SEDAR

Southeast Data, Assessment, and Review

Stock Assessment Report
of
SEDAR 9

Gulf of Mexico Gray Triggerfish

SEDAR9
Assessment Report 1

2006

SEDAR
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SEDAR 9

Stock Assessment Report 1

Gulf of Mexico Gray Triggerfish

SECTION I. Introduction

SEDAR
1 Southpark Circle # 306
Charleston, SC 29414

1. SEDAR Overview

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

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

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

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

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

SEDAR 9 was charged with assessing 3 stocks under the jurisdiction of the Gulf of Mexico Fishery Management Council: greater amberjack, gray triggerfish, and vermilion snapper.

2. Management Overview

2.1 Management Unit Definition

Gray triggerfish is the only Balistid of 40 species of reef fish in the management unit for the Gulf of Mexico Reef Fish FMP. Two are not managed, leaving 15 groupers, 14 snappers, five tilefishes, four jacks, in addition to gray triggerfish and one wrasse. The jurisdiction of the Gulf of Mexico Reef Fish FMP includes all waters of the GOM bounded outside by 200 nautical miles (nm) and inside by the state's territorial waters which are 3 nm in Alabama, Mississippi and Louisiana and 3 leagues or about 9 nm in Florida and Texas.

2.2 History of Management Relating to Gray Triggerfish

2.2.1 Fishery management plan and regulatory amendments

The Reef Fish FMP (with its associated EIS) was implemented in November 1984. It established four management objectives for the reef fish fishery. The FMP established the list of species in the management unit, which included gray triggerfish, and an inshore stressed area within which certain gear was prohibited, including fish traps and roller trawls [49FR 39548].

Amendment 16B including EA, RIR and IRFA, was implemented on November 24, 1999. This amendment set a 12 inch TL minimum size for gray triggerfish.

2.3 Current Management Criteria and Stock Benchmarks

There are no management criteria or stock benchmarks for gray triggerfish.

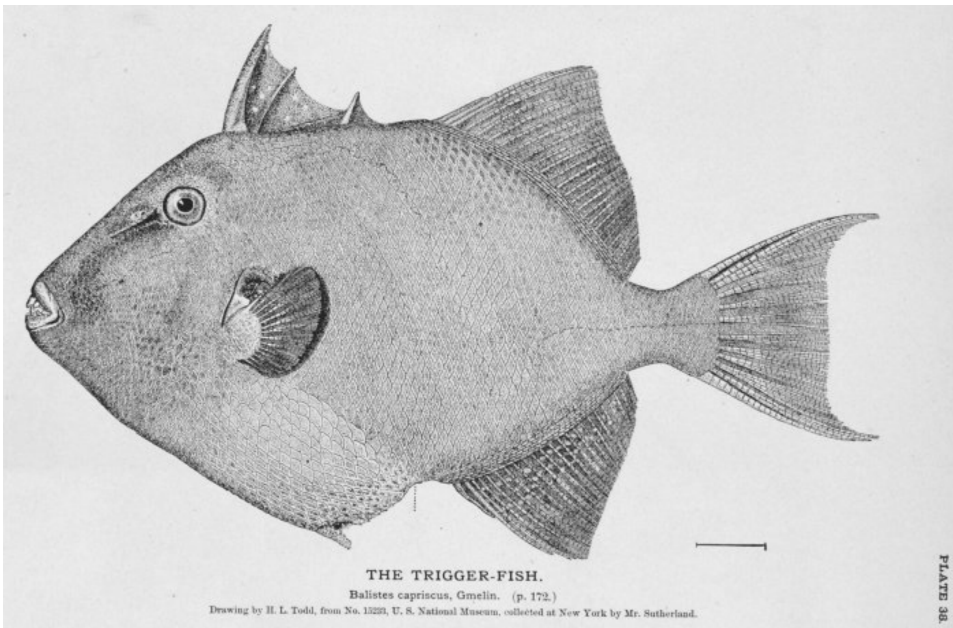
The only management regulations for gray triggerfish is a 12 inch TL minimum size and a recreational bag limit of up to 20 fish within the recreational reef fish aggregate bag limit.

Southeast Data, Assessment, and Review

SEDAR 9

Gulf of Mexico Gray Triggerfish

Balistes capriscus



SECTION II. Data Workshop Report

Developed by the Data Workshop Panel

Edited by Joshua Sladek Nowlis, Southeast Fisheries Science Center, Miami, FL

August 2005

SEDAR

1 Southpark Circle #306

Charleston, SC 29414

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1 Introduction

1.1 Workshop Time and Place

The SEDAR 9 Data Workshop convened 20-24 June 2005, at the Hotel Moteleone, New Orleans, Louisiana.

1.2 Terms of Reference

1. Characterize stock structure and develop a unit stock definition.

2. Tabulate available life history information (e.g., age, growth, natural mortality, reproductive characteristics). Provide models to describe growth, maturation, and fecundity by age, sex, or length as appropriate; recommend life history parameters (or ranges of parameters) for use in population modeling; evaluate the adequacy of life-history information for conducting stock assessments.

3. Provide indices of population abundance. Consider fishery dependent and independent data sources; develop index values for appropriate strata (e.g., age, size, area, and fishery); provide measures of precision; conduct analyses evaluating the degree to which available indices adequately represent fishery and population conditions. Document all programs used to develop indices, addressing program objectives, methods, coverage, sampling intensity, and other relevant characteristics.

4. Characterize commercial and recreational catches, including both landings and discard removals, in weight and numbers. Evaluate the adequacy of available data for accurately characterizing harvest and discard by species and fishery sector. Provide length and age distributions if feasible.

5. Evaluate the adequacy of available data for estimating the impacts of current management actions.

6. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.

7. Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible.

8. Prepare complete documentation of workshop actions and decisions (Section II. of the SEDAR assessment report).

1.3 List of Participants

Workshop Panel Members:

Robert Allman..........NMFS/SEFSC Panama City, FL
Luiz Barbieri..........FWC St. Petersburg, FL
Craig Brown..........NMFS/SEFSC Miami, FL
Shannon Calay..........NMFS/SEFSC Miami, FL
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Guy Davenport..........NMFS/SEFSC Miami, FL
Guillermo Diaz..........NMFS/SEFSC Miami, FL
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Dave Donaldson..........GSFMC
Chris Dorsett..........The Ocean Conservancy
Chris Gledhill..........NMFS/SEFSC Pensacola FL
Terry Henwood..........NMFS/SEFSC, Pascagoula MS
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Debra Murie..........University of Florida
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Bob Shipp..........University of South Alabama
Tom Turke..........GMFMC Advisory Panel
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Staff

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Dawn Aring..........GMFMC
Patrick Gilles..........NMFS/SEFSC Miami

1.4 List of Data Workshop Working Papers

Document #	Title	Authors
Documents Prepared for the SEDR 9 Data Workshop		
SEDAR9-DW1	History of vermillion snapper, greater amberjack, and gray triggerfish management in Federal waters of the US Gulf of Mexico, 1984-2005	Hood, P
SEDAR9-DW11	Length Frequency Analysis and Calculated Catch at Age Estimations for Commercially Landed Gray Triggerfish (*Balistes capriscus*) From the Gulf of Mexico	Steven Saul
SEDAR9-DW12	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Gulf of Mexico Headboat Fishery	Steven Saul
SEDAR9-DW13	Estimated Gray Triggerfish (*Balistes capriscus*) Commercial Landings and Price Information for the Gulf of Mexico Fishery	Steven Saul
SEDAR9-DW14	Estimated Gray Triggerfish (*Balistes capriscus*) Recreational Landings for the State of Texas	Steven Saul
SEDAR9-DW15	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Marine Recreational Fishery Statistics Survey (MRFSS) In the Gulf of Mexico	Steven Saul and Patty Phares
SEDAR9-DW16	Length Frequency Analysis for the Gray Triggerfish (*Balistes capriscus*) Recreational Fishery In the Gulf of Mexico	Steven Saul
SEDAR9-DW17	Estimates of Vermilion Snapper, Greater Amberjack, and Gray Triggerfish Discards by Vessels with Federal Permits in the Gulf of Mexico	Kevin J. McCarthy
SEDAR9-DW18	Size Composition Data from the SEAMAP Trawl Surveys	Scott Nichols
SEDAR9-DW21	SEAMAP Reef Fish Survey of Offshore Banks: Yearly indices of Abundance for Vermilion Snapper, Greater Amberjack, and Gray Triggerfish	Gledhill, et. al.
SEDAR9-DW22	Data Summary of Gray Triggerfish (*Balistes capriscus),* Vermilion Snapper (*Rhomboplites aurorubens)*, and Greater Amberjack (*Seriola dumerili)* Collected During Small Pelagic Trawl Surveys, 1988 – 1996	G. Walter Ingram, Jr.
SEDAR9-DW23	Abundance Indices of Gray Triggerfish and Vermilion Snapper Collected in Summer and Fall SEAMAP Groundfish Surveys (1987 – 2004)	G. Walter Ingram, Jr.
SEDAR9-DW25	Review of the early life history of gray triggerfish, *Balistes capriscus,* with a summary of data from SEAMAP plankton surveys in the Gulf of Mexico: 1982, 1984 – 2002	Lyczkowski-Shultz, J., Hanisko, D. and Zapfe, G.

SEDAR9-DW26	Shrimp Fleet Bycatch Estimates for the SEDAR9 Species	Scott Nichols
SEDAR9-DW27	SEAMAP Trawl Indices for the SEDAR9 Species	Scott Nichols
SEDAR9-DW-28	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the Marine Recreational Fisheries Statistics Survey (MRFSS)	Josh Sladek Nowlis
SEDAR9-DW-29	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the NMFS Southeast Zone Headboat Survey	Josh Sladek Nowlis
SEDAR9-DW-30	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured from commercial logbook entries with handline gear	Josh Sladek Nowlis

2 Life History

2.1 Age and Growth

2.1.1 Annulus Formation

Patterns in recreationally-caught, Alabama gray trigger growth, catch-per-unit-effort (CPUE), reproduction, and increment formation in first dorsal spines, as well as the relatedness of these patterns, is summarized by Ingram (2001) in order to validate the use of the first dorsal spine as an age estimator (Fig. 1). Both the relative marginal increment analysis, and the monthly condition of the margin of the first dorsal spines indicate that a translucent annual ring forms in December-February, and that a spawning check forms in some fish during July-August. Both of these time periods represent periods of slow somatic growth and low CPUE. The spring increase in CPUE corresponds with spring growth as indicated in the first dorsal spine by the formation an opaque band. Ingram (2001) reasoned that changes in CPUE directly correspond to changes in feeding activity and not to changes in abundance, and provide a rough index of feeding activity. Ingram (2001) reports gray trigger to have high site fidelity based on tagging. Therefore, seasonal changes in abundance due to emigration/immigration should not be the cause of changes in CPUE. During the summer months, as both male and female gonosomatic indices (GSI's) of spawning activity peaked, CPUE dropped to its lowest point during the year. After the peak in spawning activity and the observed CPUE minimum, CPUE began to increase, and a spawning check forms as indicated as another translucent band in some spines. The formation of these spawning checks is probably attributable to reproductive behavior. During the spawning season, the territorial male gray trigger prepare a number of nests (see Ingram, 2001 for review). Males then coax females to the nests, not allowing them to leave. Ingram (2001) suggested that this haremic spawning behavior, which has been described for many other species of triggerfishes (e.g., Fricke, 1980; Nellis, 1980; Thresher, 1984; Gladstone, 1994; Ishihara and Kuwamura, 1996; and Kuwamura, 1997), may affect growth of both males and females, possibly leading to the formation of false annuli in the spine. Finally, the annulus is completed when the wide opaque band indicative of fall growth forms in the spine, which is correlated with sustained high levels of CPUE. The formation of the next winter annual mark corresponds with the decrease in CPUE during the winter. With the pattern of annulus formation established, enumeration of annuli and age estimation was straightforward. There also appears to be a settlement mark that forms near the focus in the first dorsal spine of most Alabama gray trigger sampled (~ 89 %). The settlement mark is a translucent ring encircling the focus. Due to the mark's close proximity to the focus, even in small fish (80 – 100 mm fork length) less than 1 year old, it is assumed to be associated with the period of transition between pelagic and demersal habitats. The settlement mark was the only mark in the first dorsal spine resorbed by increased vacularization in larger and older fish, and thus did not affect estimates of age (Ingram, 2001).

2.1.2 Age and Growth Studies

There have been relatively few age and growth studies of gray triggerfish, and results from these studies have differed. Gray trigger growth rate based upon annuli of the first dorsal spine was estimated by Ofori-Danson (1989) off the coast of Ghana in western Africa following a tremendous increase in standing stock biomass there (from ~ 10 kg ha^{-1} in 1968 to ~ 3000 kg ha^{-1} in 1977; Pease, 1984). Ofori-Danson's estimates of the von Bertalanffy parameters were L_∞ = 408 mm and K = 0.43 $year^{-1}$. Johnson and Saloman (1984) conducted a study by sampling the hook and line fishery for gray trigger off the coast of Panama City, Florida. They used methods similar to those reported by Ofori-Danson to estimate size-at-age in the northeastern Gulf, and reported that fish reached a larger maximum length (L_∞ = 466.0 mm) but grew more slowly (K = 0.382 $year^{-1}$) than gray trigger off the West African coast. Wilson et al. (1995) and Hood and Johnson (1997) also studied gray trigger growth in the northern and eastern Gulf, respectively. Wilson et al. (1995) found that estimated ages of gray trigger landed by the commercial fishery in Louisiana ranged from 1 to 11 years, with the majority of the fish sampled being two to six years old. The mean age of females (3.9 years) was slightly, but not significantly, higher than that of males (3.3 years). Also, based on length-frequency data, gray trigger were reported to recruit to the commercial fishery at age 2, with a decline in age-class strength after age 3. Hood and Johnson (1997) studied the age and growth of gray trigger from the eastern Gulf and found that von Bertalanffy growth model (parameters: females, L_∞ = 421 mm, K = 0.329 $year^{-1}$; males, L_∞ = 664 mm, K = 0.156 $year^{-1}$; combined sexes, L_∞ = 645 mm, K = 0.152 $year^{-1}$) tended to underestimate growth when compared to empirical estimates of sizes-at-age. Also, they reported rapid growth in young gray trigger with an average length of 276 mm FL for one-year-old specimens. In addition, Escorriola (1991) sampled both the recreational and the commercial fisheries off the Carolinas on the U.S. east coast and found estimates of growth parameters that differed from those both of Johnson and Saloman (1984) and Hood and Johnson (1997). Escorriola (1991) also used methods similar to Ofori-Danson, and further suggested that gray trigger have a larger maximum length (L_∞ = 571.0 mm) and a slower approach to that maximum length (K = 0.199 $year^{-1}$) than fish off the coast of northwest Florida in the Gulf studied by Johnson and Saloman (1984). Ingram (2001) analyzed 1,628 gray trigger collected for hard-part analysis from the recreational fishery off the Alabama coast. The mean age (± standard error) of males and females collected during this study was estimated to be 3.44 years (± 0.047) and 3.44 years (± 0.039), respectively. Differences in mean ages between male and female gray trigger were not significantly different (ANOVA; α = 0.05). The oldest gray trigger in the sample was a female that was estimated to be 8.8 years of age. The oldest male was estimated to be 8.1 years of age (Ingram, 2001). The mean fork lengths (±standard error) of males and females collected during Ingram's (2001) study were estimated to be 361 mm (± 2.17) and 328 mm (± 1.59), respectively. Differences in mean fork length between males and females were significantly different (ANOVA, α = 0.05). The von Bertalanffy growth parameters (females, L_∞ = 514 mm, K = 0.208 $year^{-1}$, t_0 = -1.61; males, L_∞ = 598 mm, K = 0.200 $year^{-1}$, t_0 = -1.373; combined sexes, L_∞ = 583 mm, K = 0.183 $year^{-1}$, t_0 = -1.579) indicated that males attain a larger size than females. Hotelling's T^2 statistic indicates a highly significant difference in von Bertalanffy growth functions between males and females (T^2 = 141681.8, p << 0.001).

Presently, for SEDAR9, a study combining age and growth data from Hood and Johnson (1997), Ingram (2001), and unpublished age data from gray trigger spines collected throughout the Gulf from 1992-2002 by the NMFS Panama City Lab is currently being conducted. Presently, this study consists of the following data sets:

- Alabama Recreational, 1996-2000, N=1545
- Florida Panhandle Recreational, 1992-1998, N=221
- Florida West Coast Commercial, 1995, 1996, 1998, 2000, 2001 and 2002, N=499
- Florida West Coast Recreational, 1992, 1993, 1995, 1996, 1997, 2000, 2001 and 2002, N=198
- Louisiana Recreational, 1992, 1993, 1994, 1995, 1996, 2000 and 2001 N=184
- Texas Recreational, 1992-1994, N=44
- Summer SEAMAP Groundfish Survey, 1999, N = 71.

Regular or sloped von Bertalanffy growth models were derived for each region/fishery sector category using the trawl captured gray trigger (age-0 and age-1 gray trigger) as an 'anchor' due to the lack age-0 and age-1 gray trigger in the other data sets (Figure 2). Model fit was assessed using residual analyses and corrected R^2. Due to the very high variability in size at age, all data were combined and probabilities of age by 25-mm FL classes were derived (Table 1). Also, age-frequency histograms by year and each region/sector category (Figs. 3-7). Any years with extremely low sample sizes were not shown.

2.2 Reproduction

A study of the reproductive ecology of gray trigger was performed on specimens from Ghana in West Africa (Ofori-Danson, 1990). Ofori-Danson defined the breeding season as October to December by assigning each gonad they collected to one of five gonad maturity categories. Peak spawning occurred in the warmer months, which in Ghana are November and December. First time spawners were 133 - 157 mm in FL, 50.0 - 70.5 g, and one year old. Fecundity (F) was correlated with fork length (FL) and was described by the linear regression log F = 1.176 + 1.642 log FL. In the Gulf of Mexico, there have been a number of studies concerning the reproductive biology of gray trigger. Dooley (1972) estimated the spawning season to be from July to October in the Gulf based upon the presence of small, recently spawned gray trigger in samples. Wilson et al. (1995) reported that ovarian histology indicated that gray trigger captured off Louisiana are iteroparous and spawn during late spring and summer (April through August), with a peak in the gonosomatic index (GSI) in June for both male and female fish. Hood and Johnson (1997) similarly reported iteroparity in gray trigger and suggested that ovarian histology indicated that fish captured off west Florida spawn during summer and early fall (June through September) with a peak in the GSI in August for female fish, and in September for male fish. Mature females with ovaries containing vitellogenic oocytes were first observed in June, and were present through September. Spent females were observed from September through October. From October to March most fish had developing gonads that contained primary growth oocytes and some atretic bodies. Finally, maturing gonads first appeared in April and were present through August in fish from the eastern Gulf (Hood and Johnson, 1997). Hood and Johnson (1997) also report that 87.5% of the female fish were sexually mature by age 1, and no immature males were observed. The smallest mature male observed was 110 mm FL (age 0). Batch fecundities in fish from the eastern Gulf ranged from 213,912 to 1,172,854 oocytes from fish ranging from 267 to 388 mm FL, and relative batch fecundity had a mean of 13,809 oocytes per gram ovary and ranged from 6,318 to 24,188 oocytes per gram (Hood and Johnson, 1997). Ingram (2001) reported that both histological condition of maturity and GSI indicate that spawning activity for both male and female gray trigger from Alabama increases in May, peaks during June and July, and then decreases during August (Figs. 8-10). Sex-specific plots of GSI versus age and fork length provide insight into size and age at maturity for gray trigger (Figs. 11-14). These plots indicate that 1-year-old males (>250 mm fork length) and 2-year-old females (>250 mm fork length) exhibit seasonal maturation cycles associated with spawning. No hydrated oocytes were found in histological sections of females. Therefore, Ingram (2001) enumerated oocytes undergoing final oocyte maturation (FOM) to estimate batch fecundity. Mean diameter (± standard error) of oocytes undergoing FOM was estimated to be 418 μm (± 1). Of the 613 females from which gonads were taken, 59 were observed to be at FOM stage. Of these, 34 were used to estimate batch fecundity. Batch fecundity estimates ranged from 96,379 to 2,649,027 oocytes undergoing FOM per ovary. The mean (± standard error) number of oocytes undergoing FOM per gram was estimated to be 8,015 (± 247). The batch fecundity-fork length relationship (Fig. 15), batch fecundity-age relationship (Fig. 16), and batch fecundity-weight relationship (Fig. 17) all indicated an increase in fecundity with size and age. The mean percent (± standard error) of females spawning per day during the spawning season was 27.3 % (± 4.6). The mean interval between (± standard error) spawnings was estimated to be 3.7 days (± 0.6). Females with ovaries containing oocytes undergoing FOM were observed from late May to late August (~ 90 days). Therefore, the mean number of spawnings (± standard error) per spawning season was estimated to be 24.3 (± 4.1). Mean total annual fecundity (± standard error) was estimated to be 17,071,634 eggs year^{-1} (± 2,010,787).

2.3 Mortality

2.3.1 Previous Studies

Jones (1991) reviewed patterns of mortality in reef fishes and reported that data on mortality are difficult to obtain, and may differ widely among locations. Jones (1986) provided estimates of mortality for juvenile damselfishes *Pomacentrus wardi* and *P. amboinensis*, and mortality rates were greater on shallow reefs than deeper reefs in the same reef area. On a larger scale, mortality rates of red snapper, *Lutjanus campechanus*, tagged above artificial reefs off the Alabama coast differed greatly (i.e. instantaneous fishing mortality ranged from 0.047 to 0.620 year^{-1}) (Watterson, 1998). Watterson (1998) also estimated instantaneous fishing mortality of red snapper inhabiting publicly known reefs off the coast of Alabama and Florida to be much higher (i.e. 1.12 year^{-1}) than the more private artificial reefs off the Alabama coast. Hood and Johnson (1997) estimated instantaneous total mortality of recreationally and commercially caught gray trigger off the west Florida coast to be 0.836 and 0.825 year^{-1}, respectively. Instantaneous total mortality for gray trigger off the coast of Panama City Beach, Florida was estimated to be 0.67 year^{-1} (Johnson and Saloman, 1984). Ingram (2001) estimated instantaneous total annual mortality rate (Z ± standard error) and subsequently annual survival (S ± standard error) to be 0.82 year^{-1} (± 0.08) and 0.44 year^{-1} (± 0.04), respectively, for gray trigger off Alabama. One and two-year-old gray trigger were found to be 7.3 % and 41.4 % recruited, respectively, to the recreational fishery after back calculation. M was estimated to be 0.50 for Alabama gray trigger using Hoenig's method (1983), and F was estimated to be 0.32 (Ingram, 2001).

2.3.2 Total Mortality

From the current study for SEDAR9 of combined data sets, *Z* was derived from the descending limbs of the age-frequency histograms (Fig. 18). Table 2 summarizes the estimates of Z from each region/sector category.

2.3.3 Natural Mortality

Gray triggerfish live to at least 16 years, based on age samples available from the current SEDAR9 study. Based upon this information, the method of Hoenig (1983) results in a value for *M* of 0.27. As this results from a sample taken from an exploited population, the value could be considered somewhat high. Application of this method to the maximum age observed in the age samples from Ingram (2001) results in a maximum value of 0.5, from a sample with a maximum observed age of 8. However, due to the high fishing pressure indicated off Alabama, the estimated *M* of 0.5 is based on data from an age-truncated stock. Therefore, an *M* of 0.5 is probably too high to consider even for a sensitivity analyses. Based upon these observations, it is suggested to use a value of *M* of 0.27 for baseline evaluations, with the range of *M* from 0.2 to 0.4 for sensitivity evaluations.

2.3.4 Fishing Mortality

Using the aforementioned estimate of *M* (i.e., 0.27), estimates of *F* were derived by subtracting *M* from the *Z* of each region/fishery sector category (Table 2). This indicates that the Alabama Recreational sector has a higher *F*, with the Florida West Coast Recreational sector having the lowest.

2.3.5 Release Mortality

For an estimate of acute release mortality, Ingram (2001) visually assessed the condition of the triggerfish upon release after tagging based upon the following scale (Patterson, 1999; Ingram and Patterson, 1999; Patterson and Ingram, 2000): (1) Gray trigger immediately oriented itself toward the bottom and swam down vigorously; (2) Gray trigger appeared disoriented upon entering the water, oriented toward the bottom but swam erratically; (3) Gray trigger appeared very disoriented upon entering the water and remained at the surface; and (4) Gray trigger was either dead or unresponsive upon entering the water. Gray trigger released in a condition other than condition-1 were assigned as having suffered release mortality. Acute mortality of gray trigger due to tagging was estimated to be 1.5 %, but this percentage was statistically significant from zero (Z-test, $p < 0.05$). Out of 1,271 releases (i.e. this included initial releases and subsequent releases after recaptures), four gray trigger were released in condition-2, 14 were released in condition-3 and one was released in condition-4. Out of the 19 gray trigger released in a condition other than condition-1, two (11 %) were recaptured and released again in condition-1, indicating that some proportion of the gray trigger that were assumed to have died as a result of the tagging process actually survived. Also, the probability of occurrence of acute mortality increased slightly with gray trigger size, and the depth of capture did not significantly affect release condition.

2.4 Conversion Factors

Conversion factors for gray trigger are provided in Table 3.

2.5 Stock Recruitment Relationships

The classification scheme developed at the FAO SECOND TECHNICAL CONSULTATION ON THE SUITABILITY OF THE CITES CRITERIA FOR LISTING COMMERCIALLY-EXPLOITED AQUATIC SPECIES (Windhoek, Namibia, 22-25 October 2001; FAO 2001) was used to characterize the relative productivity of gray trigger. This information is provided in Table 4. A productivity rank was assigned to each life-history characteristic (a value of 1 was assigned for low, 2 for medium, and 3 for high productivity characteristics) and the ranks were averaged to produce an overall productivity score. This score was then used to prescribe a prior probability density function on steepness in the stock-recruitment relationship from the periodic life history strategists as summarized by Rose et.al. (2001). The dominant portion of the steepness values from these analogous species range from 0.6-0.8 with 90% of the values less than 0.9. As the gray triggerfish productivity score from this exercise is midway between the medium and high category, it is recommended that the prior probability density function on steepness for this species be lognormal with a mode of 0.8 and a CV such that there is no greater than a 10% probability of steepness values greater than 0.9.

2.6 Habitat

Eggs of Gulf gray trigger incubate in demersal nests between within 12 to 58 hours, after which they enter the plankton (Thresher, 1984). Gray triggerfish are collected in SEAMAP neuston tows, usually associated with seaweed and flotsam (mostly *Sargassum*), at sizes from 2 to 80 mm SL with a median length frequency of 15 mm SL (SEDAR9-DW25). Also, Wells and Rooker (2004) reported the SL of gray trigger associated with *Sargassum* to range from 10 to 80 mm SL, with a mode around 40 mm SL. Ingram (2001) reports that gray trigger settle between 40 and 160 mm FL with a mode around 70 mm FL (i.e., 31 to 130 mm SL, mode 56 mm SL), based on settlement marks in the first dorsal spine of trawl-caught gray trigger. Fork length of gray trigger collected in SEAMAP groundfish surveys ranged from 60 to >280 mm FL with a mode of 90 mm FL during the Summer SEAMAP Groundfish Surveys and a mode of 120 mm FL during Fall SEAMAP Groundfish Surveys. In the Gulf, the gray trigger inhabit reef areas (natural and artificial reefs, low or high-relief reefs) in waters from 10 m (Smith, 1976; Johnson and Saloman, 1984, Ingram, 2001) to 106 m (Kevin Rademacher, pers. comm.[1]) in depth as adults. National Marine Fisheries Service (NMFS) videos taken of reefs in the Gulf indicate that gray trigger are distributed from south Texas around the northern Gulf to just north of the Florida Keys with increased concentration of adults associated with the numerous artificial reef permit areas (Kevin Rademacher, per. comm., SEDAR9-DW21).

2.7 Stock Definition

Adult gray trigger off Alabama exhibit high site fidelity (Ingram, 2001). High site fidelity may result from the territorial nature of adult fish (Ingram, 2001). Bohnsack (1989) infers that fishes

[1] National Marine Fisheries Service, Pascagoula, Mississippi

exhibiting high site fidelity may be more easily overexploited. In the case of gray trigger in Ingram's (2001) study, loss of older age classes resulting from increases in fishing pressure in publicly known fishing grounds is apparent. Selective removal of large, fast-growing members of the population may be resulting in decreased growth rates of survivors on small spatiotemporal scales (Ingram, 2001).

Population parameters of adult gray trigger are heterogeneous on multiple spatial scales. Estimates of growth rates on the scale of individual reefs indicate high variability, which precludes a finding of stock heterogeneity on this small scale (Ingram, 2001). However, at a slightly larger scale (i.e. at the reef-complex or reef-permit-area scale), adult gray trigger appear to have differences in specific population parameters; differences may be attributable to differential fishing pressure between reef areas (Ingram, 2001). On a Gulf-wide scale, temporal differences in growth and mortality parameters may result from different levels of exploitation and/or habitat characteristics, and may preclude any meaningful comparisons of growth and mortality to gain insight into stock structure.

The length of the pelagic phase of young gray trigger is characterized as being prolonged and indeterminate by Richards and Lindeman (1987). Gray trigger may choose to inhabit structure in surface waters until suitable demersal habitat is found, and may be pelagic from a few weeks to several months. Gray trigger associate with *Sargassum* spp. patches and other flotsom during their pelagic phase. Gray trigger may exhibit homogeneous stock structure in relation to genetic variability, due to a prolonged pelagic phase and the potential of wide dispersal (Richards and Lindeman, 1987). However, if young gray trigger are entrained within cyclonic or anti-cyclonic currents that retain them in the same area from which they were spawned, the result would be a mostly self-recruiting population or sub-population. Moreover, comparisons between length-frequency histograms of gray trigger collected as larvae/juveniles in nueston tows during SEAMAP Ichthyoplankton Surveys (SEDAR9-DW25) and gray trigger collected during SEAMAP Groundfish Surveys (SEDAR9-DW23 and SEDAR9-DW27) indicate that many gray trigger probably settle out of surface waters to trawling grounds by late Fall.

3 Commercial Fishery Description, Data Sources, and Statistics

3.1 Commercial Landings Collection and Statistics

3.1.1 Commercial Landings Data Collection

Commercial fishery statistics include information on landings of seafood products, fishing effort, and biological characteristics of the catch. A variety of sources of information are used to obtain these statistics.

The quantity (usually weight) and value of seafood products sold to licensed seafood dealers have been collected through various state and federal programs overtime. Currently these landing statistics are collected by state fisheries agencies in Alabama, Florida, and Louisiana on each fishing trip (trip ticket programs). In Mississippi and Texas, monthly dealer reports of landings are either sent in by the dealer or collected by state and federal port agents. Prior to the implementation of trip ticket programs landings were collected from seafood dealers each month by NMFS and state agents. Trip ticket programs generally provide information on the gear used and the fishing area. For the historical landings obtained from dealers each month, fishing gear and area were assigned by the agents on an annual basis.

At the National Marine Fisheries Service (NMFS), Southeast Fisheries Science Center (SEFSC) commercial landings statistics from North Carolina through Texas from 1962 to present are maintained in a data base referred to as the Accumulated Landings System (ALS). Statistics on all seafood products other than shrimp are maintained in that data base. Landings statistics from before 1962 are maintained by NMFS in Silver Springs, MD.

3.1.2 History and overview of landings data collection

3.1.2.1 Florida

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

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

3.1.2.2 Alabama

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

3.1.2.3 Mississippi

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

3.1.2.4 Louisiana

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

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

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

3.1.2.5 Texas

The state has mandatory reporting requirement for dealers licensed by the state. Dealers are required to submit monthly summaries of the quantities (pounds) and value of the purchases that were made for individual species or market categories. Information on gear, area and distance from shore are added to the state data by SEFSC personnel.

3.1.2.6 Inter-State Transport

Often seafood products are landed in one state and transported by the purchasing dealer to another state; such landings may be recorded both in the state of landing and where the purchasing dealer is located. State and SEFSC personnel track these landings to assure that double counting does not occur and assign them to the state of landing.

3.1.3 Commercial Landings Data Base Organization and Data Handling

The data are organized into three primary components: historical annual data (1962-1976), monthly data (1977-present) and Florida annual data (1976-1996). The monthly 1977-present data for Florida does not have gear or fishing area for the period 1977-1996, while the annual Florida data (1976-1996) has gear and fishing area information which was provided by port agents based on their knowledge of the fisheries.

3.1.3.1 Accummulated Landings System (ALS)

1962-1976 Annual Landings by Year, State, County, Area, Gear, and Species for Florida West Coast through Texas.

1977-present Monthly Landings by Year, Month, State, County, Area, Gear, and Species for Florida West Coast through Texas. Data reported from some states do not have information on the area and gear of capture particularly during the 1990s.

Historically the state and county recorded in the ALS indicates where the marine resource was landed. However in recent years (with the advent of trip tickets as the source of the landings data) in some states the state and county reflect the location of the main office of the purchasing dealer..

Fishing takes place in many different regions including United States waters of the Gulf of Mexico, the South Atlantic and in foreign waters. For the years 1976-present the area codes assigned to those regions are:

- South Atlantic catch in the ALS is considered all area codes 0010, 0019, and 7xxx and higher.
- Foreign Waters are area codes 022x- 060x and 186x.
- In order to define the area of capture for Florida West coast for years 1976-1996 previous assessments use the Florida Annual Canvass data set. (Note* -The State of Florida implemented their trip ticket program in 1985 with more complete reporting starting in 1986. This data set was to contain area of capture information, but due to the nature of a public reporting, some fields on the ticket (such as area) may not have been reported consistently or completely in the early implementation years.)

3.1.3.2 Florida Annual Canvas Landings

1976-1996 - Florida Annual Canvass for area and gear estimates by county which are not in the Monthly Landings for Florida West Coast.

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

<u>Florida Annual Canvass 1976-1996 considerations:</u>

- 1976-1985 Data is as landed weight which for amberjack and vermilion snapper was normally landed in a gutted condition. In order to convert to whole weight a factor of 1.04 is universally applied for amberjack and 1.11 for vermilion. Gray Trigger fish is normally landed whole.

- All Area codes 0010, 0019, and 7xxx and higher are considered South Atlantic catch

- State 00 and Grid 0000 in the data set are marine product landed else where and trucked into the State of Florida and are considered duplicated else where because they are theoretically reported back to the state of landing and are not included in the Florida totals.

- State 12 is in the data set which represent Florida interior counties which were landed on Florida East Coast and not included in the Gulf catches.

3.1.3.3 Assignment of gear and area of capture 1990-present

The gear and fishing area designations in the landings data base has been provided by a variety of sources including port agents (annual and/or monthly landing reports), dealers (some trip ticket reports) and permit applications (some trip ticket reports, used only for gear). For some states the fishing gear and area were not reported when trip ticket programs were initiated. Beginning in 1990 fishermen have provided log books which indicate fishing gear, and area as well as catch and effort. The working group recommended that starting in 1990, landings be classified by gear and area using year and state specific information from logbooks.

3.1.4 <u>Commercial Landings</u>

3.1.4.1 Commercial landings by State

Commercial landings in pounds by state and year are shown in Table 5. Those landings are shown for landings reported as for gray triggerfish and unclassified triggerfish. The panel chose to consider both of these categories as gray triggerfish (see below).

3.1.4.2 Commercial Landings Species Composition

In the ALS four codes for for unclassified triggerfish and three triggerfish species have been used. Prior to 1993 only unclassified triggerfish was recorded. Starting in 1993 landings were recorded for gray triggerfish, ocean triggerfish, and queen triggerfish as well as unclassified triggerfish. Since 1993 gray triggerfish has accounted for nearly all of the landings.

Consequently, the assumption is made that those landings belonging to the unclassified triggerfish were gray triggerfish. (SEDAR9-DW13).

3.1.4.3 Commercial Landings for Assessment by State

Commercial landings by state are shown in Table 6.

3.1.4.4 Commercial Landings for Assessment by Gear and Area

Table 7 shows commercial landings by gear and region. For landings from 1990-2004 gear and statistical area were assigned from log books by year and state. The eastern and western regions were separated at approximately the Mississippi River with east including statistical areas 1-12 and the west including areas 13-21. Longline included vertical longline, trap included all pot and trap gears and handline included all other gears.

3.2 Bycatch

3.2.1 Commercial Finfish Fishery Discards

Estimates of gray triggerfish commercial discards were presented in SEDAR9-DW17. A 20% sample of the vessels with a Gulf of Mexico reef fish, king mackerel, Spanish mackerel or shark permit were selected to report discards. Data were available for the period August, 2001 through December, 2004. There were only about 50 trips on which gray triggerfish were reported. As a result, there were not sufficient data to conduct generalized linear modeling (GLM) analyses for gray triggerfish. Instead, the data were solely stratified by time of year (Jan-Jul or Aug-Dec).

The estimated number of discards was calculated by multiplying the number of trips in a statum by the average catch rate in the stratum. Estimates were made only for the handline fishery (included electric reel and hydraulic ‘bandit rig’ gear) due to small sample sizes of discards reported from other gears. Additionally estimates were calculated for years before the discard program was initiated. These were made using the 2001-2004 average discard rates for each stratum. These pre-July 2001 estimates were made only for periods when the size limit was the same as the size limit in 2001-2004. Since a size limit was enacted for gray triggerfish in late November, 1999, estimates were made starting in 2000 (Fig. 19).

The committee reviewed existing data which might be useful in estimating the average weight of discards. The committee suggested that the average size of discards might be estimated from information on the compostion before and after minimum sized restrictions were imposed. A review of the gray triggerfish data before and after 2000 indicated no differences in the size composition with very few fish below the minimum size; therefore the committee suggested that the weight associated with the minimum size might be used.

3.2.2 Shrimp Fishery Bycatch

The Bayesian techniques used to estimate shrimp fleet bycatch for red snapper during SEDAR7 (SEDAR7-DW3 and 54) were applied to vermilion snapper, gray triggerfish, and greater amberjack in SEDAR9-DW26. Results for all three species do not appear to be as reliable as the results for red snapper, probably in large part due to their lower abundances, but also due to reasons unique for each species. Gray triggerfish have a relatively even distribution and are probably abundant enough for a reasonable analysis, but the species was not on the list of 22 species for which data were to be recorded during “Evaluation Protocol” observer trips. Hence, shrimp observer data relevant to gray triggerfish are very, very sparse. It was not possible to obtain an estimate for bycatch with BRDs for triggerfish with the Bayesian model. Because of doubts about the reliability of the annual estimates for these species from the SEDAR7 model, a delta distribution-based version of the Bayesian approach was introduced, and a fully mixed effects model (“Model 3”) was resurrected. The mixed model had been considered for red snapper but was ultimately rejected. There is some evidence that the delta implementation may underestimate bycatch, while Model 3 central tendencies tended to be intermediate between the SEDAR7 and delta results, but the uncertainty estimates were enormous. Table 9 provides some summary statistics of the performances of the models when applied to gray triggerfish, and compare them with the more successful situation for red snapper. In view of the unrealistic results that cropped up for all three SEDAR9 species, the DW recommends setting aside the estimates of interannual variation in favor of estimating an overall average, and then constructing wide uncertainty intervals to incorporate estimation error within models, variation among model choices, and interannual variation. Working at a resolution below an annual time step is not recommended. The simplest statistic from SEDAR9-DW26 (average CPUE in all observer trips times an approximate recent effort level) is recommended as the estimate of central tendency. It was not possible to partition the bycatch estimates by age as per SEDAR7-AW20, as only a handful of fish for these 3 species have been measured across all the observer studies.

The recommended central tendency for shrimp fleet bycatch for gray triggerfish is 3.8 million fish per year.

3.3 Size composition

SEDAR9-DW-11 presented information on the size composition of gray triggerfish caught in commercial fisheries. The report showed that trap caught fish were generally smaller than fish caught by handlines and that fish caught by other gears (primarily longline were generally larger than fish caught by handlines. The report also showed that the relatively small number of fish measured from statistical areas 2-5 tended to be larger than the fish caught in the other areas. The committee recommended that if catch at age was to be estimated from size composition samples that stratification be used to account for these differences; it was noted that sample sizes were low particularly for the other gear category and for statistical areas 2-5, so that there were probably not be sufficient samples to adequately characterize the annual size composition for those strata.

4 Recreational

The recreational fishery statistics for gray triggerfish are collected by three separate surveys: Marine Recreational Fishing Statistical Survey (MRFSS), Texas Parks and Wildlife Department (TPW) and the Headboat Survey (HB). MRFSS captures statistics on shore based, charter boat and private/rental boat fishing since 1981 from Florida through Louisiana. MRFSS included headboats in the survey from 1981-1985. HB began in 1986 from Florida through Texas. TPW collects recreational fishing statistics for all fishing modes except headboats in the state of Texas.

This group expressed concern over the accuracy of the MRFSS data for the reef fish species. The group agrees that these three species are major components of the recreational fishery. The group's concern centers on the low number of intercepted fish that is used in conjunction with the fishing effort estimates from the phone survey to estimate total catch (e.g., small anomalies in the data can be expanded to large anomalies). Another concern is over species identification by contract port agents in the early years of the survey and by fisherman for the B1 and B2 catches. Species identification is the greatest issue for the jack family. The group decided that MRFSS provides the best available data at this time. The relatively high CVs associated with the landings will be incorporated into the assessment models.

> **Group Decision:** The MRFSS data is the best available data and cannot be ignored. The landings have CVs associated with them which will capture the high level of uncertainty.

<u>MRFSS</u>

1. The MRFSS data has missing information for landings in some years, waves, or states that need to be filled with some value.

   Group decision: Staff of NMFS SEFSC are developing methodology by which to fill in the missing landings information. The missing landings are most commonly from the first wave in 1981 and Texas for all years. The group decided to accept the methodology from the SEFSC staff (Appendix 1). The group was not able to review the methodology at the time of the data workshop.

<u>Headboat</u>

1. Headboats have no estimates of released fish.

   Group Decision: Use the rate of B2 from MRFSS charter boat mode only. The group felt that charter boat and headboat fishing is most similar and the rate of released fish would be most like. Private boat fishing would not be the same as the "for-hire" sector.

2. Headboat landings from the Florida Keys and Atlantic based trips to the Dry Tortugas (areas 12 and 17):

   Group Decision: The group should not be included in the Gulf of Mexico analysis. The group felt that better than 99% of the trips in area 12 and 17 are in Atlantic jurisdiction.

5 Fishery-Dependent Survey Data

5.1 Commercial Fishery Catch Rates

5.1.1 Commercial Handline

An abundance index was developed for Gulf of Mexico gray triggerfish using data from the National Marine Fisheries Service (NMFS) reef fish commercial logbook program when handline or electric reel gear was used (SEDAR9-DW30). This index spanned from 1993 to 2004, with good sample sizes throughout. Gray triggerfish was the 6th most common species in the Gulf of Mexico MRFSS dataset but occurred in 23% of trips. The Stephens and MacCall (2004) species association approach was used to identify trips that were likely to catch gray triggerfish based on the composition of other species landed. This approach selected 32,119 trips for consideration, and gray triggerfish occurred in 19,575 (61%) of them. Nominal CPUEs from these trips indicated that gray trigger may have declined over the time series. Using these trips, a delta-lognormal model was constructed considering the following factors: year, season, red snapper season, red snapper permit (class 1 or not), hooks per line, and state. The model identified year, state, and red snapper permit as significant on the binomial portion of the model, and year, hooks per line, state, state*hooks, and year*state in the lognormal portion. The resulting standardized index suggested the stock had generally increased over the time period, with relatively good confidence throughout the time period (Table 10; Fig. 20). This index will be reconstructed after including a relatively small number of unidentified gray triggerfish. These are most likely gray triggerfish and will most likely only make a small difference in the results. Additionally, concern was raised about whether hook-hours was the appropriate measure of effort for this fishery, especially considering the significance of hooks per line in the analysis. Consequently, effort will be paid to examining this and an alternative measure of effort, line-hours.

5.2 Recreational Fishery Catch Rates

5.2.1 Marine Recreational Fisheries Statistics Survey Catch Rates

An abundance index was developed (SEDAR9-DW28) for Gulf of Mexico gray triggerfish using data from the Marine Recreational Fisheries Statistics Survey (MRFSS). MRFSS data include fish landed and observed by the interviewer (A), dead fish not observed by the interviewer (B1; e.g., unavailable, filleted, used for bait, discarded dead at sea) and fish released alive (B2). Since the indices were estimated on the total catch (A+B1+B2) instead of on landings, it is expected that any impact of size limits would be minimized. This index spanned from 1981 to 2004, although data prior to 1986 was based on few sample sizes. Although there were many trips in the MRFSS system, many caught few species and so no species occurred frequently in trips. Gray triggerfish was the 13th most common species in the Gulf of Mexico MRFSS dataset but occurred in only 6.7% of trips. The Stephens and MacCall (2004) species association approach was used to identify trips that were likely to catch gray triggerfish based on the composition of other species caught. This approach selected 7,248 trips for consideration, and gray triggerfish occurred in 4,308 (59%) of them. Nominal CPUEs from these trips indicated that gray trigger may have increased over the early part of the time series and declined more recently. Using these trips, a delta-lognormal model was constructed considering the following factors: year, season, red snapper season, state, and mode. The model identified year, mode, and state as significant on the binomial portion of the model, and year, season, state, red snapper season, year*state, and year*season in the lognormal portion. The resulting standardized index suggested the stock had increased and then declined over the time period, with greater confidence on the recent observations than the older ones (Table 10; Fig. 21). This index will be reconstructed after including a relatively small number of unidentified gray triggerfish. These are most likely gray triggerfish and could make a difference in the early years of the survey, when sample sizes were generally low.

5.2.2 Headboat Survey Catch Rates

An abundance index was developed (SEDAR9-DW29) for Gulf of Mexico gray triggerfish using data from the NMFS Southeast Zone Headboat Survey. This index spanned from 1986 to 2003, with large sample sizes each year. Additionally, vessels could be tracked individually. Gray triggerfish was the most common species in the Gulf of Mexico headboat dataset and occurred in 46% of trips. The Stephens and MacCall (2004) species association approach was used to identify trips that were likely to catch gray triggerfish based on the composition of other species landed. This approach selected 64,006 trips for consideration. These were further limited to vessels that had at least 30 trips within the species association dataset. This restriction eliminated 58 of 161 vessels (36%) but only 615 trips (1%). Gray triggerfish occurred in 74% of the retained trips. Nominal CPUEs from these trips indicated that gray trigger may have increased over the early part of the time series and declined more recently. Using these trips, a delta-lognormal model was constructed considering the following factors: year, season, state, vessel, time of day, and trip duration. The model identified year, state, and year*state in the binomial portion and year, vessel, season, year*vessel, and year*season in the lognormal portion. Vessel was also significant in the binomial portion of the model and the season*vessel interaction in the lognormal portion. However, inclusion of these factors prevented the model from converging, so they were withheld. The resulting standardized index suggested the stock had increased and then declined over the time period, with fairly good confidence across all observations (Table 10; Fig. 22). This index will be reconstructed with data from 2004 when those data are available. Additional effort may also be paid to incorporating the vessel terms that caused convergence problems.

5.3 Recommendations

5.3.1 Indices to be considered for use in the assessment

As a general recommendation, each of these indices is recommended for use pending the expected revisions to the analyses and input data. Their relative values are shown for comparison in Fig. 23.

5.3.2 Data and/or analysis revisions

Investigations will be made into the appropriate measure of effort in the commercial handline analysis, and revisions made if necessary. The unidentified triggerfish will be included as gray triggerfish for both the commercial handline analysis and the MRFSS analysis.

Data are now available from the Headboat Survey in 2004. These should be incorporated in the headboat analysis prior to the assessment.

The question of whether or not size limit changes may have impacted the indices should be considered, incorporating information such as size frequency distributions, and included in the paper(s).

6 Fishery-Independent Survey Data

In preparation for the SEDAR, four fishery independent surveys were analyzed and indices of relative abundance developed. These were the Southeast Area Monitoring and Assessment Program (SEAMAP) shrimp/bottomfish surveys and their predecessors, the SEAMAP ichthyoplankton surveys, the SEAMAP reef fish survey, and the small pelagics trawl survey. The small pelagics data may be useful for extended distributional information, but is not a rigorous time series, and is not considered further here. The ichthyoplankton and reef fish surveys are intended to index spawning stock size. The trawl indices are intended to index new recruitment.

6.1 SEAMAP Ichthyoplankton Surveys

Examination of proportion occurrence and nominal mean abundance of gray triggerfish larvae captured during all SEAMAP surveys indicated that larvae consistently occurred most frequently and in highest abundance in neuston net samples during the annual Fall Plankton survey. Gray triggerfish occurred more frequently and were caught in higher numbers in this survey when compared to summer and fall shrimp/bottomfish surveys. Additionally, this is the only established SEAMAP survey that samples the entire spawning grounds of gray triggerfish in the U.S. Gulf of Mexico. The time series of larval data available for the upcoming assessment includes the years, 1986-2002 with 1998 observations excluded due to curtailed sampling that year. Catches of gray triggerfish larvae from sampling during the summer and fall shrimp/bottomfish surveys were not included in estimates of annual abundance because these surveys do not extend east of Mobile Bay, Alabama and, therefore, do not adequately sample the gray triggerfish spawning stock. It is evident from a comparison of mean annual abundances, coefficients of variation of mean abundance (CV), and annual proportion occurrence in the two plankton gear types that gray triggerfish larvae are taken more consistently in neuston than in bongo samples. CV's over the time series for neuston net catches are lower and relatively more stable than for bongo net catches. We recommend that the gray triggerfish index of larval abundance be based on neuston net samples from the SEAMAP Fall Plankton survey. This index, as reported in working document SEDAR9-DW25, should be considered a nominal or raw index only.

Two sampling issues were discussed by the workgroup that need addressing before standardized larval indices are constructed and evaluated. The first was duplicate and/or multiple sampling at some SEAMAP systematic grid sites, and the second, was gaps in spatial coverage over the survey area. Two methods to mitigate any potential bias in survey indices caused by variable spatial coverage were discussed. First was a two step process to filter sample sites used to estimate larval abundance. Step one deletes duplicate samples at a systematic grid site, retaining a single sample at each grid site in accordance with SEAMAP sample design. Priority is given to samples collected by NMFS vessels since these vessels generally collect the majority of survey samples overall, and then to the sample nearest the actual grid site. The second step deletes any sites on the systematic grid not sampled during at least 75% of years in the time series resulting in a more consistent area of coverage over the time series.

The workgroup also briefly discussed the need to construct an age or size corrected index due to inter-annual differences in size (age) composition of young gray triggerfish over the index time series. An attempt will be made, as time permits, to construct a size adjusted index (as described in Hanisko et al. SEDAR7-RW-7). The final step will be construction of a model based larval abundance index using the delta-lognormal approach (Lo et al., 1992). Joanne Lyczkowski-Shultz will provide the final indices prior to the August stock assessment.

6.2 SEAMAP Reef Fish Survey

The SEAMAP reef fish survey employs video cameras to estimate the abundance offish associated with reefs and banks located on the continental shelf of the Gulf of Mexico. Fish traps are also employed to capture fish for aging. Details of survey design and estimates of abundance for gray triggerfish are in the working paper (SEDAR9-DW21). We recommend the use of design-based estimates of abundance for gray triggerfish. There was no advantage to using the model-based estimates because no gaps were present in the survey time series that could be accounted for using a GLM approach. The size of the fish observed during the survey come from two sources, fish captured in traps and fish measured on video tape with lasers. Lasers were first introduced in 1995. However, since both the capture of fish in traps, and the instances where fish are hit by lasers was infrequent, size distributions were not estimated. We report only the average size and size range of fish. Survey indices are in working paper SEDAR9-DW21 and presented in Table 11 and Fig. 24. The size of gray triggerfish observed ranged from 123 mm FL to 623 mm FL. Therefore the video survey observes fish age 1+. The results of a 2004 survey will be added. These will be provided prior to the August stock assessment by Chris Gledhill, NMFS Pascagoula, MS.

6.3 SEAMAP Trawl Surveys

The procedures used in SEDAR7 to derive trawl survey indices of abundance for red snapper (SEDAR7-DW1 and DW2; and the age composition portion of SEDAR7-AW15) were applied to gray triggerfish, and reported in SEDAR9-DW27. A Bayesian modeling procedure is used to combine different survey designs from different time series to create a Fall index for 1972-2004 (Table 11, Fig. 25), and a summer index for 1981-2004 (Table 11, Fig. 26) based on the SEAMAP standard. Standard SEAMAP surveys are conducted between 5 and 50 fm, from Mobile Bay to the Mexican border. Within the survey area, gray triggerfish are abundant and frequent enough for derivation of meaningful indices. Triggerfish occur east of the survey area as well; where the rough, live bottom makes standard surveys impractical. Sporadic observations in the eastern Gulf suggest triggerfish catch rates there may comparable to those within the survey area, so a substantial fraction of the population probably is covered, even though the total range cannot be. Size composition data are available for 1987 forward. There appear to be at least two peaks in the summer size composition, but one broad peak in the fall size composition.

A temporary working group consisting of age / growth, larval index, and trawl index specialists met during the Data Workshop to interpret the size compositions from the SEAMAP trawl surveys collected in SEDAR9-DW-18, concentrating on the plots made from fish from all years, combined. Size data are available from 1987 forward.

For gray triggerfish in the summer, size data combined over years showed two overlapping peaks. Imposing a boundary at 140 mm would results in a reasonable separation, very consistent with a sharp transition between ages 0 and 1 from aged fish from all sources combined. (Direct ageing of trawl catches alone exist, but only for about 80 fish in one year.) The peak of smaller fish are clearly young of the year, but most of the seasonal recruitment is yet to come. Therefore, the interannual variations of fish under 140 mm are probably not suitable for describing variations in year class strength. Fish above 140 mm are interpreted as age 1+. Age 1 and 2 are known to overlap broadly in size. There are also indications of strong selection by size among gear – fish aged 1 taken in the directed fisheries are substantially larger than trawl-caught age 1s.

In the fall, only a single peak is evident. The catch is almost certainly dominated by age 0s. Based on larval CPUE patterns, recruitment to the trawls is probably substantially complete in time for the fall survey. (Triggerfish are known to be able to remain in the plankton for extended periods, but we founding nothing to indicate that any substantial fraction of the population follows that path.) We did not see a basis for extracting separate classes from the single peak. The fall survey index could probably treated in the assessment as either an index of age 0 with minor error from contamination of older fish, or of age 0+ without internal information on age selectivity.

In red snapper (SEDAR7-AW15), it was possible to establish age 0 / age 1 boundaries that varied over years. (The annual size compositions were not ambiguous for that more abundant species.) There are some cases of apparent shifting in the annual plots in SEDAR9-DW-18, but on an annual basis, the data become quite sparse. We decided to recommend against changing age 0 / age 1 boundaries among years. Such a procedure would probably add more noise than signal. Scott Nichols will provide the age composition vectors prior to the August stock assessment.

