards that die in each assessment.
    D. The treatment of the natural mortality rate and, in particular, the method used to scale the Lorenzen curve in each assessment.
    E. Recommended reference points (minimum stock size threshold, maximum fishing mortality threshold and optimal yield) and whether those choices are consistent with the goals of the respective Fishery Management Plans and the Magnuson-Stevens Reauthorization Act.

2. Discuss how consistency in methodology should be balanced against the need to address differences in the data, fisheries and biology of the three stocks in question. Include in this discussion the significance of using different stock assessment algorithms for each stock.

3. Formulate recommendations for any additional analyses, sensitivity runs, or changes to the base cases that need to be made to the Gulf gag, Atlantic gag, and Gulf red grouper assessments based on the reviews of the specific issues addressed in TOR #1 and given the conclusions reached during the discussion of TOR #2.

4. Prepare a consensus report documenting committee discussions and recommendations. The report should be drafted during the workshop and finalized within one week of workshop conclusion.

1.5. List of Participants

NAME	Affiliation
Workshop Panel	
John Carmichael	SEDAR, Chair
Andrew Cooper	SAFMC SSC
Behzad Mahmoudi	FL FWC/GMFMC FSAP
Bob Muller	FL FWC/SAFMC SSC & GMFMC FSAP
Clay Porch	SEFSC
Erik Williams	SEFSC/SAFMC SSC
Council Appointed Observers	
Dennis O'Hern	GMFMC AP
Bill Tucker	GMFMC AP
Bob Zales II	GMFMC AP
General Observers	
Theo Brainerd	SEFSC
Craig Brown	SEFSC
Shannon Calay	SEFSC
Alex Chester	SEFSC
Guillermo Diaz	SEFSC
Dennis Heinemann	The Ocean Conservancy
Larry Massey	SEFSC
Staff	
Tyree Davis	SEFSC
Rachael Lindsay	SEDAR
Larry Massey	SEFSC

1.6. Supporting Documents

SEDAR. 2006. Stock Assessment Report for South Atlantic Gag Grouper. SEDAR10-SAR1. SEDAR, Charleston SC.

SEDAR. 2006. Stock Assessment Report for Gulf of Mexico Gag Grouper. SEDAR10-SAR2. SEDAR, Charleston SC.

SEDAR. 2007. Stock Assessment Report for Gulf of Mexico Red Grouper. SEDAR12-SAR1. SEDAR, Charleston SC.

2. Responses to Terms of Reference

2.1. TOR 1.

1. Review the SEDAR 10 and SEDAR 12 assessment reports, relevant supporting documents and recommendations, along with any additional research available since the SEDAR assessments, regarding the following specific topics:

A. The length of the time series to be used for the base cases in each assessment (Gulf gag, Atlantic gag and Gulf red grouper).

The assessment evaluation panel (AEP) discussed pros and cons of different catch time series used for the base cases of each assessment. The catch time series started with 1962 for South Atlantic gag, 1963 for Gulf of Mexico gag, and 1986 for the Gulf of Mexico red grouper. The main focus of discussion was why shorter time series for red grouper given similarities among these fisheries. The AEP agreed that in order to provide best possible long-term perspective on stock status (virgin or near virgin biomass and recruitment levels) assessments must use the longest possible catch time series. Short catch time series, even with detailed composition data, can give misleading estimate of current stock status relative to un-fished stock level. However, there are difficulties with constructing long time series. These include questions concerning the quality of catch statistics, availability of reliable age composition and abundance indices data, and changes in fleet selectivity and fishing practices. These issues were discussed and evaluated by AEP for each of the three catch time series.

For all three assessments, reliable information on age composition, life history parameters, and indices were generally available from mid 1980s (except for South Atlantic gag headboat index which started in early1970s?). Age composition data with high sampling resolutions were available after 1990. The key differences between the three catch time series were the quality of catch statistics, waterbody information, and whether the historical catch trends reflected virgin or near virgin stock status. Information on waterbody of landings is available beginning in 1962 for the South Atlantic gag and 1963 for Gulf of Mexico gag. For South Atlantic gag, exploitation prior to 1962 is believed to be slight, so the model can begin with a near virgin stock. For Gulf of Mexico gag, the landings prior to 1963 were also relatively low in comparison to recent years (although they were not considered low enough to justify assuming the stock was near virgin levels). For Gulf of Mexico red grouper, however, the landings prior to the mid 1970s and perhaps as far back as the 1930s were likely quite high owing to a large Cuban fleet that fished for red grouper off Florida and Mexico. Unfortunately, the Cuban landings are not well documented in many years and it was not possible to construct a reliable time series of landings prior to the 1980s. The AEP suggested that research effort should continue with constructing the historical catch time series for future Gulf of Mexico Gag and red grouper assessments

The panel agreed that the catch time series selected for base runs of the three assessments were appropriate and noted agreements among base runs and sensitivity runs with various catch time series and alternative methods (i.e., SRA). For example, results from the Gulf of Mexico gag runs with catch time series starting in 1963 were consistent with sensitivity runs using catch time series starting in 1880. The stochastic SRA applied to the Gulf of Mexico gag and Gulf of Mexico red grouper catch time series staring in 1880 generated similar results as those generated from the base runs with catch time series staring in 1963 for Gulf of Mexico gag and in 1986 for the Gulf of Mexico red grouper. Due to the assumptions required to develop the 1880 time series, the evaluation panel agrees with the SEDAR 10 and 12 review panel decisions to develop recommendations based on models including the shorter time series.

B. The treatment of the catchability coefficient for fishery-dependent indices of abundance in each assessment.

Review of SEDAR 10 and SEDAR 12 decisions

The assessments of South Atlantic gag grouper, Gulf gag grouper, and Gulf red grouper each explored models that:

1) held the catchability coefficients constant over time for fishery dependent indices of abundance,

and

2) included an annual 2% increase in the catchability coefficients for fishery dependent indices.

Considerable discussion occurred during the SEDAR 10 Assessment Workshop concerning the use of time-varying or constant catchability coefficients for the fishery dependent abundance indices. Panelists agreed that catchability has likely increased over the last few decades, but disagreed on how much. As stated on page 8 of the SEDAR 10 Assessment Workshop report for South Atlantic gag grouper:

The group recognized that technology improvements over time, in particular better electronics, have made fishermen more effective and efficient at catching fish, although there was no firm conclusion about details. This issue is important for the present stock assessment because the assessments rely heavily on fishery-dependent catch rate abundance indices. Such indices divide catch by effort. When a unit of effort becomes more efficient at catching fish, the resulting abundance index becomes biased, making fish appear relatively more abundant.

In response, a proposal was discussed to assume an increased catchability of 2% per year (non-compounding), beginning in 1980 and continuing to the present. The value of 2% reflects findings of a recent published paper (Robins et al., 1996) and an ICES paper (Skjold et al., 1996), which examined other fisheries. The starting data reflects increased availability of better electronics…..Participants believe that some increase in catchability has occurred, but that estimating its

magnitude is too difficult to be done at this assessment workshop. Workshop participants agreed to send to the Review Workshop runs made under both assumptions (constant or increasing catchability), without labeling either one the "base run" to the exclusion of the other.

The SEDAR 10 Gulf and SA gag grouper Assessment Workshop followed a similar path, sending runs made under both assumptions to the Review Workshop without labeling either one as the "base run". The S10 Review Workshop for both South Atlantic and Gulf gag grouper, agreed that catchability has likely increased over time but did not believe that a constant 2% increase adequately describes the complex ways in which it has changed. As such, the SEDAR 10 Review Workshop rejected the assumption of a 2% annual increase in catchability for fishery dependent indices in favor of an assumption of constant catchability.

Citing the discussions during SEDAR 10, the SEDAR 12 Gulf Red Grouper Assessment Panel included both the assumption of constant catchability and a 2% annual increase in catchability for fishery dependent indices in their analyses. The "base case" sent to the Review Workshop assumed constant catchability, and a 2% annual increase was included as a sensitivity run. However, the label of "base run" versus "sensitivity" run was not intended to imply preference, but rather as a way to structure the presentation of the models (e.g., a baseline model and then a list of ways the baseline could be modified) (Behzad Mahmoudi and Shannon Cass-Calay, personal communication)

The SEDAR 12 Gulf Red Grouper Review Panel chose the assumption of a 2% increase in the catchability coefficients for the fishery dependent indices as the preferred model. On page 9 of the Review Panel Consensus Summary of the SEDAR 12 Review Workshop, it states:

The panel agreed that it would be unrealistic to assume constant fishery catchability over 20 years and requested that an annual 2% increase in catchability be incorporated in the base run to reflect increased fishing power (efficiency) principally due to technology innovations (GPS, GIS, cell phone communication, etc.) that cannot be quantitatively included in the standardization. This means that over a 15-year period, a 35% increase in observed fishery CPUE would be expected from a stock that was level in its abundance. The representatives of the fishing industry attending the meeting agreed that 2% per year was within a likely range.

<u>SEDAR Grouper Assessment ad hoc Evaluation Panel Discussion</u>

The Evaluation Panel spent considerable time discussing the history of the decisions outlined above along with the various reasons why catchability has likely increased for fishery dependent indices. The Evaluation Panel agrees with both SEDAR 10 and SEDAR 12 Assessment Panels and Review Panels in that catchability has likely increased. The discrepancy between the SEDAR 10 and SEDAR 12

decisions as to whether a constant 2% increase in catchability should be included in the preferred model arose as a result of different groups of people arriving at different conclusions when presented with imperfect information. In particular, neither panel was aware of any information quantifying the dynamics of the change in efficiency of the snapper-grouper fishery. The SEDAR 10 Review Panel was simply not comfortable with making a simplistic assumption of a constant 2% increase whereas the SEDAR 12 Review Panel decided that a simplistic assumption of a constant 2% increase was more realistic than assuming a constant catchability. Such discrepancies should not be considered unusual or cause for concern.

The Evaluation Panel does, however, feel that future assessments of gag and red grouper should be consistent in their assumption of increasing catchability, but the Panel is not in a position to comment on whether one specific value or method for modeling this increase is more appropriate than another. The assumption of constant catchability for fishery dependent abundance indices in the snapper-grouper complex, however, should no longer be the default assumption for future assessments. Future assessments should examine the sensitivity of their output to the assumed level of increasing catchability. The Evaluation panel agrees with the recommendation from the SEDAR 10 Assessment Panel and Review Panel that a special workshop be convened to estimate and quantify changes in catchability over the last 25 to 30 years.

C. The estimation of the number and size composition of discarded fish, as well as the fraction of the discards that die in each assessment.

The response to this issue is addressed in two sections. First, approaches to inferring the size composition of discarded fish is addressed. Second, methods of determining the mortality rate of fish that are discarded is discussed. Greater detail is included in these discussion because these issues were not always addressed clearly and in detail in the original SEDAR 10 and 12 reports. The greater detail herein is the result of considerable effort, including examination of spreadsheets and computer programs prepared during the various SEDAR workshops, evaluation of workshop notes and discussions with workshop participants, and discussions with those who prepared various supporting analyses.

Discard size composition

No information on the size of discarded gag grouper was available for the Atlantic population. Anecdotal accounts suggested that most of the discarded gag were below the size limit, but legal-sized gag grouper were occasionally discarded by recreational fishers owing to the bag limit. To model this, an ad hoc approach was developed where the selectivity curve on discarded fish was assumed to be equal to the difference between the selectivity curve estimated for the landings and a curve with the same shape parameters except shifted to the left by two age classes. The choice to shift by two age classes was not based directly on data, however the length composition of the discards estimated by the assessment model using this approach

was qualitatively consistent with the view that most of the discards were discarded because of the size limit. The evaluation panel noted that the Goodyear approach used for red grouper (see below) could have been applied to Atlantic gag, but would still require making ad hoc assumptions about the selectivity on young fish. The evaluation panel found little basis for recommending one approach over the other and noted that it would be difficult to fully evaluate the effect of employing the Goodyear approach in time for the upcoming review in May. Accordingly, no additional runs were recommended.

Information on the size of discarded gag in the Gulf of Mexico recreational fishery was limited to a survey out of the Mote Marine laboratory (covering mostly the region offshore of Tampa) and larger samples from GULFIN and TIP (which included landed fish). The assessment models examined by SEDAR 10 assumed that the size composition of recreational discards was similar to the size composition from these combined data sets, which effectively implies that most recreationally-caught gag were discarded because of the bag limit and a smaller fraction were discarded because they were below the legal size. Anecdotal testimony from several recreational fishers suggested that the majority of discarded fish were below the size limit and that the bag limit was seldom reached. It was pointed out that recreational discards represent a very large fraction of the total estimated removals by the fishery, therefore any substantial changes in the assumptions regarding those discards would likely have important implications for the assessment. In the case of commercial discards, the size composition was assumed to be equal to the difference between the observed distributions before and after the size limit regulations went into effect. It was pointed out that this approach cannot account for variations in discard size composition attributable to variations in year-class strength and mortality. However, it was also noted that the discard size composition was given relatively little weight in the model and that the magnitude of the commercial discards was estimated to be only a small fraction of the total removals, therefore changes in assumptions regarding the commercial discard size composition would be unlikely to have important implications for the assessment. The Evaluation panel recommends two analyses be prepared to be submitted to the upcoming Review Panel: (1) catch per trip analysis to determine how frequently recreational fishers are limited by the current aggregate-grouper bag limit; and (2) an additional assessment run that replaces the current length frequency distributions assumed for discarded fish with the same data truncated at the minimum size limit.

The sources of information on the size of discarded red grouper in the Gulf of Mexico were essentially the same as for Gulf of Mexico gag and the treatment of total discard levels was similar between the two species. The size composition of the discards, however, was not based on data observed prior to the implementation of the minimum size limits (as for commercial gag discards) or on the Mote/GULFIN observations (as for recreational gag discards). Instead, the Goodyear probabilistic approach (SEDAR7-DW56, SEDAR12-AW01) was employed whereby the length frequency of the discards was inferred from the expected distribution of lengths at age below the size limit (based on extensive growth analyses) and assumptions of the relative fraction of younger age classes available to the fishery. This approach is consistent with an assumption that discarding is due to the size limit. It was noted that

the approaches used for gag could also have been applied for red grouper. However, sensitivity runs conducted during SEDAR 12 demonstrated that the assessment results were relatively insensitive to the treatment of discard size composition. Accordingly, further exploration of the treatment of red grouper discards does not seem warranted for this review.

Discard mortality rates

Physiological and experimental studies have established a clear relationship between the mortality rate of released gag and the depth at which they were caught. However, in the case of Atlantic gag there were no data relating the distribution of catches to depth. The discard mortality estimates that were used were based on consultations with fishers relating mortality to the average depth of capture and handling procedures for the various fisheries.

In the case of Gulf gag, the TIP samples included a large number of observations on the distribution of catch at size by depth for the various commercial fisheries and 371 observations of catch at size by depth for the recreational fishery (mostly from charter fishermen). This information was used in SEDAR 10 to construct fishery-specific matrices of discard mortality by size that were multiplied by the fishery-specific estimates of total discards at size to obtain the number of dead discards by size for each fishery. Similar size at depth data were available for Gulf red grouper, but the relationship between discard mortality and depth was unclear because the available studies did not treat the study subjects in the same way for all depths. The SEDAR 12 assessment panel did note that about 20% of the red grouper caught by long liners were discarded already dead and at least 25% of those that were discarded alive would be expected to die based on the results from caging studies conducted at depths typically fished by long liners. Caging studies conducted at depths typically fished by commercial handline and recreational anglers (less than 40m) suggested that fewer than 10% of the animals die directly because of decompression, but testimony during the workshops suggested a few percent may also die owing to depredation by dolphin, barracuda and sharks.

The Evaluation panel did not find additional information that would suggest the approaches to estimating discard mortality should have been more similar across stocks. The panel noted that the effective discard mortality for recreationally caught Gulf gag may decrease with the recommended change in size composition (smaller fish tend to be caught a shallower depths with lower discard mortality rates). The panel believes that the solution to such problems is simple: data are needed to allow determination of discard mortality rates and allocation of discarded fish into size and age classes to eliminate the need for elaborate assumptions.

D. The treatment of the natural mortality rate and, in particular, the method used to scale the Lorenzen curve in each assessment.

Fish are not immortal but quantifying mortality in the absence of fishing is very difficult especially in the S.E. United States where many species have been exploited for more than a century. In previous assessments for these two species, natural mortality was treated as constant across all ages. Based on maximum ages, the natural mortality rate was 0.15 per year in both gag assessments and 0.20 per year for red grouper. However in the recent assessments, analysts thought that it was unlikely that an age-1 grouper had the same natural mortality as did an age-10 grouper and so they developed age-specific natural mortality rates based on a method proposed by Lorenzen (1996). Lorenzen's method assumes that natural mortality is inversely related to length such that older fish have progressively lower natural mortality rates. The Lorenzen age-specific rates were scaled to the cumulative survival to the maximum observed age.

The DW for gag recommended constant natural mortality rates of M= 0.15 per year for both coasts (maximum age 31 years in Gulf of Mexico gag, 30 years in South Atlantic gag); however, the AW used M = 0.14 to maintain consistency with the Hoenig's regression (1983). The red grouper DW members thought that M = 0.20 per year was too high and, because the oldest age in the dataset was 29 years, they recommended using an equivalent of M = 0.14 per year also based on Hoenig's regression. The AW stated that the maximum age of 29 was tenuous because it was based on a single fish that had been aged as young as 18 and as old as thirty by different readers, and instead recommended assuming a maximum age of 25 years with an associated M = 0.167 per year. For all three assessments, the AW's scaled the Lorenzen curve such that the cumulative mortality from age-0 to the respective maximum ages was equivalent to that for the constant value estimated from Hoenig's regression equation (this approach was also used in SEDAR 04 for snowy grouper and tilefish). The SEDAR 10 CIE reviewers recommended evaluating natural mortality with mark-recapture models but accepted the age-specific natural mortality rates using all ages to scale both the South Atlantic and the Gulf of Mexico gag. However, the SEDAR 12 CIE reviewers for red grouper recommended two modifications to natural mortality: (1) using the original maximum age of 29 years (M = 0.14 per year) instead of 25 years (M = 0.167 per year), because several red grouper had been estimated at more than 25 years, and (2) using ages 5 and older to scale the curve because the reviewers thought that "natural mortality was underestimated for the older fish".

Scaling the curve with older ages had an impact on the determination of stock status of red grouper. When the Lorenzen curve was scaled with all ages (ages 0-29), the F_{2005}/F_{MSY} was 0.91 implying that red grouper were not undergoing overfishing and SS_{2005}/SS_{MSY} was 1.04 implying that the red grouper stock was just at being rebuilt. When the Lorenzen curve was scaled with ages 5-29, the F_{2005}/F_{MSY} was 0.59 implying that red grouper were not undergoing overfishing and that current fishing mortality was less than OY (F_{2005}/F_{OY} = 1.17); SS_{2005}/SS_{MSY} was 1.40 implying that the red grouper stock was rebuilt. It would have been very fruitful for the reviewers to have included the rationale for their choice of ages to include in the scaling of natural mortality.

Since the basis of the natural mortality rates was Hoenig's regression of total mortality on maximum ages, we contacted Hoenig about which ages he included in calculating the catch curves that went into developing his regression. He responded that he included the fully recruited ages so as to avoid the confounding of selectivity with mortality in the younger ages. Determining the specific ages to use in the scaling is problematic for many reasons, not the least of which being that estimated selectivity patterns may take many forms (e.g. dome, flat, reverse logistic) and the age of full selectivity may vary over time. Another complication is that, because Hoenig used unexploited or lightly exploited stocks, his regression ignores that the maximum observed age in an exploited stock depends upon the level of exploitation.

The group supports the SEDAR 12 reviewers recommendation that a technical paper be developed regarding the application of Lorenzen's method to convert conventional constant M to age-dependent M. This exercise does not address the larger question that natural mortality is poorly known. Hence, methods and data need to be developed to allow the empirical estimation of natural mortality. A possibility noted at SEDAR 12 was to explore using marine protected areas such as the Dry Tortugas Marine Reserve to estimate natural mortality from tagging and catch curves.

E. Recommended reference points (minimum stock size threshold, maximum fishing mortality threshold and optimal yield) and whether those choices are consistent with the goals of the respective Fishery Management Plans and the Magnuson-Stevens Reauthorization Act.

- The evaluation panel considers reference points recommended by the SEDAR 12 review panel for Gulf of Mexico red grouper consistent with the management requirements as stated in the SEDAR 12 Stock Assessment report.
- The evaluation panel considers the SEDAR 10 review panel recommendations for South Atlantic gag grouper references based on MSY concepts consistent with the management requirements as stated in the SEDAR 10 Stock Assessment report.
- The evaluation panel questioned whether the SEDAR 10 review panel provided recommendations for Gulf of Mexico gag grouper management criteria that are consistent with the management requirements as stated in the SEDAR 10 Stock Assessment report. Specifically, the SEDAR 10 review panel did not provide clear recommendations for MFMT and MSST.

The concerns raised by this evaluation panel regarding the SEDAR 10 review panel's recommendations for management parameters for Gulf of Mexico gag grouper center around providing guidance for appropriate advice for MFMT, the reliability of biomass levels chosen from visual examination of stock-recruit plots, and the differences in the stock recruit relationships for Gulf and South Atlantic gag grouper. Although the SEDAR 10 Review panel provided values for exploitation, yield, and spawning stock biomass corresponding to variety of potential management criteria including F_{MAX}, $F_{0.1}$, $F_{20\%SPR}$, and $F_{30\%SPR}$, the panel

did not identify any of these as suitable values for MFMT and MSST. The panel suggested that a 'working definition' of MSST could be derived from an empirical evaluation of the stock recruitment plot, but declined to clearly recommend a particular MSST.

Given the lack of clear recommendations for management parameters MFMT and MSST in particular, the evaluation panel agreed to provide additional guidance for consideration.

MFMT

Twenty-year average exploitation of F=0.36 was cited by the SEDAR 10 Review Panel as evidence that the current F_{MSY} proxy of F30%SPR = 0.25 is unreasonably stringent:

For the Gulf of Mexico, a MFMT of 0.25 (current value of F30%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.

This evaluation panel considers F_{MAX} a reasonable proxy for F_{MSY} and useful for deriving MFMT. F_{MAX} falls below the F=0.36 boundary recommended by the SEDAR 10 Review panel. The evaluation panel notes that Fmsy seldom exceeds F_{MAX} in instances when both parameters are estimated, and further cites the estimates provided in SEDAR 10 for South Atlantic gag that suggested F_{MAX} = 0.26 and F_{MSY} = 0.24. Finally, the estimate of F_{MAX} is similar to that of $F_{30\%\ SPR}$, which is the recommended F_{MSY} proxy in the GMFMC generic SFA amendment.

MSST

Although the SEDAR 10 Review panel left MSST blank in the table of proposed management criteria, a 'working definition' for MSST of 20 million pounds was suggested based on visual examination of the stock-recruit plot. The stock recruit relationships for both stocks were considered 'equally uncertain', though MSY-based reference points were accepted for South Atlantic gag because the stock-recruit model suggested equilibrium recruitment was within the range of observed stock status, whereas the ad hoc stock-recruit model fitted externally from the assessment model for Gulf of Mexico gag suggested equilibrium recruitment was several times greater than that observed over the assessment period.

The panel discussed whether deriving biomass reference points from visual interpretation of stock-recruitment plots, as proposed for Gulf gag grouper, is a valid and objective approach. It was agreed that applying a consistent objective standard is difficult through visual evaluation, and that if a clear visual pattern emerged then it is likely that a stock-recruitment model would fit the data. The evaluation panel agrees that any biomass reference points derived without use of an accepted stock recruitment relationship will be subjective and may just as likely reflect the particular circumstances evaluated as the overall population productivity. The evaluation panel believes that the method used by the SEDAR 10 Review Panel to suggest a level of MSST for gulf gag is not consistent with methods used for other stocks with similar levels of uncertainty.

The evaluation panel considers information provided by estimates of recruitment and the Yield-per-Recruit based references value useful for deriving management parameters. The Panel recommends applying an approach that is consistent with previous solutions to this problem, and estimating a proxy for the biomass at MSY by scaling the expected SSB per recruit at the Fmsy proxy by the average recent recruitment.

The panel discussed this Term of Reference along broader lines, considering the composition of SEDAR review panels, appropriate expectations of SEDAR review panels, and the products Assessment Workshop panels should provide future Review Panels. SEDAR Review Panels are composed of independent experts selected for their knowledge in stock assessment. They are intentionally independent of both the assessments being considered and NOAA. Therefore, it is highly unlikely that they are also well-versed in US Federal fisheries management requirements. Furthermore, the charge to the Review Panel is to provide scientifically sound advice and recommendations, and not to consider other ramifications of their recommendations. They are intentionally prohibited from providing specific management advice, and are advised that such recommendations will be provided by the appropriate Council committees that will receive the SEDAR reports. For these reasons, the evaluation panel believes that ensuring compatibility with MS-SFA requirements is beyond the current charge to the Review panels, expectations for such consistency are unreasonable given the restrictions placed upon reviewer selection, and council processes exists to make the transition from review panel recommendations to FMP and MSA compatible regulations.

The Evaluation Panel recommends that such issues can best be resolved by ensuring SEDAR Assessment panels provide ample reference point and stock recruit relationship options for consideration by review panels, and that those proposed references are addressed in the Advisory Report. Those appointed to SEDAR assessment workshop panels are better versed in US management requirements than those appointed to SEDAR review panels, and are more aware of the needs and expectation of the Councils.

2.2. TOR 2.

2. Discuss how consistency in methodology should be balanced against the need to address differences in the data, fisheries and biology of the three stocks in question. Include in this discussion the significance of using different stock assessment algorithms for each stock.

There is a fine balance between model consistency and the need to address differences in data, fisheries, and biology. The frequency of benchmark assessments often occurs over a long enough time period that data collection, fishery prosecution, fishery regulations, biological studies, modeling techniques, etc. have changed. Ignoring these changes may erode confidence in the results from any modeling exercise. Incorporating these changes in new benchmark stock assessments should increase our confidence in the results.

However, consistency can be important for public perception and understanding. It is incumbent that stock assessment scientists avoid the perception that the methods being applied are constantly changing with little justification. In almost every case, the decision to change modeling methodology is done to improve our confidence in the results. The justification for a change in modeling methods needs to be documented and described in more detail in the future. Guidance from the SEDAR process suggests that consistency should not be a major force in determining modeling methodology, but instead using the best model for the situation.

In fisheries we deal with diverse species, fisheries, and stock assessment scientists; this necessitates the need for many different stock assessment models. These models include catchy names such as SPASM, CASAL, CATCHEM, ASAP, etc. However, at the core of these models, the algorithms employ the same equations that have been used for many years.

There are some fundamental differences between general categories of models. These class of models include productions models, delay-difference models, virtual population analysis (VPA), stock-reduction analysis, statistical catch-at-age models, and length-based models. In SEDAR assessments we have seen several classes of models applied to the same species being assessed. This is often done for continuity reasons or to examine results using different model classes, which have different underlying assumptions.

For South Atlantic gag, Gulf of Mexico gag, and Gulf of Mexico red grouper, several model classes were employed. In all cases, one of the secondary model classes applied was the ASPIC production modeling software. Additionally, the Gulf gag assessment applied a stochastic stock reduction analysis and a VPA model. The VPA model was run for continuity purposes to compare results from the previous stock assessment. The Gulf red grouper assessment applied an additional stochastic stock reduction model, as well.

The secondary models used in the South Atlantic gag, Gulf of Mexico gag, and Gulf of Mexico red grouper assessments all have some limitation or aspect that could be consider "incomplete". For example, the ASPIC production model does not use any age-structure and therefore does not take advantage of age/length data. The stochastic stock reduction analysis cannot capture age-specific selectivity or distinguish between age/size of landed and discarded fish. The VPA method assumes catches are known without error, an assumption that is rarely met with many snapper-grouper fisheries.

In general, the state-of-the-art model class is the statistical catch-at-age models. For South Atlantic gag, Gulf of Mexico gag, and Gulf of Mexico red grouper, the base model recommended for use in management decisions is a statistical catch-at-age model. The South Atlantic gag model is a statistical catch-at-age model which has been used for almost every snapper-grouper assessment in the South Atlantic. The Gulf of Mexico gag assessment employed the statistical catch-at-age modeling software CASAL, developed in New Zealand and used in many of the international forums. The Gulf of Mexico red grouper assessment applied the statistical catch-at-age modeling software ASAP, available in the NMFS toolbox and which was also used in the previous benchmark assessment. All these models are widely used, and, at their core, these models are almost identical.

The statistical catch-at-age models mentioned above employ the Baranov catch equation, which has been in use since the early 1900's. These models also share identical methods for estimating annual recruitment values, which are loosely conditioned to follow a stock recruit curve. Another similarity in these models includes the estimates of annual fishing mortality parameters and age-specific selectivity functions. The models are all optimized using Newton-based gradient algorithms and utilize maximum-likelihood objective functions. Given the same data and assumptions, any differences between these models are purely interface differences (i.e. methods of inputting data and outputting results). The choice of which software to use is then an analyst's preference, having no bearing on the results or conclusions about the stock.

Some stock assessment modeling software packages are more flexible than others. As is often the case with fisheries data, we deal with data types and limitations which require tailoring the model specifications to accommodate the data. Some of the software packages are better at accommodating these unique situations than others.

For the specific cases of South Atlantic gag, Gulf of Mexico gag, and Gulf of Mexico red grouper, the differences in the statistical catch-at-age models are primarily due to differences in available data. Some of the notable differences are with respect to the amount of length, age, and depth data. In the case of South Atlantic gag, the length, age, and depth data are relatively limited compared to Gulf of Mexico gag and Gulf of Mexico red grouper. The South Atlantic gag had no information on depth of fishing from the fisheries, no information on the size/age of

discards, and limited annual age sample sizes. These data limitations translated directly into modeling limitations for discards and their mortality rate, and prohibited the use of annual age-length keys. In contrast, the Gulf of Mexico gag had sufficient data to model a depth specific discard mortality rate, model the size of discards, and compute annual age-length keys.

The bottom line is that modeling methods differ primarily depending on the class of model the fall under (see classes mentioned above). Within these classes there are often several software packages for applying the model. In general, these software packages differ only in their user interfaces and their ability to handle minor details, usually resulting from species/fishery specific data limitations.

2.3. TOR 3.

3. Formulate recommendations for any additional analyses, sensitivity runs, or changes to the base cases that need to be made to the Gulf gag, Atlantic gag, and Gulf red grouper assessments based on the reviews of the specific issues addressed in TOR #1 and given the conclusions reached during the discussion of TOR #2.

Recommendations were made regarding the following specific topics identified in TOR 1 and 2. The panel identified both analyses that should be prepared and offered to the Grouper Assessment Review Panel for consideration as well as recommendations for future SEDAR assessments.

1) A. Length of analytical time series:

The AEP was satisfied with the length of time series chosen in all three assessments and made no recommendation for additional runs for the upcoming review workshop.

The Panel suggested future assessments pursue more accurate information on the Cuban catch of red grouper.

1) B. The treatment of the catchability coefficient for fishery-dependent surveys:

The AEP made no recommendations for additional runs for the upcoming review workshop. Runs are available for all 3 assessments based on constant and changing catchability.

The Panel suggested that future SEDAR assessments acknowledge and address catchability changes and examine the sensitivity of their output to the assumed trend in catchability.

The Evaluation panel agrees with the recommendation from the SEDAR 10 Assessment Panel and Review Panel that a special workshop be convened to estimate and quantify changes in catchability over the last 25 to 30 years.

1) C. The estimation of number and size composition of discard fish:

The panel offers no recommendations for changes in the discard assumptions for South Atlantic gag grouper and Gulf of Mexico red grouper.

The panel recommends constructing an analysis of Gulf of Mexico gag grouper based on assigning discarded fish to sizes below the minimum limit.

The panel requests frequency distributions from MRFSS (and other recreational sampling sources) of catch per angler for Gulf of Mexico grouper by year. This should be constructed to include all grouper species that are subject to the 5 fish bag limit.

The panel requests tabulation of the number of samples available for determining depth of recreational discards for Gulf of Mexico gag grouper.

1) D. The treatment of natural mortality:

The evaluation panel does not recommend development of assessment runs based on alternative natural mortality assumptions for evaluation by the Review Panel.

The panel recommends developing a consistent method of estimating age specific natural mortality for use in future SEDAR assessments. The panel requests that the Review panel provide guidance to facilitate such efforts, focusing on determining the appropriate ages to use in scaling and commenting on how such decisions may be affected by changes in selectivity at age over time and differing selectivity patterns.

The panel recommends studies and monitoring that will allow estimation of natural mortality

1) E. Reference Points:

The panel recommends developing reference points for Gulf of Mexico gag grouper based on yield-per-recruit concepts for consideration by the Review Panel. Expected yield and spawning stock biomass should be provided for a range of fishing mortality values for use in determining target and limit references.

For future assessments, the panel recommends that the SEDAR Assessment workshop terms of reference be modified to require that assessment workshops provide management benchmarks that meet FMP and MS-SFA requirements for consideration by subsequent review panels.

The panel recommends clarifying SEDAR Review Panel Terms of Reference to ensure that all reference points submitted by the assessment workshop are addressed and evaluated, and that the Review Panel clearly justify any deviations from Assessment workshop recommendations.

2. Consistency in methods

Due to the similarity of the base models used to assess the stocks in question, the evaluation panel does not recommend any additional analyses for consideration by the Review panel.

The panel recommends development of a glossary of common management and assessment terms and model descriptions for inclusion in all SEDAR assessment reports -- be prepared for consideration by the Review Panel.

The panel recommends that future SEDAR Assessment workshops reports include clear and explicit justification for model changes.

2.4. TOR 4.

This report addressing the recommendations of the evaluation panel was drafted during the SEDAR Grouper Review Evaluation Workshop.

3. Appendices

3.1. SEDAR 10 & 12 Grouper Assessment Comparison

Assessment / Metric	South Atlantic Gag (SEDAR 10)	Gulf of Mexico Gag (SEDAR 10)	Gulf of Mexico Red Grouper (SEDAR 12)
Preferred assessment model	Forward projecting statistical catch at age (custom ADMB)	Forward projecting statistical catch at age (CASAL)	Forward projecting statistical catch at age (ASAP)
Other Considered Models	Production (ASPIC)	VPA SRA (to 1880) ASPIC (failed)	SRA (to 1880) ASPIC (failed) ASAP (1880, failed)
Start year	1962	1963	1986
Natural mortality	Lorenzen, scale all ages base 0.14	Lorenzen, scale all ages base 0.14	Lorenzen, scale exploited ages base 0.14
Release mortality	25% recreational 40% commercial	By depth; averages: 32% recreational 67% commercial	10% recreational 10% Comm Trap 45% Longline
Discard allocation	Selectivity curve subtraction; discards restricted to below size limit applies since size reg 1990	Comm: length freq subtraction (below size limit) Rec: All observed data, includes all sizes applies since size reg	Goodyear probabilistic method, age comp same for all years with = regs. applies since size reg 1990
Fishery Dependent Catchability assumption	Constant; sensitivity run using 2% annual increase	Constant; sensitivity run using 2% annual increase	Time-varying (2% annual increase); sensitivity runs using constant q and 4% increase in q

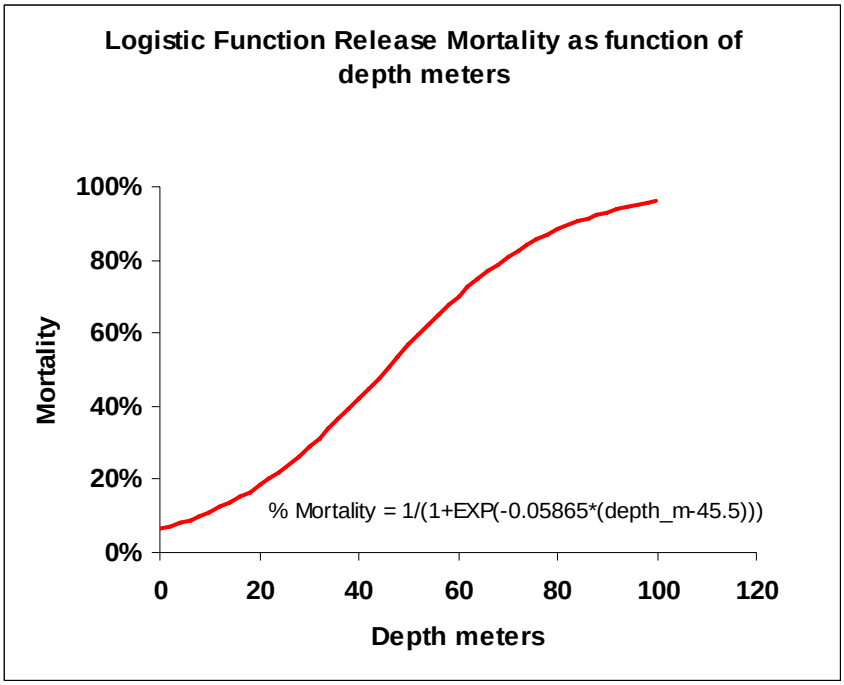
3.2. Revised Gulf of Mexico Gag Grouper Analyses

Analyses of Gulf of Mexico Gag Grouper in Response to the Recommendations of the SEDAR Grouper Assessment Review Panel

April, 2007

1. Spatio-temporal distribution of size-depth samples for gag GOM used to generate size-depth distribution matrices to estimate dead discard of recreational and commercial fisheries.

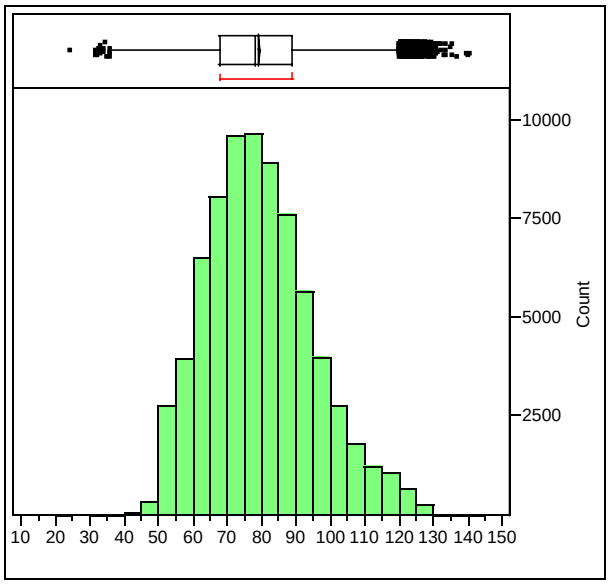
The SEDAR 10 participants recommended modeling the discard mortality of gag in the Gulf of Mexico (GOM) as a function of the depth of capture. A logistic function was fitted to data from different experiments (shown below). The estimated curve suggests dead discards increase with depth, with 50% mortality at about 45 m and 95% mortality at 100 m depth. The available data were insufficient to establish a similar relationship between discard mortality and size.



To apply this depth-release mortality function, the catch of gag must be partitioned by depth. Account must also be taken of the distribution of size at depth inasmuch as small fish tend to live in shallow waters and larger older fish tend to move toward deeper water. The Trip Interview Program (TIP) data included information on both the size and depth of capture for fish that are randomly sampled from the catch. Most of the samples are from commercial fisheries (75000), but there are also 382 samples from recreational fisheries. All size records were converted to total length (TL) measurements in cm. The information on depth of capture often included both the minimum depth and maximum depth fished, in which case the value used here was the average of these values (when only one depth was recorded, this value was used). The grouper evaluation panel was concerned about whether the data were sufficient to construct a reliable size at depth matrix and recommended "tabulating the number of samples available for determining depth of recreational discards for Gulf of Mexico gag grouper."

The following plots show the distribution of size-depth samples for the commercial and recreational fisheries from the TIP data.

Gag GOM size samples with depth information commercial fisheries
Frequency distribution of size (TL_pred_cm)



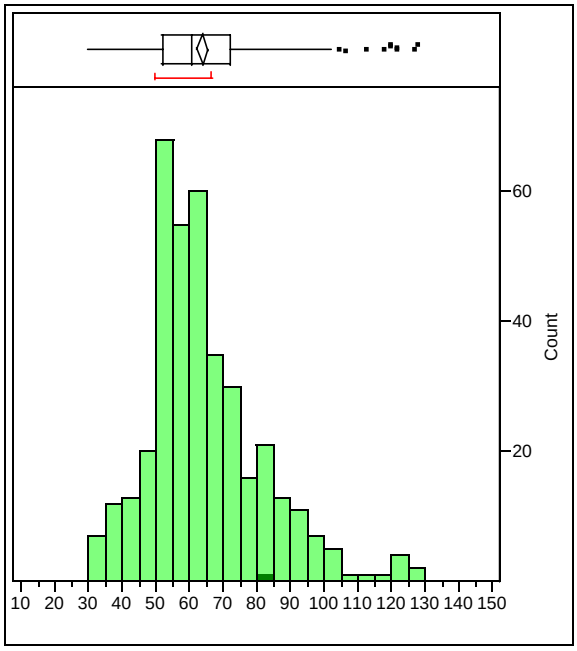
Quantiles

100.0%	maximum	255.10
75.0%	quartile	89.10
50.0%	median	78.20
25.0%	quartile	68.20
0.0%	minimum	24.50

Moments

Mean	79.489948
Std Dev	15.79022
N	75102

Gag GOM size samples with depth information recreational fisheries
Frequency distribution of size (TL_pred_cm)

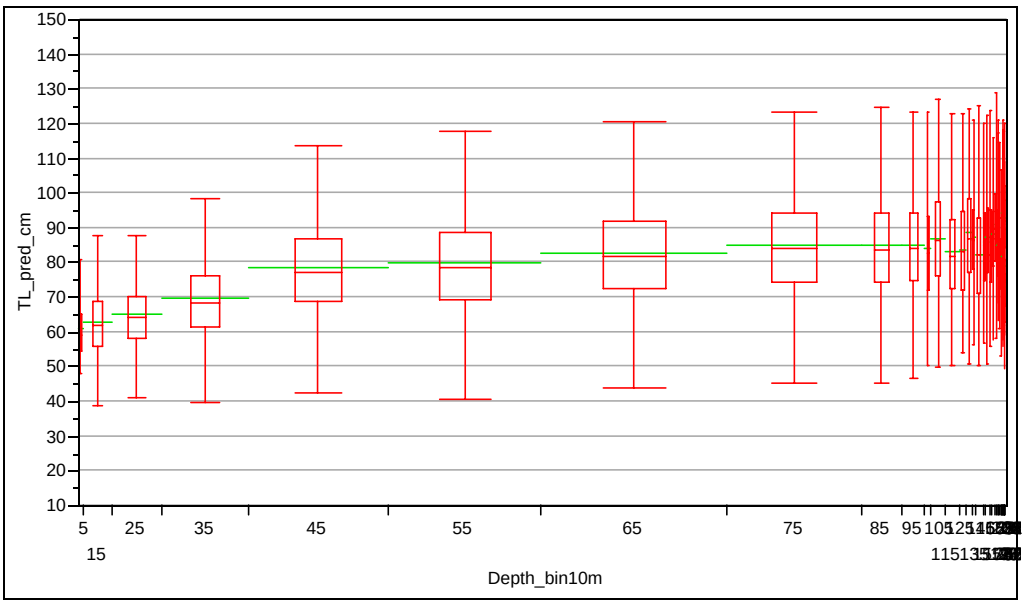


Quantiles

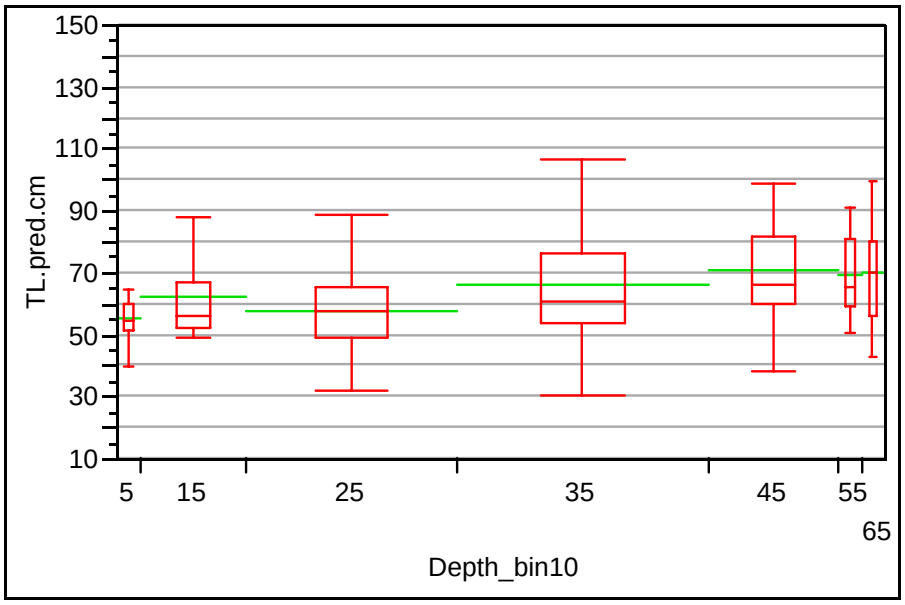
100.0%	maximum	128.20
75.0%	quartile	72.50
50.0%	median	60.90
25.0%	quartile	52.50
0.0%	minimum	30.50

Moments

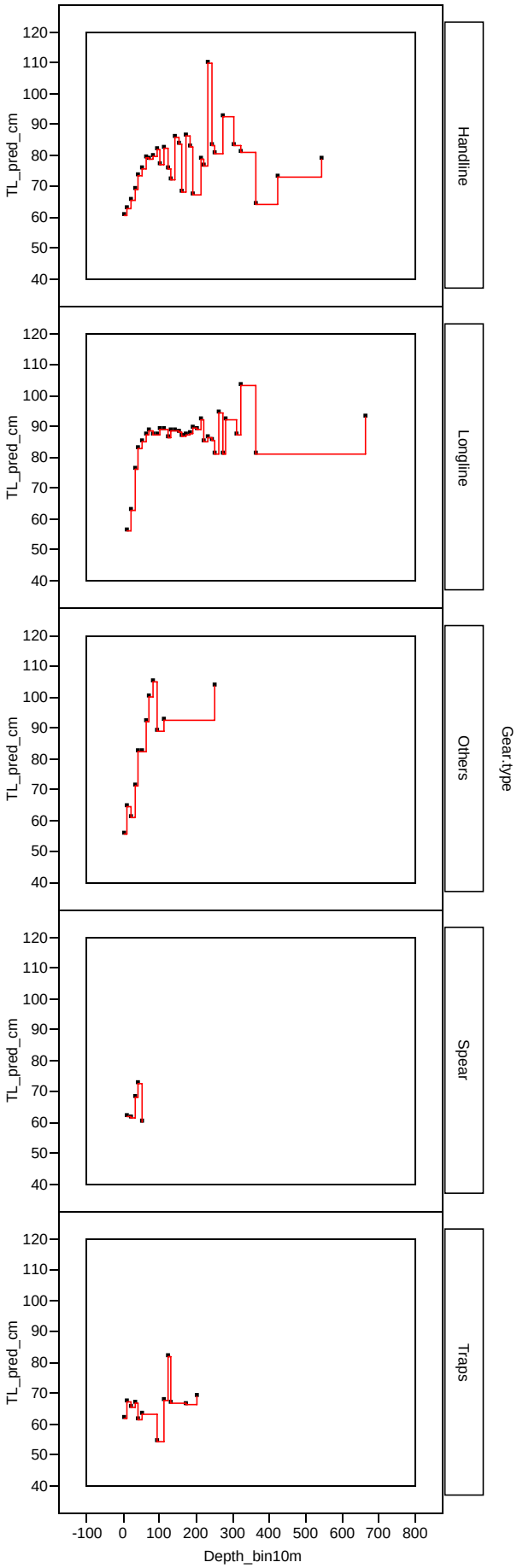
Mean	64.137173
Std Dev	17.126999
N	382

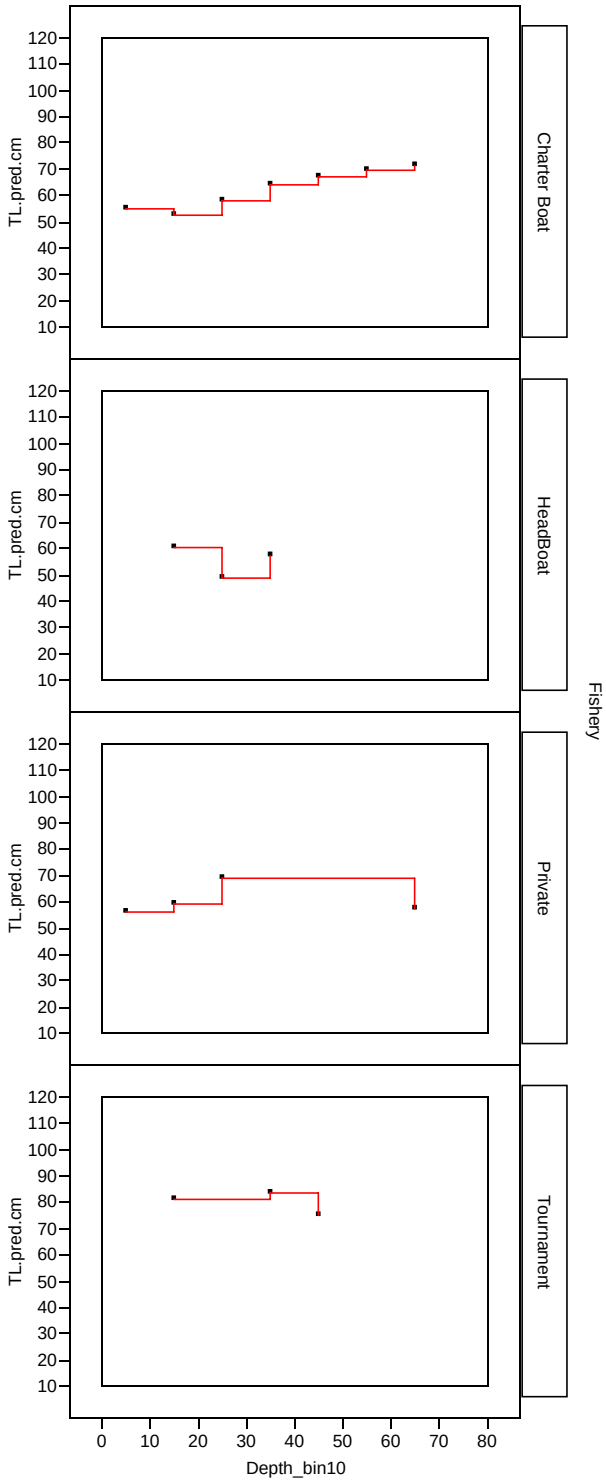


Boxplot size distribution by depth (bin 10 m) commercial gag GOM samples. Box width is proportional to number of samples by bin.

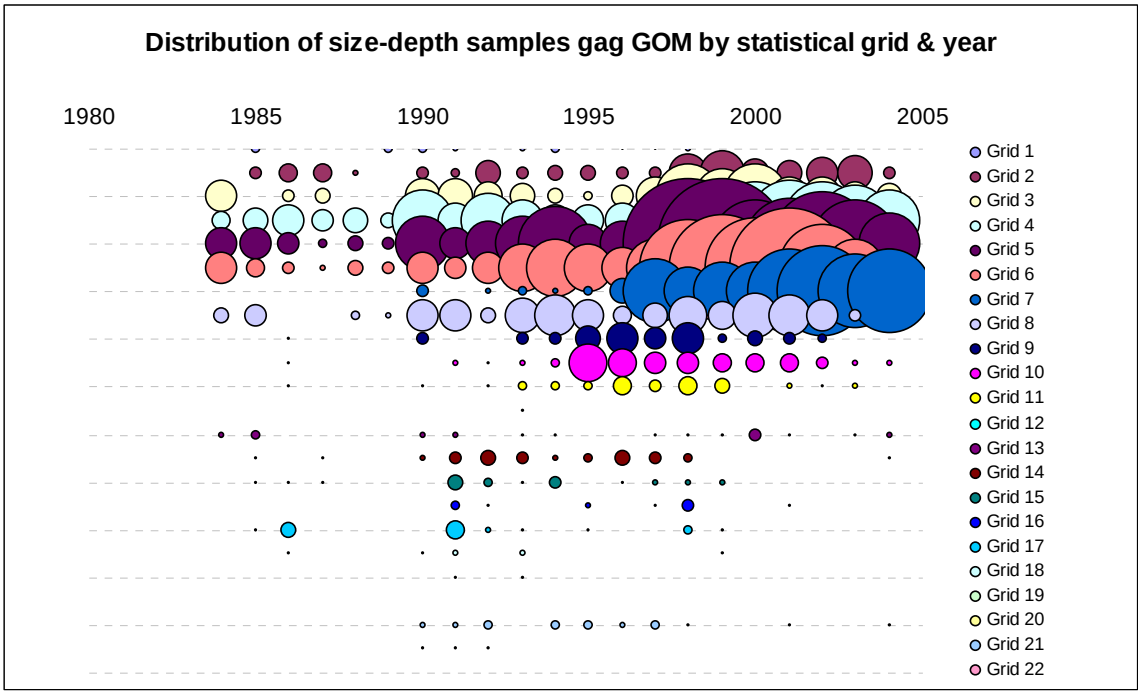


Boxplot size distribution by depth (bin 10 m) recreational gag GOM samples. Box width is proportional to number of samples by bin.



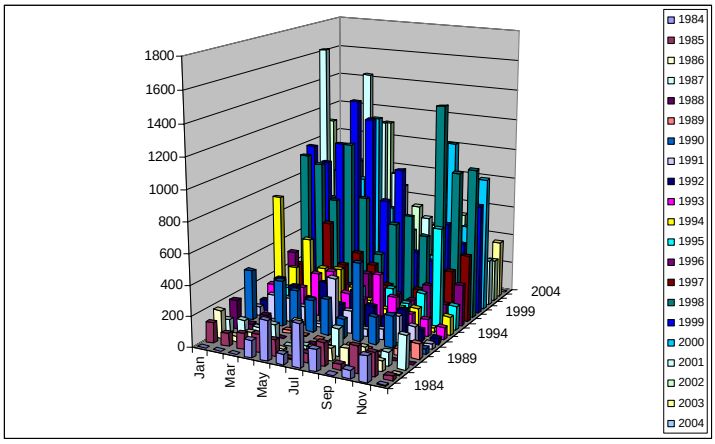


Average size (TL) gag GOM by depth for commercial (left column) and recreational fisheries (right) by gear.

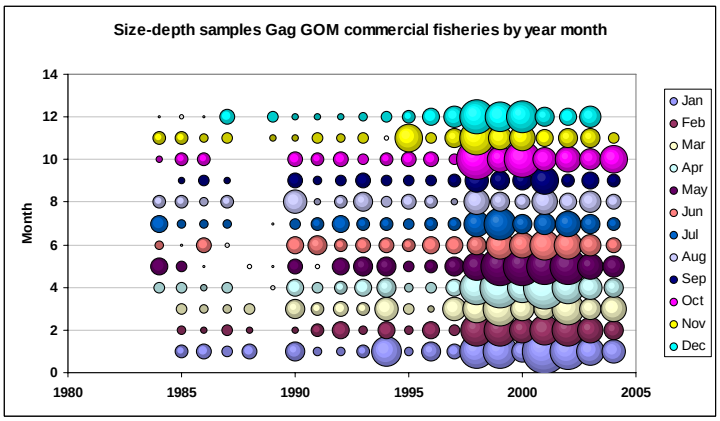


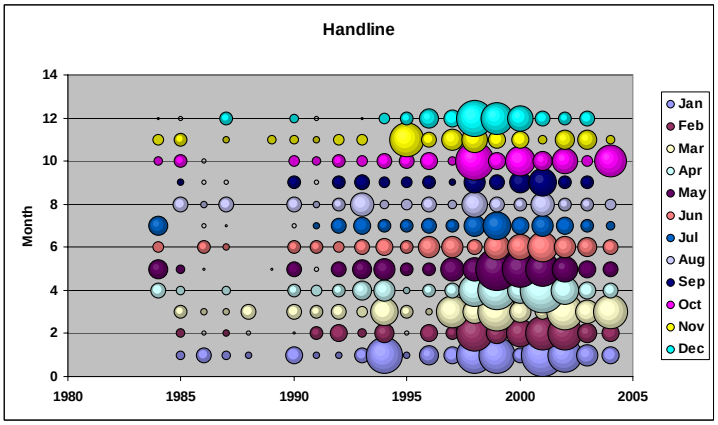
Number of samples with size-depth of capture information for gag GOM commercial fisheries from the TIP data. Grid numbers correspond to the NMFS Shrimp statistical grid sampling codes, Grid 1 Lower Keys FL, Grid 21 Southern county of Texas.

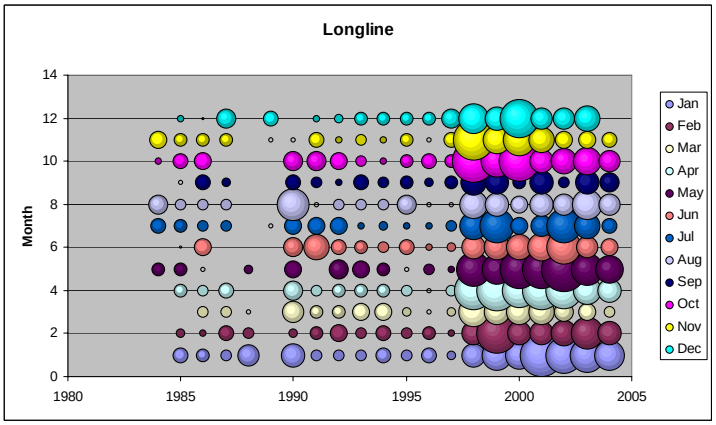
Year	Grid 1	Grid 2	Grid 3	Grid 4	Grid 5	Grid 6	Grid 7	Grid 8	Grid 9	Grid 10	Grid 11	Grid 12	Grid 13	Grid 14	Grid 15	Grid 16	Grid 17	Grid 18	Grid 19	Grid 20	Grid 21	Grid 22
1984	0	0	226	105	252	235	0	64	0	0	0	0	11	0	2	0	0	2	0	0	1	0
1985	20	44	0	147	255	86	0	123	0	0	0	0	26	3	7	0	4	1	0	0	0	0
1986	0	89	44	247	106	51	0	0	4	8	3	0	1	0	6	0	55	5	0	0	0	0
1987	0	84	72	107	33	10	0	0	0	0	0	0	2	6	4	1	1	0	0	0	0	0
1988	0	15	0	165	72	57	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	21	0	0	60	42	48	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	21	37	305	778	674	252	44	260	52	0	6	0	11	11	1	1	2	7	0	0	17	6
1991	9	34	269	266	255	129	0	216	0	10	2	0	11	50	59	23	88	12	5	0	13	7
1992	1	143	195	656	462	240	15	70	0	6	4	0	1	64	30	4	10	0	0	0	28	3
1993	18	47	171	422	634	493	32	279	46	11	30	3	4	41	8	0	7	11	8	1	0	0
1994	24	60	72	242	1149	744	14	415	53	23	25	0	3	15	35	2	1	0	0	0	32	0
1995	2	74	27	219	314	549	25	232	167	353	20	0	2	32	2	12	8	0	0	0	20	0
1996	6	39	123	307	425	369	145	81	243	184	103	0	2	54	3	1	0	0	0	0	15	0
1997	8	37	316	156	257	736	869	145	118	126	48	0	8	38	17	3	0	1	0	0	21	0
1998	10	315	945	1179	3554	2066	540	327	251	111	92	0	7	23	18	44	23	2	0	0	8	0
1999	0	430	637	1318	3469	2404	724	185	22	88	59	0	8	0	15	1	4	3	0	0	2	0
2000	0	186	888	1282	1622	2095	726	445	58	79	2	0	36	0	0	2	0	0	0	0	0	0
2001	1	168	338	1413	1769	3021	1504	410	46	96	14	0	5	1	0	6	0	0	0	0	3	0
2002	0	216	321	1250	2212	1639	1712	236	33	43	7	0	1	0	0	2	1	0	0	0	0	0
2003	0	271	180	1070	1682	724	1154	41	2	11	13	0	3	0	0	0	0	2	0	0	1	0
2004	0	42	146	821	782	316	1556	1	1	9	1	0	19	7	1	0	0	0	0	0	6	0
Total	141	2331	5275	12210	20020	16264	9060	3572	1096	1158	429	3	161	345	208	102	204	46	13	1	167	16

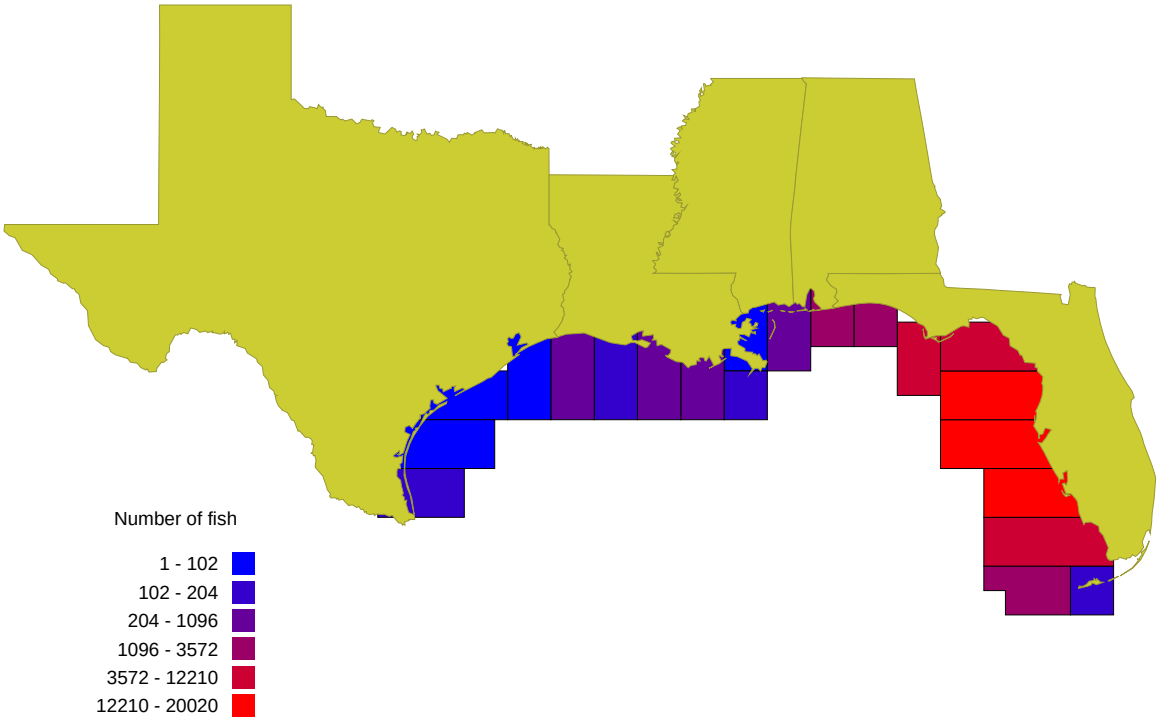


Distribution of size-depth samples of gag GOM commercial fisheries by month and year, and for the main gears.





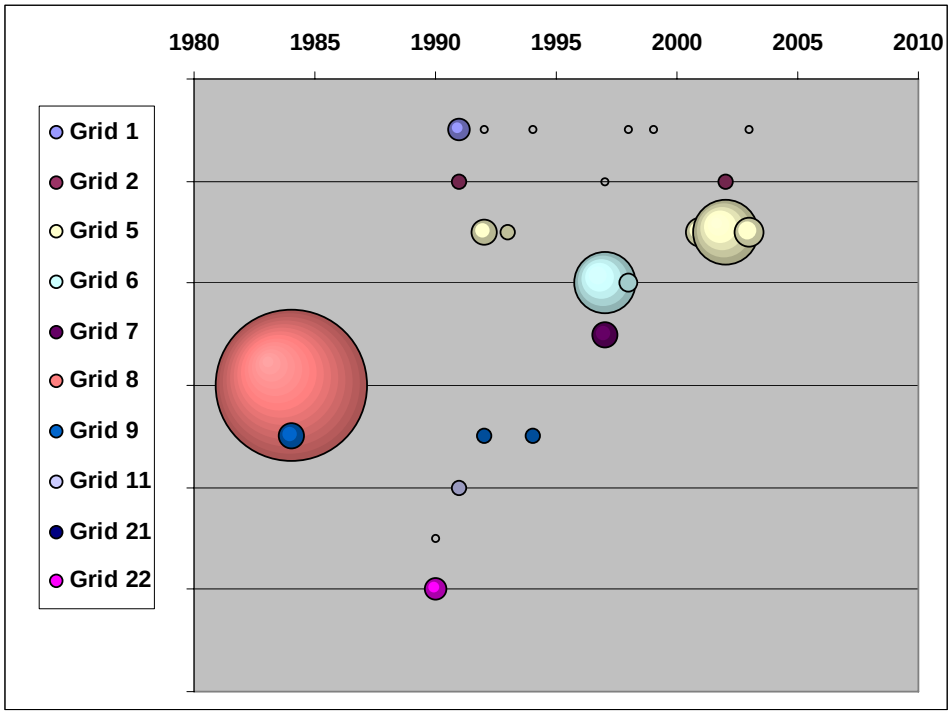




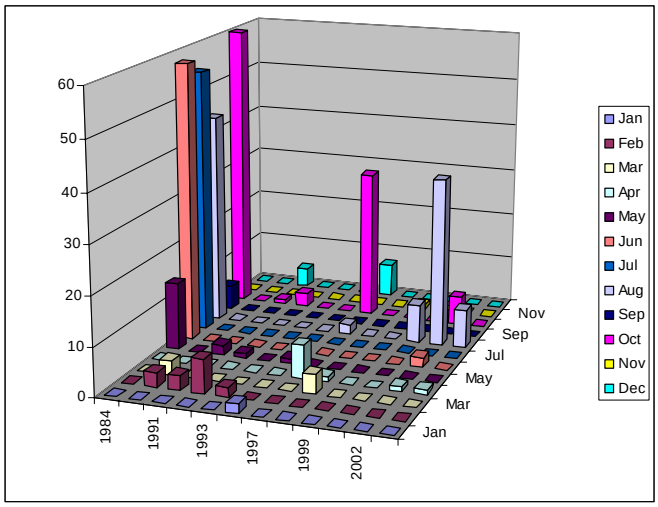
Gag GOM size-depth samples from commercial fisheries 1984-2004

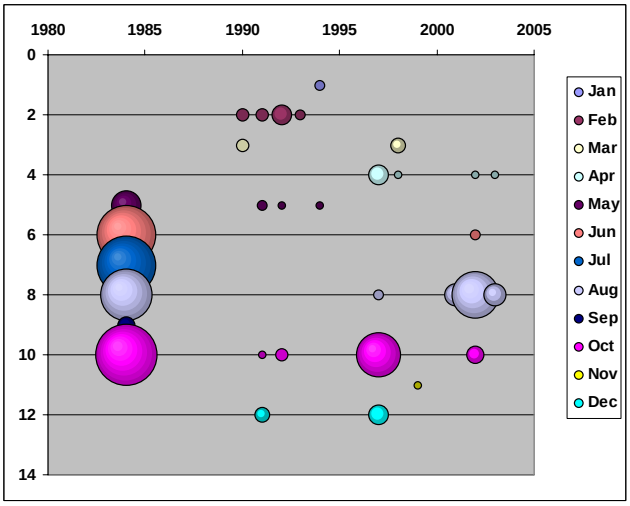
Size-depth samples for gag GOM by state and county from the TIP database.

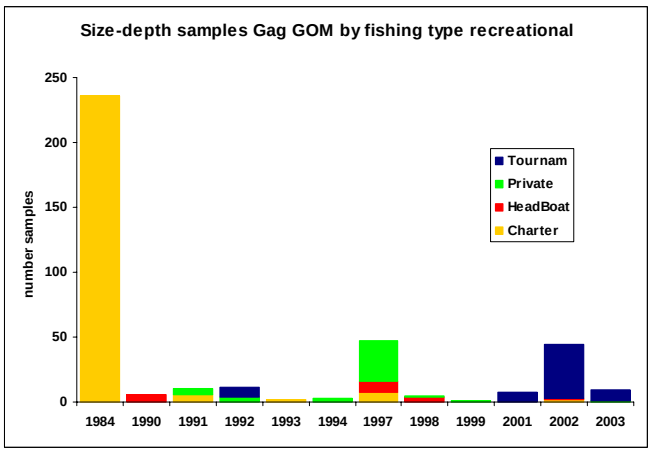
Year	State	County	nmfs_cty	fips_cty	Samples	Mean TL
1984	FL	Bay	1	5	236	62.3635593
1990	TX	Cameron	7	61	6	46.4166667
1991	FL	Monroe	29	87	8	56.3875
1991	MS	Harrison	3	47	2	45.95
1992	FL	Monroe	29	87	1	69.3
1992	FL	Okaloosa	31	91	3	92.6
1992	FL	Pinellas	35	103	7	72.1571429
1993	FL	Pinellas	35	103	2	52.5
1994	FL	Monroe	29	87	1	50.8
1994	FL	Okaloosa	31	91	2	69
1997	FL	Citrus	5	17	31	55.8967742
1997	FL	Lee	23	71	1	71.3
1997	FL	Levy	25	75	7	57.5857143
1997	FL	Pinellas	35	103	8	58.5
1998	FL	Monroe	29	87	1	53.9
1998	FL	Pinellas	35	103	4	60.625
1999	FL	Monroe	29	87	1	64.6
2001	FL	Pinellas	35	103	8	80.975
2002	FL	Monroe	29	87	2	66.9
2002	FL	Pinellas	35	103	42	76.6571429
2003	FL	Monroe	29	87	1	57.4
2003	FL	Pinellas	35	103	8	90.0375



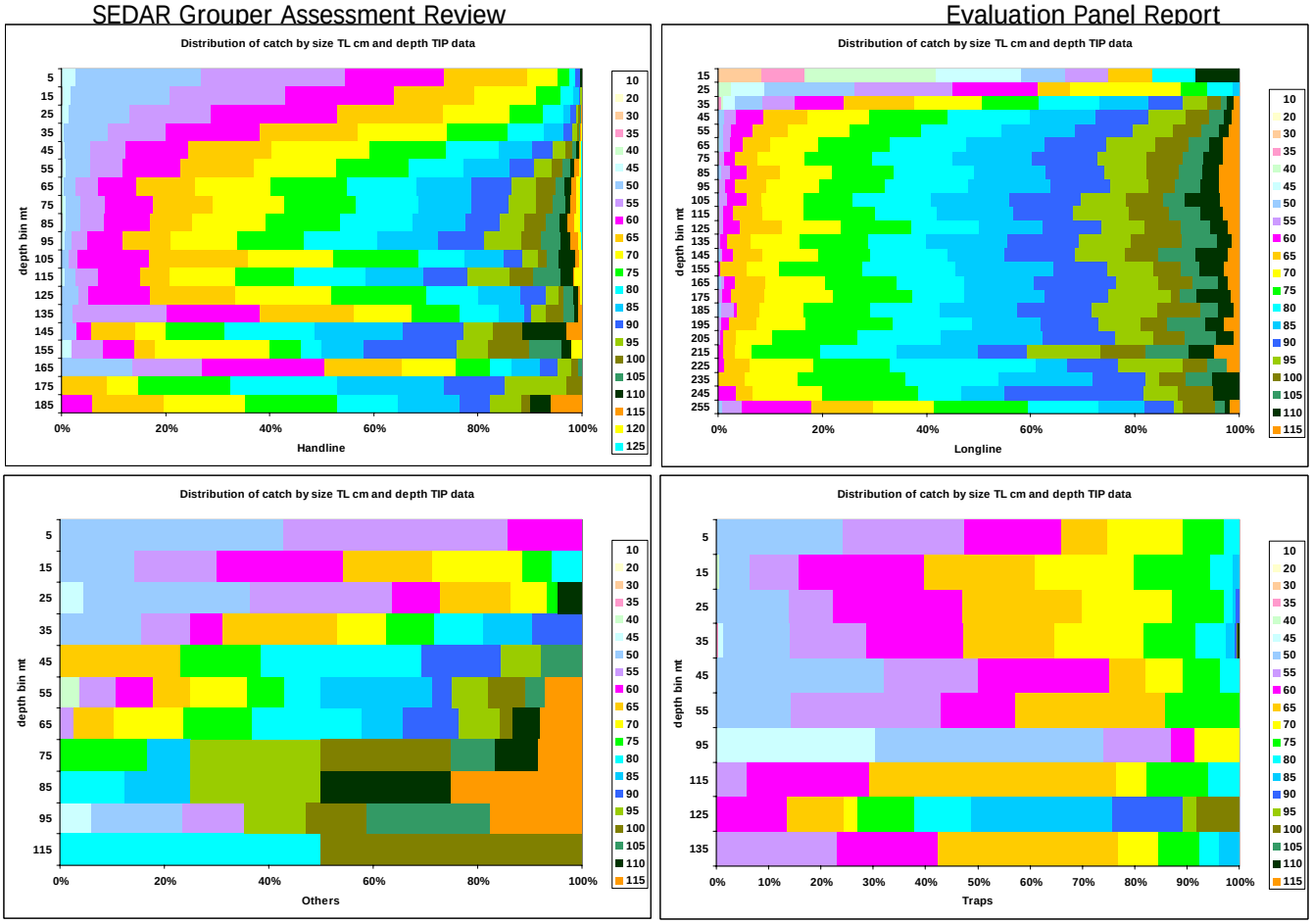
Spatial distributions of size-depth samples from TIP recreational fisheries, not all records were allocated to specific Statistical grid.



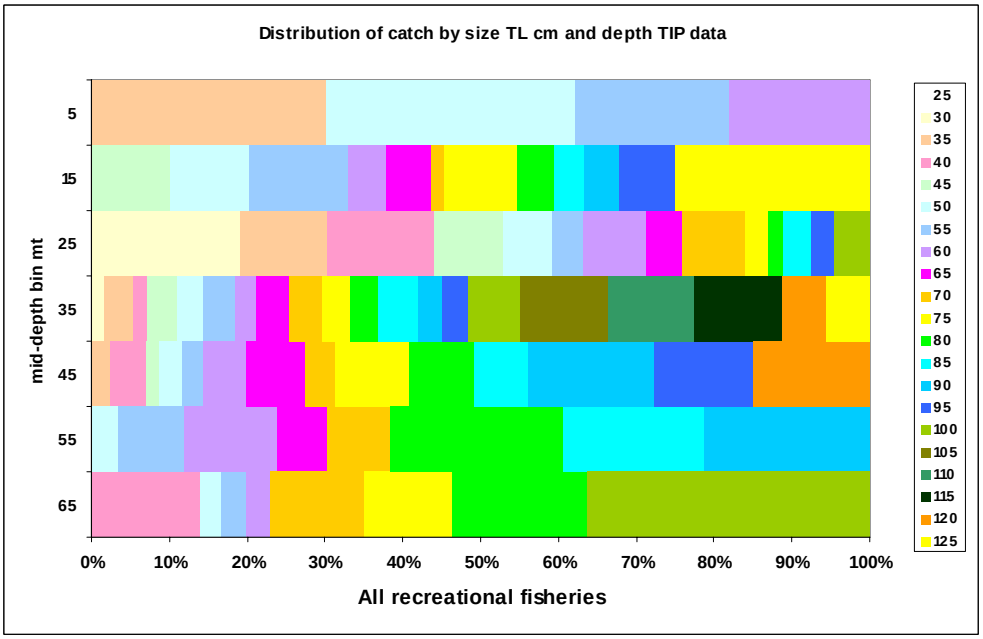




Temporal distribution of size-depth samples for recreational fisheries from the TIP database, by month and by mean type of fishery.



These plots show the matrices of size-at-depth for gag GOM derived from the commercial fisheries TIP samples. The data corroborate the assumption of larger size fish being caught primarily in deeper waters, while smaller fish are predominant in shallow water.



Size-at-depth matrix for recreational fisheries (all modes combined) Even sample size is much smaller than commercial fisheries, the spatial distribution of fish by depth is similar to the commercial size-at-depth.

The SEDAR 10 participants suggested constructing two average size-at-depth matrices; one for commercial fisheries and one for recreational fisheries. Owing to the limited number of observations, average size-at-depth matrices were constructed with all years combined (implicitly assuming that the distribution of length at depth changes little from year to year). Depths were aggregated into 10 m bins from the surface down to 60 m, with the last bin being 60 m and deeper. Lengths were aggregated by 5 cm bins, but the catch-at-size data from commercial and recreational fisheries were aggregated at 2 cm size bin intervals, therefore the size-depth matrix was interpolated for the 2 cm bin size.

The two size-at-depth matrices were used to convert the assumed size composition of the commercial and recreational discards into estimates of discards-at-depth, which in turn were multiplied by the estimated depth-mortality function and total number discarded to obtain the total number of dead discards.

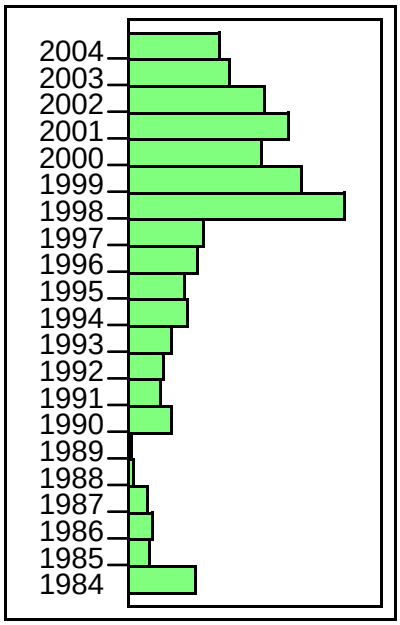
Commercial discards were assumed to be negligible prior to the minimum size regulations. Estimates for the years after the minimum size regulations were obtained by assuming the proportion of the catch that is below the size limit in each year is the same as it would have been during the years prior to the size limit regulations. The size composition of the discards was therefore computed from the difference in size-frequency distributions between the base period (1984-1989, years with no minimum size restrictions) and the phase1 period (1990-2000, 51 cm minimum size limit) or phase 2 period (2000-2004, 61 cm minimum size limit).

In the case of the recreational fishery, the B2 MRFSS estimates of the total number of gag discarded were used. Information on the size of discarded gag in the Gulf of Mexico recreational fishery was limited to a survey out of the Mote Marine laboratory (covering mostly the region offshore of Tampa) and larger samples from GULFIN and TIP (which included landed fish). The assessment models examined by SEDAR 10 assumed that the size composition of recreational discards was similar to the size composition from these combined data sets, which effectively implies that most recreationally-caught gag were discarded because of the bag limit and a smaller fraction were discarded because they were below the legal size. Section 3 presents an alternative run that uses only those length observations that were below the size limit, thus implying that essentially all discards occur in response to the minimum size regulation.

2. Spatio-temporal distribution of size samples for converting catch to Catch-at-Size data for Gag GOM.

Size or length samples were available for most commercial and recreational fisheries by year, season, area, and/or wave to allow converting catch into Catch-at-Size (CAS) for landing of gag GOM during 1981-2004 period. For commercial fisheries about 95 thousand samples were collected, the following is the distribution of these samples by year, month, state, fishing mode, and season (trimester). Most of the samples are from the longline and handline fishing modes (1 and 2), and sample size increase substantially in 1998. About 98% of samples come from Florida, where equivalently the bulk of the catch is taken. .

Distributions of gag GOM commercial size samples from 1984-2004
YEAR

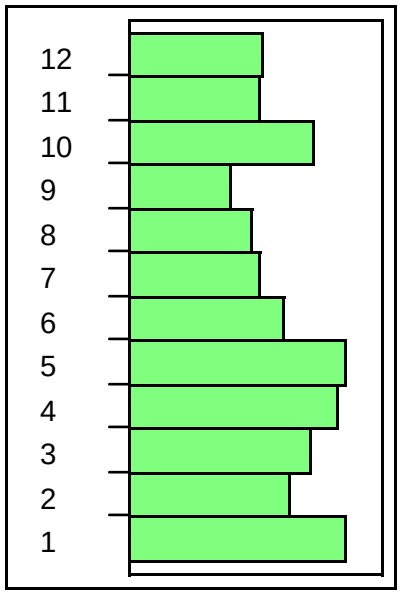


Frequencies

Level	Count	Prob
1984	4027	0.04234
1985	1372	0.01442
1986	1491	0.01567
1987	1244	0.01308
1988	451	0.00474
1989	212	0.00223
1990	2649	0.02785
1991	1945	0.02045
1992	2079	0.02186
1993	2677	0.02814
1994	3597	0.03781
1995	3434	0.03610
1996	4185	0.04400
1997	4588	0.04823
1998	13066	0.13736
1999	10531	0.11071
2000	8085	0.08500
2001	9584	0.10075
2002	8253	0.08676
2003	6122	0.06436
2004	5530	0.05814
Total	95122	1.00000

21 Levels

MONTH



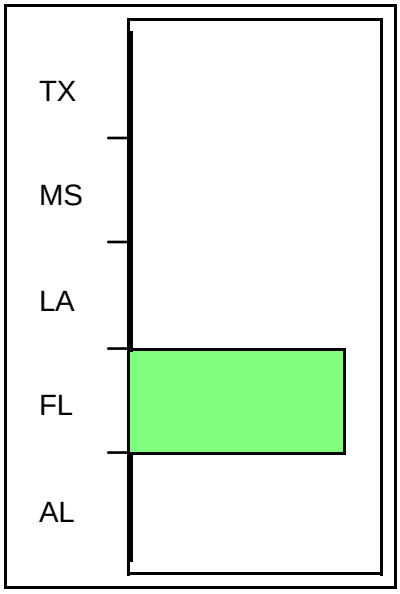
Frequencies

Level	Count	Prob
1	10642	0.11188
2	7873	0.08277
3	8845	0.09299
4	10208	0.10731
5	10569	0.11111
6	7618	0.08009
7	6432	0.06762
8	6060	0.06371
9	4970	0.05225
10	8995	0.09456
11	6389	0.06717
12	6521	0.06855

Level	Count	Prob
Total	95122	1.00000

12 Levels

state

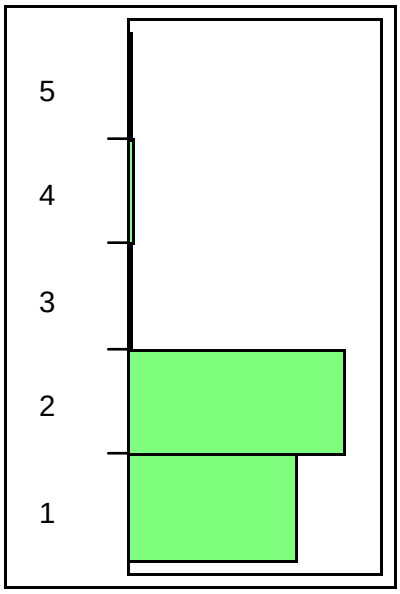


Frequencies

Level	Count	Prob
AL	80	0.00084
FL	93508	0.98303
LA	1170	0.01230
MS	137	0.00144
TX	227	0.00239
Total	95122	1.00000

5 Levels

mode

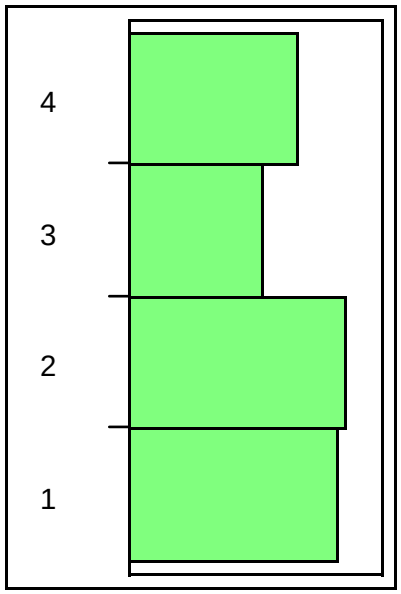


Frequencies

Level	Count	Prob
1	40440	0.42514
2	51942	0.54606
3	506	0.00532
4	1316	0.01383
5	918	0.00965
Total	95122	1.00000

5 Levels

season

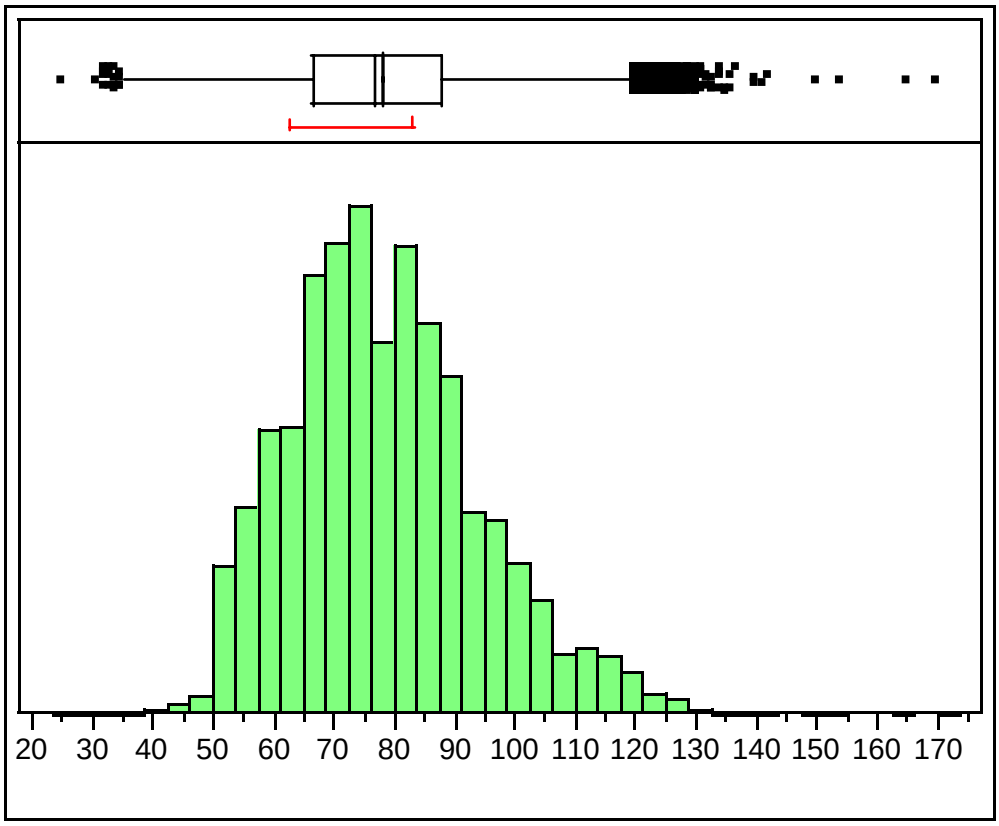


Frequencies

Level	Count	Prob
1	27360	0.28763
2	28395	0.29851
3	17462	0.18357
4	21905	0.23028
Total	95122	1.00000

The overall size frequency distribution of size samples shows a mode of 70-85 cm (TL) catch for gag GOM in commercial fisheries, with a range from 25 to 170 cm. 50% quartile is between 67 and 88 cm.

Frequency distribution of gag GOM size samples from commercial fisheries
TLcm



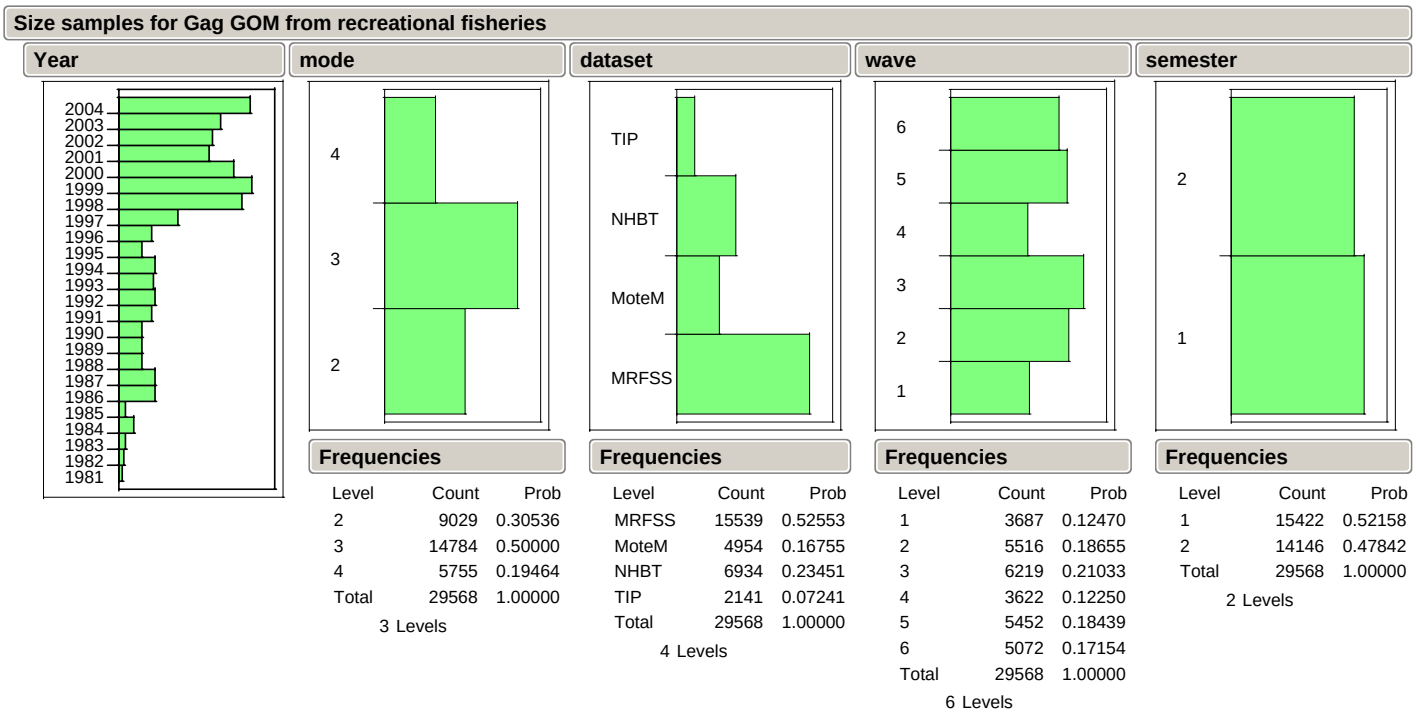
Quantiles

100.0%	maximum	170.00
99.5%		123.38
97.5%		114.00
90.0%		99.00
75.0%	quartile	88.00
50.0%	median	77.00
25.0%	quartile	67.00
10.0%		59.00
2.5%		52.00
0.5%		49.00
0.0%	minimum	25.00

Moments

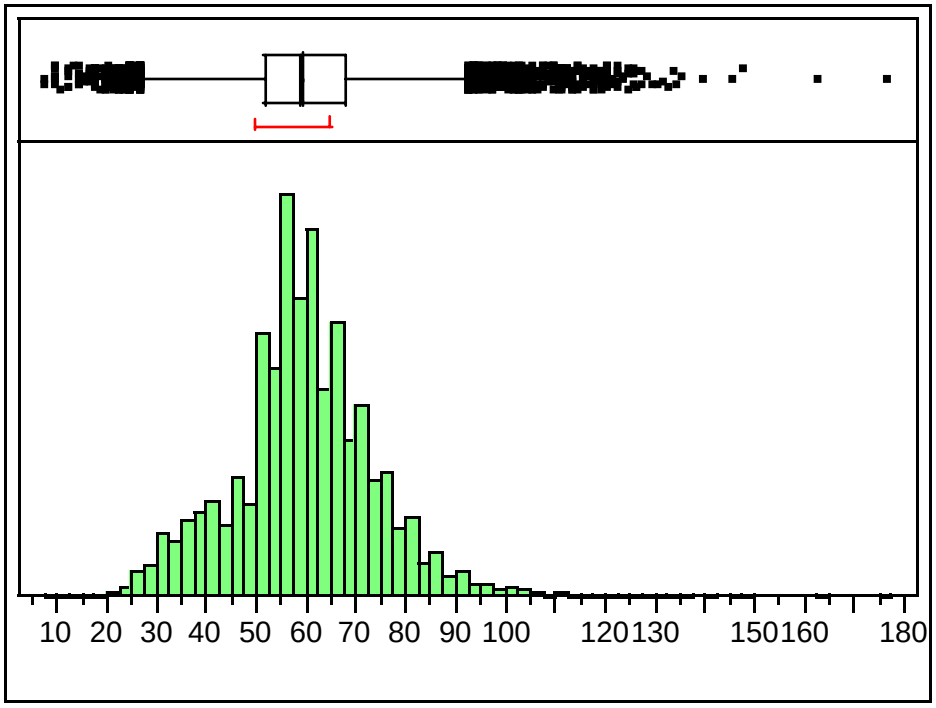
Mean	78.323784
Std Dev	15.699435
Std Err Mean	0.050903
upper 95% Mean	78.423554
lower 95% Mean	78.224015
N	95122

For recreational fisheries, about 30 thousand size samples were available since 1981. the following plots shows the distribution of these samples by year, semester, wave, fishing mode (Headboat, private, charter), and source of data.



Size samples increase in number in 1998 also, however distribution by mode, wave and semester is well balanced. The overall size frequency distribution of size samples for recreational gag GOM shows a mode at 60 cm., with a clear cut at the 50-51 cm, likely in respond to the minimum size restrictions.

Frequency distribution of TL length for gag GOM sampled from recreational fisheries 1981-2004
TLcm



Quantiles

100.0%	maximum	177.00
99.5%		108.15
97.5%		90.00
90.0%		77.00
75.0%	quartile	68.00
50.0%	median	59.00
25.0%	quartile	52.00
10.0%		40.00
2.5%		31.00
0.5%		24.00
0.0%	minimum	8.00

Moments

Mean	59.365158
Std Dev	14.5874
Std Err Mean	0.0848334
upper 95% Mean	59.531436
lower 95% Mean	59.198881
N	29568

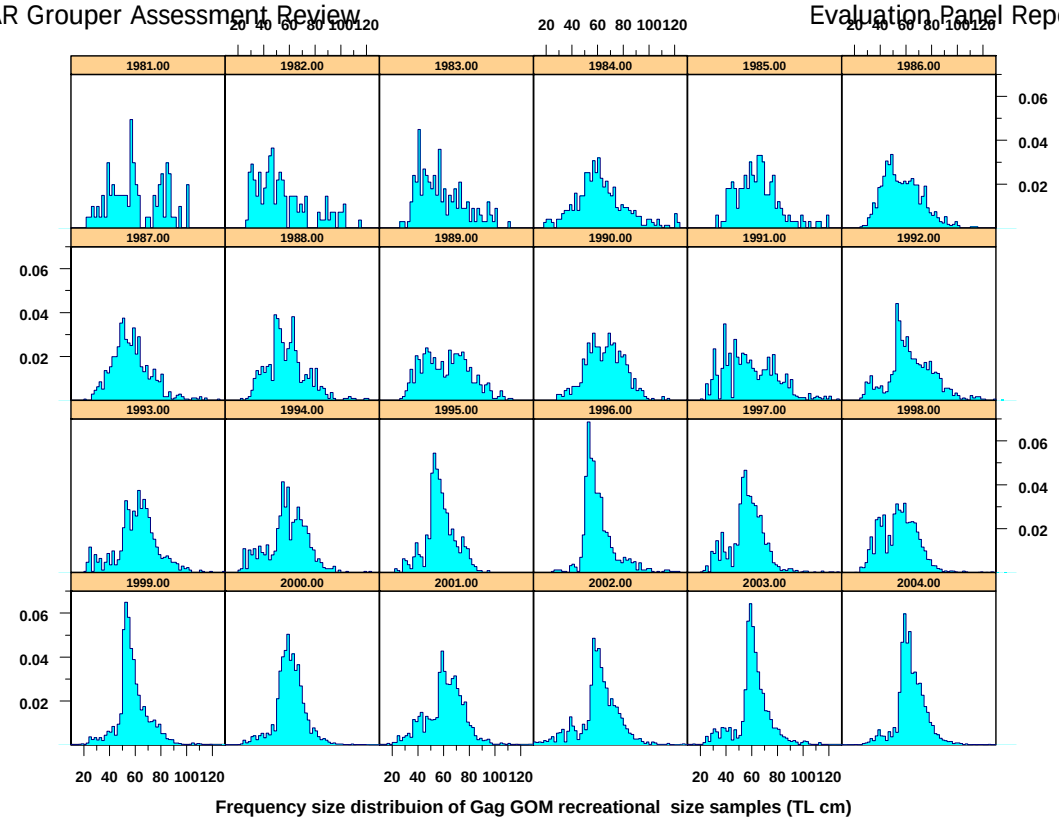
The next tables presents the size samples available for each stratum, a minimum of 150 length samples were required to used for converting catch to CAS by strata, if not available substitutions were done, see SEDAR10-AW-02 document for further detail (Ortiz 2006) by fishery type.