6.4 Summary of Outstanding Items

In summary, fishery independent index items still outstanding, but slated for completion prior to the SEDAR9-AW in August are: final larval indices (Lyczkowski-Shultz); updated reeffish indices (Gledhill), and trawl index age compositions (Nichols).

7 Literature Cited

Bohnsack, J.A. 1989. Are high densities of fishes at artificial reefs the result of habitat limitation or behavioral preference? *Bull. Mar. Sci*. 44:631-645.

Dooley, J.K. 1972. Fishes associated with the pelagic *Sargassum* complex, with a discussion of the *Sargassum* community. *Contrib. Mar. Sci*. 16:1-32.

Escorriola, J.I. 1991. Age and growth of the gray triggerfish, *Balistes capriscus*, from the southeastern United States. M.Sc. thesis, University of North Carolina at Wilmington.

FAO 2001. Report of the Second Technical Consultation on the Sustainability of the CITES Criteria for Listing Comercially-Exploited Aquatic Species. Available at: *http://www.fao.org/docrep/meeting/003/X1627E.htm*

Fricke, H.W. 1980. Mating systems, maternal and biparental care in triggerfish (Balistidae). *Z. Tierpsychol*., 53:105-122.

Gladstone, W. 1994. Lek-like spawning, parental care ad mating periodicity of the triggerfish *Pseudobalites flavimarginatus* (Balistidae). *Environ. Biol. Fishes* 39:249-257.

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

Hood, P.B. and A.K. Johnson. 1997. A study of the age structure, growth, maturity schedules and fecundity of gray triggerfish (*Balistes capriscus*), red porgy (*Pagrus pagrus*), and vermillion snapper (*Rhomboplites aurorubens*) from the eastern Gulf of Mexico. MARFIN Final Report.

Ingram, GW 2001. Stock structure of gray triggerfish, *Ballistes capriscus*, on multiple spatial scales in the Gulf of Mexico. PhD Dissertation, Department of Marine Sciences, University of South Alabama. 229pp.

Ingram, G.W., Jr. and W.F. Patterson, III. 1999. Movement patterns of red snapper (*Lutjanus campechanus*), greater amberjack (*Seriola dumerili*), and gray triggerfish (*Balistes capriscus*) in the Gulf of Mexico and the utility of marine reserves as management tools. Proceedings of 52nd Gulf and Caribbean Fisheries Institute, Key West, Florida.

Ishihara, M. and T. Kuwamura. 1996. Bigamy or monogamy with maternal egg care in the triggerfish, *Sufflamen chrysopterus*. *Ichthyol. Res*. 43:307-313.

Johnson, A.G. and C.H. Saloman. 1984. Age, growth, and mortality of gray triggerfish, *Balistes capriscus*, from the northeastern Gulf of Mexico. *Fish. Bull*. vol. 82, no. 3, p.485 - 492.

Jones, G.P. 1986. Food availability affects growth in a coral reef fish. *Oecologia*. 70:136-139.

Jones, G.P. 1991. Postrecruitment Processes in the Ecology of Coral reef Fish Populations: A Multifactorial Perspective. Chapter 11 (pages 294–328) *in* P.F. Sale, ed. *The Ecology of Fishes on Coral Reefs*. Academic Press. 754 pp.

Kuwamura, T. 1997. Evolution of female egg care in haremic triggerfish, *Rhinecanthus aculeatus*. *Ethology*. 103:1015-1023.

Nellis, D.W. 1980. Reproduction in the ocean triggerfish, *Canthidermis sufflamen*. *Carib. J. Sci*. 16:167.

Ofori-Danson, P.K. 1989. Growth of grey triggerfish, *Balistes capriscus*, based on checks of the dorsal spine. *Fishbyte*. December 1989, p. 11-12.

Ofori-Danson, P.K. 1990. Reproductive ecology of the triggerfish, *Balistes capriscus*, from the Ghanaian coastal waters. *Tropical Ecology*. 31:1-11.

Pease, N.L. 1984. Triggerfish: A Promising Net Profit. *Horizons*. Spring 1984, p. 30 -32.

Richards, W.J. and K.C. Lindeman. 1987. Recruitment dynamics of reef fishes: planktonic processes, settlement and demersal ecologies, and fishery analysis. *Bull. Mar. Sci*. 41:392-410.

Rose, K.A, JH Cowan, KO Williams, RA Myers, and R Hilborn 2001. Compensatory density dependence in fish populations: importance, controversy, understanding and prognosis. Fish and Fisheries 2001 (2):293-327

Smith, G.B. 1976. Ecology and distribution of eastern Gulf of Mexico reef fishes. Fla. Dep. Nat. Resour., Mar. Res. Publ. 19, 78 p.

Stephens, A. and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70 (2004), 299–310.

Thresher, R.E. 1984. *Reproduction in Reef Fishes*. T.F.H. Publications, Inc., Ltd., Hong Kong. 399 pp.

Watterson, J.C. 1998. Estimates of site fidelity and short-term movements of red snapper (*Lutjanus campechanus*) based upon mark/recapture on north-central Gulf of Mexico artificial reefs. M.S. Thesis. University of South Alabama. 75 p.

Wells, R.J.D. and J.R. Rooker. 2004. Spatial and temporal patterns of habitat use by fishes associated with Sargassum mats in the northwestern Gulf of Mexico. Bull. Mar. Sci. 74(1): 81-99.

Wilson, C.A., D.L. Nieland, and A.L. Stanley. 1995. Age, growth and reproductive biology of gray triggerfish (*Balistes capriscus*) from the northern Gulf of Mexico commercial harvest. Final Report, Coastal Fisheries Institute, Louisiana State University.

8 Tables

Table 1—Probability of Age Given Length Class

Probability of age for various fork length classes for Gulf gray triggerfish.

Prob / SE	Fork Length Class (mm)																			
Age Class (years)	100-124	125-149	175-199	200-224	225-249	250-274	275-299	300-324	325-349	350-374	375-399	400-424	425-449	450-474	475-499	500-524	525-549	550-574	575-599	600 +
0	1.000	0.000	0.002	0.000	0.001	0.119	0.053	0.009	0.004	0.004	0.003	0.005	0.004	0.003	0.006	0.007	0.004	0.007	0.007	0.001
	0.007	0.000	0.021	0.004	0.005	0.030	0.017	0.006	0.003	0.003	0.005	0.005	0.005	0.009	0.016	0.003	0.013	0.003	0.003	0.015
1	0.000	0.978	0.002	0.605	0.122	0.208	0.185	0.176	0.117	0.057	0.048	0.010	0.013	0.003	0.006	0.007	0.005	0.032	0.007	0.001
	0.000	0.148	0.018	17.143	0.025	0.039	0.045	0.072	0.035	0.012	0.055	0.007	0.010	0.009	0.016	0.003	0.004	0.011	0.003	0.015
2	0.000	0.022	0.525	0.395	0.267	0.289	0.269	0.294	0.297	0.190	0.143	0.130	0.038	0.031	0.007	0.008	0.005	0.008	0.008	0.002
	0.007	0.148	0.044	17.165	0.051	0.043	0.063	0.118	0.083	0.021	0.162	0.024	0.017	0.064	0.017	0.003	0.005	0.003	0.003	0.214
3	0.000	0.000	0.466	0.000	0.116	0.154	0.205	0.215	0.188	0.315	0.305	0.248	0.160	0.142	0.142	0.034	0.039	0.008	0.007	0.002
	0.000	0.000	0.043	0.003	0.024	0.034	0.049	0.087	0.054	0.025	0.342	0.031	0.033	0.287	0.342	0.013	0.039	0.003	0.003	0.017
4	0.000	0.000	0.002	0.000	0.152	0.097	0.105	0.136	0.179	0.188	0.192	0.267	0.314	0.205	0.219	0.129	0.093	0.155	0.088	0.198
	0.000	0.000	0.011	0.003	0.065	0.028	0.028	0.056	0.052	0.021	0.215	0.031	0.042	0.413	0.527	0.045	0.059	0.065	0.042	2.131
5	0.000	0.000	0.001	0.000	0.228	0.084	0.096	0.094	0.105	0.105	0.134	0.155	0.172	0.296	0.232	0.268	0.156	0.099	0.224	0.218
	0.000	0.000	0.004	0.003	0.079	0.026	0.026	0.040	0.032	0.016	0.151	0.026	0.034	0.596	0.558	0.060	0.074	0.040	0.083	2.353
6	0.000	0.000	0.001	0.000	0.112	0.024	0.070	0.044	0.083	0.070	0.076	0.047	0.110	0.142	0.197	0.170	0.304	0.181	0.224	0.198
	0.000	0.000	0.008	0.003	0.071	0.014	0.021	0.020	0.026	0.014	0.086	0.015	0.028	0.287	0.473	0.051	0.094	0.069	0.083	2.130
7	0.000	0.000	0.001	0.000	0.001	0.009	0.012	0.022	0.013	0.036	0.059	0.082	0.136	0.099	0.132	0.157	0.133	0.065	0.125	0.001
	0.002	0.000	0.018	0.000	0.006	0.009	0.214	0.386	0.227	0.010	0.972	0.019	0.031	1.570	2.011	0.049	0.069	0.044	0.066	0.102
8	0.000	0.000	0.001	0.000	0.001	0.004	0.002	0.004	0.008	0.012	0.024	0.028	0.020	0.057	0.036	0.075	0.133	0.099	0.156	0.153
	0.002	0.000	0.018	0.000	0.006	0.006	0.002	0.003	0.141	0.006	0.417	0.012	0.013	0.948	0.607	0.036	0.069	0.054	0.073	9.111
9	0.000	0.000	0.001	0.000	0.000	0.009	0.003	0.003	0.003	0.005	0.011	0.018	0.020	0.014	0.013	0.054	0.093	0.099	0.006	0.001
	0.000	0.000	0.001	0.002	0.005	0.009	0.003	0.003	0.002	0.004	0.014	0.009	0.013	0.029	0.034	0.030	0.059	0.054	0.010	0.025
10+	0.000	0.000	0.001	0.000	0.001	0.004	0.002	0.003	0.003	0.017	0.004	0.011	0.014	0.009	0.012	0.091	0.036	0.246	0.149	0.225
	0.000	0.000	0.000	0.005	0.000	0.002	0.001	0.002	0.001	0.007	0.004	0.007	0.010	0.019	0.029	0.031	0.034	0.064	0.056	2.428

Table 2—Mortality Estimates by Location from Catch Curves
Total and fishing mortality with 95% confidence limits.

State-Sector	*Z*	LCL*Z*	UCL*Z*	*M*	*F*	LCL*F*	UCL*F*
AL recreational	0.6477	0.4339	0.8614	0.27047	0.37720	0.16342	0.59097
FL Panhandle recreational	0.4070	0.2438	0.5701	0.27047	0.13651	-0.02665	0.29968
FLWest Coast commercial	0.4022	0.2868	0.5176	0.27047	0.13170	0.01629	0.24711
FL West Coast recreational	0.3432	0.2055	0.4809	0.27047	0.07275	-0.06492	0.21042
LA recreational	0.5555	0.3562	0.7548	0.27047	0.28501	0.08568	0.48434
TX recreational	0.4083	0.2786	0.5379	0.27047	0.13779	0.00818	0.26740

Table 3—Morphometric Conversions
Various morphometric conversion factors by source.

Region	Y	X	Sex	Equation	r^2	n
Alabama (Ingram 2001)	TL(mm)	FL(mm)	pooled	Y=-10.5017 + 1.1889X	0.96	2873
	Weight(kg)	FL(mm)	male	$Y=(1.566\times10^{-8})(X)^{3.0616}$	0.99	748
	Weight(kg)	FL(mm)	female	$Y=(1.792\times10^{-8})(X)^{3.0457}$	0.99	775
	Weight(kg)	FL(mm)	pooled	$Y=(2.039\times10^{-8})(X)^{3.0203}$	0.99	1533
FL West Coast (Hood and Johnson 1997)	TL(mm)	FL(mm)	pooled	Y=-2.6 + 1.13X	0.99	854
	FL(mm)	TL(mm)	pooled	Y=3.4 + 0.88X	0.99	854
	Weight(g)	Gutted Weight(g)	pooled	Y=-11.8 + 1.15X	0.99	89
	$\log_{10}$Weight(g)	$\log_{10}$TL	pooled	$\log_{10}(Y)=-4.60 + 2.87\log_{10}(X)$	0.91	646
	$\log_{10}$Gutted Weight(g)	$\log_{10}$TL	pooled	$\log_{10}(Y)=-5.01 + 3.03\log_{10}(X)$	0.99	170

Table 4—Metaanalytic Approach to Life History Parameters

Proposed guideline indices of productivity for exploited fish species based on meta-analysis of similar species.

Parameter	**Productivity**			**Species**
	Low	**Medium**	**High**	Gray Triggerfish
M	**<0.2**	**0.2 - 0.5**	**>0.5**	0.2, **0.27**, 0.5
K	**<0.15**	**0.15 - 0.33**	**> 0.33**	**0.43**
t_{mat} (years)	**> 8**	**3.3 - 8**	**< 3.3**	**1**
t_{max} (years)	**>25**	**14 - 25**	**<14**	**16**
Examples	orange roughy, many sharks	cod, hake	sardine, anchovy	Gray Triggerfish Productivity Score = 2.5 (HighMedium)

Table 5—Commercial Landings (pounds) by Year, State, and Species/Group from all waters (Gulf of Mexico, Atlantic, Caribbean)

	triggerfish unclassified							gray triggerfish							
	TX	LA	MS	AL	wFL	eFL	subtotal	TX	LA	MS	AL	wFL	eFL	subtotal	total
1963					11,500	6,900	18,400								18,400
1964					24,000	5,600	29,600								29,600
1965					25,700	2,200	27,900								27,900
1966					13,900	1,600	15,500								15,500
1967					17,400	3,500	20,900								20,900
1968					12,500	3,300	15,800								15,800
1969					22,300	1,700	24,000								24,000
1970					24,200	2,300	26,500								26,500
1971					40,400	5,300	45,700								45,700
1972					62,600	9,300	71,900								71,900
1973					53,200	9,900	63,100								63,100
1974					54,000	17,600	71,600								71,600
1975					78,000	35,000	113,000								113,000
1976					84,500	21,700	106,200								106,200
1977					59,386	20,801	80,187								80,187
1978					58,823	27,818	86,641								86,641
1979					101,403	26,628	128,031								128,031
1980					96,529	17,129	113,658								113,658
1981					89,860	9,876	99,736								99,736
1982					96,673	7,666	104,339								104,339
1983				2,670	71,360	18,180	92,210								92,210
1984		32		14,694	55,450	21,078	91,254								91,254
1985	336	4,766	25	11,840	75,961	23,777	116,705								116,705
1986	572	14,493	4,008	5,881	70,978	17,601	113,533								113,533
1987	289	21,941	5,550	3,778	92,742	16,979	141,279								141,279
1988	1,885	36,980	8,242	7,641	140,790	29,477	225,015								225,015
1989	429	60,856	7,682	10,389	238,974	50,063	368,393								368,393
1990	6,951	69,798	9,027	16,613	359,553	84,691	546,633								546,633
1991	6,242	90,572	7,991	6,993	332,674	105,267	549,739								549,739
1992	7,941	101,495	12,433	6,551	321,883	86,731	537,034								537,034
1993	11,287	123,484	27,045	10,413	374,260	75,966	622,455		5,345	11,228				16,573	639,028
1994		96,757	50	8,389	247,156	71,009	423,361	15,428	23,001	15,332				53,761	477,122
1995		75,736	3	5,268	208,449	89,641	379,097	27,371		22,678				50,049	429,146
1996		76,151	198	2,867	158,525	61,522	299,263	17,226	3,162	12,446				32,834	332,097
1997		48,973	21	2,534	109,762	62,241	223,531	16,798	1,105	8,792				26,695	250,226
1998		37,952	82	1,288	107,574	40,533	187,429	21,057		10,038				31,095	218,524
1999			147	1,709	119,777	31,599	153,232	13,281	83,394	5,466				102,141	255,373
2000			66	2,211	69,643	21,989	93,909	9,775	73,359	4,485	140			87,759	181,668
2001			19	3,795	104,275	21,938	130,027	15,202	51,317	2,222	132			68,873	198,900
2002			8		142,034	36,268	178,310	14,548	71,144	1,530	6,988			94,210	272,520
2003			26		158,849	26,298	185,173	20,810	62,251	1,754	9,135			93,950	279,123
2004			14		131188	45252	176454	27695	48666	1676	10828			88865	265319

Table 6—Commercial Landings (pounds) by Year and State

Totals include fish classified as gray trigger and unclassified triggerfish from Gulf of Mexico waters.

	TX	LA	MS	AL	wFL	eFL	total
1963					7,300		7,300
1964					20,000		20,000
1965					21,700		21,700
1966					13,800		13,800
1967					17,400		17,400
1968					12,500		12,500
1969					22,300		22,300
1970					24,200		24,200
1971					40,400		40,400
1972					62,600		62,600
1973					53,200		53,200
1974					53,100		53,100
1975					78,000		78,000
1976					84,500		84,500
1977					59,386		59,386
1978					58,715		58,715
1979					101,403		101,403
1980					96,423		96,423
1981					89,860		89,860
1982					96,673		96,673
1983				2,670	70,749		73,419
1984		32		14,694	55,435	33	70,194
1985	336	4,766	25	11,840	75,659		92,626
1986	572	14,493	4,008	5,881	70,675		95,629
1987	289	21,941	5,550	3,778	92,045		123,603
1988	1,885	36,980	7,933	7,641	140,623		195,062
1989	429	60,856	7,682	10,389	238,276		317,632
1990	6,908	69,758	9,027	16,613	356,654	78	459,038
1991	6,203	90,572	7,991	6,993	332,674	97	444,530
1992	7,891	101,436	12,433	6,551	321,883		450,195
1993	11,154	128,588	38,273	10,413	370,174	126	558,728
1994	15,391	119,758	15,382	8,389	245,785	14	404,720
1995	27,356	75,736	22,681	5,268	206,836		337,877
1996	17,138	79,313	12,644	2,867	155,283	272	267,516
1997	16,767	50,078	8,813	2,534	106,419	79	184,689
1998	21,037	37,952	10,120	1,288	106,312	15	176,723
1999	13,281	83,394	5,613	1,709	114,906	117	219,020
2000	9,703	73,359	4,551	2,351	68,148	24	158,137
2001	15,202	51,317	2,241	3,927	103,495		176,182
2002	14,548	71,144	1,538	6,988	141,138	206	235,563
2003	20,804	62,251	1,780	9,135	157,840		251,810
2004	27,589	48,666	1,690	10,828	129,697	62	218,533

Table 7—Commercial Landings (pounds) by Year, Gear, and Region

Totals include fish classified as gray trigger and unclassified triggerfish from Gulf of Mexico waters.

	handline+		longline		trap		
	west US Gulf	east US Gulf	west US Gulf	east US Gulf	west US Gulf	east US Gulf	total
1963	4,200	3,100					7,300
1964	4,300	15,700					20,000
1965	4,300	17,400					21,700
1966	5,200	8,600					13,800
1967	5,200	12,200					17,400
1968	3,900	8,600					12,500
1969	7,700	14,600					22,300
1970	8,200	16,000					24,200
1971	9,900	30,500					40,400
1972	15,200	47,400					62,600
1973	13,200	40,000					53,200
1974	13,100	40,000					53,100
1975	16,000	62,000					78,000
1976	14,800	69,700					84,500
1977	9,290	50,096					59,386
1978	10,197	48,518					58,715
1979	31,814	65,670	3,919				101,403
1980	28,707	64,015	2,294	1,406			96,423
1981	20,636	61,465	4,726	3,033			89,860
1982	26,316	55,317	7,398	7,642			96,673
1983	19,350	40,486	4,481	9,102			73,419
1984	29,392	29,099	3,334	8,346	23		70,194
1985	32,230	43,333	5,556	11,507			92,626
1986	14,919	60,397	7,852	12,461			95,629
1987	33,653	65,974	637	23,339			123,603
1988	54,586	124,927	2,498	13,051			195,062
1989	77,330	187,798	9,941	30,166		12,397	317,632
1990	99,018	270,238	279	12,979	54	76,469	459,038
1991	103,179	341,216	32	8		96	444,530
1992	111,628	173,268	368	143,092	79	21,758	450,195
1993	174,339	286,999	452	13,557	2,657	80,723	558,728
1994	152,702	200,702	439	20,207		30,669	404,720
1995	130,156	182,072	509	6,385		18,755	337,877
1996	124,950	112,642	381	6,722		22,821	267,516
1997	75,918	80,972	991	10,456		16,352	184,689
1998	70,479	87,576	92	5,521		13,055	176,723
1999	102,620	93,581	206	9,516		13,097	219,020
2000	94,814	48,132	281	5,467		9,442	158,137
2001	67,669	87,073	49	6,129		15,261	176,182
2002	86,904	128,026	59	3,052		17,522	235,563
2003	85,385	143,688		8,571		14,166	251,810
2004	76,381	114,102	741	14,229		13,080	218,533

Table 9—Bycatch Estimates from Shrimp Fleet
Summary of unexpected levels and ranges for shrimp fleet bycatch estimates for the SEDAR9 species from SEDAR9-DW-26, compared with similar analyses for red snapper, and some supporting statistics.

	Gray Triggerfish	**Red Snapper**
average CPUE x approx effort	3.8M	27.6M
SEDAR7 model results		
median of annual medians	8.3M	26.3M
range of annual medians	130x	15x
range of annual 95% ci ranges	4.9x-67x	1.7x-29x
Delta model results		
median of annuals	2.2m	13M
range of annual medians	140x	6x
range of annual 95% ci ranges	3.9x-360x	1.4x-6.7x
Model 3 results		
median of annuals	1.7M	14M
range of annual medians	160x	19x
range of annual 95% ci ranges	810x-1300x	190x-270x
frequency of occurrence in C	9%	43%
frequency of occurrence in R	8%	30%
frequency of occurrence in B	0	55%
number of stations		
C	2863	9943
R	26983	26486
B	402	8130

C refers to observer data for commercial shrimp tows without BRDs
B refers to observer data for commercial shrimp tows with BRDs
R refers to research vessel (Oregon II) tows

Table 10—Standardized Fishery Dependent Indices

Preliminary results from a generalized linear modeling (GLM) standardization procedure, applied to each of three fishery dependent data series: Marine Recreational Fisheries Statistics Survey (MRFSS), headboat surveys (HB), and commercial handline logbook records (CmHL).

YEAR	MRFSS		HB		CmHL	
	ln(CPUE)	SE	ln(CPUE)	SE	ln(CPUE)	SE
1981	-0.73841	0.664575				
1982	-0.13741	0.791705				
1983	-0.75398	0.701211				
1984	-1.00749	1.129571				
1985	-1.28787	0.7645				
1986	0.095956	0.228956	0.358655	0.237242		
1987	-0.3655	0.271743	0.435488	0.236496		
1988	0.173357	0.328415	0.634518	0.234249		
1989	0.791917	0.523376	0.892188	0.230057		
1990	0.846615	0.49101	1.001365	0.21588		
1991	0.274018	0.297221	1.072999	0.216655		
1992	0.61553	0.223591	1.217308	0.214983		
1993	0.035172	0.240358	0.921846	0.21026	0.066111	0.131782
1994	-0.02243	0.273638	0.758721	0.208563	0.306531	0.119644
1995	-0.02395	0.325085	0.557595	0.213566	0.561	0.142356
1996	-0.40134	0.275559	0.458898	0.217863	0.311129	0.108223
1997	-0.30689	0.212177	0.370537	0.221584	0.247547	0.104575
1998	-0.59082	0.169536	0.349206	0.218645	0.137542	0.104335
1999	-0.29001	0.134901	0.346791	0.226467	0.261546	0.095402
2000	-0.54454	0.138038	0.225678	0.231349	0.124708	0.105021
2001	-0.22646	0.150328	0.125933	0.229549	0.244972	0.103453
2002	-0.32847	0.137688	0.192833	0.245457	0.432149	0.097882
2003	-0.44001	0.136298	0.348264	0.245239	0.61988	0.097557
2004	-0.09139	0.124442			0.506137	0.101281

Table 11—Standardized Fishery Independent Indices

Preliminary results from analyses of various Southeast Area Monitoring and Assessment Program (SEAMAP) surveys, including fall and summer trawl surveys and video surveys.

YEAR	Fall Trawl	Summer Trawl	Video
	Median CPUE	Median CPUE	Frequency Occurrence
1972	4.478		
1973	2.838		
1974	2.128		
1975	0.9269		
1976	0.4308		
1977	4.49		
1978	1.348		
1979	1.326		
1980	3.888		
1981	2.628	0.1286	
1982	4.18	0.634	
1983	2.086	0.5065	
1984	1.75	0.3237	
1985	1.855	0.2881	
1986	2.119	0.4816	
1987	2.212	0.5751	
1988	1.902	0.2917	
1989	3.379	0.6378	
1990	0.7793	0.9617	
1991	12.91	1.377	
1992	0.7577	0.5725	0.68549
1993	6.407	0.3844	0.37395
1994	6.133	1.48	0.33632
1995	2.572	1.099	0.31823
1996	2.263	0.3611	0.29654
1997	1.545	0.8732	0.62533
1998	0.1468	0.2662	
1999	3.463	2.321	
2000	6.024	3.764	
2001	11.14	4.151	
2002	2.58	1.111	0.29957
2003	2.188	0.3406	
2004	2.616	0.3721	

Table 12. Available recreational landings in numbers (Type A + B1).

Recreational Year	Headboat Gulf	East	West	MRFSS Gulf	East	West	Texas DFW
1981				345898	307135	38763	
1982				892388	834149	58239	
1983				357551	159396	198156	27889
1984				120098	53267	66831	36599
1985				120334	104775	15559	7237
1986	45042	29024	16018	327963	316590	11373	4425
1987	38730	22033	16697	443284	438551	4732	6522
1988	68565	27125	41440	679382	669026	10356	14058
1989	80522	55630	24892	776593	727140	49453	32744
1990	131381	105816	25565	1057504	961088	96416	9190
1991	89259	58121	31138	756265	658143	98121	8930
1992	110677	68925	41752	609676	572261	37415	72429
1993	102971	58787	44184	545558	528962	16596	39204
1994	110185	53468	56717	498669	458115	40555	6302
1995	97666	45825	51841	567541	502196	65345	4439
1996	76526	36195	40331	259844	254894	4950	2317
1997	63685	34458	29227	272134	257813	14321	4965
1998	53188	37085	16103	232073	225889	6184	4852
1999	40981	34143	6838	211015	178960	32055	2973
2000	32223	26245	5978	180783	128213	52570	6741
2001	40057	32563	7494	216954	198300	18654	4460
2002	53854	44858	8996	298349	292474	5876	2767
2003	63483	46468	17015	366181	353300	12880	1885
2004	56216	43101	13115	432002	403068	28934	

Table 13. MRFSS landings in numbers by state (Type A + B1)

Year	AL	FL	LA	MS	TX
1981	19562	287573	27197		11566
1982	42019	791901	53685	229	4554
1983	10405	148991	198156		
1984	355	52912	35198	0	31633
1985		104775	10785		4774
1986	24226	292364	11373		
1987	21248	415858	4732	1446	
1988	95308	572660	10356	1058	
1989	165717	558956	49453	2467	
1990	597233	354460	96416	9395	
1991	152593	504151	98121	1399	
1992	177880	390688	37415	3692	
1993	177417	349715	16596	1830	
1994	86137	367505	40555	4473	
1995	217284	276246	65345	8666	
1996	126955	122138	4950	5800	
1997	96917	158213	14321	2683	
1998	64765	152620	6184	8505	
1999	51916	126197	32055	847	
2000	42455	85254	52570	504	
2001	62384	135559	18654	356	
2002	107235	183227	5876	2012	
2003	92958	259561	12880	781	
2004	129301	260953	28934	12815	

Table 14. Headboat landings in numbers by state.

Year	Texas	Louisiana	Alabama and Florida
1986	15611	407	29024
1987	16085	612	22033
1988	39513	1927	27125
1989	23537	1355	55630
1990	21650	3915	105816
1991	24110	7028	58121
1992	35890	5862	68925
1993	38226	5958	58787
1994	50039	6678	53468
1995	47925	3916	45825
1996	37503	2828	36195
1997	28731	496	34458
1998	15222	881	37085
1999	5854	984	34143
2000	5721	257	26245
2001	7315	179	32563
2002	8817	179	44858
2003	12782	4233	46468
2004	13115	5750	41906

Table 15. Texas DPW recreational landings in numbers by year and mode.

Year	Headboat Landings (# fish)	Charter Landings (# fish)	Private Landings (# fish)
1983	23897	152	3840
1984	33679		2920
1985		80	7157
1986	31		4394
1987		1388	5134
1988	58	203	13797
1989	53	102	32589
1990	112	315	8763
1991		137	8793
1992		1870	70559
1993			39204
1994		30	6272
1995			4439
1996		26	2291
1997		815	4150
1998		559	4293
1999		510	2463
2000			6741
2001		792	3668
2002		307	2460
2003		449	1436

9 Figures

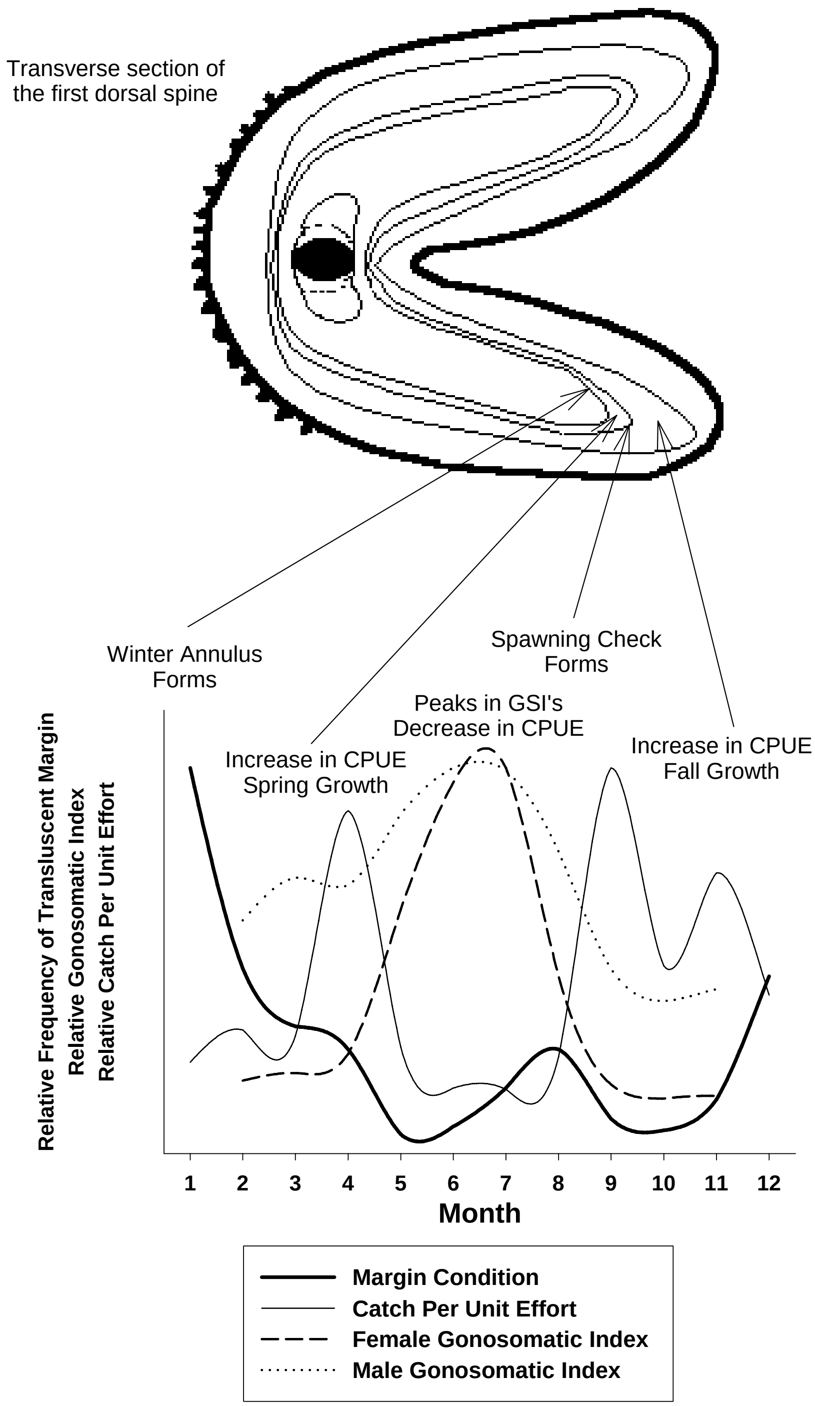

Figure 1. Annulus formation in the first dorsal spine of gray triggerfish.

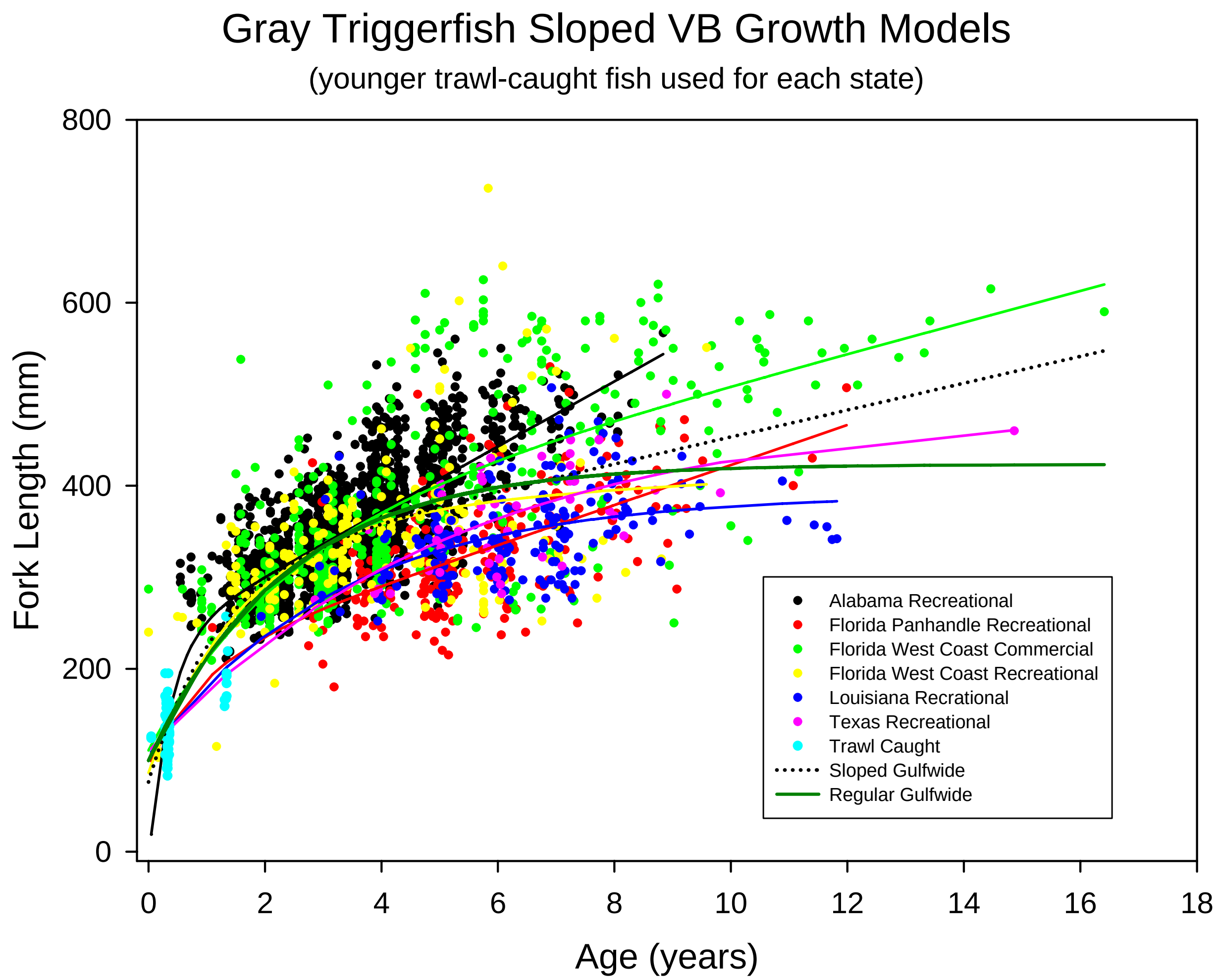

Figure 2. Regular and sloped von Bertalanffy models of Gulf of Mexico gray triggerfish.

- Alabama Recreational: $FL_{age}=229.6+(35.5536age)(1-e^{-2.9344(age-0.0179)})$
- Florida Panhandle Recreational: $FL_{age}=203.9+(21.8820age)(1-e^{-1.1739(age+0.5177)})$
- Florida West Coast Commercial: $FL_{age}=339.4+(17.0939age)(1-e^{-0.4966(age+0.7957)})$
- Florida West Coast Recreational: $FL_{age}=373.3+(3.0551age)(1-e^{-0.5968(age+0.4418)})$
- Louisiana Recreational: $FL_{age}=390.6(1-e^{-0.3071(age+1.0193)})$
- Texas Recreational: $FL_{age}=482.4(1-e^{-0.1913(age+1.3446)})$
- Sloped Gulfwide: $FL_{age}=306.4+(14.6865age)(1-e^{-0.9099\,(age+0.3142)})$
- Regular Gulfwide: $FL_{age}=423.4\,(1-e^{-0.4269\,(age+0.6292)})$

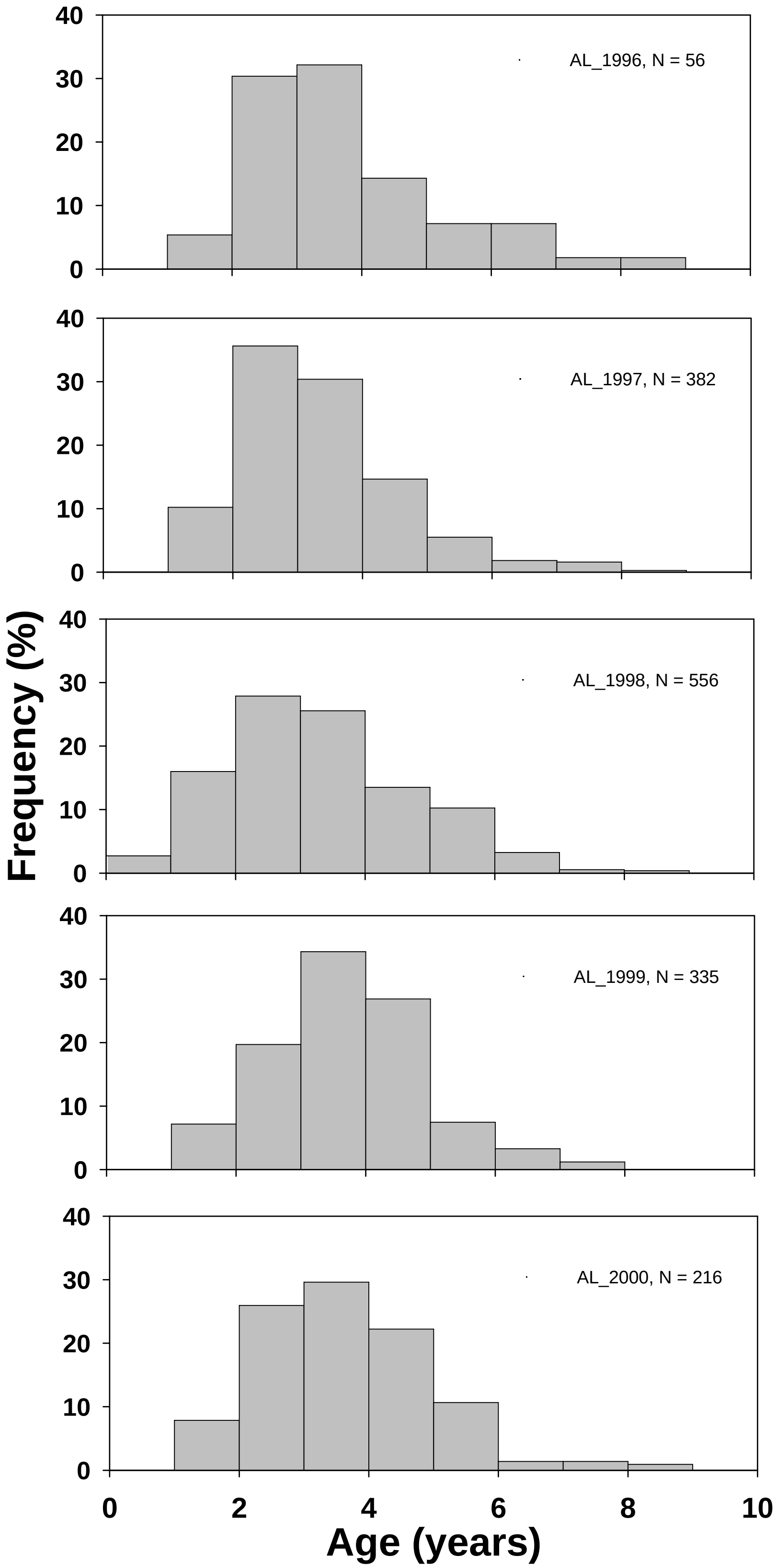

Figure 3. Age frequency histograms of gray triggerfish collected off Alabama.

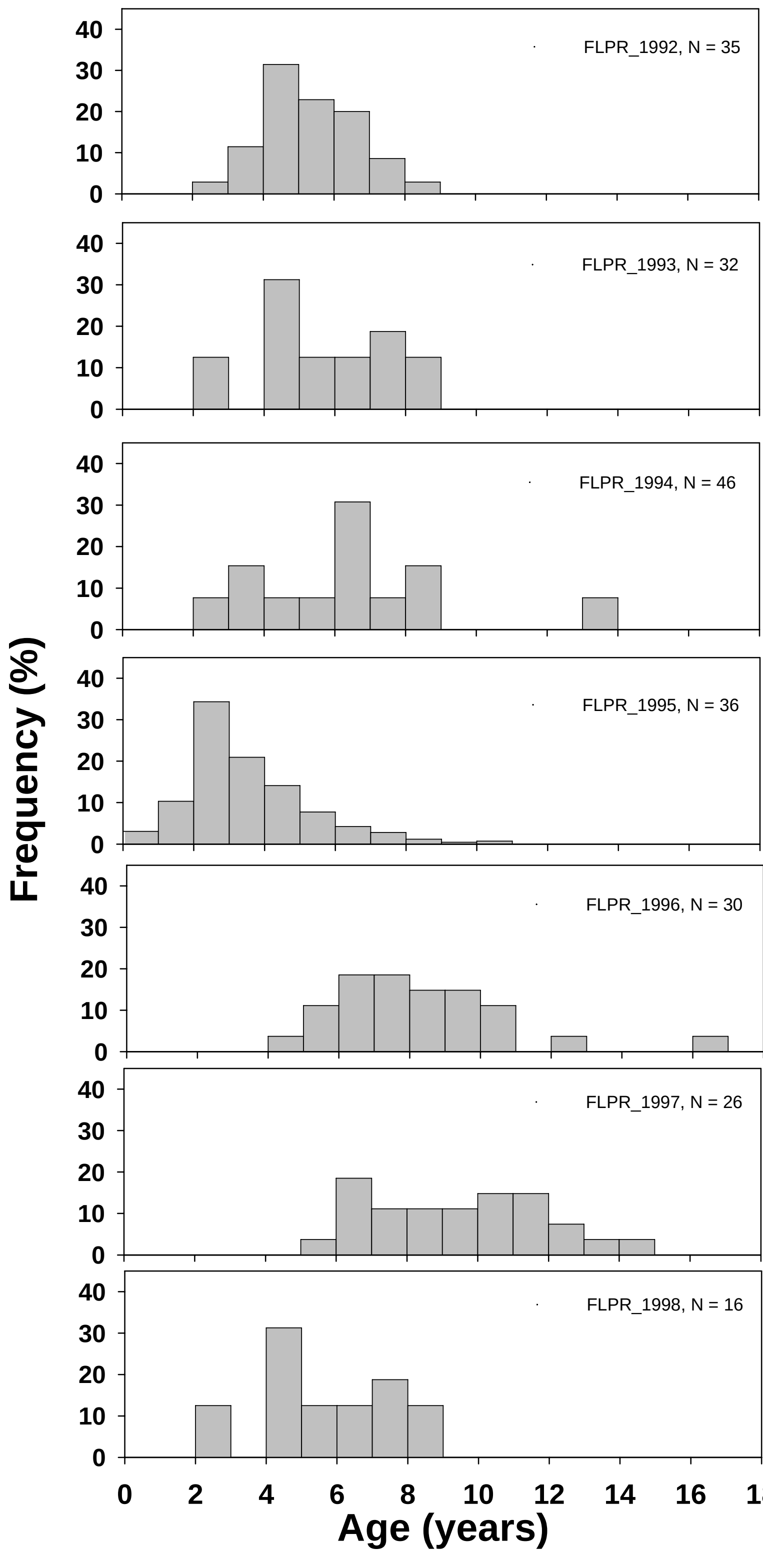

Figure 4. Age frequency histograms of gray triggerfish collected from Florida panhandle recreational fishery (1992 - 1998).

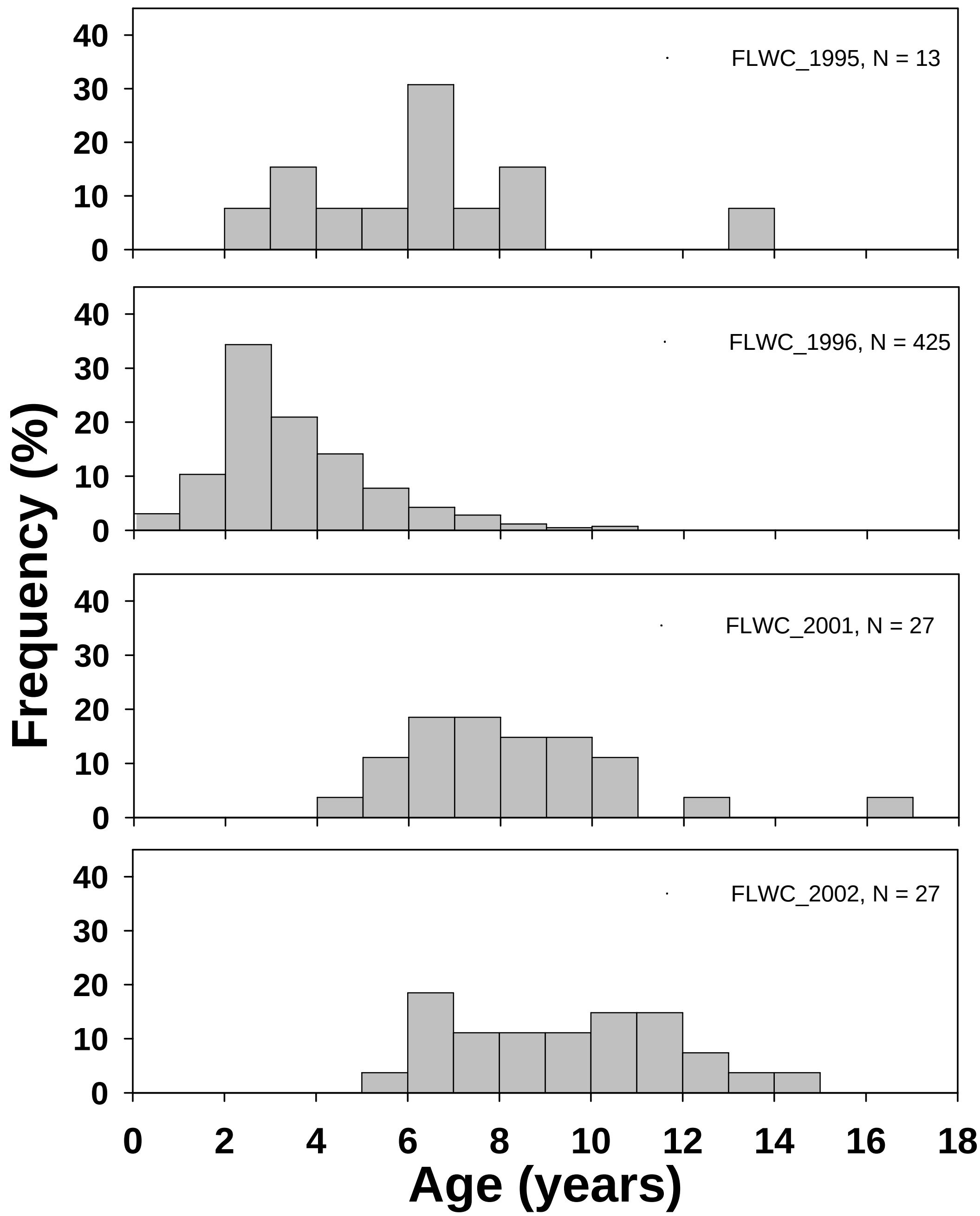

Figure 5. Age frequency histograms of gray triggerfish collected from Florida west coast commercial fishery (1995, 1996, 2001, and 2002).

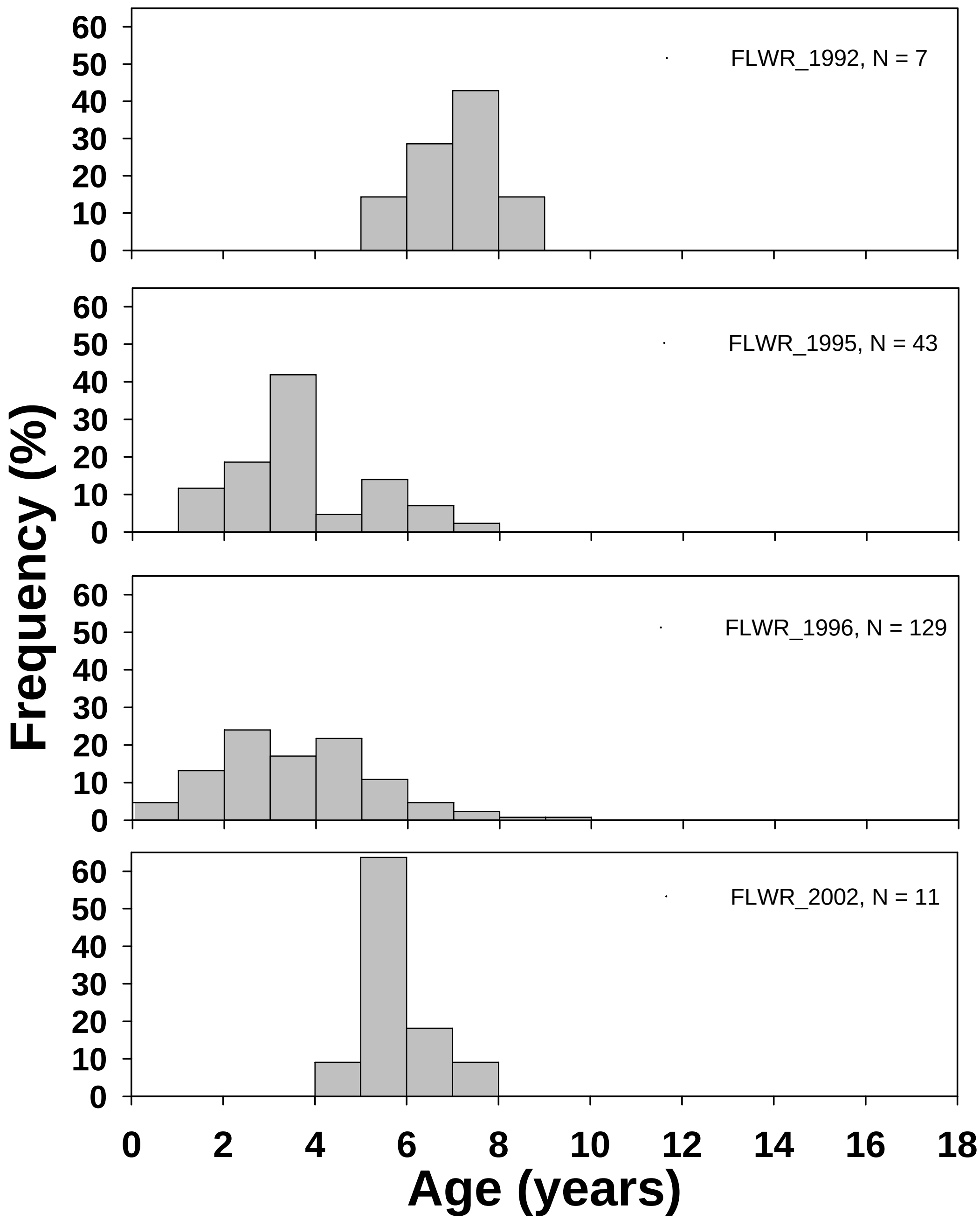

Figure 6. Age frequency histograms of gray triggerfish collected from Florida west coast recreational fishery (1992, 1995, 1996, and 2002).

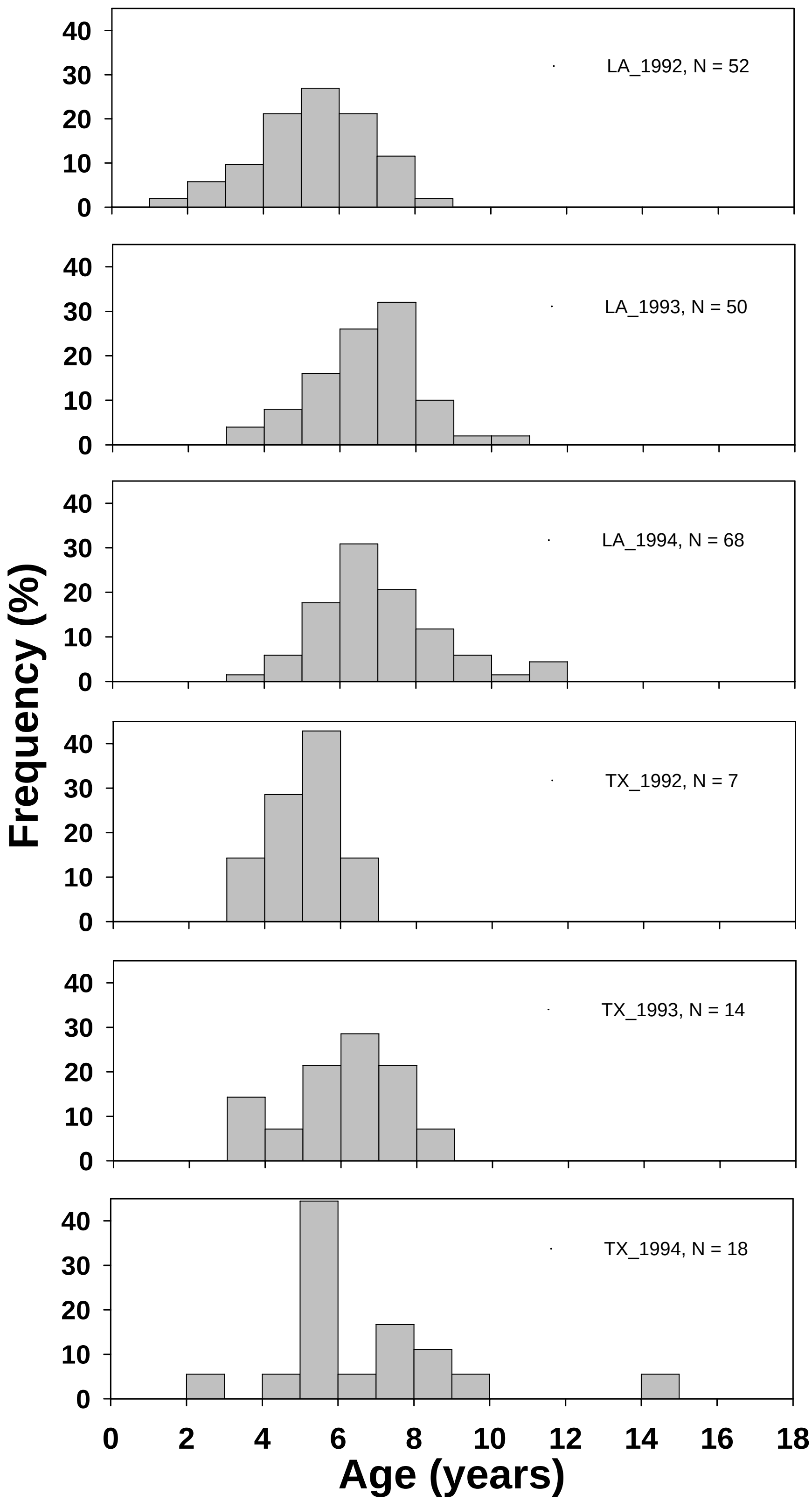

Figure 7. Age frequency histograms of gray triggerfish collected off Louisiana and Texas (1992 - 1994).