Commercial Length Frequency Samples used in converting Catch to CAS

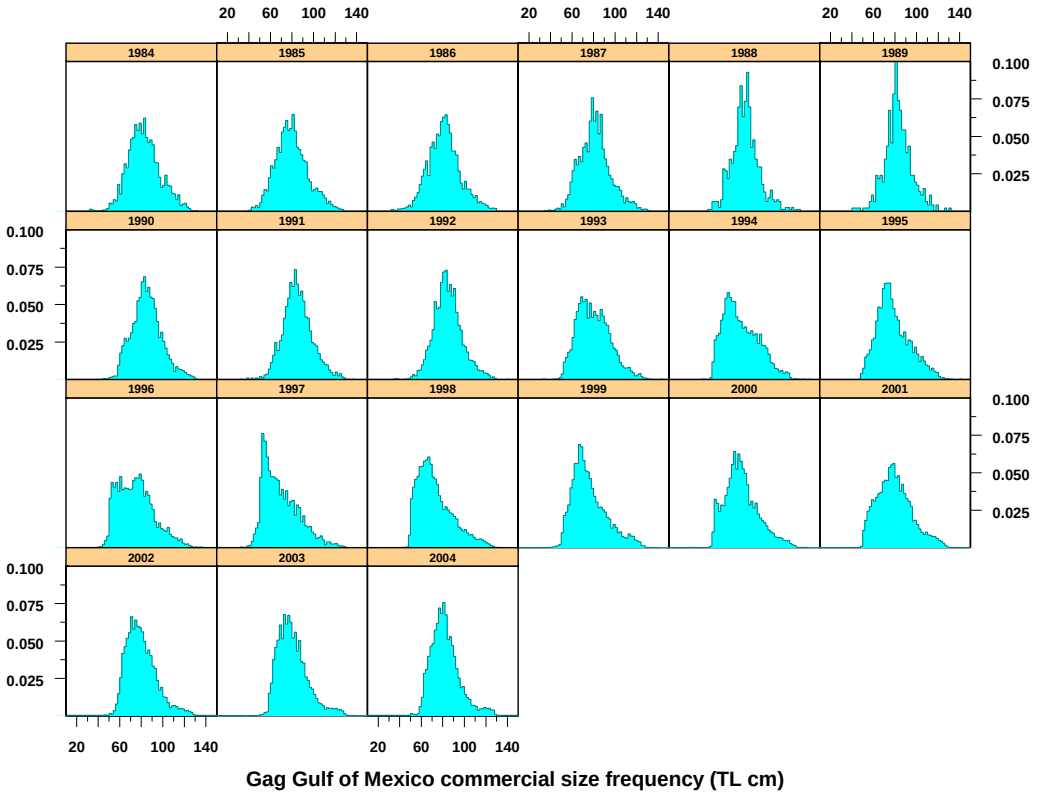
Year	Semester	Season	Mode1 Longline	Mode2 Handline	Mode3 Spear	Mode4 Traps	Mode5 Others
1984	1	1	0	0	81	284	334
1984	1	2	59	444	166	416	237
1984	2	3	242	195	121	309	193
1984	2	4	157	190	138	307	154
1985	1	1	128	299	0	0	0
1985	1	2	146	118	0	0	0
1985	2	3	151	152	0	0	0
1985	2	4	172	206	0	0	0
1986	1	1	145	170	0	0	0
1986	1	2	167	101	0	0	0
1986	2	3	447	75	0	0	0
1986	2	4	374	12	0	0	0
1987	1	1	180	166	0	0	0
1987	1	2	141	102	0	0	0
1987	2	3	130	152	0	0	0
1987	2	4	234	139	0	0	0
1988	1	1	244	175	0	0	0
1988	1	2	32	0	0	0	0
1989	1	2	0	7	0	0	0
1989	2	3	10	0	0	0	0
1989	2	4	160	35	0	0	0
1990	1	1	461	273	0	0	0
1990	1	2	406	306	0	0	0
1990	2	3	650	257	0	0	0
1990	2	4	148	148	0	0	0
1991	1	1	216	400	0	0	0
1991	1	2	292	393	0	0	0
1991	2	3	176	84	0	0	0
1991	2	4	256	128	0	0	0
1992	1	1	236	308	0	0	0
1992	1	2	340	338	0	0	0
1992	2	3	185	331	0	0	0
1992	2	4	168	173	0	0	0
1993	1	1	209	386	0	0	0
1993	1	2	260	662	0	0	0
1993	2	3	149	650	0	0	0
1993	2	4	171	190	0	0	0
1994	1	1	293	1467	0	0	0
1994	1	2	187	782	0	0	0
1994	2	3	171	301	0	0	0
1994	2	4	126	270	0	0	0
1995	1	1	187	361	0	0	0
1995	1	2	182	487	0	0	0
1995	2	3	377	293	0	0	0
1995	2	4	251	1296	0	0	0
1996	1	1	231	885	0	0	0
1996	1	2	220	753	0	0	0
1996	2	3	176	614	0	0	0
1996	2	4	411	895	0	0	0
1997	1	1	227	928	0	0	0
1997	1	2	209	1015	0	0	0
1997	2	3	316	801	0	0	0
1997	2	4	472	620	0	0	0
1998	1	1	830	2610	0	0	0
1998	1	2	1387	1606	0	0	0
1998	2	3	1009	1240	0	0	0
1998	2	4	1841	2543	0	0	0
1999	1	1	1268	2365	0	0	0
1999	1	2	1383	2018	0	0	0
1999	2	3	988	655	0	0	0
1999	2	4	1015	839	0	0	0
2000	1	1	802	843	0	0	0
2000	1	2	1390	1503	0	0	0
2000	2	3	436	588	0	0	0
2000	2	4	1540	983	0	0	0
2001	1	1	1250	1845	0	0	0
2001	1	2	1531	2214	0	0	0
2001	2	3	695	951	0	0	0
2001	2	4	675	423	0	0	0
2002	1	1	894	1969	0	0	0
2002	1	2	1830	1062	0	0	0
2002	2	3	737	340	0	0	0
2002	2	4	676	745	0	0	0
2003	1	1	935	754	0	0	0
2003	1	2	1189	723	0	0	0
2003	2	3	931	356	0	0	0
2003	2	4	866	368	0	0	0
2004	1	1	740	981	0	0	0
2004	1	2	936	655	0	0	0
2004	2	3	605	223	0	0	0
2004	2	4	383	1007	0	0	0

Recreational Length Frequency Samples used in converting Catch to CAS

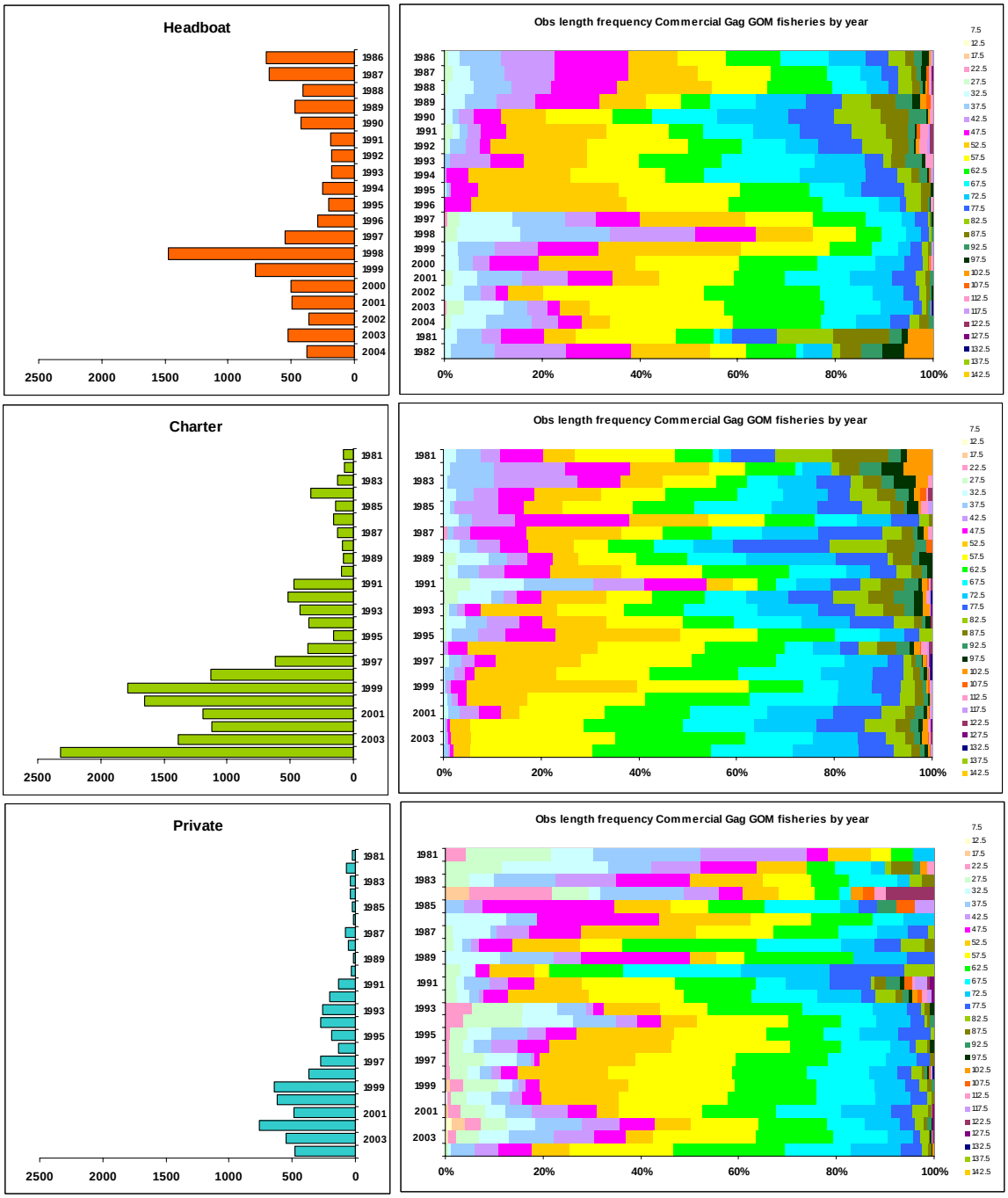
Year	Semester	Wave	Mode2 Headboat	Mode3 Charter	Mode4 Private
1981	1	1	0	15	0
1981	1	2	0	16	0
1981	1	3	0	13	0
1981	2	4	0	13	5
1981	2	5	0	12	8
1981	2	6	0	9	10
1982	1	1	0	7	1
1982	1	2	0	33	8
1982	1	3	0	5	24
1982	2	4	0	8	16
1982	2	5	0	4	4
1982	2	6	0	11	16
1983	1	1	0	10	0
1983	1	2	0	33	16
1983	1	3	0	31	14
1983	2	4	0	21	9
1983	2	5	0	13	1
1983	2	6	0	19	0
1984	1	1	0	18	3
1984	1	2	0	14	0
1984	1	3	0	96	11
1984	2	4	0	110	15
1984	2	5	0	85	2
1984	2	6	0	11	10
1985	1	1	0	18	0
1985	1	2	0	15	1
1985	1	3	0	15	1
1985	2	4	0	9	14
1985	2	5	0	65	6
1985	2	6	0	18	4
1986	1	1	168	49	0
1986	1	2	132	36	0
1986	1	3	100	3	2
1986	2	4	92	36	2
1986	2	5	107	23	10
1986	2	6	96	8	2
1987	1	1	114	0	4
1987	1	2	104	43	24
1987	1	3	134	60	26
1987	2	4	88	5	12
1987	2	5	117	13	5
1987	2	6	118	8	5
1988	1	1	95	20	0
1988	1	2	69	0	1
1988	1	3	111	10	17
1988	2	4	63	8	6
1988	2	5	64	34	11
1988	2	6	5	14	23
1989	1	1	56	27	8
1989	1	2	72	13	4
1989	1	3	76	7	3
1989	2	4	80	1	0
1989	2	5	90	13	3
1989	2	6	98	15	0
1990	1	1	118	0	3
1990	1	2	132	1	2
1990	1	3	85	7	13
1990	2	4	50	0	1
1990	2	5	12	18	6
1990	2	6	29	70	8
1991	1	1	38	106	22
1991	1	2	29	148	17
1991	1	3	41	60	23
1991	2	4	21	38	12
1991	2	5	25	47	23
1991	2	6	33	72	35
1992	1	1	18	60	14
1992	1	2	53	184	30
1992	1	3	34	102	32
1992	2	4	24	20	32
1992	2	5	31	102	53
1992	2	6	19	50	40
1993	1	1	25	10	58
1993	1	2	20	129	30
1993	1	3	59	146	45
1993	2	4	44	67	32
1993	2	5	17	47	24
1993	2	6	13	21	68
1994	1	1	68	2	7
1994	1	2	21	80	62
1994	1	3	19	113	27
1994	2	4	21	46	109
1994	2	5	78	49	17
1994	2	6	41	61	50
1995	1	1	31	33	14
1995	1	2	46	39	23
1995	1	3	32	11	24
1995	2	4	34	9	35
1995	2	5	38	27	61
1995	2	6	24	38	33
1996	1	1	10	14	3
1996	1	2	42	102	34
1996	1	3	61	208	28
1996	2	4	41	15	23
1996	2	5	84	5	26
1996	2	6	52	17	22
1997	1	1	35	35	14
1997	1	2	55	26	21
1997	1	3	69	128	44
1997	2	4	87	57	24
1997	2	5	218	154	74
1997	2	6	82	222	96
1998	1	1	488	191	31
1998	1	2	320	161	36
1998	1	3	257	221	66
1998	2	4	222	98	56
1998	2	5	107	202	82
1998	2	6	80	252	100
1999	1	1	120	273	91
1999	1	2	123	389	179
1999	1	3	206	356	82
1999	2	4	177	189	56
1999	2	5	106	261	59
1999	2	6	55	318	172
2000	1	1	61	213	80
2000	1	2	133	353	156
2000	1	3	57	513	153
2000	2	4	59	134	38
2000	2	5	131	274	77
2000	2	6	57	169	112
2001	1	1	75	118	42
2001	1	2	103	226	53
2001	1	3	109	307	122
2001	2	4	67	98	55
2001	2	5	55	242	66
2001	2	6	84	201	144
2002	1	1	31	122	62
2002	1	2	31	181	80
2002	1	3	15	232	51
2002	2	4	61	70	126
2002	2	5	78	212	214
2002	2	6	148	306	224
2003	1	1	51	75	43
2003	1	2	77	260	132
2003	1	3	125	401	127
2003	2	4	81	213	73
2003	2	5	84	223	89
2003	2	6	108	218	88
2004	1	1	24	91	54
2004	1	2	81	373	109
2004	1	3	133	455	61
2004	2	4	29	213	52
2004	2	5	35	819	110
2004	2	6	77	372	91



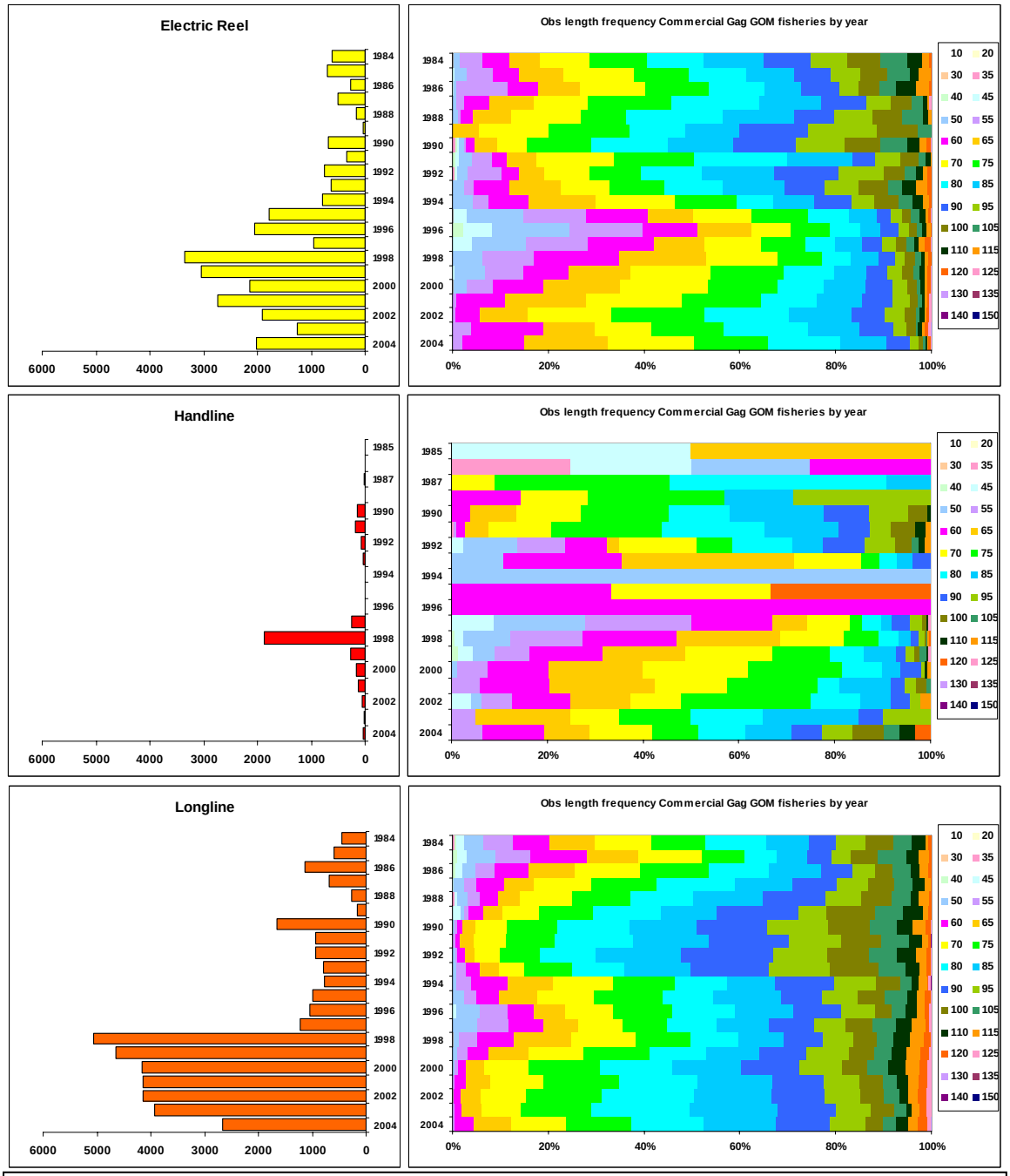
Frequency distribution of size samples from recreational fisheries for gag GOM by year.



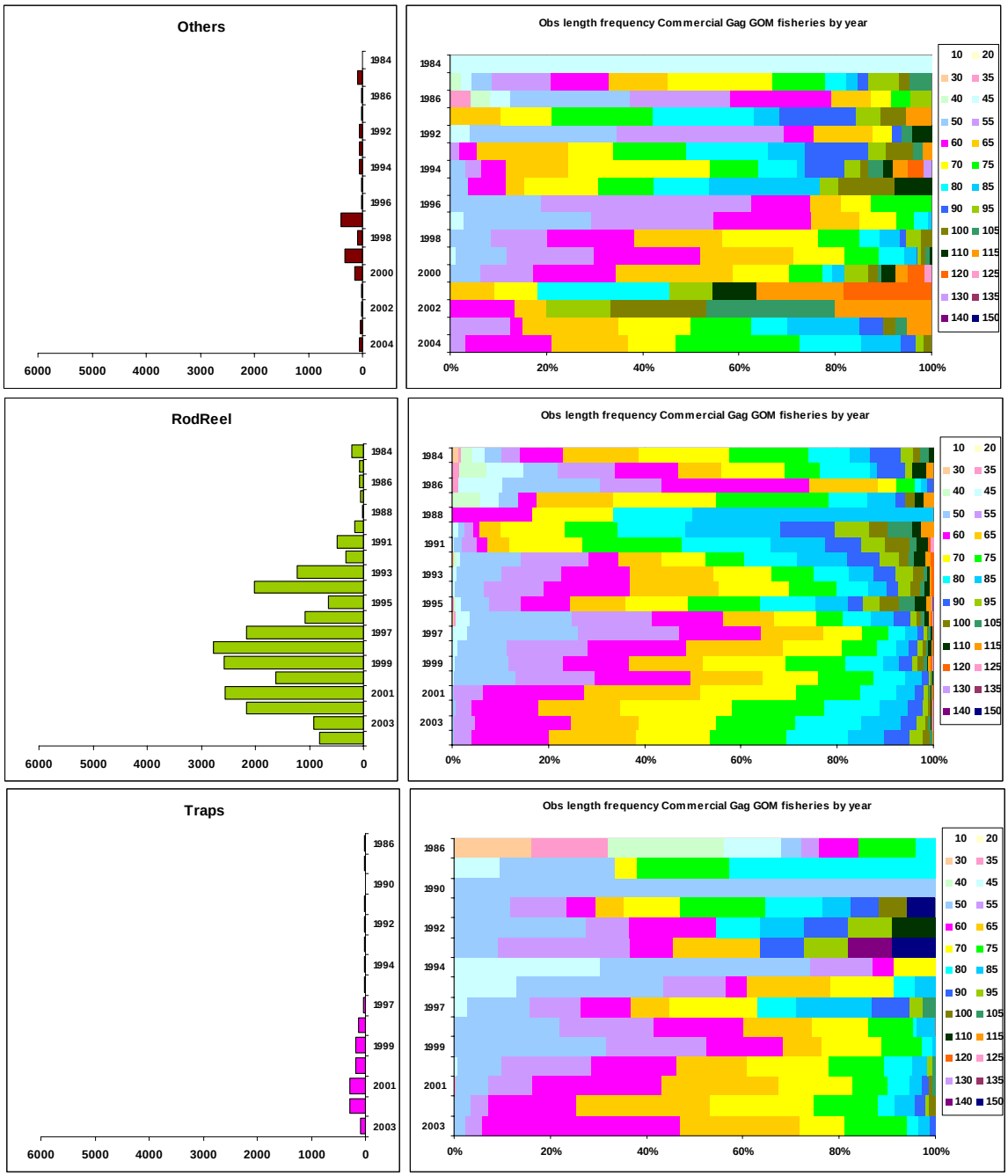
Frequency distribution of size samples from commercial fisheries for gag GOM by year.



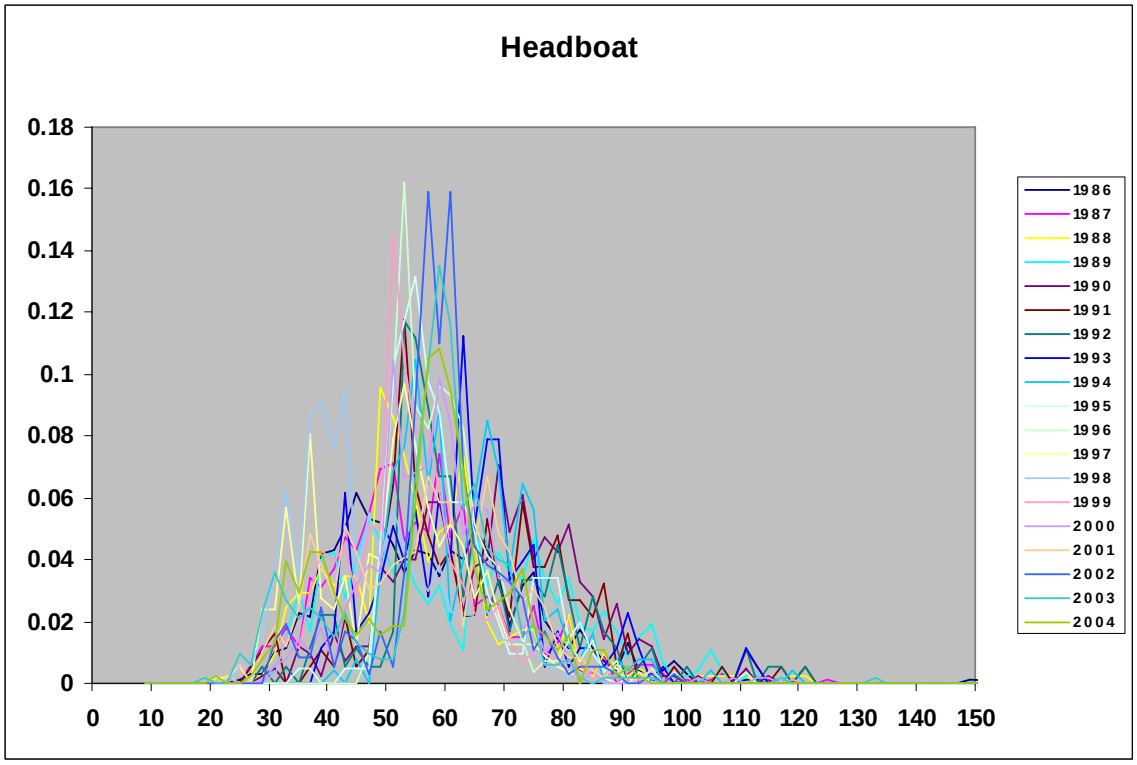
Size proportions (right column) and sample size (left column) by year and mode of gag GOM from recreational fisheries.

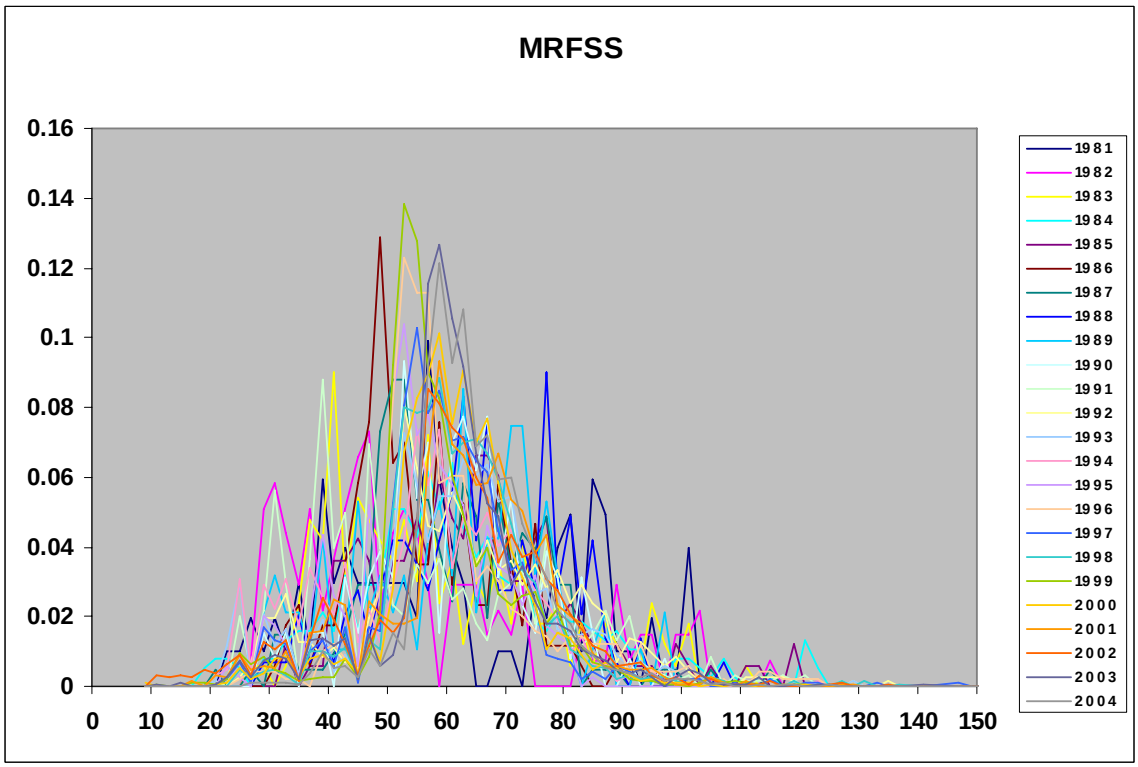


Size proportions (right column) and sample size (left column) by year and mode of gag GOM from commercial fisheries.

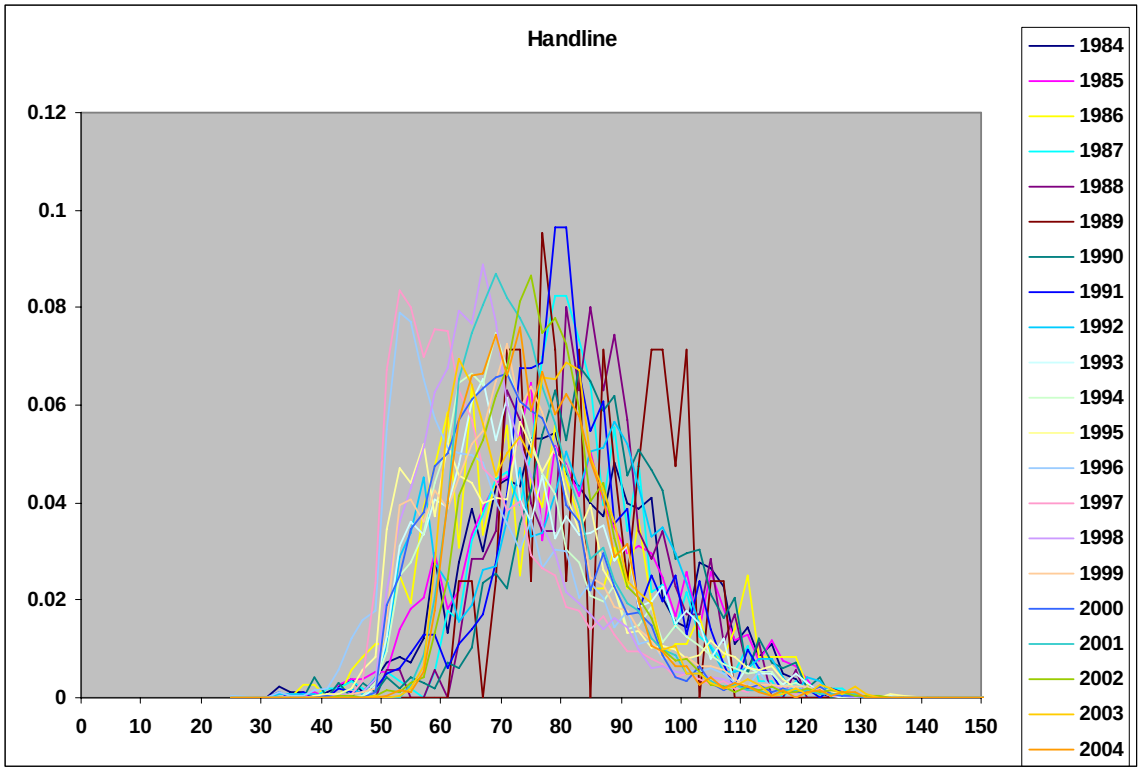


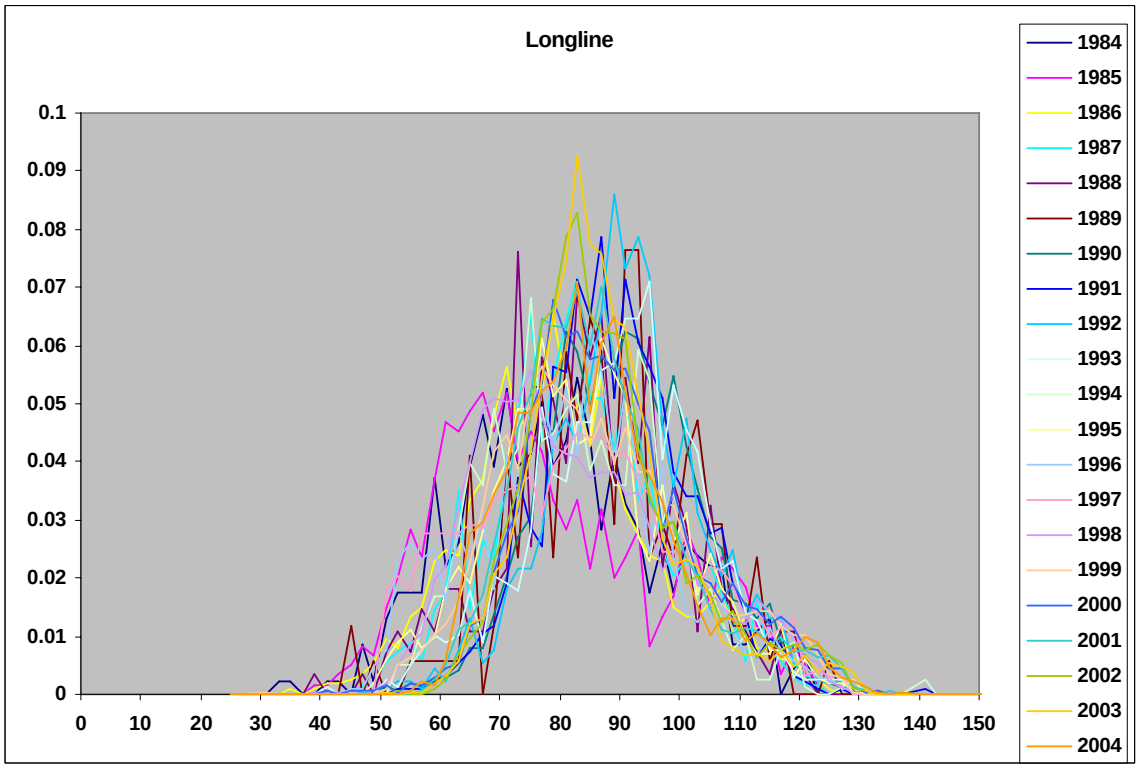
Size proportions (right column) and sample size (left column) by year and mode of gag GOM from commercial fisheries.





Estimated CAS for the recreational fisheries gag GOM by year and main fishery type.

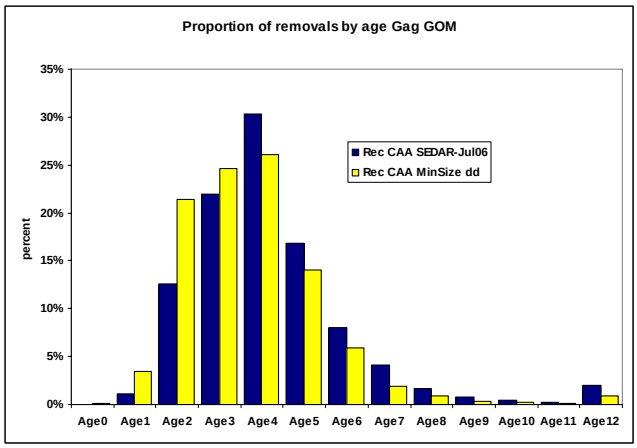


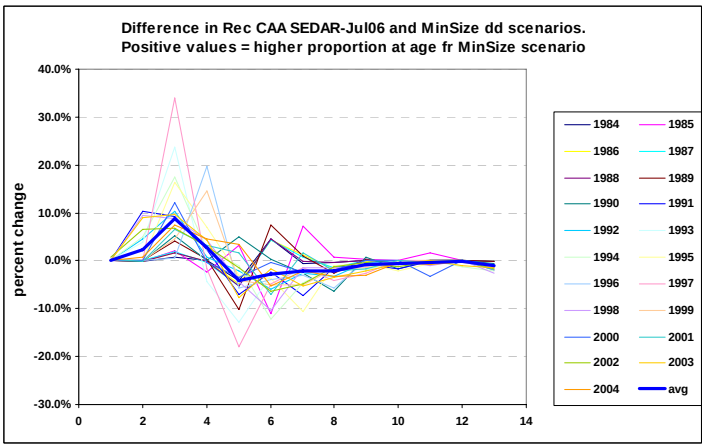


Estimated CAS for the commercial fisheries gag GOM by year and main fishery type

3. The panel recommends constructing an analysis of Gulf of Mexico gag grouper based on assigning discarded fish to sizes below the minimum limit.

Following the recommendations from the review panel, the final (SEDAR-Jul06) run for Gag GOM was modified such that all discarded fish from recreational fisheries were below the applicable minimum size limits. Thus all B2 estimates from MRFSS and Headboat were assumed to be less than 20 inches (51 cm TL) from Jan-1990 to Jun-2000, and less than 22 inches (56 cm TL) from Jul-2000 to Dec-2004. Discards prior to 1990 were treated as in the base case, i.e. assuming the same size distribution as of landed fish for those years. The estimation of dead discards as a function of depth was otherwise accomplished as describer earlier for the final SEDAR-Jul06 run. The total number of discards was set to the MRFSS B2 estimates as before, but the total number of dead discards decreased in comparison to the original base run because gag larger than the size limit are no longer assumed to be released (larger gag tend to reside in deeper water and therefore have higher mortality rates). Moreover, the age composition of the removals was shifted towards younger fish as shown in the following plots of recreational catch at age (CAA).





As expected, assuming that discards were only fish below minimum size, the age distribution of total removals was different. For the recreational CAA (the commercial CAA did not change), assuming a discards of fish below min-size implied that more fish ages 1, 2 and 3 were removed from the stock, while for older ages, 4 and above the proportion at age decreased. The right plot shows the same information but for each year since 1984. Because smaller size fish have a higher probability of survive if discarded (i.e. lower mortality at depth), the total numbers of removals between the scenarios were also different. Tables 1 and 2 show the total estimated catch removals in weight units by year and fishery for the two scenarios:

Table 1. Estimated final catch removals (landings + dead discards) SEDAR Jul06. The highlighted show the differences in weight when it is assumed that all discards are below minimum size regulations.

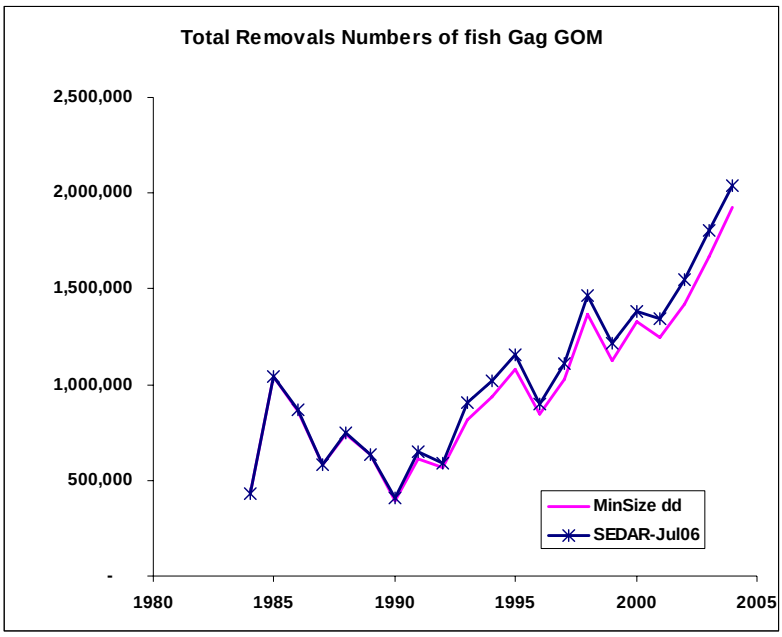
thousand lbs

Year	Longline	Handline	Others	MRFSS	Headboat	Total
1963	-	1,289	1	444	-	1,734
1964	-	1,632	9	479	-	2,121
1965	-	1,816	1	518	-	2,334
1966	-	1,457	1	559	-	2,017
1967	-	1,156	10	604	-	1,769
1968	-	1,192	4	652	-	1,849
1969	-	1,377	3	704	-	2,084
1970	-	1,284	3	761	-	2,047
1971	-	1,377	3	869	-	2,249
1972	-	1,460	4	994	-	2,458
1973	-	1,081	5	1,136	-	2,222
1974	-	1,184	1	1,298	-	2,483
1975	-	1,447	4	1,483	-	2,934
1976	-	1,198	9	1,697	-	2,905
1977	-	977	8	1,942	-	2,927
1978	-	875	11	2,226	-	3,112
1979	1	1,342	10	2,551	-	3,905
1980	89	1,318	12	2,909	-	4,328
1981	467	1,499	16	2,459	-	4,440
1982	1,010	1,335	14	3,509	-	5,868
1983	681	1,039	18	7,460	-	9,198
1984	433	1,098	18	2,134	-	3,684
1985	381	1,398	28	6,967	-	8,774
1986	517	1,155	29	4,263	308	6,273
1987	656	853	30	2,827	231	4,596
1988	402	791	23	4,224	165	5,605
1989	426	1,235	31	3,264	338	5,295
1990	625	1,130	41	1,991	308	4,094
1991	510	993	63	4,843	111	6,520
1992	593	1,003	69	3,951	156	5,771
1993	482	1,281	106	5,874	211	7,954
1994	352	1,148	119	6,458	317	8,394
1995	394	1,158	105	7,251	195	9,102
1996	397	1,107	68	5,311	177	7,059
1997	420	1,101	83	6,794	168	8,565
1998	609	1,849	82	8,598	428	11,565
1999	550	1,481	68	7,252	315	9,666
2000	637	1,605	81	8,375	271	10,969
2001	1,053	2,088	101	8,767	167	12,175
2002	1,059	1,934	62	10,641	145	13,840
2003	1,190	1,477	67	12,219	240	15,193
2004	1,191	1,757	73	13,718	327	17,066

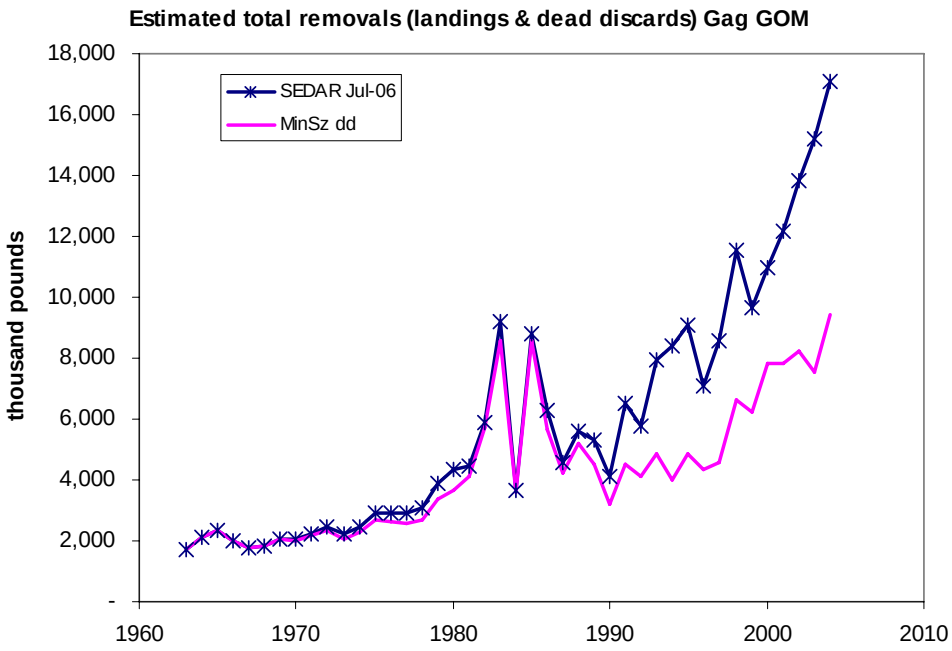
Table 2. Estimated total biomass removals (landings + death discards) gag GOM Depth-release mortality MinSize discards only (thousand lbs). The highlighted show the differences in weight when it is assumed that all discards are below minimum size regulations.

Year	Longline	Handline	Others	MRFSS	Headboat	Total
1963	-	1,289	1	444	-	1,734
1964	-	1,632	9	479	-	2,121
1965	-	1,816	1	514	-	2,331
1966	-	1,457	1	547	-	2,005
1967	-	1,156	10	582	-	1,748
1968	-	1,192	4	620	-	1,816
1969	-	1,377	3	659	-	2,039
1970	-	1,284	3	701	-	1,987
1971	-	1,377	3	789	-	2,168
1972	-	1,460	4	887	-	2,351
1973	-	1,081	5	997	-	2,084
1974	-	1,184	1	1,121	-	2,307
1975	-	1,447	4	1,260	-	2,711
1976	-	1,198	9	1,418	-	2,625
1977	-	977	8	1,595	-	2,580
1978	-	875	11	1,796	-	2,682
1979	1	1,342	10	2,022	-	3,376
1980	89	1,318	12	2,265	-	3,684
1981	467	1,499	16	2,108	-	4,089
1982	1,010	1,335	14	3,341	-	5,699
1983	681	1,039	18	6,820	-	8,558
1984	433	1,098	18	2,023	-	3,573
1985	381	1,398	28	6,750	-	8,557
1986	517	1,155	29	3,671	289	5,662
1987	656	853	30	2,483	204	4,225
1988	402	791	23	3,850	155	5,221
1989	426	1,235	31	2,507	318	4,517
1990	625	1,130	41	1,179	198	3,173
1991	510	993	63	2,857	107	4,530
1992	593	1,003	69	2,339	125	4,129
1993	482	1,281	106	2,828	173	4,870
1994	352	1,148	119	2,204	188	4,011
1995	394	1,158	105	3,055	129	4,841
1996	397	1,107	68	2,633	114	4,319
1997	420	1,101	83	2,843	102	4,548
1998	609	1,849	82	3,820	246	6,605
1999	550	1,481	68	3,907	201	6,207
2000	637	1,605	81	5,263	214	7,801
2001	1,053	2,088	101	4,436	125	7,803
2002	1,059	1,934	62	5,093	91	8,238
2003	1,190	1,477	67	4,652	132	7,518
2004	1,191	1,757	73	6,215	199	9,434

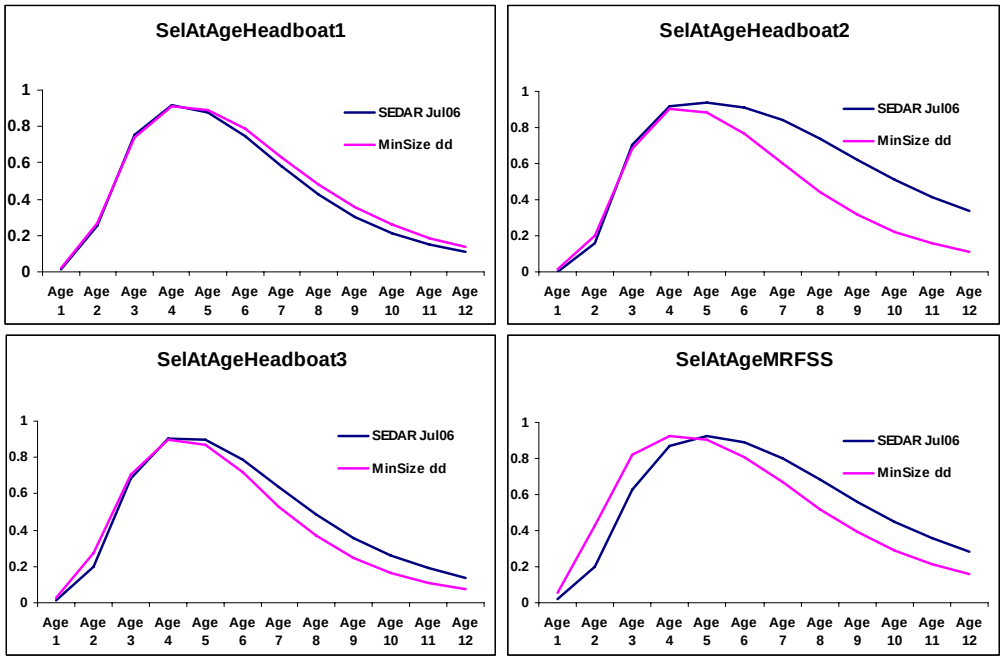
Minimum size regulations only started in 1990, changes of recreational discards prior to 1989 were also different because for those years, due to the lack of B2 estimates, it was assumed that discards were proportional to the average of 1989-1990, plus average weight of discards for 1984-1989 were used to convert estimated numbers of fish to weight removals. The following plot shows the estimated total removals for the two scenarios in numbers of fish. Differences are notable from 1990 on, ranging from 4 to 10% by year, with fewer removals under the minimum size (MinSize dd) scenario.



The estimated removals in terms of weight units shows a larger differences(30 to 100%) between scenarios, particularly in the latest years, when the proportion of B2 fish discarded fish from recreational fisheries) has increase significantly.



Under the minimum size scenario, the CASAL model estimated selectivity patterns of the recreational fisheries (Headboat and MRFSS) that were shifted towards younger age-classes and reduced selectivity of older age classes, particularly in the years of the minimum size implementations.

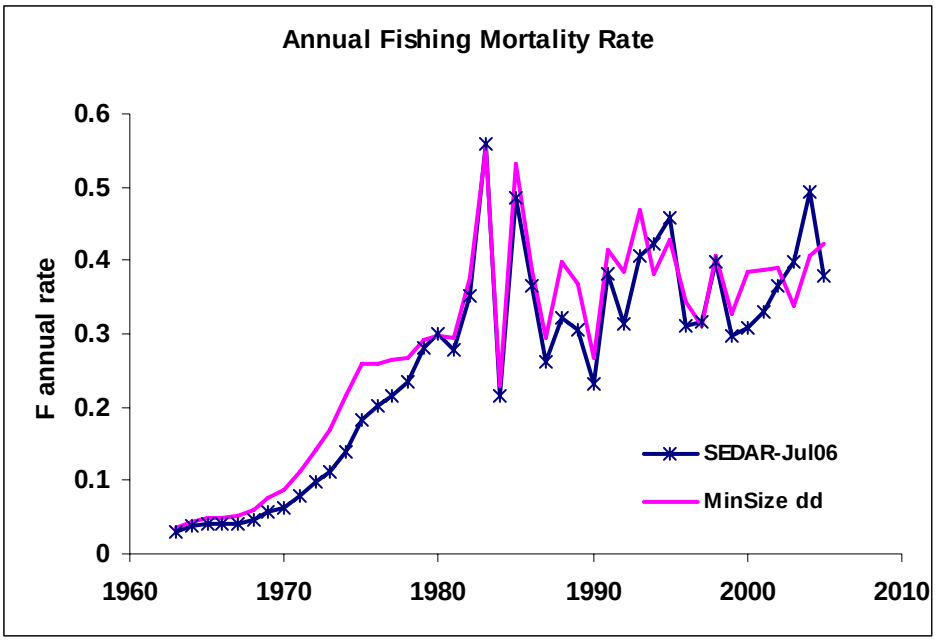


The model also estimated larger fishing mortality rates for younger age-classes and overall for all ages. Table 3 shows the percent change in FAA by year for the

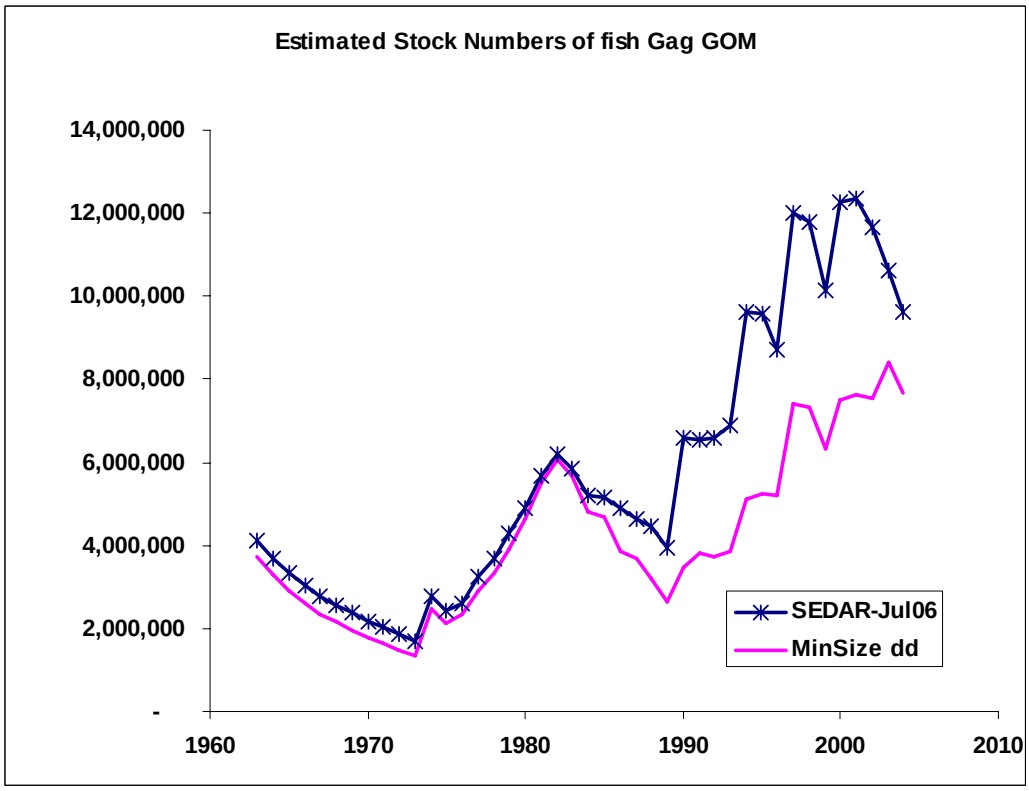
Table 3. Percent difference between FAA SEDAR-Jul06 and FAA MinSize dd scenarios by age and year.

higher F-age MinSize dd; lower F-age MinSize dd

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
1963	75%	67%	45%	29%	21%	16%	12%	9%	7%	5%	5%	5%
1964	76%	67%	45%	28%	21%	16%	12%	9%	7%	6%	6%	6%
1965	76%	67%	46%	30%	22%	17%	13%	10%	8%	7%	6%	6%
1966	77%	68%	48%	32%	25%	20%	15%	11%	9%	7%	6%	6%
1967	77%	69%	50%	35%	28%	22%	18%	13%	10%	7%	6%	5%
1968	78%	70%	51%	37%	30%	25%	19%	15%	11%	8%	7%	6%
1969	78%	71%	52%	39%	31%	26%	21%	16%	12%	10%	8%	7%
1970	79%	71%	53%	40%	33%	28%	22%	18%	14%	11%	9%	8%
1971	79%	72%	54%	41%	34%	29%	24%	19%	14%	11%	10%	9%
1972	79%	72%	54%	42%	35%	30%	25%	19%	15%	12%	10%	9%
1973	79%	72%	55%	43%	37%	32%	26%	21%	16%	12%	10%	8%
1974	79%	72%	55%	44%	38%	32%	26%	21%	16%	12%	10%	9%
1975	77%	69%	51%	38%	32%	27%	22%	16%	12%	10%	8%	8%
1976	74%	65%	44%	31%	25%	20%	14%	9%	6%	3%	3%	3%
1977	72%	63%	41%	27%	21%	16%	10%	4%	1%	-1%	-2%	-1%
1978	69%	60%	35%	20%	14%	8%	2%	-3%	-7%	-8%	-8%	-7%
1979	67%	56%	29%	13%	8%	4%	-1%	-4%	-6%	-6%	-4%	-2%
1980	64%	53%	23%	7%	2%	-1%	-5%	-8%	-9%	-8%	-5%	-3%
1981	66%	54%	26%	11%	8%	6%	4%	3%	3%	4%	6%	8%
1982	68%	57%	31%	16%	11%	9%	7%	5%	5%	6%	8%	10%
1983	66%	56%	29%	11%	3%	-2%	-8%	-12%	-13%	-13%	-11%	-8%
1984	67%	56%	29%	14%	10%	8%	6%	5%	5%	6%	7%	8%
1985	69%	60%	36%	20%	13%	7%	1%	-5%	-8%	-9%	-8%	-6%
1986	67%	55%	30%	15%	9%	6%	2%	-1%	-3%	-2%	-1%	1%
1987	69%	57%	33%	19%	14%	11%	8%	6%	5%	5%	6%	8%
1988	72%	63%	42%	28%	22%	17%	12%	7%	4%	2%	2%	3%
1989	69%	58%	36%	24%	20%	17%	14%	12%	11%	11%	12%	13%
1990	65%	51%	24%	14%	14%	14%	13%	13%	14%	16%	18%	20%
1991	66%	55%	29%	14%	11%	8%	5%	3%	3%	4%	7%	10%
1992	68%	58%	33%	21%	20%	18%	16%	15%	16%	17%	19%	22%
1993	64%	52%	25%	13%	14%	14%	13%	12%	14%	17%	20%	24%
1994	50%	33%	-6%	-18%	-14%	-10%	-8%	-5%	0%	6%	12%	18%
1995	55%	40%	4%	-11%	-9%	-7%	-6%	-3%	1%	6%	12%	18%
1996	60%	47%	17%	5%	8%	10%	11%	13%	16%	19%	24%	27%
1997	55%	40%	4%	-8%	-5%	-1%	1%	4%	8%	13%	19%	24%
1998	55%	39%	4%	-7%	-2%	2%	5%	8%	12%	17%	22%	27%
1999	61%	47%	17%	5%	7%	9%	10%	12%	15%	19%	23%	27%
2000	68%	57%	31%	19%	20%	20%	19%	18%	18%	18%	20%	22%
2001	62%	49%	18%	7%	11%	15%	16%	17%	19%	21%	23%	26%
2002	59%	46%	12%	-1%	3%	6%	8%	9%	11%	14%	17%	20%
2003	48%	30%	-14%	-31%	-25%	-18%	-15%	-11%	-6%	-1%	5%	10%
2004	51%	34%	-7%	-27%	-25%	-21%	-19%	-17%	-13%	-9%	-4%	1%

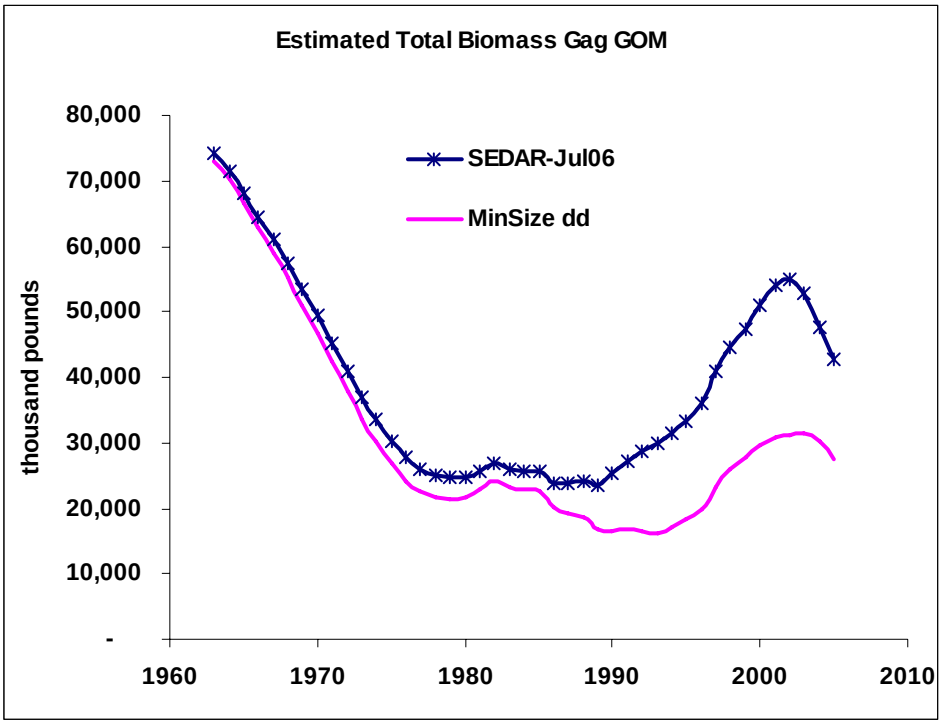


The overall annual fishing mortality rate (F) was larger with the MinSize dd scenario for the early years 1963-1979, and during 1985-1994, but lower in the latest years except in 2004.

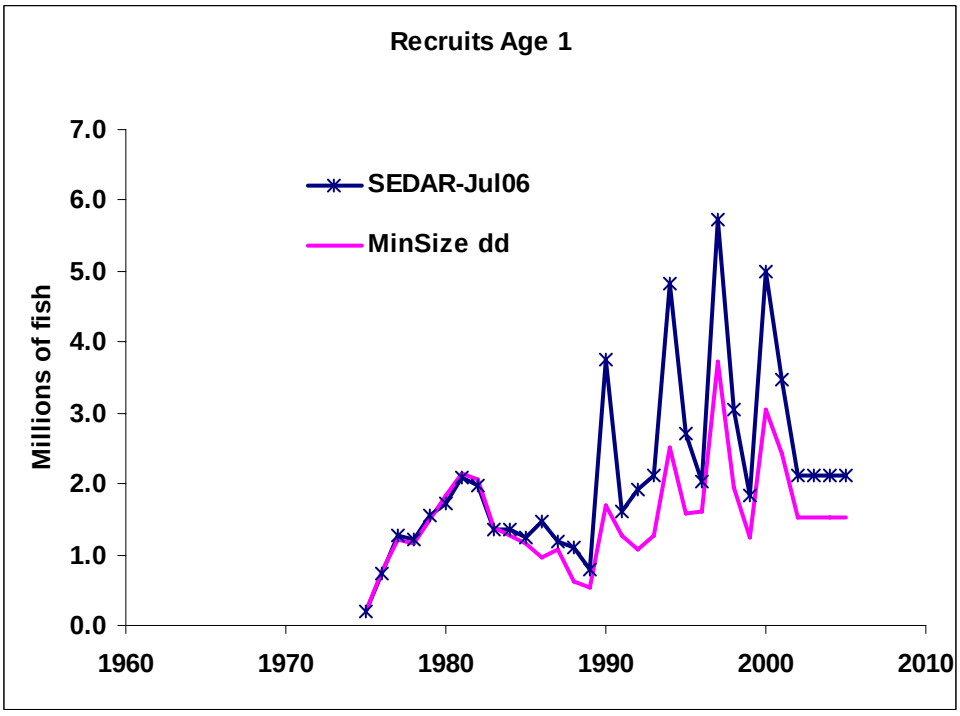


The CASAL model estimated overall lower number of fish for the gag GOM stock under the MinSize dd scenario compare to the SEDAR-Jul06 results. Differences were greater since 1985 on.

Consistently, the estimated total biomass of gag GOM stock was lower for the MinSize dd scenario, again mainly since 1990 on.



Estimated numbers of recruits (Age 1) were also lower under the minimum size scenario, especially for the strong year classes 1990, 1994, 1997 and 2000.



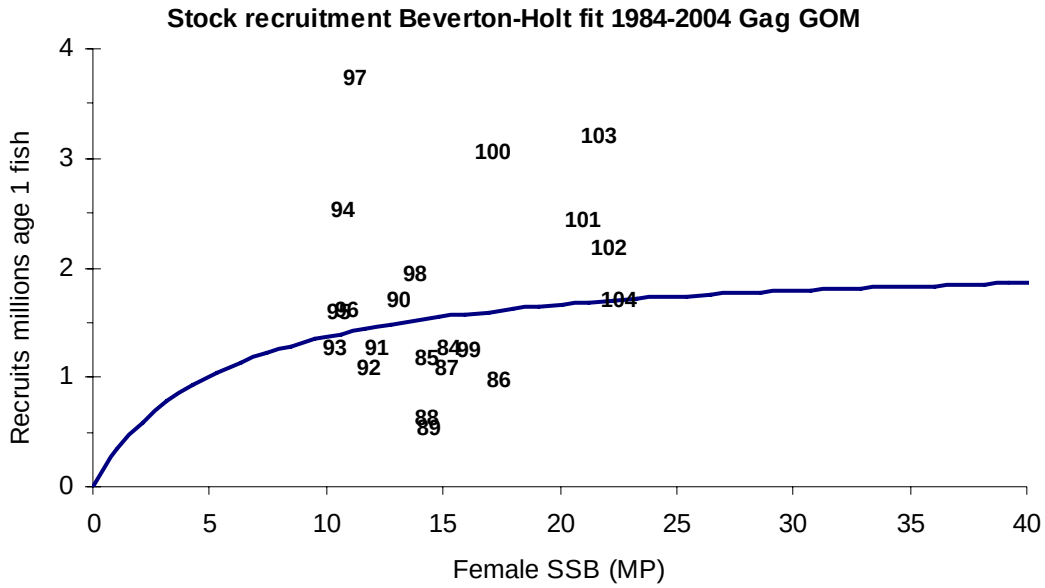
In summary, assuming that gag GOM discards were only of minimum size fish within the 1990-2004 period did change the perception of the status of the stock relative to that of the base run accepted by the SEDAR 10 RW. Overall the model predicted a smaller stock, fewer numbers and lower biomass, undergoing higher fishing mortality rates (affecting primarily younger age classes). Although survival of smaller fish is higher due to the size-depth distribution patterns, the main difference in inputs correspond to the age distribution of the removals (catch + dead discards) with higher percentages of ages 1 and 2 primarily, and lower proportions of older age classes. Thus, the biomass of removals was greatly reduced in the latest years. The model then estimated a lower recruitment levels. Trends of selectivity, and estimated yields were as expected, and patterns of CPUE fits were very similar between the two scenarios.

Table 4. benchmarks estimates assuming a constant recruitment projection. Landings refer to landed fish; all removals include landed and dead discards.

	Benchmarks			
	Landings		All removals	
	SEDAR (July06)	MinSz Discards	SEDAR (July06)	MinSz Discards
Fmsy	0.248	0.145763	0.2284	0.2007
MSY thousand lbs	4,269.96	4,944.41	8,661.21	6,327.49
SSBmsy	35,019.60	33,888.33	37,619.38	26,320.93
YPRmsy	2.01	3.24	4.08	4.14
Fmax	0.248	0.146	0.2284	0.201
YPRmax	2.01	3.24	4.08	4.14
$F_{20\%SPR}$	0.37	0.32	0.37	0.32
$F_{30\%SPR}$	0.25	0.22	0.25	0.22
$F_{40\%SPR}$	0.18	0.16	0.18	0.16
$YPR_{20\%SPR}$	1.92	2.58	3.88	3.94
$YPR_{30\%SPR}$	2.01	3.05	4.07	4.13
$YPR_{40\%SPR}$	1.95	3.23	4.02	4.08
$SSB_{20\%SPR}$	23,116.08	16,096.83		
$SSB_{30\%SPR}$	34,641.41	24,152.20		
$SSB_{40\%SPR}$	46,113.88	32,161.89		
F2004	0.4925	0.4067		
F2005	0.3780	0.4238		
SSB2004	40,550.66	21,169.60		
SSB2005	33,281.94	19,185.02		
Yield 2004	7,627.75	5,378.85		
Yield 2005	5,808.37	5,808.37		
GeoMean Rec84-04	2,124,871	1,527,669		
Steepness CASAL	0.75140	0.847733		

Table 4 summarizes the estimates of various benchmarks assuming a constant recruitment (geometric mean of estimated recruits 1984-2004). The benchmarks are given in terms of landings (only) or all removals (landings + dead discards). MSY estimates were lower for the MinSize dd scenario in terms of all removals, but higher in terms of landings (implying a larger yield per recruit in this scenario). The F reference

points are somewhat lower under the minimum size scenario, but the average F is somewhat higher. This implies a greater degree of overfishing than did the previous SEDAR 10 base run. CASAL estimated a higher steepness for the minimum size scenario (0.84) but lower on average recruitment (1.5 million recruits per year).



The stock-recruitment fit for the minimum size scenario showed a similar pattern as the SEDAR-Jul06 run, but with lower absolute values and without the cluster of low values just below 20 mp (which the SEDAR 10 RW used to justify their *ad hoc* recommendation of a 20 mp MSST). The estimates of recruitment for in recent years (2000-2004) continue to be larger than expected from the spawner-recruit curve.

If fishing rates are compare to the MSY benchmarks, at the end of 2004 the stock of gag GOM experience a larger F particularly with the minimum size only discard assumption, 2.8 times greater than the F at MSY. Similarly, the spawning stock biomass was below that estimated at MSY (0.62). Therefore the stock is estimated to be overfished and undergoing overfishing relative to MSY (maximum YPR) levels. This is in contrast to the results from the SEDAR 10 base run which suggested only that the stock was undergoing overfishing, and not overfished (see below)

	SEDAR-Jul06	MinSize dd
F2004/Fmsy	1.99	2.79
SSB2004/SSBmsy	1.16	0.62

3.3. Gulf of Mexico Grouper Recreational Catch per Trip

Gag and Aggregate Grouper Bag Limits

Southeast Regional Office
April 26, 2007

At the Grouper Southeast Data, Assessment, and Review (SEDAR) meeting in Miami, Florida, on March 19-22, 2007, the evaluation panel requested:

> **…frequency distributions from the Marine Recreational Fishery Statistics Survey (MRFSS) and other recreational sampling sources of catch per angler for Gulf of Mexico grouper by year. This should be constructed to include all grouper species subject to a five fish bag limit.**

The following tables summarize frequency distributions of landings per angler for Gulf of Mexico gag and all aggregate groupers combined. There are 13 species included in the aggregate bag limit, including: gag, red grouper, black grouper, scamp, yellowfin grouper, yellowedge grouper, yellowmouth grouper, snowy grouper, misty grouper, warsaw grouper, rock hind, red hind, and speckled hind. Frequency distributions were generated for the years 2003 through 2005 by mode (MRFSS, headboat). Frequency distributions of landings per angler and catch per angler were constructed from MRFSS and the Southeast Fisheries Science Center's Headboat Logbook survey data. MRFSS type A catch (fish that were caught, landed whole, and available for identification and enumeration by the interviewers) and type B1 catch (fish that were caught and filleted, given away, or disposed of in some way) represented landings for purposes of analysis. MRFSS type A catch represents the total catch of all anglers on a fishing trip. However, some or all of the anglers contributing to the type A catch are also interviewed to report type B1 catch, and those may be recorded on an individual basis. If the number of people contributing to the type A catch was greater than the number of people interviewed to report B1 catch, then B1 catch was adjusted by multiplying the catch by the ratio of people in the fishing party divided by the number of people interviewed to report the B1 catch. For total catch estimates, which included released fish, adjustments to MRFSS type B2 catch (released alive) were made in a similar manner as those described for type B1 catch. Only landed fish were used to construct frequency distributions for headboats, since no information on releases was available.

Table 1. **Frequency of number of gag caught and retained per angler by year. Source: MRFSS, all modes (charter, private) combined.**

Year	Number of Fish Kept Per Angler	Number of Trips	Number of Anglers	Avg. Anglers Per Trip	Number of Fish:		Cumulative Pct of Fish:	
					Caught	Retained	Caught	Retained
2003	0	1163	3816	3.28	4172	0	32.4	0.0
	0.01-0.99	516	2825	5.47	3268	951	57.7	32.4
	1-1.99	166	632	3.81	2372	794	76.1	59.4
	2-2.99	61	237	3.89	1612	538	88.6	77.7
	3-3.99	24	73	3.04	564	248	93.0	86.1
	4-4.99	11	51	4.64	528	216	97.1	93.5
	>=5	8	30	3.75	376	191	100.0	100.0
2004	0	1288	4213	3.27	5052	0	29.6	0.0
	0.01-0.99	652	3520	5.40	4356	1289	55.0	26.0
	1-1.99	206	925	4.49	2849	1187	71.7	49.9
	2-2.99	93	404	4.34	2098	941	84.0	68.8
	3-3.99	41	183	4.46	1194	617	91.0	81.3
	4-4.99	28	120	4.29	958	518	96.6	91.7
	>=5	21	73	3.48	589	411	100.0	100.0
2005	0	994	3501	3.52	3531	0	27.3	0.0
	0.01-0.99	612	3617	5.91	4976	1311	65.8	38.5
	1-1.99	168	744	4.43	2232	944	83.1	66.3
	2-2.99	50	209	4.18	1017	484	90.9	80.5
	3-3.99	15	62	4.13	378	203	93.9	86.5
	4-4.99	15	63	4.20	516	275	97.8	94.6
	>=5	9	32	3.56	278	184	100.0	100.0

Table 2. **Frequency of number of grouper (all species) caught and retained per angler by year. Source: MRFSS, all modes (charter, private) combined.**

Year	Number of Fish Kept Per Angler	Number of Trips	Number of Anglers	Avg. Anglers Per Trip	Number of Fish:		Cumulative Pct of Fish:	
					Caught	Retained	Caught	Retained
2003	0	1428	4738	3.32	6346	0	25.7	0.0
	0.01-0.99	666	3695	5.55	5733	1241	48.9	24.9
	1-1.99	251	1006	4.01	4769	1283	68.2	50.7
	2-2.99	97	415	4.28	3309	958	81.6	69.9
	3-3.99	44	155	3.52	1683	506	88.4	80.1
	4-4.99	23	103	4.48	1479	446	94.4	89.0
	>=5	24	89	3.71	1385	546	100.0	100.0
2004	0	1568	5235	3.34	7867	0	24.2	0.0
	0.01-0.99	825	4436	5.38	6685	1746	44.7	19.2
	1-1.99	315	1352	4.29	6241	1806	63.9	39.0
	2-2.99	143	669	4.68	4194	1589	76.8	56.5
	3-3.99	85	389	4.58	2516	1329	84.5	71.1
	4-4.99	39	179	4.59	1514	788	89.2	79.8
	>=5	76	313	4.12	3520	1842	100.0	100.0
2005	0	1122	3795	3.38	4525	0	20.8	0.0
	0.01-0.99	672	3824	5.69	6483	1535	50.6	24.3
	1-1.99	290	1380	4.76	4998	1850	73.6	53.7
	2-2.99	109	554	5.08	2796	1302	86.5	74.3
	3-3.99	41	194	4.73	1201	638	92.0	84.5
	4-4.99	19	90	4.74	703	394	95.3	90.7
	>=5	24	103	4.29	1029	586	100.0	100.0

Table 3. **Frequency of number of gag caught and retained per angler by year. Source: SEFSC Headboat survey.**

Year	Number of Fish Kept	Number of Trips	Number of Anglers	Avg. Anglers Per	Number of Fish Retained	Cumulative Pct of Fish Retained
2003	0.01-0.99	1548	48117	31.08	4740	94.8
	1-1.99	8	205	25.63	262	100.0
	2-2.99	0	0	0	0	100.0
	3-3.99	0	0	0	0	100.0
	4-4.99	0	0	0	0	100.0
	>=5	0	0	0	0	100.0
2004	0.01-0.99	2169	71644	33.03	7888	87.9
	1-1.99	26	628	24.15	840	97.3
	2-2.99	5	112	22.40	245	100.0
	3-3.99	0	0	0	0	100.0
	4-4.99	0	0	0	0	100.0
	>=5	0	0	0	0	100.0
2005	0.01-0.99	1982	61642	31.10	8892	69.5
	1-1.99	35	809	23.11	1055	77.7
	2-2.99	11	370	33.64	929	85.0
	3-3.99	7	302	43.14	996	92.8
	4-4.99	2	94	47.00	392	95.8
	>=5	3	82	27.33	533	100.0

Table 4. **Frequency of number of grouper caught and retained per angler by year. Source: SEFSC Headboat survey.**

Year	Number of Fish Kept	Number of Trips	Number of Anglers	Avg. Anglers Per	Number of Fish Retained	Cumulative Pct of Fish Retained
2003	0.01-0.99	4329	134515	31.07	15864	86.9
	1-1.99	65	1549	23.83	1938	97.6
	2-2.99	7	138	19.71	340	99.4
	3-3.99	1	10	10.00	32	99.6
	4-4.99	1	17	17.00	74	100.0
	>=5	0	0	0.00	0	100.0
2004	0.01-0.99	5331	173985	32.64	22341	78.7
	1-1.99	121	2960	24.46	3763	92.0
	2-2.99	24	550	22.92	1254	96.4
	3-3.99	3	119	39.67	360	97.7
	4-4.99	3	111	37.00	505	99.4
	>=5	2	29	14.50	159	100.0
2005	0.01-0.99	5618	179222	31.90	23749	75.1
	1-1.99	123	2856	23.22	3789	87.1
	2-2.99	18	535	29.72	1286	91.1
	3-3.99	12	440	36.67	1442	95.7
	4-4.99	5	165	33.00	707	97.9
	>=5	5	102	20.40	656	100.0

ADDENDUM
May 9, 2007

During the May 8-10, 2007, SEDAR Grouper Review Workshop it was discovered that data summarized in Table 4 was incorrect. While summarizing statistics, trips landing multiple species of grouper were inadvertently estimated to represent separate trips, rather than a single trip. This error was corrected and trips reporting multiples species of grouper were aggregated into a single headboat fishing trip. Table 5 updates and corrects the results summarized in Table 4 above.

Table 5. **REVISED frequency of number of grouper caught and retained per angler by year. Source: SEFSC Headboat survey.**

Year	Number of Fish Kept	Number of Trips	Number of Anglers	Avg. Anglers Per	Number of Fish Retained	Cumulative Pct of Fish Retained
2003	0.01-0.99	2799	87193	31.15	11188	78.1
	1-1.99	100	2323	23.23	2334	94.4
	2-2.99	13	307	23.62	487	97.8
	3-3.99	4	101	25.25	239	99.5
	4-4.99	1	17	17.00	74	100.0
	>=5	0	0	0.00	0	100.0
2004	0.01-0.99	3292	110089	33.44	15485	69.8
	1-1.99	148	3422	23.12	3417	85.2
	2-2.99	30	673	22.43	1209	90.7
	3-3.99	20	591	29.55	1231	96.2
	4-4.99	2	48	24.00	129	96.8
	>=5	6	156	26.00	709	100.0
2005	0.01-0.99	3388	107978	31.87	15608	66.1
	1-1.99	150	3429	22.86	3117	79.3
	2-2.99	35	792	22.63	1280	84.7
	3-3.99	13	368	28.31	880	88.5
	4-4.99	10	357	35.70	1159	93.4
	>=5	11	355	32.27	1566	100.0

SEDAR

Southeast Data, Assessment, and Review

SEDAR Grouper Assessment Review

Section II

Review Panel Report

May 8 - 10, 2007

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1. Introduction

1.1. Executive Summary

The Grouper Review Panel (RP) met May 8-10, 2007 in St. Petersburg, FL to review the recommendations of the Grouper Evaluation Panel (EP) regarding the SEDAR 10 results for Atlantic and Gulf gag grouper in 2006 and SEDAR 12 results for Gulf red grouper in 2007. The RP appreciates the substantial work done by the assessment teams in conducting additional analyses and preparing documents, and the constructive insights provided by many participants at the RP workshop. In general, the RP agrees with the findings and recommendations of the EP and recommends that these assessments, including the revised Gulf gag assessment, are now ready to serve as the scientific basis for updated management advice.

Differences among the two gag assessments and red grouper assessment included: beginning year of modeled time series, trend in catchability used to interpret the fishery catch per effort time series, estimation of discard mortality, scaling of natural mortality curve, calculation of management reference points, and assessment modeling software. The differences in assessment start years are logical given the available data and different catch histories. The differences in treatment of catchability trends and the natural mortality scaling do affect the results of each assessment, but the reasoning used by each SEDAR is sound and there is no available information that could be used to recommend changing either result simply to achieve consistency. Greater consistency can be achieved in the future through workshops that investigate methods that will subsequently be applied to multiple stocks. The RP recommends including sensitivity analyses with regard to catchability and natural mortality to better acknowledge that neither can be known with perfect precision and that future assessments will almost certainly include revisions to both. The RP supports the EP finding that the size composition of Gulf gag recreational discards should be based on effects of the size limit because of the low frequency with which the bag limit is reached and additional size frequency information from the FWC study on headboat discards. The RP further finds that the depth distribution of the Gulf gag recreational catch discards should be shifted towards shallower water on the basis of the high fraction of the recreational discards that come from State waters. This shift will cause a decrease in the average mortality rate of discards. The RP concurs with the EP with regard to the inappropriateness of the ad hoc reference points recommended by SEDAR 10 for Gulf gag. Reference points based on maximizing yield per recruit are appropriate at this time, but development of new reference points that explicitly account for the female to male life history transition are needed. The RP finds that the three assessment models differ mostly with regard to user interface and these differences do not cause technical differences in results that warrant revisions to achieve greater consistency at this time. However, differences in way in which discarded catch is modeled impeded clear communication of the methods and results. In addition, future demonstration of comparable results when different models are applied to the same data set would add confidence to all the results. In addition, the RP advises development of a next generation model that can deal with all three of these stocks and other SE and national stocks in a clear, consistent and comprehensive manner.

1.2. 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.

This SEDAR Review Workshop Panel consisted of a chair, a reviewer appointed by the Gulf Council and 2 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.

1.3. SEDAR Grouper Assessment Review Overview and Need

The SEDAR Steering Committee determined that additional scrutiny should be devoted to recent grouper assessments.

A basic tenet of each SEDAR assessment is that all previous assessment decisions and assumptions are up for debate, and that each decision and assumption included in the current assessment is to be specifically evaluated and judged on scientific merit. Participants are clearly instructed that any decisions made in previous assessments are to be thoroughly evaluated in light of current knowledge. There is no requirement or expectation that decisions made regarding one assessment should be consistent with those in prior assessments, and, in fact, justifications based solely on past decisions are explicitly discouraged. As a result, SEDAR participants are compelled to continually improve assessment quality and it is acknowledged within the Southeast fisheries management community that SEDAR has improved assessment methods, data evaluation techniques, and awareness of critical data collection program characteristics.

One consequence of continually evaluating all prior decisions and striving to improve methods is that current assessments may develop solutions to data deficiencies and analytical challenges that differ from solutions applied in previous assessments. Previous SEDAR assessments have faced post-approval criticism brought on by technological advancements and improved understanding of data sources stemming from later assessments, and the accepted solution has been to apply the most up to date methods to each problem at the next available opportunity. For example, updates to SEDAR 1 and 2 assessments included model configurations and data treatments developed through subsequent assessments.

A similar situation arose recently when the findings of assessments for Gulf of Mexico and South Atlantic gag grouper were compared with those for Gulf of Mexico red grouper. Although many of the same datasets were included in the assessments for gag and red grouper in the Gulf of Mexico, the two species are exploited by similar fisheries, and there is overlap in the species range, the SEDAR 10 (gag) and SEDAR 12 (red grouper) assessments differed in key areas including data time series, discard mortality rates, estimation of natural mortality, and analysis of fishery-dependent catchability. Similar differences are also noted within the SEDAR 10 assessments for South Atlantic gag grouper and Gulf of Mexico gag grouper. It should be noted that the assessments prepared during SEDAR 10 and SEDAR 12 were judged separately on their individual merits and found adequate and acceptable by independent scientific review panels. In addition, the SEDAR 10 assessment of Gulf of Mexico gag grouper was also reviewed and deemed acceptable by the Gulf of Mexico Fishery Management Science and Statistics Committee. Nonetheless, the SEDAR Steering Committee determined that additional scrutiny should be devoted to recent grouper assessments.

This special review project was convened by request of the SEDAR Steering Committee to evaluate key decisions of the SEDAR 10 and SEDAR 12 stock assessments. The Steering Committee determined that additional evaluation should be devoted to these issues to ensure confidence in both the assessment process and

assessment findings. The Steering Committee recognizes the inherent challenge in balancing demands on scientists to prepare each assessment with the best available data and most up to date methods, with constituents' expectations that similar fisheries should receive similar analytical treatments. By initiating this project, the SEDAR Steering Committee intends to ensure every effort is made to verify that all decisions are scientifically sound and adequately scrutinized within the assessment process.

The SEDAR Grouper Assessment Review was carried out in two steps. First, an evaluation panel (EP hereafter) of experts knowledgeable in the fisheries and the SEDAR 10 and 12 stock assessments was convened to review the assessment findings and recommendations in light of current knowledge. That group prepared a report including recommendations for subsequent assessment analyses. Second, a SEDAR review panel (RP) was convened to independently review the findings and recommendations of the evaluation panel as well as any additional assessment analyses prepared as a result of the evaluation panel findings.

1.4. Workshop Time and Place

The SEDAR Grouper Assessment Review Panel met May 8 - 10, 2007, in St. Petersburg, FL.

1.5. Attendees and affiliations

Name	Affiliation
Workshop Panel	
Richard Methot, Chair	NMFS NWFSC
Robert Mohn	CIE/DFO
Mike Murphy	GMFMC FSAP/FL FWC
Graham Pilling	CIE/CEFAS
Presenters	
Mauricio Ortiz	NMFS SEFSC
Clay Porch	NMFS SEFSC
Erik Williams	NMFS SEFSC
Shannon Cass-Calay	NMFS SEFSC
Appointed Observers	
Tom Burgess	SAFMC AP
Martin Fisher	GMFMC AP
Dennis O'Hern	GMFMC AP
Mark Robson	SAFMC/FL FWC
Bill Teehan	GMFMC/FL FWC
Bob Zales, II	GMFMC AP

Observers

Andy Strelcheck ..... NMFS SERO
Beverly Sauls ..... FL FWC
Libby Fetherston ..... The Ocean Conservancy
Luiz Barbieri ..... FL FWC
Joe O'Hop ..... FL FWC
Jim Gray ..... CCA FL
Peter Hood ..... NMFS SERO
Steve Bramstetter ..... NMFS SERO

Staff

John Carmichael ..... SEDAR
Rachael Lindsay ..... SEDAR
Rick DeVictor ..... SAFMC
Gary Fitzhugh ..... NMFS SEFSC
Stu Kennedy ..... GMFMC
Tyree Davis ..... NMFS SEFSC

1.6. Terms of Reference

1. Review the Evaluation Panel report and determine whether the Panel's responses to its Terms of Reference are adequate, complete, and scientifically sound.
2. Review any analyses prepared as a result of Evaluation Panel recommendations and determine whether there is sufficient evidence to justify using these new analyses in place of those adopted by the preceding review panels as the basis for determining stock status and developing management references.
3. Document Panel discussions and recommendations in a Review Panel Consensus Summary Report.

1.7. Documents provided for the Review Panel

SEDAR. 2007. SEDAR Supplement 1: Grouper Assessment Review. Section 1, Report of the Evaluation Panel.

SEDAR. 2006. Stock Assessment Report for South Atlantic Gag Grouper. SEDAR10-SAR1. SEDAR, Charleston SC.

SEDAR. 2006. Stock Assessment Report for Gulf of Mexico Gag Grouper. SEDAR10-SAR2. SEDAR, Charleston SC.

SEDAR. 2007. Stock Assessment Report for Gulf of Mexico Red Grouper. SEDAR12-SAR1. SEDAR, Charleston SC.

SEDAR. 2007. Analyses of Gulf of Mexico Gag Grouper in Response to the Recommendations of the SEDAR Grouper Assessment Review Panel. (SEDARS1-RW01).

Lorenzen, K. 2004. Population dynamics and potential of fisheries stock enhancement: practical theory for assessment and policy analysis. Phil. Trans. of the Royal Soc. of London. Fisheries Theme Issue 2004. (SEDARS1-RD01)

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Jour. of Fish Biol. 49:627-647. (SEDARS1-RD02)

Hoenig, J. M. 1983. Empirical use of longevity to estimate natural mortality rates. Fish. Bull. 82(1). (SEDARS1-RD03)

2. Response to Terms of Reference

ToR 1: Review the Evaluation Panel report and determine whether the Panel's responses to its Terms of Reference are adequate, complete, and scientifically sound.

EP ToR 1a: The length of the time series to be used for the base cases in each assessment (Gulf gag, Atlantic gag and Gulf red grouper).

The RP endorsed the conclusion of the EP that producing the best assessment possible should not be compromised by imposing similar time series on the various assessments. The RP found that the rationale for the starting times of each assessment time series was scientifically sound.

EP ToR 1b: The treatment of the catchability coefficient for fishery-dependent indices of abundance in each assessment.

The EP concluded that the treatment of catchability among these stocks should be consistent, and that constant catchability should not be the default. The RP did not have enough information to endorse or refute this position and would have liked to see more sensitivity runs to better understand the implications of this issue. However, the RP concluded that the base cases need not be redefined at this time. The EP's recommendation for a workshop on the modeling of catchability (including other species) and new directed research is warranted.

EP ToR 1c: The estimation of the number and size composition of discarded fish, as well as the fraction of the discards that die in each assessment.

The RP reviewed the EP report and work initiated by them. The RP endorsed their recommendation to use the size composition of undersized recreational catch, instead of total recreational catch size compositions, in the calculation of discarded catch for

Gulf gag. However, the RP found that adjustments to the estimated depth distribution of the Gulf gag recreational discards were also needed before application of the depth-specific mortality rates. This topic is discussed further in ToR 2. The RP accepted the EP's recommendation to accept the treatment of discards in Atlantic gag and Gulf red grouper, given the limited information available for the assessments.

EP ToR 1d: The treatment of the natural mortality rate and, in particular, the method used to scale the Lorenzen curve in each assessment.

The RP concluded they had no criteria or data to recommend change to the specification of M in each base case. The RP noted the sensitivity of the results to the assumption about the starting age when matching the Lorenzen curve to the previously used constant M values. This source of uncertainty needs to be acknowledged in assessments and sensitivity runs included. We endorse the EPs recommendation of a workshop on natural mortality estimation including the application of the Lorenzen method.

EP ToR 1e: Recommended reference points (minimum stock size threshold, maximum fishing mortality threshold and optimal yield) and whether those choices are consistent with the goals of the respective Fishery Management Plans and the Magnuson-Stevens Reauthorization Act.

The EP found that the reference points recommended by the SEDAR 12 review panel for Gulf red grouper and the SEDAR 10 review panel for Atlantic gag were consistent with the management requirements stated in the respective assessment reports. The RP concurs with these findings. The RP agrees with EP that the empirical F limit recommended by SEDAR 10 for Gulf gag was inconsistent with FMP requirements and we endorse their recommendation to use reference points based on yield per recruit.

In a hermaphroditic species, the definition of reproductive potential is complex and this complicates calculation of conventional biological reference points, including the default proxy of F30%. We endorse the EPs recommendation of Fmax and recommend further research on the development of reference points that address the reproductive potential of these stocks.

EP ToR 2: Discuss how consistency in methodology should be balanced against the need to address differences in the data, fisheries and biology of the three stocks in question. Include in this discussion the significance of using different stock assessment algorithms for each stock.

The EP felt, and the RP agreed, that providing the best advice should not be compromised for consistency. If anything, this Panel felt more strongly than the EP on this point. Moreover, the models used in each assessment should not be developed in isolation. Several of the models should be used on a single stock, at least once to disentangle model and stock/data effects. While it is true that the three assessment models used to assess these three stocks have similar internal structure, e.g. all are

based on tracking numbers at age acted on by natural plus fishing mortality, the significance of the distinct "algorithms" and their specific implementations into models can only be assessed by using common data. Although synthesized data could be used, the sensitivity of results for these stocks can only be assessed by testing them. As well as assessment models, these arguments should be applied to data preparation models. Of specific interest is the handling of discards and their mortality. For example, in the future, the Goodyear discard model should be applied to the other two stocks both to gauge its performance in a situation when there is data (Gulf gag) and to offer a bridge among the models. Similarly, how the various age-structured models handled the estimation of the initial age distribution needs some inter-stock comparisons.

In terms of communication of results and ease of review, the divergent assessment models make review more difficult in general, and especially for this panel because of its brevity. Specifically, the different manner in which discards were handled by each of the assessment models was an impediment to communication and review. Although a weak secondary consideration, consistency does help review and in its absence care in synthesizing and communicating results is required.

Comprehensive reporting of assessment results is a daunting challenge, especially when this involves diverse data inputs, complex model configurations, and extensive consistency and sensitivity analyses. The problem is compounded in the three-stage SEDAR process (and now four-stage in the case of this special grouper review) such that independent reviewers have a extraordinarily difficult time absorbing enough of the detail to be able to provide a thorough review. The NMFS-SEFSC and SEDAR staffs do an excellent job in organizing the material and cross-referencing relevant sections. More roadmaps to the array of documents and summary tables of issues and decisions could help.

<u>EP ToR 3:</u> Formulate recommendations for any additional analyses, sensitivity runs, or changes to the base cases that need to be made to the Gulf gag, Atlantic gag, and Gulf red grouper assessments based on the reviews of the specific issues addressed in EP ToR #1 and given the conclusions reached during the discussion of EP ToR #2.

The EP requested more information on the effect of bag limits on Gulf gag recreational discard, more analysis of the size composition of Gulf gag recreational discard, and model runs that incorporate these findings. These additional analyses represent a significant step in meeting the RP's ToR 2 as described below.

TOR 2: Review any analyses prepared as a result of Evaluation Panel recommendations and determine whether there is sufficient evidence to justify using these new analyses in place of those adopted by the preceding review panels as the basis for determining stock status and developing management references.

The RP thanks the assessment staff for their prompt response to requests for additional analysis during this review and we thank the several other meeting participants who provided insight regarding the issues. The new analysis (both after

the EP and during the Review) on Gulf gag discards was accepted by the RP as an improvement over the SEDAR 10 formulation and should be the basis of a revised assessment. The RP agrees with the EP's conclusion that the SEDAR 10 development of the age composition of mortal discards in the Gulf gag recreational fishery was not the most accurate estimate that could be made with available data. The RP agrees with the EP's conclusion that a discard size composition that is based on the observed size composition of caught fish below the size limit is a better estimate of the discard size composition than the total size composition of all recreationally caught fish.

The RP reached this conclusion after reviewing data showing that the 5 fish bag limit is rarely reached and that the newly available observations from a FWC study of headboats corroborates the alternative discard size composition used in the analysis. However, the RP concluded that the estimated depth distribution of this discard was skewed towards deeper depths where mortality is higher. This may be because the recreational samples with depth-size information were primarily from the panhandle region where deep water is closer to shore. This conclusion was based on information provided by several meeting participants, and by the MRFSS data that show approximately 50% of the recreational discards (B2) are from state waters where the depths are shallow and in which a lower mortality of approximately 10% occurs. The revision lowered the overall estimate of average discard mortality to 20%.

The RP recommends that these revised data be used in updated stock assessment model runs and subsequent updates to benchmark calculations and stock projections. These results are found in Appendix A (Ortiz ms). The results were not available to the RP prior to the end of the meeting. However, given no change to the assessment model, and the perceived improvement to the input data, the Panel feels resultant runs will be a significant improvement and justifies the update of the base model for determining stock status and developing management references.

ToR 3: Document Panel discussions and recommendations in a Review Panel Consensus Summary Report.

This report documents the RP's response to this term of reference.

General comment. The RP's ToR is to evaluate the EP's report in terms of adequacy, completeness and scientific validity. There were no suggestions that there was any problem with the scientific content. The adequacy (for review and for the provision of advice) and completeness are more difficult to evaluate. The EP commented for example on the similarity between the stochastic SRA model results and the long term CASAL model results but they were not summarized and presented to the RP prior to the workshop. Part of the problem is that the EP members were familiar with these stocks and their assessments and were already up to speed. For them, detail was not needed in their report because of this familiarity. External reviewers need time to assimilate and work with new assessments. In a 2 day meeting with the expectations of a draft report, such time was not available. Pre-meeting documentation was helpful, but could not fully prepare the RP on many aspects of the

assessments, the rationale behind various decisions and their attendant issues. The EP completely covered their terms of references, but the communication of their deliberations and results was not sufficiently detailed to afford complete review by the RP.

Discussion with Respect to ToR

ToR 1A: length of modeled time series

The RP discussed the rationales for selection of the starting year for the three stock assessments. For the Atlantic gag model, the start year was set far enough back in time so that it could reasonably be assumed that the effect of fishing mortality on the stock was negligible prior to that year. This was not possible for Gulf gag because landings were made long before reliable statistics were kept, so the start year was set to 1963, which is the year when the region of capture (domestic or foreign) began to be recorded. The situation was even more problematic for red grouper because of its long history of foreign catch from U.S. waters, the level of which is not known with high precision. Consequently, the starting year for red grouper was set at the onset of substantial improvement in the quality of available data and the model was configured to estimate the age composition of the stock at that time in a way that would represent the effects of historical fishing levels without directly including those fishing levels. Results from sensitivity analyses examining the impact of the length of the time series for red grouper and Gulf gag indicated that the results were robust to this uncertainty. The RP believes that these are adequate justifications for the different starting years in the three assessments, while acknowledging that use of the earliest feasible start years is likely to provide more insight regarding the potential productivity of the stock.

Tor 1B: Catchability

The RP discussed the different conclusions made by SEDAR 10 and 12 with regard to the change in fishery catchability over time in the base case assessments. Trends in fishery catch per unit effort have been included in all three assessments to provide a quantitative measure of trends in stock abundance. This is necessary because of the near lack of fishery independent surveys for these stocks. However, fishery CPUE is an imperfect measure of stock trends because the calibration (e.g. catchability) can change over time. Both SEDAR 10 and 12 discussed this situation and considered models with and without a change in catchability over time. SEDAR 10 concluded that the degree of change was not known, so endorsed the no change model result. SEDAR 12 independently examined the same circumstances and concluded that use of some drift was better than none. The EP concluded that all groups came to reasonable, but different, conclusions and that there was insufficient information to force a change to either base case simply to align the catchability assumptions. The RP had no further information to evaluate the situation and felt it would be misleading to simply offer an expert judgment in lieu of a detailed factual evaluation. The RP endorsed the EP recommendation for a future workshop focused on this topic.

Tor 1C: Discard numbers, composition and mortality

Discussion on this topic is merged into the discussion on ToR 2 regarding analyses conducted at the workshop.

ToR 1D: Natural mortality

The RP noted that the assessment result was sensitive to the values of natural mortality (M) used in the model, as shown by the Red Grouper assessment. Such a finding is not unexpected. In addition to discussing the scaling of a Lorenzen M curve to prior estimates of average M, the RP initially considered the relevance of the use of Hoenig's method to estimate the overall M level, noting the availability of alternative approaches (e.g. Pauly's or Ralston's empirical formulae based on life history parameters). The RP generally concluded that the levels of average M to which the Lorenzen curves were being calibrated have substantial uncertainty themselves. With regard the scaling of the Lorenzen curve to prior estimates of average M, the RP discussed the merits of forcing consistency between the gag and red grouper scaling methods against the merits of supporting previously deliberated decisions by SEDAR 10 and 12, embedded within the overall large uncertainty in the average level of M. The RP concluded that the existing gag and red grouper base case models were adequate with regard to the M levels and did not require forced consistency. However, none of these values can be considered to be definitive so future updates are to be expected and the RP felt that it is important to demonstrate the sensitivity of the assessment results to the uncertainty in M.

ToR 1E: Management reference points

The EP did not believe that the SEDAR 10 gulf gag review panel provided reference points consistent with the Fishery Management Plan developed to implement the Magnuson-Stevens Sustainable Fisheries Reauthorization Act. The SEDAR 10 review panel did not reach a conclusion on the Maximum Fishing Mortality Threshold and recommended only that the fishing mortality rate be reduced below the mean fishing mortality rate that occurred over a 21-year period (1984-2004). The RP concurs with the EP's rejection of this *ad hoc* method and with the EP's recommendation for the yield-per-recruit-based metric of Fmax as a proxy for Fmsy and MFMT. The EP also noted that Fmax was similar to F30%, which is the Fmsy proxy defined in the Gulf of Mexico Fishery Management Council's Fishery Management Plan. The RP notes that conventional calculation of the F30% rate may not be applicable for hermaphroditic species such as gag and red grouper. The current practice of measuring the stock's reproductive potential only as female spawning biomass may result in excessive depletion of males in these species. Alternatively, simply combining males and females may not be an optimal measure of reproductive potential.

The EP also rejected the SEDAR 10 gulf gag recommended Minimum Stock Size Threshold which was set at the 20 million pound spawning biomass level, estimated

by visual interpretation as a point below which lower recruitment prevailed. The RP concurs with the EP recommendation that the MSST be based on an appropriate offset from the Bmsy proxy, which is spawning biomass-per-recruit at Fmax multiplied by the mean recent recruitment level (1984-2004).

The RP also agreed that the Advisory Report generated by NMFS analysts should provide clear estimates of the reference points necessary for meeting the requirements of managers and that are consistent with regulatory guidelines. This would ensure that review panel members unfamiliar with the U.S. federal fisheries management system are asked to consider estimates of the complete suite of appropriate and required management benchmarks.

ToR 2: Additional analyses

The RP engaged in substantial discussion of the methods and results for the calculation of discard age composition and mortality. Thus, this discussion of ToR 2 incorporates the RP's discussion of ToR 1c. The RP accepts that the estimates of total numbers of recreational catch that is released alive (B2) are adequately estimated from available data. Studies indicate that a fraction of these fish subsequently die. The RP found the discard mortality rate information available in SEDAR 10 and 12 to be acceptable and sound given the limitations on information available, though there is a clear need for more studies of both species especially to better calibrate the relationship between mortality and depth of capture and possibly other factors. The specific issues addressed by the EP and RP are with regard to size composition of the discards and their depth distribution which, in the case of Gulf gag, is used to calculate the average mortality rate of the discards. The situation is complicated by the fact that the depth distribution of fishing affects both the size composition of fish encountered and the mortality rate of the released recreational catch of Gulf gag.

The assessment with the most limited information on recreational discard is Atlantic gag. Here the discard was estimated by simply shifting the fishery selectivity curve 2 years towards younger ages. The RP concurs that this is a pragmatic approach given the data situation. It would be informative to compare this to the Goodyear (1995) method that was used for red grouper.

The SEDAR 12 red grouper data workshop considered using a depth distribution function to weight the depth-specific release mortality rate estimates to determine fisheries-specific discard mortality rates. However, the depth-mortality relationship has not been fully calibrated for red grouper so a constant mortality rate was applied. The age distribution of the red grouper discards needed to be estimated for application of the ASAP assessment model. This was done using an approach developed by Phil Goodyear (1995) that uses the size retention function to model the fraction of each age's size distribution that will be retained versus discarded. Application of this method assumes that the youngest age groups have nearly as high a probability of encountering recreational fishing effort as do older, more retainable ages.

Gulf of Mexico gag had the most information with regard to recreational discard, and the most controversy in its analysis. Available data on the depths of capture for Gulf of Mexico gag were combined with the depth-specific release mortality relation to determine the estimated number of dead discards in the Gulf fisheries. The RP raised concerns that the data used to describe the length frequency and depth distribution of gag may have been biased by the reliance on the Trip Interview Program (TIP) database, which included primarily landed fish. Since implementation of the federal size limit landed fish represent primarily the legal portion of the total catch at a particular depth and will give a biased estimate of average length at depth if large numbers of small gag are released at that depth.

Concerns that the use of total observed size composition data (below the size limit) would not adequately represent the length frequency of discarded individuals were reduced by the length frequency data available from a recent FWC study on headboat discarding. Visual comparison of the size distribution of landed and discarded gag from the two years of information available (2005, 2006) suggested that the length distribution of the fish used within the assessment model was not unreasonable. Further, the Mote Marine Lab tag/recapture data included lengths of all gag encountered and may be more appropriate for describing the depth distribution of gag though most of the samples from this program were geographically limited to the waters off west-central Florida.

A further issue considered by the RP was the depth distribution of Gulf gag recreational discard used in the mortality-at-depth model. The available data to assess the depth distribution of recreational catch are spatially limited, mostly being from the Panhandle, where deeper waters are more accessible to fishing. Alternatively, the MRFSS data on the distance of fishing from shore suggested that 50% of released alive (B2) data come from inside state waters. Preliminary analysis suggested that the corresponding average depth was less than 10m. However, only a small proportion (less than 5% of the data) of the samples used to generate the pre review depth-distribution function were from depths less than 10m. This will bias the estimates of mortality. As a result, the RP recommended that the data be investigated further to provide a better division of catch by depth zone, to which the mortality-at-depth relationship can be applied.

The RP noted that, given the uncertainty in the models for discarding in the gag stocks, the Goodyear probabilistic estimation technique as applied to red grouper should also be considered for the gag stocks at least once, as part of an alternative assessment run. This would examine the sensitivity of results to the discarding assumptions made.

The RP also noted that the models differed in the way they calculate the overall ‘kill’ at age. The kill-at-age was the combination of the catchability or availability at age, the proportion of fish released at age and the proportion of released fish that die. In the red grouper model, these three steps were explicit within the assessment model. In the Gulf gag model, proportion released and mortality of released fish was handled outside of the assessment model so that the model effectively calculated the

catchability relative to the dead fish. In the red grouper assessment, age 1 fish had near complete catchability, but the level of discarding and mortality at that age resulted in levels of age-specific fishing mortality that were similar to that in the other models as shown in kill-at-age figures prepared at the request of the RP. However, the difference in treatment impeded clear communication on the issue.

3. Panel Requests

1) Prepare figures showing comparison of time series results between model configurations and retrospective analyses to show degree of consistency among results.
2) Prepare figure showing age composition of landed catch separate from age composition of discard (Provided for red grouper in Appendix 1)
3) Show map with depth contours relative to State jurisdiction boundary (Provided as Appendix 2)
4) Sensitivity model runs for gag at alternative natural mortality (see recommendation #2)(Provided for Atlantic gag as Appendix 3)
5) Reconstruction of discard component of GOM gag recreational catch age composition (see recommendation #1) and subsequent re-runs of the assessment model (Appendix 4).

4. Panel Recommendations (short and long term)

The panel made two short term recommendations that should be carried out and made available before management action is to be taken for these stocks. Other RP recommendations are for the longer term and may require considerable time and resources.

In the short term the RP recommends:

1) Reconstruction of discard component of Gulf of Mexico gag recreational catch age composition, and completion of an updated base model using these data. The details of the requested discard mortality analysis are documented under ToR 1C and ToR 2.
2) Performing sensitivity runs of the assessment using alternative methods for scaling the Lorenzen curve for the two gag stocks per ToR 1D. The runs for the gag stocks should be made with the Lorenzen curve M scaled for ages 5+, rather than the 0+ age range used in the base assessment. It was noted that some assessment clients may want to receive only the results of the ‘base case’ run, without explicit demonstration of uncertainty. The RP felt there was a need to acknowledge and address uncertainty in the assessment, even though they have no

criteria or data to reject the scientific validity of the base cases already used and presented in the Assessment and Review reports. Acknowledging and demonstrating uncertainty in the present assessment creates a more valid basis for comparison to future updated assessments.