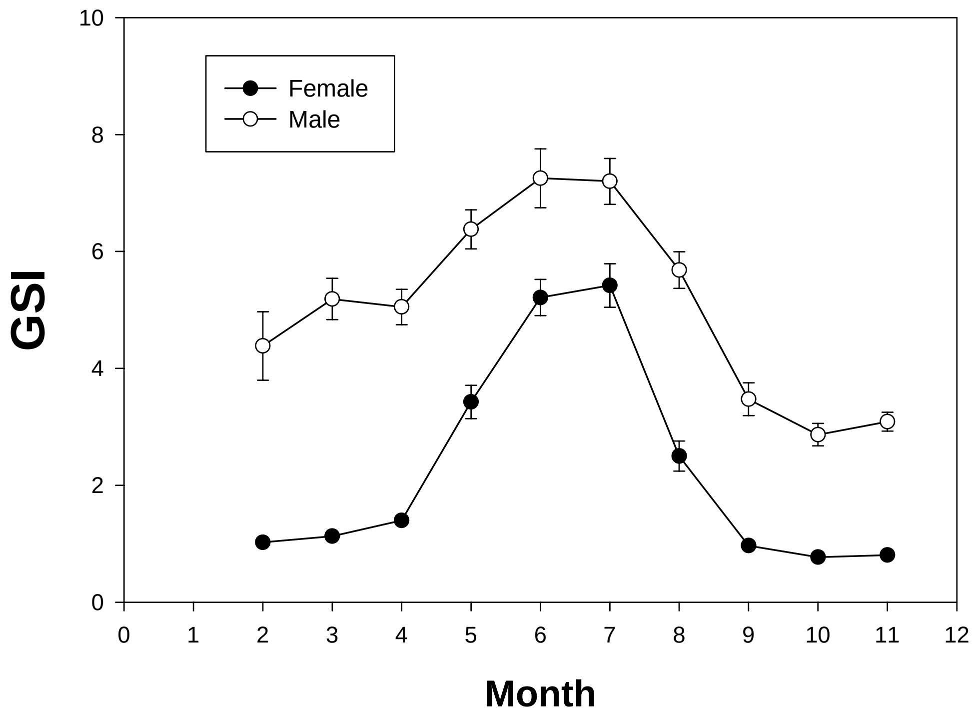

Figure 8. Mean monthly gonosomatic indices for male [100*(gonad weight as % body weight)] and female (gonad weight as % body weight) gray triggerfish. Error bars represent standard error and numbers represent monthly sample sizes.

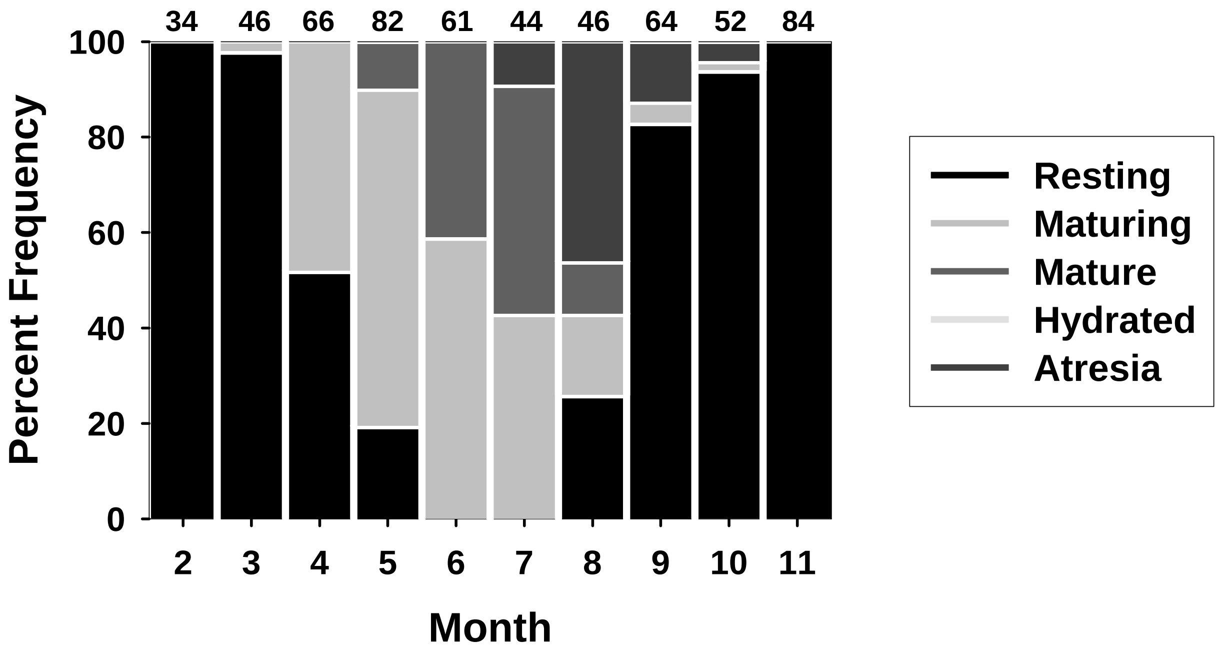

Figure 9. Monthly histological condition of female gray triggerfish gonads. Numbers on the upper axis represent monthly sample sizes.

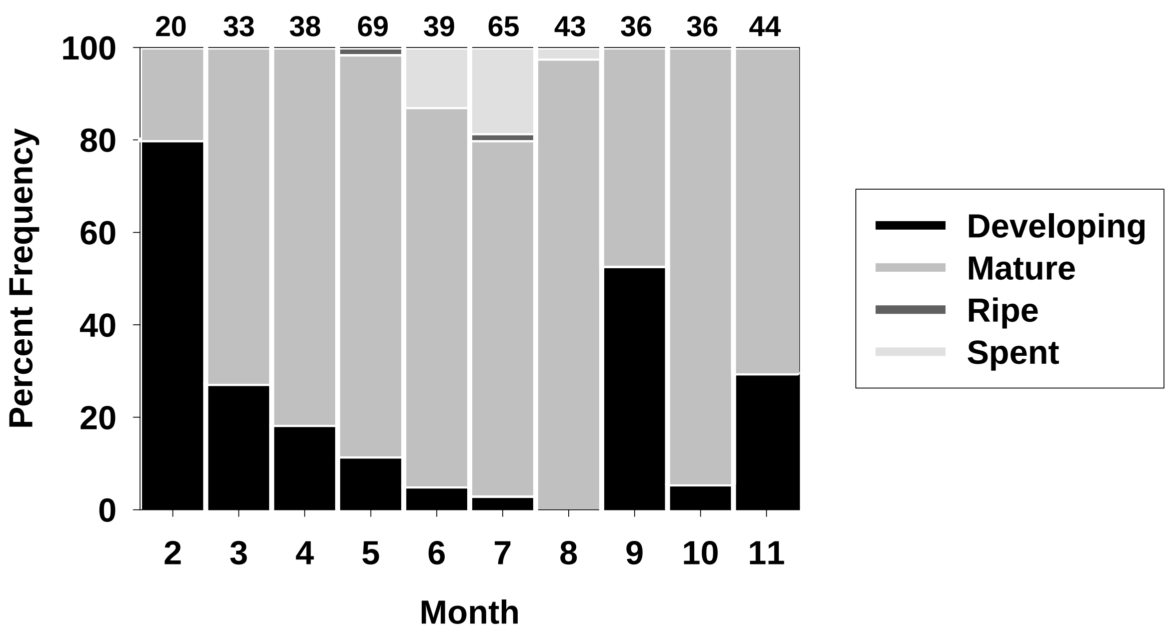

Figure 10. Monthly histological condition of male gray triggerfish gonads. Numbers on upper axis represent monthly sample sizes.

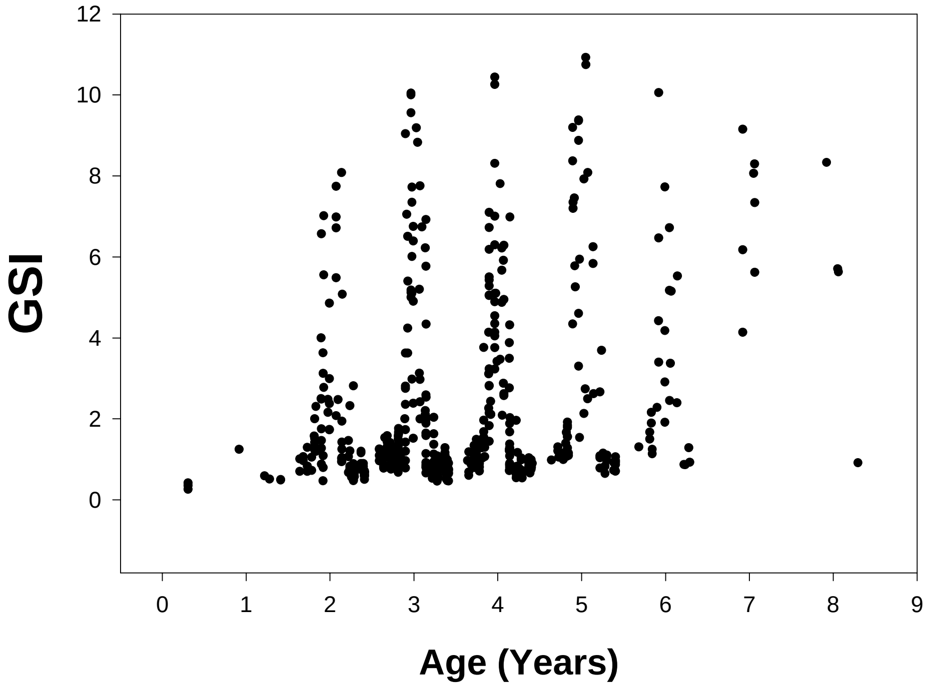

Figure 11. Gonosomatic index (gonad weight as % body weight) versus age of female gray triggerfish.

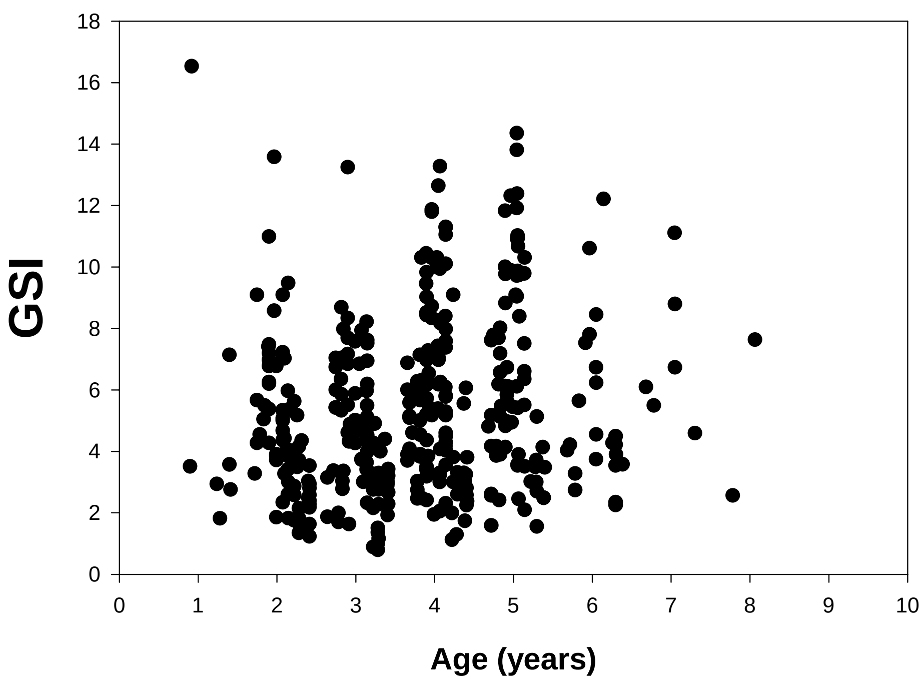

Figure 12. Gonosomatic index [100*(gonad weight as % body weight)] versus age of male gray triggerifsh.

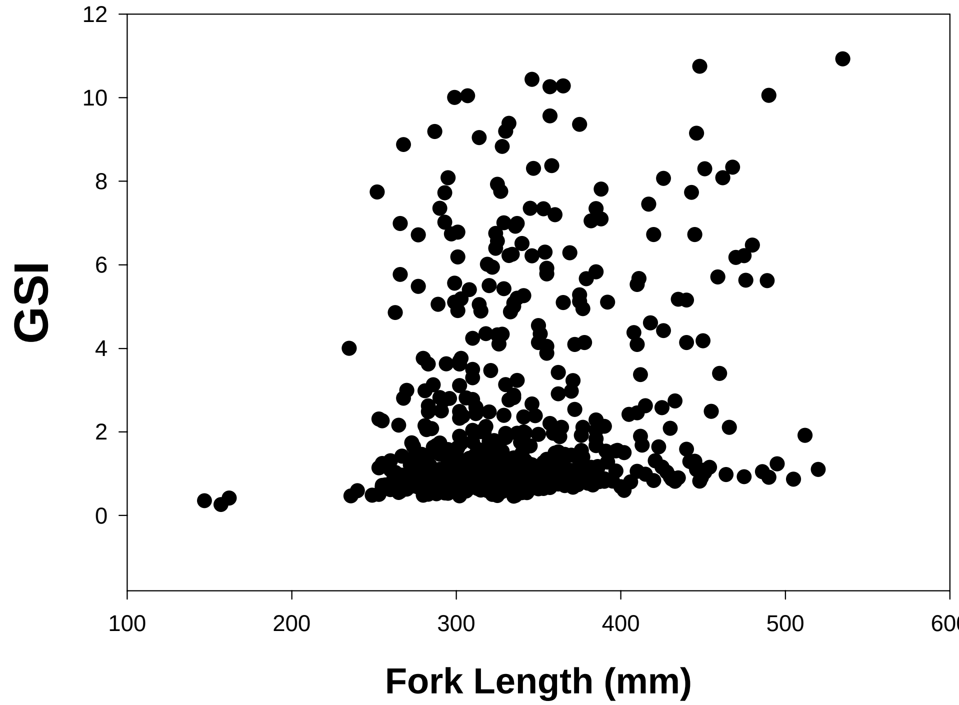

Figure 13. Gonosomatic index (gonad weight as % body weight) versus fork length of female gray triggerfish.

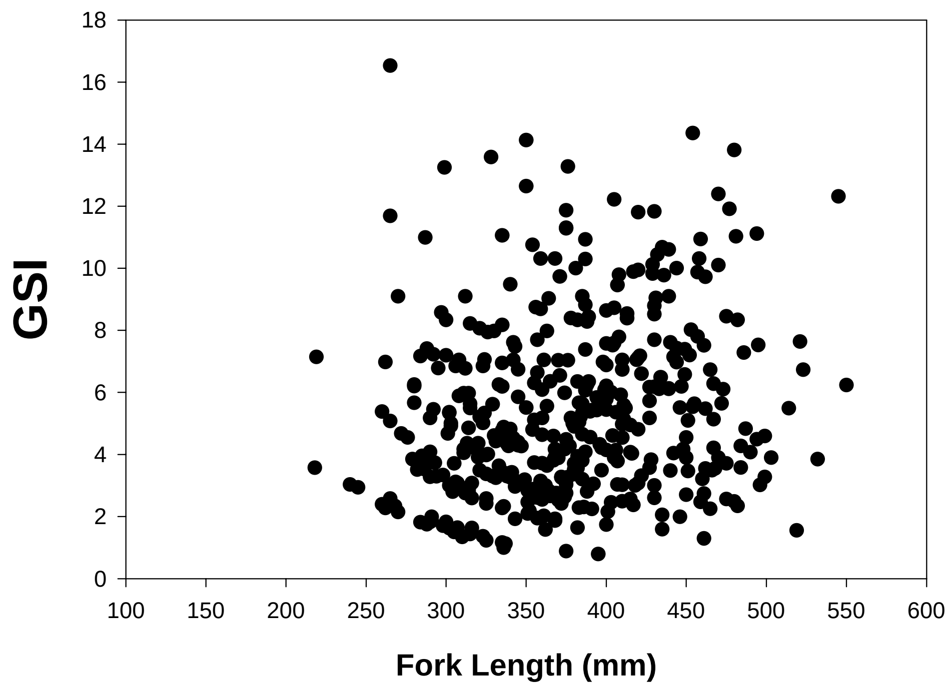

Figure 14. Gonosomatic index [100*(gonad weight as percent body weight)] versus fork length of male gray triggerfish.

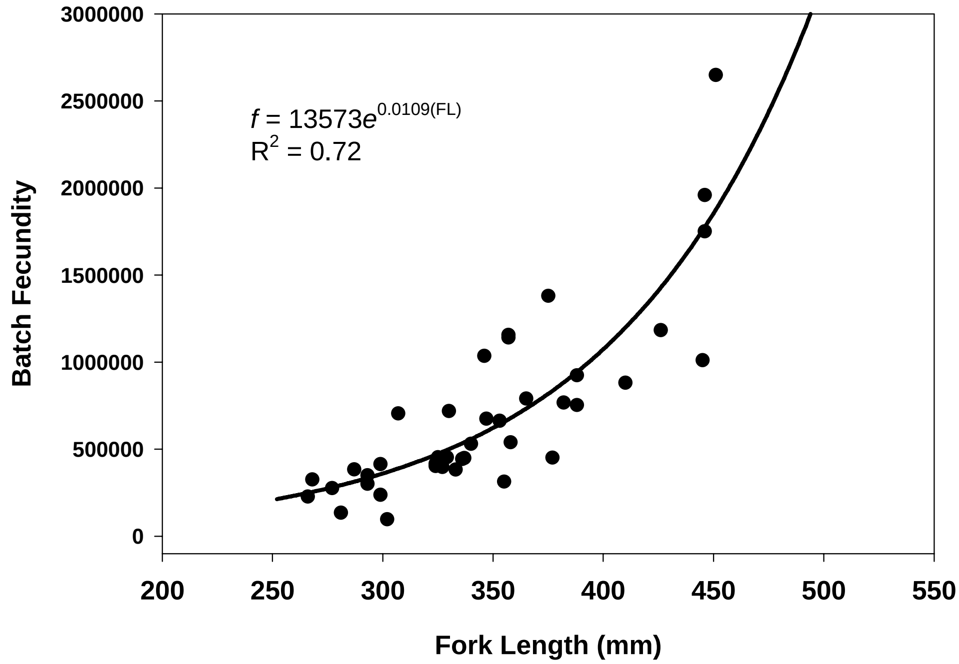

Figure 15. Batch fecundity versus fork length of gray triggerfish.

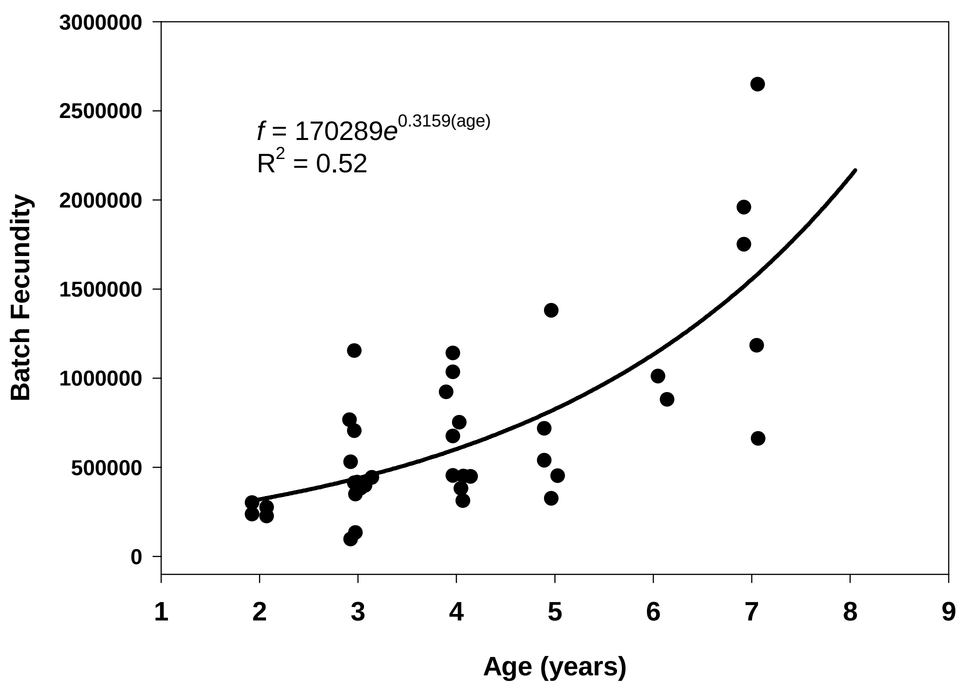

Figure 16. Batch fecundity versus age of gray triggerfish.

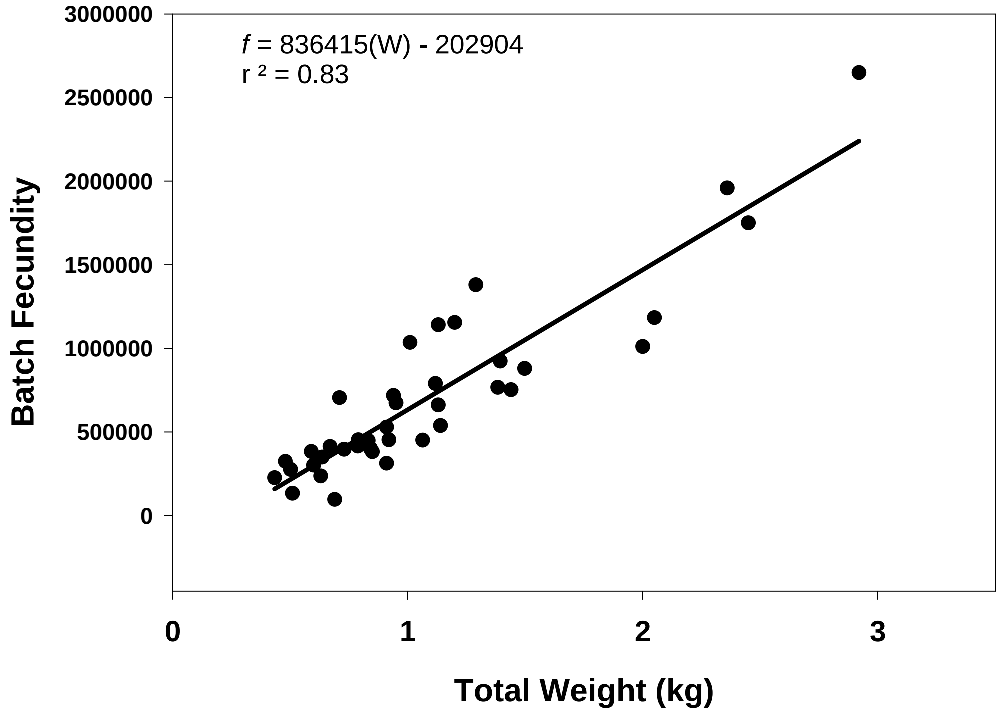

Figure 17. Batch fecundity versus total weight of gray triggerfish.

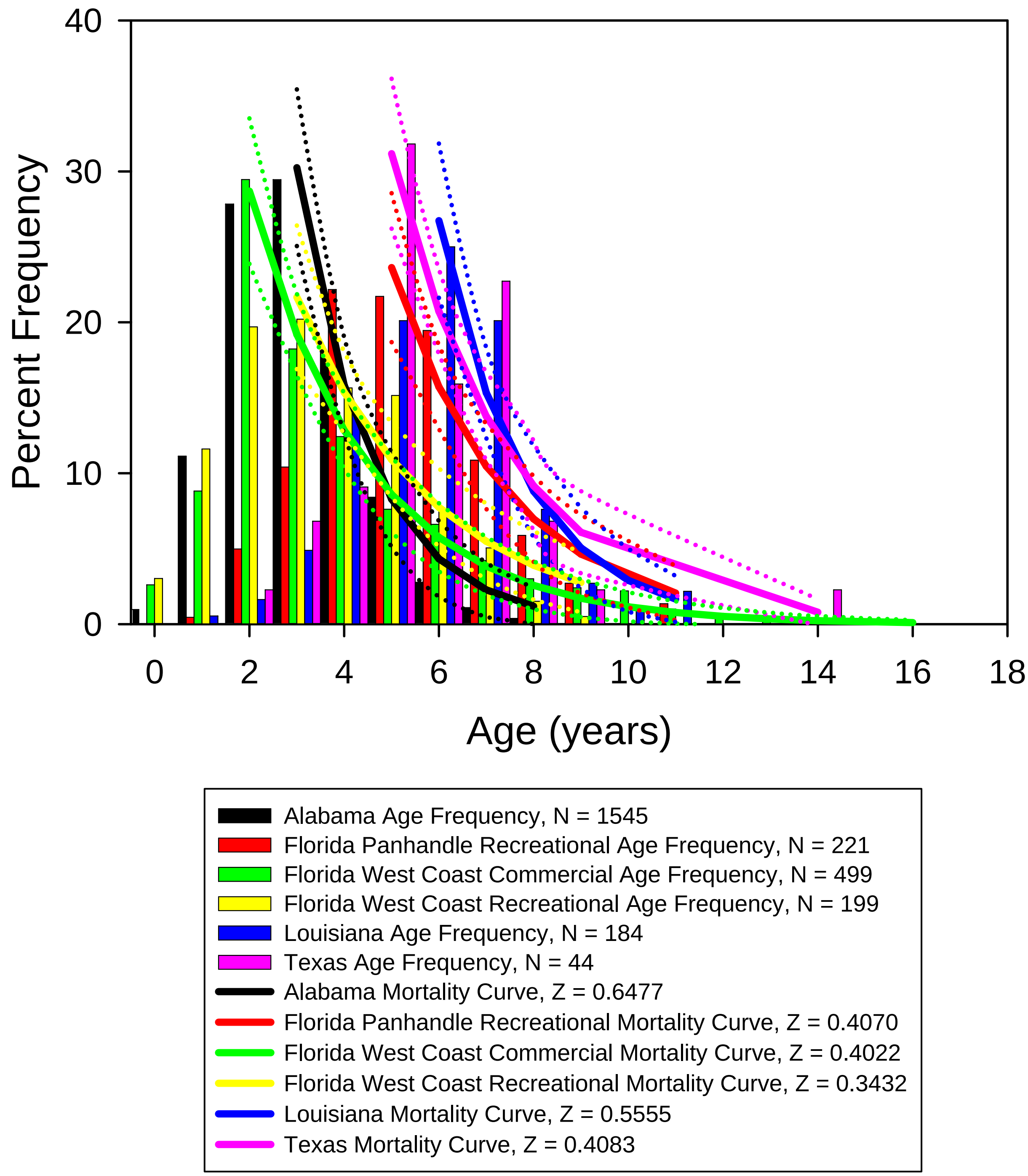

Figure 18. Age frequency histograms and total instantaneous mortality estimates by state (95 % confidence intervals shown).

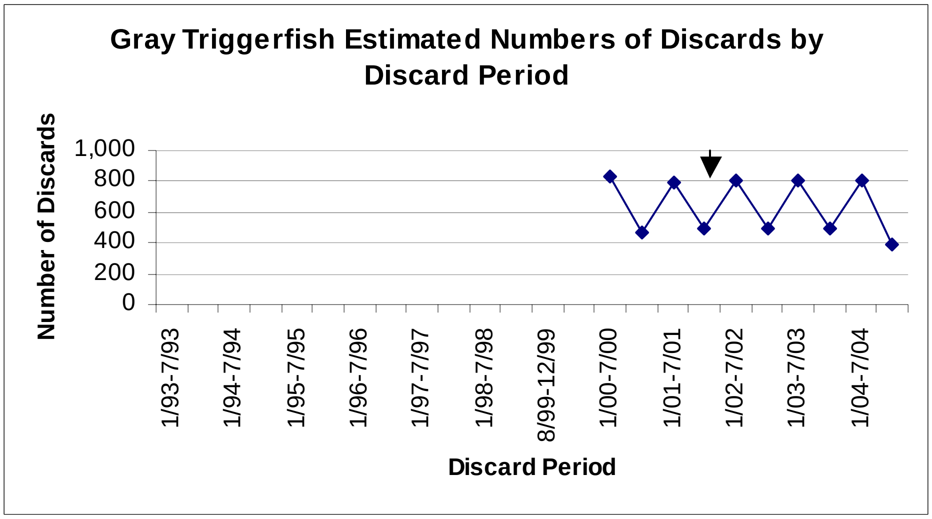

Figure 19—Estimated Numbers of Commercial Discards over Time

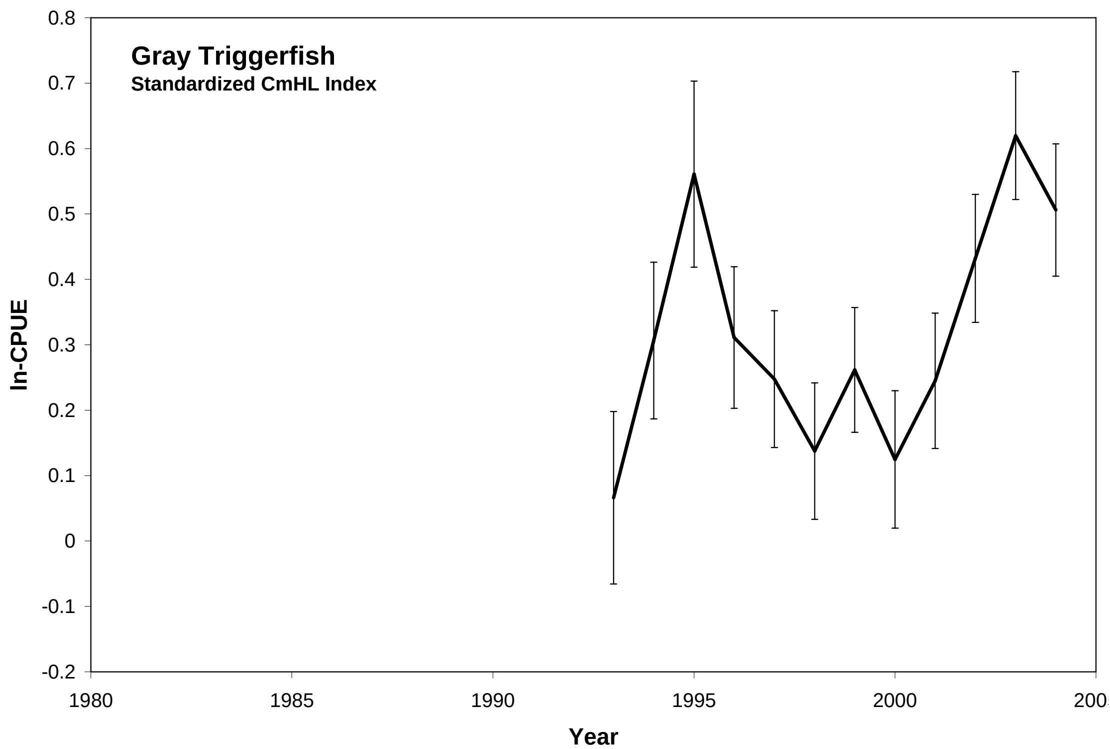

Figure 20—Standardized Commercial Handline Logbook Index
Generalized linear model (GLM) used to standardize observation. Error bars represent standard errors.

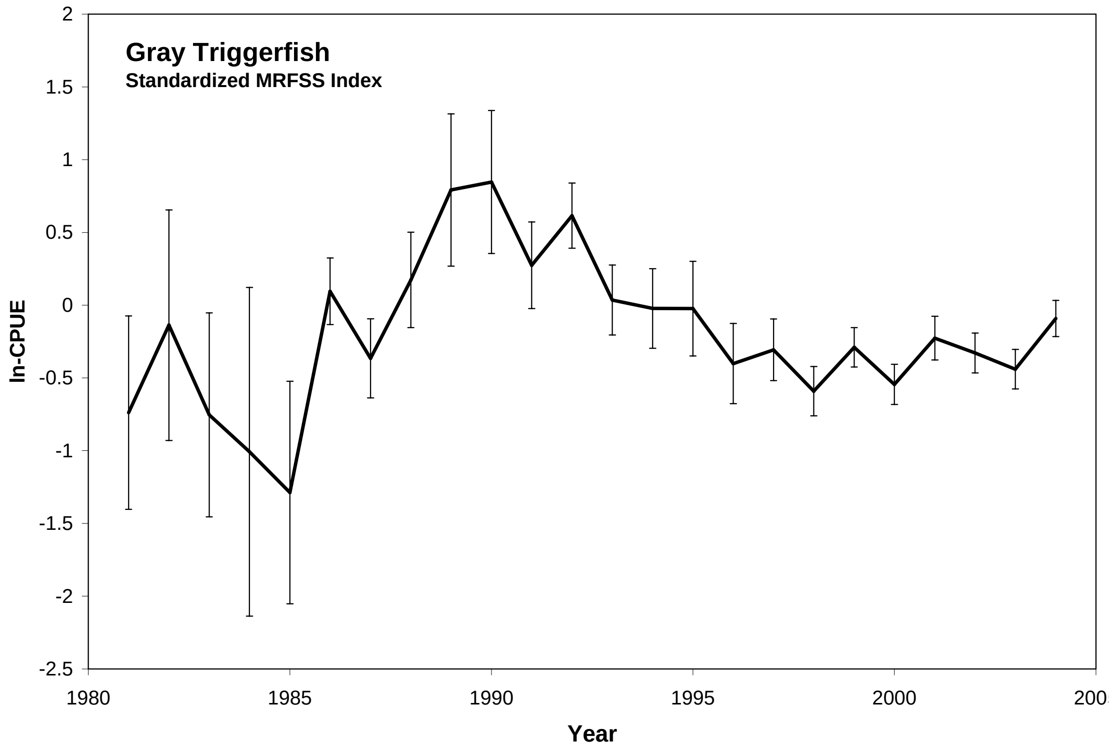

Figure 21—Standardized MRFSS Index

GLM used to standardize observation. Error bars represent standard errors.

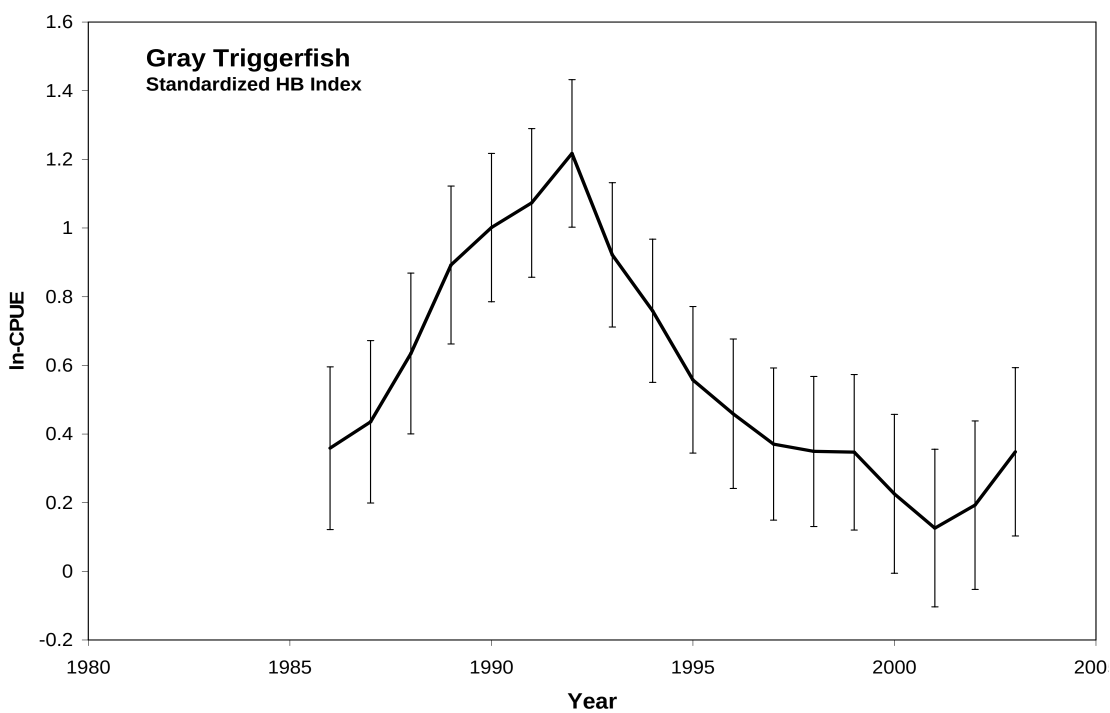

Figure 22—Standardized Headboat Index

GLM used to standardize observation. Error bars represent standard errors.

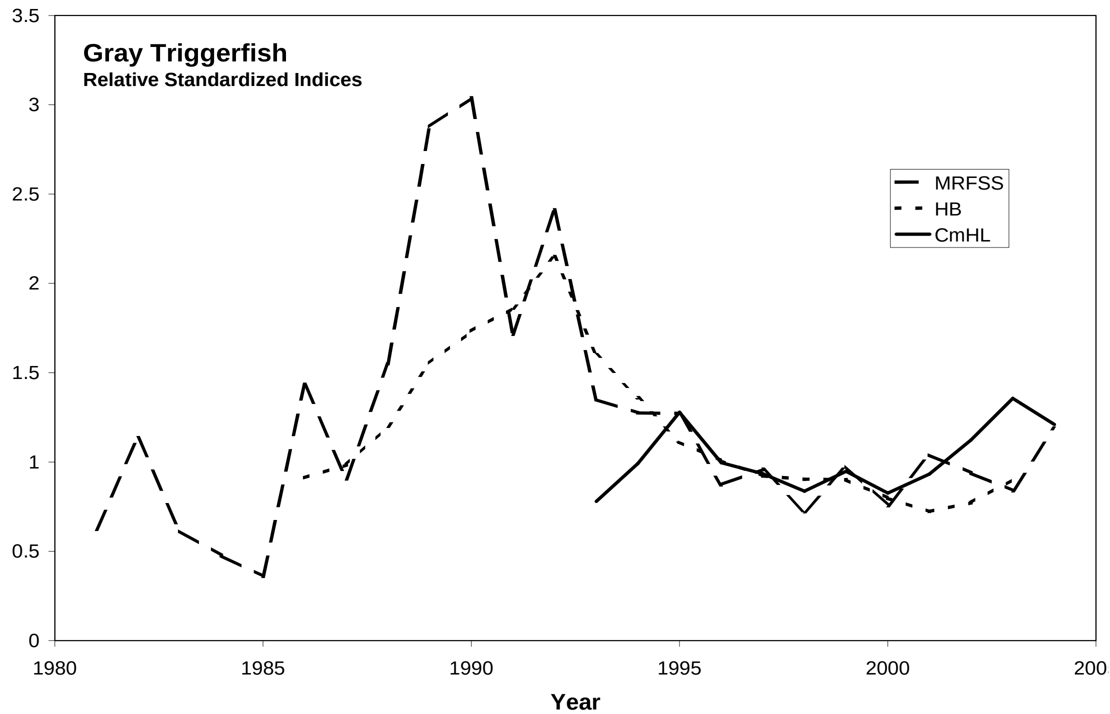

Figure 23—Relative Standardized Fishery Dependent Indices
Normalized to share an average value of 1 from the period of complete overlap, 1993-2003

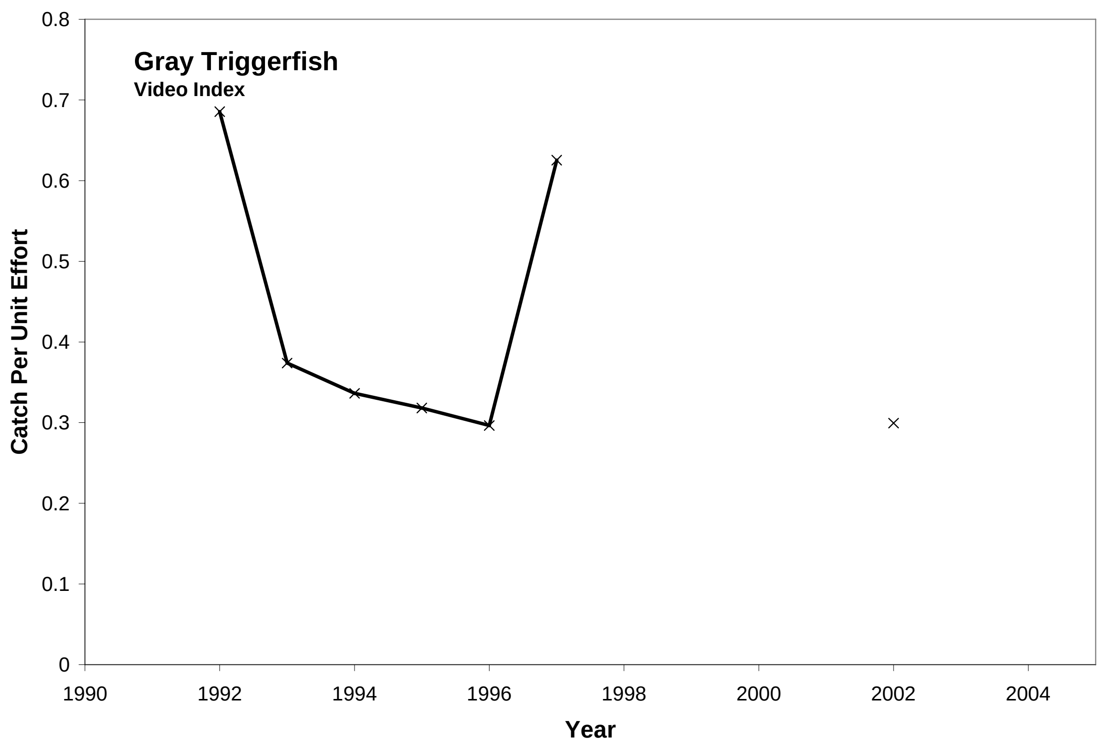

Figure 24—Survey-Derived SEAMAP Video Survey Index

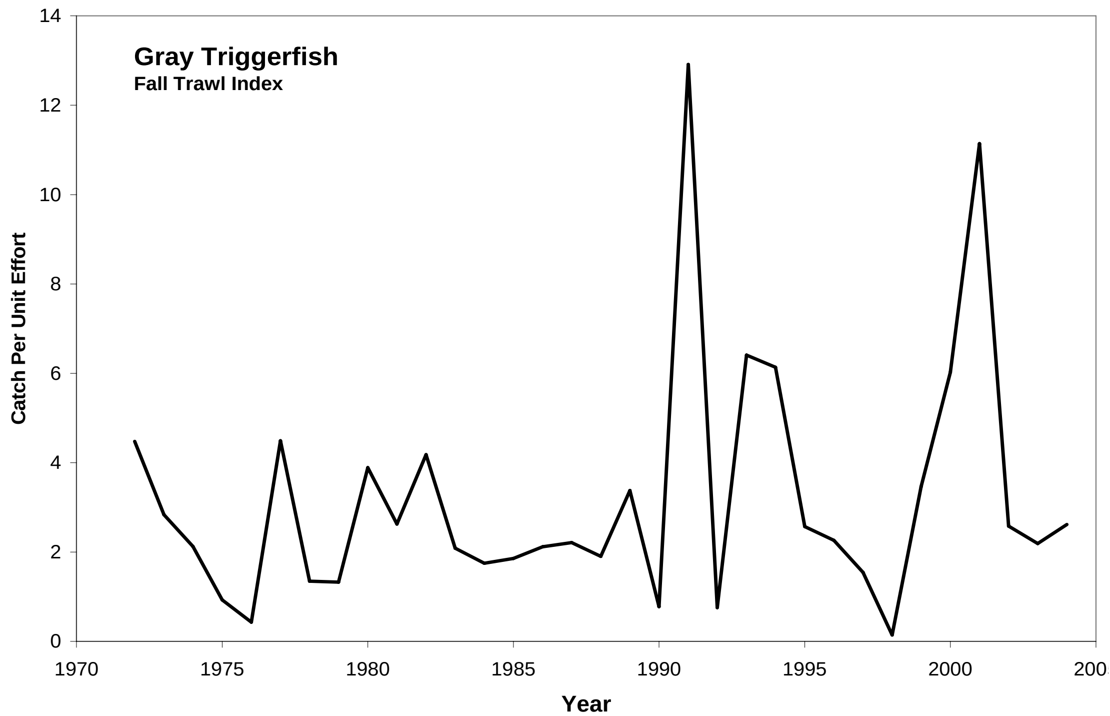

Figure 25—Bayesian Fall SEAMAP Trawl Survey Index

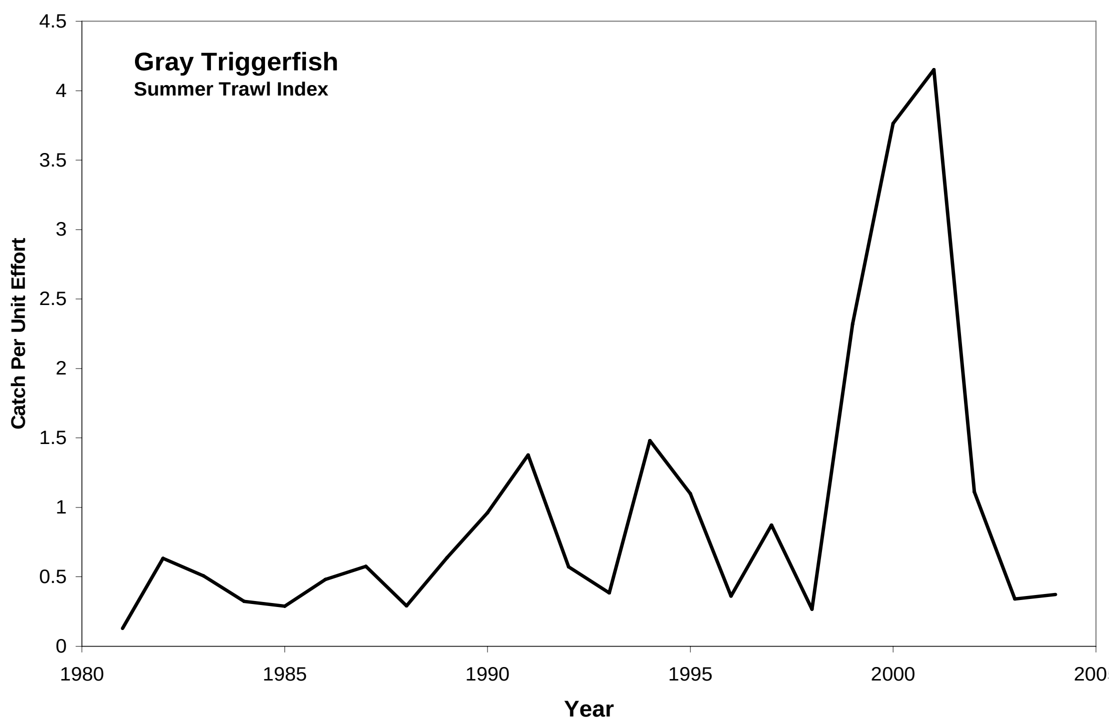

Figure 26—Bayesian Summer SEAMAP Trawl Survey Index

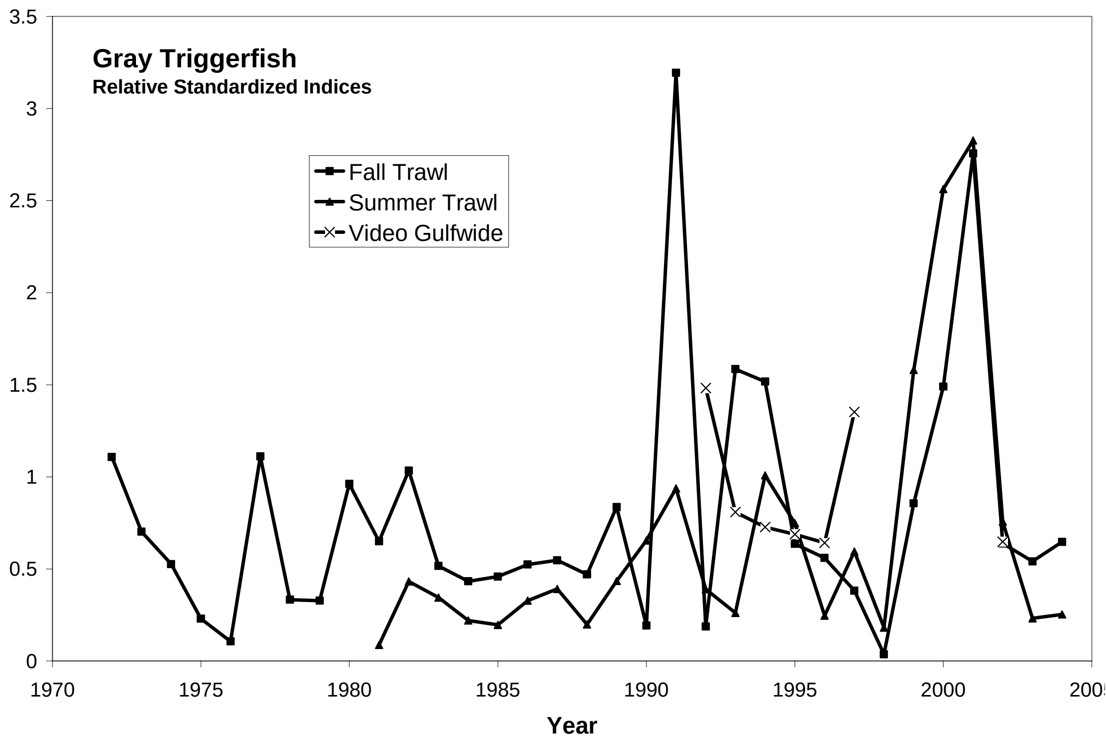

Figure 27—Relative Standardized Fishery Independent Indices

10 Appendix 1.

Recreational landings estimates for TX, 1981-1985.

Prepared June 21, 2005, Patty Phares

I. Available estimates for gray triggerfish, greater amberjack and vermilion snapper in TX

A. TPWD Management Data Series 204 – Private and charterboat only (no headboat).

Annual landings estimates, with a year defined as May 15 - May 14, for 1983/84 through 1997/98.

(Estimates for 1998-99 and later years have not been received yet.)

These annual estimates are what TPWD uses and are based on the same survey data they use to compute the TPWD wave estimates sent to us. If landings by wave are not needed, these annual estimates may be best, at least until the wave estimates for 1983-1997 are replaced (see notes below).

Notes:

(1) The annual estimates were recomputed in the mid-1990s using a revision to the "pressure files", thus eliminating some extreme estimates.

The wave estimates for the 1980s and early 1990s have not yet been recomputed to use the revised pressure files and still contain outliers which may disappear when the wave estimates are recomputed.

(2) The annual estimates are based on 2 fishing seasons (high use and low use) and may be more precise than the sum of the 6 wave estimates.

(3) The annual estimates incorporate data entry corrections not yet made to the wave estimates.

(4) TPWD makes species-specific estimates for selected "target species". The rest of the species are combined in to "other". A "substitute" estimate can be derived for the species in "other" based on the counts of species observed, but these may not be very reliable estimates.

The annual estimates have species-specific estimates for each of these 3 species in gulf areas (not bays) in all years.

Before 1994, the wave estimates have species-specific estimates for vermilion snapper in gulf areas but not for gray triggerfish and vermilion snapper.

B. TPWD Management Data Series 29 and 58 – gulf headboats, through May 1983.

(#29) Annual landings estimates (use gulf headboats):

Sept 1978 - Aug 1979

Sept 1980 -- Aug 1981

Sept 1981 -- Aug 1982

(#58) Landings estimates for a partial year (use gulf headboats):

Sept 1 1982 -- May 14 1983

Notes:

(1) These MDSs were published in 1984 and may not incorporate needed revisions as do those in MDS 204 (no confirmation from TPWD on this yet).

(2) The Sept-Aug years are not comparable to either the May 15-May 14 years or to calendar years.

(3) According to the MDS, not all headboat in the survey areas were found and contacted (apparently a census was attempted) and possibly not all regions were covered (survey areas listed do not include the current "major areas" of gulf waters off Sabine Lake, Matagorda, San Antonio). **The MDS 29 states "Harvest estimates in this study should be considered minimum estimates...".**

C. TPWD wave estimates (estimates made for NMFS) – summed into May-April.

Summed to be comparable to TPWD annual estimates in A (May 1 - April 30, 1983/84 -- 2002/03).

Private and charterboats all years, headboats only in May 1983 - Aug 1984.

D. TPWD wave estimate (estimates made for NMFS) – same as C. but summed into annual Jan-Dec

Summed into annual estimates (Jan-Dec) as would be used in assessments.

Private and charterboats (wave 3-6 only in 1983), headboats only in May 1983 - Aug 1984.

F. MRFSS 1981- 1985. The only estimates are:

1981 waves 2, 3, 5, 6 (waves 1 and 4 are missing). All modes, charterboat and headboat combined.

1982-1984 waves 1-3, 5-6 (wave 4 is missing). Only shore mode.

1985 waves 1-2, 5-6 (wave 4 is missing). All modes, charterboat and headboat combined.

G. NMFS HEADBOAT SURVEY, 1986-1989

Use these estimates to evaluate magnitude and trends in pre-1986 headboat landings in TX.

Before 1997, TX landings were combined for Jan-May and for Sept-Dec.

Area (TTS, EEZ is not known), but all can be assigned to EEZ (area=4) for this purpose. These are gulf headboats (not in the bays).