In the longer term, the Review Panel recommends:

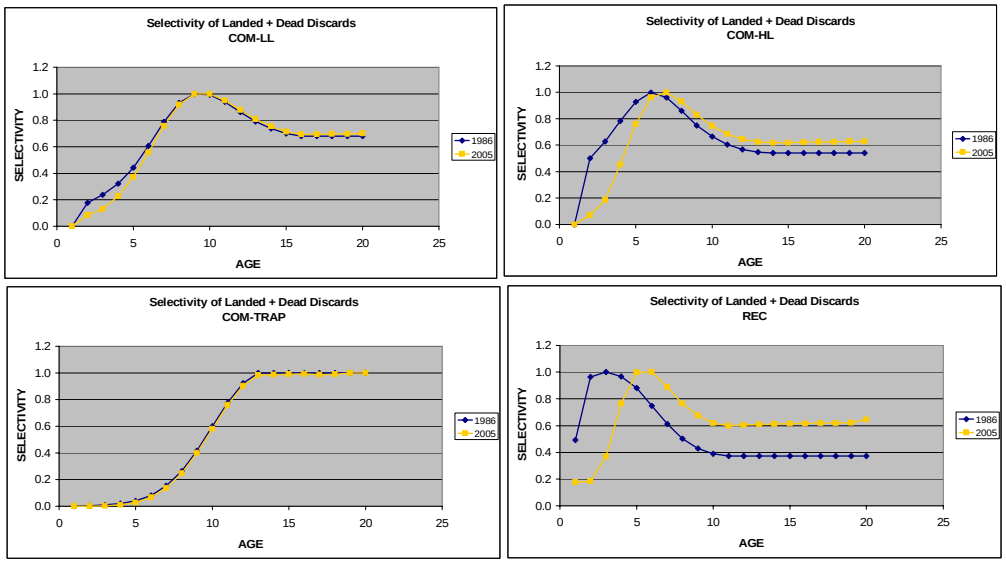
3) The sensitivity to the length of the data series in each assessment should be evaluated in a more systematic way (ToR 1A). A series of data windows varying the onset of each data set analogous to retrospective analysis is suggested.
4) Conduct a profile on various models of the catchability (ToR 1B). Metrics for these profiles would include goodness of fit to the assessment data and the impact on assessment outputs, for example terminal biomass and F. An examination of exogenous information on the timing of technological changes to fishing that might have affected catchability should be undertaken. This work could define better models for changes in catchability than the simple linear models examined so far.
5) Conduct a workshop on calibration of fishery catch per effort as a measure of relative stock abundance, including possible changes in catchability (ToR 1B) due to technical modifications, management actions and environmental influences (red tide, hurricanes…). Extending the workshop to include other species and scientists from other regions may be helpful.
6) Development of fishery mortality rate targets and limits that are specifically adapted to the hermaphroditic life history of gag and grouper (ToR 1E).
7) Conduct a technical workshop on natural mortality estimation (ToR 1D), per the EP's recommendation. A national (and international) scale for this workshop is warranted given the prominence of the issue. The RP also supports the observation of using data from closed areas to investigate natural mortality on unexploited stocks (taking into account immigration/emigration, ecosystem differences, etc.).
8) Work on development and testing of future assessment and data processing models (EP ToR 2). The models should be developed with the ability to be applied to more than one stock. Such flexibility and consistency will facilitate collaboration among assessment scientists and communication to review panels and constituents. However, this model development should not be to the exclusion of consideration and application of alternative models to evaluate and assure the robustness of assessment conclusions.

5. Reviewer Statement of Consent

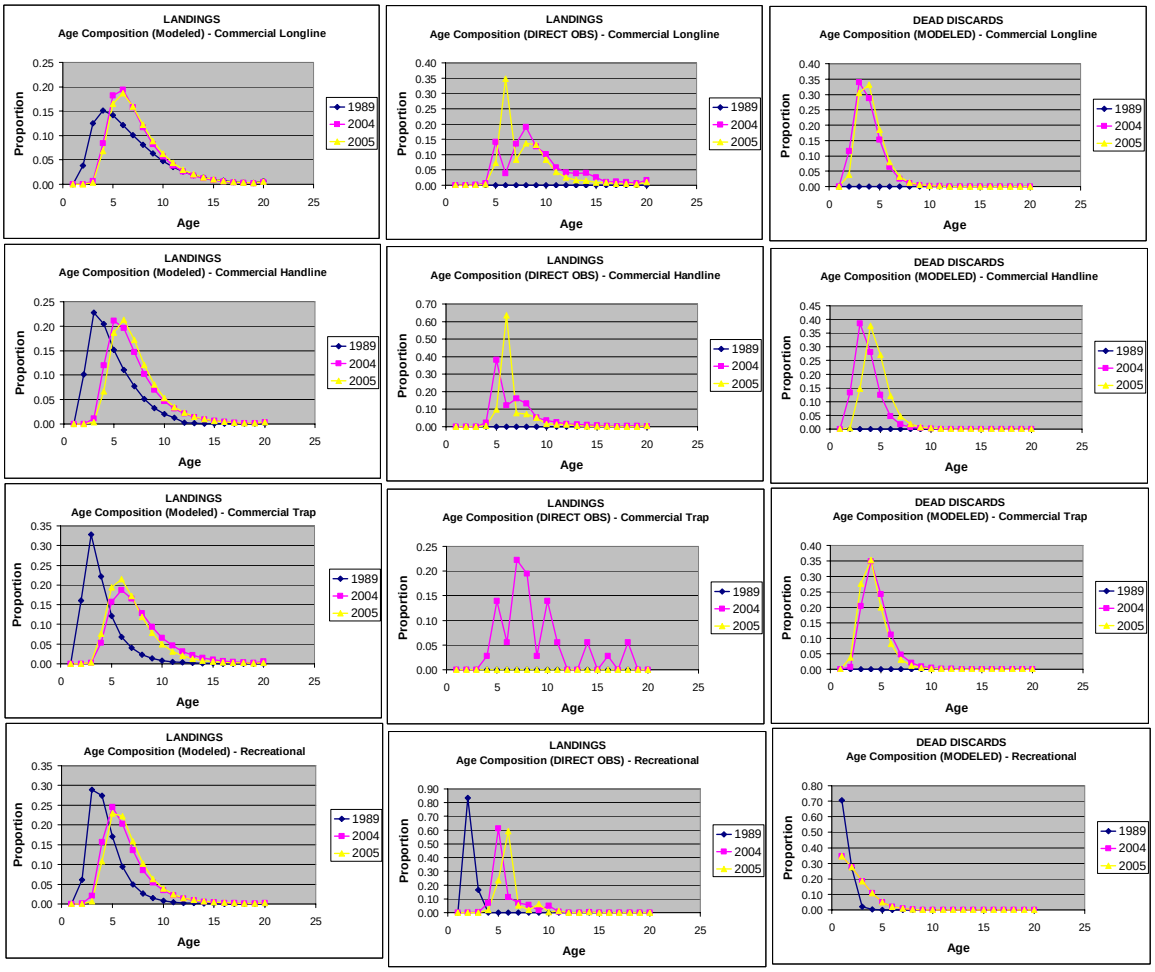
The RP consisted of a chair appointed by NMFS, two independent reviewers appointed by the Center for Independent Experts, and an independent reviewer appointed by the Gulf of Mexico Fishery Management Council. The consensus summary reported in this document represents the joint work of all members of the RP. The conclusions, findings and recommendations of the RP are agreed to by its members.

6. Appendices

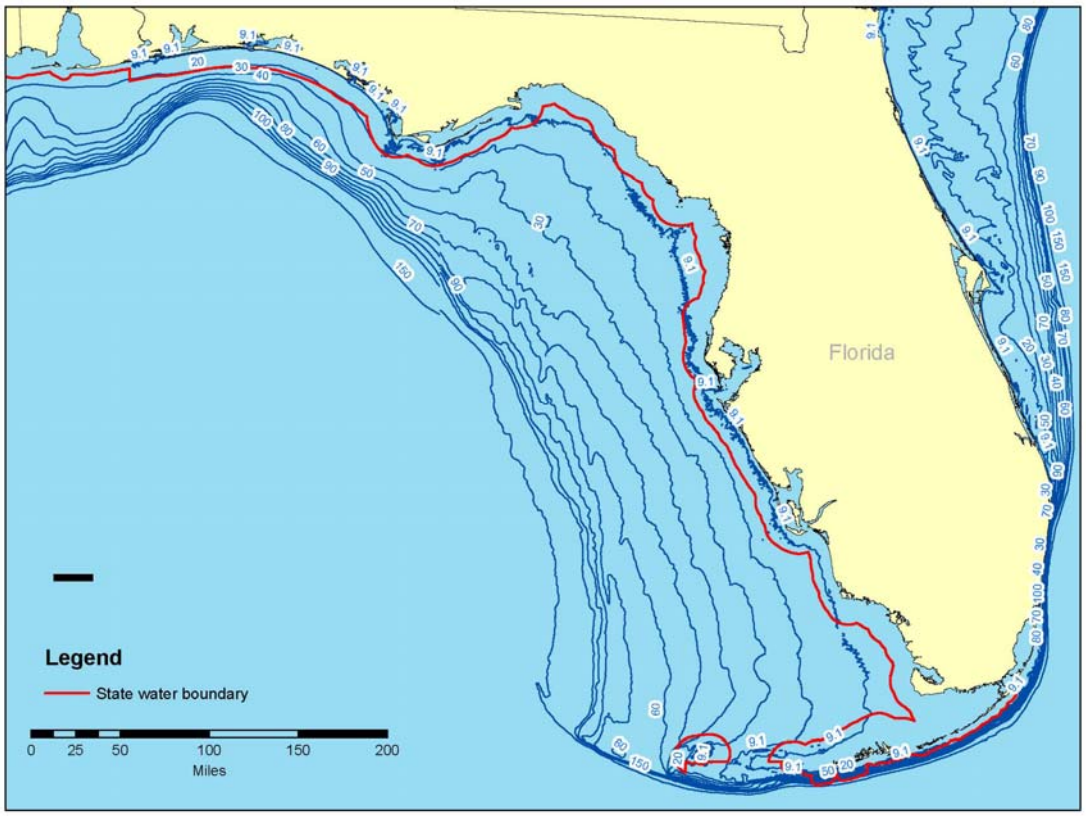
6.1. Gulf Red Grouper selectivity and catch composition at age



Gulf Red Grouper discard and landings age composition.



6.2. West Florida depth chart



6.3. Atlantic Gag Natural Mortality evaluation

SEDAR
Southeast Data, Assessment, and Review

SEDAR Grouper Assessment Review

U.S. South Atlantic Gag Grouper

Sensitivity Analysis to Ages of Re-Scaling applied to the Lorenzen Natural Mortality Estimates

May 2007

Introduction

On May 8-10, 2007 a review panel convened in St. Petersburg, Florida as part of the SEDAR Grouper Assessment Review. The SEDAR Grouper Assessment Review was tasked with reviewing the stock assessments from SEDAR 10 and 12 for South Atlantic gag, Gulf of Mexico gag, and Gulf of Mexico red grouper.

One of the specific items reviewed by this panel was the re-scaling of the Lorenzen age-specific natural mortality rates used in each of the grouper stock assessments. At SEDAR 12, the Gulf of Mexico red grouper assessment had used exploited ages 5+ to re-scale the Lorenzen M estimates to match the cumulative mortality from a constant natural mortality rate based on Hoenig's method. In contrast, both gag grouper assessments conducted during SEDAR 10 had used ages 0+ to re-scale the natural mortality rates.

The review panel requested a sensitivity run of the South Atlantic gag grouper stock assessment model utilizing natural mortality rates re-scaled for ages 5+ to match the methodology used in the SEDAR 12 Gulf of Mexico red grouper assessment. The results of that sensitivity run are presented here.

Methods/Results

The age-specific natural mortality rates used in the base run of the SEDAR 10 South Atlantic gag grouper stock assessment were re-scaled using age 5+. The resulting age-specific natural mortality rates are show in Table 1. These natural mortality rates were applied to the base run model (which assumes constant catchability for fishery dependent CPUE indices) and the results for spawning stock biomass and fishing mortality are shown in Figures 1-4.

Table 1. Natural mortality rates used in the base run (re-scaled with ages 0-30+) and a sensitivity run (re-scaled with ages 5-30+) of the gag grouper stock assessment.

Age	Re-scaled to Ages 0-30+	Re-scaled to Ages 5-30+
0	0.460	0.545
1	0.271	0.321
2	0.207	0.245
3	0.175	0.207
4	0.156	0.185
5	0.144	0.171
6	0.136	0.161
7	0.131	0.155
8	0.126	0.150
9	0.123	0.146
10	0.121	0.143
11	0.119	0.141
12	0.118	0.140
13	0.117	0.138
14	0.116	0.137
15	0.115	0.137
16	0.115	0.136
17	0.114	0.136
18	0.114	0.135
19	0.114	0.135
20+	0.114	0.135

Figure 1. Spawning stock biomass (1000 lbs. gutted weight) estimates from the base run (M re-scaled to ages 0+) and sensitivity run (M re-scaled to ages 5+) of the SEDAR 10 South Atlantic gag stock assessment model. Horizontal dashed line corresponds to the SSB_{MSY} value for the base run and the horizontal dotted line corresponds to the SSB_{MSY} value for the sensitivity model run.

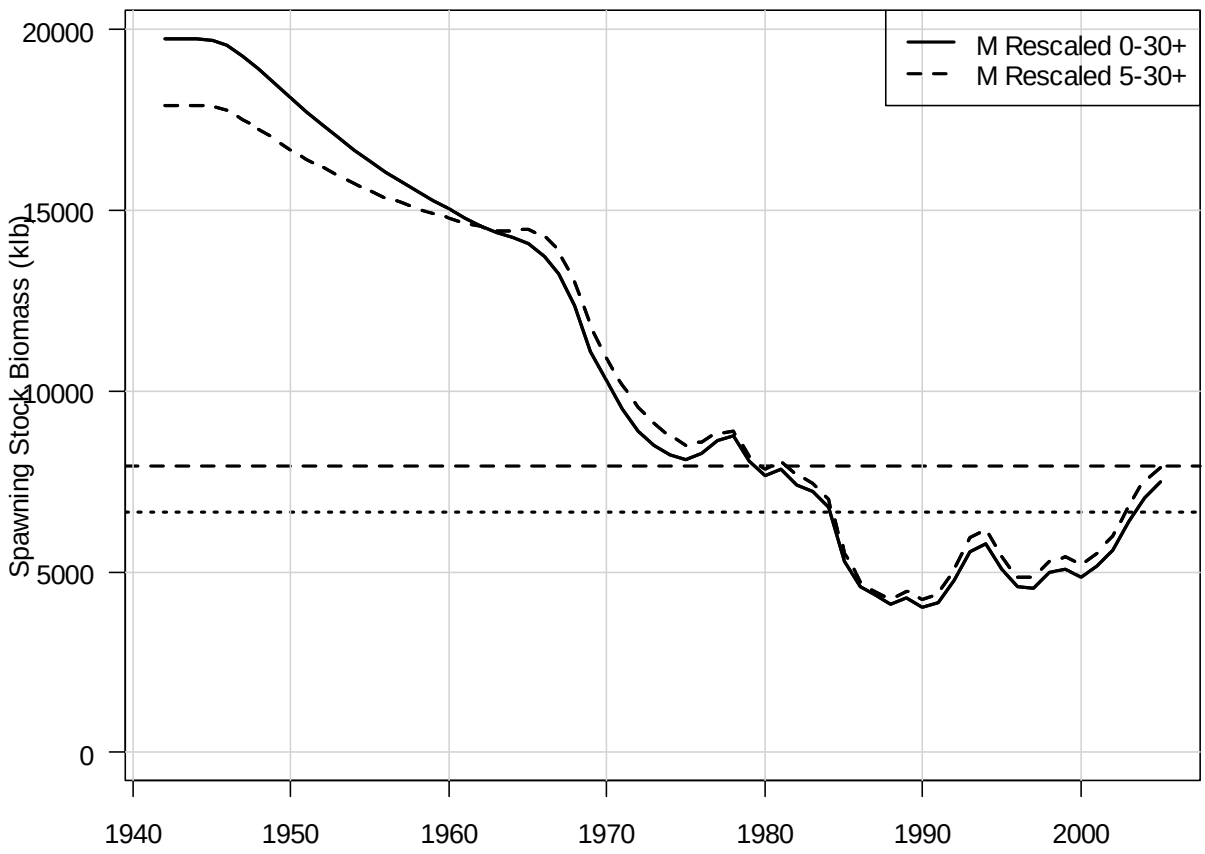


Figure 2. Relative spawning stock biomass (1000 lbs. gutted weight) divided by SSB_{MSY} estimates from the base run (M re-scaled to ages 0+) and sensitivity run (M re-scaled to ages 5+) of the SEDAR 10 South Atlantic gag stock assessment model.

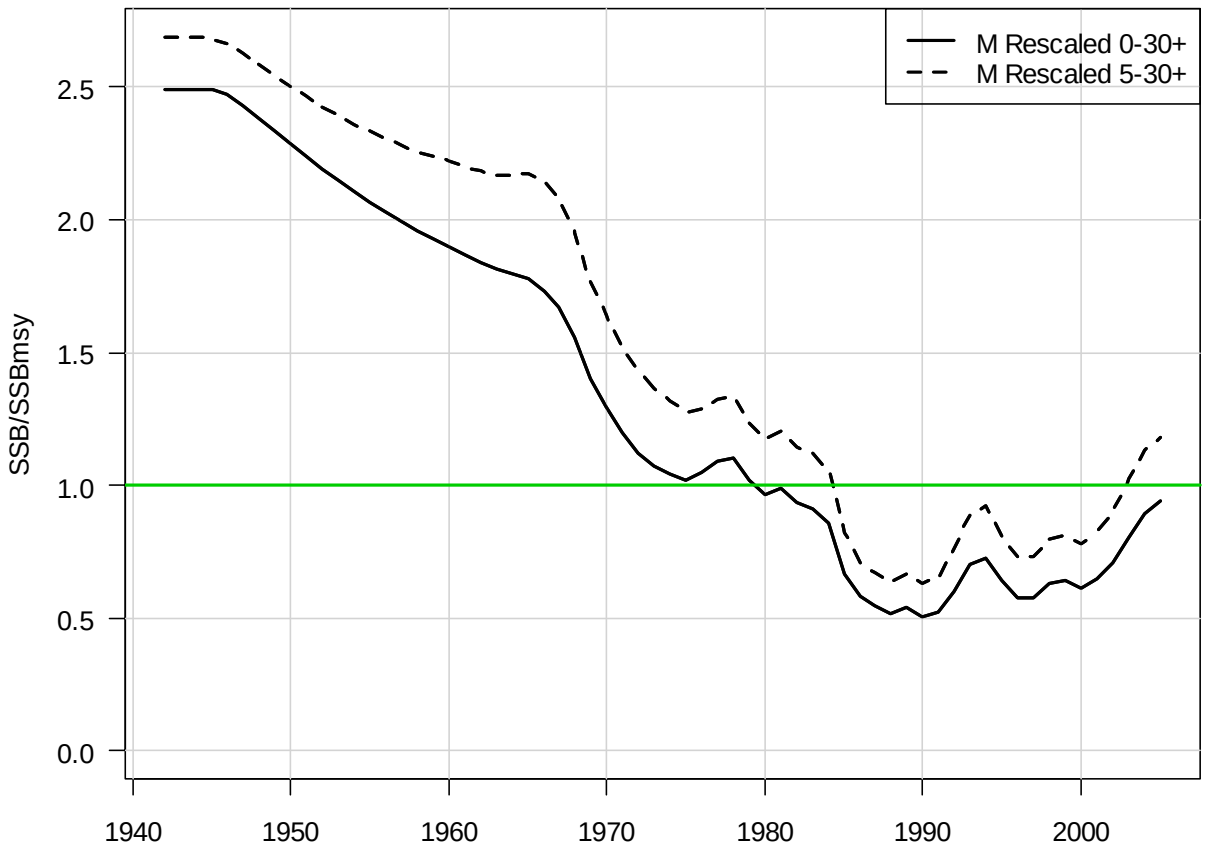


Figure 3. Fully selected fishing mortality estimates from the base run (M re-scaled to ages 0+) and sensitivity run (M re-scaled to ages 5+) of the SEDAR 10 South Atlantic gag stock assessment model. Horizontal dashed line corresponds to the F_{MSY} value for the base run and the horizontal dotted line corresponds to the F_{MSY} value for the sensitivity model run.

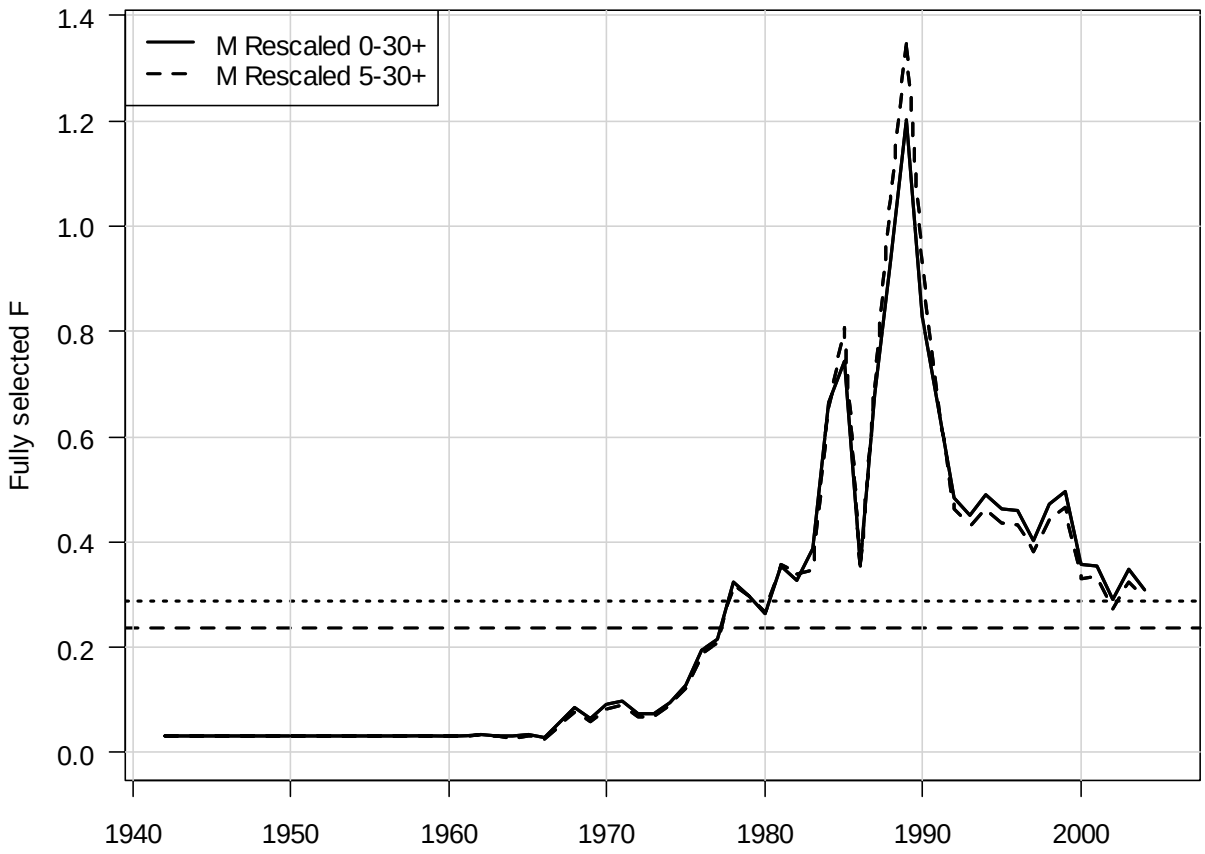
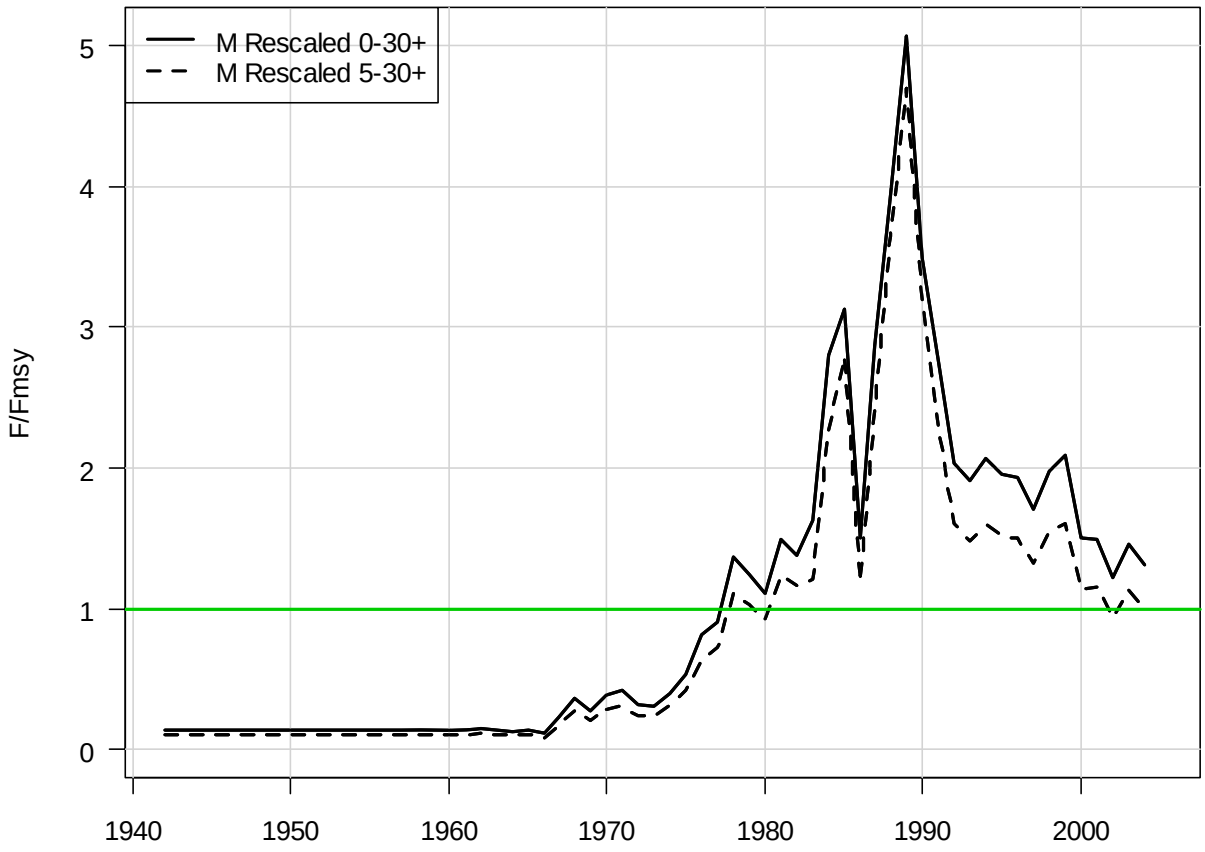


Figure 4. Relative fully selected fishing mortality divided by F_{MSY} estimates from the base run (M re-scaled to ages 0+) and sensitivity run (M re-scaled to ages 5+) of the SEDAR 10 South Atlantic gag stock assessment model.



6.4. Revised Gulf of Mexico Gag Assessment Results

Introduction

The Grouper Review Panel (RP) that met May 8-10, 2007 in St. Petersburg, FL, recommended additional analyses for the Gag Gulf of Mexico stock. Briefly, the RP concluded that Gulf gag recreational discards are primarily due to minimum size restrictions and that the assumed size distribution of these discards should reflect this. They also found that the spatial distribution of the size-at-depth information used previously for the recreational fishery was not representative of the distribution of the fishery as a whole, coming mostly from the Florida Panhandle where deeper waters are closer to shore. In contrast, the MRFSS B2 estimates indicate a high proportion of the recreational fishery takes place in state waters (inside 10 miles) off peninsular Florida, where the average depth is on the order of 10 meters. Thus the original depth-at-size matrix is likely biased. The RP recommended instead partitioning discards (B2 MRFSS/Headboat) by regions (< 10 miles or > 10 miles) and assigning average depths to each of these regions based on examination of depth contour plots and consultations with fishermen.

[1]Gag GOM model runs and stock evaluation

The following is a brief explanation of the data inputs and modifications for the current CASAL Gag GOM model evaluation.

Review of catch and effort input data

The assessment workshop (AW) group reviewed the catch and effort input data for th4e gag Gulf of Mexico (GOM) stock and concluded the following:

Commercial landings

Commercial landings were available since 1963. All commercial landings were converted to gutted weight and partitioned into the following fisheries: commercial longline (1979-2004), commercial handline (1963-2004), and “other commercial fisheries” (1963-2004). The last category included landings from trawls, traps, spear fishing, and “unclassified” from several years. The handline fishery also groups several gears (electric reels, hand reels, handlines and commercial rod and reel). Commercial landings also reflected the conversion of black grouper landings to gag grouper due to miss-identification problems, particularly for the North Gulf of Mexico (see data workshop for further details).

[1] Not to be distributed without the report from the SEDAR AW panel and the Grouper SEDAR Review Panel report.

The AW group recommended extending the historical landing series as far back as possible, following the protocol(s) for reconstructing commercial catch trends of red snapper. The earliest estimated Gag Gulf catches are from 1880; however the SEDAR10 assessment workshop (AW), the review workshop (RW) and the Grouper Review Panel (RP) recommended using the commercial catch series starting in 1963 owing to the lack of information on the water body of capture prior to that time (i.e., the inability to distinguish landings of fish that were originally caught in Mexico). Table 1 shows the 'final' working estimates of commercial catch, there were no modifications in the commercial catch series in the present analysis compared to the SEDAR10-RW model adopted. [See text in SEDAR10-AW report for further details in the procedures for estimation of historical commercial catch.]

Commercial Discards

A preliminary report of commercial discards was presented at the SEDAR10-DW, from logbooks submitted by fisherman. The Catch group concluded that those estimated were limited and of few years/vessels and recommended not to use them for estimating commercial discards. The DW concluded that commercial discards are exclusively due to minimum size regulations, which started in 1990 in Federal waters. Thus it was assumed that commercial fisheries did not discard Gag grouper prior to 1990 and after that discarded only fish below the legal size limit. The size distribution of discarded fish was estimated from the cumulative size frequency distribution observed for the respective commercial sectors (handline, longline, other) during 1984-1989 up to the corresponding minimum size. From 1990 to June-2000 the minimum size regulation of Gag for commercial fisheries was 20 inches (51 cm TL). From Jul-2000 to the present the minimum size increased to 24 inches (61 cm TL).

Recreational Catch

Estimates of recreational retained catch (A+B1) and live discards (B2) were available for the Gulf of Mexico from MRFSS since 1981 and from the Headboat survey since 1986. Texas Parks and Wildlife Division (TPWD) provided estimates of recreational landings in Texas, but not discards. For modeling purposes, the recreational fisheries were classified into two sectors, Headboat (1986-2004) and other recreational (MRFSS; 1981-2004). There were some adjustments to the estimates of AB1 (kept recreational catch) and B2 (discards) in response to the re-assignment of black grouper as gag grouper for most of the Gulf with exception of the Florida Keys catches. Also ratios of discards to retained catch for the Headboat fishery are based on the ratios of discards from the MRFSS estimates. Finally it was known that a substantial recreational fishery existed for Gag in 1963, therefore the AW recommended extrapolating back to 1960 using indicators that take into account human coastal population, commercial catch, number of vessels and estimated total expenditure in dollars for recreational fisheries (see RW report and supporting documentation). The historical discards (back to 1960) were determined from the extrapolated historical recreational catch using the ratios of 1981-1989 discards/kept fish. The size composition of the AB1 retained catch was determined from size samples collected by MRFSS. Very little size data has been collected on discarded fish.

Estimation of Dead Discards

The SEDAR10-DW concluded that the mortality of discarded gag grouper is highly dependent on the depth of capture of the fish. Based on several research studies, a depth-mortality function was estimated (Fig 1). Gag grouper show an ontogenic migration pattern, where larger fish move offshore to greater depths, while young and smaller fish tend to concentrate in shallow waters. Size-at depth data was available from the TIP survey, GULFIN and other survey data (Mote Marine Laboratory). In general most of the size-depth information came from commercial samples (about 72 thousand samples), while very few from recreational fisheries (382 samples). A report prepared to address recommendations of the SEDAR Grouper Review Evaluation Panel (SEDAR Document S1-RW01), Analyses of Gulf of Mexico Gag Grouper in Response to the Recommendations of the SEDAR Grouper Assessment Review Panel, summarized the spatio-temporal distribution of the size-depth samples available. In general the information corroborates the notion of larger fish at greater depths, however it is also clear that all sizes are represented even at the greatest depths (65+ meters).

The size-at-depth data allows the estimation of two probability matrices of size at depth, one for the commercial fisheries and one for recreational fisheries (in both cases assumed to be constant through the years). These size-at-depth matrices allow converting Discards-at-size (DAS) into Discards-at-size-at-depth (DAS-AD). Once DAS-AD is available, the depth-mortality function can be applied to estimate the portion of dead-discards-at-size (DDAS). For the commercial discards, the frequency size distribution was assumed to be that of the illegal size fish (below minimum size regulations) of 1984-1989. Recall, that it was assumed that prior to 1990 there were no discards on commercial fisheries, so this size frequency and dead discards estimation is only for 1990 forward.

In the case of the recreational fisheries the RP considered that the size-at-depth information was limited, and restricted to a small area (off the Panhandle coast, FL) where deep water is close to shore, and this sample did not represent the main recreational fisheries operations of the rest of the Florida West Coast (where the shallow waters extend for several miles off the coast, Fig 2). Therefore the RP concluded that the size-at-depth recreational matrix was likely biased and recommended an alternative procedure to estimate average depth of discards for these fisheries. The alternative method was based on an analysis of the distribution of B2 MRFSS discards between 3 zones (inshore, ocean < 10 m, ocean >10 m) in three regions (Panhandle FL, Florida Keys and Peninsular FL). The RP recommended using these strata to partition all recreational discards (B2) and assign an average depth by each stratum base on depth-contour plots and information from recreational fisherman and scientist familiar with these fisheries. Table 2 shows the assigned depth and correspondent mortality-at-depth for each stratum. Furthermore, as most of the recreational catch of gag is from the Florida West coast, Alabama, Mississippi and Louisiana B2 discards were treated similar to those from the Panhandle region and Texas was treated similar to the Peninsula region. The partition of B2 discards was done for each year-area-region (1981-2004). For the years prior to 1981; it was assumed that dead-discards were the same proportion as the 1981-1989 average of dead-discard/kept fish of the overall recreational estimates.

The Grouper RP concluded that discards from recreational fisheries were due primarily to size regulations, thus recommending that discards size distributions are of fish below 20" (51 cm TL) from 1990 to 1999 and fish below 22" (56 cm TL) from 2000-2004. Prior to 1990, when no federal size regulations were in effect, size distribution of discards was assumed to be of fish below 16" (46 cm TL) in accordance with consultation with recreational fisherman after the RP meeting. Because no direct samples are available from discarded fish, the size frequency distribution was estimated from samples of sub-legal sized fish included in data sets from the TIP, Headboat bioprofile, GULFIN, and Mote Marine. It was found during the RP that the distribution of sub-legal size fish in these samples was similar to those collected during a the 2005 and 2006 FWC headboat survey. Document SEDARS1-RW01 summarized the spatio-temporal distribution of the size samples available to convert catch into catch at size (CAS) for both commercial and recreational fisheries. Table 1 shows the 'final' working estimates of recreational catch, there were modifications in the recreational catch series in the present analysis compare to the SEDAR10-RW model adopted. These differences are on the number of estimated recreational dead discards, and the size/age composition of this discards. Figure 3 shows the differences in terms of total biomass removals, and Figure 4 shows the differences in terms of numbers of fish removals.

Catch At Age

CAS tables from commercial and recreational kept, and commercial/recreational dead discards were converted to Catch at Age (CAA) following the procedures described in SEDAR10-AW02 document. Briefly, age-length-keys (ALK) were used when sufficient age samples were available (1991-2004), otherwise a stochastic length deconvolution method (SAR) was used (1984-1990) (Table 6 SEDAR10-AW02). In the assessment model CASAL, partial CAAs were input for each of the five fisheries, 3 commercial (handline, longline, others) and 2 recreational (Headboat, MRFSS).

Given the changes in assumptions regarding the size distribution of dead-discards in recreational fisheries, and their significant contribution to the total removals in the recreational fishery particularly in the latest years, the CAA distribution by year shifts towards younger ages compared to the CAA of the final model in SEDAR10-RW (Fig 5 and Fig 6). For the recreational CAA Ages 1, 2 and 3 increased in proportion of at-age removals, while older ages 4 and older decreased. In addition total number of removals by year also decreases, as more recreational discard fish were allocated to shallow mean depths, thus reducing their discard mortality.

Maturity

No changes were recommended for Gag Gulf maturity vector. As previously indicated, spawning biomass results represent female biomass only for this stock. Gag is a protogynous species, maturing first as female (50% mature females at 3.7 year old) and switch then to males (50% mature males at 10.8 year old). At age 6 is presumed 100% mature females, but at age 10 proportion maturity has decrease to 80% (females) as a portion of fish has transition to males.

Natural Mortality

Following the recommendations of the SEDAR10-AW and RW Gag Gulf follow a declining natural mortality with age. The assessment use the Lorenzen's model to estimate M at age using age 30 as the maximum age and estimating mean size at age in the mid-year. The model was applied to all ages (0-30). The RP recommended evaluating alternative M vectors.

Size at age

Size at age follows the von Bertalanffy growth model (SEDAR10-SAR2) estimated and adopted by the SEDAR10-DW. This model includes a modification to estimate growth parameters from samples subject to biases due to minimum size restrictions.

Indices of Abundance

Relative indices of abundance for Gag Gulf were derived from fishery independent (SEAMAP Video Survey indices for all gag, and mature male gag 1993-97,02,04), and fishery dependent sources (MRFSS 1981-2004, Headboat 1986-2004, Handline 1990-2004, and Longline 1990-2004). No modifications were recommended for these indices, detailed description of standardization methods and estimation are provided in the SEDAR10-DW report CPUE section. Because of the changes in minimum size regulations (1990, and 2000) some of the fishery dependent indices were split at these years. In the assessment model CASAL, each time period is associated with a different catchability coefficient for the catch and fishery-index.

Gag GOM CASAL runs

Assessment model assumptions

The AW and RW 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 represents the plus group.
- Natural mortality vector age dependent, based on the Lorenzen's method.
- Size at age following a von Bertalanffy growth model SEDAR10- DW.
- 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.

- 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.

Scenario(s)

The following are the main input differences between the final model adopted by the SEDAR10-Review Panel (Jul-06) and the model recommended by the Grouper Review Panel (RP) (May-07). For comparison purposes the final model SEDAR10 will be label as SEDAR-Jul06, while the recommended run by the RP will be label MinSz DDB2P (Minimum size dead discards with partition of B2 recreational estimates).

1. Discards from recreational fisheries only due to minimum size restrictions, thus size distribution of discards are fish below 16" (1963-1989), fish below 20" (1990-1999) and fish below 22" (2000-2004).
2. Discards from recreational fisheries (B2) were partitioned between areas (inshore, ocean<10, ocean>10) and regions (Panhandle, Peninsula, FLKeys) for each year based on the proportions of B2 derived from the MRFSS estimates of Florida West coast (Web MRFSS estimates). Then for each stratum an average depth was assigned base on consultation with recreational fisherman and scientist familiar with these fisheries. Dead-discards were then estimated as the depth-mortality times the B2 by stratum for each year.

Results

The CASAL assessment model fit for MinSz-DDB2P scenario estimated a relative smaller Gag Gulf stock compare to the SEDAR10-Jul06 results both for unexploited biomass and initial biomass (1963) (Table 3). However the overall trend of both scenarios is comparable, with a rapid decline of total biomass since 1963 up to 1980, when the rate of biomass decline was reduced. After a slight increase of biomass in 1982, the decline trend resumed. From 1988 on the trends differ between scenarios; in the SEDAR10-Jul06 run, by 1990 the stock biomass start to increase rapidly reaching a peak in 2002. Instead the MinSz-DDB2P run shows continued declines of biomass upto 1993, when the trend shift and increases are seen until 2002. However the biomass in the 2000's is much lower compare to the SEDAR10-Jul06 levels (Fig 7). A similar trends are estimated for the spawning stock biomass (SSB) component, however in the SEDAR-Jul06 run, the SSB in the 2000's is much higher than any historical estimates, while the MinSz-DDB2P run shows a much smaller SSB, about half of what it was in 1963 (Fig 8).

Trends of the stock size in numbers of fish shows similar patterns and levels for both runs between 1963 and 1982, slight higher numbers in the SEDAR10_Jul06 run. However, the magnitude of stock size differs from 1983 forward, albeit they follow similar trend of decrease and increases. By 2002, the SEDAR10_Jul06 estimate a total stock of about 12.3 million fish, while the MinSz-DDB2P run estimate a total stock of about 6.9 million fish (Fig 9). Trends of recruits (Age 1 class) are similar up to 1982, when they diverge, with larger recruitments predicted in the SEDAR10-Jul06 run than the MinSz-DDB2P scenario. The geometric mean recruitment from 1984 to 2004 was estimated at 2.1 million fish in the SEDAR10-Jul06 run, and 1.6 million fish in the MinSz-DDB2P run. Peaks of recruitments are similar between scenarios but the magnitude of them is much lower in the MinSz-DDB2P run (Fig 10).

In terms of exploitation rates, both models estimated similar rates and trends. Fig 11 shows the estimated annual fishing mortality rate (F) for both scenarios. The MinSz-DDB2P run estimated consistent higher F in the early time 1963-1982. At 2004, the estimated F is about 0.49 for the SEDAR10-Jul06 run and 0.41 for the MinSz-DDB2P scenario.

Fits to indices and partial Catch-at-age were similar between scenarios (Fig 12 and 13). While estimated selectivity by fishery show the expected patterns. In the scenario of MinSz-DDB2P, the estimated selectivity's of the recreational fisheries were shifted towards smaller-younger age classes (Fig 14). Selectivity for the commercial components was similar between scenarios (Fig 15).

Gag GOM Stock Status

Following the recommendations of the SEDAR10-AW and RW, estimates of benchmarks were calculate assuming an average recruitment (constant) for the period

when relative indices of abundance were available [1984-2004]. The average recruitment was estimated as the geometric mean of each scenario recruits 1984-2004 (2.12 million recruits SEDAR10-Jul06 case, and 1.47 million recruits MinSz-DDB2P case). It was also assumed an average selectivity pattern given by the last 4 years 2001-2004. Projections and benchmark estimates were calculated using alternative age-structure software (PVPA-2BOX). Table 4 summarizes the estimated benchmarks. Overall the SEDAR10-Jul06 case estimated higher fishing mortality benchmarks (F_{MSY}, F_{MAX}, $F_{X\%SPR}$) than the MinSz-DDB2P scenario. Comparable also, higher SSB benchmarks were estimated for the SEDAR10-Jul06 case. MSY was estimated at 4.3 million pounds (MP) for the SEDAR10-Jul06 case and 5.3 MP for the MinSz-DDB2P case. These benchmark estimates of MSY are for runs optimizing the landings (kept catch) component of the fisheries.

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 40,550 MP and 19,839 MP for the SEDAR10-Jul06 and MinSz-DDB2P scenarios, respectively. These SSB_{2004} were about 35.8% and 26.2% of their respective virgin biomass estimates. Compared to SSB_{MSY} the SSB_{2004} were 1.16 and 0.67, respectively. The estimated fishing rates in 2004 were between 0.49 and 0.41 for the SEDAR10-Jul06 and MinSz-DDB2P scenarios, respectively. Overall the F_{2004} were higher than F_{MAX}, F_{MSY}, or $F_{30\%SPR.}$

Gag GOM Stock Projections

Projections of stock status at 2004 were done for MinSz-DDB2P scenario, also using the age-structure PVPA-2BOX. The projections assumed a preliminary catch in 2005, 2006 and 2007 of 6,230 MP (these catch included both retained landings and estimated dead discards for commercial and recreational components). It also assumes the average recruitment and average selectivity pattern as in the benchmark calculations as describe above.

Table 1. Final estimates of total removals (landings + dead discards) from commercial and recreational fisheries 1963-2004 Grouper Review Panel May-07 (MinSz-DDB2P case) . Discards of recreational fisheries B2 were partitioned by year/area/region and assigned an average depth to estimate dead discards. Dead discards from recreational fisheries are only fish below minimum size regulations. Values in thousand pounds

Year	Longline	Handline	Others	MRFSS	Headboat	Total
1963	-	1,289	1	444	-	1,734
1964	-	1,632	9	479	-	2,121
1965	-	1,816	1	514	-	2,331
1966	-	1,457	1	547	-	2,004
1967	-	1,156	10	581	-	1,746
1968	-	1,192	4	617	-	1,814
1969	-	1,377	3	655	-	2,035
1970	-	1,284	3	696	-	1,982
1971	-	1,377	3	781	-	2,161
1972	-	1,460	4	877	-	2,341
1973	-	1,081	5	984	-	2,070
1974	-	1,184	1	1,104	-	2,290
1975	-	1,447	4	1,238	-	2,689
1976	-	1,198	9	1,390	-	2,598
1977	-	977	8	1,561	-	2,545
1978	-	875	11	1,753	-	2,639
1979	1	1,342	10	1,969	-	3,322
1980	89	1,318	12	2,199	-	3,618
1981	467	1,499	16	1,852	-	3,834
1982	1,010	1,335	14	3,234	-	5,592
1983	681	1,039	18	6,414	-	8,152
1984	433	1,098	18	1,962	-	3,512
1985	381	1,398	28	6,592	-	8,399
1986	517	1,155	29	3,377	277	5,355
1987	656	853	30	2,284	190	4,012
1988	402	791	23	3,631	150	4,998
1989	426	1,235	31	2,058	292	4,042
1990	623	1,130	41	1,156	193	3,142
1991	510	993	63	2,773	107	4,445
1992	593	1,003	69	2,258	124	4,046
1993	480	1,280	106	2,771	172	4,808
1994	352	1,148	119	2,058	176	3,853
1995	391	1,157	105	2,937	125	4,715
1996	394	1,106	68	2,510	109	4,187
1997	415	1,101	83	2,694	98	4,391
1998	603	1,848	82	3,667	240	6,439
1999	549	1,481	68	3,799	196	6,094
2000	621	1,596	81	5,096	211	7,605
2001	1,011	2,065	101	4,305	123	7,604
2002	1,041	1,910	62	4,866	86	7,965
2003	1,138	1,461	67	4,358	126	7,150
2004	1,138	1,737	73	5,782	193	8,924

Table 2. Assigned average depth (m) and corresponding discard mortality (% mort) for each of the regions; Florida Keys, Panhandle and the rest of FL West coast (Peninsula). And distance to shore (Zone) inshore, Ocean < 10 miles, and Ocean > 10 miles. This table was used to partition the total discards (B2) numbers for the recreational fisheries of Gag Gulf of Mexico by year and to estimate dead discards.

Region	Zone	Average depth (m)	%mort
Panhandle	Inshore	10	0.11
Panhandle	Ocean<10	20	0.18
Panhandle	Ocean>10	40	0.42
Peninsula/Keys	Inshore & Ocean<10	10	0.11
Peninsula/Keys	Ocean>10	30	0.29

Table 3. CASAL estimates of total biomass, female spawning biomass, recruits (age 1), fishing mortality rate and removals of gag Gulf stock for the SEDAR10-Jul06 model and the recommended model by the Grouper Review Panel May07 (MinSz DDB2P).

	SEDAR10-Jul06					MinSz DDB2P			
Year	Total Biomass	Spawning Stock Biomass	Recruits	F	Yield (landings + Dead Disc)	Total Biomass	Spawning Stock Biomass	Recruits	F
	1000 lbs	1000 lbs	millions Age1	annual rate	1000 lbs	1000 lbs	1000 lbs	millions Age1	annual rate
1963	74,075	37,225	0.2146	0.030	1,736	69,600	30,600	0.1796	0.037
1964	71,432	36,322	0.2146	0.037	2,126	66,844	29,652	0.1801	0.046
1965	68,128	35,088	0.2132	0.042	2,341	63,427	28,418	0.179	0.052
1966	64,559	33,062	0.2113	0.040	2,023	59,789	26,544	0.178	0.052
1967	61,013	30,683	0.208	0.040	1,770	56,240	24,427	0.1755	0.055
1968	57,357	28,260	0.204	0.046	1,856	52,602	22,245	0.1727	0.064
1969	53,414	25,749	0.1993	0.056	2,107	48,722	19,983	0.1684	0.079
1970	49,361	23,238	0.1938	0.063	2,070	44,710	17,765	0.1661	0.091
1971	45,220	20,956	0.1873	0.079	2,289	40,653	15,734	0.1599	0.114
1972	40,969	18,877	0.1803	0.098	2,504	36,487	13,871	0.1576	0.144
1973	36,850	17,018	0.1726	0.111	2,262	32,496	12,240	0.1525	0.171
1974	33,502	15,207	1.394	0.140	2,526	29,233	10,688	1.355	0.217
1975	30,352	13,410	0.2022	0.183	2,982	26,169	9,151	0.1911	0.257
1976	27,687	11,826	0.7214	0.202	2,921	23,634	7,943	0.7361	0.258
1977	25,991	11,742	1.267	0.215	2,896	22,035	7,897	1.166	0.265
1978	25,088	11,447	1.216	0.236	3,115	21,226	7,657	1.112	0.268
1979	24,714	11,487	1.542	0.280	3,815	20,893	7,743	1.443	0.293
1980	24,736	12,267	1.713	0.300	4,167	21,083	8,389	1.747	0.298
1981	25,639	13,436	2.094	0.279	4,355	22,179	9,389	2.075	0.281
1982	26,828	15,507	1.972	0.352	5,615	23,347	10,882	1.996	0.378
1983	25,837	17,289	1.365	0.559	8,758	22,509	11,810	1.331	0.539
1984	25,705	16,388	1.358	0.216	3,504	22,179	12,214	1.197	0.232
1985	25,661	19,914	1.253	0.485	8,231	21,577	13,841	1.136	0.546
1986	23,877	18,141	1.476	0.365	5,306	19,114	12,403	0.9398	0.383
1987	23,943	17,577	1.193	0.262	3,989	18,444	11,949	0.898	0.293
1988	24,207	18,273	1.087	0.321	4,872	17,670	11,799	0.7717	0.402
1989	23,634	18,205	0.7932	0.305	4,079	16,301	10,807	0.5569	0.342
1990	25,352	17,930	3.761	0.233	3,196	16,277	10,199	1.681	0.274
1991	27,181	18,337	1.602	0.383	4,317	16,484	9,720	1.212	0.413
1992	28,700	16,952	1.916	0.315	3,921	16,305	8,598	1.028	0.379
1993	29,824	20,372	2.119	0.406	4,760	16,025	8,785	1.218	0.465
1994	31,432	21,029	4.814	0.422	3,700	16,740	8,849	2.492	0.370
1995	33,282	20,478	2.712	0.458	4,447	18,102	9,081	1.562	0.420
1996	35,903	20,610	2.033	0.310	3,890	19,584	9,632	1.499	0.335
1997	41,057	26,806	5.741	0.315	4,531	22,862	12,158	3.609	0.302
1998	44,670	30,727	3.062	0.399	6,610	25,684	14,013	1.866	0.399
1999	47,181	31,057	1.833	0.297	5,914	27,337	15,139	1.16	0.324
2000	51,035	37,665	5.007	0.309	7,963	28,836	18,417	2.885	0.382
2001	54,097	40,639	3.468	0.330	6,980	29,652	19,114	2.18	0.386
2002	54,868	40,463	2.125	0.364	8,009	29,851	18,473	1.467	0.390
2003	52,841	41,784	2.125	0.400	7,214	29,696	19,222	1.467	0.339
2004	47,489	40,551	2.125	0.493	7,628	28,418	19,839	1.467	0.415

Table 4. Estimated benchmarks Gag Gulf stock assuming a constant recruitment and average selectivity of last four years (2001-04). Comparison between SEDAR10-Jul06 model and the recommended model by the Grouper Review Panel (MinSz DDB2P). Units of biomass are thousand pounds (MSY, SSB, Yield, Biomass, SSB virgin), and units of YPR are pounds.