II. Summary of “holes”

If both MRFSS and TPWD wave estimates are used:

* charter and headboat are combined in MRFSS (are bay headboats included in MRFSS?) .

x = “hole” (no survey or MRFSS estimate lost)

		Shore	Private	Charter	Headboat (gulf)	Headboat (bay)
1981	wave 1	x	x	x	x	x
	wave 2	MR	MR	MR*	MR*	with gulf?
	wave 3	MR	MR	MR*	MR*	with gulf?
	wave 4	x	x	x	x	x
	wave 5	MR	MR	MR*	MR*	with gulf?
	wave 6	MR	MR	MR*	MR*	with gulf?
1982	wave 1	MR	x	x	x	x
	wave 2	MR	x	x	x	x
	wave 3	MR	x	x	x	x
	wave 4	x	x	x	x	x
	wave 5	MR	x	x	x	x
	wave 6	MR	x	x	x	x
1983	wave 1	MR	x	x	x	x
	wave 2	MR	x	x	x	x
	wave 3	MR	TX	TX	TX	TX
	wave 4	X	TX	TX	TX	TX
	wave 5	MR	TX	TX	TX	TX
	wave 6	MR	TX	TX	TX	TX
1984	wave 1	MR	TX	TX	TX	TX
	wave 2	MR	TX	TX	TX	TX
	wave 3	MR	TX	TX	TX	TX
	wave 4	X	TX	TX	TX	TX
	wave 5	MR	TX	TX	x	TX
	wave 6	MR	TX	TX	x	TX
1985	wave 1	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 2	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 3	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 4	x	TX/x	TX/x	x/x	TX/x
	wave 5	MR	TX/MR	TX/MR*	x/MR*	TX/MR*
	wave 6	MR	TX/MR	TX/MR*	x/MR*	TX/MR*

III. DISCUSSION

Comparing data sources in Tables 1 and 2, there is not appearance of comparability among data sources. For instance, in Table 1(a) for gray triggerfish, the TPWD Management Data Series estimates (based on May15-May14 year) and TPWD wave estimates made for NMFS are very different in many years. For MRFSS, there are almost no gray triggerfish estimates, but the leatherjacket family (Table 1(d) bears slight resemblance to the estimates from other sources.

This is true for private and charter (including MRFSS charter + headboat) for all three species (gray triggerfish, greater amberjack, vermilion snapper).

For headboats (without charterboats) compared between TPWD and the NMFS Headboat Survey, the comparisons cannot be made in the same year, but the general magnitude of TPWD estimates before 1985 is not like that of Headboat Survey estimates in 1986+ except for vermilion snapper.

Comparisons are destined to be faulty because of the abundance of "holes" and the different time periods for estimates (not the same 12-month period), different grouping of modes (charterboat and headboat alone vs. separate), and poor quality of some of the estimates. The TPWD wave estimates for these years do not have the benefit of revisions slated to be done, and the sampling levels are especially low for charterboats. The MRFSS estimates before 1986 also are considered less reliable – the charterboat component uses the "old" method for charterboats, and there are weaknesses in the estimates for all modes (early years of survey, less thorough editing of data when all estimates were revised in early 1990s, some procedural or methodological differences?).

In short, it's too messy to try to consolidate the different estimates and fill in the holes. My suggestions are:

(1) Use MDS private and charterboat estimates for 1983-1997 (and use then as though they are calendar year estimates)

(2) Use TPWD wave estimates for 1998+ (these use the calculation procedures that will be applied to the earlier years when time allows for TPWD to do replace the old estimates).

(3) Use the average of the Headboat Survey for 1986-1989 for all years 1981-1985 (perhaps modified by Bob Dixon and TPWD if they believe the fleet was smaller or different).

If this is unsatisfactory, anyone's procedure may be just as good. But there will never be more data, just re-hashing of the same data presented here.

SEDAR

SouthEast Data, Assessment, and Review

SEDAR 9

Stock Assessment Report 1

Gulf of Mexico

Gray Triggerfish

SECTION 3. Assessment Workshop

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1. Introduction

1.1. Workshop Time and Place

The SEDAR 9 Assessment Workshop was held in Miami, FL, August 22 – 26, 2005.

A follow-up Assessment Workshop was held in Atlanta, GA, December 19-20, 2005

1.2. Terms of Reference

1. Select several appropriate modeling approaches, based on available data sources, parameters and values required to manage the stock, and recommendations of the Data Workshop.
2. Provide justification for the chosen data sources and for any deviations from Data Workshop recommendations.
3. Estimate stock parameters (fishing mortality, abundance, biomass, selectivity, stock-recruitment relationship, etc); include appropriate and representative measures of precision for parameter estimates and measures of model 'goodness of fit'.
4. Characterize uncertainty in the assessment, considering components such as input data, modeling approach, and model configuration.
5. Provide yield-per-recruit and stock-recruitment analyses.
6. Provide complete SFA criteria. This may include evaluating existing SFA benchmarks or estimating alternative SFA benchmarks (SFA benchmarks include MSY, Fmsy, Bmsy, MSST, and MFMT). Develop stock control rules.
7. Provide declarations of stock status relative to SFA benchmarks: MSY, Fmsy, Bmsy, MSST, MFMT.
8. Estimate Allowable Biological Catch (ABC) and provide an appropriate confidence interval.
9. Project future stock conditions and develop rebuilding schedules if warranted; include estimated generation time. Projections shall be developed in accordance with the following:

    A) If stock is overfished:
    F=0, F=current, F=Fmsy, Ftarget (OY),

    F=Frebuild (max that rebuild in allowed time)

    B) If stock is overfishing

    F=Fcurrent, F=Fmsy, F= Ftarget (OY)

    C) If stock is neither overfished nor overfishing

    F=Fcurrent, F=Fmsy, F=Ftarget (OY)

10. Evaluate the results of past management actions and probable impacts of current management actions with emphasis on determining progress toward stated management goals.
11. Provide recommendations for future research and data collection (field and assessment); be as specific as practicable in describing sampling design and sampling intensity. Prioritize recommendations based on their likelihood for improving stock assessment.

12. Fully document all activities: Draft Section III of the SEDAR Stock Assessment Report and provide complete tables of estimated values.
    Reports are to be finalized and distributed to the panel for review by September 30.
    Comments due to editors by October 14.
    Final version due to Coordinator by October 28.

1.3. List of Participants

1.3.1 Assessment Workshop I, August 22-26 2005

Workshop Participants:

Harry Blanchet .... LA DWF/ GMFMC FSAP
Liz Brooks .... NMFS/SEFSC Miami, FL
Craig Brown .... NMFS/SEFSC Miami, FL
Shannon Calay .... NMFS/SEFSC Miami, FL
Guillermo Diaz .... NMFS/SEFSC Miami, FL
Bob Dixon .... NMFS/SEFSC Beaufort, NC
Bob Gill .... GMFMC Advisory Panel
George Guillen .... Univ. Houston/GMFMC SSC
David Hanisko .... NMFS/SEFSC, Pascagoula MS
Walter Ingram .... NMFS/SEFSC Pascagoula MS
Bob Muller .... FL FWCC/GMFMC SSC
Debra Murie .... University of Florida/GMFMC FSAP
Josh Sladek Nowlis .... NMFS/SEFSC Miami, FL
Scott Nichols .... NMFS/SEFSC Pascagoula MS
Dennis O'Hern .... GMFMC Advisory Panel
Larry Perruso .... NMFS/SEFSC Pascagoula MS
Steven Saul .... RSMAS/ SEFSC Miami FL
Jerry Scott .... NMFS/SEFSC Miami, FL
Steve Turner .... NMFS/SEFSC Miami, FL

Observers:

Kay Williams .... GMFMC
Elizabeth Fetherston .... Ocean Conservancy
Albert Jones .... .GMFMC SSC

Staff:

John Carmichael .... SEDAR
Stu Kennedy .... GMFMC
Dawn Aring .... GMFMC
Patrick Gilles .... NMFS/SEFSC Miami FL

1.3.2 Assessment Workshop II, December 19-20 2005

Workshop Participants:

Liz Brooks .... NMFS/SEFSC Miami, FL
Craig Brown .... NMFS/SEFSC Miami, FL

Shannon Calay .... NMFS/SEFSC Miami, FL
Guillermo Diaz.. NMFS/SEFSC Miami, FL
George Guillen.. Univ. Houston/GMFMC SSC
Walter Ingram .... NMFS/SEFSC Pascagoula MS
Bob Muller .... FL FWCC/GMFMC SSC
Debra Murie .... University of Florida/GMFMC FSAP
Josh Sladek Nowlis .... NMFS/SEFSC Miami, FL
Dennis O'Hern .... GMFMC Advisory Panel
Jerry Scott .... NMFS/SEFSC Miami, FL
Steve Turner.. NMFS/SEFSC Miami, FL

Observers:

Roy Williams .... GMFMC

Staff:

John Carmichael.. SEDAR
Stu Kennedy.. GMFMC
Dawn Aring... GMFMC
Patrick Gilles... NMFS/SEFSC Miami FL

1.4. List of Assessment Workshop Working Papers, Assessment Workshop I & II

SEDAR9-AW1	Incorporating age information into SEAMAP trawl indices for SEDAR9 species	Nicholls, S.
SEDAR9-AW2	Separating Vermilion Snapper Trawl Indexes into East and West Components	Nicholls, S
SEDAR9-AW3	Modeling Shrimp Fleet Bycatch for the SEDAR9 Assessments	Nicholls, S
SEDAR9-AW4	Status of the Vermilion Snapper (*Rhomboplites Aurorubens)* Fisheries of the Gulf of Mexico	Cass-Calay, S.
SEDAR9-AW5	Gulf of Mexico Greater Amberjack Stock Assessment	Diaz, Guillermo A., and Elizabeth Brooks
SEDAR9-AW6	A Categorical Approach to Modeling Catch at Age for Various Sectors of the Gray Triggerfish (*Balistes Capriscus)* Fishery in the Gulf of Mexico	Saul, Steven and G. Walter Ingram, Jr.
SEDAR9-AW7	Updated Fishery-Dependent Indices of Abundance for Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)*	Nowlis, Joshua Sladek
SEDAR9-AW8	An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)* Stock	Nowlis, Joshua Sladek and Steven Saul
SEDAR9-AW9	Age-Based Analyses of the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock	Nowlis, J. S.
SEDAR9-AW10	Gulf of Mexico greater amberjack virtual population analysis assessment	Brown, C. A.,C. E. Porch, and G. P. Scott
SEDAR9-AW11	Rebuilding Projections for the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock.	Nowlis, J. S.

2. Data Issues

The AW did not identify any deviations from the recommendations of the Data Workshop with regards to data issues.

The DW recommended that gray triggerfish in the Gulf of Mexico be considered a single stock based on its prolonged, indeterminate larval stage. For the most part, the AW agrees with this conclusion. However, the AW notes that examination of the Gulf as Eastern and Western sub-regions could help elucidate variations in stock dynamics, including variations in age at recruitment and in fishing mortality rates. Therefore, the AW suggested that age-based models be considered that used sub-regions, as well as models based on gulf-wide stocks. This is not seen as a deviation from the recommendations of the DW, as many of the indices developed for the AW from recommendations of the DW were divided into eastern and western GOM at the Mississippi River. These analyses are viewed as sensitivity runs to evaluate potential for trends in different regions rather than as a recommendation to divide the species into separate stocks.

2.1. Harvest

2.1.1. Shrimp Fleet Bycatch

Three methods were examined to estimate shrimp fleet bycatch of gray triggerfish. The initial approach was the Bayesian approach used for the red snapper assessment (SEDAR9-DW-26), but results did not appear to be as reliable for the current species, in part due to lower abundance, but also due to reasons unique to gray triggerfish. Gray triggerfish have a distribution appropriate for analysis, and are probably abundant enough for a reasonable analysis, but the species was not on the list of 22 species to be worked up during "Evaluation Protocol" observer trips aboard the shrimp fleet. Hence, shrimp observer data relevant to gray triggerfish are very, very sparse. As a result, it was not possible to obtain an estimate for bycatch with BRDs for triggerfish with the Bayesian model.

Because of doubts about the reliability of the annual estimates for any of the SEDAR 9 species from the SEDAR7 model, Nichols (SEDAR9-AW-03) also examined a delta distribution-based version of the Bayesian approach, and brought back Model 3 from the red snapper assessment (Nichols 2004, SEDAR7-DW-03). There is some evidence that the delta implementation may be underestimating bycatch, and the frequencies of occurrence of vermilion and greater amberjack are so low that one has to be suspicious about results of the CPUE portion of the delta distribution analysis. Model 3 central tendency was generally intermediate between the SEDAR7 and delta results, but the uncertainty estimates were enormous. It was not possible to partition the bycatch estimates by age as per Nichols (2004, SEDAR7-AW-20), as only a handful of fish for the SEDAR9 species have been measured across all the observer studies.

Estimates of catch from the shrimp fleet were given CVs that were double those of other harvest estimates. It was the recommendation of the AW that this was a good starting value, and if the model seemed to be fitting the shrimp bycatch at the expense of fit on the directed fishery, the CVs would be expanded to allow a better fit to the directed harvest. Based on the ability of the delta log-normal model to capture information on annual harvest, the AW accepted that model as the most appropriate method to estimate shrimp fleet harvest.

2.1.2. ***Directed Harves***t

Directed harvest estimates were aggregated into three fleets: recreational headboat, other recreational, and all commercial. Discards were ignored because of the extraordinarily high discard survival rate of gray triggerfish (SEDAR9-DW Report). At present, bycatch of juvenile fish by the shrimp fleet was not included in the surplus production model due to data limitations. The models were conditioned on catches, meaning that they were assumed to be correct measures of fishing removals. Values are shown in Table 1 and Fig. 1.

2.2. Indices

Six indices were available. The three catch fleets were used to develop three related fishery-dependent indices calculated from (1) the NMFS Southeast zone headboat survey, (2) the marine recreational fisheries statistics survey (MRFSS), and (3) commercial handline logbook entries (Sladek Nowlis 2005 - SEDAR9-AW-7). Additionally, three fishery-independent surveys were considered: (4) the Neuston larval survey (using the standardized index with diurnal cycle accounted for), (5) an age-1-based trawl survey index, and (6) a video survey. Values are shown in Table 2 and Fig. 2a and 2b (from SEDAR9-AW08, assessment). There were E, W, and Gulf-Wide indices developed from each of these datasets. For the surplus production model, only GW indices were used. For the age-structured, E and W versions were used for the fishery-dependent indices to address differences in F and selectivity.

Two general analyses of the trawl survey data were available for consideration. Nichols (SEDAR9-AW-01) developed two methods of estimating the fishery-independent trawl survey abundance. Both created a Summer Index from the Summer SEAMAP, Early SEAMAP, and Texas Closure datasets, and a Fall Index from the Fall SEAMAP, "First Fall" and Fall Groundfish data. He used a Bayesian, Markov Chain Monte Carlo approach to handle problems with missing observations, to adjust for differences among cruise programs, and to deal with observations of zero catch. Both models assumed a negative binomial distribution for samples within each dataset. The models differed in the information used to predict catch rates, and in the assumptions about the structure of survey error above the level of within-stratum variation (Nichols 2004, SEDAR7–DW-02). The output from the model provided a lognormal distribution of indexed abundance estimates from each index.

For future assessments, the group concluded that more careful examination should be given to a separate, alternative estimate of the fishery-independent trawl survey (SEDAR9-DW-23). In this alternative approach, Ingram generated indices based on an age-1 standardized index of annual average CPUE (number of fish per trawl-hour) for gray triggerfish, developed through use of a delta-lognormal model as described by Lo et al. (1992) and comparable with the standard methods used when generating fishery-dependent indices. This technique seems promising and future assessments would benefit from comparing it to the Bayesian model described above.

3. Models

Two different model types were used to examine the gray triggerfish stock condition: an aggregated stock production model and an age-based stock production. These models were selected because there was relatively little information on the age structure of the harvest of gray triggerfish. VPA models typically assume that the harvest at age is known. That is a weak assumption in the case of this fish, since length is not a very good predictor of age, and there are very few age (or length) samples taken.

The previous stock assessment used A Stock Production Model Incorporating Covariates (ASPIC) procedure (NOAA Fisheries Toolbox Version 5.10, 2005, http://nft.nefsc.noaa.gov). That model was used for the continuity case, and some exploration of that methodology was evaluated to include additional information in that model.

3.1. ASPIC MODEL

3.1.1. ASPIC Methods

The ASPIC model was explored using a number of data sets for the Gulf of Mexico gray triggerfish (*Balistes capriscus*) stock (see SEDAR9-AW-08 for more detail).

ASPIC is a non-equilibrium implementation of the Schaefer (1954, 1957) surplus production model. ASPIC also allows one to run models with other stock-recruitment relationships along the continuum identified by Pella and Tomlinson (1969). More details can be found in Prager (1994). ASPIC models presented here were conditioned on catch, forcing the model to match the catch inputs while estimating the abundance-related parameters (i.e., effort, CPUE), and all runs used the logistic or Schaefer version of the stock-recruitment relationship.

3.1.1.1. Data Sources

ASPIC relies on catch and abundance estimates to reconstruct a stock's history. Because ASPIC assumes that a unit of biomass is equivalent regardless of the age of the fish in question, life history information does not influence this aggregated production model. Instead, the model is driven entirely by catch in biomass terms and abundance indices.

3.1.1.2. Model Configuration and Equations

A "continuity case" model was constructed, in the sense that all fishery-dependent indices were used, similar to the previous assessment (Valle et al., 2001). The previous assessment removed the earlier data (1986-1989) to achieve greater stability. Our continuity case did so as well. Since understanding of this model required exploring the full time series, additional analyses were performed.

An initial model was configured using a logistic stock-recruitment relationship, equal weighting of fishery-dependent and fishery-independent indices, and starting points for parameter estimation specified as follows: initial biomass ratio (B0/K) = 0.75, maximum sustainable yield (MSY) = 1.5 m (range 1m to 4, 6, or 12m), and carrying capacity (K) equal to 10 times MSY (implies an intrinsic population growth rate parameter, r, value of 0.4). Note that total catches average about 1.5 m pounds over the time period being modeled. The consequences of varying the maximum possible MSY values were explored.

Next, a similar model was constructed except that the Neuston larval and trawl survey indices were down weighted to 1% of the influence of other indices, effectively turning them off. The base model used a logistic stock-recruitment relationship and starting points for parameter estimation specified as follows: B0/K = 0.75, MSY = 1.5 m (range 1m to 6m), and K = 10xMSY. Consequences of varying the starting point for the estimation procedure were explored. In a well-conditioned model, the final estimation result should be insensitive to the starting point of its estimation. A finding of sensitivity would raise concern about the ability to make robust conclusions from the model results.

3.1.1.3. Parameters Estimated

ASPIC estimates surplus production parameters (carrying capacity, intrinsic population growth rate) and biomass trajectories over the course of the time period modeled. These parameters are then combined to determine other useful benchmarks, such as MSY-related biomass and fishing mortality rates, and fishing mortality rate trajectories.

ASPIC contains no information on the size of the individuals or the age of the harvest, therefore has no basis to determine such characteristics of the stock as F at age, age at recruitment to the fishery, numbers of individuals in the population, or other age-dependent and size-dependent parameters.

3.1.1.4. Uncertainty and Measures of Precision

Uncertainties in the ASPIC models were explored in two main steps. First, we checked for sensitivities to the starting point of the fitting procedure by varying the initial estimates. Had that exercise indicated a well-conditioned model, then we would have examined sensitivity to one or more key parameters.

3.1.2. ASPIC Results

The first problem encountered with the gray triggerfish ASPIC model was conflicting trends among indices. The Neuston larval and trawl survey indices were negatively correlated with several others. Nonetheless, the models did converge, although the model's behavior suggested that convergence on a clear best fit was problematic given the data.

When all indices were weighted equally, results were highly dependent on the value set for the maximum boundary for the estimation of MSY. When varied from 4 to 12m, the current status of fishing on the population changed by nearly a factor of two (Fig. 3). Oddly, the best fit, in terms of sum of square errors, was the estimate produced with the smallest range (4m → SSE =36.8, 6m → SSE = 46.4, 12m → SSE = 68.4). Due to this problem and the negative correlation among the larval, trawl, and other indices, further runs were conducted with the larval and trawl indices substantially down weighted (1% of others).

Runs with these new weightings indicated a generally good fit of the model to the data (Fig. 4). Additionally, population trajectories were consistent with the general findings of indices and conceptually plausible (Fig. 5). Even with the larval and trawl indices down weighted, the model showed sensitivities to the starting points for the estimation procedure. Starting biomass values varied by more than a factor of four, although the lowest estimate was for a solution that fit poorly (Table 3). Final biomass and fishing mortality ratios also varied over a fairly broad range (Table 3, Fig. 6). And, with the exception of the run with initial estimation point for carrying capacity (K) set lower relative to MSY, all runs produced generally good fits to the data (Table 3).

As was true in the previous gray triggerfish assessment (Valle et al., 2001), limiting the analysis to only fishery-dependent indices and the timeframe to only 1990-present (2004 in our case) made the model more stable (Table 4, Fig. 7). This stability is especially notable in the contrast between Figs. 6 and 7. Both show the sensitivity of the model's predictions to where the estimation procedure started. It is apparent that the continuity case showed far less sensitivity. It also produced similar conclusions about stock status. In both the former assessment model and the continuity case, biomass declined from 1990-1999. The continuity case showed a slight increase in biomass in the first few years of the new millennium, but followed by a recent decline back to 1999 levels. Both also showed a peak in fishing mortality rates relative to MSY levels in 1995, followed by a consistent decline through the late 1990s. The continuity case shows increasing fishing mortalities from 2000 to present. These results confirm that the addition of recent data did not appreciably change the dynamics or the details of the model's predictions.

Due to the sensitivity of the model to the starting point for the estimation procedure, we have concerns about our ability to make robust conclusions from the model results. Clearly, the data are not adequate to resolve the status of the Gulf of Mexico gray triggerfish stock with any precision using an aggregated production model.

In total, the ASPIC runs were thus of limited value because of the need to use only a subset of the data. However, one finding does appear to be robust. Nearly every run conducted, both those presented here and numerous runs with draft data, indicated that the Gulf of Mexico gray triggerfish stock was overfished and experiencing overfishing. However, large differences among runs make it difficult to ascertain the magnitude of the problem.

For future research, we recommend that the performance of the ASPIC model be explored further. The sensitivities identified here are not unique to this stock (e.g., see Caribbean yellowtail snapper, SEDAR8-AW Report). Phenomena such as the apparent observation of poor status for the Gulf of Mexico gray triggerfish stock could possibly be resolved by investigating a surface of goodness-of-fit values across a broad range of parameter values. Results here and from previous experience would suggest that there is often a ridge of relatively good fit, with many small local peaks. If this is indeed the case, one might be able to draw conclusions about the status of the stock based on where the ridge lies, and might even be able to explore probabilistic projections by bootstrapping across this ridge.

3.2. State-Space Age Structured Production Model

3.2.1. State Space Age-Structured Production Model Overview

A state space age-structured production model (SSASPM) was developed for the Gulf of Mexico gray triggerfish stock. This model was possible due to great improvements in our understanding of gray triggerfish growth and age distribution, largely as a result of work by Ingram (2001).

Using our more detailed understanding of gray triggerfish growth patterns, size distributions were used to estimate age distributions. These were combined with other life history, fishery-dependent, and fishery-independent data to produce the age-structured production model.

Several decisions were made about the basic structure of the SSASPM model when used to describe gray triggerfish. These decisions were primarily based on conclusions made at the SEDAR9 Data Workshop (SEDAR9-DW-Report). Structural and data choices for the base model are summarized below, and additional details can be found in SEDAR9-AW2-09.

3.2.1.1. Stock Structure

The Data Workshop concluded that although multiple Gulf stocks of gray trigger were possible, the evidence did not support a split. Nonetheless, examination of the age or size composition from the eastern and western Gulf indicated that younger fish are generally caught in the eastern Gulf (Saul and Ingram SEDAR9-AW06), presumably as a result of differential fishing pressure. Consequently, we modeled directed fleets separately as eastern and western components, with the split occurring at the Mississippi River.

3.2.1.2. Age structure

Gray triggerfish are caught as bycatch in shrimp trawls during their first year of life. However, modeling age-0 fish presents a number of difficulties, including the technical problem that SSASPM is not yet designed to accommodate age-0 fish. Moreover, it is very likely that age-0 fish experience much heavier natural mortality than older fish and this mortality may have density-dependent relationships which could differ from the patterns of density-dependence during reproduction. We can get around some of these problems by using a model that starts with age-1 fish, but this approach also raises the issue of how to account for fishing mortality on the youngest fish (in this case, from the shrimp fleet). This issue is addressed below. Gray triggerfish can live to at least 16 years of age. However, they become uncommon after age 10. Consequently, we modeled the stock in age classes starting at 1 and ending at 10+ years old.

3.2.1.3. Stock-recruitment

SSASPM allows one to model recruitment as a Beverton-Holt or Ricker curve. We chose a Beverton-Holt curve as it is believed to fit most stocks better, excepting those that experience especially strong, population-wide density-dependent competition. For initial exploration of the model, a prior distribution of the α parameter was used. It relied on a meta-analysis by Myers and colleagues (1999), which was modified to address various life history strategies by Rose and co-authors (2001). Gray triggerfish fit Rose and colleagues' definition of a periodic life history species. The distribution of α parameters for periodic species had a median value of 12.85, a mean of 17.98, and a log-normally distributed standard deviation of 0.97. These values closely correspond with the data workshop's advice to examine a range of steepness values centered around 0.8 (α = 16) (SEDAR9-DW-Report).

3.2.1.4. Time Period

The quantity and quality of data streams for gray triggerfish improved dramatically in 1981 and again in 1986. From 1963 to 1980, only commercial catches were recorded. Starting in 1981, catch and catch-at-size information were recorded from the recreational fishery. In 1986, recreational sampling improved markedly, and by 1993 all current data streams were online. Although 1993 was the first year when virtually all sources were operational, the information in 1981 was deemed adequate to inform the model directly. The historic phase of the model stretches from 1963, when commercial catches were first reported, to 1980. Given the low level of catches in 1963, it may be reasonable to consider the stock virgin at that time. However, shrimp bycatch may have reduced it even at that early date.

3.2.2. SSASPM Methods

3.2.2.1. Data Sources

Catches

Catch information was derived from several fleets (SEDAR9-DW-Report). Based on age-structure of the catches, these were pooled into four directed fleet categories: recreational east, recreational west, commercial east, and commercial west, with the east-west split occurring at the Mississippi River. Shrimp bycatch was derived for the Gulf as a whole (Table 5, Fig. 8). Bycatch from other fleets was ignored because of the extremely low release mortality of gray triggers (SEDAR9-DW-Report).

All directed catches were converted into weights even though SSASPM is capable of taking catches in numbers. Recreational catches were reported in numbers and converted using size distributions. This conversion provided consistency with the non-age-structured surplus production model but could be explored further. Commercial catches were reported in weight and so required no conversions. Shrimp bycatch were reported in numbers.

Shrimp trawls catch both 0- and 1-year old fish, which can be difficult to distinguish without direct aging. However, we chose a model structure that started with 1-year olds for reasons described above. Using unconverted numbers would imply many more 1-year old fish were killed than was the case, while ignoring age-0 fish entirely would under represent bycatch by the shrimp fishery. Instead, a catch series was produced for age-1 equivalents. To do so, the total shrimp bycatch estimates were separated into age-0 and age-1 portions using an estimated total mortality for this age class of Z = 2. Specifically, the number of age-1 fish for a given year was calculated from the number of age-0 fish estimated to have been caught in the previous year, as reduced by estimated total mortality. Finally, when calculating the age-1 equivalency of bycatch for any year, the number of age-1 fish was added to the number of age-0 fish that would have survived from the previous year.

The resulting catch series are shown in Table 5 and Fig. 8.

Indices of Abundance

Eight indices of abundance were used for the SSASPM model. Five fishery-dependent indices were based on MRFSS data from the eastern Gulf (western Gulf data were inadequate), headboat data from the eastern and western Gulf, and commercial logbook reports for handline gear from the eastern and western Gulf. These indices are discussed in greater detail elsewhere (Sladek Nowlis, SEDAR9-AW07) and are presented in Table 6 and Fig. 9a.

Three fishery-independent indices were also used, all Gulf-wide since selectivity differences should not be a concern for scientific surveys. These included Neuston net surveys, which sample pelagic larvae, assumed to represent spawning biomass; bottom trawl surveys, which sample young fish; and video surveys, which sample adults on hard bottom habitat using a baited video camera.

These indices are presented in Table 6 and Fig. 9b.

Age Composition

Catch at age data were derived from size distributions and probabilistic assignment of age. Size distributions came from the Trip Interview Program. Interviews included the direct measurement of catches from both commercial and recreational fishers in the eastern and western Gulf (split as close to the Mississippi River as the data allowed). The resulting size distributions were converted to ages using age-length relationships developed in the SEDAR9 Data Workshop (SEDAR9-DW- Report).

Instead of directly assigning an age to each fish based on its size, a probabilistic approach was used (Saul and Ingram, SEDAR9-AW06). Fish were sorted into 25 mm length bins and a multinomial model was used to estimate the probability of a fish of a particular length class occurring in a particular age class. The probability distributions for each fish were stacked to produce an overall distribution for strata defined by year, region (eastern or western Gulf), and sector (commercial or recreational).

3.2.2.2. Base Model Configuration

Fixed Parameters

A number of life history parameters were treated as fixed and taken from the Data Workshop report (SEDAR9-DW-Report). These included:

Maturity = 87.5% of 1-year olds and 100% of other age classes assumed to be mature.

Fecundity = $170289e^{0.3159x}$, where x = age.

M = 0.27 for all modeled age classes.

$FL = 423.4\ (1-e^{-0.4269(x+0.6292)})$, where FL = fork length in mm and x = age.

$Wt = 4.4858 \times 10^{-8}\ FL^{3.0203}$, where Wt = weight in lbs and FL = fork length in mm.

Parameters Estimated

Several parameters were estimated, or at least explored over a range of values. These included:

The unfished recruitment levels;

Catchability for each fleet and index; and

Fleet selectivities.

In tuning the Gulf of Mexico gray triggerfish SSASPM model, three elements proved to have strong influence on the results. The first element was the α parameter from the stock-recruitment relationship. The second was a variance scalar applied to recruitment deviations. The third was a similar variance scalar applied to the shrimp fleet fishing effort.

α

When run using the prior distribution of α values from the meta-analysis of periodic life history strategists, the SSASPM model estimated a very high parameter value (70.9, corresponding to a steepness of 0.95). Alternatively, several runs were conducted using highly constrained estimates of α, ranging from 6 to 36 (runs with fixed values had the disconcerting property that they usually produced non-positive-definite Hessian matrices, suggesting instability). A reasonable base model might be the one that used a constrained $\alpha = 12$, which estimated $\alpha = 13.5$, just above the median of the meta-analytic distribution. The equivalent steepness = 0.77.

Recruitment Deviations

Initially, the model was constructed with a variance scalar applied to recruitment deviations that was high but on par with those applied to index observation errors (i.e., 2). Configured like this, the model predicted recruitment from the mid-1980s to the mid-1990s at levels that exceeded the underlying maximum recruitment parameter (Fig. 10a). This disconnect could have been addressed by assuming it was a signal that recent recruitment has been higher than it was in the past or by assuming that the deviations were inadequately constrained. Using the second approach, the variance scalar was set to 0.05, below even the value applied to effort deviations for most fleets (0.223). When constructed this way, the model predicted recruitment patterns (Fig. 10b) much more in line with dynamics of the population as indicated by abundance indices.

Shrimp Effort Deviations

Initially, the model was constructed with variance scalars applied to effort deviations of all fleets at values that corresponded with CVs of 50% (0.223). For most fleets, we don't have independent measures of effort and there is real potential for big fluctuations, especially given the less preferred nature of gray triggerfish. However, we do have independent estimates of shrimp fleet effort dynamics, derived for the recent Gulf of Mexico red snapper assessment (Nance 2004, SEDAR7-DW-24). The effort series for eastern and western Gulf fleets are shown in Fig. 11a. When the variance scalar for shrimp effort was set at the same level as other fleets, the model estimated large fluctuations in shrimp effort, which did not agree well with the independent estimates (Fig. 11b). When this variance scalar was set lower (0.0392, equivalent to a 20% CV), the modeled effort fluctuations were more on par with those estimated in the red snapper assessment (Fig. 11b).

Uncertainty and Measures of Precision

A number of sensitivity analyses were performed. These runs explored the degree to which the conclusions from the base model were sensitive to potential inaccuracies in the specification of various model parameters. The sensitivity runs included:

Runs described above, which explored a range of α, recruitment deviations, and shrimp effort deviations values.

Beginning the burning-in period in 1950 instead of 1963.

Using natural mortality values of M = 0.25 or M = 0.3.

3.2.3. SSASPM Results

3.2.3.1. SSASPM Overall Model Fit

The base model generally performed well compared to sensitivity runs, according to AIC scores (Tables 7 and 8). There were some exceptions, though. Fits were best with very high α values, and so runs with values constrained higher than the base or estimated were more parsimonious with the data than the base run. Additionally, the model fit the data slightly better when natural mortality were set at M = 0.3.

3.2.3.2. SSASPM Catch Fits

Catches fits were mediocre for the base model (Fig. 12), although they did not improve markedly in any sensitivity analyses. Directed commercial catches showed the best fit, while shrimp bycatch was too flat (see discussion, above, of effort deviations) and recreational catches only captured some of the patterns of the underlying data.

3.2.3.3. SSASPM Index Fits

Indices fit better. They generally captured the broad pattern of the underlying data but missed most spikes (Fig. 13). Since the spikes may represent data issues rather than true population fluctuations, this result may be desirable.

3.2.3.4. Stock Recruitment Parameters

As is typical for most fisheries models, especially those with relatively short time series of information, the stock-recruitment relationship was poorly resolved. In addition to the *a priori* considerations paid to this important issue, we performed some *posteriori* analyses to further explore it. To do so, we began by examining the results from the base run. Only years with extensive data were used (1986-2004), and these were examined to identify what the recent pattern of stock-recruitment has been, noting that these recent years included recruitment deviations that could have produced a different relationship than the underlying one defined by the stock-recruitment parameters themselves. The result indicated a steepness of 0.65 (Fig. 14a), a bit lower than the median value proposed in the base run (which corresponded to a steepness of 0.77. This difference was relatively minor and provided further support for the proposed base run.

However, this result was highly sensitive to the degree to which recruitment deviations were constrained. Recall from the earlier discussion that they were constrained so as to resolve the inconsistency between recent recruitment levels and the stock-recruitment relationship. When these constraints were removed, the model produced a series of recruitments with a steepness of 0.2, suggesting no density-dependent compensation at reduced abundance (Fig. 14b). Alternatively, when recruitment deviations were eliminated (i.e., fully constrained), so that recruitment in the model had to fit the internal stock-recruitment relationship, recruitment since 1986 appears to follow a relationship with a steepness of 0.976 (Fig. 14c), near the maximum of 1. The ramifications of various steepness values were explored in sensitivity analyses and do have a significant influence on estimated stock status.

3.2.4. Base Model Recommendation

Weighing all of the evidence, the assessment workshop panel recommended the originally-proposed base model to serve that purpose for the gray triggerfish assessment. The rationale for doing so was as follows. First, although recruitment deviations were discovered to play a more important role in determining stock status than was originally anticipated, this finding does not change the logic behind the constraints that were used on the size of deviations. The constrained deviations limited the model from estimating greater-than-virgin recruitment levels from the mid-1980s through the mid-1990s (Fig. 10). Note, though, that another approach would have been to assume that recent recruitment has been higher than the underlying stock-recruitment relationship would suggest.

The other issue to resolve is an appropriate treatment of the α parameter in the stock-recruitment relationship. Although the best fits were associated with high values of α, the improvement in fit over a wide range of α values was slight (Table 7). Thus, we can conclude that the data were not very informative about the stock-recruitment relationship. Our additional efforts to examine this relationship by looking only at the most data rich years (1986-2004) were also inconclusive (Fig. 14). Accepting the treatment of recruitment deviations recommended above, the value of α is driven lower by examining only the most data rich years (Fig. 14a).

Thus, we have the data en masse providing weak justification for using a high steepness and the most informative data providing a weak justification for lower steepness. Lacking any conclusive analysis illustrating that the data point to a single value for this parameter, the assessment workshop panel concluded that using the median value of the meta-analysis was appropriate. To aid consideration of this meta-analysis, the species used are listed in Table 9.

3.2.5. Stock Status

Although the base model's behavior was not ideal, it may have been adequate. Greater confidence was gained by examining the key management benchmarks across a wide range of sensitivity analyses (Tables 7 and 8). Current status as a function of SPR- and MSY-based management benchmarks was consistent with those analyses across a range of input parameters.

Using SPR benchmarks, the base run and most sensitivity analyses indicated that the Gulf of Mexico gray triggerfish stock was overfished and experiencing overfishing (Tables 7 and 8, Fig. 15). Exceptions included the $\alpha \sim 6$, M = 0.3, no or large recruitment deviations, and equal shrimp effort deviations runs, which estimated the stock was not overfished (but in most cases was close to it). All runs indicated overfishing was occurring relative to a 30% SPR benchmark.

Using MSY benchmarks, the base run and most sensitivity analyses also indicated that the Gulf of Mexico gray triggerfish stock was overfished and experiencing overfishing (Tables 7 and 8, Fig. 16). The only exceptions here were the two highest α runs, which indicated the stock was above SSB_{MSY} and not experiencing overfishing; the M = 0.3 run, which indicated the stock was nearly but not quite overfished but still experiencing overfishing; the large recruitment deviations run which indicated the stock was just above SSB_{MSY} levels but still experiencing overfishing.

According to the base run, the stock dropped below MSY levels in the late 1970s, recovered briefly in the late 1980s and has steadily declined since 1990 (Fig. 17a). The model indicates that stock abundance reflects overfishing, which began in the 1970s and has continued to the present day (Fig. 17b).

4. Assessment Workshop Panel Recommendations and Comment

4.1. Model Comparisons

4.1.1. Compare and Contrast Models Considered

4.1.1.1. Aggregated Production Model (ASPIC implementation)

The ASPIC model was the only model considered in the previous assessment of gray triggerfish (Valle et al., 2001). The current application of the model does add the benefit of allowing uncertainty in model inputs. As in the prior assessment, the ASPIC model was very sensitive to input parameters. After updating the continuity case, additional runs of the model deleted some of the fishery-independent indices and provided more consistent results. However, since there is probably some correlation between fishery-dependent indices and harvest, the AW is concerned that removal of information from the model might provide a better fit to the data but may not increase the ability of the model to characterize the status of the stock. As was also noted in the vermilion snapper portion of this report, the model does not have information on age (or size) selectivity compared to age at maturity, thus may not capture resiliency of the stock.

4.1.1.2. State-Space Age-Structured Production Model (SSASPM)

The AW preferred the SSASPM model for several reasons. It incorporates information on life history and on the age structure of the harvest. This allows information on relative ages of maturity and harvest to be evaluated within the model structure. In a case such as gray triggerfish, where selectivity seems to be different across the geographic range, this information has the potential to provide more realistic evaluation of the stock status. While the model seemed to still have significant problems coming to resolution regarding the exact status of the stock, the general consensus of the outputs was persuasive regarding the estimated condition of the stock.

4.2. Preferred Model Recommendation

The AW preferred the SSASPM on the basis that it considers more of the biology and fishery characteristics of gray triggerfish. At the time of the first AW, participants had not seen the results of the SSASPM model, but were concerned about the shortcomings of the ASPIC model discussed above, and felt that this model could be more informative. Based on the presentation and evaluation of the model and results at the second AW, the participants present considered this model preferable, and recommended using it as the basis of determining stock status. The consistency of the ASPIC and the SSASPM models in their stock determination criteria added a degree of confidence in the models' ability to represent the condition of the stock.

4.3. Selected Rebuilding Trajectories

Given the likely determination that Gulf of Mexico gray triggerfish are overfished and experiencing overfishing, rebuilding scenarios were explored to facilitate management action. Outputs were taken directly from the base SSASPM model and these were used to project the population forward in time under various scenarios. Given the relative ease with which the stock rebuilt to the legally-required MSY abundance levels, analyses were limited to simple projections that linked all fleets together. In other words, overall fishing mortality rates were manipulated but the selectivity-at-age patterns remained constant, which is the equivalent of assuming that all catch cuts were distributed proportionally across all directed and bycatch fleets. Moreover, it was assumed that the status determination will become official in early 2006 and that management action would take place in early 2007.

Detailed tools for achieving rebuilding were not explored. Yet management choices will be simplified by the fact that gray triggerfish survive catch and release remarkably well, at least in directed fleets. As a result, size or trip limits can be used effectively for all but the shrimp fleet.

According to the proposed base assessment model, the gray triggerfish stock was at about 60% of MSY abundance levels and experiencing about 145% of MSY fishing mortality rates in 2004 (Fig. 17). Scenarios explored the rebuilding of this stock back to MSY abundance levels and used a maximum timeframe of 10 years.

Under a no fishing scenario, in which all directed and bycatch fisheries were eliminated, gray triggerfish were able to rebuild extremely quickly—less than 2 years after fishing were eliminated (Table 10; Fig. 18).

Without any management action, the stock does not fare so well. It is currently experiencing overfishing and, as a result, it fails to recover at all under current fishing mortality rates (Table 10; Fig. 19).

If fishing mortality rates were reduced by about 30%, to F_{MSY} levels, the stock would also fail to rebuild fully to MSY abundance levels but overfishing would be halted if using MSY as a benchmark (Table 10; Fig. 20). If using 30%SPR, as is currently stated in the management plan, overfishing would still occur even with this reduction.

If fishing mortality rates were reduced by about 40%, to $F_{30\%SPR}$ levels, overfishing would end regardless of the benchmark used. And the stock would rebuild to nearly MSY levels by the end of 2016 (Table 10; Fig. 21). It would take only an extremely minor additional reduction of 2% to achieve rebuilding within this timeframe (Table 9; Fig. 22).

Finally, a scenario was explored using a common definition of optimum yield, noting that the current management plan has not identified this benchmark. Using 75% of the fishing mortality rate associated with MSY (i.e., $F_{OY} = 0.75F_{MSY}$) achieved rebuilding by 2012 but required cutting the fishing mortality rate nearly in half. The benefits of this strategy would primarily be in the future, noting that by

2016 catches under this lighter fishing pressure would nearly equal those under other, more aggressive fishing pressure scenarios (Table 10; Fig. 23).

5. References

Ingram, GW, Jr. 2001. *Stock Structure of Gray Triggerfish,* Balistes capriscus*, on multiple spatial scales in the Gulf of Mexico*. PhD Dissertation, Department of Marine Science, University of South Alabama. 229 p.

Myers, RM, KG Bowen, NJ Barrowman. 1999. Maximum reproductive rate of fish at low population sizes. *Can. J. Fish. Aquat. Sci.* 56: 2404-2419.

Pella, JJ, PK Tomlinson. 1969. A generalized stock production model. *Int. Amer. Trop. Tuna Comm. Bull.* 13: 419-496.

Prager, MH. 1994. A suite of extensions to a nonequilibrium surplus-production model. *Fish. Bull.* 92: 374-389.

Rose, KA, JH Cowan Jr, KO Winemiller, RA Myers, R Hilborn. 2001. Compensatory density dependence in fishing populations: importance, controversy, understanding and prognosis. *Fish Fish.* 2: 293-327.

Schaefer, MB. 1954. Some aspects of dynamics of populations important to the management of commercial marine fisheries. *Int. Amer. Trop. Tuna Comm. Bull.* 1: 25-56.

Schaefer, MB. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. *Int. Amer. Trop. Tuna Comm. Bull.* 2: 247-268.

Valle, M, CM Legault, M Ortiz. 2001. *A Stock Assessment for Gray Triggerfish,* Balistes capriscus*, in the Gulf of Mexico*. Sustainable Fisheries Division Contribution SFD-00/01-124, NOAA Fisheries, Department of Commerce, Miami, FL. 56 p.

6. Tables

TABLE 1—Catches by Fleet (in lbs)

Year	Headboat	Other recreational	Commercial	Total
1986	93,772	864,229	95,629	1,053,630
1987	76,584	1,115,841	123,603	1,316,027
1988	134,501	1,592,524	195,062	1,922,088
1989	162,639	1,672,689	317,632	2,152,960
1990	263,606	2,184,440	459,038	2,907,083
1991	187,270	1,758,437	444,530	2,390,237
1992	222,532	1,497,032	450,195	2,169,759
1993	215,132	1,268,698	558,728	2,042,558
1994	222,428	1,077,372	404,720	1,704,519
1995	200,838	1,125,930	337,877	1,664,645
1996	156,388	673,879	267,516	1,097,783
1997	129,477	605,403	184,689	919,569
1998	107,159	517,647	176,723	801,530
1999	82,666	388,552	219,020	690,238
2000	67,913	341,086	158,137	567,136
2001	82,164	531,165	176,182	789,511
2002	110,960	670,356	235,563	1,016,879
2003	128,529	775,486	251,810	1,155,825
2004	115,965	889,761	218,533	1,224,258

TABLE 2—Index Values (CPUE)

Year	Headboat	MRFSS	Commercial Handline	Larval	Trawl	Video
1986	0.8094	1.7697	0.8122			
1987	0.6924	0.8929	0.5985	0.8678		
1988	0.9383	2.5591	0.4037	0.4113		
1989	1.3966	3.0805	0.2314	0.3900		
1990	2.1313	5.5935	0.3990	1.1514		
1991	1.9838	3.0457	0.8050	1.3974		
1992	2.0453	3.1726	2.6547	0.8699	1.8348	
1993	1.7649	1.3323	1.5312	0.9001	0.3532	1.0011
1994	1.4882	1.2347	1.4616	1.0343	1.0221	0.9002
1995	1.2666	2.6720	1.4322	1.0305	1.3458	0.8517
1996	1.0442	1.1268	0.8714	0.6992	0.5557	0.7936
1997	1.0093	0.7435	0.8598	0.7347	0.7730	1.6737
1998	0.9698	0.5663	0.8463	0.2781		
1999	0.7009	0.6776	0.7264	0.2326	0.7434	
2000	0.5770	0.5961	0.6296	2.4034	0.3067	
2001	0.6140	0.6567	0.6727	0.3967	1.5582	0.1430
2002	0.8430	0.8021	0.9638	0.5497	1.5220	0.8019
2003	0.8353	0.7308	1.0854	0.2740		
2004	0.8867	0.8609	0.9196	0.5518		

TABLE 3—Sensitivities to Starting Points of the Estimation Procedure

Results from models where larval and trawl survey indices were down weighted. The base model used a logistic stock-recruitment relationship and starting points for parameter estimation specified as follows: B0/K = 0.75, MSY = 1.5 m (range 1m to 6m), and K = 10xMSY.

Model	Bratio	Fratio	Bo ratio	Bo (m)	SSE
Base	0.2828	1.94	0.6661	3.41	31.498
max MSY 4 m lb	0.2128	3.107	0.9872	8.46	52.799
Bo ratio 0.25	0.3003	1.901	0.7408	3.76	25.26
MSY 2.1 m lb.	0.2047	3.509	1.137	9.97	38.58
K=5*MSY	0.2336	2.146	0.7069	2.3	1348

TABLE 4—Sensitivities to Starting Points of the Estimation Procedure in Continuity Case

Results from models where only fishery-dependent indices were used and the timeframe was restricted to 1990-2004. The base model used a logistic stock-recruitment relationship and starting points for parameter estimation specified as follows: B0/K = 0.75, MSY = 1.5 m (range 500t to 6m), and K = 10xMSY.

Model	Bratio	Fratio	Bo ratio	Bo (m)	SSE
Base	0.2762	1.933	1.009	4.666	2.959
max MSY 4 m lb	0.3547	1.834	1.614	5.744	3.003
Bo ratio 0.25	0.3578	1.808	1.655	5.632	2.996
MSY 2.1 m lb.	0.3826	1.795	1.945	6.438	3.071
K=5*MSY	0.4085	1.756	2.46	7.517	3.204

TABLE 5—Gulf of Mexico Gray Triggerfish Catches
Directed catches are reported in pounds, while shrimp bycatch is reported in age-1 equivalent fish (described in text).

YEAR	Recreational EAST	Recreational WEST	Commercial EAST	Commercial WEST	Shrimp Age-1 Equivalent
1963			3100	4200	
1964			15700	4300	
1965			17400	4300	
1966			8600	5200	
1967			12200	5200	
1968			8600	3900	
1969			14600	7700	
1970			16000	8200	
1971			30500	9900	
1972			47400	15200	
1973			40000	13200	112278
1974			40000	13100	342365
1975			62000	16000	380204
1976			69700	14800	220050
1977			50096	9290	189051
1978			48518	10197	460315
1979			65670	35733	1771057
1980			65422	31001	606638
1981	748779	179617	64498	25362	1467734
1982	2032601	362711	62959	33714	1206518
1983	397614	387301	49588	23831	1462755
1984	120970	844623	37445	32749	304994
1985	280865	479950	54840	37786	855586
1986	898096	79077	72858	22771	279374
1987	1135998	199066	89313	34290	1044555
1988	1638073	158328	137978	57084	1364168
1989	1765965	212002	230361	87271	906437
1990	2313261	184941	359686	99351	1286703
1991	1688392	399955	341319	103211	523154
1992	1434485	688825	338119	112076	3100516
1993	1317044	309425	381279	177448	432660
1994	1152103	186425	251578	153141	1951471
1995	1139967	329441	207212	130664	1065855
1996	618125	226006	142185	125332	1498133
1997	664794	100211	107780	76909	1751775
1998	560509	93309	106153	70571	1004208
1999	445430	43997	116194	102826	242741
2000	337241	109209	63042	95095	1656166
2001	487622	152571	108464	67718	490376
2002	721872	77016	148600	86963	5115407
2003	856626	58622	166425	85385	854441
2004	951559	78092	141411	77122	167162

TABLE 6—Gulf of Mexico Gray Triggerfish Relative Abundance Indices.
Fishery-dependent and independent indices were transformed separately, in such a manner that each index averaged 1 over the years where all indices of that category were available (1993-2004 for FD; 1992-97 and 2001-02 for FI).

Year	MRFSS EAST	Headboat EAST	Headboat WEST	Commercial Handline EAST	Commercial Handline WEST	Neuston FI Survey	Trawl FI Survey	Video FI Survey
1981	1.6548							
1982	1.4133							
1983	0.9873							
1984	5.9438							
1985	0.2173							
1986	3.641	0.7848	0.8973			0.8122		
1987	1.1654	0.5169	0.8861			0.5985	0.5298	
1988	2.0648	0.6791	1.2201			0.4037	0.4556	
1989	3.3945	1.5569	1.1254			0.2314	0.8096	
1990	7.1257	2.4939	1.5849			0.399	0.1866	
1991	2.9727	1.9669	1.8749			0.805	3.0919	
1992	2.6319	2.2737	1.6657			2.6547	0.1815	1.8348
1993	1.6326	1.7824	1.6771	1.7512	1.0824	0.9001	1.5339	1.0009
1994	1.4808	1.3821	1.6302	1.6507	1.3808	1.0343	1.4693	0.9002
1995	2.2807	1.2025	1.4973	1.7105	1.5589	1.0305	0.616	0.8518
1996	1.3233	0.8525	1.527	0.753	0.9714	0.6992	0.5421	0.7937
1997	0.742	0.9032	1.3769	0.6298	0.7733	0.7347	0.37	1.6738
1998	0.5624	0.7762	0.9371	0.5943	1.0118		0.0351	
1999	0.5828	0.8224	0.4182	0.5719	1.3704	0.2326	0.8293	
2000	0.4573	0.5781	0.4236	0.4171	1.0247	2.4034	1.4431	
2001	0.7023	0.6481	0.5009	0.6182	0.7079	0.3967	2.6692	0.143
2002	0.7272	0.9847	0.5528	1.1006	0.7565	0.5497	0.618	0.8018
2003	0.7016	0.9971	0.6782	1.2278	0.6793		0.524	
2004	0.8071	1.0708	0.7807	0.975	0.6826		0.6266	

TABLE 7—Stock Recruitment α Runs. 292 data points, 170 estimated parameters, base run described in the text used an α value of 12 since the estimation procedure tended to inflate this number in the final estimate (median steepness was ~ 13).

	$\alpha \sim 6$	$\alpha \sim 9.33$	Base	$\alpha \sim 16$	$\alpha \sim 36$	Est α
FIT						
Estimated params	170	170	170	170	170	170
Objective function	383.8	373.6	369.9	367	362.8	364.6
AIC	1108	1087	1080	1074	1066	1069
BENCHMARKS						
Alpha	8	11	13.5	17.4	37.1	70.9
Steepness	0.67	0.73	0.77	0.81	0.9	0.95
Max recr (m)	3.462	3.081	2.911	2.758	2.504	2.409
SSB_{VIRGIN} (m)	12.118	10.782	10.188	9.652	8.764	8.433
SSB_{MSY} (m)	3.083	2.447	2.158	1.881	1.36	1.117
$SSB_{20\%tSPR}$ (m)	1.052	1.298	1.391	1.46	1.559	1.593
F_{MSY}	0.273	0.332	0.372	0.424	0.594	0.74
$F_{30\%SPR}$	0.331	0.327	0.325	0.324	0.321	0.32
MSY (m)	1.846	1.848	1.861	1.887	1.988	2.067
CURRENTLY						
SSB_{2004} (m)	1.208	1.287	1.326	1.362	1.426	1.45
SSB_{2004}/SSB_{MSY}	0.39	0.53	0.61	0.72	1.05	1.3
$SSB_{2004}/SSB_{20\%tSPR}$	1.15	0.99	0.95	0.93	0.91	0.91
F_{2004}	0.561	0.545	0.537	0.531	0.52	0.515
F_{2004}/F_{MSY}	2.05	1.64	1.44	1.25	0.87	0.7
$F_{2004}/F_{30\%SPR}$	1.69	1.67	1.65	1.64	1.62	1.61

TABLE 8—Sensitivity Runs. 292 data points, base run described in Table 3.

	Base	1950 start	M 0.25	M 0.3	No recr. devs	Lg recr devs	Eq effort devs
FIT							
Estimated params	170	170	170	170	146	170	170
Objective function	369.9	389.8	378.5	358.8	431.4	391.3	379.1
AIC	1080	1120	1097	1058	1155	1123	1098
BENCHMARKS							
Alpha	13.5	13.4	14	13.1	14.2	12.7	13.6
Steepness	0.77	0.77	0.78	0.77	0.78	0.76	0.77
Max recr (m)	2.911	3.061	2.867	3.03	3.366	1.798	2.969
SSB_{VIRGIN} (m)	10.188	10.713	11.784	8.481	11.782	6.293	10.393
SSB_{MSY} (m)	2.158	2.276	2.49	1.807	2.455	1.37	2.197
$SSB_{20\%tSPR}$ (m)	1.391	1.456	1.629	1.136	1.646	0.829	1.418
F_{MSY}	0.372	0.371	0.339	0.427	0.384	0.343	0.379
$F_{30\%SPR}$	0.325	0.326	0.294	0.378	0.327	0.313	0.33
MSY (m)	1.861	1.955	1.92	1.828	2.177	1.122	1.906
CURRENTLY							
SSB_{2004} (m)	1.326	1.359	1.257	1.436	1.779	1.486	1.437
SSB_{2004}/SSB_{MSY}	0.61	0.6	0.5	0.79	0.72	1.08	0.65
$SSB_{2004}/SSB_{20\%tSPR}$	0.95	0.93	0.77	1.26	1.08	1.79	1.01
F_{2004}	0.537	0.529	0.559	0.504	0.433	0.513	0.511
F_{2004}/F_{MSY}	1.44	1.43	1.65	1.18	1.13	1.5	1.35
$F_{2004}/F_{30\%SPR}$	1.65	1.62	1.9	1.33	1.32	1.64	1.55

TABLE 9—Species Used in Meta-Analysis of α Parameter Values
Adapted from Rose et al. (2001) using "periodic" species.

Species	α
Pacific hake	1.9
bombay duck	2
chub mack	2.4
silver hake	2.7
southern bluefin	2.9
medit. Horse mack	3.5
walleye pollock	5
atlantic bluefin tuna	5.2
Gulf menhaden	5.3
bigeye tuna	5.3
European flounder	5.3
alewife	5.7
northern pike	6.1
black angler	6.7
yellowfin tuna	9.3
walleye	9.5
Blue whiting	10
atka mack	12
horse mack	12.1
Pacific sardine	12.7
haddock	13
yellowtail flounder	13
hake	18
pollock	18
shad	18.5

striped bass	18.6
Atl Herring	22.1
Atl. Menhaden	24.8
plaice	25.1
Atlantic cod	26
white croaker	26.1
sole	28.7
greenland halibut	29.3
swordfish	30.1
whiting	30.8
atlantic mack	31.8
blueback herring	31.9
Gulf of Mexico red snapper	47.8
new zealand snapper	65.6
scup	74.6

TABLE 10—Catches Under Various Rebuilding Scenarios

Lighter shading represents the ending of overfishing while darker shading represents the achievement of rebuilding.

Year	No Fishing			Current F			MSY		
	Catch	F/Fmsy	B/Bmsy	Catch (m)	F/Fmsy	B/Bmsy	Catch (m)	F/Fmsy	B/Bmsy
2004	1.34	1.44	0.6	1.34	1.44	0.6	1.34	1.44	0.6
2005	1.29	1.44	0.58	1.29	1.44	0.58	1.29	1.44	0.58
2006	1.27	1.44	0.57	1.27	1.44	0.57	1.27	1.44	0.57
2007	0	0	0.88	1.25	1.44	0.57	0.99	1	0.64
2008	0	0	1.12	1.24	1.44	0.56	1.06	1	0.69
2009	0	0	1.38	1.23	1.44	0.56	1.12	1	0.72
2010	0	0	1.67	1.22	1.44	0.55	1.17	1	0.75
2011	0	0	1.96	1.22	1.44	0.55	1.21	1	0.78
2012	0	0	2.25	1.22	1.44	0.55	1.24	1	0.8
2013	0	0	2.55	1.21	1.44	0.55	1.27	1	0.82
2014	0	0	2.84	1.21	1.44	0.55	1.29	1	0.83
2015	0	0	3.11	1.21	1.44	0.55	1.31	1	0.85
2016	0	0	3.34	1.21	1.44	0.55	1.32	1	0.85

Year	30% SPR			Min F to Rebuild			OY		
	Catch (m)	F/Fmsy	B/Bmsy	Catch (m)	F/Fmsy	B/Bmsy	Catch (m)	F/Fmsy	B/Bmsy
2004	1.34	1.44	0.6	1.34	1.44	0.6	1.34	1.44	0.6
2005	1.29	1.44	0.58	1.29	1.44	0.58	1.29	1.44	0.58
2006	1.27	1.44	0.57	1.27	1.44	0.57	1.27	1.44	0.57
2007	0.9	0.87	0.67	0.89	0.86	0.67	0.81	0.75	0.7
2008	0.98	0.87	0.73	0.97	0.86	0.73	0.9	0.75	0.77
2009	1.06	0.87	0.78	1.05	0.86	0.79	0.98	0.75	0.84
2010	1.12	0.87	0.83	1.12	0.86	0.84	1.06	0.75	0.91
2011	1.18	0.87	0.87	1.17	0.86	0.88	1.12	0.75	0.96
2012	1.22	0.87	0.9	1.22	0.86	0.91	1.18	0.75	1.01
2013	1.26	0.87	0.93	1.25	0.86	0.94	1.22	0.75	1.05
2014	1.29	0.87	0.95	1.28	0.86	0.96	1.26	0.75	1.08
2015	1.31	0.87	0.97	1.31	0.86	0.98	1.29	0.75	1.11
2016	1.33	0.87	0.98	1.33	0.86	1	1.31	0.75	1.13

7. Figures

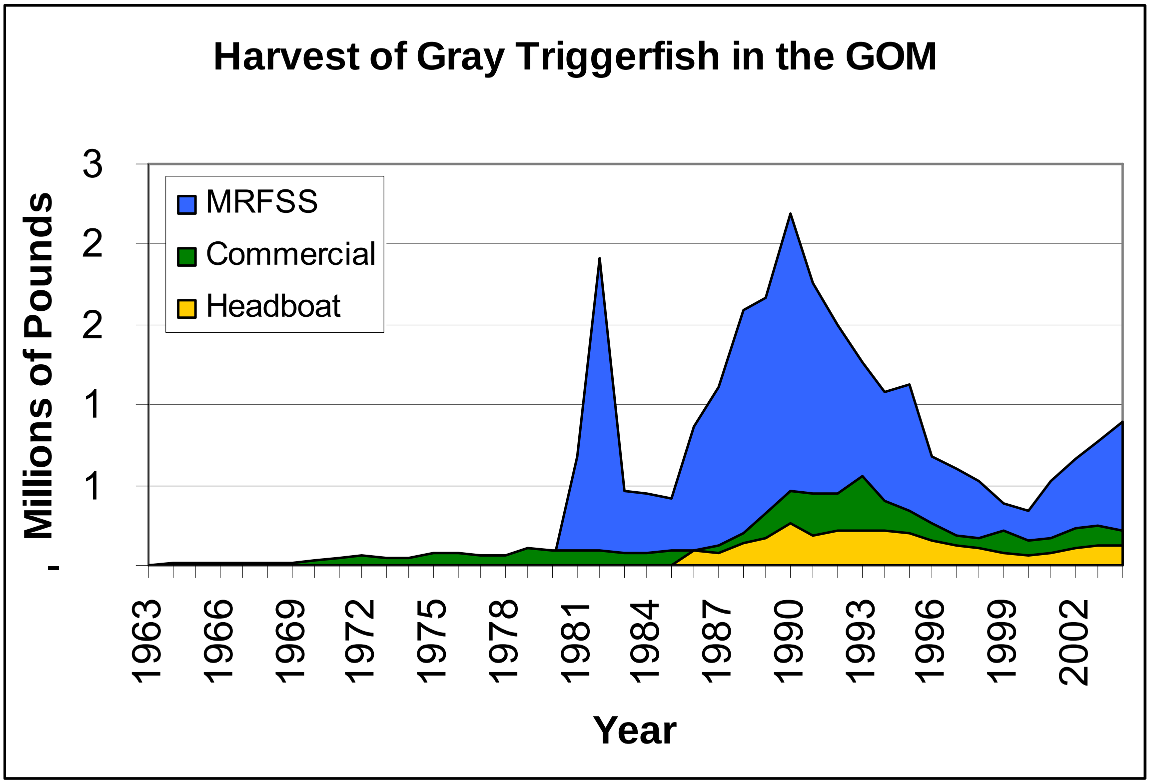
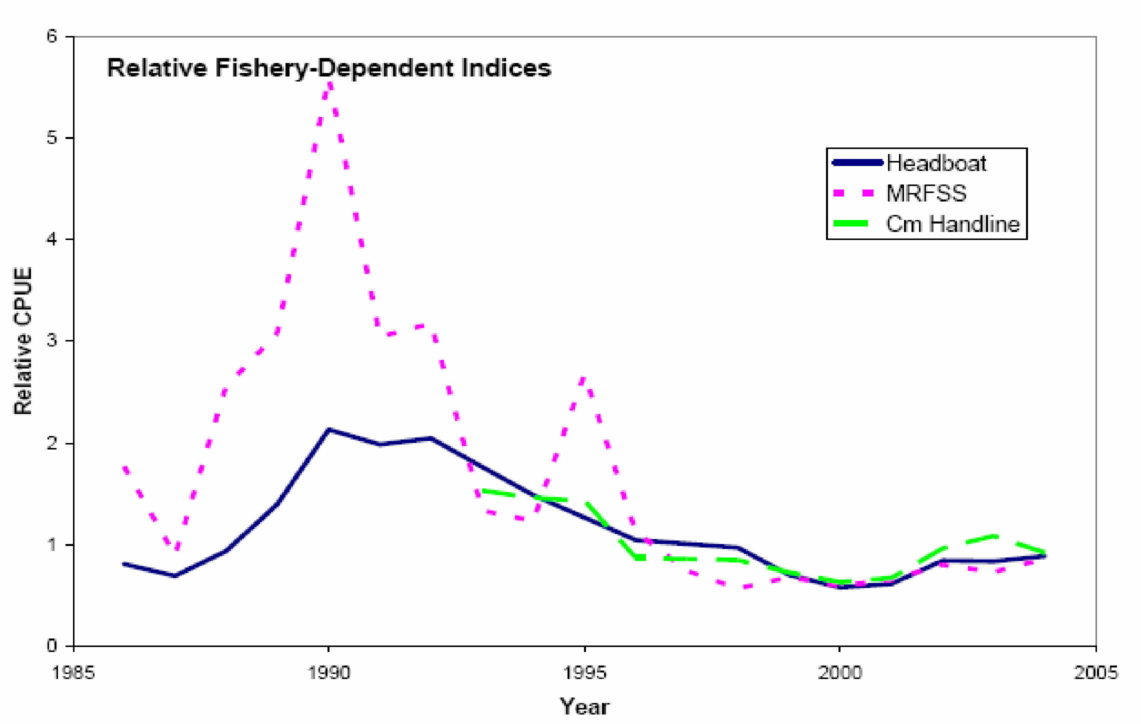


Fig. 1—Gulf of Mexico Gray Triggerfish Catches By Fleet
Values stacked to demonstrate trends in cumulative landings. Note: MRFSS survey began in 1981, and Headboat Survey (HB) began in 1984.(from SEDAR9-AW-08)



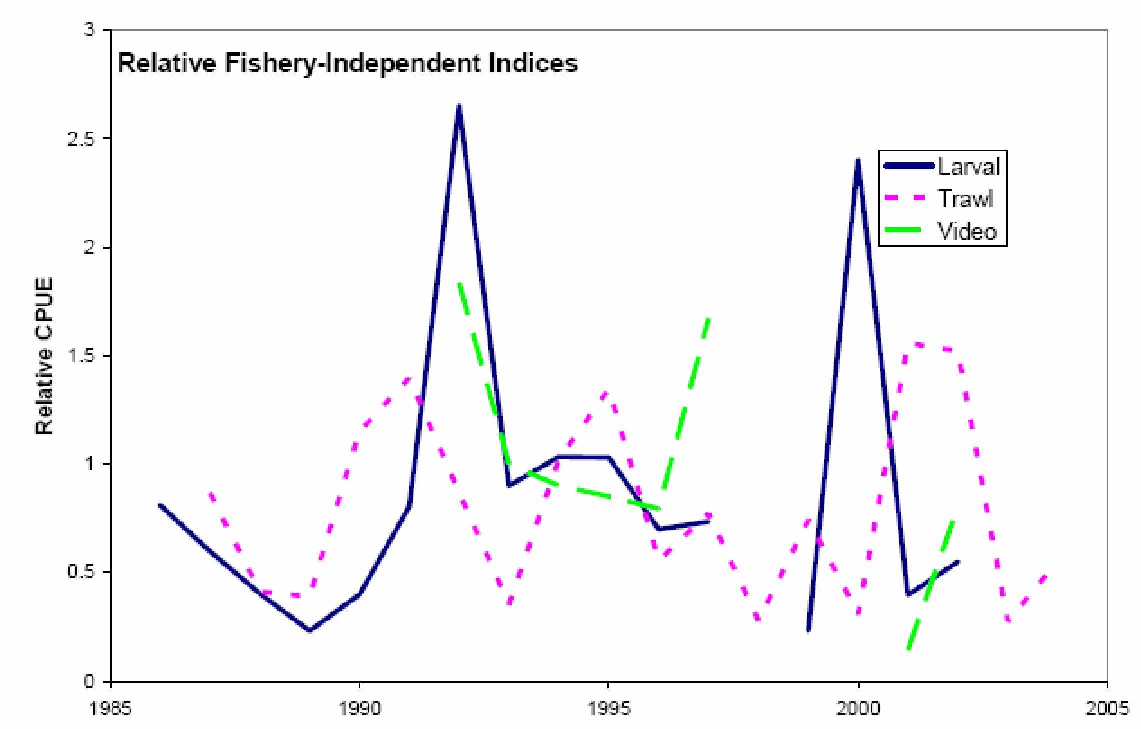


FIG. 2—Gulf of Mexico Gray Triggerfish Indices of Abundance
(a) Fishery-independent and (b) fishery-dependent indices of abundance. Normalized across the years where all indices were calculated (1992-97, 2001-02 for FI; 1993-2004 for FD).

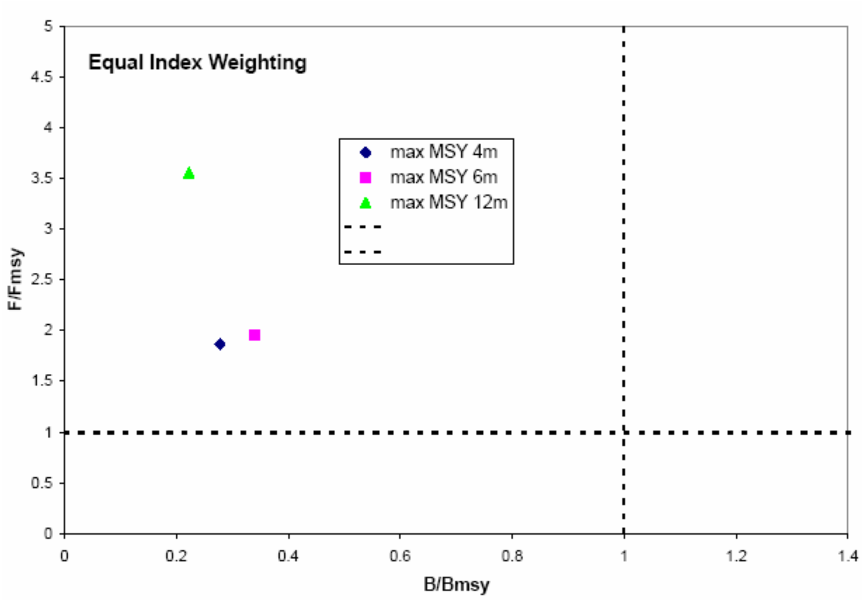


FIG. 3—Extreme Sensitivities, Equal Index Weightings
All runs had same inputs and varied only in constraints placed on MSY estimation. From SEDAR9-AW-08.

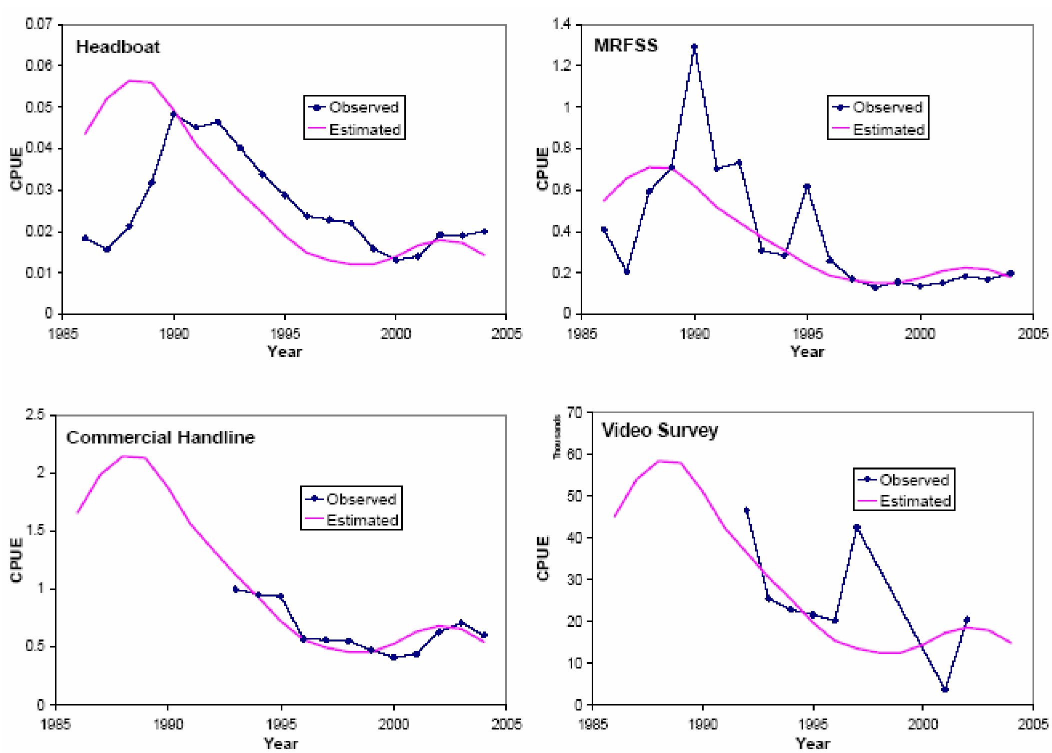


FIG. 4—Base ASPIC Model Fit to Indices
(A) Headboat, (B) MRFSS, (C) Commercial Handline, (D) SEAMAP Video Survey.

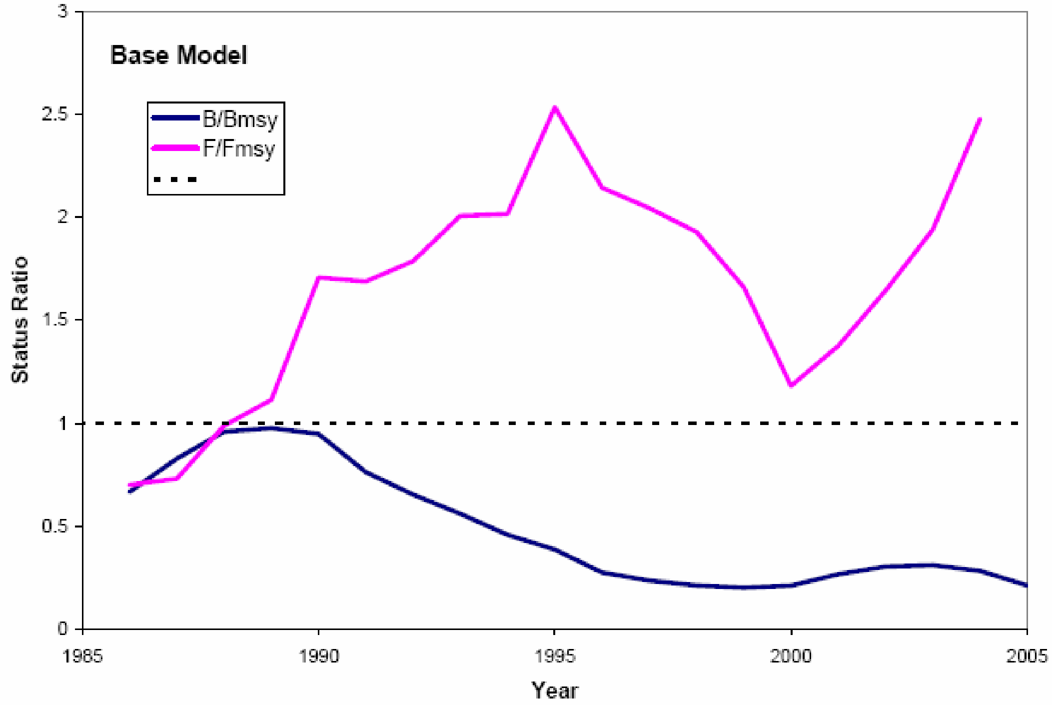


FIG. 5—Status Trajectories of ASPIC Base Model

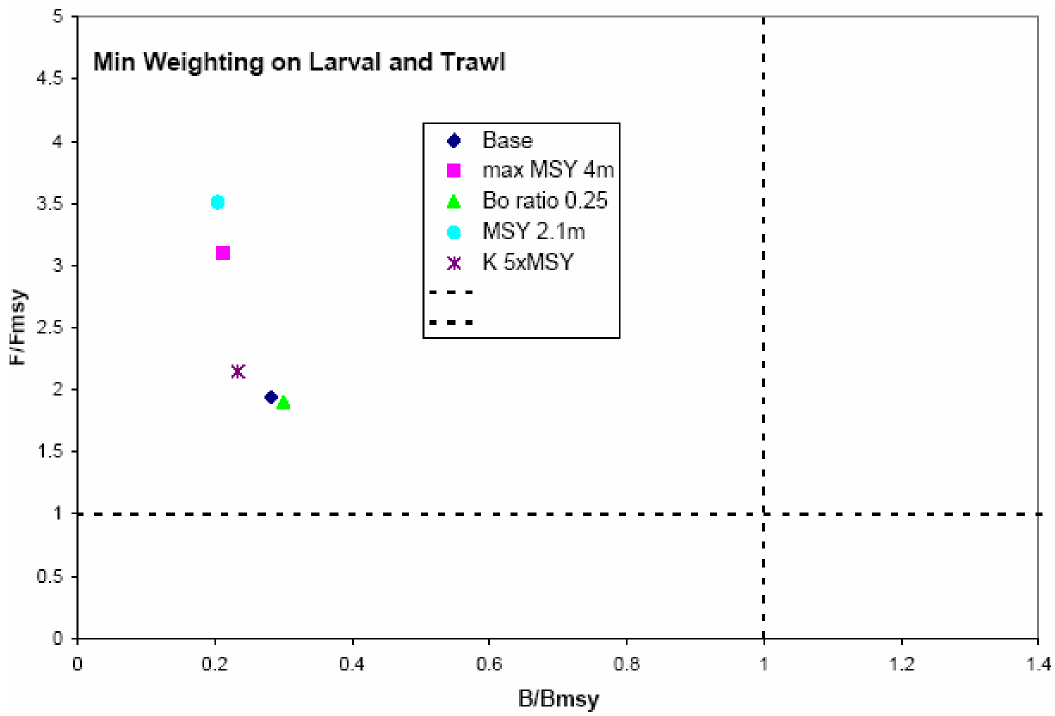


FIG. 6—Continued Extreme Sensitivities, Minimal Weightings on Larval and Trawl Indices
All runs had same inputs and varied only in constraints placed on MSY or in the starting point used for the estimation procedure. From SEDAR9-AW-08.

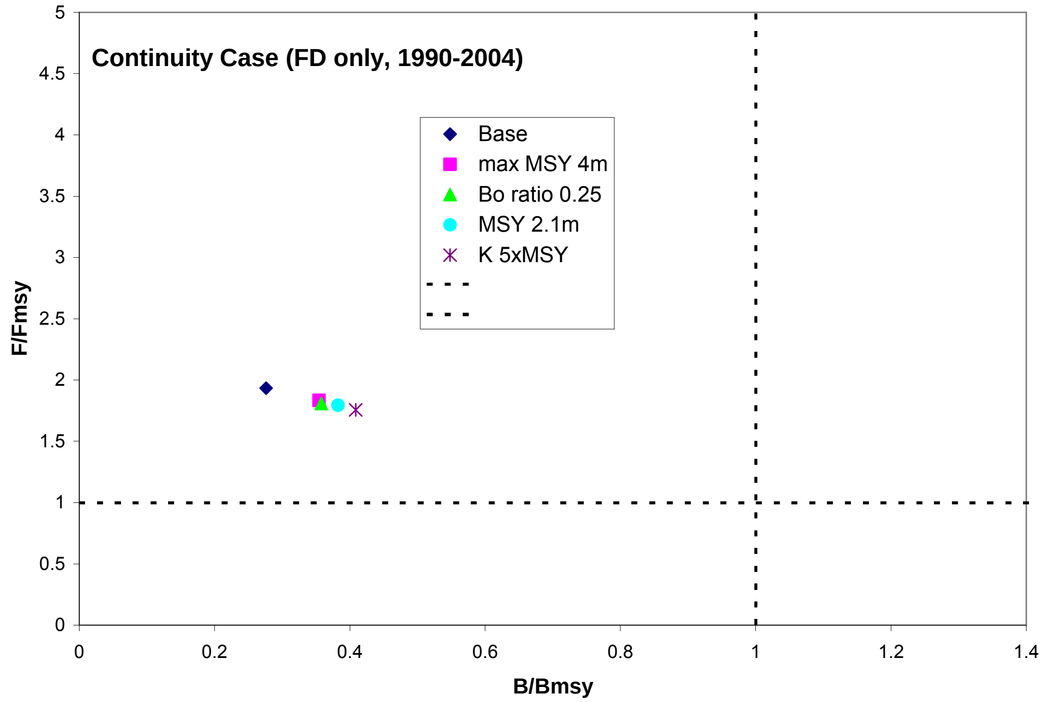


FIG. 7—Less Sensitive, Continuity Case
Similar figure as Figs. 5 and 6, but restricting analysis to fishery-dependent indices and years 1990-2004 increased stability.

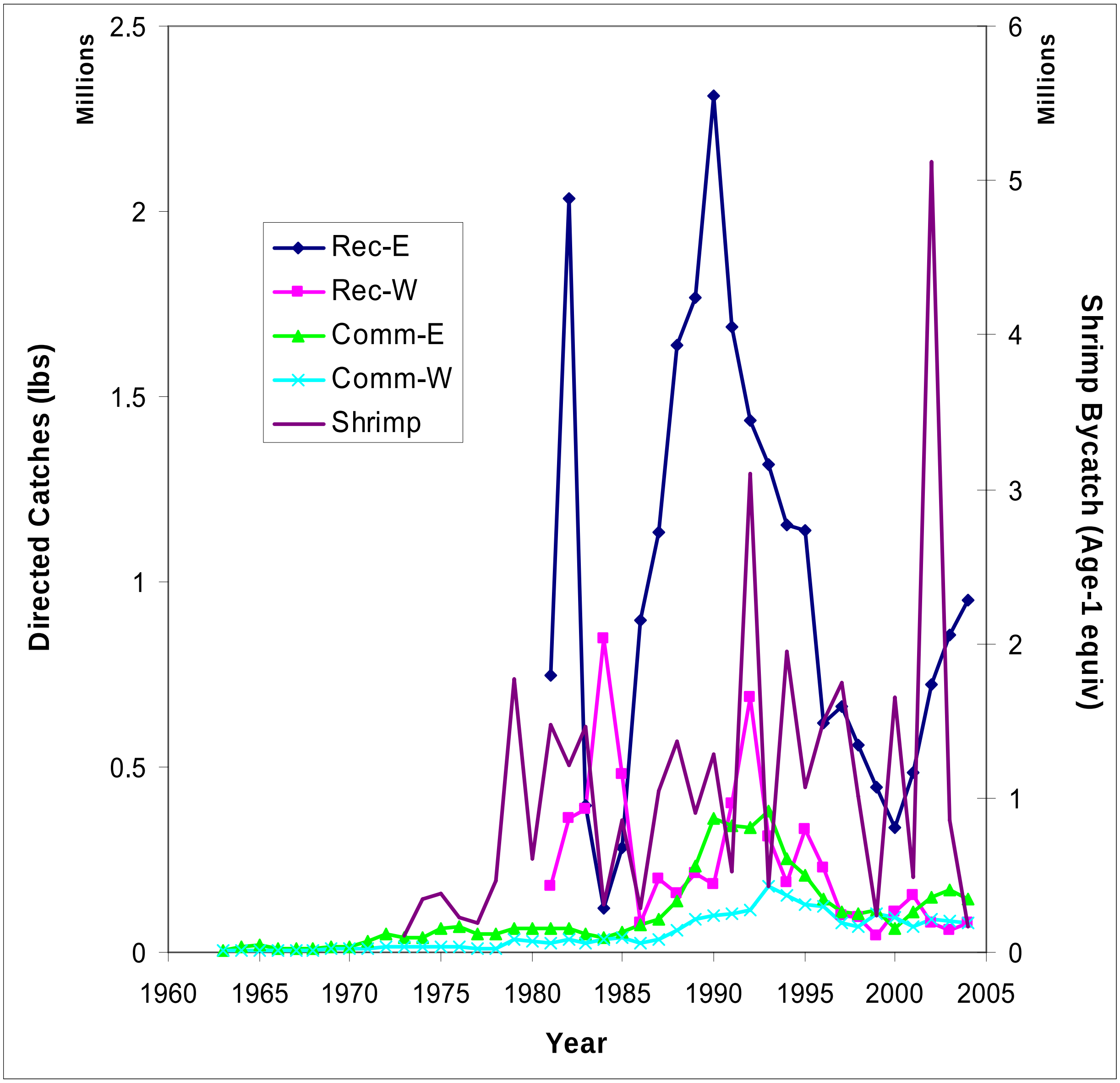
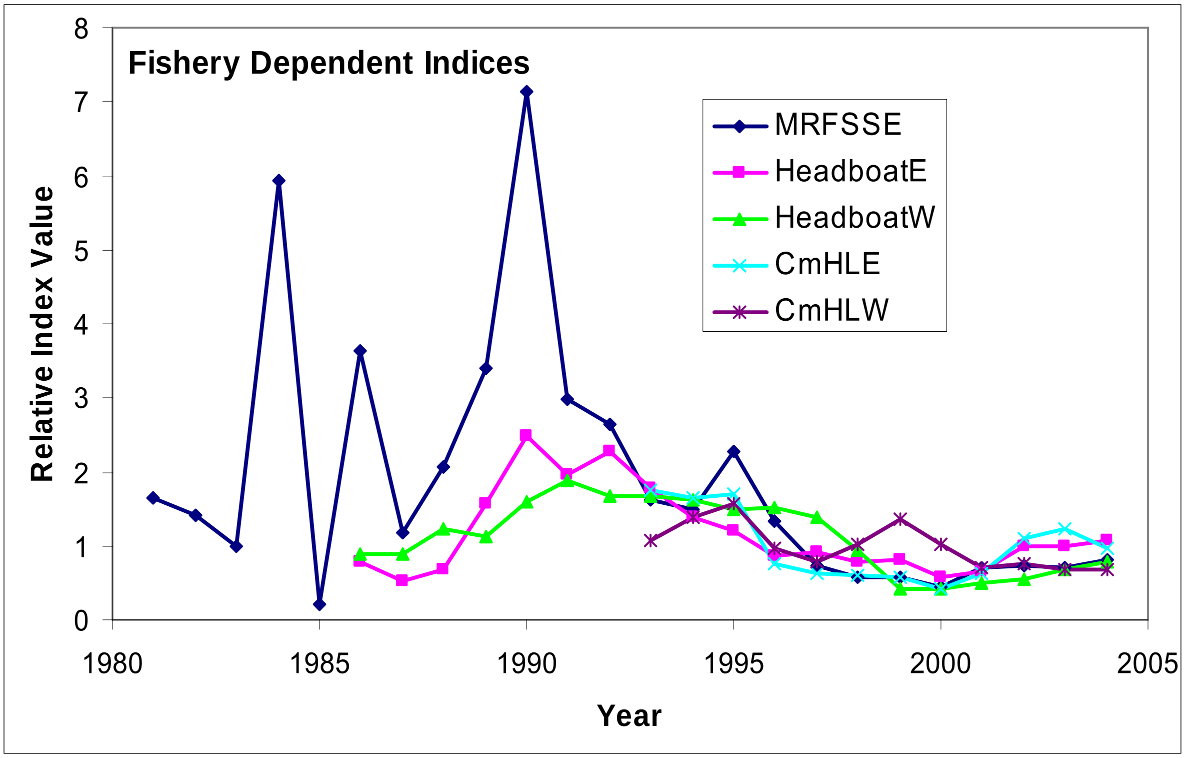


FIG. 8—Gulf of Mexico Gray Triggerfish Catches By Fleet and Region
Directed catches are reported in pounds, while shrimp bycatch is reported in age-1 equivalent fish (described in text).



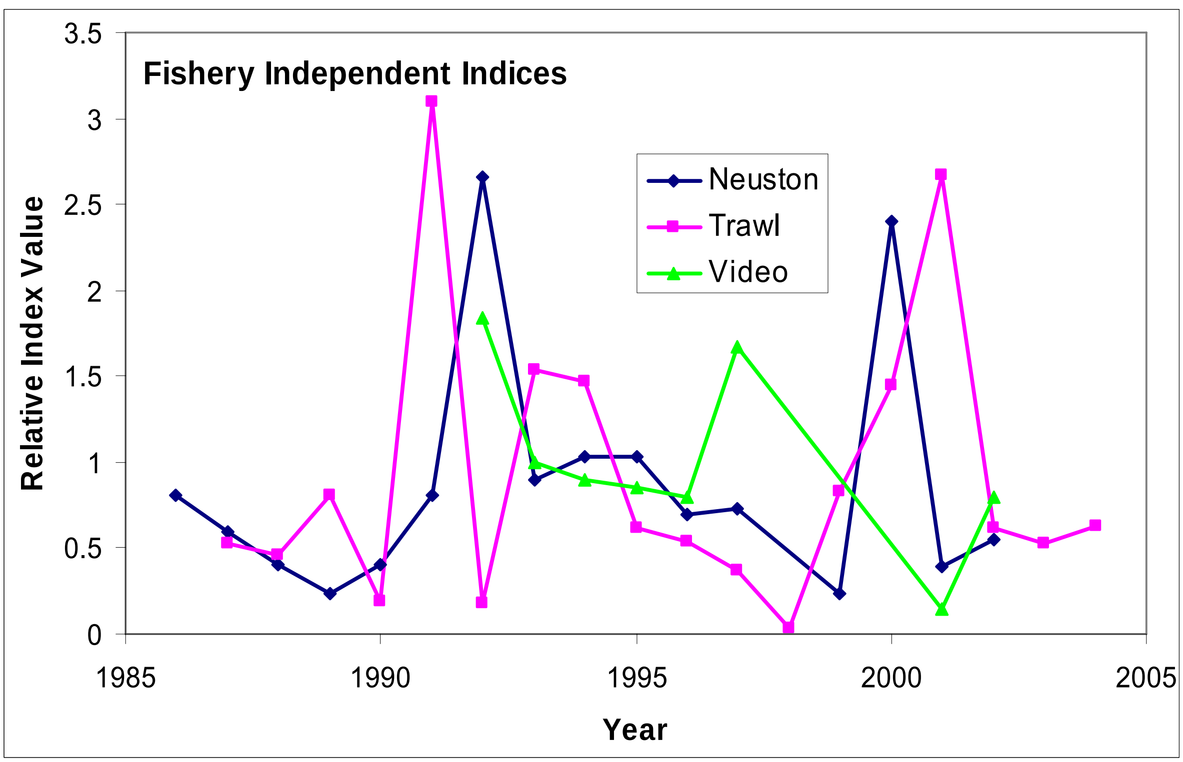


FIG. 9—Gulf of Mexico Gray Triggerfish Indices of Abundance
(a) Fishery-independent and (b) fishery-dependent indices of abundance. Normalized across the years where all indices were calculated (1992-97, 2001-02 for FI; 1993-2004 for FD).

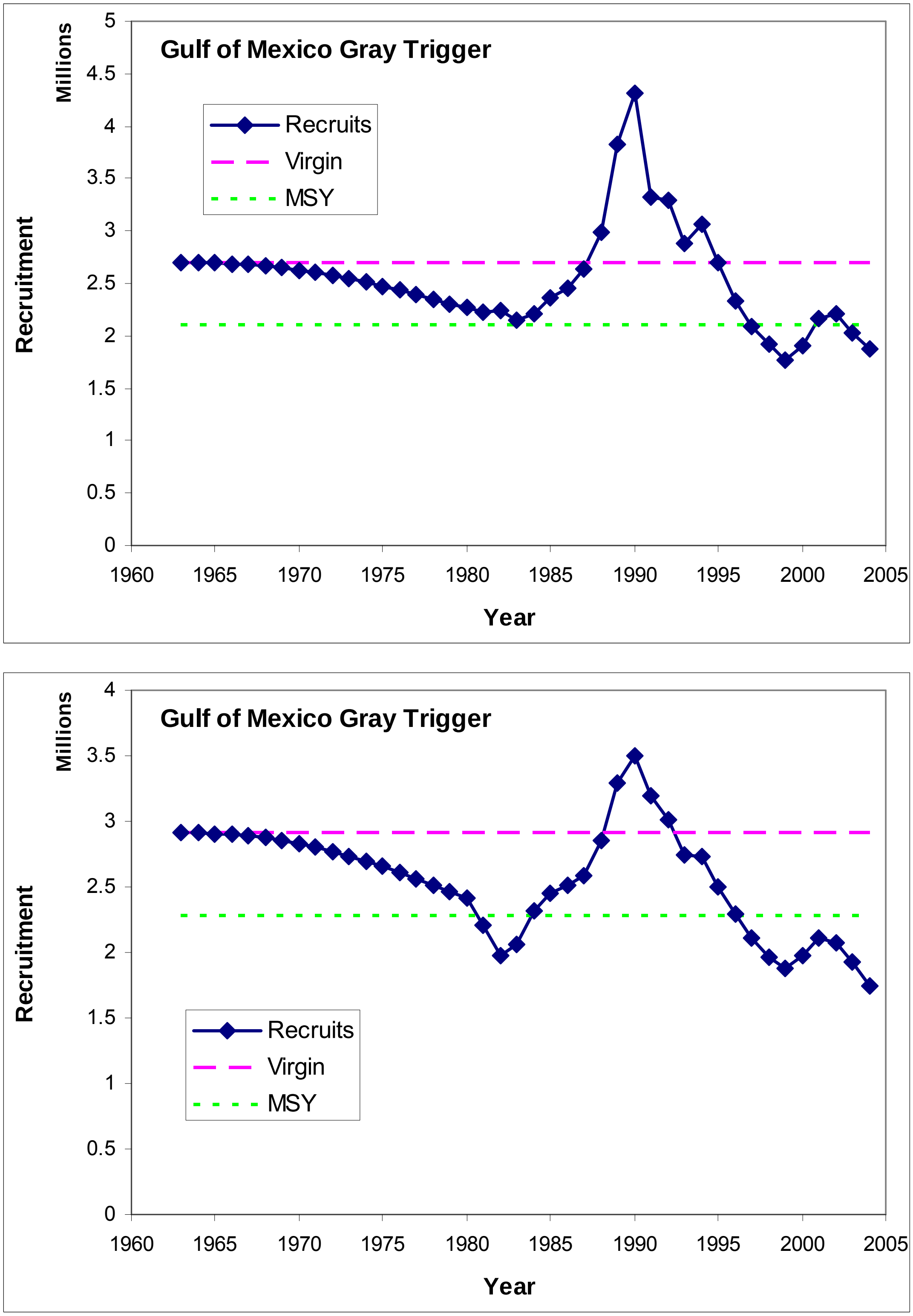


FIG. 10—Recruitment Trajectory
(a) Large Deviations (= 2), (b) Small Deviations (= 0.05).

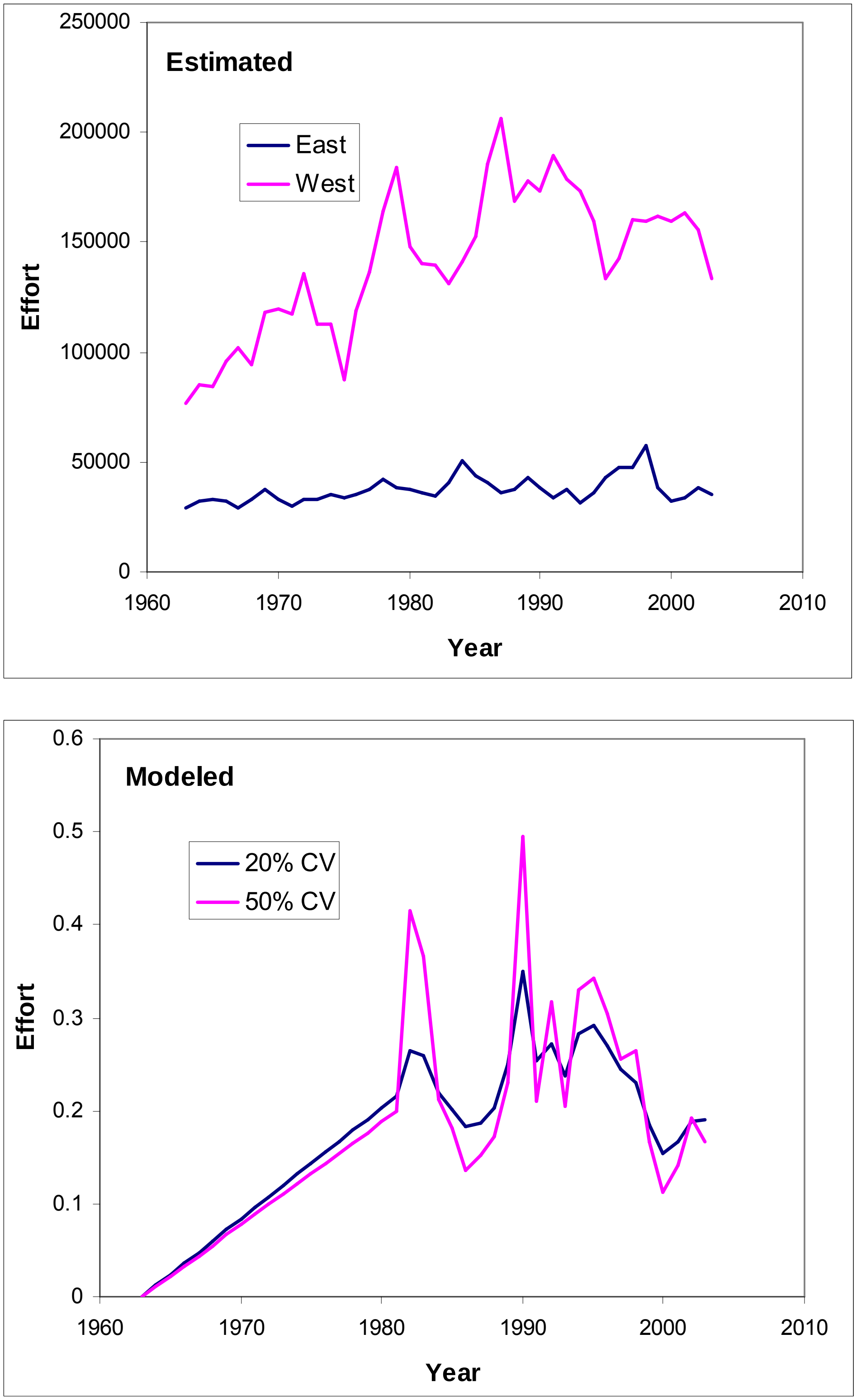


FIG. 11—Shrimp Effort Deviations
(a) Estimated values, (b) modeled values.

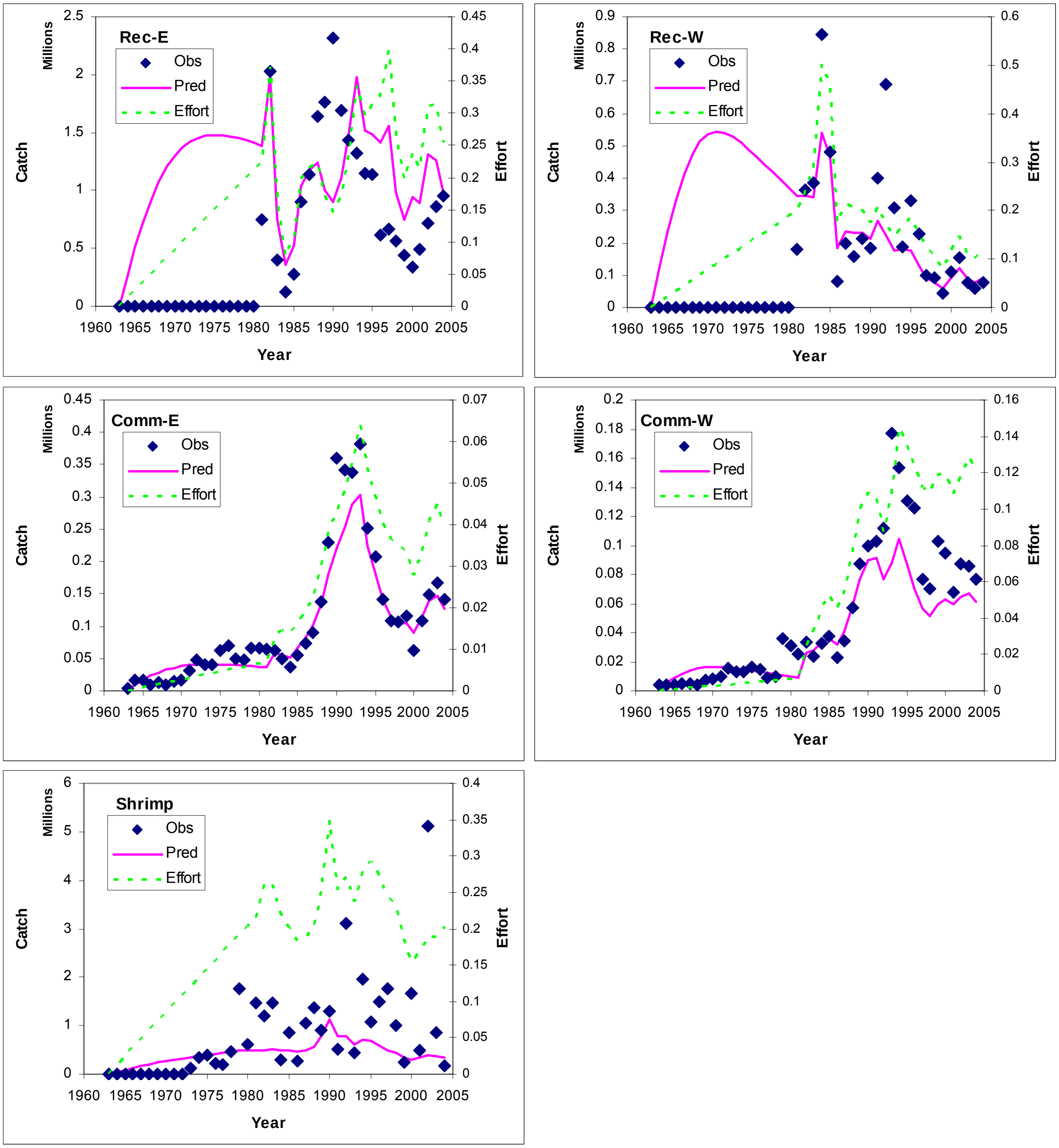


FIG. 12—Base Run Catch Fits

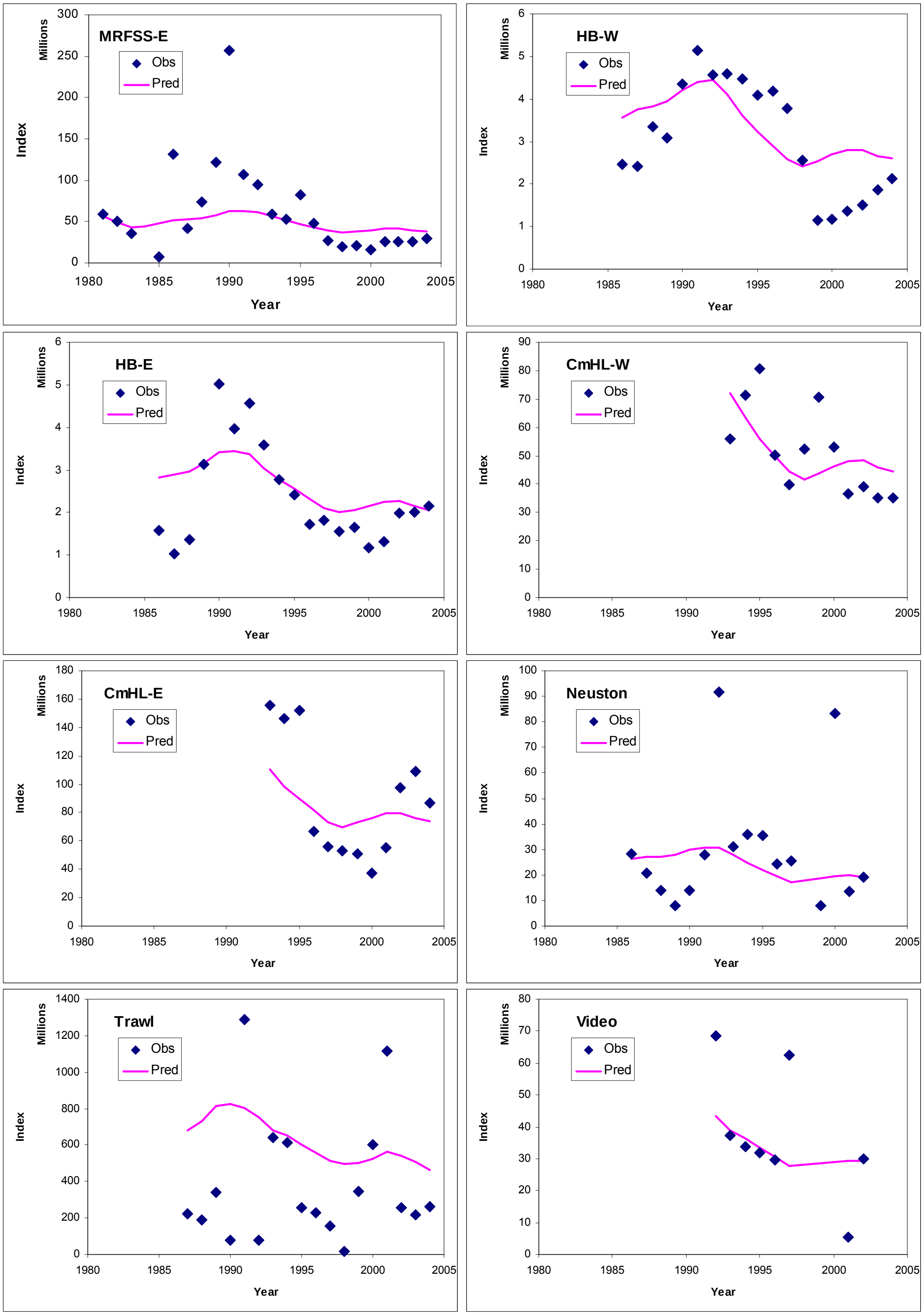


FIG. 13—Base Run Index Fits

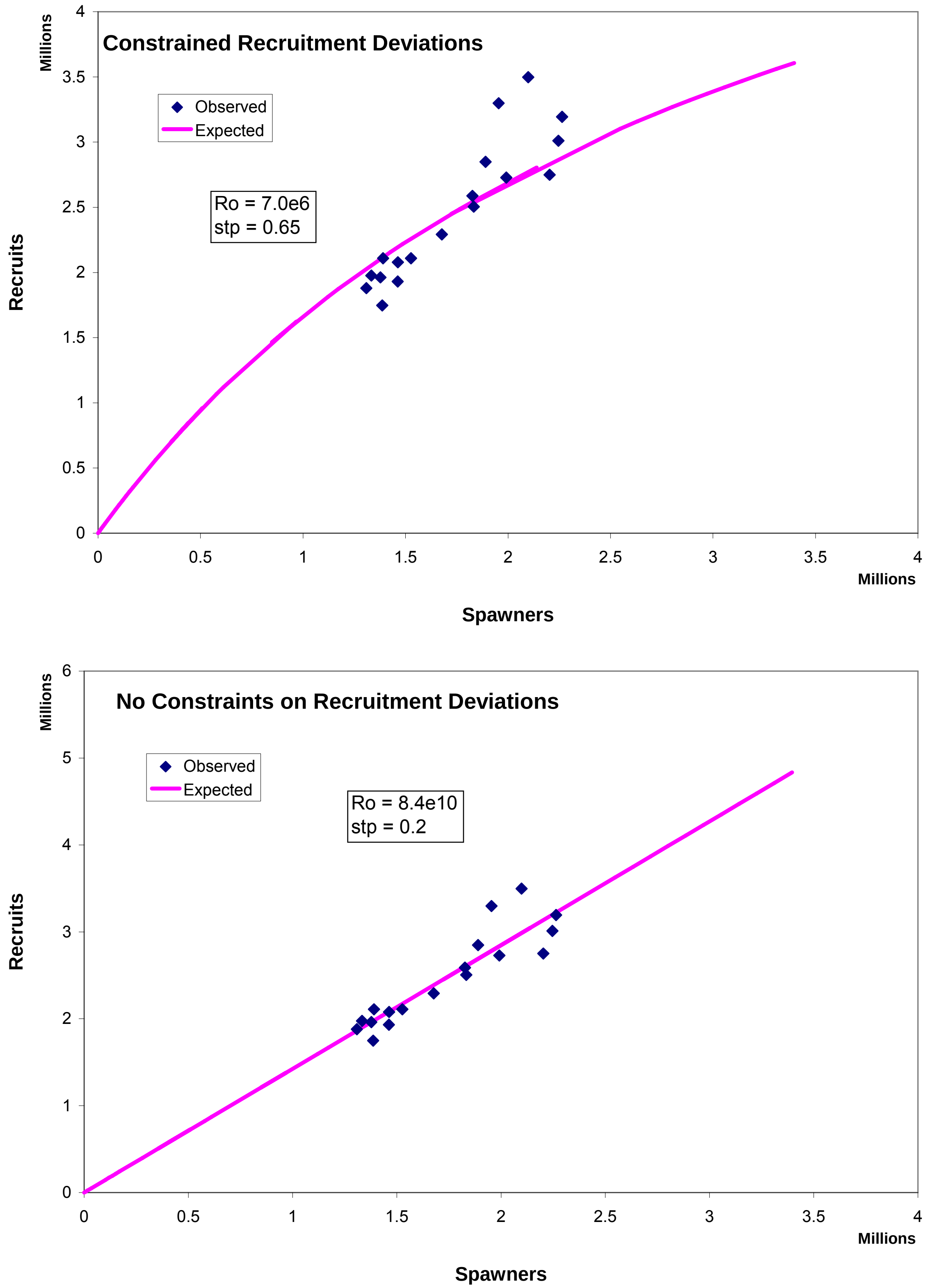


FIG. 14—Gray Triggerfish Stock Recruitment Relationships.
All based on recruitment patterns since 1986. (a) Base run with constraints on recruitment deviations as described in the text. (b) No constraints on the size of recruitment deviations.