Benchmark	SEDAR10-Jul06	MinSz DDB2P
Fmsy	0.248	0.166
MSY thousand lbs	4,269.96	5,299.03
SSBmsy	35,019.60	29,639.61
YPRmsy	2.01	3.61
Fmax	0.248	0.166
YPRmax	2.01	3.61
$F_{20\%SPR}$	0.37	0.32
$F_{30\%SPR}$	0.25	0.22
$F_{40\%SPR}$	0.18	0.16
$YPR_{20\%SPR}$	1.92	3.16
$YPR_{30\%SPR}$	2.01	3.52
$YPR_{40\%SPR}$	1.95	3.61
$SSB_{20\%SPR}$	23,116.08	15,496.60
$SSB_{30\%SPR}$	34,641.41	23,204.32
$SSB_{40\%SPR}$	46,113.88	30,925.35
F2004	0.4925	0.4151
F2005	0.3780	0.3980
SSB2004	40,550.66	19,839.40
SSB2005	33,281.94	17,941.22
Yield 2004	7,627.75	6,688.83
Yield 2005	5,808.37	6,230.26
GeoMean Rec84-04	2,124,871	1,467,473
B virgin	192,763	139,119
R virgin	2,660,980	1,918,740
SSB virgin	113,238	75,685
F2004/Fmsy	1.99	2.50
SSB2004/SSBmsy	1.16	0.67

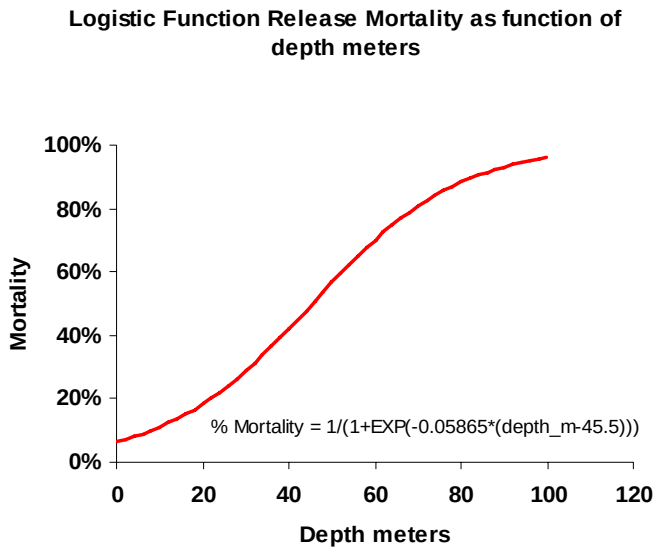


Figure 1. Estimated depth-mortality function for Gag Gulf of Mexico stock from research data compiled by the life historic group at the SEDAR10-Data Workshop.

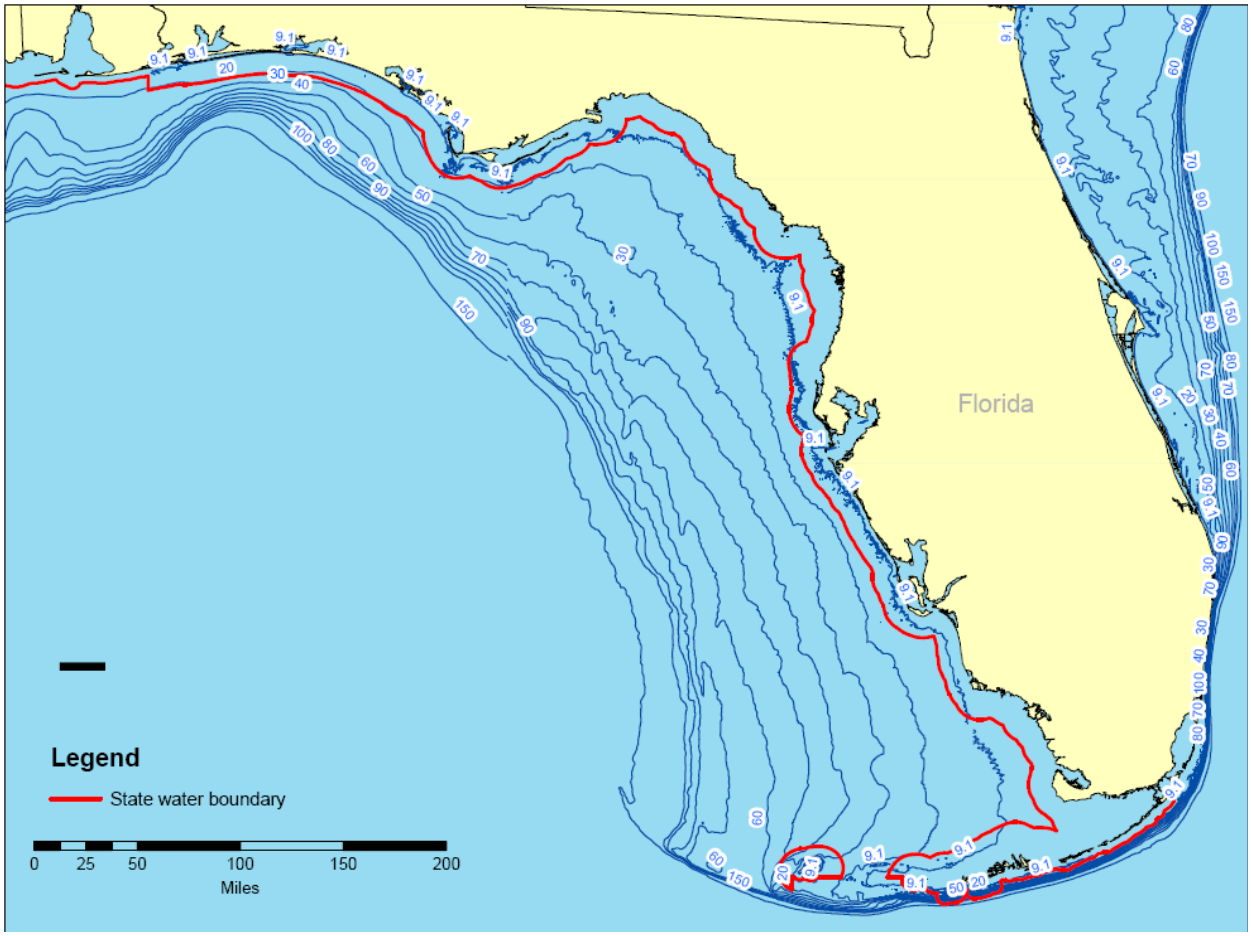


Figure 2. Depth contours for the Florida West coast. Red line defines the State water boundary. Courtesy of the SERO.

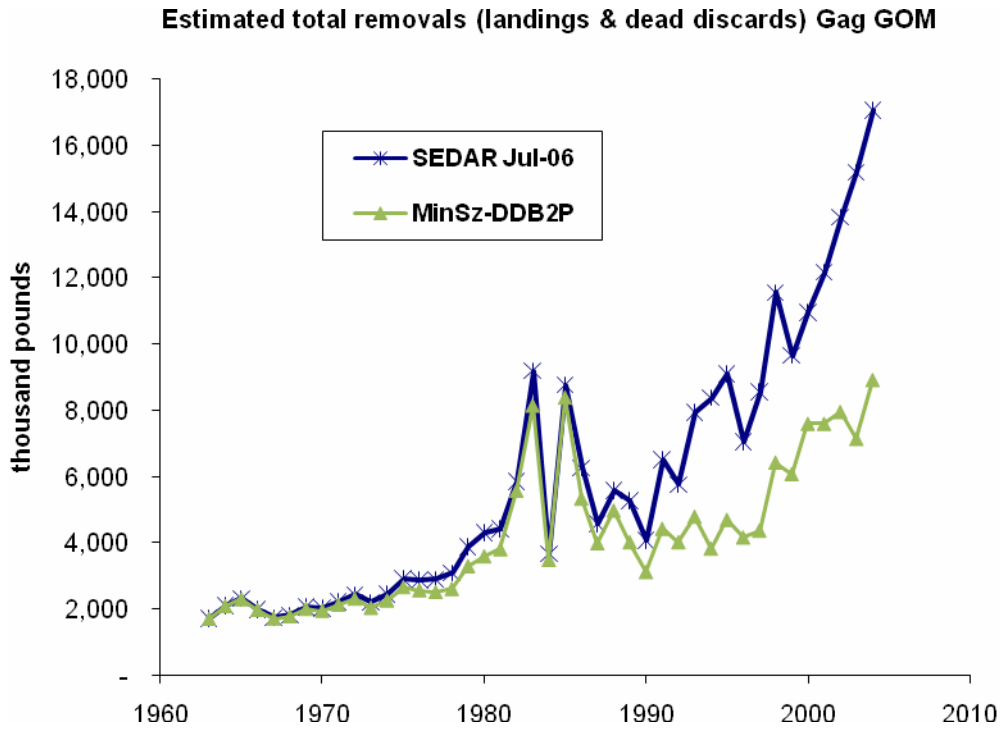


Figure 3. Comparison of estimated total removal (landings + dead discards) for Gag Gulf of Mexico between the final input data for SEDAR10-Jul06 model and the recommended input by the Grouper Review Panel May-07 (MinSz DDB2P) assigning all recreational discards to fish below minimum size and partition discards (B2) among regions and distance from shore to assign average depth to each stratum.

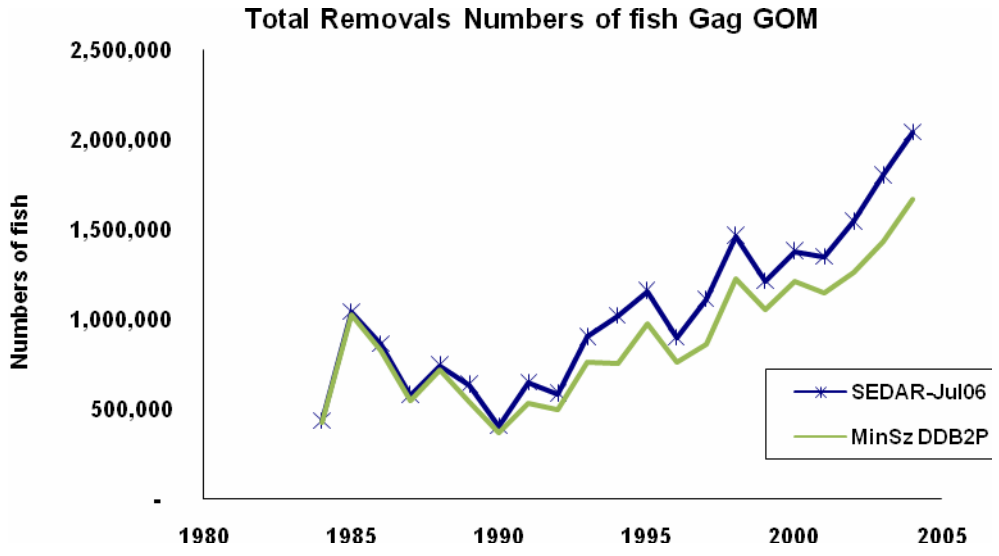


Figure 4. Comparison of estimated total removals in numbers of fish for Gag Gulf of Mexico stock (see text for further details).

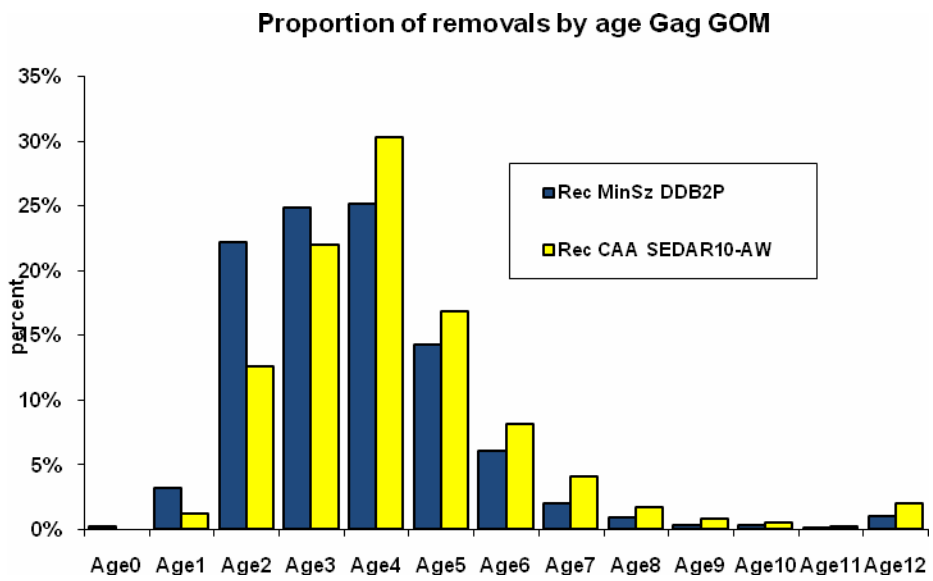


Figure 5. Average proportion of Catch at Age for the recreational fisheries removals (landings + dead discards) between the SEDAR10-AW model and the Grouper Review Panel recommendations (MinSz DDB2P).

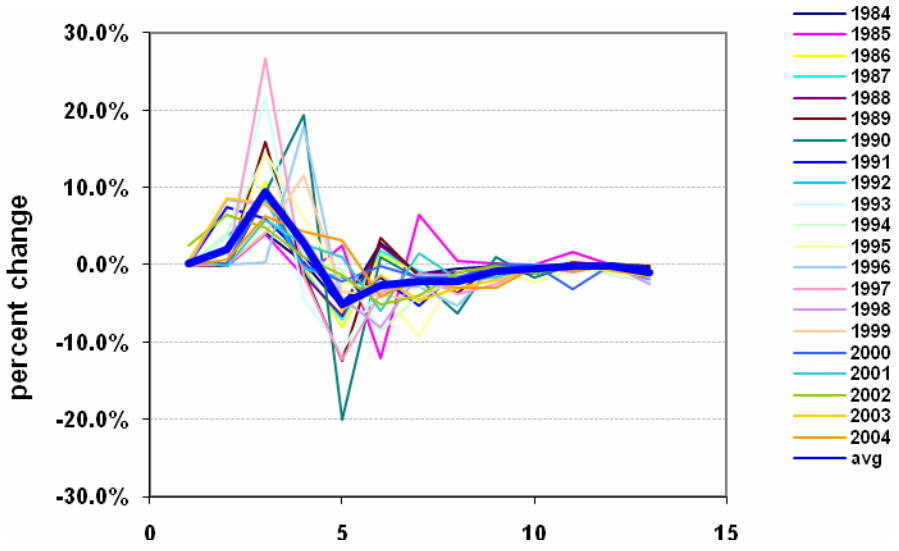


Figure 6. Differences in the recreational Catch-at-age (CAA) between the SEDAR10-Jul06 model input and the recommended inputs by the Grouper Review Panel (MinSz DDB2P) by year. Positive deviations indicate a higher proportion at age in the MinSz DDB2P case. Thick line is the average overall years, x-axis is the age-class.

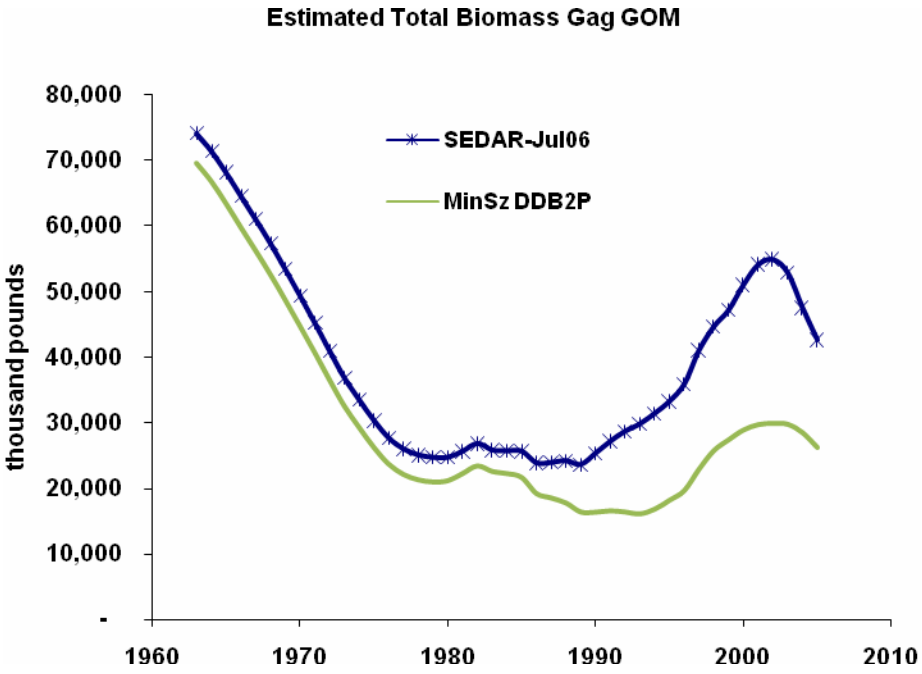


Figure 7. CASAL estimated total biomass trends for the SEDAR10-Jul06 model and the recommended model by the Grouper Review Panel (MinSz DDB2P) from 1963 to 2005.

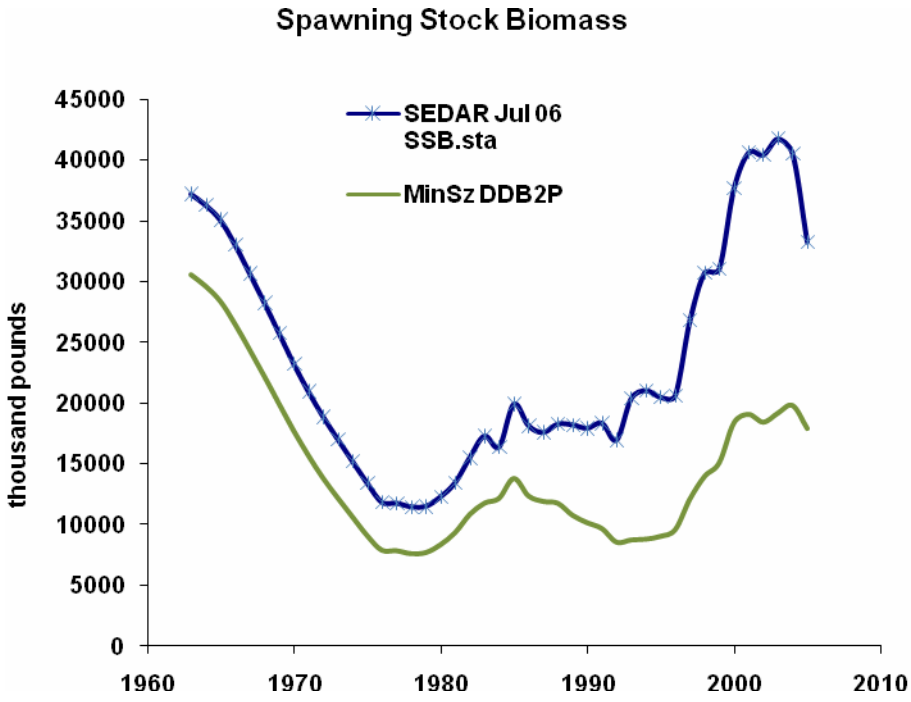


Figure 8. CASAL estimated spawning stock biomass (female component) trends for the SEDAR10-Jul06 model and the recommended model by the Grouper Review Panel (MinSz-DDB2P) from 1963-2005.

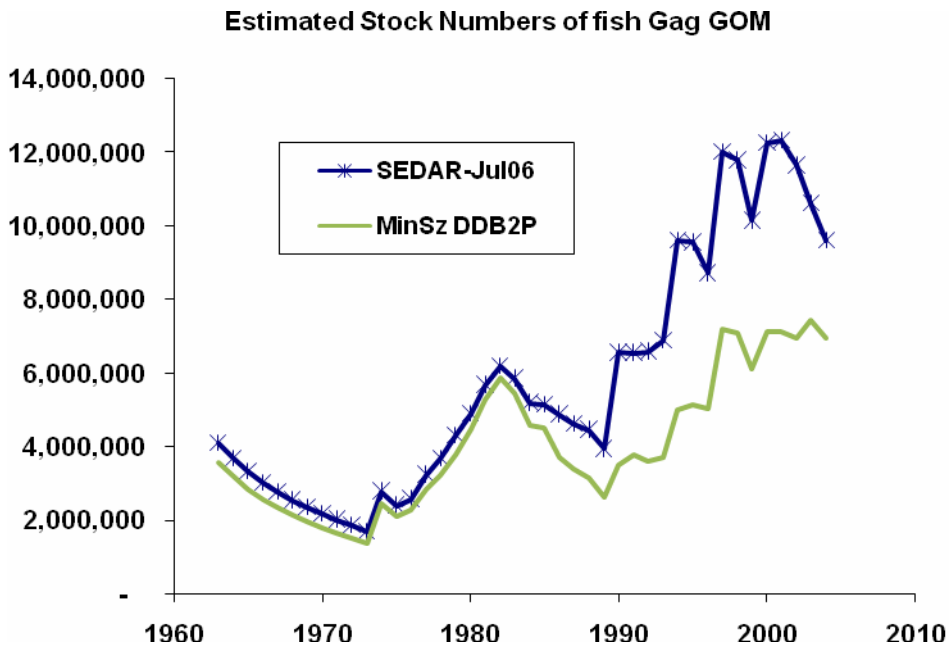


Figure 9. CASAL estimated stock size trends for the SEDAR10-Jul06 model and the recommended model by the Grouper Review Panel (MinSz DDB2P) from 1963-2005.

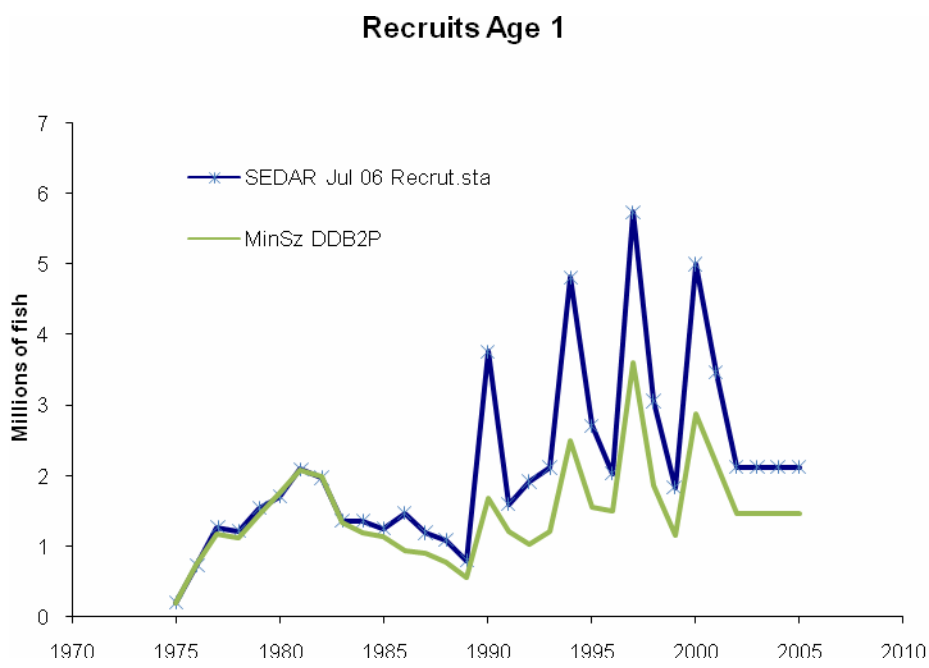


Figure 10. CASAL estimates of recruit trends (Age 1) for gag gulf stock for the SEDAR10-Jul06 model and the Grouper Review Panel model (MinSz DDB2P) from 1975-2005.

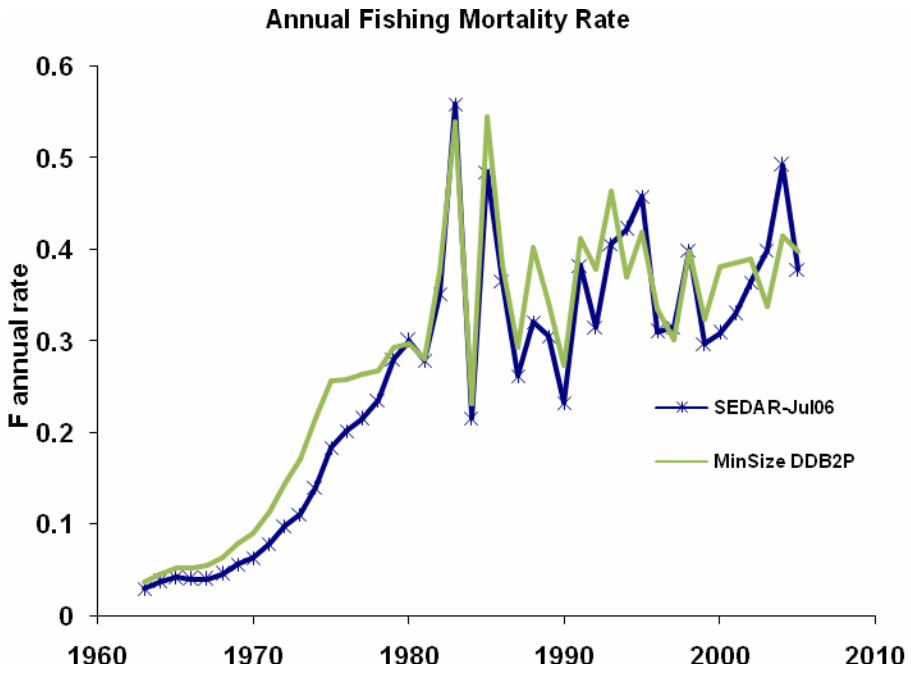
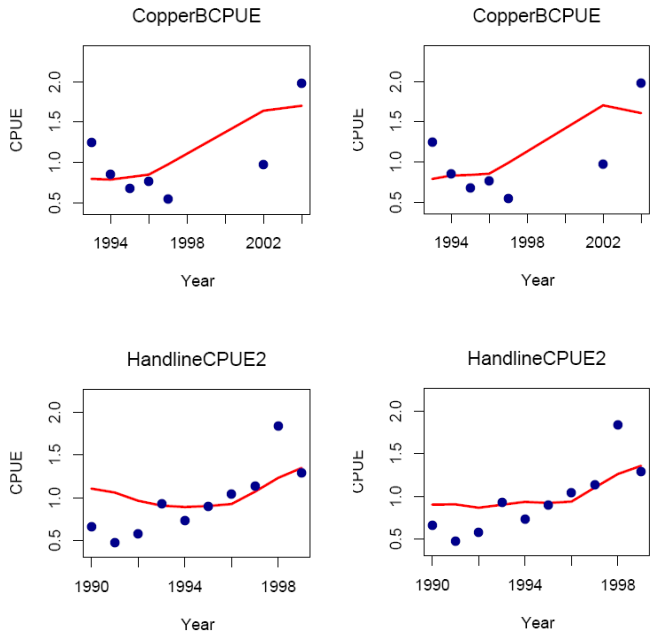
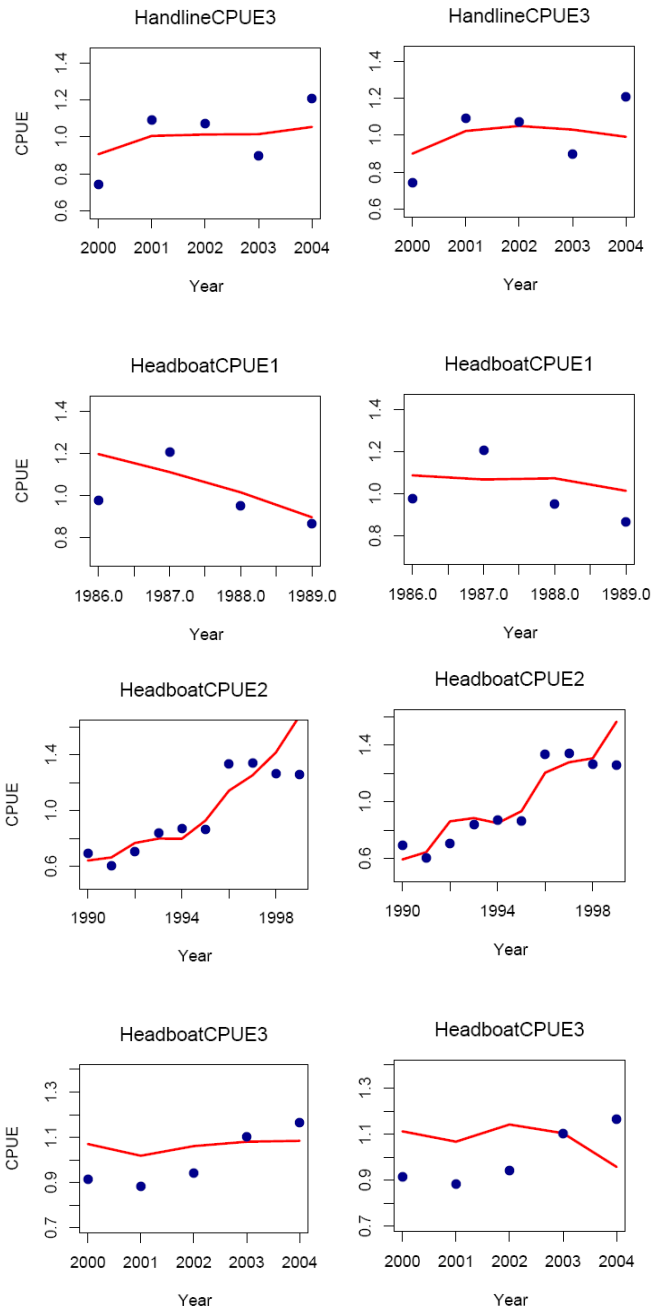


Figure 11. Estimates of annual trends of fishing mortality rate (F) by the CASAL model for the SEDAR10-Jul06 case and the recommended model by the Grouper Review Panel (MinSz DDB2P).




HandlineCPUE3
CPUE
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HeadboatCPUE3
Year

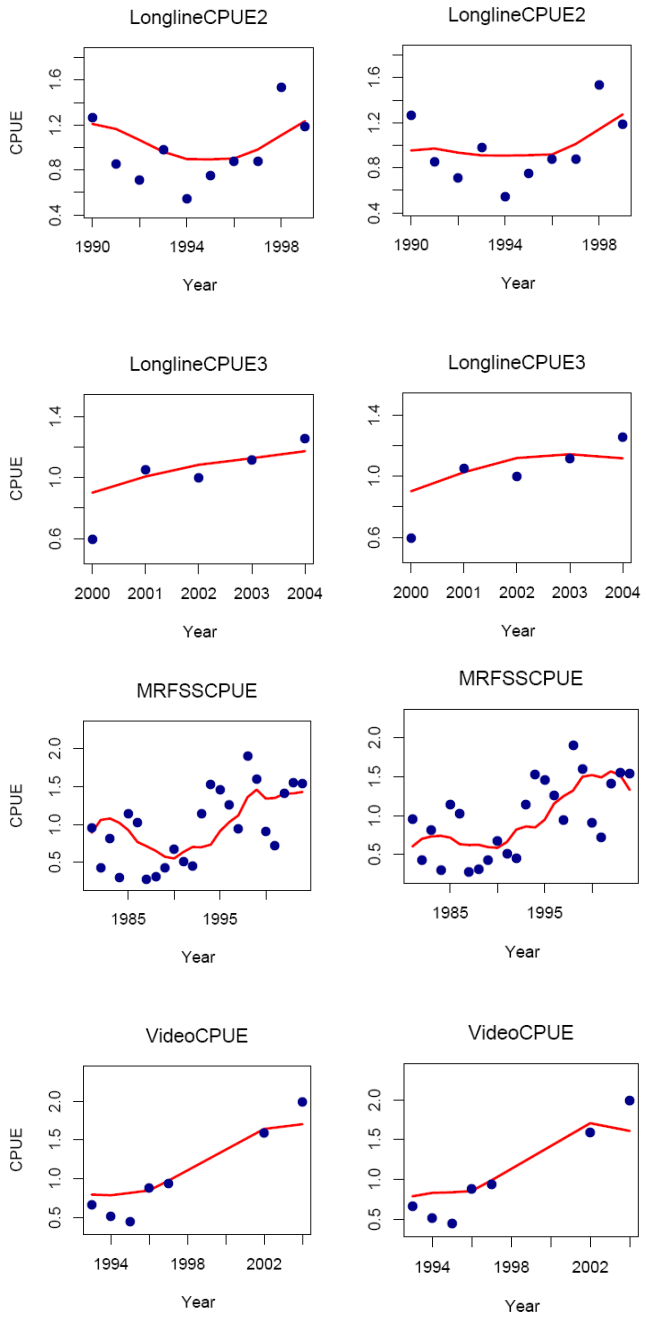
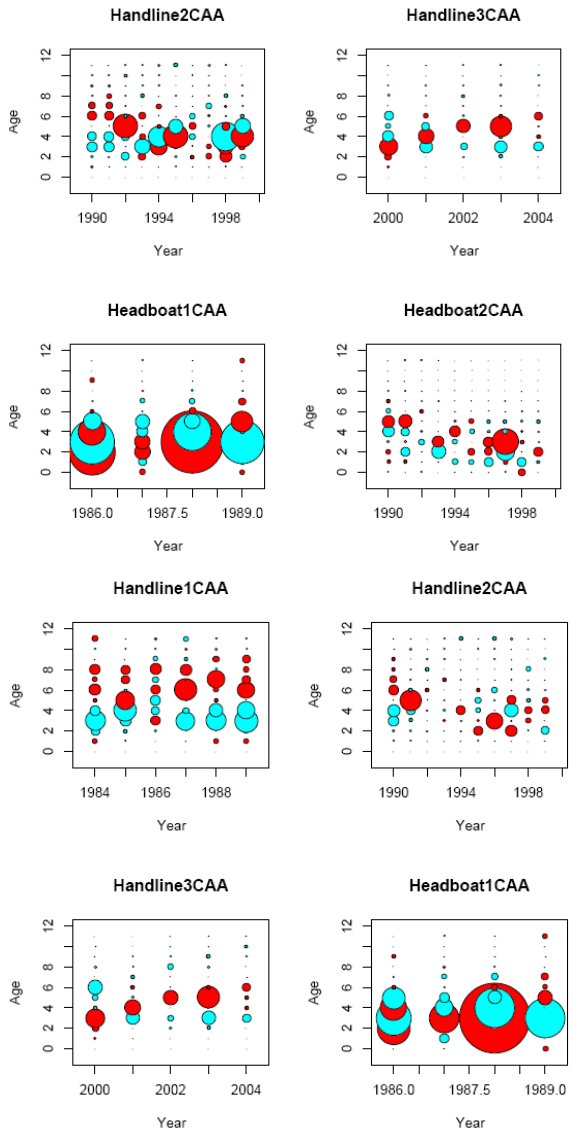
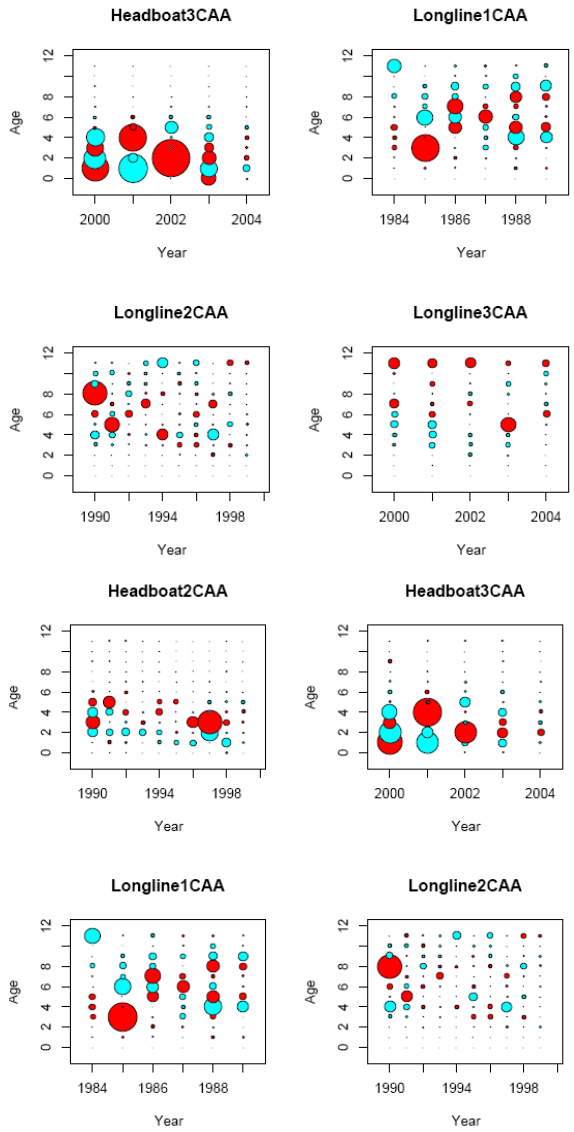


Figure 12. Comparison of fit to relative indices of abundance for Gag Gulf stock between SEDAR10-Jul06 model (right column) and the recommended model by the Grouper Review Panel (left column).

MinSz DDB2P CAA fit



SEDAR10-Jul06 CAA fit


Headboat3CAA
Longline1CAA
Longline2CAA
Longline3CAA
Headboat2CAA
Headboat3CAA
Longline1CAA
Longline2CAA
Age
Year

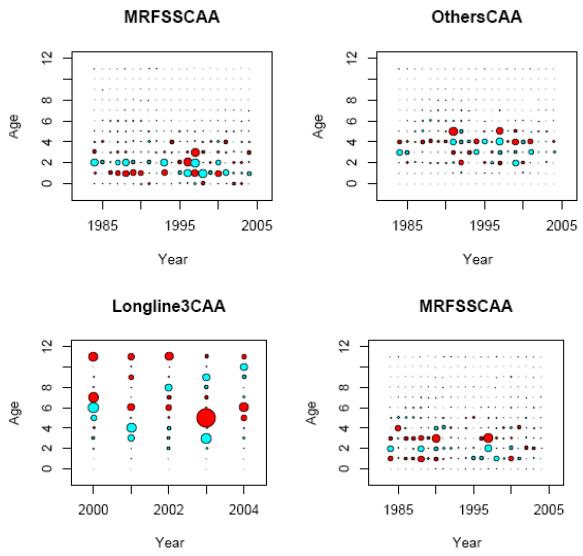


Figure 13. Comparison of fits to partial CAA inputs from the SEDAR10-Jul06 model (col 3 and 4) and the recommended model by the Grouper Review Panel (MinSz DDB2P, col 1 and 2).

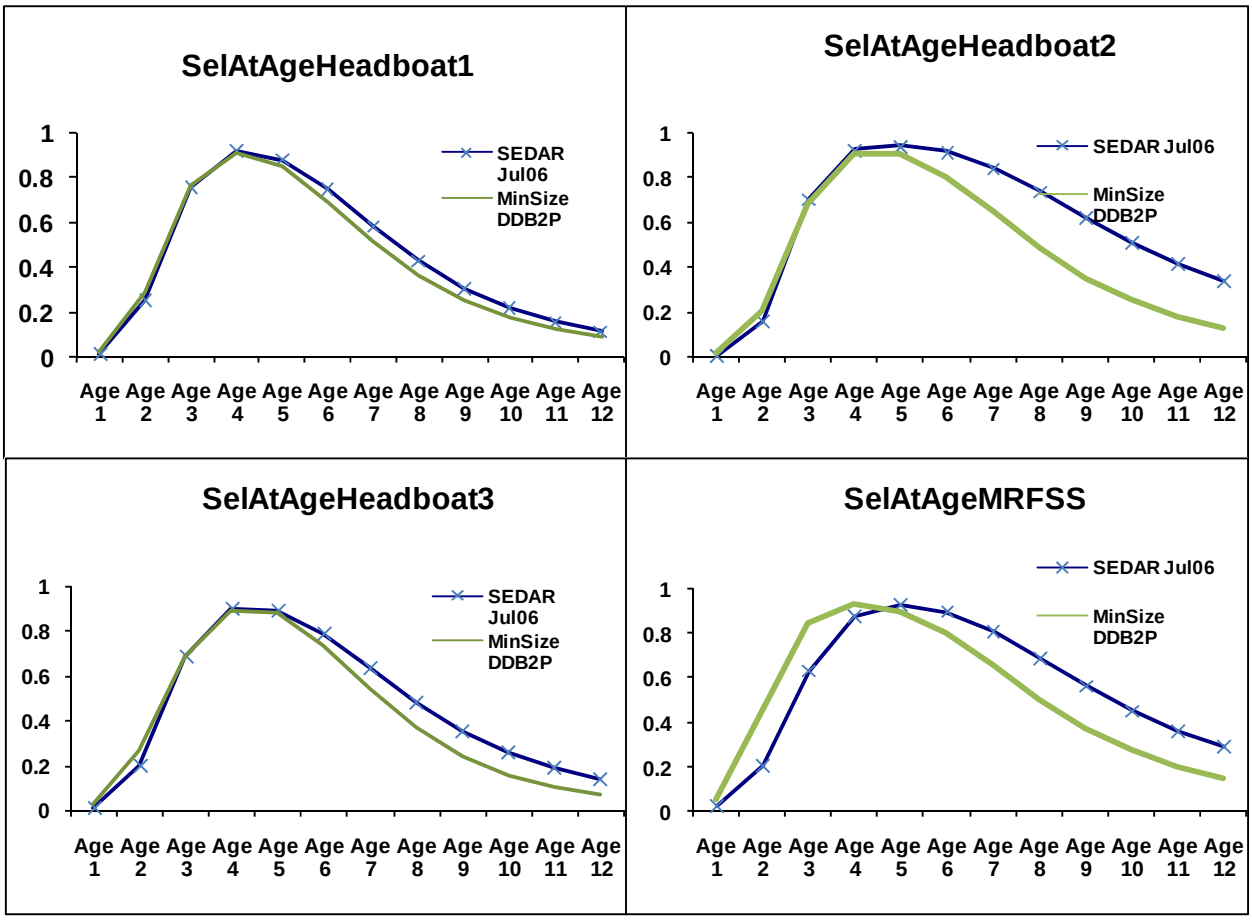


Figure 14. Model estimated selectivity for the recreational fisheries. Comparison of the selectivities between SEDAR10-Jul06 model and the recommended by the Grouper Review Panel (MinSz DDB2P).

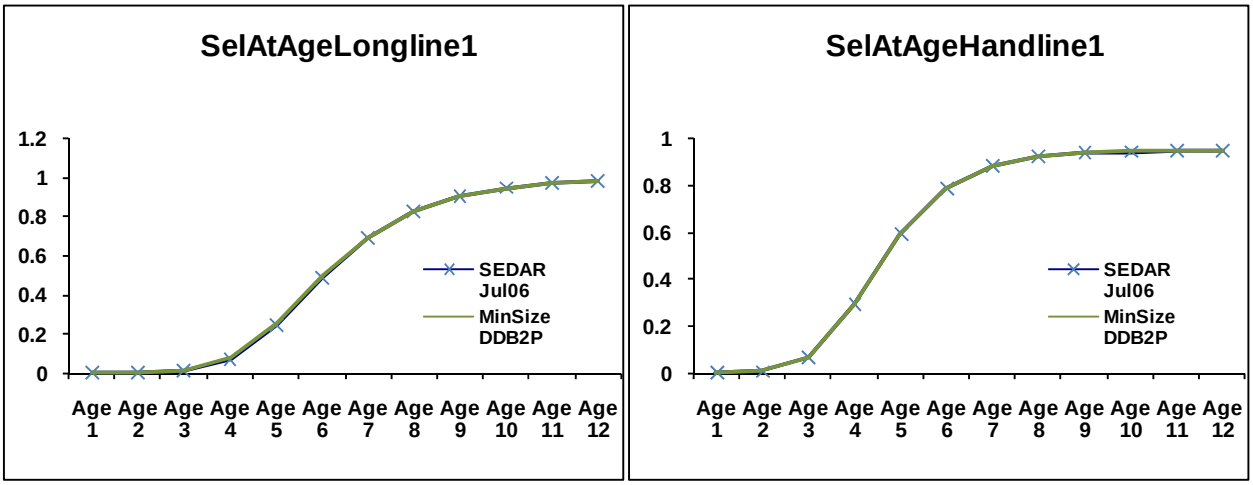


Figure 15. Comparison of model estimated selectivity for commercial fisheries between SEDAR10-Jul06 model and the recommended by the Grouper Review Panel May07 (MinSz DDB2P).

SEDAR

Southeast Data, Assessment, and Review

SEDAR Grouper Assessment Review

Section III

Supporting Documentation

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III.1 SEDAR 10 Gulf of Mexico Gag Grouper Advisory Report

III.2 SEDAR 10 South Atlantic Gag Grouper Advisory Report

III.3 SEDAR 12 Gulf of Mexico Red Grouper Advisory Report

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	F 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 $(1\text{-}M)*SSB_{MSY}$, 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

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
20.48	20.48	20.48	20.48	20.48	20.48	20.48
20.61	20.61	20.61	20.61	20.61	20.61	20.61
26.81	26.81	26.81	26.81	26.81	26.81	26.81
30.73	30.73	30.73	30.73	30.73	30.73	30.73
31.06	31.06	31.06	31.06	31.06	31.06	31.06
37.67	37.67	37.67	37.67	37.67	37.67	37.67
40.64	40.64	40.64	40.64	40.64	40.64	40.64
40.46	40.46	40.46	40.46	40.46	40.46	40.46
41.78	41.78	41.78	41.78	41.78	41.78	41.78
40.55	40.55	40.55	40.55	40.55	40.55	40.55
33.28	33.28	33.28	33.28	33.28	33.28	33.28
30.20	30.20	30.20	30.20	30.20	30.20	30.20
28.06	30.95	32.82	33.57	31.04	31.04	27.69
25.88	31.06	34.67	36.15	31.19	31.19	25.24
24.96	31.92	37.14	39.36	32.11	32.11	24.12
24.49	32.89	39.52	42.44	33.13	33.13	23.55

F annual mortality rate

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
0.46	0.46	0.46	0.46	0.46	0.46	0.46
0.31	0.31	0.31	0.31	0.31	0.31	0.31
0.32	0.32	0.32	0.32	0.32	0.32	0.32
0.40	0.40	0.40	0.40	0.40	0.40	0.40
0.30	0.30	0.30	0.30	0.30	0.30	0.30
0.31	0.31	0.31	0.31	0.31	0.31	0.31
0.33	0.33	0.33	0.33	0.33	0.33	0.33
0.36	0.36	0.36	0.36	0.36	0.36	0.36
0.40	0.40	0.40	0.40	0.40	0.40	0.40
0.49	0.49	0.49	0.49	0.49	0.49	0.49
0.38	0.38	0.38	0.38	0.38	0.38	0.38
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39
0.37	0.25	0.18	0.15	0.25	0.25	0.39

Total landed yield million pounds

SPR20%	SPR30%	SPR40%	F0.1	Fmax	Fmsy	Fcurrent
4.45	4.45	4.45	4.45	4.45	4.45	4.45
3.89	3.89	3.89	3.89	3.89	3.89	3.89
4.53	4.53	4.53	4.53	4.53	4.53	4.53
6.61	6.61	6.61	6.61	6.61	6.61	6.61
5.91	5.91	5.91	5.91	5.91	5.91	5.91
7.96	7.96	7.96	7.96	7.96	7.96	7.96
6.98	6.98	6.98	6.98	6.98	6.98	6.98
8.01	8.01	8.01	8.01	8.01	8.01	8.01
7.21	7.21	7.21	7.21	7.21	7.21	7.21
7.63	7.63	7.63	7.63	7.63	7.63	7.63
5.81	5.81	5.81	5.81	5.81	5.81	5.81
5.24	3.68	2.67	2.27	3.64	3.64	5.44
4.79	3.69	2.83	2.46	3.66	3.66	4.91
4.53	3.77	3.04	2.69	3.75	3.75	4.60
4.41	3.90	3.26	2.93	3.88	3.88	4.44
4.32	3.98	3.43	3.12	3.96	3.96	4.33

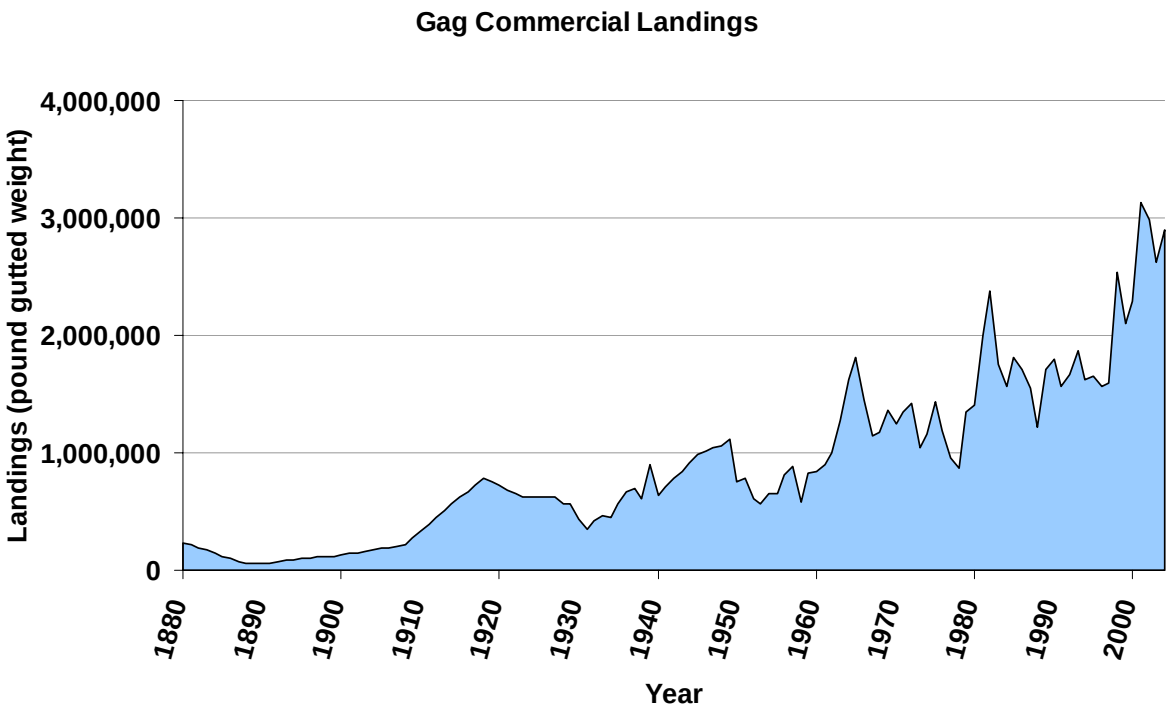


Figure 1. Estimated historical commercial landings of gag from U.S. Gulf of Mexico waters from 1880 to 2004 in pounds gutted weight.