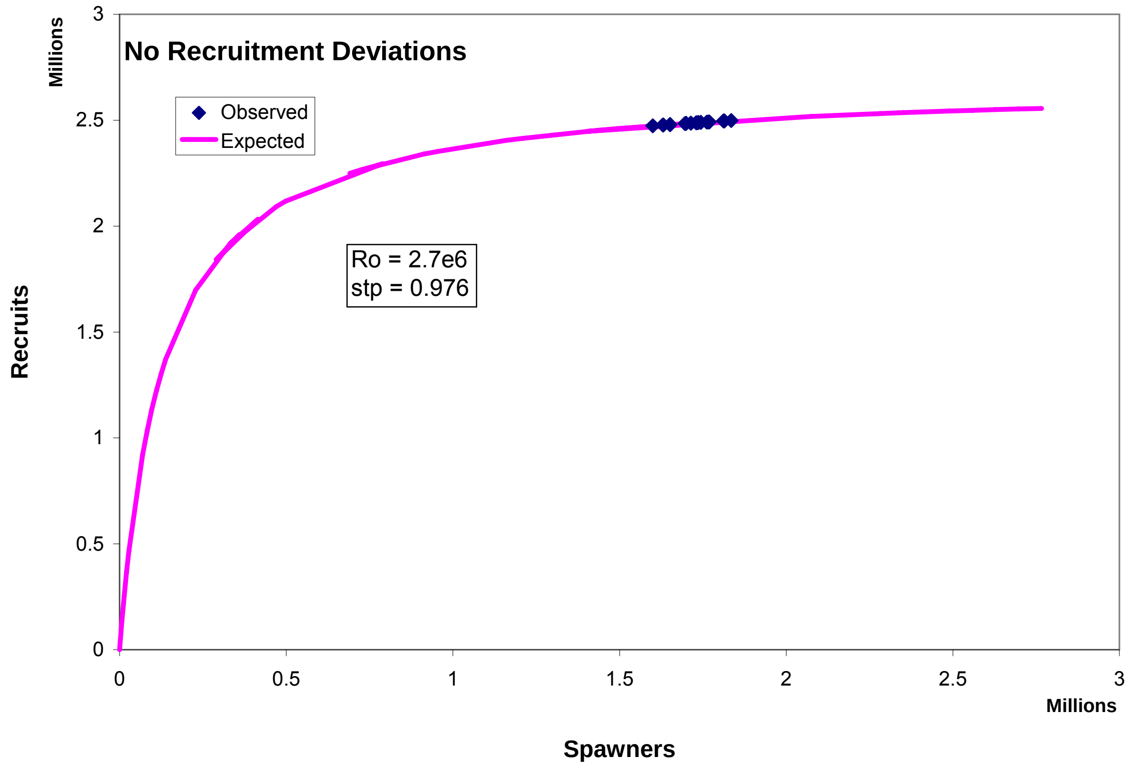


FIG. 14 (cont.)—Gray Triggerfish Stock Recruitment Relationships Under Various Scenarios. All based on recruitment patterns since 1986. (c) No recruitment deviations allowed.

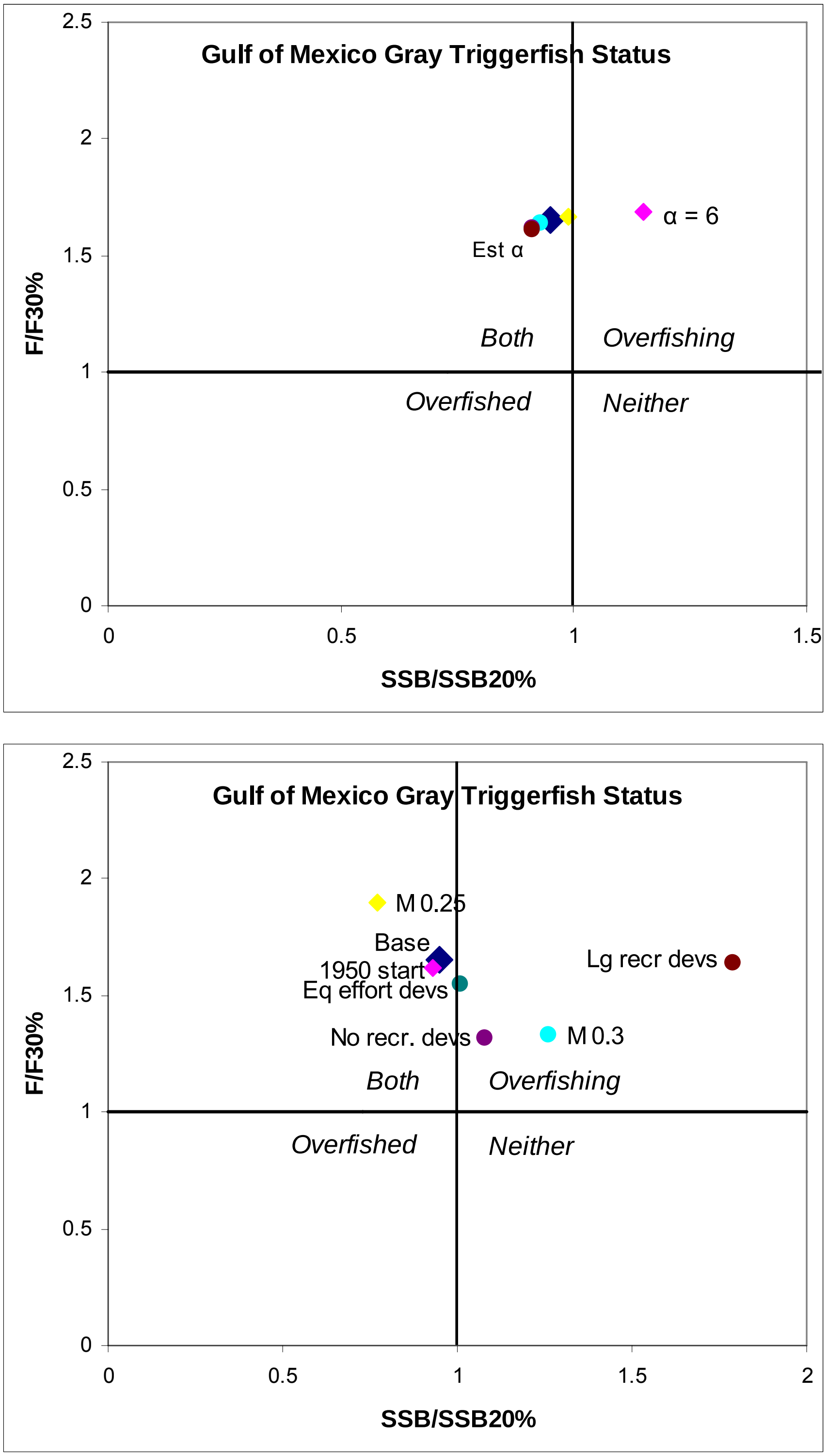
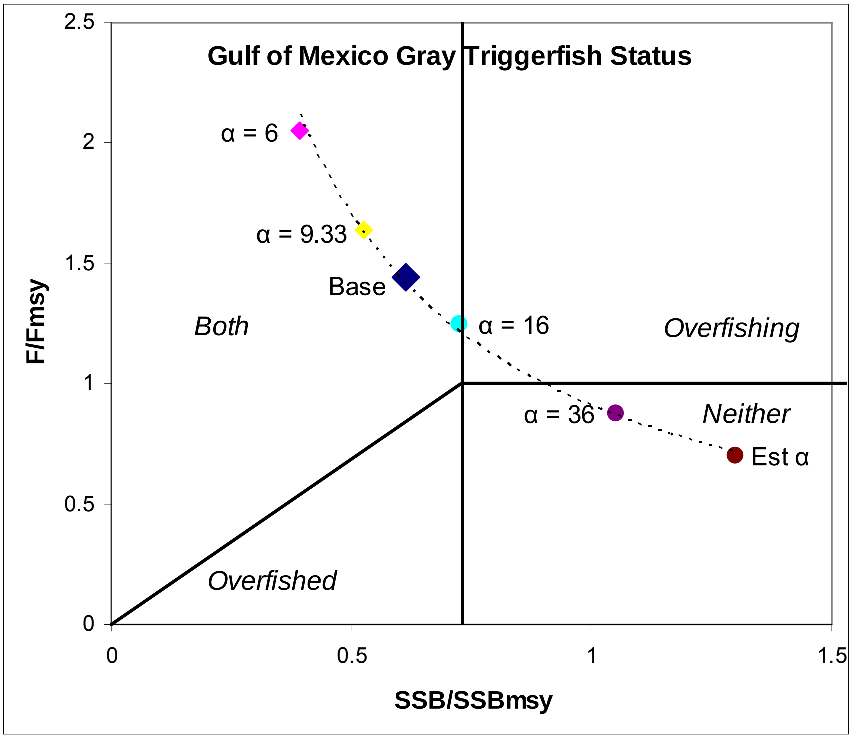


FIG. 15—Gray Triggerfish Status Relative to SPR
(a) Across steepness values; (b) across sensitivity trials.



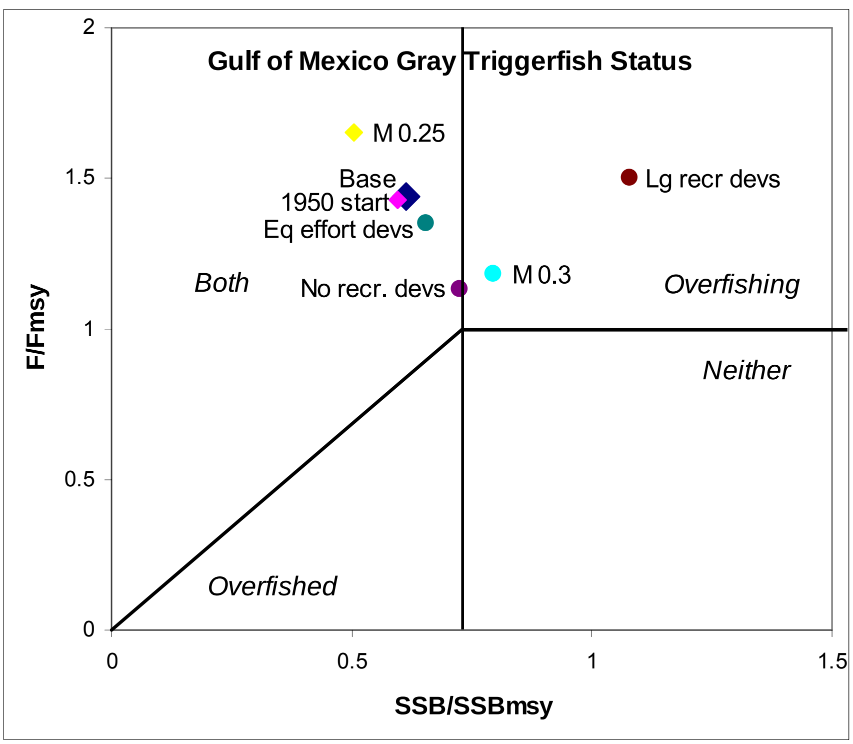


FIG. 16—Gray Triggerfish Status Relative to MSY
(a) Across steepness values; (b) across sensitivity trials.

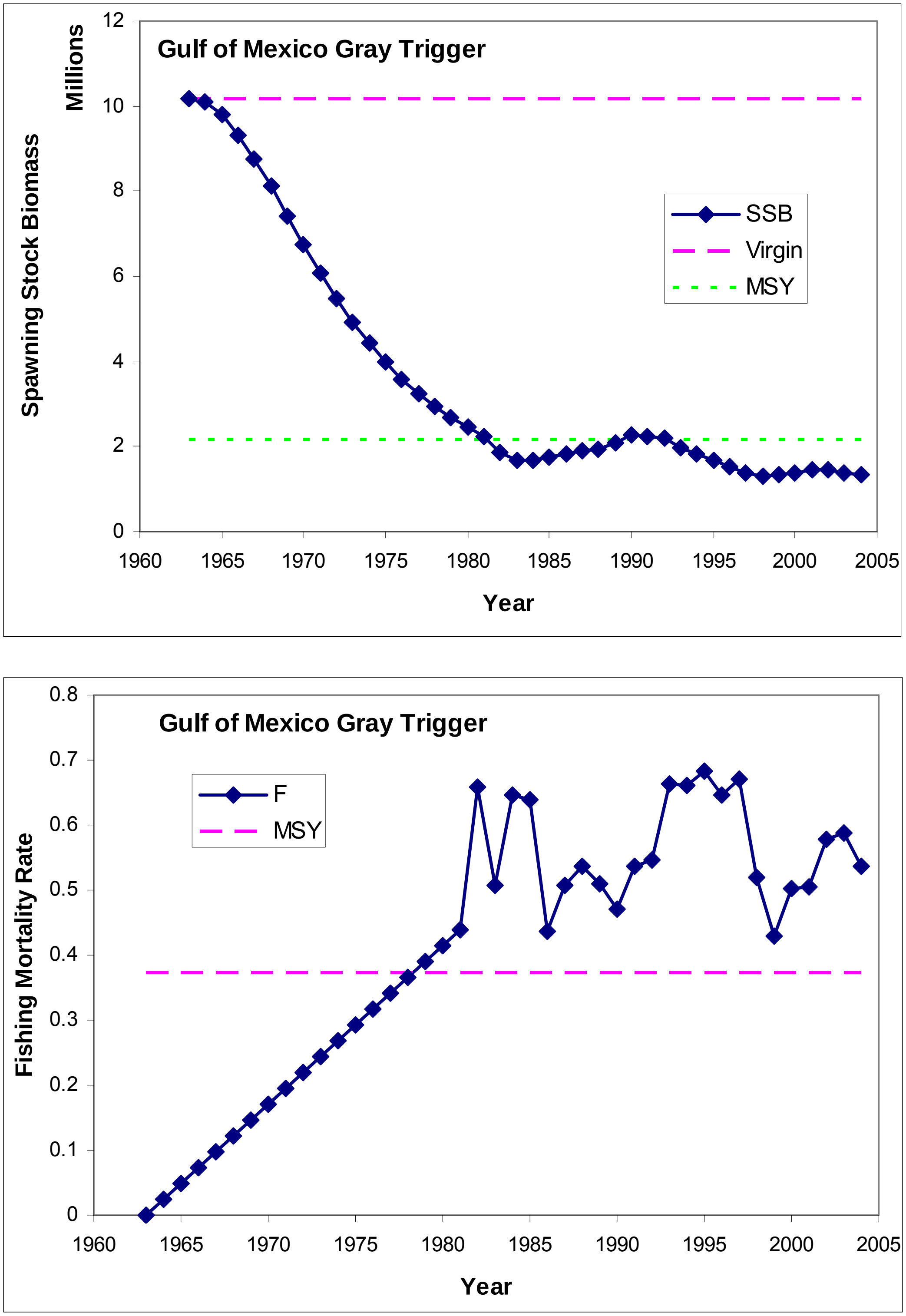


FIG. 17—Gray Triggerfish Status in 2004
(a) Spawning stock biomass (overfished); (b) Fishing mortality rate (overfishing).

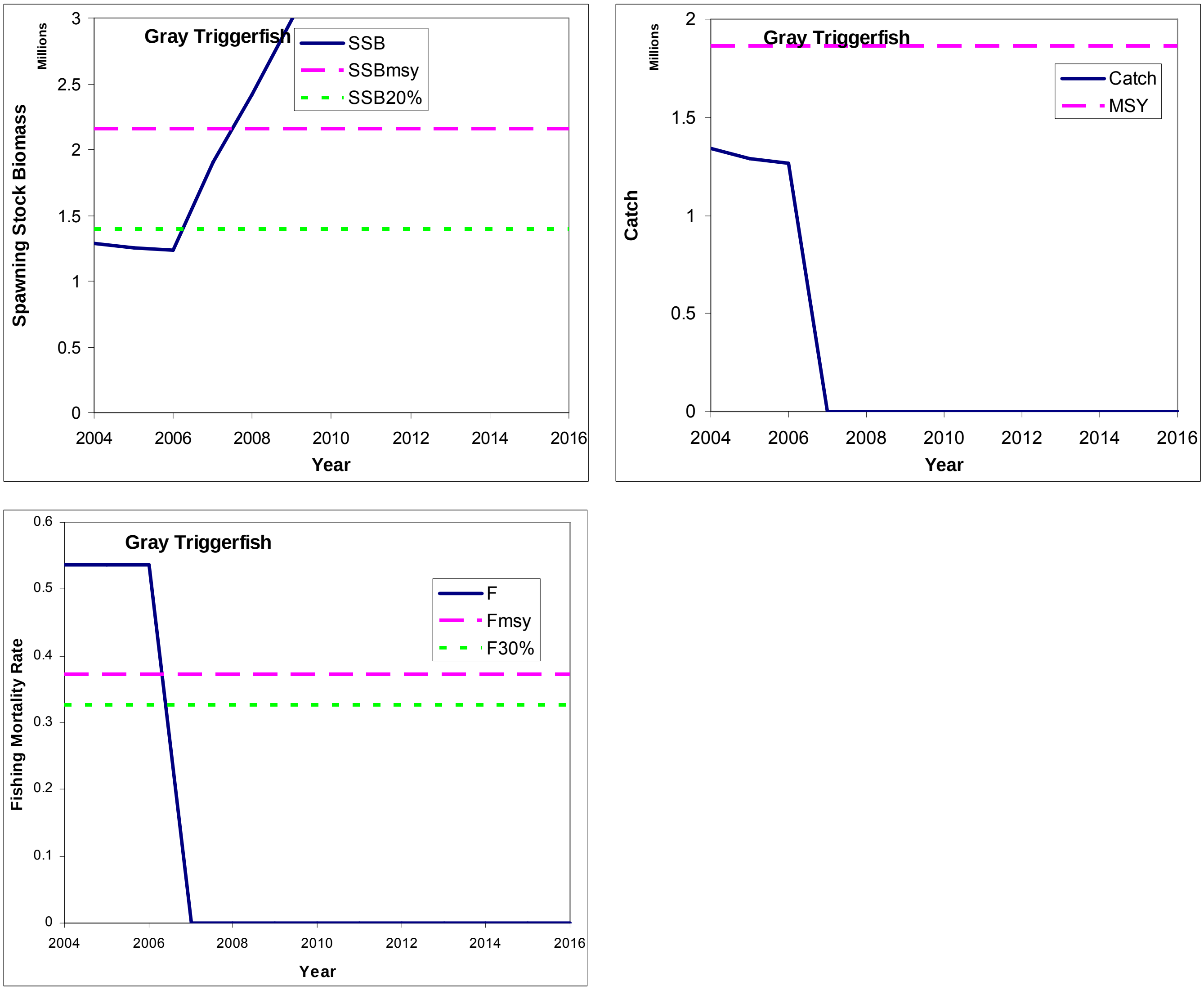


FIG. 18—Projections Under No Fishing
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

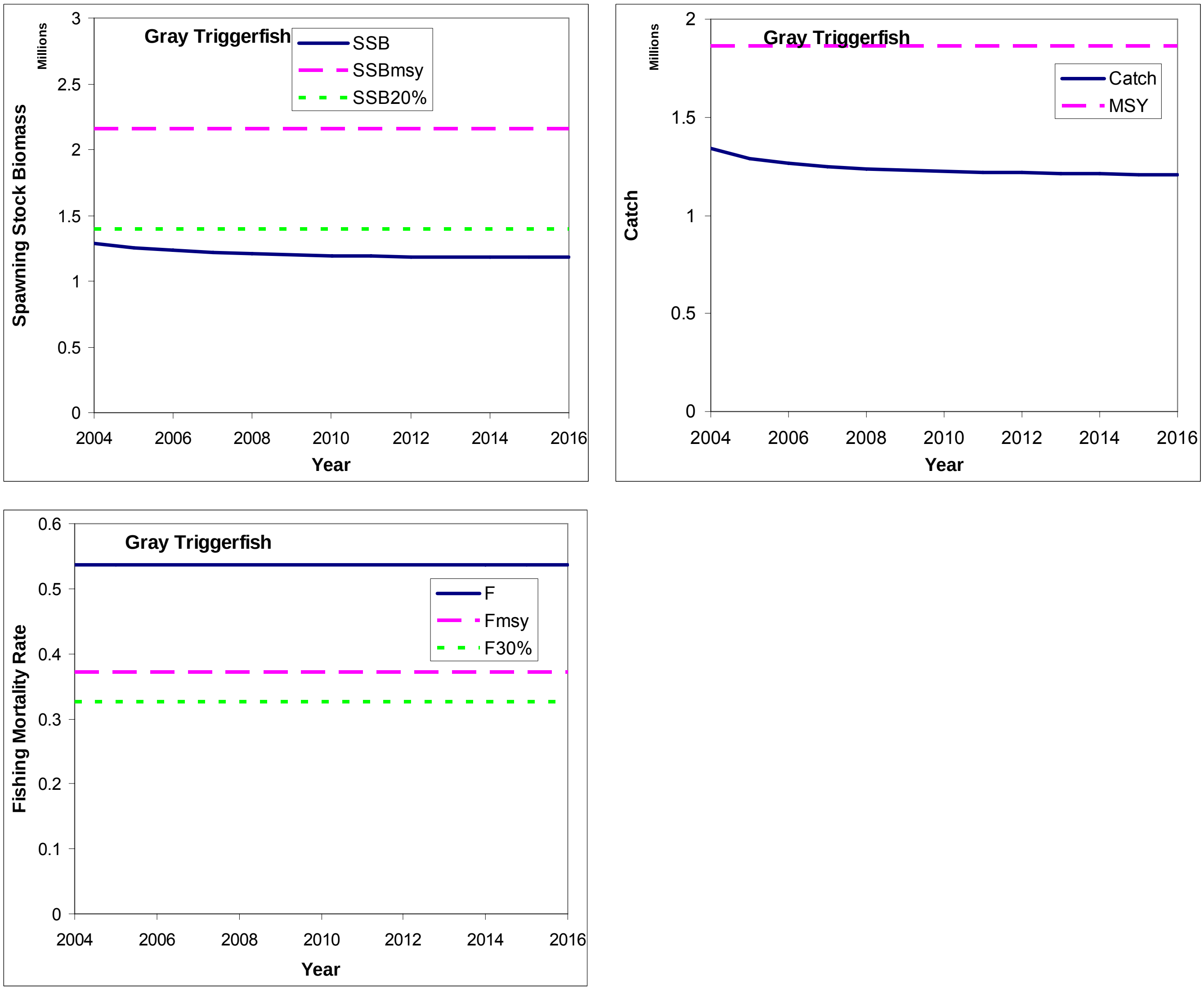


FIG. 19—Projections Under Current F (2004)
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

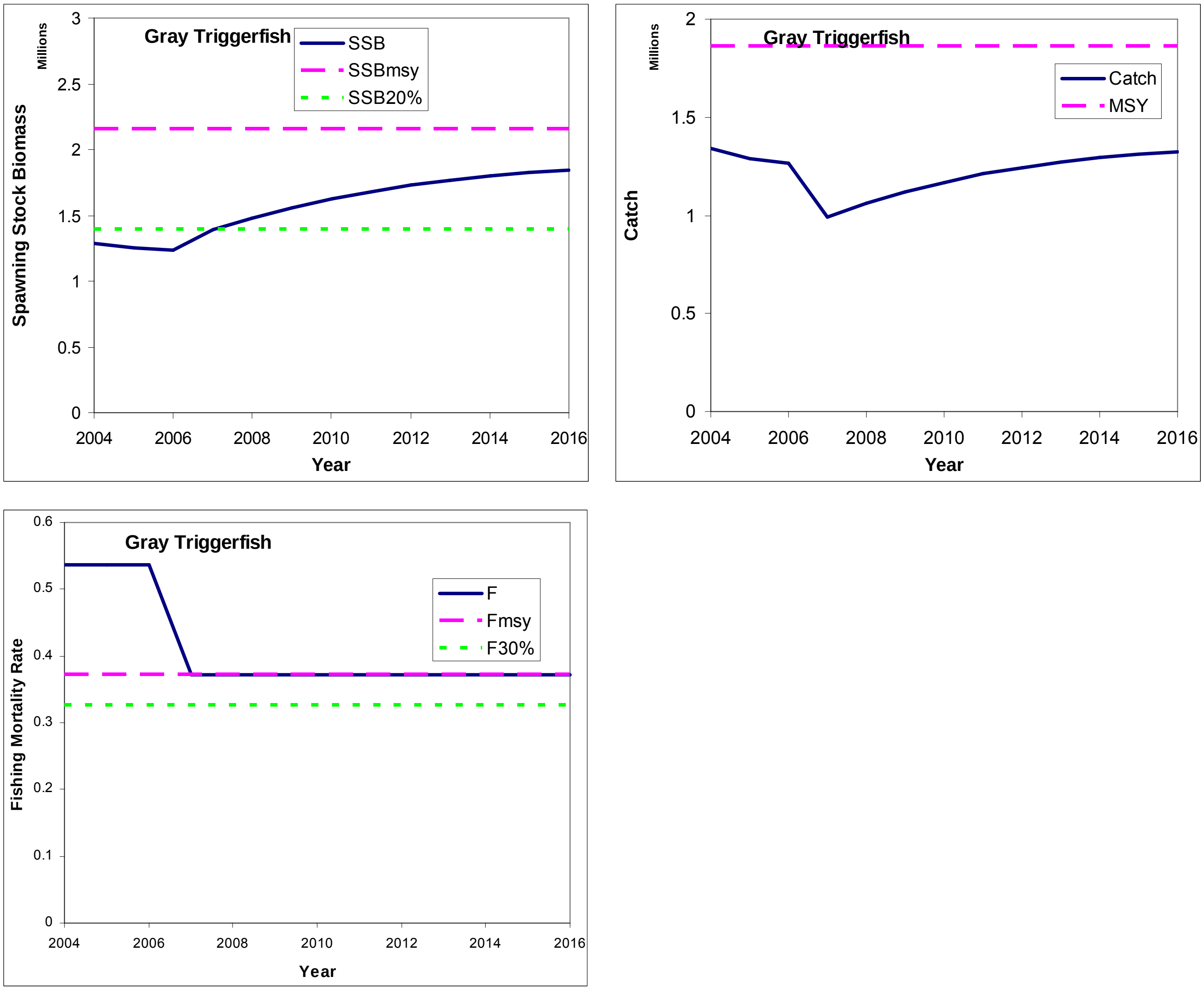


FIG. 20—Projections Under F_{MSY}
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

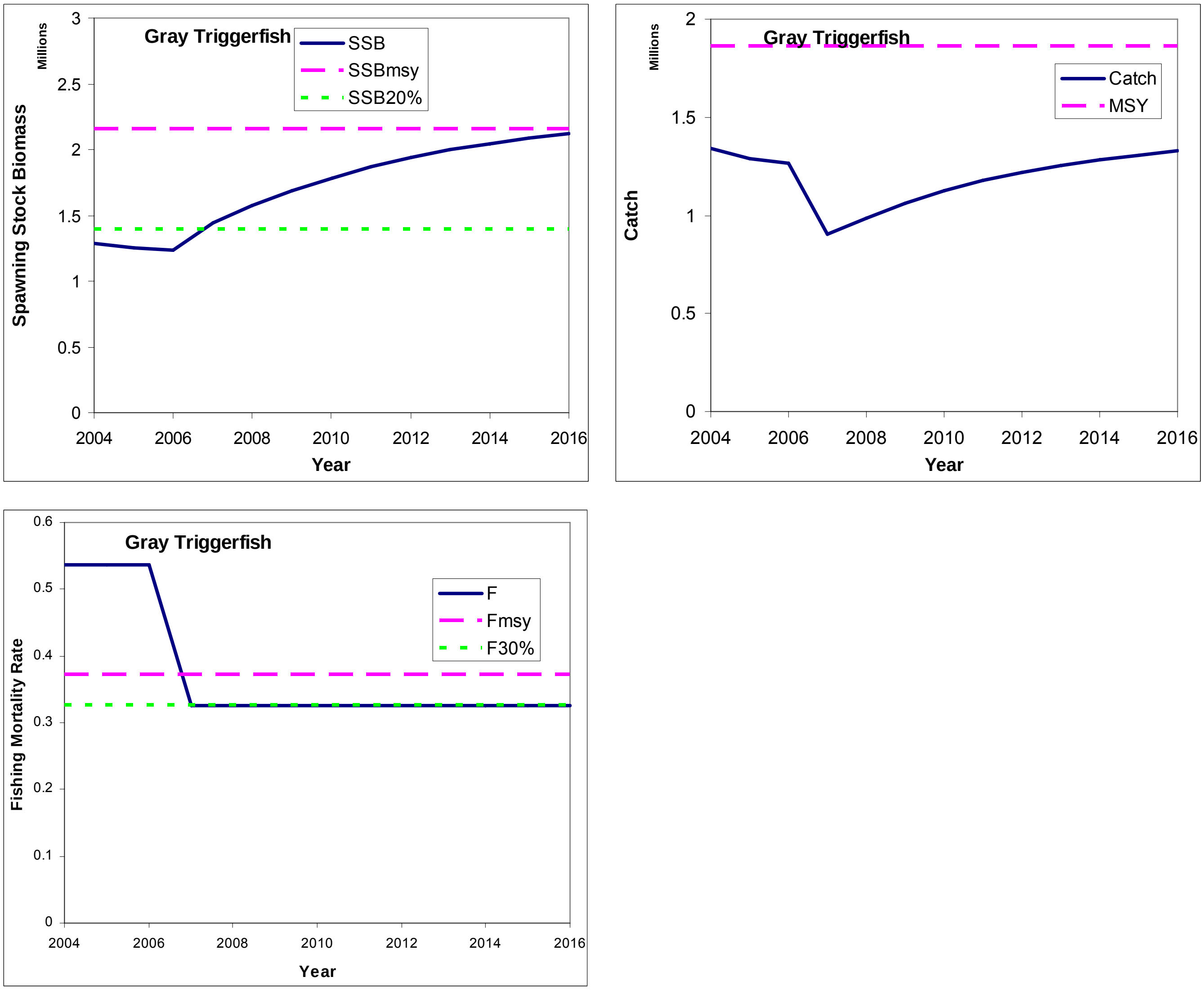


FIG. 21—Projections Under $F_{30\%SPR}$
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

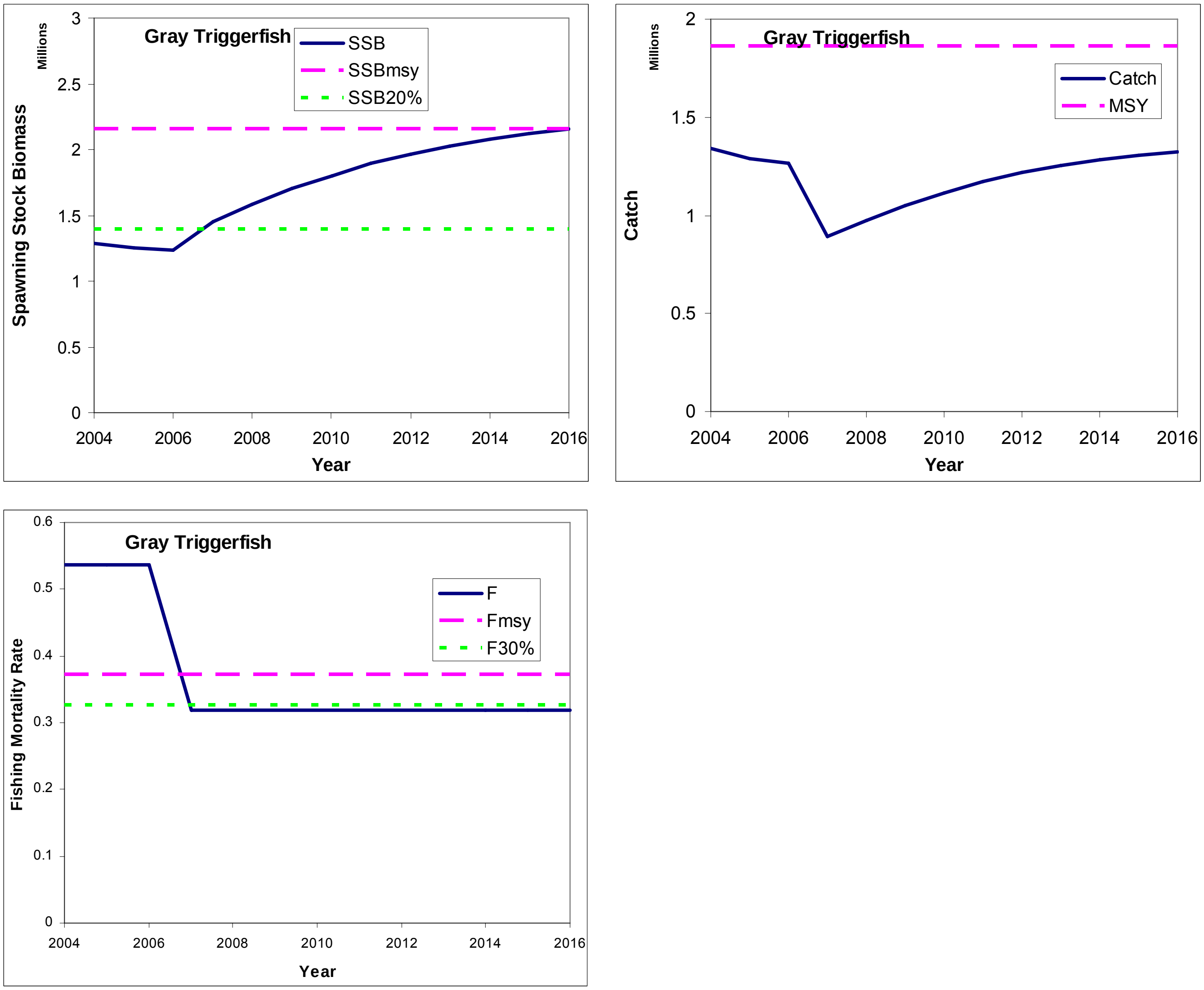


FIG. 22—Projections Under Minimum F Required to Rebuild by 2016
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

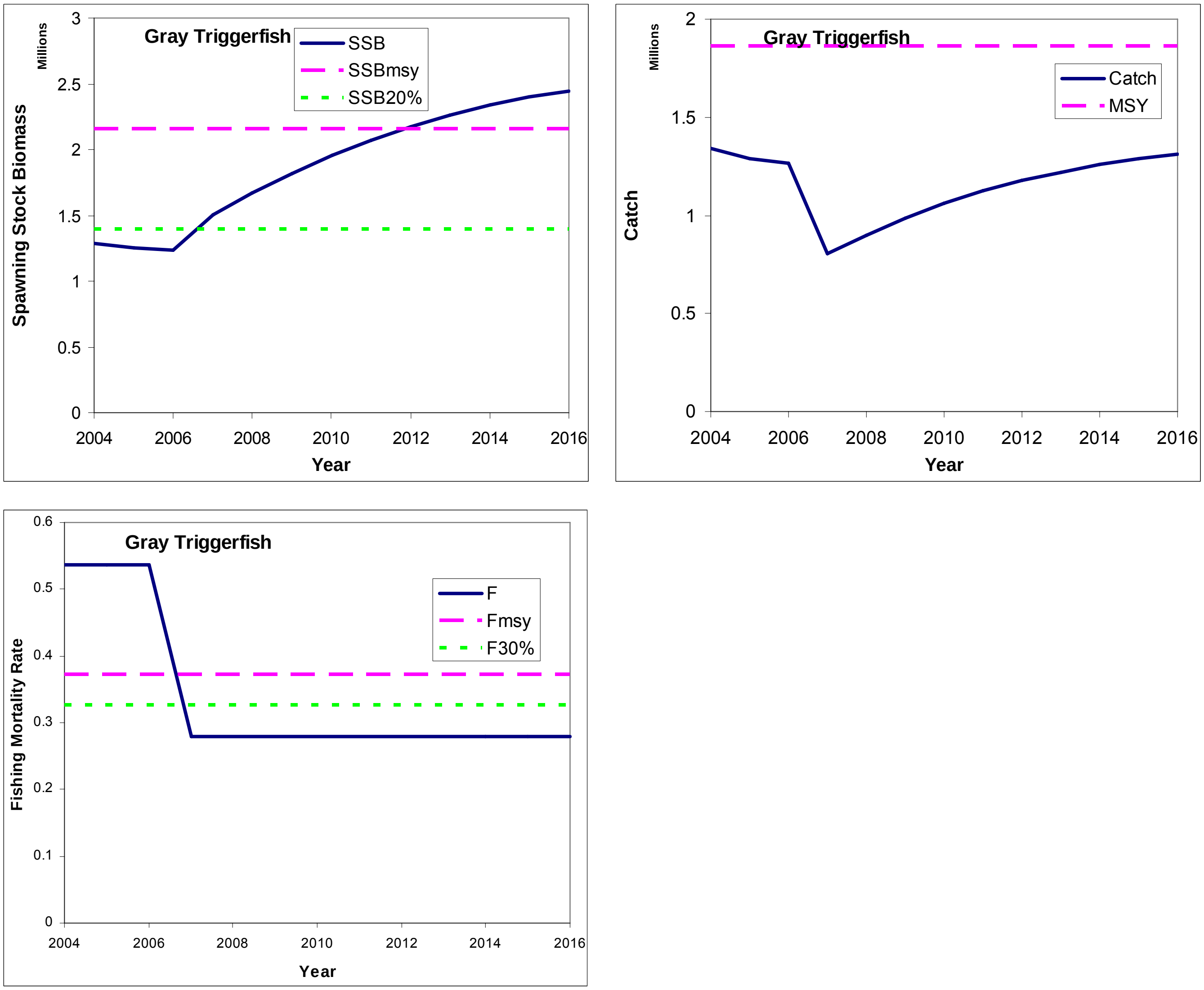


FIG. 23—Projections Under F_{OY}
(a) Spawning stock biomass; (b) Allowable catch; (c) Fishing mortality rate.

SEDAR

SouthEast Data, Assessment, and Review

Gulf of Mexico Gray Triggerfish

SEDAR 9
Stock Assessment Report 1

SECTION 4. Review Workshop

Contents

1. Review Panel Consensus Report

2. Review Panel Advisory Report

Consensus Summary Report

Gulf of Mexico Gray Triggerfish (*Balistes capriscus*)

Prepared by the SEDAR 9 Review Panel

Edited by M. Elizabeth Clarke for
SEDAR 9, March 27- 31, 2006
New Orleans, Louisiana

Executive summary

The SEDAR 9 Review Workshop met in New Orleans, LA from March 27 to 31, 2006 to review the stock assessment of Gray Triggerfish in the Gulf of Mexico. The first day consisted primarily of presentations by the Assessment Team covering the Data Workshop, the two Assessment Workshop, and their preferred base case assessment. During the second and third days, the workshop reviewed the assessment by addressing the terms of reference for the Review Workshop, including the consideration of additional model runs. On the final day, preliminary drafts of the Consensus Summary Report and the Advisory Report were reviewed.

The SEDAR for Gray Triggerfish has extended over more than 12 months and was interrupted by the effects of Hurricane Katrina in New Orleans. During this time the Assessment Team and other Data Workshop and Assessment Workshop participants have worked towards producing a credible and reliable stock assessment. The previous stock assessment was conducted in 2001 and a Stock Production Model Incorporating Covariates (ASPIC) procedure (NOAA Fisheries Toolbox Version 5.10, 2005, http://nft.nefsc.noaa.gov) was used.

For the current assessment, the authors used "State-Space Age-Structured Production Models" (SSASPM). The panel agreed that this was an appropriate method for the base case model. The panel did recommend some changes to the base model particularly recommending some specific weighting and constraints.. The assessment using the suggested base case model is documented in an Addendum to the Stock Assessment document,. The results of the final assessment indicated that the stock is experiencing overfishing. The panel could not come to a conclusion if it is in an overfished status at this time. Panel did conclude that at the least the stock appears to be approaching an overfished condition.

The Review Panel was impressed by the quantity of the work that had gone into the assessment. Several changes to the base case assessment were requested during the Review Workshop. The final base case model will be documented in an addendum to the stock assessment report produced by the assessment author.

The panel noted that the methods are not adequate for forecasting the effects of management measures that involve changing selection patterns, such as changes to minimum landing sizes and bag limits. They are however adequate for exploring the information content and management implications of small and incomplete data sets such as that available for gray triggerfish. Management agencies should be aware that high uncertainty is attached to this assessment.

The panel thanks the authors for their efforts and feels that the SEDAR process proceeded smoothly.

1. Introduction

1.1 Time and Place

The SEDAR 9 Review Workshop met in New Orleans, Louisiana, from 27 to 31 March 2006.

1.2 Terms of Reference for the Review Workshop

1. Evaluate the adequacy, appropriateness, and application of data used in the assessment.
2. Evaluate the adequacy, appropriateness, and application of methods used to assess the stocks.
3. Recommend appropriate estimates of stock abundance, biomass, and exploitation.
4. Evaluate the methods used to estimate population benchmarks and management parameters (*e.g., MSY, Fmsy, Bmsy, MSST, MFMT, or their proxies*); provide estimated values for management benchmarks, a range of ABC, and declarations of stock status.
5. Evaluate the adequacy, appropriateness, and application of the methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass).
6. Evaluate the adequacy, appropriateness, and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure the implications of uncertainty in technical conclusions are clearly stated.
7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations. (In the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above, ensure that corrected estimates are provided by addenda to the assessment report)
8. Evaluate the performance of the Data and Assessment Workshops with regard to their respective Terms of Reference; state whether or not the Terms of Reference for those previous workshops were met and are adequately addressed in the Stock Assessment Report.
9. Review research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments.
10. Prepare a Peer Review Consensus Summary summarizing the Panel's evaluation of the stock assessment and addressing each Term of Reference. Prepare an Advisory Report summarizing key assessment results. (Reports to be drafted by the Panel during the review workshop with a final report due two weeks after the workshop ends.)

1.3 List of Participants

Participants	Affiliation
Panel Chair:	
M. Elizabeth Clarke	NOAA Fisheries/NWFSC
Review Panel:	
Haddon, Malcolm	CIE Reviewer
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1.4 Review Workshop Documents

The following documents were available to the Review Panel during SEDAR 9.

Document #	Title	Authors
Documents Prepared for the Data Workshop		
SEDAR9-DW1	History of vermillion snapper, greater amberjack, and gray triggerfish management in Federal waters of the US Gulf of Mexico, 1984-2005	Hood, P.
SEDAR9-DW2	Vermillion Snapper Otolith Aging: 2001-2004 Data Summary	Allman, R J., J. A. Tunnell. B. K. Barnett
SEDAR9-DW3	Reproduction of vermillion snapper from the Northern and Eastern Gulf of Mexico, 1991-2002.	Collins, L. A., R. J. Allman, and H. M Lyon
SEDAR9-DW4	Standardized catch rate indices for vermilion snapper landed by the US recreational fishery in the Gulf of Mexico, 1986-2004	Cass-Calay, S. L.
SEDAR9-DW5	Standardized catch rate indices for vermilion snapper landed by the US commercial handline fishery in the Gulf of Mexico, 1990-2004	McCarthy, Kevin J., and Shannon L. Cass-Calay
SEDAR9-DW6	Standardized catch rates of vermilion snapper from the US headboat fishery in the Gulf of Mexico, 1986-2004	Brown, Craig A.
SEDAR9-DW7	Estimated Gulf of Mexico greater amberjack recreational landings (MRFSS, Headboat, TXPW) for 1981-2004	Diaz, Guillermo
SEDAR9-DW8	Size frequency distribution of greater amberjack from dockside sampling of recreational landings in the Gulf of Mexico 1986-2003	Diaz, Guillermo
SEDAR9-DW9	Size frequency distribution of greater amberjack from dockside sampling of commercial landings in the Gulf of Mexico 1986-2003	Diaz, Guillermo
SEDAR9-DW10	Standardized catch rates of gulf of Mexico greater amberjack for the commercial longline and handline fishery 1990-2004	Diaz, Guillermo
SEDAR9-DW11	Length Frequency Analysis and Calculated Catch at Age Estimations for Commercially Landed Gray Triggerfish (*Balistes capriscus*) From the Gulf of Mexico	Saul, Steven
SEDAR9-DW12	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Gulf of Mexico Headboat Fishery	Saul, Steven

SEDAR9-DW13	Estimated Gray Triggerfish (*Balistes capriscus*) Commercial Landings and Price Information for the Gulf of Mexico Fishery	Saul, Steven
SEDAR9-DW14	Estimated Gray Triggerfish (*Balistes capriscus*) Recreational Landings for the State of Texas	Saul, Steven
SEDAR9-DW15	Estimated Gray Triggerfish (*Balistes capriscus*) Landings From the Marine Recreational Fishery Statistics Survey (MRFSS) In the Gulf of Mexico	Saul, Steven, and Patty Phares
SEDAR9-DW16	Length Frequency Analysis for the Gray Triggerfish (*Balistes capriscus*) Recreational Fishery In the Gulf of Mexico	Saul, Steven
SEDAR9-DW17	Estimates of Vermilion Snapper, Greater Amberjack, and Gray Triggerfish Discards by Vessels with Federal Permits in the Gulf of Mexico	McCarthy, Kevin J.
SEDAR9-DW18	Size Composition Data from the SEAMAP Trawl Surveys	Nichols, Scott
SEDAR9-DW19	Species Composition of the various amberjack species in the Gulf of Mexico	Chih, Ching-Ping
SEDAR9-DW20	Standardized Catch rates of Gulf of Mexico greater amberjack catch rates for the recreational fishery (MRFSS, Headboat) 1981-2004	Diaz, Guillermo
SEDAR9-DW21	SEAMAP Reef Fish Survey of Offshore Banks: Yearly indices of Abundance for Vermilion Snapper, Greater Amberjack, and Gray Triggerfish	Gledhill, et. al.
SEDAR9-DW22	Data Summary of Gray Triggerfish (*Balistes capriscus),*Vermilion Snapper (*Rhomboplites aurorubens)*, and Greater Amberjack (*Seriola dumerili)* Collected During Small Pelagic Trawl Surveys, 1988 – 1996	Ingram, Jr., G. Walter
SEDAR9-DW23	Abundance Indices of Gray Triggerfish and Vermilion Snapper Collected in Summer and Fall SEAMAP Groundfish Surveys (1987 – 2004)	Ingram, Jr., G. Walter
SEDAR9-DW24	Review of the Early Life History of Vermilion Snapper, *Rhomboplites auroubens,* With a Summary of Data from SEAMAP plankton surveys in the Gulf of Mexico: 1982 – 2002	Lyczkowski-Shultz, J. and Hanisko, D.
SEDAR9-DW25	Review of the early life history of gray triggerfish, *Balistes capriscus,* with a summary of data from SEAMAP plankton surveys in the Gulf of Mexico: 1982, 1984 – 2002	Lyczkowski-Shultz, J., Hanisko, D. and Zapfe, G.
SEDAR9-DW26	Shrimp Fleet Bycatch Estimates for the SEDAR9 Species	Nichols, Scott

SEDAR9-DW27	SEAMAP Trawl Indexes for the SEDAR9 Species	Nichols, Scott
SEDAR9-DW-28	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the Marine Recreational Fisheries Statistics Survey (MRFSS)	Nowlis, Josh Sladek
SEDAR9-DW-29	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured by the NMFS Southeast Zone Headboat Survey	Nowlis, Josh Sladek
SEDAR9-DW-30	Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus)* based on catch rates as measured from commercial logbook entries with handline gear	Nowlis, Josh Sladek
SEDAR9-DW-31	Estimated Gulf of Mexico vermillion snapper recreational landings (MRFSS, headboat, TPWD) for 1981-2004	Cass-Calay, Shannon, & Guillermo Diaz
Documents Prepared for the Assessment Workshop		
SEDAR9-AW1	Incorporating age information into SEAMAP trawl indices for SEDAR9 species	Nicholls, S.
SEDAR9-AW2	Separating Vermilion Snapper Trawl Indexes into East and West Components	Nicholls, S
SEDAR9-AW3	Modeling Shrimp Fleet Bycatch for the SEDAR9 Assessments	Nicholls, S
SEDAR9-AW4	Status of the Vermilion Snapper (*Rhomboplites Aurorubens)* Fisheries of the Gulf of Mexico	Cass-Calay, S.
SEDAR9-AW5	Gulf of Mexico Greater Amberjack Stock Assessment	Diaz, Guillermo A., and Elizabeth Brooks
SEDAR9-AW6	A Categorical Approach to Modeling Catch at Age for Various Sectors of the Gray Triggerfish (*Balistes Capriscus)* Fishery in the Gulf of Mexico	Saul, Steven and G. Walter Ingram, Jr.
SEDAR9-AW7	Updated Fishery-Dependent Indices of Abundance for Gulf of Mexico Gray Triggerfish (*Balistes Capriscus)*	Nowlis, Joshua Sladek
SEDAR9-AW8	An Aggregated Production Model for the Gulf of Mexico Gray Triggerfish (Balistes Capriscus) Stock	Nowlis, Joshua Sladek and Steven Saul
SEDAR9-AW9	Age-Based Analyses of the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock	Nowlis, J. S.
SEDAR9-AW10	Gulf of Mexico greater amberjack virtual population analysis assessment	Brown, C. A.,C. E. Porch, and G. P.

		Scott
SEDAR9-AW11	Rebuilding Projections for the Gulf of Mexico Gray Triggerfish (Balistes capriscus) Stock.	Nowlis, J. S.
Documents Provided for the Review Workshop		
SEDAR9-RW01	Performance of production models on simulated data. (Presentation for NMFS National SAW 8, 2006)	Brooks, E. N. et al
Reference Documents Provided at Workshops		
SEDAR9-RD01 Univ. South AL. PhD Thesis	Stock structure of gray triggerfish on multiple spatial scales in the Gulf of Mexico.	Ingram, W.G.
SEDAR9 RD02 2002. Proc. 53rd GCFI	Indirect estimation of red snapper and gray triggerfish release mortality	Patterson, W. F. et al.
SEDAR9-RD03 1997 Proc. 49th GCFI	Preliminary Analysis of Tag and Recapture Data of the Greater Amberjack, *Seriola dumerili,* in the Southeastern United States	McClellan, D. and Cummings, N.
SEDAR9 RD04 SEFSC Doc. No. SFD-99/00-99	Trends in Gulf of Mexico Greater Amberjack Fishery through 1998: Commercial landings, Recreational Catches, Observed length Frequencies, Estimates of Landed and Discarded Catch at Age, and Selectivity at Age.	Cummings, N. J., and D. B McClellan
SEDAR9-RD05 Fish. Res. 70 (2004) 299-310	A multispecies approach to subsetting logbook data for purposes of estimating CPUE	Stephens, A. and A. MacCall.
S9-RD06 SFD 99/00-100	Stock assessments of Gulf of Mexico greater amberjack using data through 1998.	Turner, S. C, N.J. Cummings, and C. E. Porch
S9-RD07 SFD 99/00-92	Catch rates of greater amberjack caught in the handline fishery in the Gulf of Mexico in 1990-1998	Turner, S. C.
S9-RD08 SFD 99/00-107	Catch rates of greater amberjack caught in the headboat fishery in the Gulf of Mexico, 1986-1998.	Turner, S. C.
S9-RD09 SFD 01/02-150	Projections of Gulf of Mexico greater amberjack from 2003-2012	Tuner, S. C. and G. P. Scott

S9-RD10 SFD 99/00-98	Gulf of Mexico greater amberjack abundance from recreational charter and private boat anglers from 1981-1998.	Cummings, N. J.
S9-RD11 SFD00/01-124	A stock assessment for gray triggerfish in the Gulf of Mexico.	Valle, M, C. Legault, and M. Ortiz.
S9-RD12 SFD00/01-126	Another assessment of gray triggerfish in the Gulf of Mexico using a space-state implementation of the Pella-Tomlinson production Model	Porch, C. E.
S9-RD13 SFD01/02-129	Status of the vermilion snapper fishery in the Gulf of Mexico. Assessment 5.0	Porch, C. E. and S. Cass-Calay.
S9-RD14 Panama City 01-1	Report of vermilion snapper otolith aging; 1994-2000 data summary	Allman, R. J., G. R. Fitzhugh, and W. A. Fable
S9-RD15 FWRI IHR2005-3	Genetic stock structure of vermilion snapper in the Gulf of Mexico and southeastern United States	Tringali, M. D. and M. Higham
S9-RD16 SCDNR	Age, growth, and reproduction of greater amberjack in the Southwestern North Atlantic. December 2004 Analytical Report	Harris, P. J.
S9-RD17	Preliminary Assessment of Atlantic white marlin using a state-space implementation of an age-structured production model	Porch, C. E.
S9-RD18	VPA-2BOX Program Documentation, Version 2.01. 2003. ICCAT Assessment Program Documentation.	Porch, C. E.
S9-RD19	VPA-2BOX Program Documentation, Version 3.01. 2003. ICCAT Assessment Program Documentation.	Porch, C. E.
Final Assessment Reports		
SEDAR9-AR1	Gray Triggerfish	
SEDAR9-AR2	Greater Amberjack	
SEDAR9-AR3	Vermillion Snapper	

2. Response to Terms of Reference

2.1. Background

- The Review Workshop is the third meeting in the SEDAR 9 process. The Panel was provided reports (documents: *S9DWREP GT.pdf* and *S9AWREP GRT.pdf*) from both Data Workshop (DW) and Assessment Workshop (AW) before the Review Workshop. The panel reviewed these documents and the series of working documents cited in those reports.

- The Gray Triggerfish assessment was presented by Dr. Josh Sladek-Nowlis on Monday, the March 27th.

- The Assessment was based on the data from the Data Workshop. The assessment methodologies used for this assessment were "A Stock Production Model Incorporating Covariates" (ASPIC) and "State-Space Age-Structured Production Models" (SSASPM).

- The review Panel evaluated the assessment and identified a number of concerns. Consequently, the Panel requested several sensitivity runs. With this investigation, the Panel recommended a preferred "base model" for this stock. The recommended "base model" utilized a number of constraints and weightings and the details can be found from the Addendum to the Assessment Report and outlined below. Data series were weighted as follows using CV multipliers unless otherwise stated, such that larger numbers represent greater uncertainty:

  - Commercial catch: 1;
  - Recreational catch: 2 from 1981-1987; 1 from 1988-2004;
  - Shrimp bycatch: 2;
  - All indices: 1.5; and
  - Catch at age was weighted using a sample size equivalent—these were set annually with a maximum of 25, and 1 sample counted for every 10 fish.

  Restrictions were placed on deviations of various series as follows:

  - Recruitment deviations were penalized using a variance term of 0.15, equivalent to a 40% CV;
  - Effort deviations for directed fleets were penalized using a variance term of 0.223, equivalent to a 50% CV;
  - Effort deviations for the shrimp fleet were penalized using a variance term of 0.0392, equivalent to a 20% CV; and

- All effort series were serially autocorrelated with a correlation coefficient of 0.5.

2.2. Review of the Panel's deliberations

The deliberations on each species are presented in the form of responses to the terms of reference questions specifically, followed by relevant comments on the discussions.

<u>2.2.1. Evaluate the adequacy, appropriateness and application of the data used in the assessment.</u>

- The data for this species were finalized from the SEDAR Data Workshop (DW) and reported in *S9DWREP GT.pdf*. Overall, the panel deemed the data appropriate and applied in an appropriate manner. There were serious concerns about the amount of information on bycatch in shrimp fleet.

- Data used for the assessment were:
  - Annual catches of gray triggerfish by relevant sector (recreational East, recreational West, commercial East, commercial West, shrimp bycatch).
  - Indices of abundance from a variety of sources, including fishery-dependent catch and effort series from headboat surveys, other recreational surveys (MRFSS), and commercial logbooks (restricted to handlines and equivalent gears). Fishery-independent surveys were also used, including a Neuston net larval survey, a shrimp-trawl style young-of-year survey, and a video survey which primarily sampled adult habitat.
  - Life history parameters were entered based on recent studies of the biology of gray triggerfish in the Gulf of Mexico.
  - Catch at age, which was inferred from size at age data using area-specific growth patterns.

However, there are serious weaknesses in the data:

- Shrimp bycatch: data were very sparse since this species was not separately noted by the observers", therefore this data series was lack of adequate sampling of the shrimp bycatch. However it is a major source of mortality on this stock (more than 1 million fish for some years). There were concerns that the shrimp bycatch might be biased high if fishers reported gray triggerfish only when they caught large amounts and the known catches were extrapolated to cover the fleet and all catches.

- The high variability in the MRFSS recreational index; essentially fishery-dependent index since it is tracing the fishery; limited coverage with mostly in Florida (eastern) and not in western (such as TX, note that TX conducts its own survey, so not included in comparisons of MRFSS).

- The panel questioned if the fishery dependent indices of abundance were truly representative. The fishery dependent data only come from Florida but this is species is fished in both the eastern and western gulf with different effort in both areas.

- No discard information for Headboat fishery. The discard mortality was assumed to be zero in the assessment

- The absence of complete catch-at-age information substantially limited the precision of the analysis and the accuracy of the forecasts.

- Stock structure – there are two management regions of east and west. The assessment should treat the stock as two management areas (since they have different Fs and selectivity). A more precautionary approach would be to separate the Gulf into two management areas.

- There were no quantitative studies, such as mark-recapture, that describes the movement of fish between these two regions. It is known that there is little or no adult movement but there is long larval phase and therefore there could be plenty of mixing during this phase.

2.2.2. Evaluate the adequacy, appropriateness and application of methods used to assess the stocks.

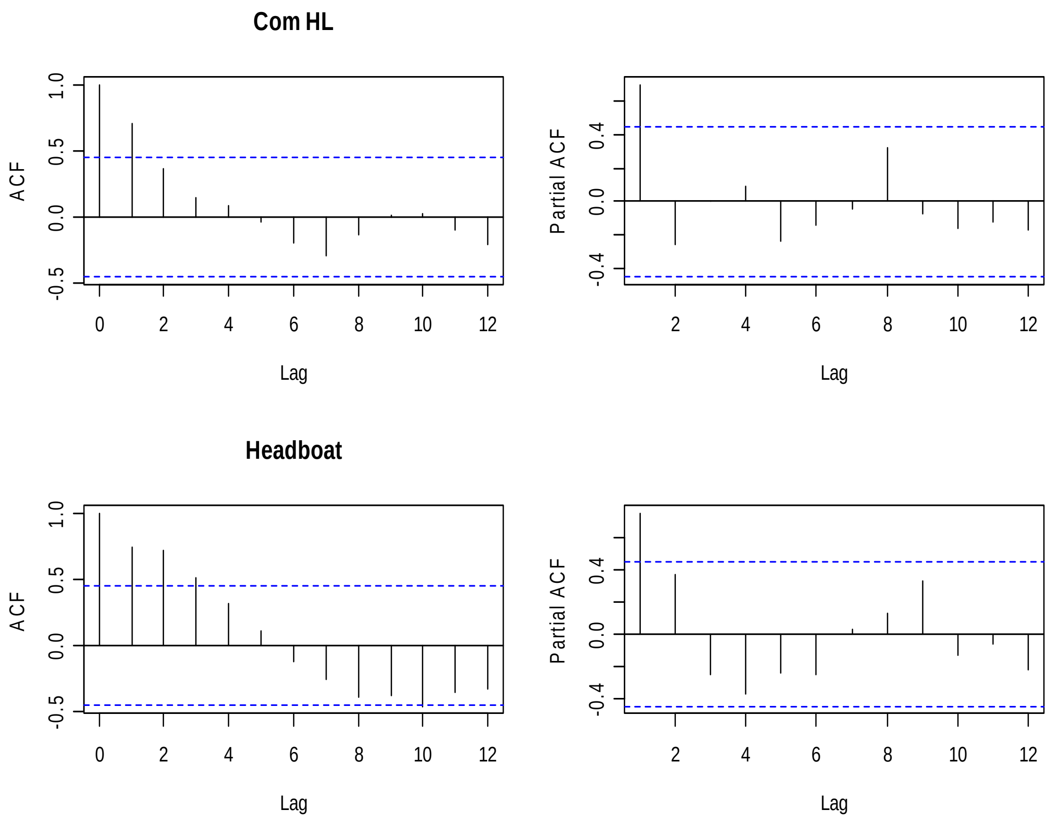
- The assessment methods are considered to be appropriate for the available data. The methods used for standardization of the catch and effort data are appropriate.

- For the available data, two models (ASPIC and SSASPM) were used as the assessment methods for this stock.

- The ASPIC model was used as a continuity run from the previous assessment and still concluded that the stock is overfished and experiencing overfishing. There are questionable issues in ASPIC about convergence, ignoring all fishery-independent indices and age information; therefore it is not very informative and not recommended by this Panel.

- The SSASPM was the newly developed age-structured model for this stock using more information from growth patterns, size/age distribution, age-structure of the harvest, etc. with a weighted likelihood-based structure. Therefore the SSASPM was determined as more informative and preferable by the Panel.

- However, concerns about the time series structures in the model residuals indicated that the model did not fit the data properly possibly because of the lack of optimal/appropriate weighting and the implemented first-order autoregressive model assumption. The following figures are used to illustrate this concern, which are the autocorrelation function (ACF) and partial ACF for commercial Headline and Headboat residuals (other landing series and indices can be also generated). It revealed that the residuals from the default SSASPM model structure with first-order autoregressive assumption still existed further time series structure, i.e. first-order autoregressive and moving average for commercial headline, second-order autoregressive and first-order moving average for headboat.



No absolute levels of adequacy of the assessments methods can be determined at present. Simulation testing of the assessment methods would have to be performed under conditions approximating those believed to pertain to gray triggerfish. Such simulations were not available to the review panel.

- The methods are not adequate for forecasting the effects of management measures that involve changing selection patterns, such as changes to minimum landing sizes and bag limit. They are however adequate for exploring the information content and management implications of small and incomplete data sets such as that available for gray triggerfish. Although it is true that the assessment models do not specifically address such management measures, it is worth noting that (1) they are sufficient for exploring total allowable catches, and (2) the very low release mortality indicates that size limits and bag/trip limits would be appropriate methods for controlling total allowable catches. It is noted that data collection in the Gulf of Mexico fisheries is a difficult and challenging task.

- The application of the methods was considered to be appropriate. Sensitivity runs were established in order to identify the change in perception of stock status in response to new information. Methods were chosen in order to reflect the availability of data and the way in which it was collected. However, it was clear that insufficient time and resources had been made available to consider fully the model constraints and parameterizations. In this context, further model and data explorations at the review workshop were a helpful step in the process.

- The practice of testing the sensitivity of model interest parameters (e.g. current F/F msy) to the use of simulated data series, and to the fixing of structural parameters and constraints is essential in the application of stock assessment models and should be developed and continued.

2.2.3. Recommend appropriate estimates of stock abundance, biomass and exploitation.

- The panel evaluated the original assessment results and requested several sensitivity runs

- Further evaluated the sensitivity runs, the panel had a consensus for the preferred "base model" for this stock defined in Section 2.1 "Background" and also detailed in the Addendum to the Assessment Report prepared by Dr. Josh Sladek Nowlis.

- A number of issues were explored but not fully resolved during the meeting. The assessment model was unexpectedly inflexible in fitting to simulated indices of abundance, which could suggest that some structural features of the model could have a strong influence on the model fit. Also, the review meeting did not identify which – if any – of the model parameters were bound constrained at the solution, did not investigate correlations in the parameters at the solution, and did not examine parameter uncertainty estimates. Despite this, the review panel considered the final assessment as an acceptable representation of the stock dynamics because the main data trends were represented and the model structure was, *a priori,* reasonable. However, some research recommendations concerning the foregoing concerns are included below.

- The details for the appropriate estimate of stock abundance, biomass and exploitation are listed in the Addendum to the Assessment Report.

- SEDAR and management agencies should be aware that high uncertainties are attached to this assessment

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

- The methods to estimate population benchmarks and management parameters are based on the maximum-likelihood parameter estimates from the recommended "base model". The estimates of these benchmarks are listed in the Addendum to the Assessment report.

- In general, the ASPIC model (the continuity case) estimates the surplus production parameters (carrying capacity, intrinsic population growth) and biomass trajectories over the course of the time period in the assessment model. These estimated parameters are then combined to produce other useful population benchmarks and management parameters, such as MSY-related reference points of biomass and fishing mortality rates and fishing mortality rate trajectories.

- For the SSASPM base model, the reference points are calculated numerically with reference to the maximum of the product of the equilibrium fecundity-per-recruit and recruitment-per-fecundity functions

- These methods are considered to be appropriate for the available data and in the present situation. However, improved methods based on stochastic modeling of the fishery, the stock, and the sampling from the stock could be developed that would give greater insight into the dynamics of the assessment and management process if more resources were available. Such studies could lead to different benchmarks.

- With the recommended base model run, the detailed estimates of management benchmarks and management parameters with reference to the population parameters from the SSASPM are listed in the Addendum to the Assessment report and summarized as follows:

  - Current MFMT, the Maximum Fishing Mortality Threshold, = $F_{30\%SPR}$.
  - Current MSST, the Minimum Stock Size Threshold, = SSB20%SPR.
  - F_{OY}, the optimum yield, is not currently defined.

The parameters relevant to management are estimated as follows:

Parameter	***Base Value (Low-High Steepness)***
Population parameters and management benchmarks	
$F_{20\%SPR}$	0.419
$F_{30\%SPR}$ = MFMT	0.269
$F_{40\%SPR}$	0.186
F_{msy}	0.45 (0.294-0.525)
SSB_{msy} (eggs)	1.21t (1.78t-1.049t)
SSB20%SPR = MSST	1.316t (1.083t-1.355t)
F_{OY}	Not defined
MSY (lbs, incl shrimp bycatch)	1.638m (1.441m-1.707m)

Parameter	***Base Value (Low-High Steepness)***
Stock parameters in 2004	
F_{2004}	0.435 (0.431-0.435)
F_{2004}/MFMT	1.62 (1.6-1.62)
SSB_{2004} (eggs)	1.345t (1.323t-1.351t)
SSB_{2004}/MSST	1.02 (1.22-1)
F_{2004}/OY	Not defined

Declarations of Stock Status:

- The stock experienced overfishing, but there is high uncertainty in the underlying stock-recruitment relationship .
- The Review Workshop could not come to a conclusion whether the stock is overfished or not, although it appears to be approaching an overfished condition.

2.2.5. Evaluate the adequacy, appropriateness and application of methods used to project future population status; recommend appropriate estimates of future stock condition (e.g., exploitation, abundance, biomass)

- Projection of this stock is based on the "base model" recommended by the Panel.
- Projections of the future population status for this stock depend upon the assumption that the both the fishery catches and shrimp bycatch continue along the current trends and the model assumptions remain unchanged.
- The methods are not adequate for forecasting the effects of management measures that involve changing selection patterns, such as changes to minimum landing sizes and bag limits. They are however adequate for exploring the information content and management implications of small and incomplete data sets such as that available for gray triggerfish. It is noted that data collection in the Gulf of Mexico fisheries is a difficult and challenging task.
- Management agencies should be aware that high uncertainty is attached to this assessment
- The panel recommended the present "base model" be used for the projection for this stock and the estimate the stock condition (Fig 9 in the Assessment Report Addendum).

2.2.6. Evaluate the adequacy, appropriateness and application of methods used to characterize uncertainty in estimated parameters. Provide measures of uncertainty for estimated parameters. Ensure the implications of uncertainty in technical conclusions are clearly stated.

- The primary uncertainties are from the model process errors and the data measurement errors. Because of the inherited high uncertainties from the data and the model structure, the basic tool for evaluating this type of uncertainty is the calculation of sensitivity analyses, by investigating the robustness of interest parameter estimates to alternative choices about data usage, to specification of structural parameters. Numerous trial runs are calculated in order to identify key sensitivities and develop appropriate relevant treatments. This is considered highly appropriate.

- With the selected base model, the model-based estimates of the standard errors in the most important parameter estimates were calculated. The method is based on using automatically-calculated derivatives of the interest parameter with respect to the inverse Hessian matrix of the likelihood at the solution (the method is specific to the software used, "AD model builder"). The AD will automatically produce the standard error for the parameters and the specified MSY management benchmark parameters. The uncertainty measures for the ratio estimates, such as SSB/SSBmsy and F/Fmsy should be produced and in fact can be produced by the delta (approximate Taylor expansion) method and recommended by the panel to be included in the assessment report.

- Improvement in the documentation of the method would be encouraged. These uncertainty estimates are considered to be more useful as diagnostics of model fitting rather than as reflecting the "real" uncertainty in the assessment.

2.2.7. Ensure that stock assessment results are clearly and accurately presented in the Stock Assessment Report and that reported results are consistent with Review Panel recommendations. (In the event corrections are made in the assessment, alternative model configurations are recommended, or additional analyses are prepared as a result of review panel findings regarding the TORs above, ensure that corrected estimates are provided by addenda to the assessment report).

- The panel recommended a new "base model" for this stock and the alternative configurations for the new base model are listed in the Assessment Report Addendum.

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

- The terms of reference and the results of gray triggerfish Data Workshop are documented in *S9DWREP GT.pdf.* The review panel evaluated the terms of reference and agreed that the TOR were met in general except for TOR 5 ("Evaluate the adequacy of available data for estimating the impacts of current management actions") and TOR 6 ("Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements"), which were not pertinent and outside the scope of the Data Workshop and recommended removing these from the TOR in the future data workshop. The TOR 7 ("Provide recommendations for future research in areas such as sampling, fishery monitoring, and stock assessment. Include specific guidance on sampling intensity and coverage where possible") was not addressed sufficiently in the Report.

- The terms of reference and the results of gray triggerfish Assessment Workshop are documented in *S9AWREP GRT.pdf.* The review panel evaluated the terms of reference with consensus that the TOR were met generally with deviations for the best possible base model. The panel evaluated data and the model and suggested several sensitivity runs. The Panel recommended a preferred "base model" for gray triggerfish (see Addendum to the Assessment Report for details).

- In general, there were not sufficient recommendations for research that needed to addressed contained both Data and Assessment Workshop

<u>2.2.9. Review research recommendations provided by the Data and Assessment workshops and make any additional recommendations warranted. Clearly indicate the research and monitoring needs that may appreciably improve the reliability of future assessments.</u>

The Panel strongly recommends:

- The Review Panel should be provided an executive summary for substantive documents from Data and Assessment Workshops, a succinct table of model structural equation and parameters, and if appropriate a table of management options. A glossary of all the acronyms used in the assessments should be provided as an appendix in every assessment report.

- All of the data used for the assessment should be included in the Reports as well as the model formulations for the assessment. Some of the data in gray Triggerfish (such as age composition data) used in the assessment were missing from the Assessment Report, which could preclude further independent evaluation of the assessment results. The Addendum to the gray triggerfish Assessment Report includes these data now.

- An observer program should be implemented to estimate levels of shrimp bycatch and appropriate age composition with some well-designed, systematic research programs, which are essential to provide the data necessary for effective management. Shrimp by catches for gray triggerfish are the dominant removals for this species and it is scientifically important for better estimates for an accurate stock assessment. Catch in numbers of fish is dominated by shrimp bycatch which mainly consists of age-0 and age-1 fish (Table 1 and Fig 1 in the Addendum). The shrimp bycatch fishery annually removes roughly 1 million fish age-1 equivalent and peaked at 5 million fish at year 2002. However the recreational and commercial fisheries' combined take was roughly 1 million pounds in recent years but had past peaks reaching 3 million pounds annually.

- A comprehensive age-reading programme should be established in the major sectors. This will allow a more accurate age distribution and therefore a more accurate and precise assessment. This is more important for this species since the assessment method has changed from ASPIC model to SSASPM using catch at age data.

- MRFSS programme should be strengthened so that more precise estimations of total catches are available for the assessment.

- A mark-recapture study should be initiated. Such a study will help:
  - Identifying movements and migrations between east and west regions;
  - Estimating fishing mortality;
  - Enhancing the population estimates; and
  - Identifying the stock structure;
  - Better understanding habitat preferences.

- The methods should be more thoroughly documented, including the structural model equations, the observation-error models, process-error models (if appropriate), values of constants, constraints and priors, and description of the fitting algorithm including the uncertainty-estimation method.

- The panel should be provided more detailed model diagnostics, such as complete lists of estimated parameters together with their estimated standard errors, the most important investigation of model sensitivity runs.

- The model residuals diagnostics should be included to test whether there is still time series autocorrelation for lack of goodness of fit in the assessment.

- The resources available to the assessment data collection, processing and modeling teams should be significantly increased. This increase in resources would be required in order to allow the foregoing recommendations to be implemented realistically.

- The panel's internally-adopted guidelines for assessing assessments developed during the SEDAR 9 Review Workshop (see Appendix 1) should be followed.

2.3. General recommendations to SEDAR

- There were some concerns expressed in the Review Workshop that pressure may have been brought to participants at some of those workshops to progress management further than was possible within the available time frame and with available time series data.

-
- Incorporation of fishermen’s knowledge into the data and assessment process.

- There was large volume of documentation associated with this Review Workshop. The Review Panel recommended the need for a clear executive summary for all substantive Data and Assessment Documents. It could be more informative to distribute a succinct table of model equations and parameters (estimated and observed) to be provided for each assessment along with, if appropriate, a table of management options (e.g. a decision table) and the risks associated with them.

Appendix: Panel's approach to evaluating stock assessments

Basic Principles

The review panel considered the characteristics that would ideally be desirable in a stock assessment process used for advisory purposes. In order to guide its deliberations relevant to the terms of reference, the panel considered the following attributes to be desirable. Specific issues of concern addressed for each stock are addressed in this framework. Overall conclusions are summarized in Section 2.2.

1. All relevant data should be used, unless there is an *a priori* reason to exclude a data series, or a sound *a posteriori* reason can be identified. Data should be real observations, not “filled-in” using assumptions or other criteria, to the extent possible. Fish stock assessment depends on having reasonably long time-series of catch, effort and fishery-independent abundance estimates.

2. Conclusions about stock status with respect to reference points should be robust to underlying assumptions about data and structural model, e.g. reliance on filling-in assumptions, dependence on most contested parts of the data sets.

3. Assessments should include the following :

- 3.1 Data screening, to check assumptions in 1 and 2.
- 3.2 Model screening, to see if broadly similar conclusions are drawn from different models, including sensitivity to constraints etc.
- 3.3 Residual pattern screening: Does the model replicate the trends in the data?
- 3.4 Credibility check: are the estimated model parameters reasonable (e.g. selection pattern, r, B_0/B_{msy} , trends in F etc. in the context of biological knowledge about the stock and the fishery ?
- 3.5 Variance estimates (or posteriors) for the estimated interest parameters, and *a priori* model testing, using simulated data, which should demonstrate that the model has useful precision in predicting interest parameters when presented with data.

4. Assessment documentation should include :

- 4.1. Data used to fit the assessment model.
- 4.2. Structural model equations, including process-error model if applicable
- 4.3. Observation-error model
- 4.4. Description of estimating algorithm
- 4.5. List of final parameter estimates and their sd.s
- 4.6. Computational validation, including simulation testing
- 4.7. Source code (and ideally documentation) of the programs used should be made available.

Review Workshop Advisory Report
Gulf of Mexico Gray Triggerfish
SEDAR 9 Review Workshop

Stock Distribution:

- The gray triggerfish are found throughout the Gulf of Mexico, which is considered a single stock based on its prolonged, indeterminate larval stage.
- This assessment addresses gray triggerfish in the U.S. Gulf of Mexico. The stock is divided into eastern and western gulf components at the Mississippi River to allow application of area-specific life history characteristics, catch statistics, and survey indices.

Assessment Methods & Data:

- Gray triggerfish in the Gulf of Mexico were assessed with two models, including ASPIC and SSASPM. Within each type of model various configurations and sensitivity runs were explored. Details of all models are available in the Stock Assessment Report and the Review Panel Consensus Summary.
- The Assessment Workshop chose the SSASPM model to provide the base assessment results based on its flexibility and better mathematical rigor to incorporate more information on life history and on the age structure of the harvest. The RW accepted this model with modifications that are detailed in the Assessment Report Addendum (prepared by Dr. Josh Sladek Nowlis and attached with this report in the Appendix) and summarized here in a subsequent section.
- Data sources include landings by relevant sectors from recreational east, recreational west, commercial east, commercial west and shrimp bycatch (Table 1 and Fig 1 in the Addendum); five fishery-dependent indices and three fishery-independent indices (Table 2 and Fig 2 in the Addendum); gray triggerfish life history parameters based on the biological studies (Table 3 in the Addendum), as well as relative age composition data inferred from size at age data using area-specific growth patterns (Table 4 in the Addendum).

Sources of Information:

- Results are summarized in the following bullets. Complete details are available in the SEDAR 9 Data and Assessment Reports, Assessment Report Addendum and the SEDAR 9 Review Panel Consensus Summary, and the many SEDAR 9 workshop working papers.
- Complete results of the SSASPM model configuration preferred by the Review Panel are contained in the Stock Assessment Report Addendum.

Catch Trends:

- Catch in numbers of fish is dominated by shrimp bycatch which mainly consists of age-0 and age-1 fish (Table 1 and Fig 1 in the Addendum). The shrimp bycatch fishery annually removes roughly 1 million age-1 equivalent and peaked at 5 million fish at year 2002 (Table 1 and Fig 1 in the Addendum). The recreational and commercial fisheries combined take roughly 1 million pounds in recent years but had past peaks reaching 3 million pounds annually.
- Catch information was derived from several fleets (SEDAR9-DW-Report). Based on age-structure of the catches, these were pooled into four directed fleet categories: recreational east, recreational west, commercial east, and commercial west, with the east-west split occurring at the Mississippi River.

Fishing mortality trends

- Fishing mortality is variable and irregular ranged about between 0.4 to 0.6 with MSY at 0.45 (Fig 6 in the Addendum). Generally, it shows a decreasing trend from the mid 80s to the early 90s and an increasing trend to its peak during the mid 90s (F = 0.65), then decreasing from the mid 90s to 2000, slowly building to F_{MSY} in recent years.

Stock abundance and biomass trends

- Model assumed virgin condition in 1963 with virgin SSB of 7.5 trillion eggs, model predicts a drop to ¼ virgin at trough in the mid 1980s, 50% increase through early 1990s, cut in half by late 1990s to MSST, 25% rise by 2002 and drop by 10% in 2004 (Fig 6 in the Addendum).

Status determination criteria and Stock Status

- The parameters relevant to management are estimated from the preferred base model by the Review Workshop as follows:

Parameter	***Base Value (Low-High Steepness)***
Population parameters and management benchmarks	
$F_{20\%SPR}$	0.419
$F_{30\%SPR}$ = MFMT	0.269
$F_{40\%SPR}$	0.186
F_{msy}	0.45 (0.294-0.525)
SSB_{msy} (measured as egg production)	1.21t (1.78t-1.049t)
$SSB_{20\%SPR}$ = MSST	1.316t (1.083t-1.355t)
F_{OY}	Not defined
MSY (lbs, incl. shrimp bycatch)	1.638m (1.441m-1.707m)
Stocks parameters in 2004	
F_{2004}	0.435 (0.431-0.435)
F_{2004}/MFMT	1.62 (1.6-1.62)

Parameter	***Base Value (Low-High Steepness)***
SSB_{2004} (eggs)	1.345t (1.323t-1.351t)
$SSB_{2004}/MSST$	1.02 (1.22-1)
F_{2004}/OY	Not defined

- Declarations of Stock Status:
  - The stock experienced overfishing. According to the existing $F_{30\%SPR}$ maximum fishing mortality threshold (MFMT), current fishing mortality rates are 60% too high (Table 6 and Fig 8 in the Addendum). Current fishing mortality rates are in the range of MSY-based fishing mortality rates (F_{MSY}) as estimated by the base model ($F_{2004}/F_{MSY} = 0.97$). However, this status measure is sensitive to the stock-recruitment relationship, which is poorly estimated with the data available on this stock. Over a range of potentially realistic parameter values, current fishing mortality rates range from 83 to 147 percent of F_{MSY} (Table 6 and Fig 8 in the Addendum).
  - The Review Workshop cannot come to a conclusion whether the stock is overfished or not, although it appears to be approaching an overfished condition. The stock is estimated to be just above the minimum stock size threshold, currently defined as a stock condition below 20%SPR. This status measure has some sensitivity to the stock-recruitment relationship, but in most cases the stock is identified as being just above the threshold. However, current fishing rates are predicted to drive the stock below the threshold in the near future.

Projections

- Quantitative projections are available for the preferred base model from Review Workshop (Table 7 and Fig 9 in the Addendum). These indicate:
  - If conditions in 2004 continue, forecasts are uncertain but indicate the stock is slightly more likely to decrease than to increase;
  - The extent of reduction in fishing mortality brought about by additional management measures in 2005 cannot be evaluated at present since no new management measures were put in place for gray triggerfish in 2005.

SEDAR

SouthEast Data, Assessment, and Review

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Stock Assessment Report 1

Gulf of Mexico Gray Triggerfish

SECTION 5. Post Review Addendums

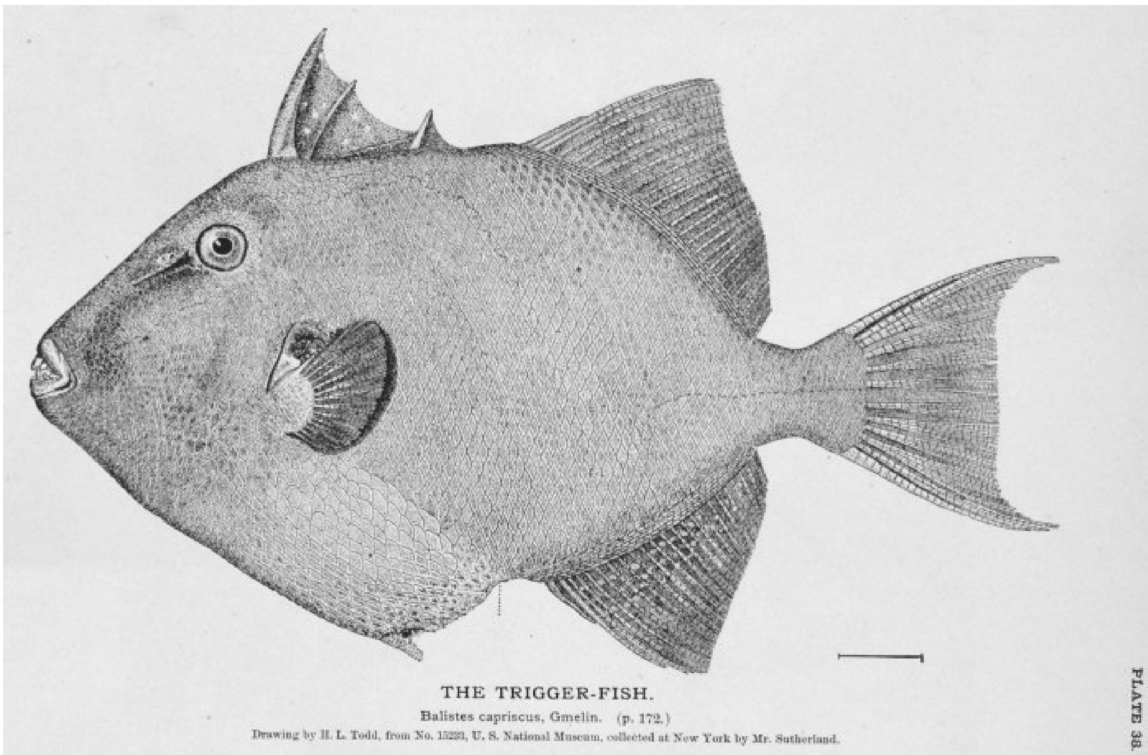
Contents

Addendum 1. Updated ASPM Model Results for Gray Triggerfish.

Summary of model configuration changes recommended by the Review Workshop Panel. Includes input data, results and measures of fit, and projections.

Addendum

Assessment Report for Gray Triggerfish



by
Josh Sladek Nowlis

March 2006

SFD Contribution ###

Based on Results of the Southeast Data Assessment Review (SEDAR) 9 Review Workshop

Held 27-31 March 2006
New Orleans, LA

BASE MODEL STRUCTURE

After extensive review of available data and attributes of gray triggerfish biology and the fisheries that catch it, it was determined that an age-structured production model would best describe the Gulf of Mexico gray triggerfish (*Balistes capriscus*) stock. The particular model used, a State Space Age-Structured Production Model (SSASPM) is described elsewhere (Porch 2002). Its fundamental features include:

- Fits to catch, abundance index, and catch-at-age data;
- Fits to or use of fixed parameters describing the life history of the stock (e.g., natural mortality, growth rates, stock-recruitment relationships);
- Recruitment deviations from the stock-recruitment relationship, constraints on which are controlled by the user—note that these recruitment deviations can be asymmetrical (i.e., they need not sum to 1) and as a result they can create a circumstance in which recruitment patterns in recent years, and corresponding management benchmarks, may differ from the underlying stock-recruitment relationship;
- Effort deviations that can include serial autocorrelation;
- The ability to weight the importance of each data series in the objective function, as well as specifying interannual variability within each series; and
- A “pre-historical” or “burn in” period, which begins the model at virgin condition and uses prescribed effort patterns (e.g., linear increase) until the time period when more data streams are available—this feature is principally used to condition the model for the beginning of the “historical” period.

DATA INPUTS

Several types of data were used as input to the model. These included:

- Annual catches of gray triggerfish by relevant sector (recreational East, recreational West, commercial East, commercial West, shrimp bycatch). See Table 1 and Fig. 1 for the data.
- Indices of abundance from a variety of sources, including fishery-dependent catch and effort series from headboat surveys, other recreational surveys (MRFSS), and commercial logbooks (restricted to handlines and equivalent gears). Fishery-independent surveys were also used, including a Neuston net larval survey, a shrimp-trawl style young-of-year survey, and a video survey which primarily sampled adult habitat. See Table 2 and Fig. 2 for the data.
- Life history parameters were entered based on recent studies of the biology of gray triggerfish in the Gulf of Mexico. See Table 3 for the data.

- Catch at age, which was inferred from size at age data using area-specific growth patterns. See Table 4 for the data.

The model began in 1963, at which point the stock was assumed to be unfished. The burn in/pre-historic period lasted through 1980, while the historical/data-oriented period stretched from 1981 to 2004. A single stock was assumed for the entire US Gulf of Mexico, but directed fishing sectors were split into western and eastern components at the Mississippi River (resulting in five fleets—recreational west, recreational east, commercial west, commercial east, and shrimp Gulf-wide). The stock was modeled using 10 age classes spanning from 1 year olds to 10+ year olds.

The base model used a number of constraints and weightings that reflected tinkering and the advice and input of the review panel. Data series were weighted as follows using CV multipliers unless otherwise stated, such that larger numbers represent greater uncertainty:

- Commercial catch: 1;
- Recreational catch: 2 from 1981-1987; 1 from 1988-2004;
- Shrimp bycatch: 2;
- All indices: 1.5; and
- Catch at age was weighted using a sample size equivalent—these were set annually with a maximum of 25, and 1 sample counted for every 10 fish.

Restrictions were placed on deviations of various series as follows:

- Recruitment deviations were penalized using a variance term of 0.15, equivalent to a 40% CV;
- Effort deviations for directed fleets were penalized using a variance term of 0.223, equivalent to a 50% CV;
- Effort deviations for the shrimp fleet were penalized using a variance term of 0.0392, equivalent to a 20% CV; and
- All effort series were serially autocorrelated with a correlation coefficient of 0.5.

This fully summarizes the base model. The actual input files are shown in Appendix 1.

FITS TO DATA

The base model's fits to the data series were generally good. Catches were not perfectly fit but captured most of the dynamics of rising and falling catches over time (Fig. 3). The fit to shrimp bycatch was most problematic, but so was that data and as a result the model was given more latitude to sacrifice this fit to the benefit of better fits elsewhere. Indices also generally fit well, although only in broad form and not necessarily in detail (Fig. 4). In particular, large spikes in abundance were not well represented in the model's predictions (e.g., MRFSS 1990, trawl 1991 and 2001). Catch at ages, despite having been down weighted substantially compared to previous version of the base model, were still fit well as exemplified by the 2004 fits (Fig. 5).

MODEL ESTIMATES

Estimates for key parameters and management benchmarks from both the base model and sensitivity analyses are shown in Table 5. These data illustrate the sensitivity of the model to changes in assumptions.

The model estimated trajectories for spawning stock biomass, fishing mortality rates, and recruitment (Fig. 6). With respect to SSB, the model assumed virgin condition in 1963 and predicted a drop to one-fourth virgin SSB in the mid-1980s. It then predicted a 50 percent increase through early 1990s, followed by a drop to the minimum stock size threshold by the late-1990s. The stock was predicted to have risen about 25 percent by 2002 and then to have dropped by 10 percent in 2004. These patterns were consistent across different stock-recruitment relationships, but with differences in benchmark reference points (see Table 5).

Fishing mortality rates were predicted to have ranged between about 0.4 and 0.6 in the base model, with peaks in the early-1980s and throughout the 1990s, and troughs in the late 1980s and in 2000, slowly building to F_{MSY} in recent years. In this version, F_{MSY} was estimated at 0.45, corresponding to an SPR level of less than 20 percent, and the maximum fishing mortality threshold (MFMT) of 30% SPR corresponded to a fishing mortality rate equal to 0.269. Different stock recruitment relationships showed the same annual trends but with shifted F_{MSY} values (see Table 5).

Recruitment followed the underlying stock-recruitment relationship in the pre-historical/burn in period. However, the pattern of recruitment was clearly different when the model was allowed to estimate recruitment deviations starting in the early 1980s. One can see that recruitment was estimated to be above virgin levels throughout most of the 1980s and into the early-1990s, with a subsequent high peak occurring in 2001. When recruitment in recent years (1986 to 2004) was examined as a function of spawning stock biomass, a dramatically different stock-recruitment relationship is inferred. The underlying S-R relationship was fixed at a steepness of 0.89, and the maximum recruitment was estimated as 2.146 million fish, while the relationship estimated from the model's results, which included deviations, was a steepness of only 0.442 and a maximum recruitment of 15.3 million fish (Fig. 7). Considering that steepness must fall between 0.2 and 1, these results are starkly different and illustrate the inability of the data on gray triggerfish to inform us of the actual stock-recruitment function. As a result, any S-R dependent benchmarks, including MSY and its associated reference points, should be viewed as highly uncertain. SPR-based benchmarks, which are independent (F) or only slightly dependent (SSB) on S-R, should be viewed as more reliable.

STOCK STATUS

The stock experienced overfishing. According to the existing $F_{30\%SPR}$ maximum fishing mortality threshold (MFMT), current fishing mortality rates are 60% too high (Table 6, Fig. 8). Current fishing mortality rates are in the range of MSY-based fishing mortality rates (F_{MSY}) as estimated by the base model (F_{2004}/F_{MSY} = 0.97). However, this status measure is sensitive to the stock-recruitment relationship, which is poorly estimated with the data available on this stock. Over a range of potentially realistic parameter values, current fishing mortality rates range from 83 to 147 percent of F_{MSY} (Table 6, Fig. 8).

We cannot come to a conclusion whether the stock is overfished or not, although it appears to be approaching an overfished condition. The stock is estimated to be just above the minimum stock size threshold, currently defined as a stock condition below 20%SPR. This status measure has some sensitivity to the stock-recruitment relationship, but in most cases the stock is identified as being just above the threshold. However, current fishing rates are predicted to drive the stock below the threshold in the near future.

MODEL PROJECTIONS

The base model was used to project stock status into the future under various F-based management scenarios (Table 7, Fig. 9). The scenarios included no fishing (F=0) and fishing at current rates (Fcurr), rates associated with the poorly estimated MSY level (Fmsy), 30% SPR rates (F30, also MFMT), and 75 percent of F30 (0.75F30). All scenarios were predicted to result in a reduction in catches over the next five to ten years, while fishing at Fcurr or Fmsy were predicted to drive the stock to an overfished condition. The F30 scenario was significant because it would end overfishing, and it and the more restrictive 0.75F30 would avoid an overfished condition.

REFERENCES

Porch, CE. 2002. Preliminary assessment of Atlantic white marlin (*Tetrapturus albidus*) using a state-space implementation ff an age-structured production model. *Col. Vol. Sci. Pap. ICCAT* 55(2): 559-577.

TABLES

Table 1—Catches. Directed fleets expressed in pounds, while shrimp bycatch is expressed in the number of age-1 equivalent fish.

Year	Rec-E	Rec-W	Comm-E	Comm-W	Shrimp
1963			3100	4200	
1964			15700	4300	
1965			17400	4300	
1966			8600	5200	
1967			12200	5200	
1968			8600	3900	
1969			14600	7700	
1970			16000	8200	
1971			30500	9900	
1972			47400	15200	
1973			40000	13200	112277.6
1974			40000	13100	342364.6
1975			62000	16000	380204.4
1976			69700	14800	220049.9
1977			50095.91	9290.086	189051.1
1978			48518.03	10196.7	460314.5
1979			65670.02	35732.98	1771057
1980			65421.67	31001.23	606637.6
1981	748779.46	179616.8	64498	25362	1467734
1982	2032601.4	362711	62959	33714	1206518
1983	397613.53	387301.1	49588	23831	1462755
1984	120970.49	844622.8	37445	32749	304993.5
1985	280865.15	479950.2	54840	37786	855586
1986	898096.37	79076.84	72858	22771	279373.7
1987	1135997.7	199066.1	89313	34290	1044555
1988	1638073.3	158328.2	137978	57084	1364168
1989	1765965.4	212002	230361	87271	906437.2
1990	2313261.1	184940.6	359686.4	99351.17	1286703
1991	1688391.7	399955	341319.2	103211.2	523154.4
1992	1434485.1	688825	338118.9	112075.7	3100516
1993	1317044.1	309425.4	381279.2	177448.4	432659.9
1994	1152103	186425.4	251578.1	153141.4	1951471
1995	1139966.8	329440.7	207212.3	130664.3	1065855
1996	618124.69	226005.8	142184.6	125331.6	1498133
1997	664793.77	100211.2	107779.8	76909.41	1751775
1998	560509.32	93309.19	106152.6	70570.89	1004208
1999	445429.52	43997.12	116194.3	102826.1	242741.5
2000	337240.63	109208.6	63041.56	95094.95	1656166
2001	487621.94	152571.5	108463.6	67718.28	490376.2
2002	721871.85	77016.21	148600.1	86962.79	5115407
2003	856626.38	58622.49	166424.7	85385.05	854441.3
2004	951559.09	78092.38	141411.1	77121.77	167161.8

Table 2—Indices

Year	MRFSS E	Rel CV	HB E	Rel CV	HB W	Rel CV	CmHL E	Rel CV	CmHL W	Rel CV	Neuston	Rel CV	Trawl	Rel CV	Video	Rel CV
1981	59.56	2.35														
1982	50.87	2.07														
1983	35.54	2.76														
1984	213.94	6.95														
1985	7.82	7.2														
1986	131.05	0.94	1.58	1.37	2.46	0.95					28.09					
1987	41.94	1.21	1.04	1.83	2.43	0.85					20.7	0.93	221.22	1.06		
1988	74.32	1.13	1.37	1.29	3.34	0.72					13.96	1.09	190.22	1.12		
1989	122.18	1.15	3.13	0.68	3.08	0.81					8	1.16	338.04	0.53		
1990	256.47	1.09	5.02	0.45	4.34	0.61					13.8	0.87	77.93	3.7		
1991	107	1.05	3.96	0.55	5.13	0.52					27.84	0.83	1291	0.21		
1992	94.73	0.85	4.57	0.48	4.56	0.56					91.81	0.9	75.78	3.27	68.55	0.87
1993	58.76	1	3.59	0.57	4.59	0.56	155.57	1.06	55.92	1.02	31.13	1.13	640.45	0.31	37.4	0.91
1994	53.3	1.09	2.78	0.71	4.46	0.53	146.65	0.97	71.33	1	35.77	0.84	613.49	0.33	33.63	0.88
1995	82.09	1.17	2.42	0.85	4.1	0.56	151.96	1.08	80.53	1.02	35.64	0.81	257.2	0.74	31.82	0.97
1996	47.63	1.22	1.72	1.05	4.18	0.57	66.9	1.01	50.18	1.01	24.18	0.97	226.35	0.82	29.65	0.87
1997	26.71	1.07	1.82	1.02	3.77	0.66	55.95	1.07	39.95	1.01	25.41	0.93	154.5	1.79	62.53	1.06
1998	20.24	1.04	1.56	1.11	2.57	0.87	52.8	1.11	52.27	1		1.18	14.68	0.74		
1999	20.98	0.9	1.65	1.04	1.14	1.73	50.81	0.95	70.79	0.99	8.05	0.86	346.25	0.51		
2000	16.46	0.98	1.16	1.38	1.16	1.64	37.05	1.07	52.93	0.99	83.12	1.18	602.55	0.31		
2001	25.28	0.9	1.3	1.33	1.37	1.39	54.92	1.02	36.57	1	13.72	1.03	1114.51	0.21	5.34	1.4
2002	26.18	0.89	1.98	1.02	1.51	1.39	97.78	0.91	39.08	0.99	19.01	0.82	258.03	0.7	29.96	1.04
2003	25.25	0.9	2.01	1	1.86	1.09	109.07	0.85	35.09	0.99		1.44	218.78	0.88		
2004	29.05	0.82	2.15	0.91	2.14	1	86.61	0.92	35.26	0.99		1.02	261.61	0.77		

Table 3—Life History Attributes

- Maturity: 87.5% @ 1 yr, 100% when older.
- $Fec = 170289e^{0.3159x}$, where x = age.
- $M = 0.27$ for all modeled age classes.
- $FL = 423.4\ (1-e^{-0.4269(x+0.6292)})$, where FL = fork length in mm and x = age.
- $Wt = 4.4858*10^{-8}\ FL^{3.0203}$, where Wt = weight in lbs and FL = fork length in mm.

Table 4—Catch at Age by Fleet and Year.

A. Recreational East

Year	N	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1981	5	0.136	0.34	0.47	0.51	0.42	0	0	0	0	0
1982	9	0.14	0.32	0.46	0.51	0.47	0	0	0	0	0
1983	7	0.114	0.32	0.46	0.5	0.42	0	0	0	0	0
1984	2	0.158	0.41	0.48	0.44	0.36	0	0	0	0	0
1985	3	0.1	0.25	0.34	0.43	0.39	0	0	0	0	0
1986	25	0.103	0.29	0.41	0.46	0.45	0.01	0	0	0	0
1987	25	0.135	0.31	0.4	0.46	0.49	0.01	0.01	0	0	0
1988	25	0.128	0.33	0.44	0.49	0.49	0.01	0.01	0	0	0
1989	25	0.179	0.36	0.43	0.47	0.52	0.02	0.01	0	0	0
1990	25	0.177	0.4	0.47	0.49	0.52	0.03	0.01	0	0	0
1991	25	0.136	0.33	0.44	0.5	0.51	0.03	0.01	0	0	0
1992	25	0.136	0.34	0.45	0.5	0.5	0.04	0.01	0.01	0	0
1993	25	0.141	0.36	0.46	0.5	0.5	0.02	0.01	0	0	0
1994	25	0.164	0.38	0.46	0.49	0.51	0.02	0.01	0	0	0
1995	25	0.156	0.39	0.48	0.5	0.51	0.02	0.01	0	0	0
1996	25	0.148	0.38	0.48	0.51	0.51	0.01	0.01	0	0	0
1997	25	0.143	0.36	0.46	0.49	0.51	0.02	0.01	0	0	0
1998	25	0.14	0.38	0.49	0.5	0.5	0.04	0.01	0	0	0
1999	25	0.136	0.38	0.49	0.51	0.5	0.04	0.01	0	0	0
2000	25	0.126	0.34	0.46	0.5	0.51	0.04	0.01	0	0	0
2001	25	0.139	0.38	0.48	0.5	0.51	0.05	0.01	0	0	0
2002	25	0.129	0.37	0.48	0.5	0.5	0.05	0.01	0	0	0
2003	25	0.133	0.37	0.48	0.51	0.51	0.05	0.01	0	0	0
2004	25	0.128	0.36	0.48	0.51	0.5	0.05	0.01	0	0	0

Table 4 (cont.)—Catch at Age by Fleet and Year.

B. Recreational West

Year	N	0	0	0.05506	0.27679	0.33185	0.45536	0.42411	0.28274	0.05506	0.11905
1981	1	0	0	0.02	0.14	0.23	0	0	0	0	0
1982	1	0.014	0.11	0.13	0.23	0.3	0	0	0	0	0
1983	1	0	0	0.03	0.14	0.09	0	0	0	0	0
1984	3	0	0	0.03	0.06	0.14	0	0.01	0	0	0
1985	1	0	0.02	0.03	0.15	0.14	0	0	0	0	0
1986	22	0.026	0.09	0.11	0.21	0.32	0.02	0.01	0	0	0
1987	24	0.021	0.07	0.09	0.2	0.33	0.02	0.02	0	0	0
1988	17	0.015	0.09	0.1	0.22	0.34	0.02	0.01	0	0	0
1989	25	0.008	0.06	0.08	0.2	0.34	0.03	0.02	0.01	0	0
1990	25	0.007	0.05	0.07	0.19	0.32	0.04	0.02	0.01	0	0
1991	25	0.004	0.03	0.06	0.18	0.31	0.03	0.02	0.01	0	0.01
1992	25	0.013	0.06	0.08	0.2	0.33	0.07	0.05	0.02	0	0.01
1993	25	0.003	0.03	0.05	0.16	0.29	0.05	0.04	0.01	0	0.01
1994	25	0.005	0.05	0.07	0.18	0.32	0.07	0.05	0.02	0.01	0.01
1995	25	0.003	0.03	0.05	0.17	0.32	0.06	0.04	0.01	0	0.01
1996	25	0.005	0.04	0.06	0.18	0.34	0.05	0.04	0.01	0	0.01
1997	19	0.005	0.05	0.07	0.18	0.28	0.02	0.02	0.01	0	0
1998	25	0.004	0.04	0.06	0.17	0.32	0.04	0.03	0.01	0	0
1999	14	0.003	0.03	0.06	0.18	0.32	0.02	0.01	0	0	0
2000	6	0	0.03	0.06	0.14	0.29	0.01	0.01	0	0	0
2001	11	0.003	0.03	0.05	0.18	0.33	0.01	0.01	0	0	0
2002	15	0.005	0.02	0.03	0.17	0.3	0.02	0.01	0	0	0
2003	18	0.003	0.04	0.06	0.18	0.3	0.02	0.01	0.01	0	0
2004	12	0.001	0.03	0.06	0.17	0.31	0.01	0.01	0	0	0

Table 4 (cont.)—Catch at Age by Fleet and Year.

C. Commercial East

Year	N	0	0	0	0	0	0	0	0	0	0
1989	1	0.087	0.44	0.52	0.59	0.02	0	0	0	0	0
1990	7	0.048	0.15	0.23	0.27	0.27	0	0	0	0	0
1991	4	0.026	0.04	0.07	0.16	0.2	0	0	0	0	0
1992	5	0.047	0.14	0.21	0.27	0.3	0	0	0	0	0
1993	25	0.084	0.26	0.39	0.45	0.42	0.02	0.01	0	0	0
1994	25	0.096	0.27	0.39	0.46	0.46	0.02	0.01	0	0	0
1995	25	0.097	0.29	0.42	0.49	0.49	0.02	0.01	0	0	0
1996	25	0.102	0.29	0.42	0.49	0.47	0.02	0.01	0	0	0
1997	25	0.112	0.3	0.43	0.51	0.5	0.02	0.01	0	0	0
1998	25	0.119	0.33	0.43	0.46	0.44	0.01	0.01	0	0	0
1999	25	0.086	0.26	0.38	0.44	0.42	0.02	0.01	0	0	0
2000	25	0.085	0.27	0.4	0.46	0.42	0.01	0	0	0	0
2001	25	0.101	0.29	0.43	0.49	0.47	0.02	0.01	0	0	0
2002	25	0.11	0.31	0.42	0.45	0.43	0.01	0	0	0	0
2003	25	0.101	0.26	0.35	0.39	0.4	0.01	0	0	0	0
2004	19	0.069	0.22	0.35	0.42	0.41	0.01	0	0	0	0

D. Commercial West

Year	N	0	0	0	0	0	0	0	0	0	0
1990	25	0.001	0.01	0.04	0.12	0.22	0.03	0.03	0.01	0	0
1991	25	0.002	0.02	0.04	0.14	0.26	0.06	0.06	0.02	0.01	0.01
1992	25	0.001	0.02	0.04	0.14	0.27	0.1	0.08	0.03	0.01	0.01
1993	25	0.001	0.01	0.04	0.11	0.23	0.05	0.05	0.02	0.01	0.01
1994	25	0.002	0.02	0.04	0.11	0.22	0.07	0.07	0.03	0.01	0.01
1995	25	0.002	0.02	0.04	0.13	0.25	0.04	0.03	0.01	0	0.01
1996	25	0	0.01	0.03	0.12	0.23	0.02	0.02	0.01	0	0
1997	25	0	0	0.03	0.11	0.22	0.02	0.03	0.01	0	0
1998	12	0.006	0.02	0.04	0.14	0.28	0.01	0.01	0	0	0
1999	5	0	0	0.03	0.12	0.21	0.01	0.01	0	0	0
2000	4	0	0.01	0.03	0.13	0.23	0	0	0	0	0
2001	10	0.001	0.01	0.04	0.11	0.22	0.01	0.01	0	0	0
2002	15	0.001	0.01	0.04	0.12	0.25	0.02	0.02	0.01	0	0
2003	21	0.003	0.01	0.04	0.13	0.23	0.02	0.02	0.01	0	0
2004	8	0	0.02	0.04	0.15	0.27	0.01	0.01	0	0	0

Table 5—Model Estimates and Benchmarks. *Note that the estimated α run is presented in a form where α was fixed to facilitate comparison to other runs, which also fixed α.

A. Fits

	Base	Median α	Est α*	M = 0.25	M = 0.3	20% recr dev	60% recr dev	1950 start
Data pts	292	292	292	292	292	292	292	292
Est params	170	170	170	170	170	170	170	170
Obj Func	-78.5	-74.1	-79.3	-74.4	-77.7	-82.3	-75.8	-49.9
AIC	183	192	181	191	185	175	188	240

B. Benchmarks

	Base	Median α	Est α*	M = 0.25	M = 0.3	20% recr dev	60% recr dev	1950 start
Alpha	32.8	12.9	50.3	33	32.5	32.9	32.6	32.9
Steepness	0.89	0.76	0.93	0.89	0.89	0.89	0.89	0.89
Max Recr (m fish)	2.146	2.326	2.105	2.019	2.344	2.522	1.893	2.193
SSB_{virgin} (t eggs)	7.513	8.14	7.369	8.298	6.561	8.826	6.627	7.675
SSB_{MSY} (t eggs)	1.21	1.78	1.049	1.345	1.051	1.421	1.071	1.233
$SSB_{20\%SPR}$ (t eggs)	1.316	1.083	1.355	1.456	1.148	1.546	1.159	1.343
$SSB_{30\%SPR}$ (t eggs)	2.094	1.967	2.109	2.315	1.823	2.458	1.842	2.138
$SSB_{40\%SPR}$ (t eggs)	2.868	2.855	2.861	3.17	2.505	3.373	2.526	2.933
$SSB_{50\%SPR}$ (t eggs)	3.648	3.743	3.618	4.029	3.188	4.276	3.215	3.722
F_{MSY}	0.45	0.294	0.525	0.406	0.484	0.448	0.447	0.465
$F_{20\%SPR}$	0.419	0.421	0.419	0.38	0.449	0.417	0.418	0.432
$F_{30\%SPR}$	0.269	0.27	0.269	0.246	0.289	0.268	0.269	0.276
$F_{40\%SPR}$	0.186	0.186	0.186	0.171	0.199	0.185	0.186	0.19
$F_{50\%SPR}$	0.131	0.131	0.131	0.121	0.14	0.131	0.131	0.134
MSY (m lbs)	1.638	1.441	1.707	1.595	1.703	1.925	1.443	1.678

Table 6—Stock Status.

	Base	Median α	Est α*	M = 0.25	M = 0.3	20% recr dev	60% recr dev	1950 start
SSB_{2004} (t)	1.345	1.323	1.351	1.286	1.461	1.478	1.319	1.372
$/SSB_{MSY}$	1.11	0.74	1.29	0.96	1.39	1.04	1.23	1.11
$/SSB_{20\%SPR}$	1.02	1.22	1	0.88	1.27	0.96	1.14	1.02
$/SSB_{30\%SPR}$	0.64	0.67	0.64	0.56	0.8	0.6	0.72	0.64
F_{2004}	0.435	0.431	0.435	0.451	0.371	0.422	0.435	0.436
$/F_{MSY}$	0.97	1.47	0.83	1.11	0.77	0.94	0.97	0.94
$/F_{30\%SPR}$	1.62	1.6	1.62	1.83	1.28	1.58	1.62	1.58

Table 7—Projections. New F rates applied starting in 2007.

Directed Catches (m lbs) Under Various Fishing Mortality Rates.

Year	F=0	F_{2004}	F_{MSY}	$F_{30\%SPR}$	$0.75*F_{30\%SPR}$
2000	0.762	0.762	0.762	0.762	0.762
2001	1.0032	1.0032	1.0032	1.0032	1.0032
2002	1.1784	1.1784	1.1784	1.1784	1.1784
2003	1.0896	1.0896	1.0896	1.0896	1.0896
2004	0.9864	0.9864	0.9864	0.9864	0.9864
2005	0.9828	0.9828	0.9828	0.9828	0.9828
2006	0.9168	0.9168	0.9168	0.9168	0.9168
2007	0	0.8598	0.8826	0.56514	0.43278
2008	0	0.7998	0.8148	0.57924	0.46206
2009	0	0.8328	0.8442	0.6384	0.52212
2010	0	0.8526	0.861	0.6882	0.57648
2011	0	0.735	0.738	0.6342	0.54666
2012	0	0.6978	0.6996	0.6216	0.5451
2013	0	0.6546	0.6546	0.6042	0.5391
2014	0	0.657	0.657	0.6102	0.54786
2015	0	0.6636	0.663	0.621	0.55962
2016	0	0.696	0.696	0.645	0.58014
2017	0	0.8178	0.8196	0.7374	0.6552

Spawning Stock Biomass Relative to 20% SPR Levels Under Various Fishing Mortality Rates.