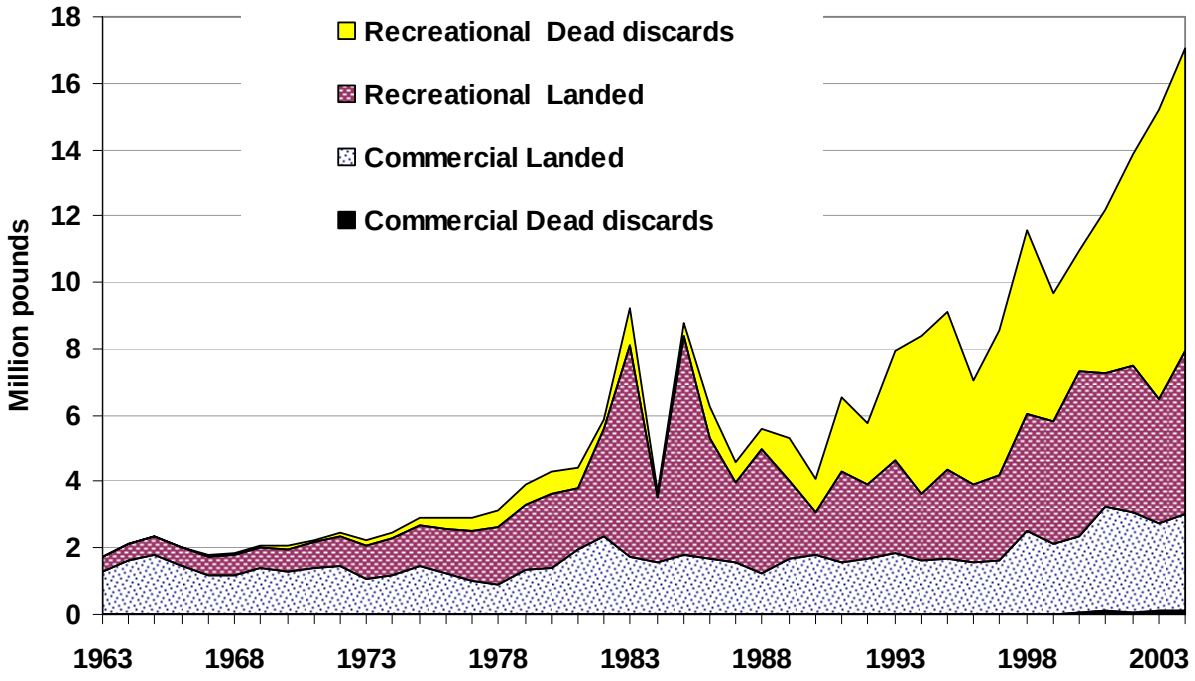


Figure 2. Gulf of Mexico gag landings and dead discards by the commercial and recreational fisheries in pounds gutted weight.

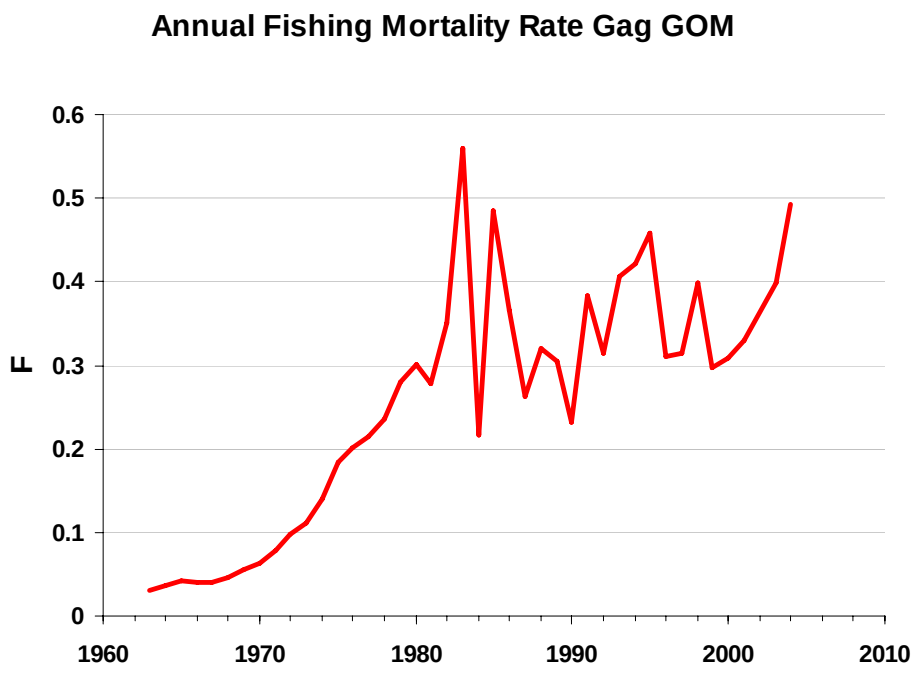


Figure 3. Estimated annual fishing mortality rate on Gulf of Mexico gag.

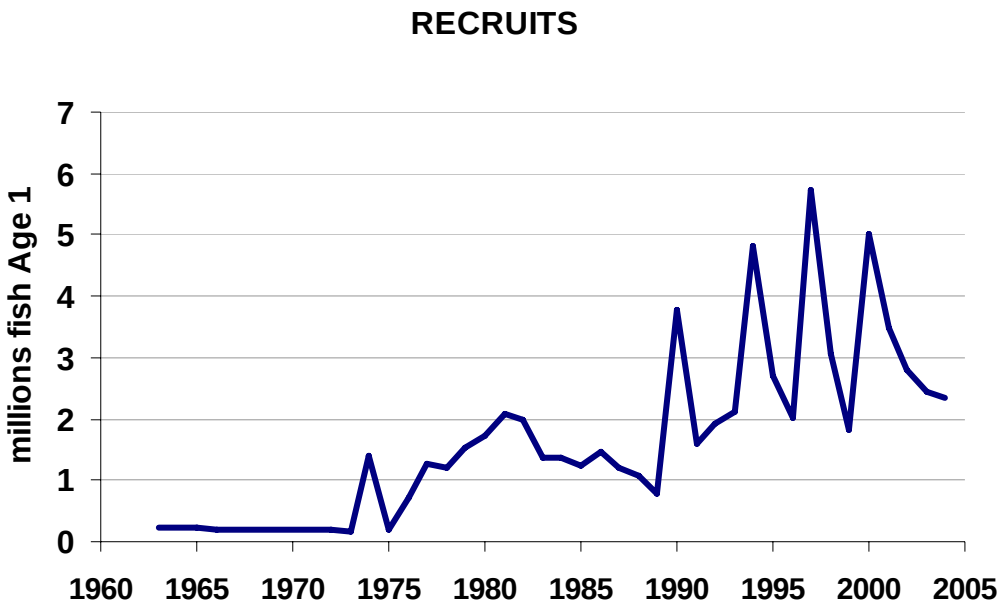


Figure 4. Estimated recruitment of Gulf of Mexico gag. Early recruitment estimates are considered unreliable and are thought to be due in large part to the absence of age composition and indices of abundance before 1981.

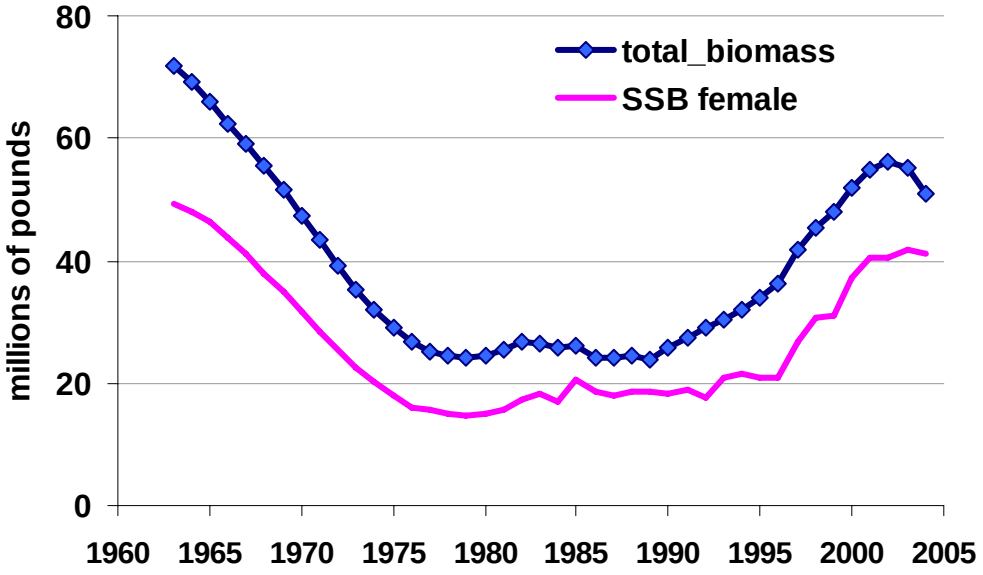


Figure 5. Estimated biomass of Gulf of Mexico showing spawning stock biomass (SSB, mature female) and total biomass in gutted weight.

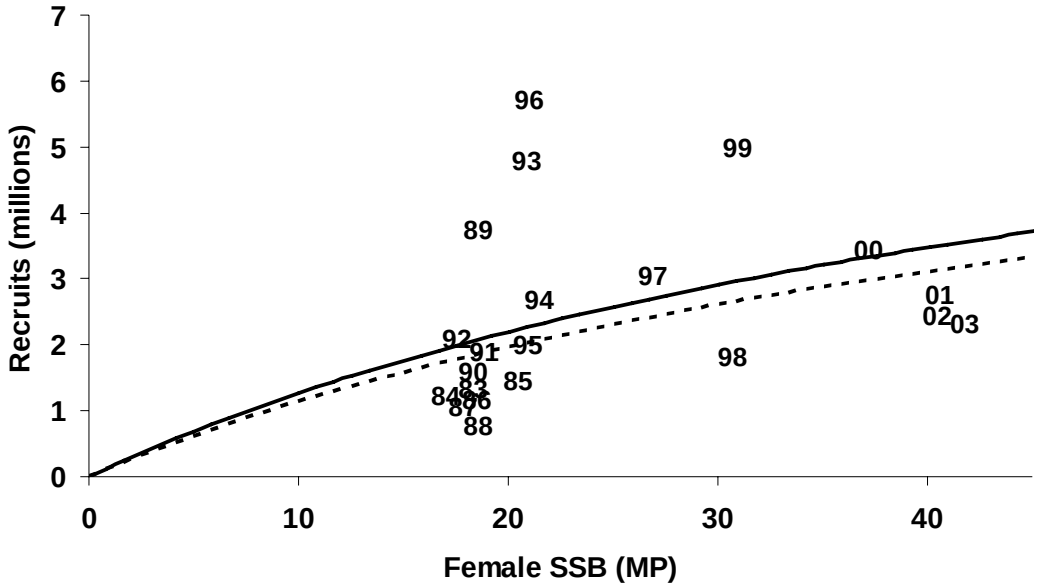


Figure 6. Estimated Beverton-Holt stock-recruitment relationship for Gulf of Mexico gag. Two digit year labels represent estimated recruitment for the 1983-2003 year classes and the associated female spawning stock biomass. The dashed curve is the estimated relationship, and the solid curve is the estimated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

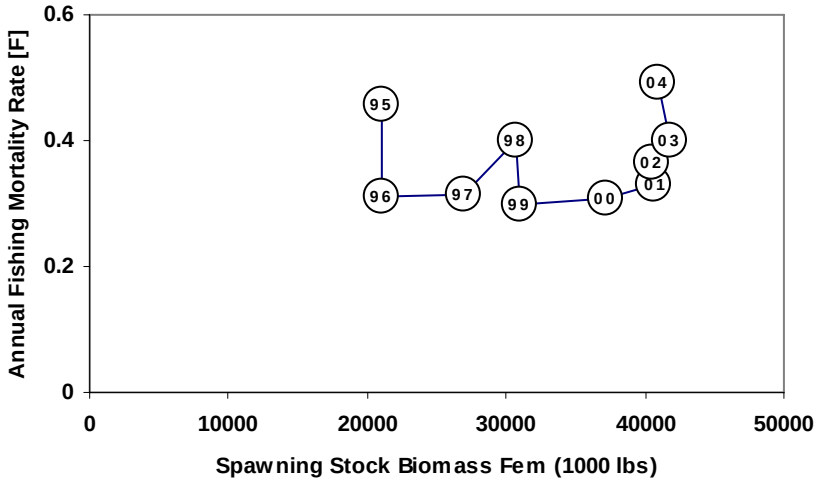


Figure 7. Phase plot of recent estimates of female spawning biomass (thousand pounds, gutted weight) and annual fishing mortality rate for gag GOM stock.

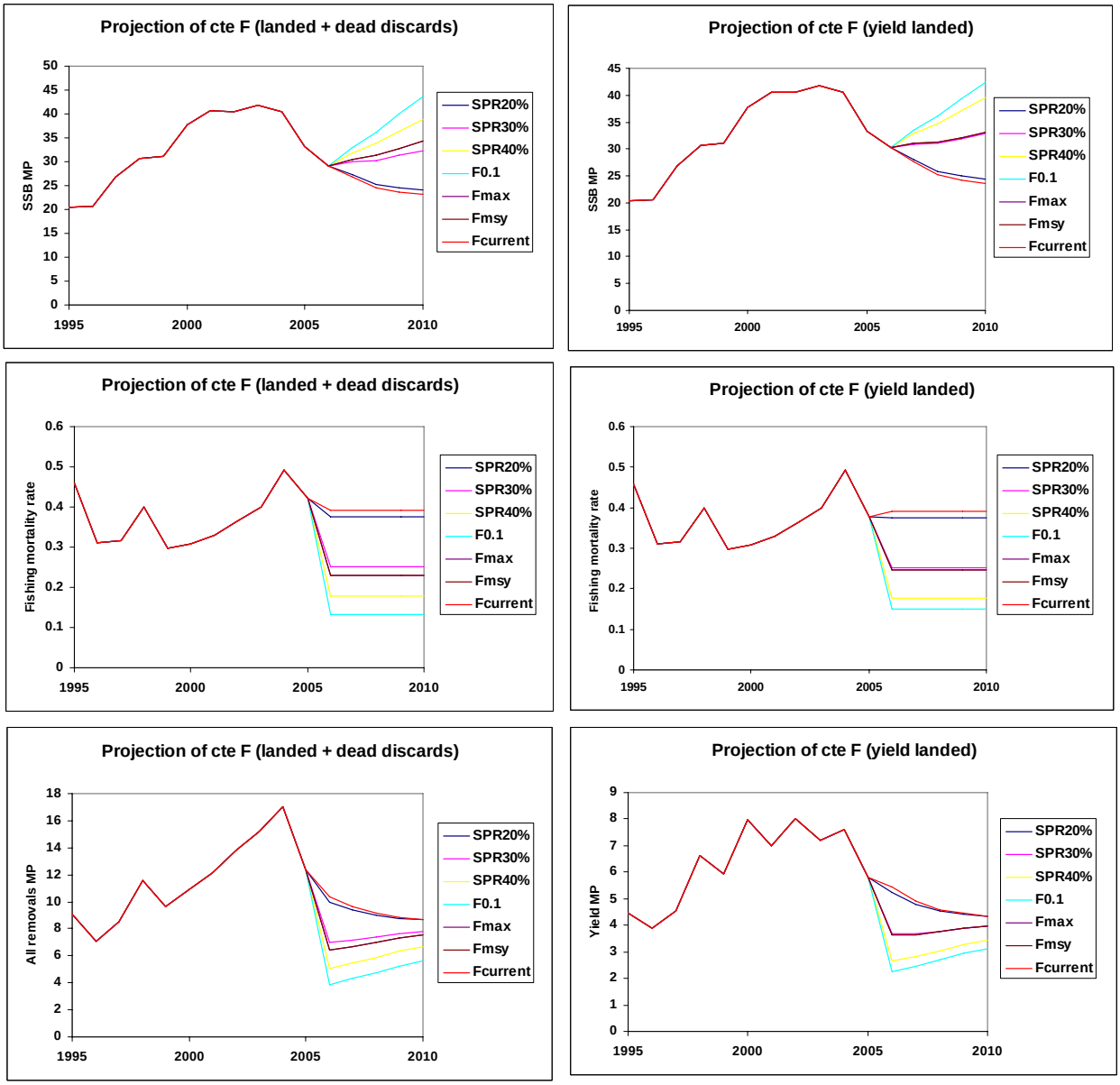


Figure 8. Projection trends from base model run assuming constant future recruitment. Projections of constant F mortality rate scenarios, projections on the left include total removals (landings & dead discards), those shown on the right are landed yield only

SEDAR 10 Review Workshop

Assessment Advisory Report

South Atlantic Gag Grouper

Reflecting recreational catch correction, February 2007

Stock Distribution and identification

- The management unit for South Atlantic gag grouper includes gag grouper found in all waters within South Atlantic 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.

Assessment Methods

- The South Atlantic gag grouper stock was assessed with two models: a statistical catch-at-age model, as the primary assessment model, and an age-aggregated production model to investigate results under a different set of model assumptions. Within each type of model various configurations and sensitivity runs were explored. Details of all models are available in the Stock Assessment Report and Addendum to the Stock Assessment Report.

- The assessment workshop (AW) developed two base runs: one assuming a time-varying catchability and one assuming constant catchability for the fishery dependent indices. Each base run of the catch-at-age model was the basis for estimation of benchmarks and stock status.

- The SEDAR 10 RW recommended the run with constant catchability as the preferred 'base run'.

Assessment Data

- Data sources include fishery-dependent abundance indices, recorded landings, and samples of annual length and age compositions from fishery-dependent sources.

- Three fishery–dependent abundance indices were developed by the SEDAR 10 data workshop: one from the NMFS headboat survey, one from the commercial logbook program, and one from the Marine Recreational Fishing Statistical Survey (MRFSS). Currently, there are no usable fishery–independent abundance data for this stock of gag grouper.

- Landings data were available from all recreational (headboat, charter boat, private boat, and shore sectors) and commercial fisheries (handline and diving gears). This benchmark assessment included data through 2004.

- Complete details are available in the SEDAR 10 Data and Assessment 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 South Atlantic Gag Grouper.

Catch Trends

- Landings are reported from the commercial and recreational sectors. The commercial landings are in gutted weight in pounds, while recreational landings are estimated in numbers. Commercial landings were converted to numbers for the assessment model (Table 1 and Figures 1-2).
- The commercial landings were dominated by handline gear peaking at over 1,000,000 pounds in 1984. Landings from the diving gear have been significant in recent years and are modeled separately. The contribution from other gears is small and included with the handline gear (Table 1 and Figure 1).
- The recreational sector catch peaked in 1984 at about 153,000 fish, and has two components: catch estimated from MRFSS which includes private and charter boats and a minor shore component, and catch estimated from a survey of headboats (larger for-hire vessels) (Table 1).
- When comparing across sectors, the largest landings in numbers are associated with the MRFSS (Table 1 and Figure 2).
- Coastwide landings of gag grouper in the South Atlantic had been increasing but have recently leveled off. The catch share among sectors has been changing over the last decade, with increased landings from the charter/private boat and shore mode recreational sectors relative to the commercial handline sector, which has been decreasing.

Fishing mortality trends

- Fishing mortality (fully selected F) increased from 0.03 in 1962 to 0.32 in 1983 (above F_{MSY} = 0.24; see discussion below). Fishing mortality has remained above F_{MSY} since then (Table 2 and Figure 3). Fishing mortality in 2004 was estimated as 0.31.

Stock abundance and biomass trends

- Total and spawning stock biomass (both sexes combined) declined from initial high values in the 1960s, went below levels corresponding to MSY in 1980s, continued in declined through the remainder of the 1980s and have apparently been on an increasing trend since the 1990s (Table 2 and Figure 4). In particular, spawning stock biomass declined from 14.6 million pounds (gutted weight) in 1962 to 4.0 million pounds in 1990 (below the current value of SSB_{MSY} = 7.9 million pounds). Spawning stock biomass rose to 7.0 million pounds in 2004 (above the MSST of 6.8 million pounds; Table 2). The 2005 SSB value is estimated to be 7.4 million pounds.

Status determination criteria and Stock Status

- 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	$(1\text{-}M)B_{MSY}$	NA	6816 klb
MFMT	F_{MSY} Proxy = $F_{30\%SPR}$	0.18	0.21
MSY	Yield at F_{MSY}	NA	1238 klb
F_{OY}	$F_{45\%SPR}$	NA	0.12
OY SSB_{MSY}	Yield at F_{OY} ($F_{45\%SPR}$) Biomass @ MSY	NA NA	1570 klb 7925 klb

Proposed Status Criteria	Definition	Value
MSST	$(1\text{-}M)SSB_{MSY}$ *(see special comment)	6816 klb
MFMT	F_{MSY}	0.24
MSY	Yield at F_{MSY}	1238 klb
OY	$65\%F_{MSY}$ (Alt. 1) $75\%F_{MSY}$ (Alt. 2) $85\%F_{MSY}$ (Alt. 3)	1188 klb 1217 klb 1230 klb
F_{OY}	$65\%F_{MSY}$ (Alt. 1) $75\%F_{MSY}$ (Alt. 2) $85\%F_{MSY}$ (Alt. 3)	0.16 0.18 0.20
M (Age-varying)	Constant Equivalent	0.14

Stock Status

- Current rates of exploitation indicate that overfishing is occurring for the South Atlantic gag grouper stock (Figure 5). Based on the current MFMT, which is an F_{MSY} proxy of $F_{30\%SPR}$, F_{2004}/MFMT = 1.5. Exploitation in 2004 relative to F_{MSY} = 1.3.
- Relative to the current MSST specified by the FMP {$(1\text{-}M)SSB_{MSY}$}, the South Atlantic stock of gag is approaching an overfishing condition (see projections, Figure 6). Relative to the MSST proposed by the RW, the stock is not overfished and is not projected to become overfished.
- The MSY-based benchmarks in this assessment are deemed useful for management.
- The current definition of MSST may be overly conservative. The RW recommends an operational definition of MSST of 5 million pounds (see Special Comments).

Projections

- Estimates of recruitment in 2002-2004 are below average and fishing mortality rates in 2002-2004 are above the MSY level. As a result, stock projections suggest that the stock will decline below the existing MSST in 2007. Projections for biomass, recruitment and fishing mortality at various levels of constant fishing mortality rates starting in 2008 are shown in Table 3 and Figures 6-10. The levels are based on current F (geometric mean of last three years of the base run, Figure 6), on F_{MSY} (Figure 7), and three levels of F_{OY} (65%, 75% and 85% of F_{MSY}, Figures 8-10).

Special Comments

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

- **Uncertainties**: The primary uncertainties in the assessment are from the model process errors and the data measurement errors. Because of the inherited high uncertainties from the assessment data and the estimated stock-recruitment relationship, the RW evaluated the uncertainties in this assessment with sensitivity runs to investigate the robustness of management benchmark parameter estimates to alternative choices about data usage.

- **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 RW 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, currently defined by the South Atlantic Council as $(1\text{-}M)B_{MSY}$, is very close to B_{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 the true biomass were close to B_{MSY}. In addition, MSST, as currently defined, may be overly conservative. There are no indications of impaired recruitment at the lowest observed SSB (around 5 million lbs[1]) and the RW suggests that MSST could be set at this level, operationally, to be re-examined at the next assessment.

[1]*Update Note: Based on the revised assessment including corrected recreational harvest values, the lowest observed SSB changed to 4.0 million pounds, rather than the 5 million pounds estimated originally.*

- **Sensitivity investigations**: The RW requested sensitivity model runs for the constant catchability model. The Panel wished to better understand the behavior of the model when certain data were left out of the model. The base model run contains three fishery-dependent CPUE indices and three sets of age and length composition datasets (one for the commercial handline, commercial diving, and recreational headboat fisheries). The stock analysts completed nine additional model runs removing each index, each fishery age composition dataset, and each fishery length composition dataset, one at a time. The results from this analysis suggest that the selected model provides a balanced fit to all data sources, illustrated by the base run falling within the middle of this set of sensitivity runs (Figures 12-14). When examining the spawning stock biomass time series, the run with the headboat CPUE data omitted shows the population increasing rapidly in the most recent years, reaching the highest terminal value of all the runs. In contrast, the run with the commercial handline CPUE omitted produces the lowest estimate of SSB value in the terminal year (Figure 12).

Sources of Information:

- The report from the Data Workshop along with the associated workshop documents.
- The report from the Assessment workshop along with associated documents.
- The SEDAR10 Review workshop discussions and presentations
- The SEDAR10 Review Workshop Consensus Summary Assessment of South Atlantic Gag Grouper

Report Revision History

Tables and figures included in this report were revised in February 2007 to reflect updated model results. The South Atlantic gag assessment model was revised to correct an error discovered in the recreational landings component of the model input.

Tables: Catch and Status

Table 1. Commercial landings by gear in weight (gutted), recreational landings in numbers, and discards in numbers for gag grouper from the U.S. South Atlantic, 1962-2004.

	Commercial (gutted klb)		Recreational (1000s)		Discards (1000s)		
Year	Handline	Diving	Headboat	MRFSS	Handline	Headboat	MRFSS
1962	150.3		8.41	6.17			
1963	137.0		7.66	5.62			
1964	128.4		7.18	5.27			
1965	130.4		7.41	5.44			
1966	99.1		5.58	4.09			
1967	210.9		11.77	8.62			
1968	309.9		17.72	12.98			
1969	217.2		12.13	8.89			
1970	299.0		16.66	12.20			
1971	306.7		17.18	12.59			
1972	204.5		13.44	8.37			
1973	290.5		17.99	12.15			
1974	372.8		13.92	15.68			
1975	421.8		8.57	17.48			
1976	565.0	3.75	7.56	23.77			
1977	627.6	8.81	8.48	21.94			
1978	967.4	13.87	6.01	37.54			
1979	907.5	18.92	9.55	35.70			
1980	846.2	16.40	6.96	35.39			
1981	984.0	13.88	13.86	56.69		0.03	0.00
1982	1027.4	15.85	11.84	17.85		0.02	4.32
1983	1101.1	9.08	16.46	74.82		0.04	91.88
1984	1108.2	18.75	18.69	153.25		0.03	11.95
1985	865.7	11.62	16.13	52.22		3.76	3.09
1986	819.8	6.34	17.35	46.78		4.05	12.48
1987	857.8	21.93	24.09	87.38		5.63	10.30
1988	672.4	12.96	24.21	62.07		5.65	15.01
1989	967.0	22.26	22.42	75.28		5.23	43.41
1990	784.3	19.07	17.59	52.20		4.11	11.46
1991	656.4	85.01	13.55	36.71		3.16	24.19
1992	691.7	106.76	13.94	49.32		7.74	38.66
1993	756.6	78.15	11.80	51.80		6.54	31.23
1994	800.0	97.50	9.81	56.22		5.45	68.29
1995	840.4	83.77	10.54	40.53		5.85	73.97
1996	751.9	118.56	7.50	43.92		4.16	43.00
1997	608.2	98.71	6.85	32.33		3.81	82.41
1998	654.5	138.79	8.67	40.32		4.82	32.22
1999	538.1	113.49	5.34	50.45	7.37	4.80	58.86
2000	438.2	63.02	5.98	29.87	7.77	5.38	126.63
2001	450.1	82.30	5.12	42.74	13.71	4.60	47.41
2002	448.3	84.52	4.58	24.03	11.91	4.12	85.73
2003	443.9	117.41	3.27	46.11	5.10	2.95	137.62
2004	476.4	74.97	6.66	46.25	7.20	6.00	89.54

Table 2. Estimated time series and status indicators. Exploitation rate (E) is of ages 2+, F is the fully selected fishing mortality rate, and SPR is static spawning potential ratio. SSB is in thousands of gutted pounds.

Year	E	E/Emsy	F	F/Fmsy	SSB	SSB/SSBmsy	SPR
1962	0.0217	0.335	0.0346	0.1460	14577	1.839	0.747
1963	0.0200	0.308	0.0324	0.1365	14375	1.814	0.761
1964	0.0197	0.304	0.0313	0.1321	14257	1.799	0.768
1965	0.0219	0.337	0.0331	0.1395	14094	1.778	0.755
1966	0.0181	0.279	0.0272	0.1149	13714	1.730	0.794
1967	0.0405	0.624	0.0552	0.2326	13242	1.671	0.629
1968	0.0651	1.002	0.0861	0.3632	12342	1.557	0.504
1969	0.0462	0.711	0.0646	0.2723	11101	1.401	0.586
1970	0.0615	0.947	0.0910	0.3838	10279	1.297	0.493
1971	0.0643	0.990	0.0992	0.4184	9498	1.198	0.471
1972	0.0485	0.747	0.0749	0.3158	8872	1.120	0.549
1973	0.0413	0.636	0.0733	0.3090	8503	1.073	0.559
1974	0.0519	0.799	0.0953	0.4017	8254	1.042	0.502
1975	0.0513	0.790	0.1267	0.5344	8085	1.020	0.447
1976	0.0647	0.997	0.1934	0.8157	8292	1.046	0.368
1977	0.0695	1.069	0.2155	0.9086	8635	1.090	0.358
1978	0.1188	1.829	0.3251	1.3708	8739	1.103	0.281
1979	0.1078	1.661	0.2956	1.2464	8075	1.019	0.279
1980	0.0953	1.467	0.2636	1.1114	7670	0.968	0.299
1981	0.1352	2.082	0.3539	1.4924	7818	0.986	0.221
1982	0.1063	1.637	0.3282	1.3840	7396	0.933	0.280
1983	0.1506	2.318	0.3867	1.6308	7243	0.914	0.171
1984	0.2855	4.396	0.6640	2.7999	6792	0.857	0.106
1985	0.1746	2.689	0.7424	3.1303	5269	0.665	0.187
1986	0.1756	2.704	0.3566	1.5039	4601	0.581	0.157
1987	0.2021	3.111	0.6809	2.8711	4354	0.549	0.132
1988	0.1498	2.306	0.9333	3.9356	4100	0.517	0.169
1989	0.1996	3.074	1.2012	5.0650	4287	0.541	0.121
1990	0.1684	2.593	0.8273	3.4884	4015	0.507	0.149
1991	0.1183	1.822	0.6567	2.7689	4133	0.522	0.179
1992	0.1285	1.978	0.4836	2.0393	4742	0.598	0.172
1993	0.1597	2.459	0.4518	1.9050	5549	0.700	0.174
1994	0.1979	3.047	0.4905	2.0685	5777	0.729	0.153
1995	0.1746	2.689	0.4634	1.9539	5091	0.642	0.163
1996	0.1518	2.337	0.4592	1.9363	4581	0.578	0.172
1997	0.1158	1.784	0.4038	1.7028	4562	0.576	0.197
1998	0.1450	2.232	0.4704	1.9833	4979	0.628	0.182
1999	0.1529	2.355	0.4947	2.0862	5076	0.641	0.176
2000	0.0946	1.457	0.3560	1.5011	4862	0.614	0.220
2001	0.1030	1.586	0.3554	1.4985	5153	0.650	0.221
2002	0.0749	1.153	0.2899	1.2224	5597	0.706	0.271
2003	0.0841	1.295	0.3471	1.4635	6368	0.804	0.232
2004	0.0992	1.527	0.3105	1.3091	7058	0.891	0.244
2005	.	.	.	.	7468	0.942	.

Table 3. Biomass, landings and discard projections under various fishing mortality (F) scenarios starting in 2008 (F fixed at the current value in 2005-2007). All results are in 1,000s of gutted pounds (klb). For reference, SSB_{MSY} = 9,374 klb, MSY = 1,774 klb, discards at MSY (D_{MSY}) = 88 klb

	Fcurrent	**Fmsy**	**85% Fmsy**	**75% Fmsy**	**65% Fmsy**
SSB (2005) (klb)	7468	7468	7468	7468	7468
SSB (2007) (klb)	6062	6062	6062	6062	6062
SSB (2010) (klb)	5660	6206	6478	6667	6863
SSB (2014) (klb)	6008	7227	7908	8413	8965
Landings (2005) (klb)	1462	1462	1462	1462	1462
Landings (2007) (klb)	1299	1299	1299	1299	1299
Landings (2010) (klb)	1079	925	836	768	693
Landings (2014) (klb)	1183	1125	1070	1020	956
Discards (2005) (klb)	108	108	108	108	108
Discards (2007) (klb)	99	99	99	99	99
Discards (2010) (klb)	135	105	91	81	71
Discards (2014) (klb)	134	105	91	82	72

Figure 1. Commercial gag grouper landings (gutted weight in pounds) by gear from the U.S. South Atlantic, 1962-2004.

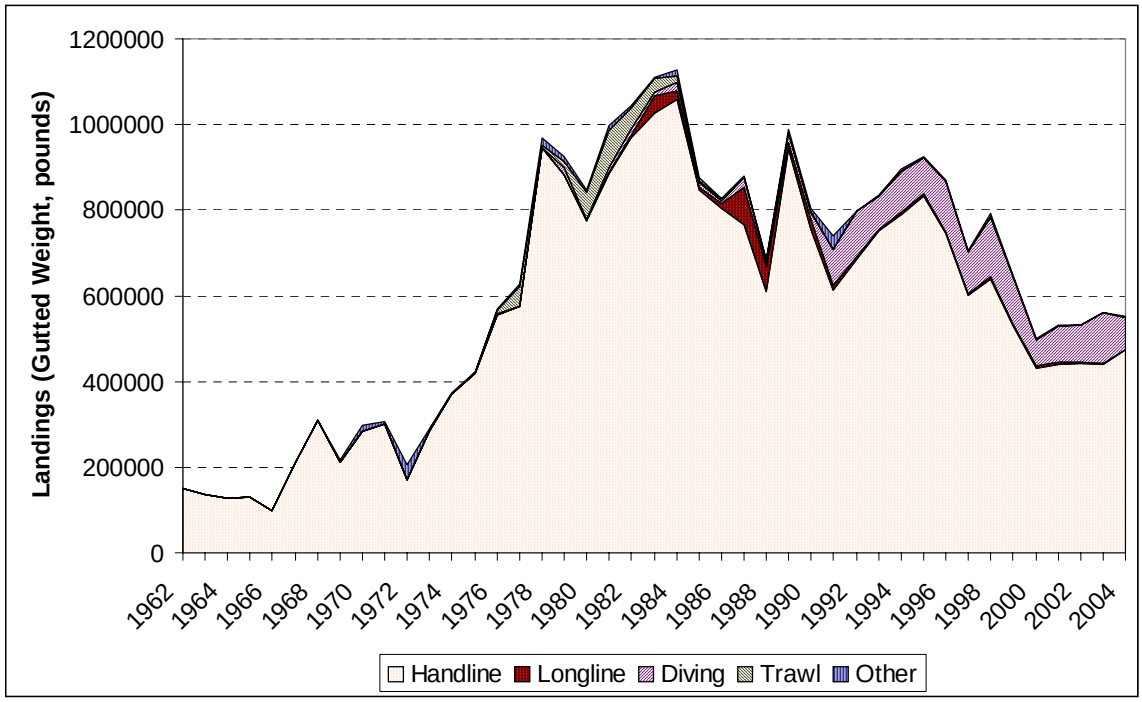


Figure 2. Total gag grouper catches (landings and discards) in numbers by sector from the U.S. South Atlantic, 1962-2004.

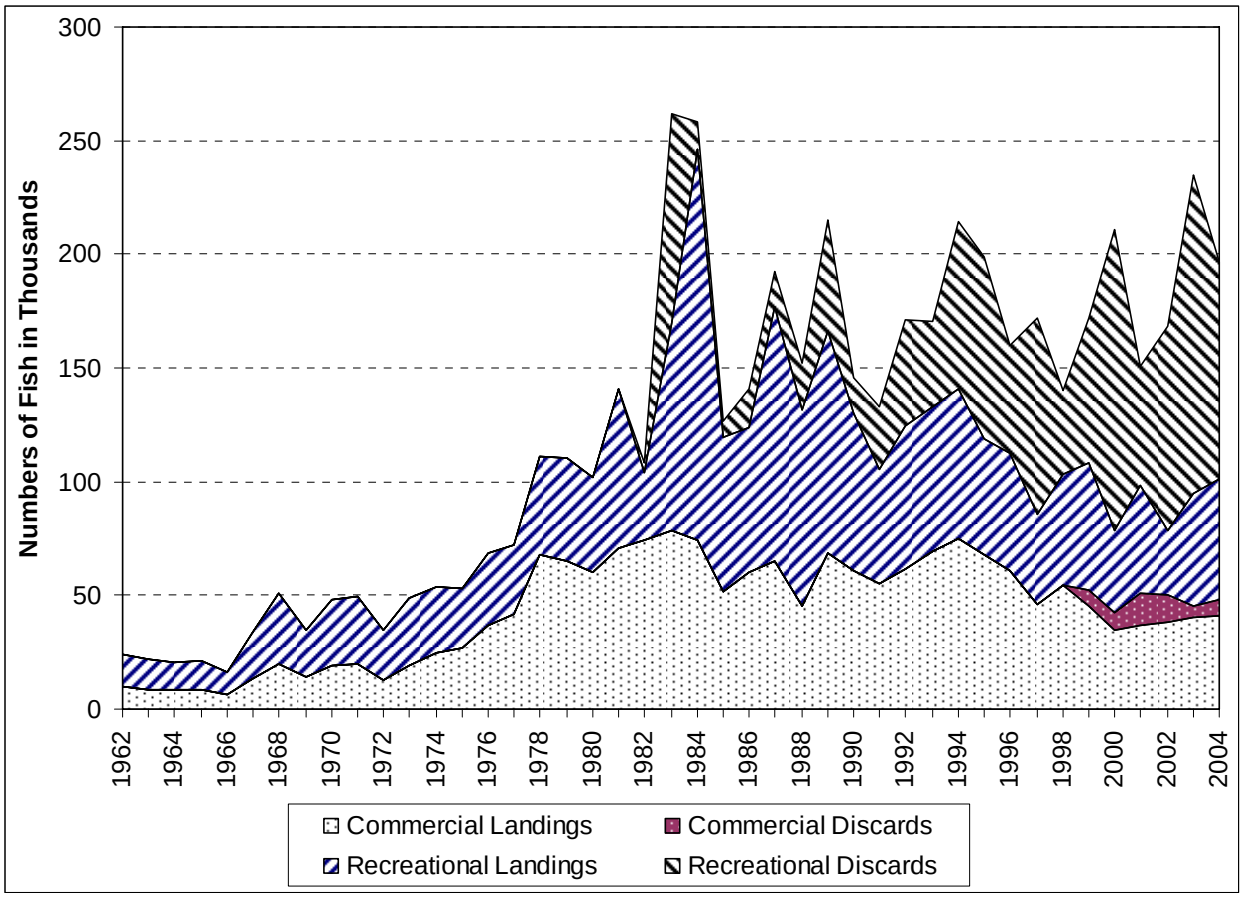


Figure 3. Estimated fully-selected fishing mortality rate. Solid horizontal line represents $F_{MSY.}$

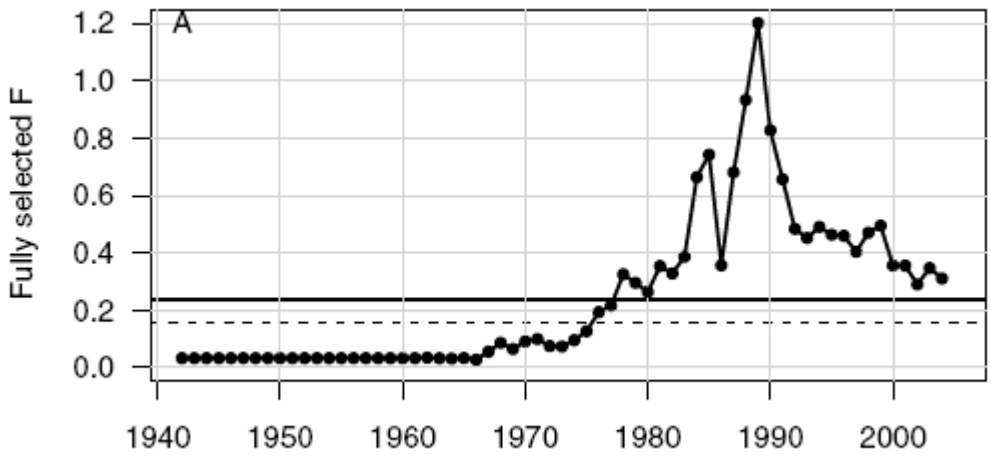


Figure 4. Estimated biomass time series (biomass in gutted weight). Total biomass (TOP) and spawning stock biomass (male mature biomass + female mature biomass, Bottom). The horizontal lines represents the level of biomass corresponding to MSY (B_{MSY} and SSB_{MSY}).

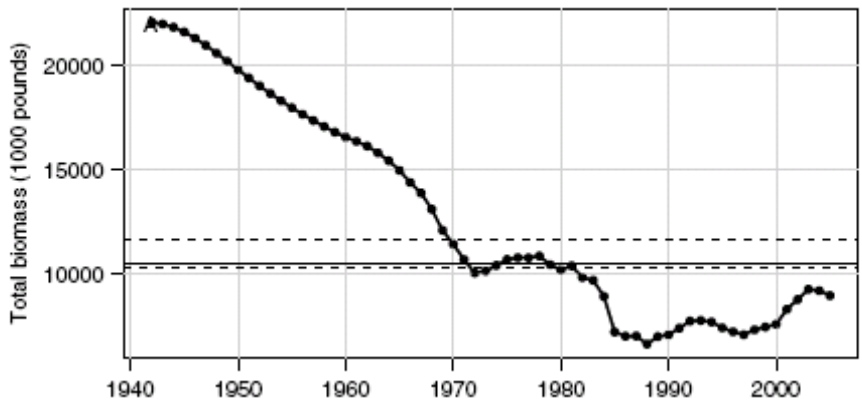


Figure 5. Phase plot of recent estimates of spawning stock biomass (klb, gutted weight) and fishing mortality rate. Solid lines correspond to MSY levels; vertical dashed line corresponds to MSST, defined as (1-M)SSB_{MSY}; and the vertical dotted line corresponds to the RW recommendation for an operational MSST.

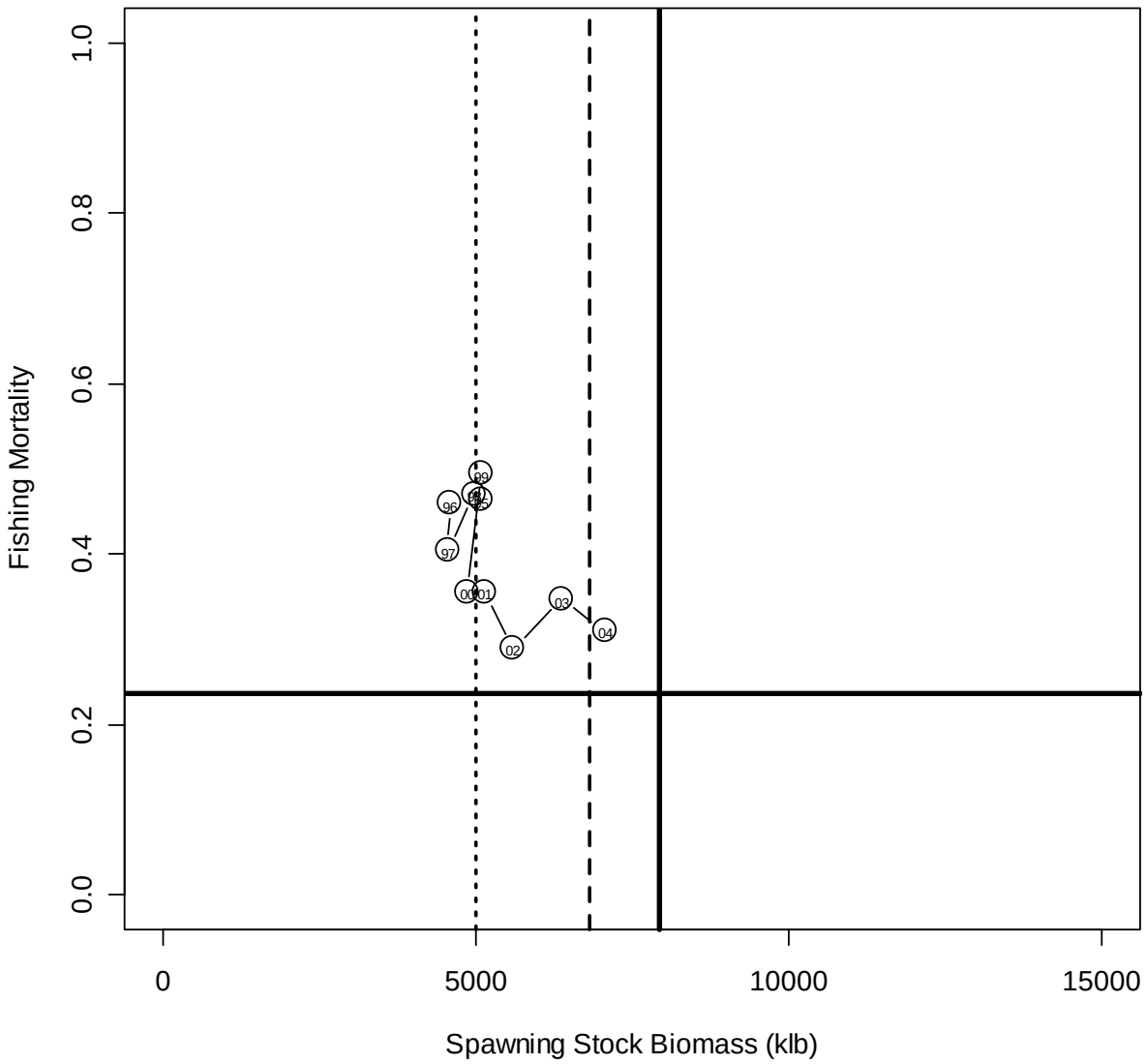


Figure 6. Projections under current fishing mortality rate for all years. Expected values represented by solid lines with circles, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 bootstrap replicates. A) SSB, horizontal solid line is SSB_{MSY} and dashed line is MSST (defined as $(1\text{-}M)SSB_{MSY}$); B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

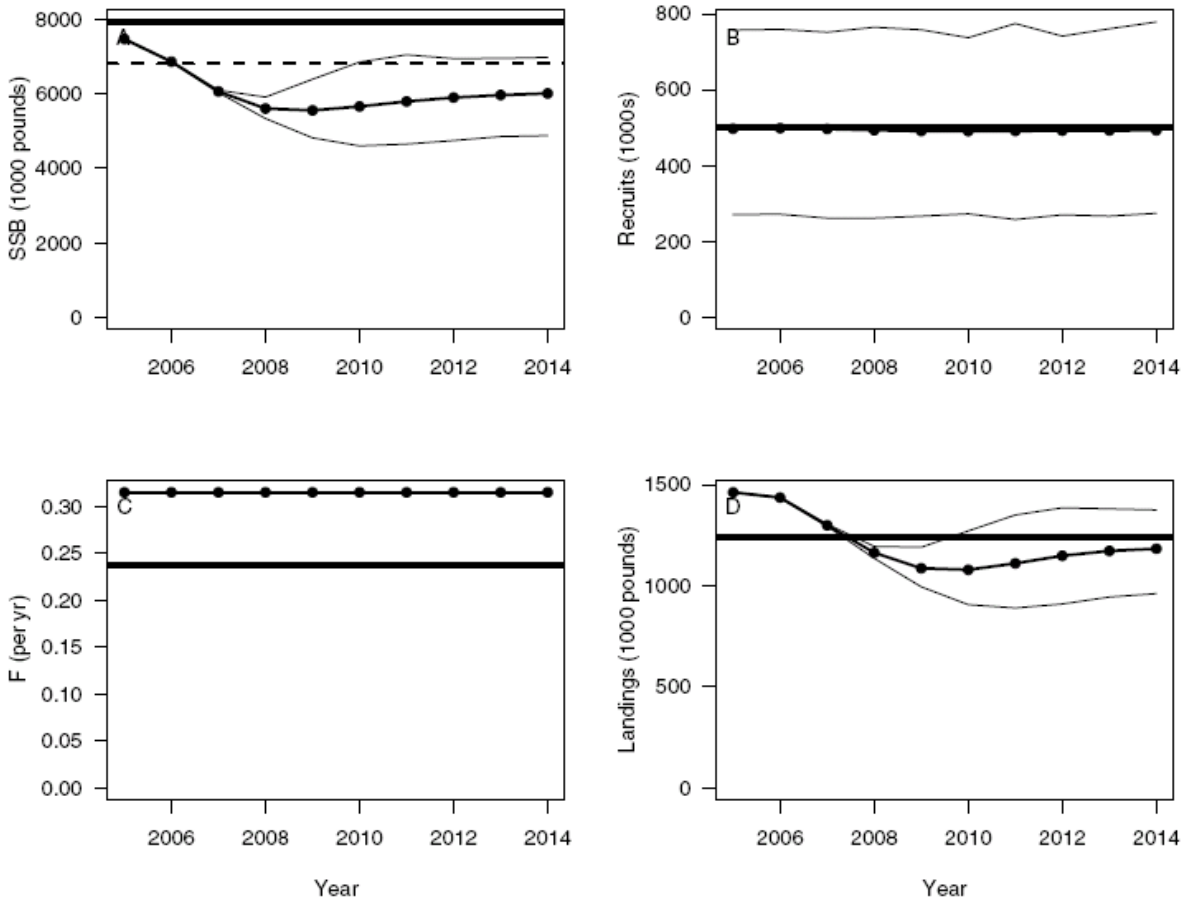


Figure 7. Projections under current fishing mortality rate in 2005-2007 and F_{MSY} in 2008-2014. Expected values represented by solid lines with circles, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 bootstrap replicates. A) SSB, horizontal solid line is SSB_{MSY} and dashed line is MSST (defined as (1-M)SSB_{MSY}); B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

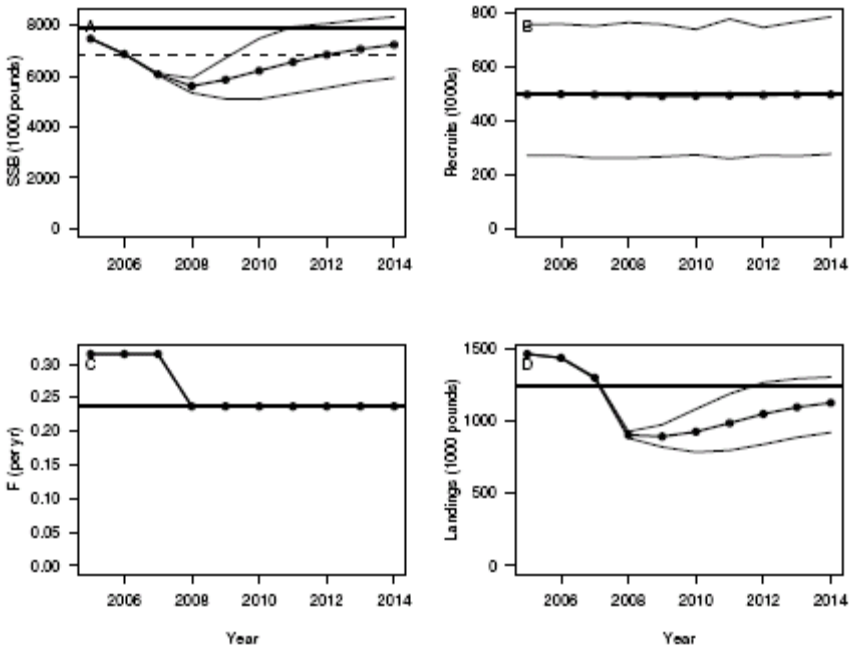


Figure 8. Projections under current fishing mortality rate in 2005-2007 and 85% of F_{MSY} in 2008-2014. Expected values represented by solid lines with circles, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 bootstrap replicates. A) SSB, horizontal solid line is SSB_{MSY} and dashed line is MSST (defined as (1-M)SSB_{MSY}); B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

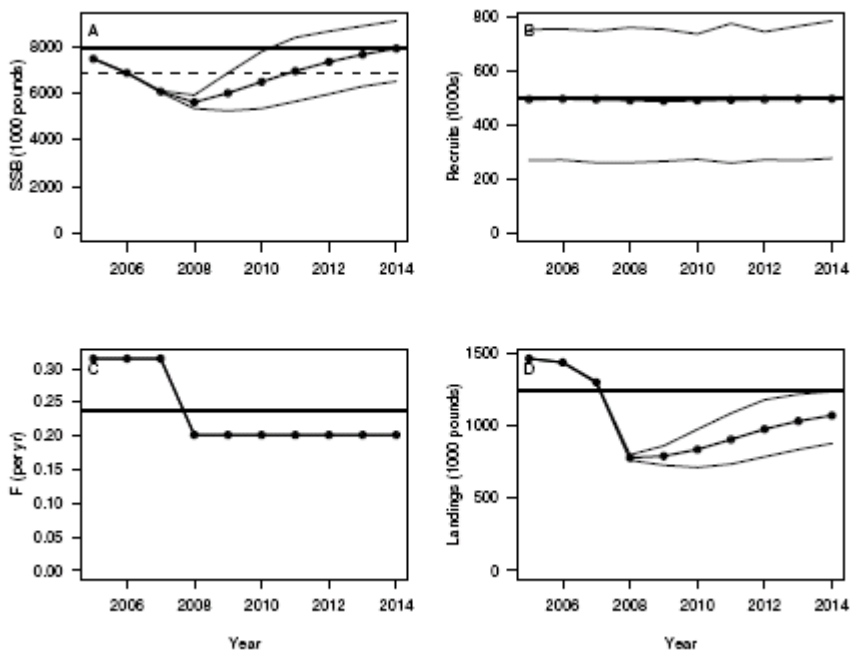


Figure 9. Projections under current fishing mortality rate in 2005-2007 and 75% of F_{MSY} in 2008-2014. Expected values represented by solid lines with circles, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 bootstrap replicates. A) SSB, horizontal solid line is SSB_{MSY} and dashed line is MSST (defined as $(1\text{-}M)SSB_{MSY}$); B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

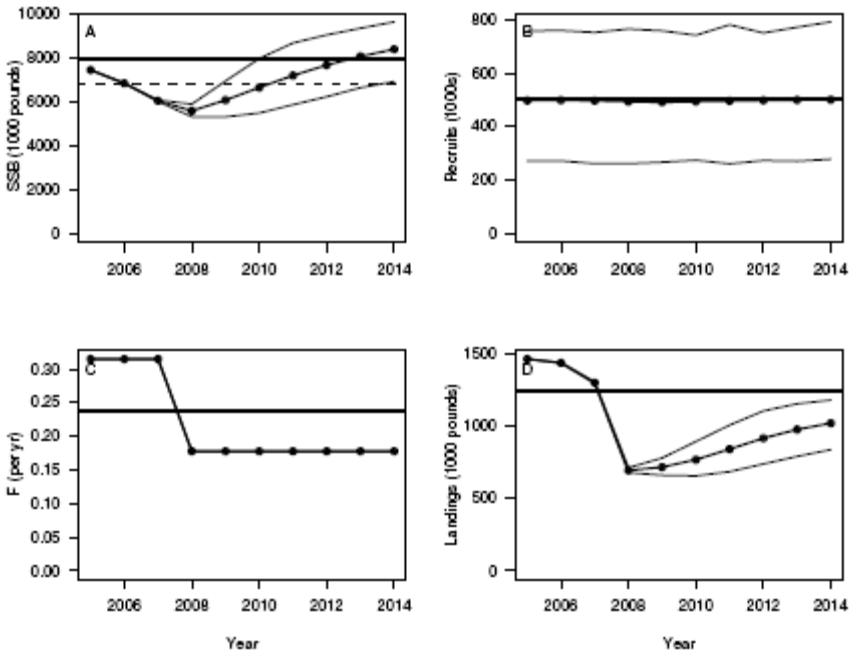


Figure 10. Projections under current fishing mortality rate in 2005-2007 and 65% of F_{MSY} in 2008-2014. Expected values represented by solid lines with circles, and uncertainty represented by thin lines corresponding to 10th and 90th percentiles of 1000 bootstrap replicates. A) SSB, horizontal solid line is SSB_{MSY} and dashed line is MSST (defined as $(1\text{-}M)SSB_{MSY}$); B) Recruits, horizontal line is R_{MSY}; C) Fishing mortality rate, horizontal line is F_{MSY}; and D) Landings, horizontal line is MSY.

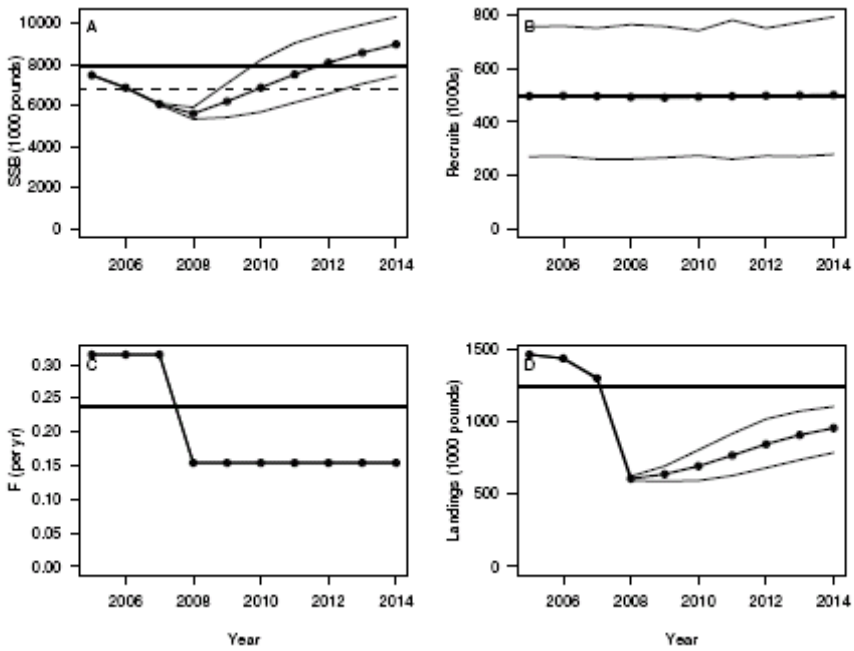


Figure 11. Estimated Beverton-Holt stock-recruitment relationship presented for South Atlantic gag grouper. Dashed curve is estimated relationship; Solid curve is estimated relationship with lognormal bias correction, from which benchmarks are derived.

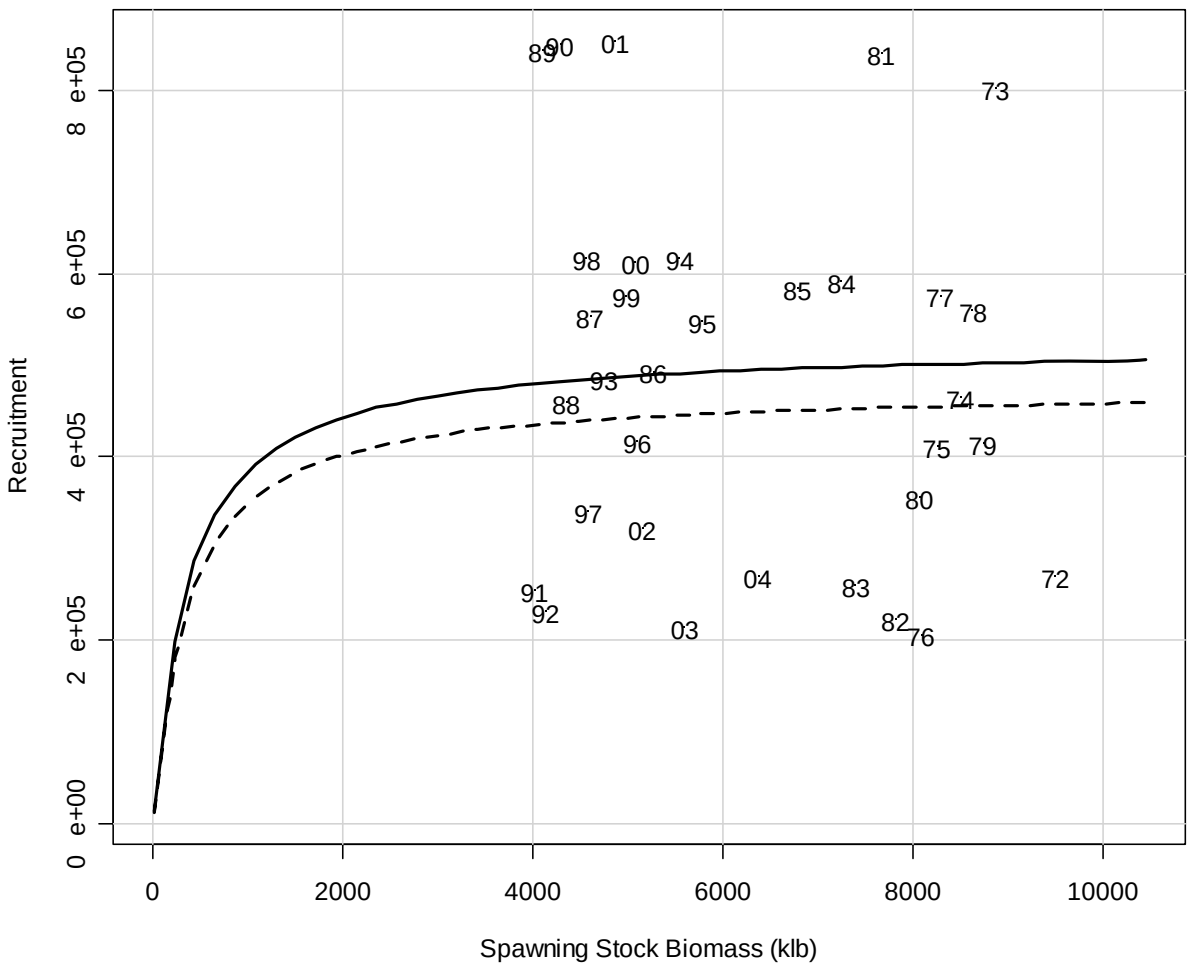


Figure 12. Estimated time series of spawning stock biomass (klb, gutted weight) from the base run model with constant catchability. The base run model with all data included is illustrated with a thick black line. Other runs with the labeled dataset left out of the model are shown in various colors and point markers.

Note: The time series of estimates for several of these sensitivities, notably logbook CPUE, handline age comp, and diving age comp changed considerably following the recreational data correction. The large spike in SSB predicted for these runs around 1970 did not appear in the original versions.

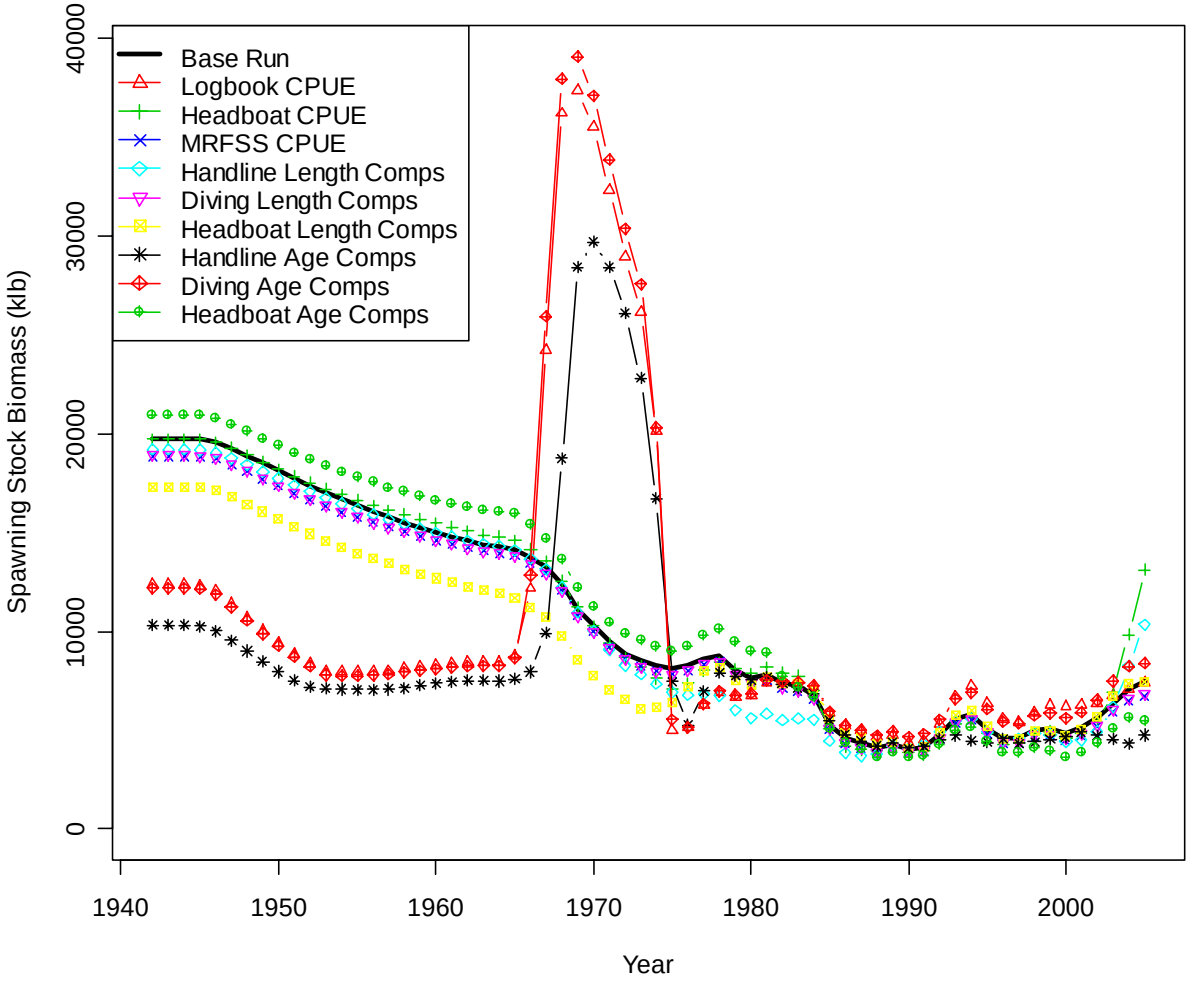


Figure 13. Estimated time series of fishing mortality rate from the base run model with constant catchability. The base run model with all data included is illustrated with a thick black line. Other runs with the labeled dataset left out of the model are shown in various colors and point markers.

Note: The time series of estimates for several of these sensitivities, notably logbook CPUE, handline age comp, and diving age comp changed considerably following the recreational data correction. In the original analyses these data series were less divergent from the others during the mid 1970's and mid 1990's.

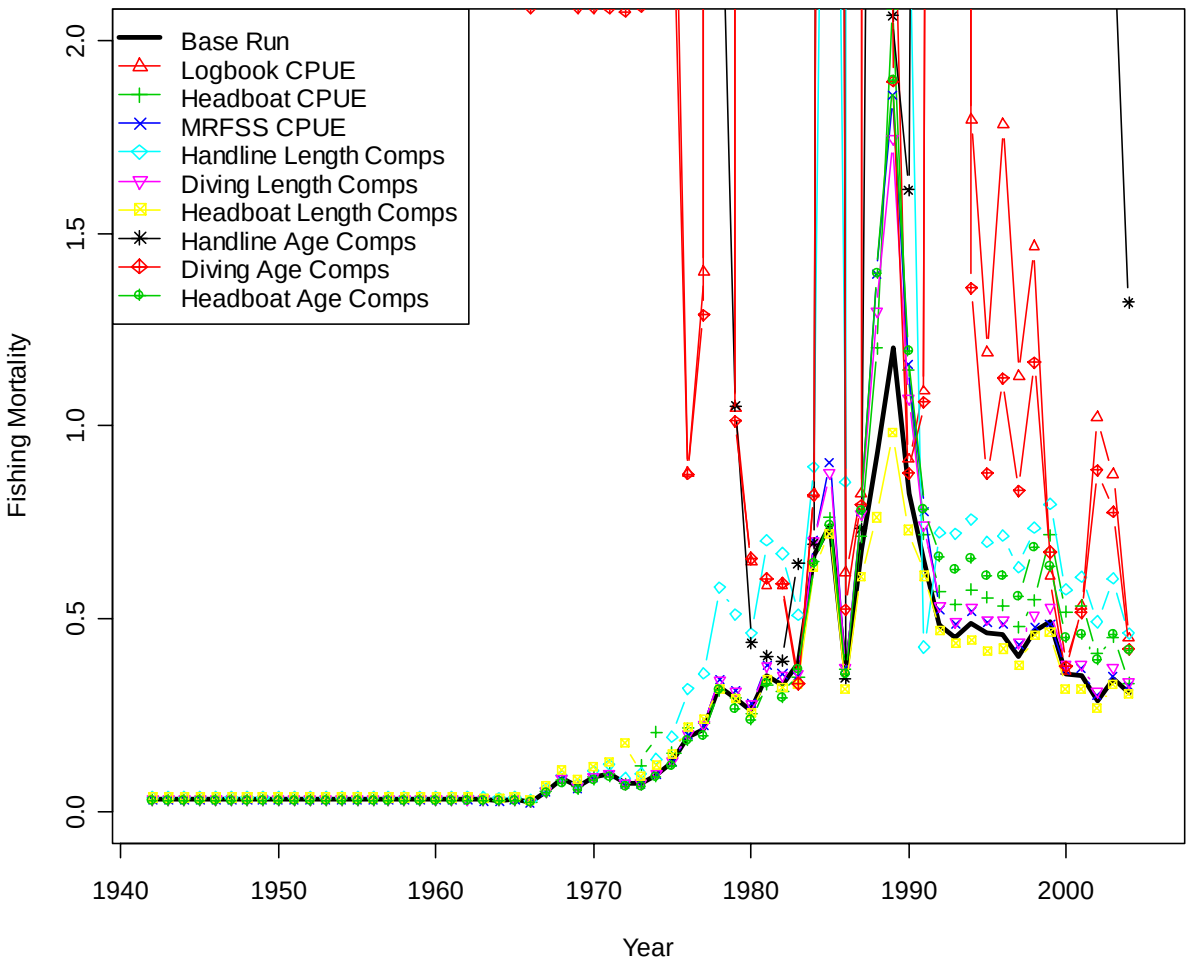
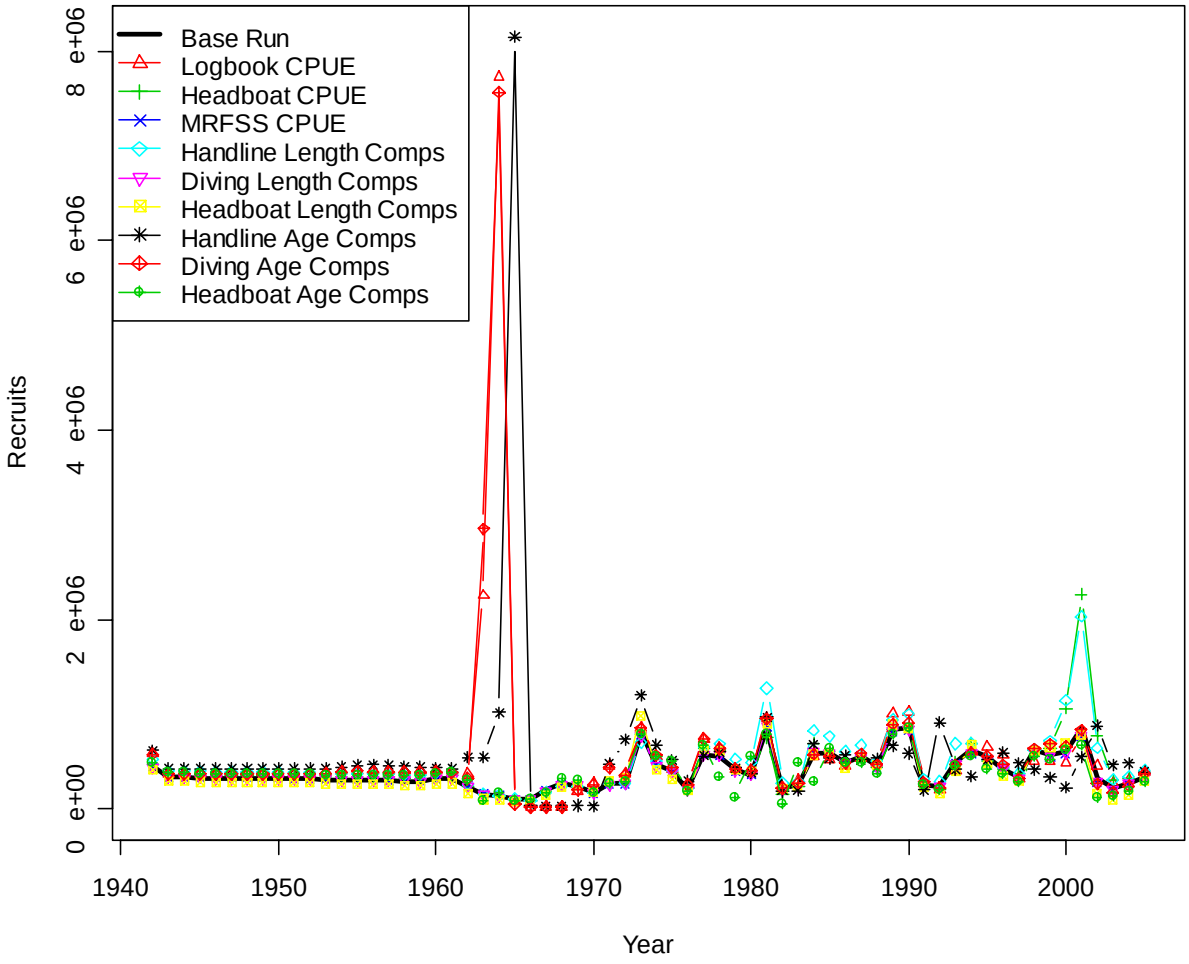


Figure 14. Estimated time series of recruitment from the base run model with constant catchability. The base run model with all data included is illustrated with a thick black line. Other runs with the labeled dataset left out of the model are shown in various colors and point markers.

Note: The time series of estimates for several of these sensitivities, notably logbook CPUE, handline age comp, and diving age comp changed considerably following the recreational data correction. The large recruitment spikes in the mid-1960's did not appear in the original analyses.



SEDAR 12 Advisory Report
Gulf of Mexico Red Grouper

Stock Distribution and Identification

This assessment applies to red grouper within the jurisdiction of the Gulf of Mexico Fishery Management Council. This includes all U. S. federal waters in the Gulf of Mexico between the State territorial waters and the 200 mile seaward boundary of the EEZ. Red grouper within these boundaries are assumed to represent a unit stock.

Assessment Methods

Three modeling approaches are considered in this assessment: a surplus production model (ASPIC), a forward projection age-structured model (ASAP), and a stochastic stock reduction analysis (SRA). A VPA was consulted to evaluate assumptions and configuration options regarding changes and catchability and selectivity for the age structured model.

The forward projection catch-age model using the ASAP software was chosen for evaluating stock status and providing management advice.

Assessment Data

The base assessment includes data from 1986 - 2005. The fishery is divided into four fleets and the population is modeled over ages 1 - 20 with the final age (20) treated as a plus group. Specific data sources included in the ASAP model and the years over which information is available are summarized as follows:

- Landings (fleets):
  - Commercial longline, 1986- 2005
  - Commercial handline 1986-2005
  - Commercial trap 1986-2005
  - Recreational, 1986 - 2005 (MRFSS and headboat combined)
- Discards
  - Discards are estimated for each fleet for 1990-2005. Discards estimated in numbers for both recreational and commercial fisheries are converted to weight (gutted pounds) using the estimated age composition and the growth model.
- Length & Age Composition
  - The assessment model accepts direct age composition information available from otolith sampling of the fisheries. Otolith sampling is sporadic across years and fisheries between 1986 and 1991. Sampling intensity increases considerably for 1991 and later. All available otolith samples are used for evaluating age composition.
  - Discard age composition is provided through an iterative probabilistic modeling approach.
- Indices
  - Commercial longline CPUE, 1990-2005
  - Commercial handline CPUE, 1990-2005
  - MRFSS recreational CPUE, 1986-2005
  - Headboat CPUE, 18” size limit, 1986-1990

Headboat CPUE, 20" size limit, 1991-2005
SEAMAP Video, 1993-2005 (incomplete)

Life History

Natural mortality is set at a base M=0.14. Specific values vary across ages based on a scaled Lorenzen curve.

Reproductive information (maturity, fecundity, and sex ratio) is updated from previous assessments to incorporate results from several recent studies.

Discard mortality rates are updated from previous assessments to incorporate results of recent research.

Catch Trends

Total landings are variable but exhibit an overall declining trend during the start of the assessment period, falling from over 9 million pounds in the initial year 1986 to the period low of below 5 million pounds in 1997. Total landings then increased sharply to just over 7 million pounds in 1999. Total landings observed between 1999 and the terminal year 2005 averaged 7.5 million pounds which compares favorably to the estimated Optimal Yield (OY) of 7.6 million pounds.

Commercial longline landings gradually increase during the 1986-2005 assessment period. Landings during the late 1980's through early 1990's are more variable than in later years, therefore both the high (4.3 mpds in 1993) and the low (2.0 mpds in 1990) observed values occur within a few years.

Commercial handline landings decline considerably over the assessment period, falling from 3.74 million pounds in 1990 to less than 1 million pounds in 1998. Handline landings increase by 2000 to the current level around 1.5 million pounds.

Commercial trap landings are considerably lower than either handline or longline, seldom exceeding 1 mpds over the assessment period.

Recreational landings including all components are slightly less than total commercial landings. With the exception of the 1995-1997 period when landings were considerably less than average at 0.5 mpds, recreational landings vary between 1 and 3 mpds.

Fishing Mortality Trends

Annual values of instantaneous fishing mortality (F) reported for each fishery, including those for both discard and directed components, are apical or peak values observed across all ages for the given fishery and year. This is analogous to 'fully recruited' fishing mortality.

Total apical fishing mortality for all fleets combined is estimated at F=0.18 in 1986 at the start of the analytical period. Mortality increases steadily in the early portion of the series, reaching a peak of F = 0.30 in 1993 before falling steadily to F=0.15 in 1998. Total mortality increases slightly to around F=0.2, although a downward trend since 2000 ends with a terminal estimate of F=0.15 for 2005.

Mortality attributed to the commercial longline fishery increases over the early portion of the assessment period, from a low of F=0.07 in 1986 to a high of F=0.17 in 1993. Longline mortality thereafter declines, falling to F=0.1 in the terminal year (2005). Fishing mortality contributed by the commercial handline fishery exhibits a pattern similar to that of the commercial longline, reaching a peak F=0.1 in 1990 before

declining steadily to the terminal estimate of F=0.04. Commercial trap mortality is variable, but generally below F=0.07.

Recreational mortality estimates also peak during the middle of the assessment period, initially rising from F=0.01 in 1986 to the observed peak in 1992 of F=0.15 before falling to the minimum observed F=0.04 in 1997. Mortality increases slightly thereafter, reaching F=0.11 in 2004 and averaging 0.08 during 1998-2005.

Stock Abundance and Biomass Trends

Total stock abundance averages 27.6 million fish and varies with little trend between 1986 and 1999. However, abundance jumps sharply in 2000 to 40.5 million fish as the strong 1999 year class enters the estimated population at age 1. Total abundance tapers off gradually thereafter to the terminal estimate of 31.7 million fish for 2005.

Spawning stock is measured as total female gonad weight. Estimated spawning stock gradually improves over the assessment period, from just below 500 MT of eggs in late 1980's to over 700 MT in the last few years which include the observed high of 752 MT of eggs in 2005.

Estimated recruitment at age 1 exhibits two notably strong year classes (1996 and 1999) but little overall trend otherwise. Recruitment over the assessment period averages 9.6 million fish, with peak values of 13 million in 1997 and 22 million in 2000.

Status Determination Criteria

Criteria	Recommended Values[1]	
	Definition	Value
MSST (egg weight)	$(1\text{-}M)SS_{MSY}$	509 MT
MFMT (apical F)	F_{MSY}	0.21
MSY (gutted weight)	Yield at F_{MSY}	7.72 mp
F_{MSY}	F_{MSY}	0.21
OY (gutted weight)	Yield at $0.75*F_{MSY}$	7.6 mp
F_{OY}	$0.75*F_{MSY}$	0.16
M (base)	--	0.14

1. Note that reference points and yield reflect only directed fisheries landings. There is an additional allowance for estimated discards.

Stock Status

The Gulf of Mexico stock of red grouper was not overfished and was not experiencing overfishing in 2005.

The stock is considered recovered based on estimated spawning stock in excess of the MSY level as of January 1, 2005. Current model estimates indicate the stock ceased being overfished in 1992 and reached recovered status 7 years later in 1999. Increases in the spawning stock observed over the last 5 years are largely due to recent strong year classes and therefore represent a trend which may not continue into the future.

Current model estimates indicate the stock has not experienced overfishing since 1994. Exploitation dropped to target levels (F_{OY}) in 1997 and 1998, then climbed above F_{OY} during most years thereafter. Exploitation in 2005 is 97% of F_{OY}.

Stock status determinations relative to current estimates for benchmark values are summarized in the *Status Summary Table* below.

Status Summary Table

Criteria	Value
SS_{MSY} (MT eggs)	591
SS_{2005} (MT eggs)	752
SS_{2005}/SS_{MSY}	1.27
SS_{2005}/MSST	1.48
F_{MSY} (MFMT)	0.21
F_{OY}	0.16
F_{2005}	0.16
F_{2005}/MFMT	0.73
F_{2005}/F_{OY}	0.97

Projections

Short term projections (2006 - 2015) were prepared to evaluate a range of future fishing mortality (F_{MSY}, F_{OY}, $F_{current}$) and harvest strategies (OY, current harvest limit). Projections were prepared assuming management changes could take place in 2008, selectivity remains constant for all fisheries, and discard rates remain constant for all fisheries. Future recruitment is estimated from the average estimated over the assessment period.

Projection results indicate spawning stock will remain above SS_{MSY} and stabilize around its current level through at least 2015 if fishing mortality and total removals are held at current conditions which are consistent with management at the stated optimal yield. Spawning stock will decline to SS_{MSY} levels by 2015 if mortality increases to F_{MSY}. Fishing mortality will stabilize near the current level which is just below F_{OY} if landings are maintained at either current or OY levels.

ABC

Because overfishing is not occurring and estimated spawning stock exceeds the MSY spawning stock level, ABC levels are recommended base on exploitation at F_{OY}. Recommendations for 2008-2015 are summarized in the table below, including 80% confidence intervals addressing future recruitment variability:

Annual deterministic ABC for landings only, including 80% confidence intervals. Values are millions of gutted pounds.

YEAR	ABC (landings)	Lower	Upper
2008	7.97	7.97	7.97
2009	7.94	7.88	8.03
2010	7.89	7.68	8.26
2011	7.84	7.43	8.52
2012	7.79	7.22	8.84
2013	7.75	7.09	9.07
2014	7.72	7.03	9.21
2015	7.69	7.02	9.35

Table 1. Landings and discards[1] by sector in gutted pounds, 1986 – 2005.

	Landings			Dead Discards[1]					
YEAR	Commercial	Recreational	Total Landings	Commercial	Recreational	Total Dead Discard	Total Commercial	Total Recreational	Total Removal
1986	6,312,986	2,400,380	8,791,536	0	20,657	20,657	6,312,986	2,421,037	8,812,193
1987	6,717,890	1,464,710	8,228,790	0	19,021	19,021	6,717,890	1,483,731	8,247,811
1988	4,742,496	2,476,070	7,301,856	0	34,758	34,758	4,742,496	2,510,828	7,336,614
1989	7,367,911	2,761,150	10,216,221	0	81,650	81,650	7,367,911	2,842,800	10,297,871
1990	4,809,282	1,131,710	5,979,852	733,671	228,556	962,227	5,542,953	1,360,266	6,942,079
1991	5,094,501	1,775,110	6,929,161	1,155,185	407,354	1,562,539	6,249,686	2,182,464	8,491,700
1992	4,463,277	2,658,180	7,213,947	721,264	356,598	1,077,862	5,184,541	3,014,778	8,291,809
1993	6,379,626	2,091,160	8,542,076	732,983	234,183	967,166	7,112,609	2,325,343	9,509,242
1994	4,902,862	1,808,240	6,773,962	446,280	224,934	671,214	5,349,142	2,033,174	7,445,176
1995	4,746,140	1,862,570	6,673,620	601,308	225,097	826,405	5,347,448	2,087,667	7,500,025
1996	4,454,146	893,755	5,379,232	566,243	159,758	726,001	5,020,389	1,053,513	6,105,233
1997	4,848,486	562,328	5,430,648	623,516	149,181	772,697	5,472,002	711,509	6,203,345
1998	3,948,566	643,058	4,614,135	543,057	208,428	751,485	4,491,623	851,486	5,365,620
1999	5,974,706	1,152,810	7,166,716	734,532	283,487	1,018,019	6,709,238	1,436,297	8,184,735
2000	5,838,300	2,107,730	8,017,470	621,851	300,042	921,893	6,460,151	2,407,772	8,939,363
2001	5,964,506	1,327,770	7,338,286	756,182	223,726	979,908	6,720,688	1,551,496	8,318,194
2002	5,907,248	1,611,110	7,574,308	726,561	260,670	987,231	6,633,809	1,871,780	8,561,539
2003	4,937,970	1,275,830	6,258,080	623,068	283,721	906,789	5,561,038	1,559,551	7,164,869
2004	5,749,039	3,000,140	8,851,689	812,431	421,755	1,234,186	6,561,470	3,421,895	10,085,875
2005	5,410,594	1,630,140	7,095,044	894,328	243,491	1,137,819	6,304,922	1,873,631	8,232,863

1. Information on the size of discards from the various fisheries is not available; the amounts presented here are based on assumptions about the age composition (as used in the assessment) and their weight at age.

Table 2. Estimated total annual fishing mortality attributed to both landings and discard components with stock status evaluations relative to MFMT and F_{OY}.

APICAL F[1]		Relative Fishing Mortality[2] (Landings)	
LANDINGS	DISCARD	F/Fmsy	F/Foy
0.18	0.01	0.84	1.13
0.19	0.01	0.87	1.16
0.16	0.01	0.76	1.02
0.23	0.01	1.06	1.41
0.20	0.03	0.95	1.27
0.23	0.03	1.09	1.46
0.23	0.03	1.08	1.44
0.27	0.03	1.25	1.67
0.22	0.03	1.02	1.36
0.20	0.02	0.96	1.28
0.16	0.02	0.77	1.03
0.16	0.02	0.74	0.98
0.13	0.02	0.62	0.83
0.18	0.02	0.85	1.13
0.19	0.02	0.90	1.19
0.18	0.02	0.86	1.14
0.18	0.02	0.85	1.14
0.16	0.02	0.73	0.97
0.18	0.02	0.84	1.13
0.16	0.02	0.73	0.97

1. Landings and discard Fs are additive. Apical F reflects the maximum annual value across ages for all fleets combined.
2. Relative fishing mortality used to evaluated stock status is determined based on the landings component.

Table 3. Stock abundance, age-1 recruitment, spawning stock, and spawning stock status.

	Spawning Stock			Abundance (Millions of fish)	
YEAR	SS (Metric Tons[1])	Status SS/SS_{msy}	Status SS/MSST	Total Stock	Recruitment (Age 1)
1986	506	0.99	0.85	23.11	6.07
1987	485	0.95	0.82	27.73	12.45
1988	473	0.93	0.80	29.91	11.77
1989	476	0.94	0.81	27.98	8.35
1990	475	0.93	0.80	29.60	11.52
1991	500	0.98	0.84	30.22	10.17
1992	531	1.04	0.90	29.13	8.71
1993	549	1.08	0.93	26.32	6.53
1994	550	1.08	0.93	24.99	7.02
1995	567	1.11	0.96	26.14	8.87
1996	561	1.10	0.95	24.91	6.97
1997	568	1.12	0.96	31.23	13.81
1998	582	1.15	0.98	28.71	7.40
1999	618	1.21	1.04	25.83	5.60
2000	639	1.26	1.08	40.57	22.34
2001	626	1.23	1.06	34.78	7.98
2002	660	1.30	1.12	31.85	7.72
2003	700	1.38	1.18	32.02	9.65
2004	734	1.44	1.24	32.49	10.03
2005	752	1.48	1.27	31.70	9.33

1. Spawning stock is measured in mature female gonad weight.

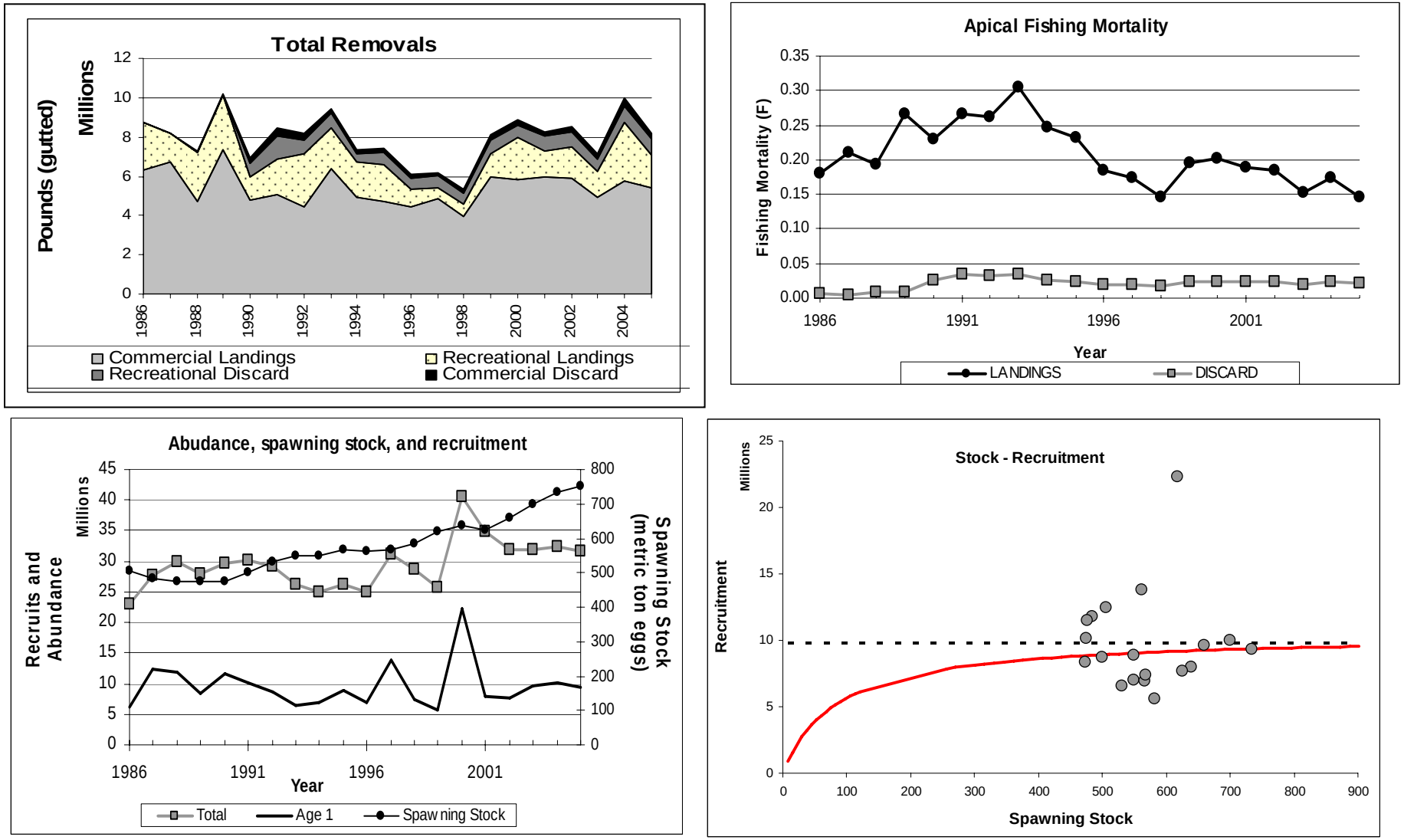


Figure 1. Stock estimates. Total removals in gutted pounds by fishery (upper left); total apical mortality attributed to discard and directed removals (upper right); time series of important population parameter estimates including recruits at age 1, total abundance in numbers, and spawning stock egg weight (lower left); stock recruitment plot showing annual estimates (points) predicted relationship (solid line) and series average (dashed line) (lower right).

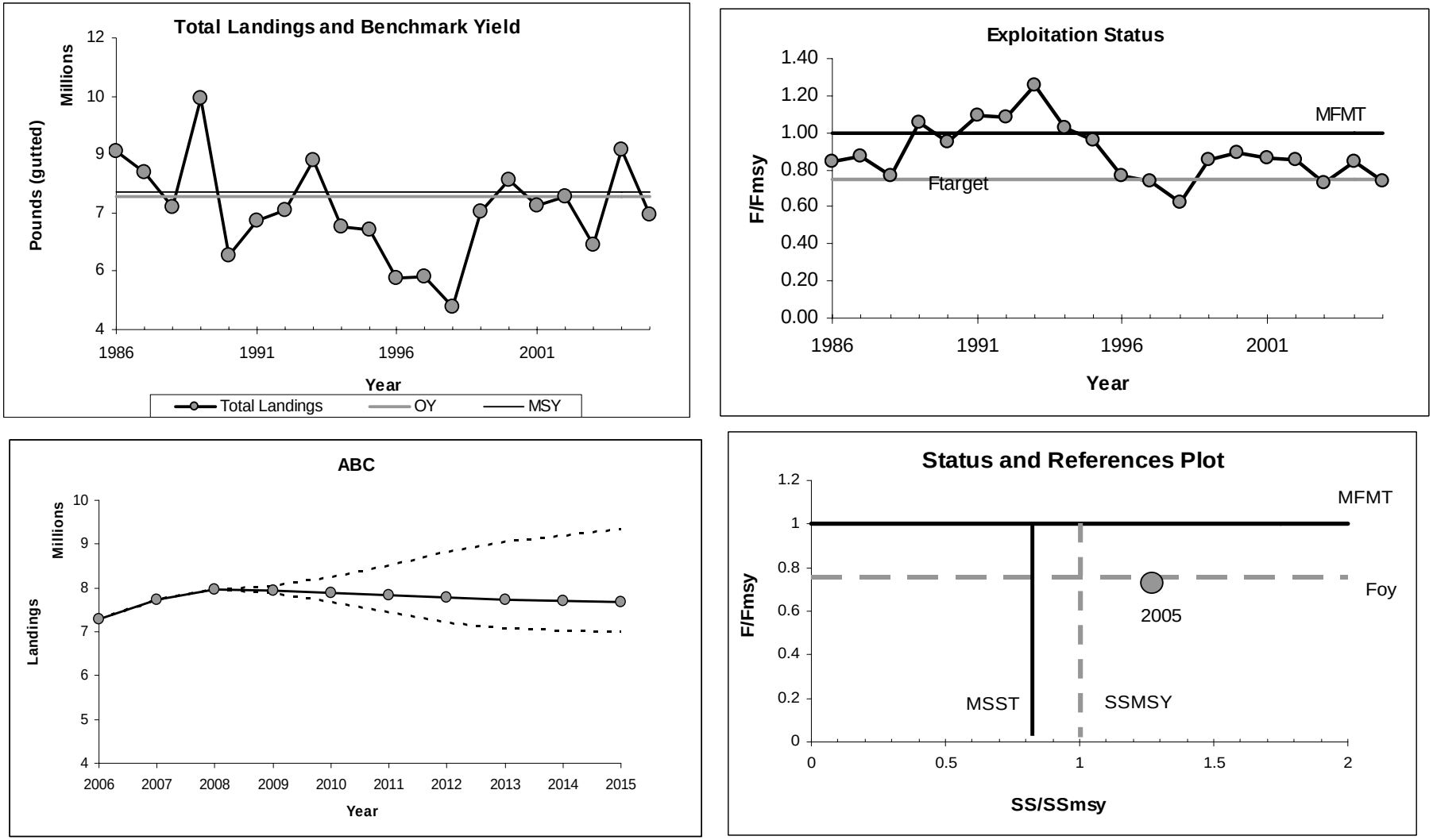
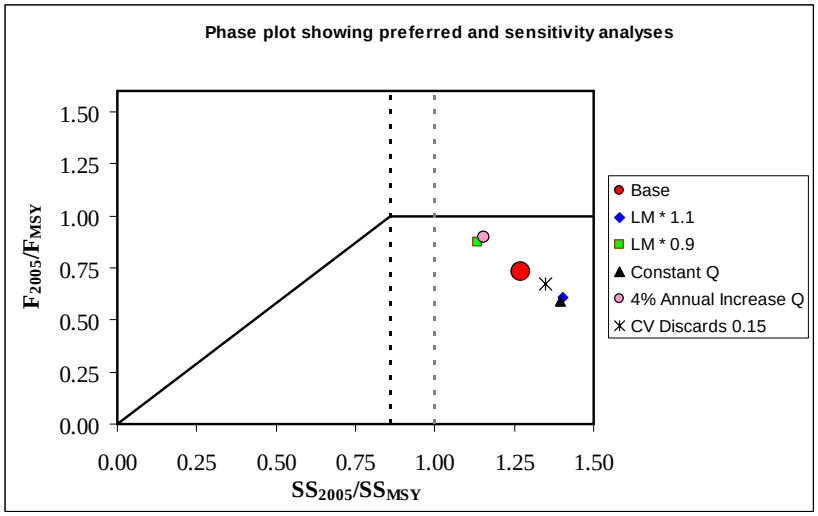
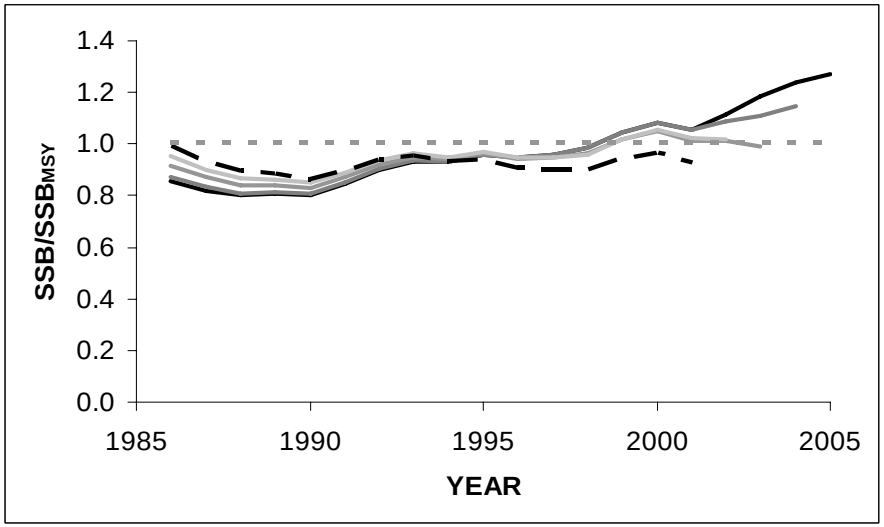


Figure 2. Population management benchmarks. Total landings compared to estimated benchmark landings (upper left); estimated exploitation compared to target and limit exploitation levels as estimated in this assessment (Upper right); phase plot comparing current status and management reference levels (lower right); estimated future landings based on exploitation at F_{OY} including 80% confidence intervals based on recruitment deviations (lower left).





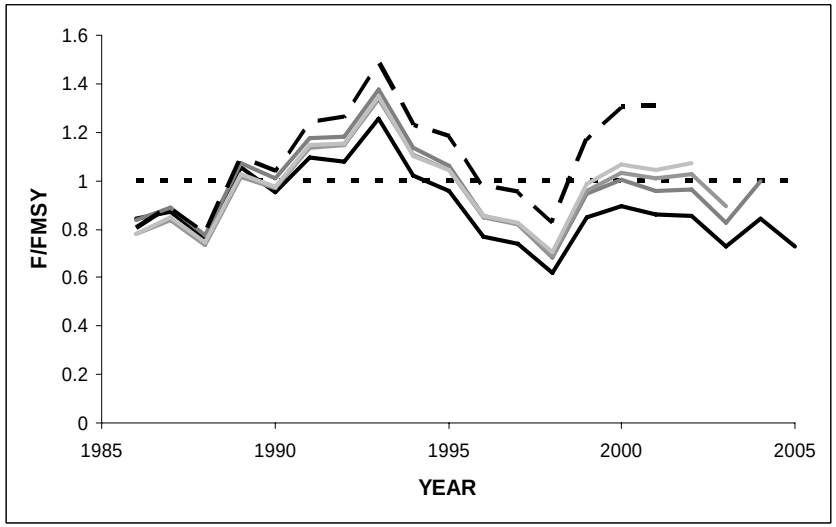


Figure 3. Illustrated model uncertainties. Point estimates of terminal stock status relative to management limits for base and review sensitivity runs (Upper panel); results of retrospective analyses for spawning stock (lower left) and exploitation (lower right)