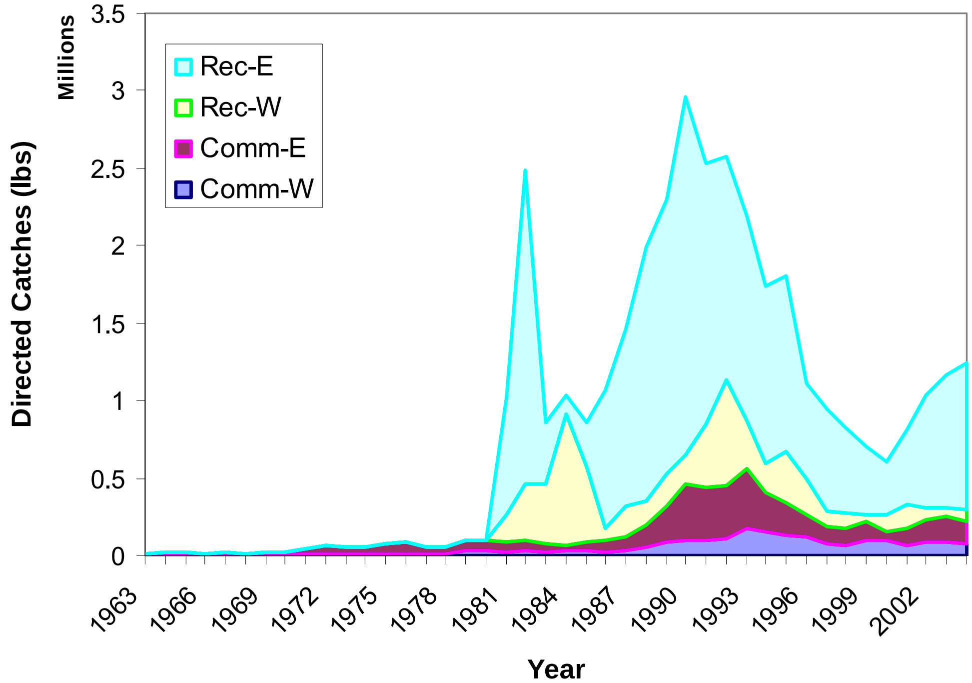
Year	F=0	F_{2004}	F_{MSY}	$F_{30\%SPR}$	$0.75*F_{30\%SPR}$
2000	0.953753	0.953753	0.953753	0.953753	0.953753
2001	1.123578	1.123578	1.123578	1.123578	1.123578
2002	1.129644	1.129644	1.129644	1.129644	1.129644
2003	1.064443	1.064443	1.064443	1.064443	1.064443
2004	0.980288	0.980288	0.980288	0.980288	0.980288
2005	0.97953	0.97953	0.97953	0.97953	0.97953
2006	0.912813	0.912813	0.912813	0.912813	0.912813
2007	1.030326	0.874905	0.870356	0.931008	0.954511
2008	1.269901	0.815011	0.803639	0.961334	1.030326
2009	1.608795	0.838514	0.822593	1.065201	1.178923
2010	1.937074	0.835481	0.81577	1.13116	1.289613
2011	2.145565	0.743518	0.721531	1.084913	1.278999
2012	2.402578	0.719333	0.696133	1.094769	1.319181
2013	2.608795	0.663306	0.639651	1.059894	1.308567
2014	2.86884	0.664746	0.640561	1.079606	1.349507
2015	3.091736	0.655118	0.630705	1.082638	1.369219
2016	3.345716	0.683927	0.658908	1.125853	1.428355
2017	3.651251	0.777104	0.750569	1.242608	1.561789

Table 7 (cont.)—Projections. New F rates applied starting in 2007.

Fishing Mortality Rates Relative to 30% SPR Levels Under Various Fishing Mortality Rates.

Year	F=0	F_{2004}	F_{MSY}	$F_{30\%SPR}$	$0.75*F_{30\%SPR}$
2000	1.412698	1.412698	1.412698	1.412698	1.412698
2001	1.501512	1.501512	1.501512	1.501512	1.501512
2002	1.566893	1.566893	1.566893	1.566893	1.566893
2003	1.613757	1.613757	1.613757	1.613757	1.613757
2004	1.643235	1.643235	1.643235	1.643235	1.643235
2005	1.60771	1.60771	1.60771	1.60771	1.60771
2006	1.60771	1.60771	1.60771	1.60771	1.60771
2007	0	1.60771	1.657596	1	0.748299
2008	0	1.60771	1.657596	1	0.748299
2009	0	1.60771	1.657596	1	0.748299
2010	0	1.60771	1.657596	1	0.748299
2011	0	1.60771	1.657596	1	0.748299
2012	0	1.60771	1.657596	1	0.748299
2013	0	1.60771	1.657596	1	0.748299
2014	0	1.60771	1.657596	1	0.748299
2015	0	1.60771	1.657596	1	0.748299
2016	0	1.60771	1.657596	1	0.748299
2017	0	1.60771	1.657596	1	0.748299

FIGURES



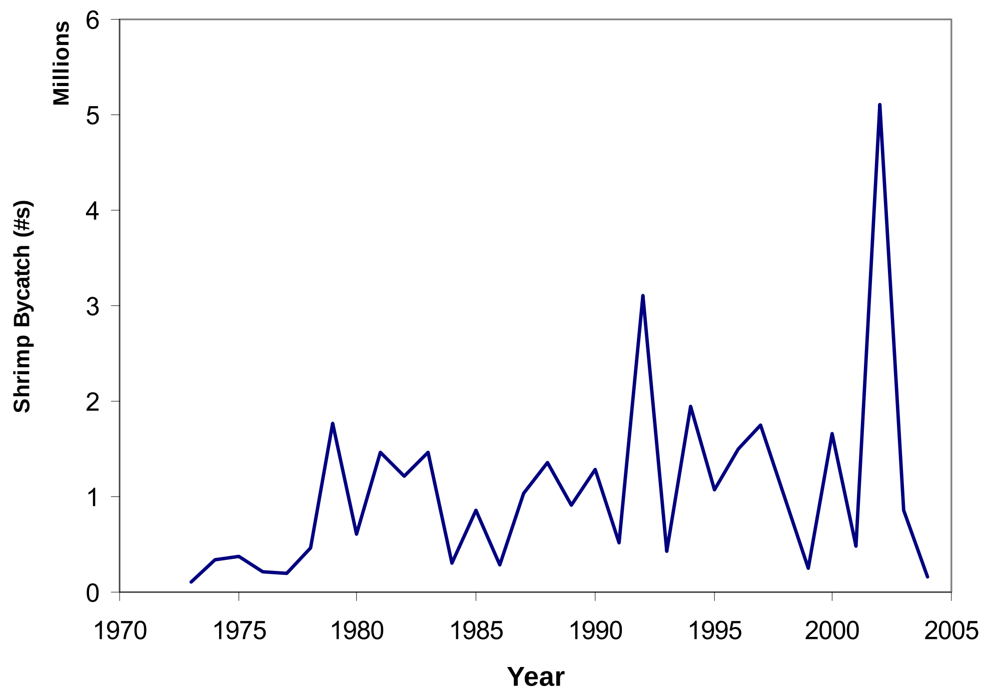
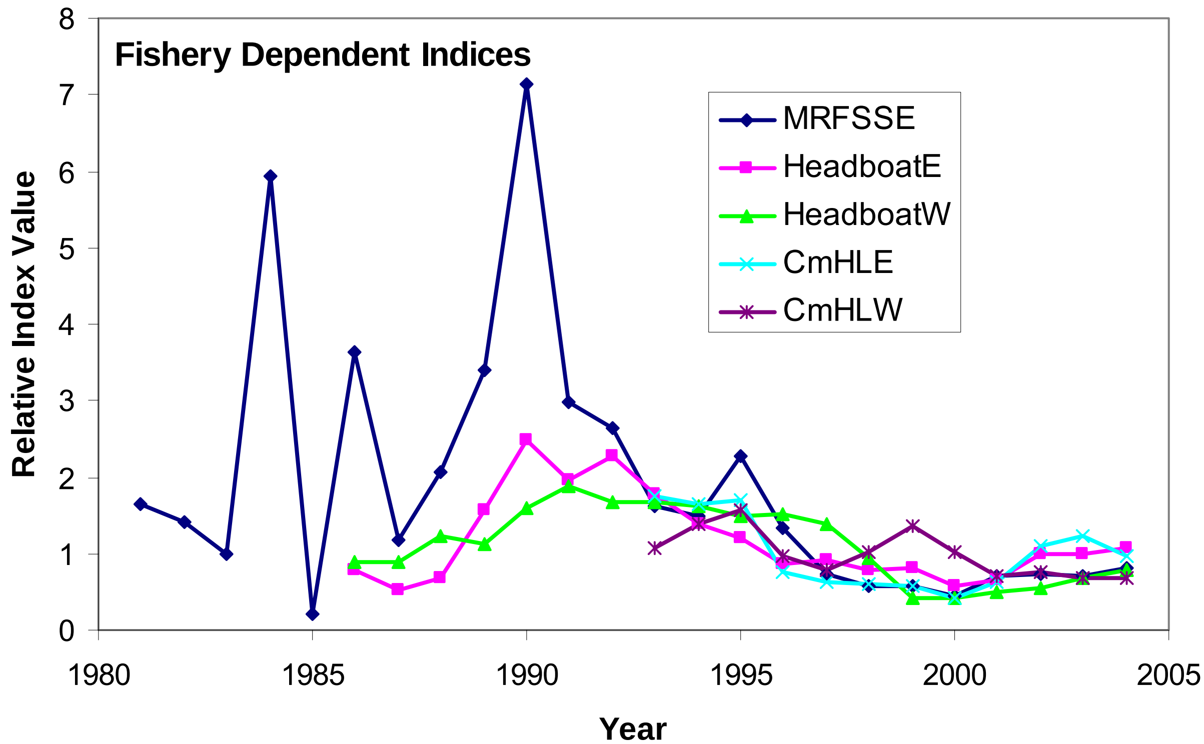


Fig. 1—Catches by Sector (stacked).



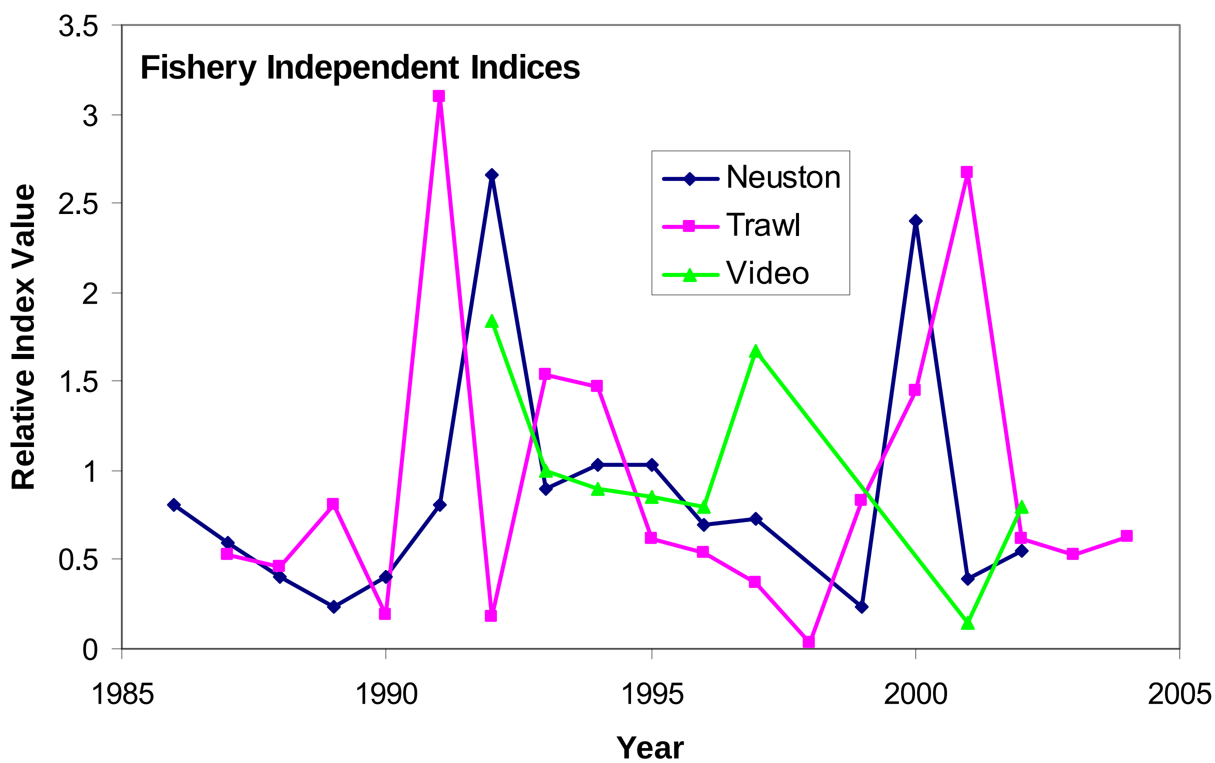


Fig. 2—Indices of Abundance.

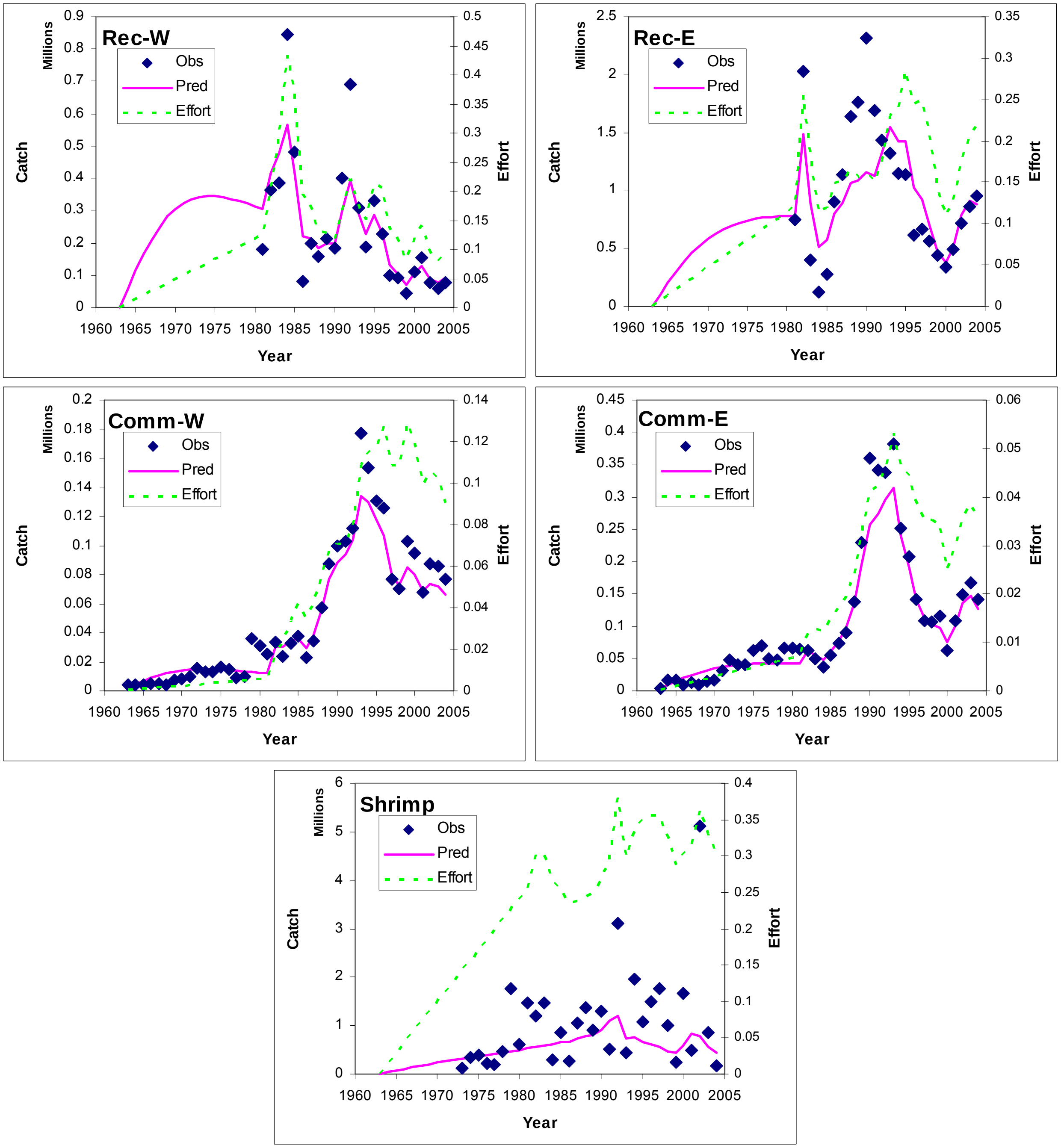


Fig. 3—Catch Fits.

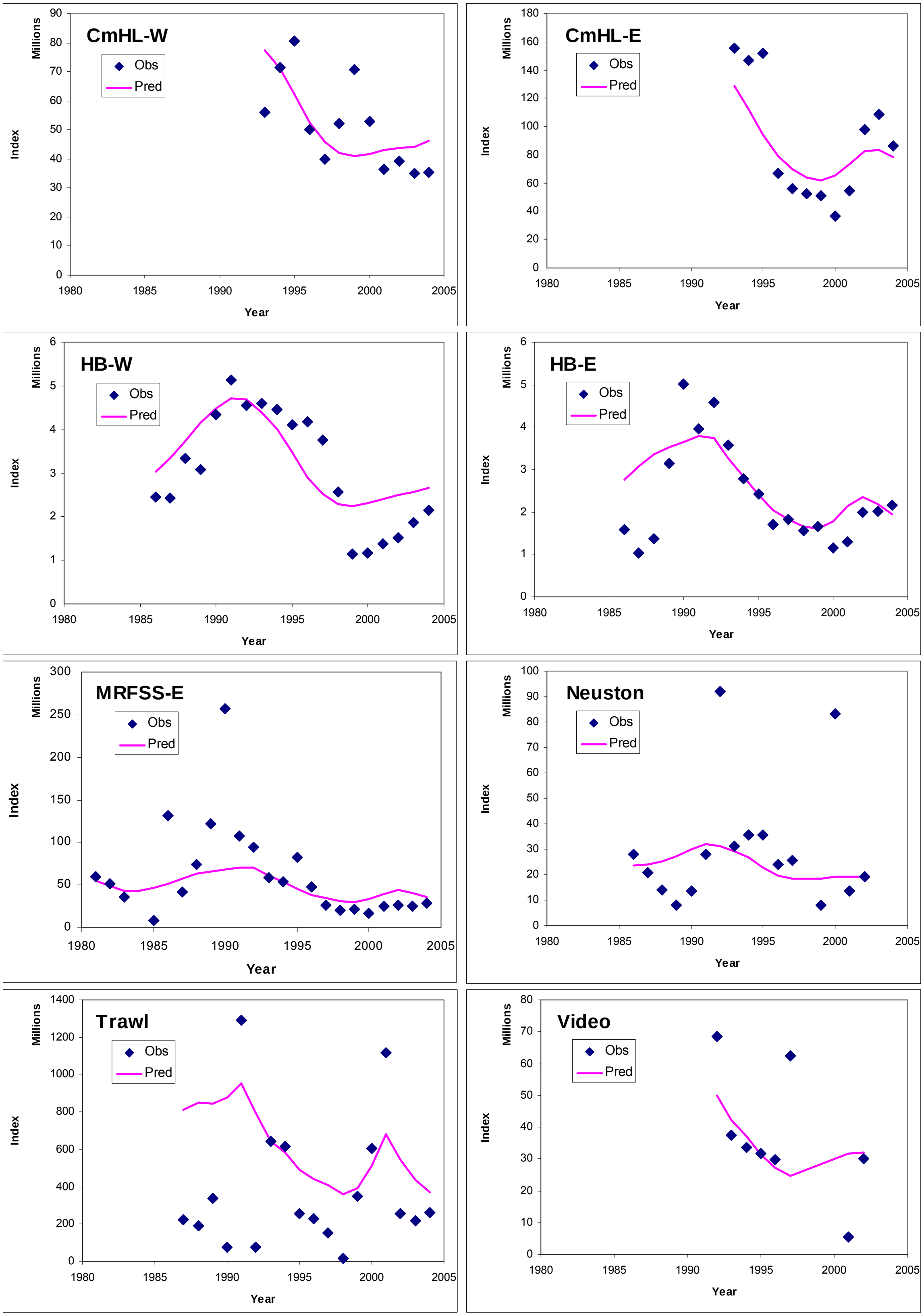


Fig. 4—Index Fits.

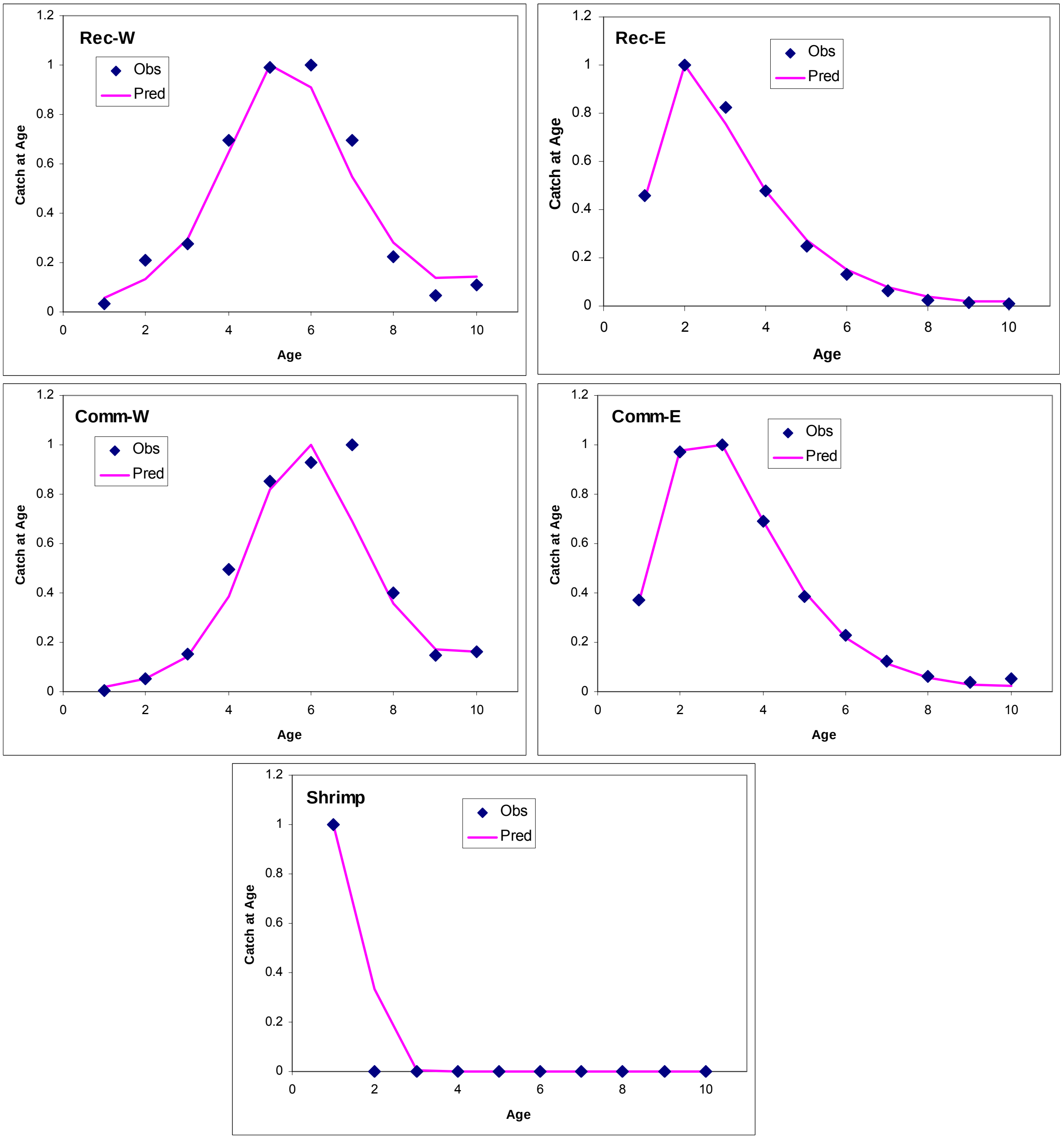


Fig. 5—Catch at Age Fits in 2004

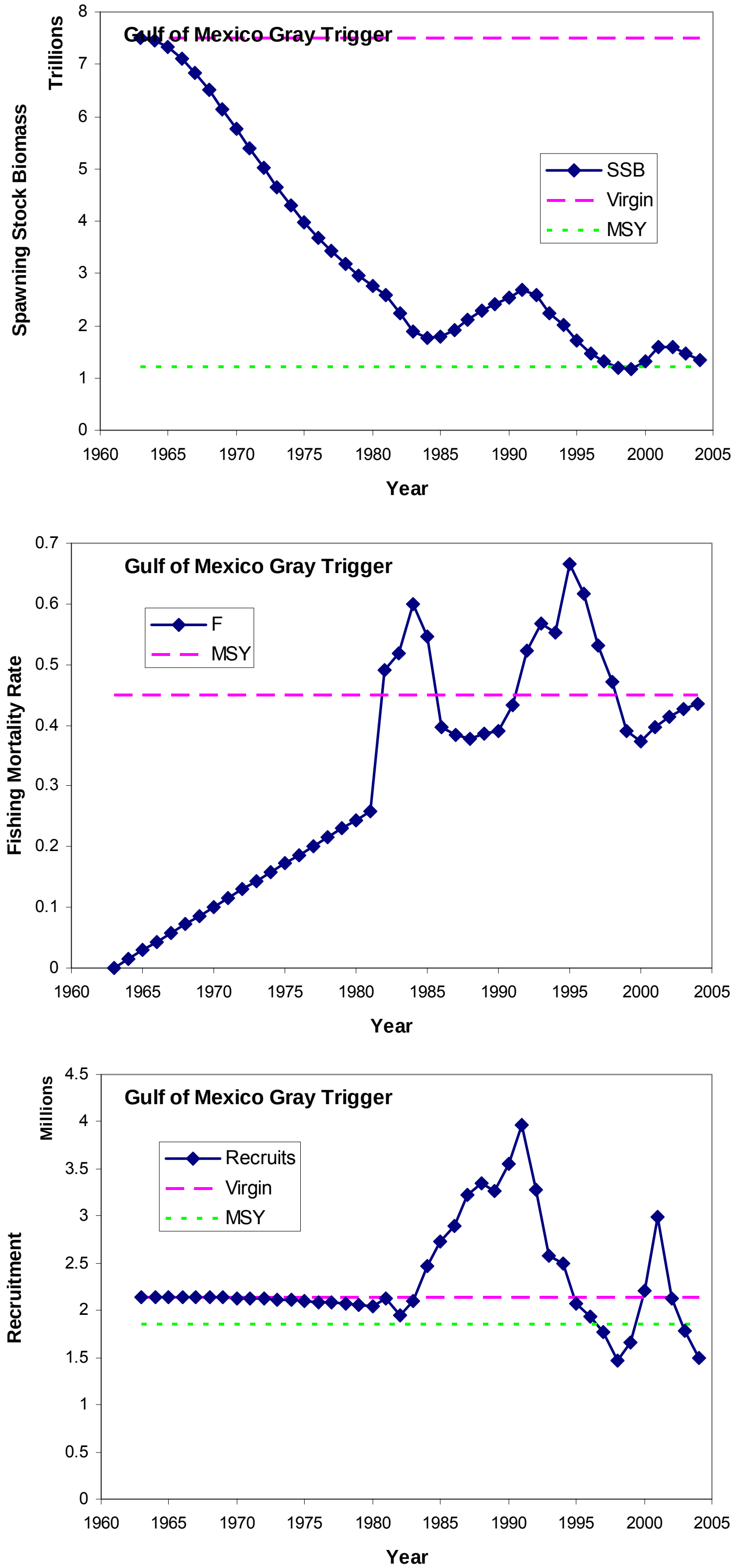


Fig. 6—Trajectories According to the Base Model. (a) SSB, (b) F, (c) recruitment.

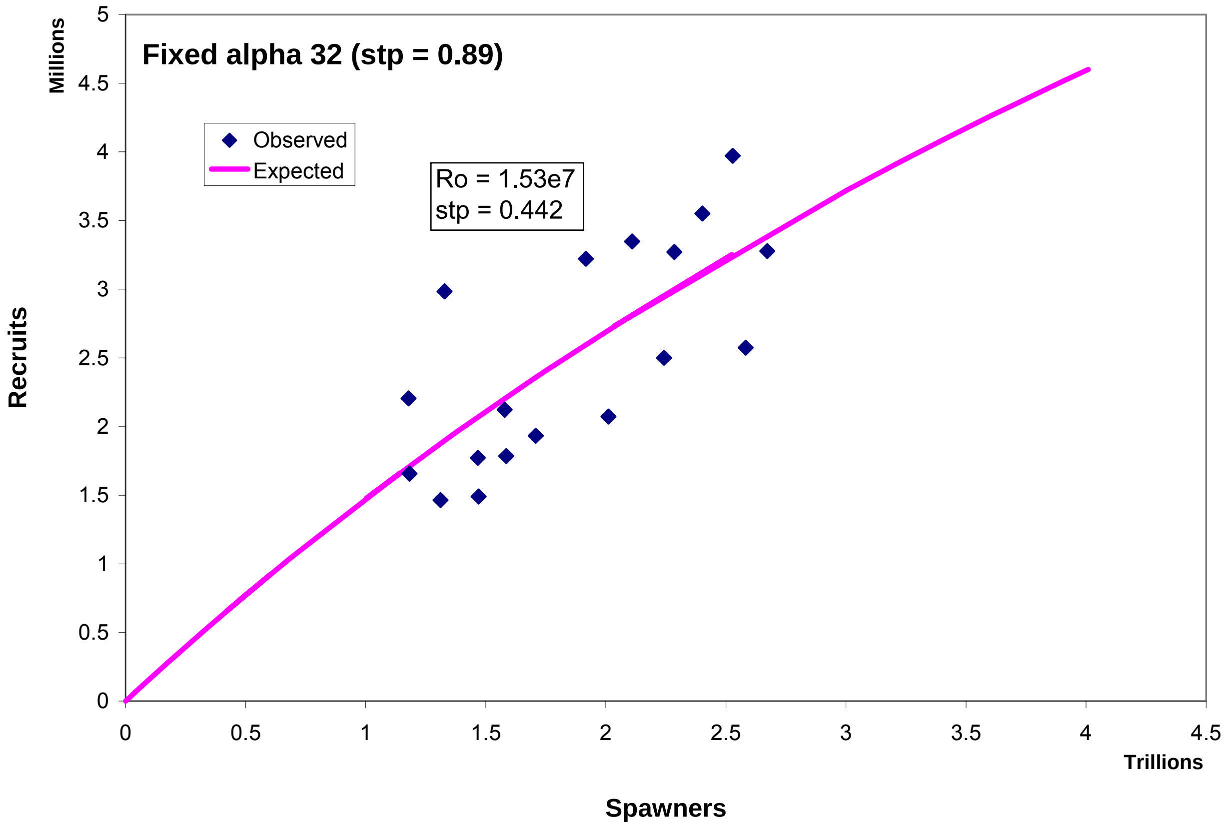


Fig. 7—Stock-Recruitment Patterns Considering the Deviations Predicted by the Model.

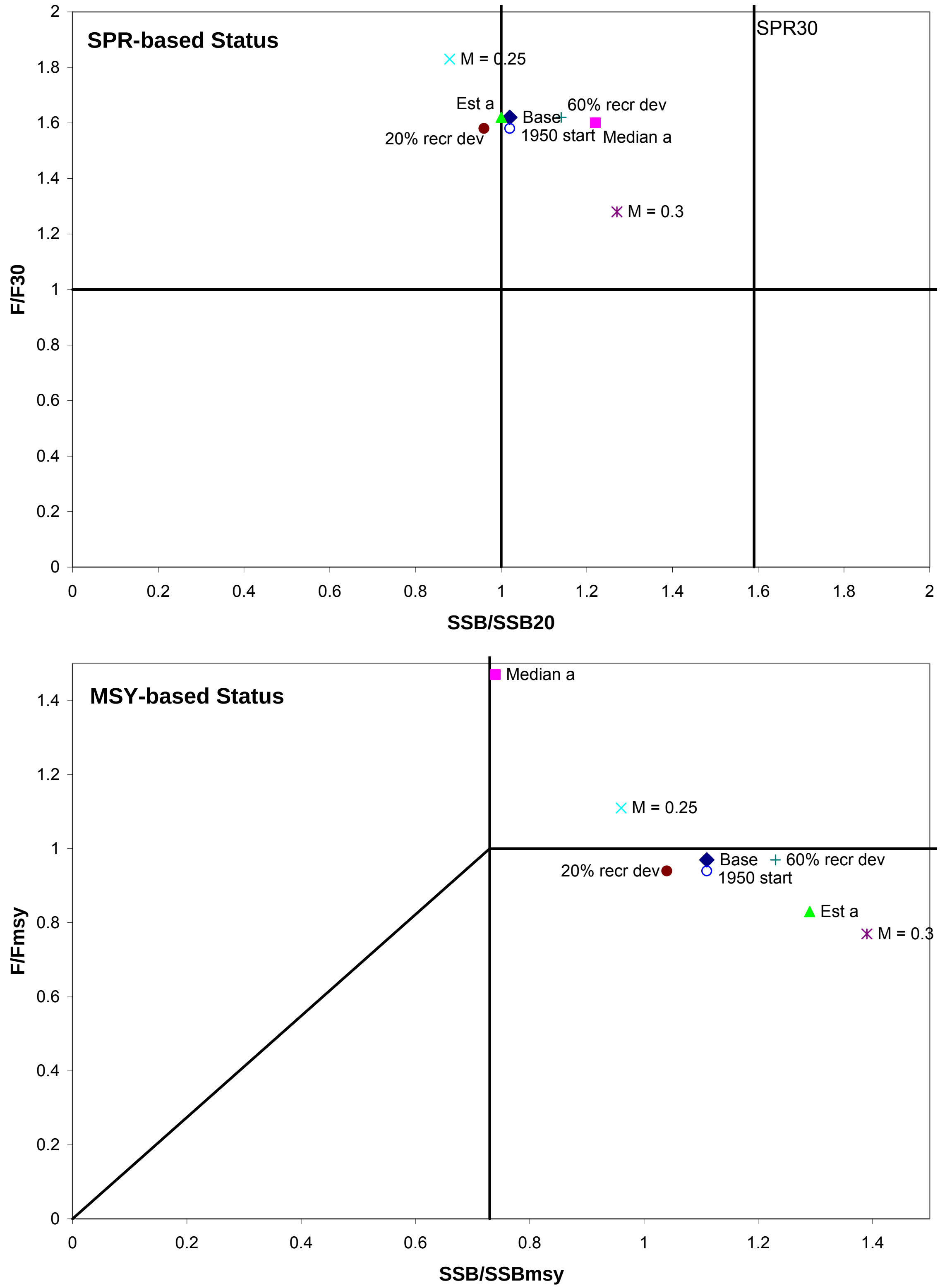


Fig. 8—Status Across Sensitivity Analyses. (a) SPR-based benchmarks (current practice), (b) MSY-based benchmarks (sine the Gulf Council has not yet specified these, the benchmarks are assumed based on history).

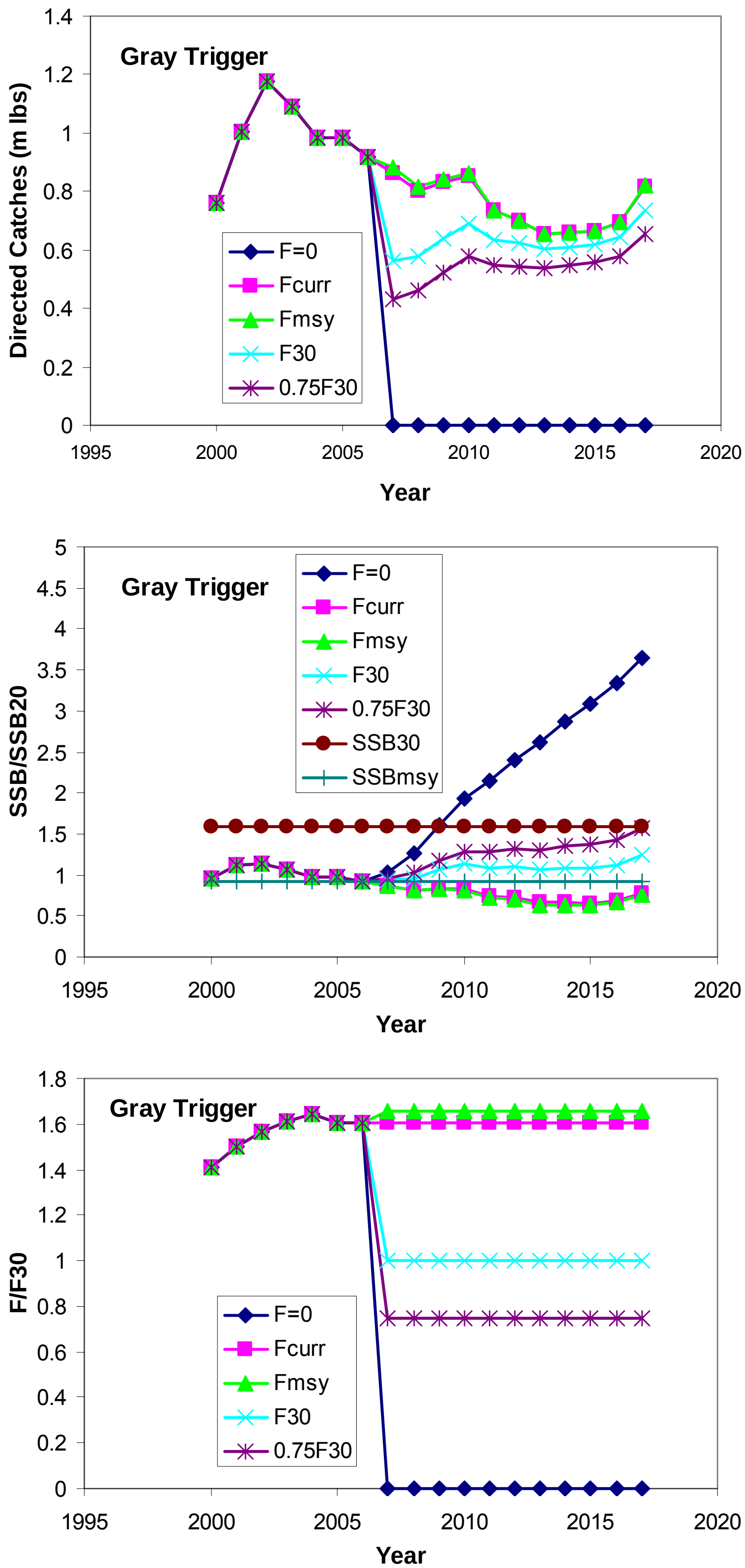


Fig. 9—Projections Under Various Fishing Mortality Rates. (a) Directed catches, (b) SSB rel to 20% SPR (MSST), (c) F relative to 30% SPR (MFMT). New F rates applied starting in 2007.

Appendix 1--Input Data Files for SSASPM Base Run

```
#////////////////////////////////////////////////////////////////////////////////////////////
#////////////////////////////////////////////////////////////////////////////////////////////
#// INPUT DATA FILE FOR PROGRAM SSASPM
#//
#// Gulf of Mexico Gray Triggerfish
#// August 2005                    Modified    30-Mar-06
#//
#// Josh Sladek Nowlis
#// NOAA Fisheries
#// Southeast Fisheries Science Center
#// Miami, FL
#// (305) 361-4222
#// Joshua.Nowlis@noaa.gov
#//
#//
#// Select columns A-M, save as ssaspmlinear.dat
#//   Important notes:
#//    (1) Comments may be placed BEFORE or AFTER any line of data, however they MUST begin
#//        with a # symbol in the first column.
#//    (2) No comments of any kind may appear on the same line as the data (the #
#//        symbol will not save you here)
#//    (3) Blank lines without a # symbol are not allowed.
#//
#////////////////////////////////////////////////////////////////////////////////////////////
#////////////////////////////////////////////////////////////////////////////////////////////
#
##########################################################
# GENERAL INFORMATION
##########################################################
# first and last year of data
    1963    2004
# number of years of historical period
      18
# Historic effort (0 = exact match to effort data, 1 = estimated constant, 2 = estimated linear)
       2
# first and last age of data
       1      10
# number of seasons (months) per year
      12
# type of overall variance parameter (1 = log scale variance, 2 = observation scale variance, 0=force equal weighting)
       1
# spawning season (integer representing season/month of year when spawning occurs)
       7
# maturity schedue (fraction mof each age class that is sexually mature
   0.875       1       1       1       1       1       1       1       1       1
# fecundity schedule (index of per capita fecundity of each age class--batch fecundity in millions of eggs)
 0.2335502  0.320312  0.439306  0.602506  0.826332  1.133309  1.5543255  2.131747  2.923676  4.009801
##########################################################
# CATCH INFORMATION
##########################################################
# number of catch data series (if there are no series, there should be no entries after the next line below)
       5
# pdf of observation error for each series (1) lognormal, (2) normal
       1       1       1       1       1
# units (1=numbers, 2=weight)
       2       2       2       2       1
# season (month) when fishing begins for each series
       1       1       1       1       7
# season (month) when fishing ends for each series
      12      12      12      12      12
# set of catch variance parameters each series is linked to
       1       1       1       1       2
# set of q parameters each series is linked to
       1       2       3       4       5
# set of s parameters each series is linked to
       1       2       3       4       5
# set of e parameters each series is linked to
```

1	2	3	4	5	
# observed catches by set (no column for year allowed)					
# Rec-E	Rec-W	Comm-E	Comm-W	Shrimp Age	Year
-1	-1	3100	4200	-1	1963
-1	-1	15700	4300	-1	1964
-1	-1	17400	4300	-1	1965
-1	-1	8600	5200	-1	1966
-1	-1	12200	5200	-1	1967
-1	-1	8600	3900	-1	1968
-1	-1	14600	7700	-1	1969
-1	-1	16000	8200	-1	1970
-1	-1	30500	9900	-1	1971
-1	-1	47400	15200	-1	1972
-1	-1	40000	13200	112277.6	1973
-1	-1	40000	13100	342364.6	1974
-1	-1	62000	16000	380204.4	1975
-1	-1	69700	14800	220049.9	1976
-1	-1	50095.91	9290.086	189051.1	1977
-1	-1	48518.03	10196.7	460314.5	1978
-1	-1	65670.02	35732.98	1771057	1979
-1	-1	65421.67	31001.23	606637.6	1980
748779.46	179616.8	64498	25362	1467734	1981
2032601.4	362711	62959	33714	1206518	1982
397613.53	387301.1	49588	23831	1462755	1983
120970.49	844622.8	37445	32749	304993.5	1984
280865.15	479950.2	54840	37786	855586	1985
898096.37	79076.84	72858	22771	279373.7	1986
1135997.7	199066.1	89313	34290	1044555	1987
1638073.3	158328.2	137978	57084	1364168	1988
1765965.4	212002	230361	87271	906437.2	1989
2313261.1	184940.6	359686.4	99351.17	1286703	1990
1688391.7	399955	341319.2	103211.2	523154.4	1991
1434485.1	688825	338118.9	112075.7	3100516	1992
1317044.1	309425.4	381279.2	177448.4	432659.9	1993
1152103	186425.4	251578.1	153141.4	1951471	1994
1139966.8	329440.7	207212.3	130664.3	1065855	1995
618124.69	226005.8	142184.6	125331.6	1498133	1996
664793.77	100211.2	107779.8	76909.41	1751775	1997
560509.32	93309.19	106152.6	70570.89	1004208	1998
445429.52	43997.12	116194.3	102826.1	242741.5	1999
337240.63	109208.6	63041.56	95094.95	1656166	2000
487621.94	152571.5	108463.6	67718.28	490376.2	2001
721871.85	77016.21	148600.1	86962.79	5115407	2002
856626.38	58622.49	166424.7	85385.05	854441.3	2003
951559.09	78092.38	141411.1	77121.77	167161.8	2004
# annual scaling factors for observation variance (relative annual CVs)					
2	2	1	1	1	1963
2	2	1	1	1	1964
2	2	1	1	1	1965
2	2	1	1	1	1966
2	2	1	1	1	1967
2	2	1	1	1	1968
2	2	1	1	1	1969
2	2	1	1	1	1970
2	2	1	1	1	1971
2	2	1	1	1.254428	1972
2	2	1	1	0.911815	1973
2	2	1	1	0.99788	1974
2	2	1	1	1.047959	1975
2	2	1	1	0.563759	1976
2	2	1	1	0.56537	1977
2	2	1	1	0.604555	1978
2	2	1	1	1.259889	1979
2	2	1	1	0.442638	1980
2	2	1	1	0.776054	1981
2	2	1	1	0.936054	1982
2	2	1	1	1.073982	1983
2	2	1	1	1.065109	1984
2	2	1	1	1.061948	1985
2	2	1	1	1.135625	1986

2	2	1	1	1.177493	1987
1	1	1	1	1.155266	1988
1	1	1	1	1.109468	1989
1	1	1	1	1.139841	1990
1	1	1	1	1.144917	1991
1	1	1	1	0.477896	1992
1	1	1	1	0.443595	1993
1	1	1	1	0.935097	1994
1	1	1	1	1.088391	1995
1	1	1	1	1.143002	1996
1	1	1	1	1.120295	1997
1	1	1	1	1.127864	1998
1	1	1	1	1.074978	1999
1	1	1	1	1.184296	2000
1	1	1	1	1.187074	2001
1	1	1	1	1.173661	2002
1	1	1	1	1.219074	2003
1	1	1	1	1.400728	2004

##

INDICES OF ABUNDANCE (e.g., CPUE) If there are no series, there should be no entries between the comment lines.

##

number of index data series

8

pdf of observation error for each series (1) lognormal, (2) normal

1	1	1	1	1	1	1	1

units (1=numbers, 2=weight)

1	1	1	2	2	1	1	1

season (month) when index begins for each series

1	1	1	1	1	10	9	5

season (month) when index ends for each series

12	12	12	12	12	11	11	8

option to (1) scale or (0) not to scale index observations

0	0	0	0	0	0	0	0

set of index variance parameters each series is linked to

1	1	1	1	1	1	1	1

set of q parameters each series is linked to

6	7	8	9	10	11	12	13

set of s parameters each series is linked to

1	1	2	3	4	6	7	8

observed indices by series x 10^8 (no column for year allowed)

# MRFSSE	HBE	HBW	CmHLE	CmHLW	LarvalGW-	TrawlGW	VideoGW	Year
-1	-1	-1	-1	-1	-1	-1	-1	1963
-1	-1	-1	-1	-1	-1	-1	-1	1964
-1	-1	-1	-1	-1	-1	-1	-1	1965
-1	-1	-1	-1	-1	-1	-1	-1	1966
-1	-1	-1	-1	-1	-1	-1	-1	1967
-1	-1	-1	-1	-1	-1	-1	-1	1968
-1	-1	-1	-1	-1	-1	-1	-1	1969
-1	-1	-1	-1	-1	-1	-1	-1	1970
-1	-1	-1	-1	-1	-1	-1	-1	1971
-1	-1	-1	-1	-1	-1	-1	-1	1972
-1	-1	-1	-1	-1	-1	-1	-1	1973
-1	-1	-1	-1	-1	-1	-1	-1	1974
-1	-1	-1	-1	-1	-1	-1	-1	1975
-1	-1	-1	-1	-1	-1	-1	-1	1976
-1	-1	-1	-1	-1	-1	-1	-1	1977
-1	-1	-1	-1	-1	-1	-1	-1	1978
-1	-1	-1	-1	-1	-1	-1	-1	1979
-1	-1	-1	-1	-1	-1	-1	-1	1980
59559378	-1	-1	-1	-1	-1	-1	-1	1981
50868542	-1	-1	-1	-1	-1	-1	-1	1982
35535094	-1	-1	-1	-1	-1	-1	-1	1983
213935444	-1	-1	-1	-1	-1	-1	-1	1984
7822068.2	-1	-1	-1	-1	-1	-1	-1	1985
131048572	1578860	2456749	-1	-1	28090000	-1	-1	1986
41944300	1039815	2426165	-1	-1	20700000	221222766	-1	1987
74319582	1366135	3340596	-1	-1	13960000	190217886	-1	1988
122178177	3132138	3081381	-1	-1	8002000	338042013	-1	1989
256472874	5017220	4339279	-1	-1	13800000	77926820	-1	1990
106996949	3957055	5133360	-1	-1	27840000	1.291E+09	-1	1991

94729530	4574219	4560725	-1	-1	91810000	75775134	68549000	1992
58760545	3585924	4591890	1.56E+08	55916617	31130000	640449444	37395000	1993
53296524	2780550	4463384	1.47E+08	71327783	35770000	613493817	33632000	1994
82087588	2419154	4099585	1.52E+08	80526939	35640000	257204165	31823000	1995
47628834	1715052	4180940	66896638	50180949	24180000	226347219	29654000	1996
26705984	1816977	3769818	55949368	39948460	25410000	154496306	62533000	1997
20243170	1561531	2565767	52796109	52268125	-1	14675364	-1	1998
20977824	1654448	1144995	50808752	70790644	8045000	346253161	-1	1999
16458045	1162980	1159826	37050498	52932912	83120000	602549721	-1	2000
25277308	1303939	1371411	54917389	36569329	13720000	1.115E+09	5343000	2001
26175442	1981108	1513616	97778962	39080538	19010000	258028537	29957000	2002
25252012	2005931	1856765	1.09E+08	35090550	-1	218780772	-1	2003
29049705	2154191	2137627	86613049	35260095	-1	261614013	-1	2004

annual scaling factors for observation variance (relative annual CVs)

1	1	1	1	1	1	1	1	1963
1	1	1	1	1	1	1	1	1964
1	1	1	1	1	1	1	1	1965
1	1	1	1	1	1	1	1	1966
1	1	1	1	1	1	1	1	1967
1	1	1	1	1	1	1	1	1968
1	1	1	1	1	1	1	1	1969
1	1	1	1	1	1	1	1	1970
1	1	1	1	1	1	1	1	1971
1	1	1	1	1	1	1	1	1972
1	1	1	1	1	1	1	1	1973
1	1	1	1	1	1	1	1	1974
1	1	1	1	1	1	1	1	1975
1	1	1	1	1	1	1	1	1976
1	1	1	1	1	1	1	1	1977
1	1	1	1	1	1	1	1	1978
1	1	1	1	1	1	1	1	1979
1	1	1	1	1	1	1	1	1980
2.3481011	1	1	1	1	1	1	1	1981
2.070742	1	1	1	1	1	1	1	1982
2.761414	1	1	1	1	1	1	1	1983
6.9512632	1	1	1	1	1	1	1	1984
7.2024144	1	1	1	1	1	1	1	1985
0.9399457	1.371901	0.951521	1	1	1	1	1	1986
1.2098526	1.832588	0.853511	1	1	0.934014	1.0551807	1	1987
1.1323095	1.285721	0.715741	1	1	1.090213	1.1171951	1	1988
1.1524367	0.684331	0.810134	1	1	1.158219	0.5279337	1	1989
1.0877329	0.446229	0.605246	1	1	0.868347	3.6978365	1	1990
1.0518819	0.549589	0.520694	1	1	0.834705	0.2072022	1	1991
0.8458045	0.480808	0.56144	1	1	0.900859	3.274347	0.865553	1992
1.0022765	0.566484	0.557139	1.060936	1.018465	1.132716	0.3129469	0.914865	1993
1.0913614	0.714003	0.528381	0.966938	0.999512	0.841992	0.3307473	0.878982	1994
1.174345	0.850946	0.563249	1.077523	1.01527	0.812304	0.7384777	0.974878	1995
1.2204588	1.053125	0.569626	1.006893	1.005816	0.970142	0.8194269	0.866941	1996
1.0742782	1.021767	0.661811	1.07055	1.006119	0.928487	1.7887012	1.060699	1997
1.041824	1.113295	0.873661	1.107454	0.996958	1.177347	0.7444719	1	1998
0.9039276	1.036357	1.727267	0.947706	0.985043	0.860483	0.5112333	1	1999
0.9771672	1.37544	1.643842	1.071766	0.992177	1.183722	0.3145877	1	2000
0.8978562	1.334974	1.392549	1.015394	1.003783	1.031773	0.2086763	1.395689	2001
0.8906162	1.023834	1.39093	0.906473	0.993139	0.820741	0.7019244	1.042393	2002
0.9040351	1.004179	1.088876	0.852938	0.991271	1.436616	0.8752888	1	2003
0.8218537	0.905594	1.002669	0.915428	0.992447	1.017321	0.7738224	1	2004

##
EFFORT OBSERVATIONS If there are no series, there should be no entries between the comment lines.
##
number of effort data series
0
##
AGE COMPOSITION OBSERVATIONS If there are no series, there should be no entries between the comment lines.
##
number of age-composition series (If there are no series,there should be no more entries in this section)
5
first year in age-composition series
1981
probability densities used for age-comp. series (0 = ignore, 3 = multinomial, 8 = robustified normal)

3	3	3	3	0

units (only 1=numbers, no other options at this time)
1 1 1 1 1
season (month) when age collections begin for each series
1 1 1 1 7
season (month) when age collections end for each series
12 12 12 12 12
age composition data for all years in the modern period MAX 25 Divisor 10

# series	year	sample siz	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1	1981	5	6.683833	14.55645	12.9313	7.567416	3.479636	1.86342	0.940379	0.330072	0.289612	0.357806
1	1982	9	12.85183	25.20349	24.64398	15.073289	7.110661	3.663385	1.909051	0.78574	0.472655	0.285686
1	1983	7	7.990986	20.09468	19.24166	11.4367	5.114646	3.066469	1.520591	0.673263	0.395281	0.465488
1	1984	2	3.781056	8.243904	5.741553	2.7614778	1.589708	0.953419	0.424684	0.258591	0.068488	0.177131
1	1985	3	2.700271	6.048892	6.216951	5.2300015	3.051017	1.439593	1.254609	0.325129	0.32401	0.409568
1	1986	25	28.21374	70.70483	71.30153	47.530052	25.87361	14.52127	8.029534	3.354134	2.084648	2.386021
1	1987	25	77.85847	155.1662	139.2159	93.993625	54.70624	29.33744	14.72234	6.233203	3.829021	2.93678
1	1988	25	88.74984	199.2801	177.8355	112.98372	57.91839	30.61759	16.32679	5.815902	3.698644	2.772721
1	1989	25	199.2858	328.4621	251.3632	158.14253	91.6563	47.31169	21.74484	6.898737	5.589603	3.54586
1	1990	25	279.2999	513.461	367.1782	203.73874	112.1557	60.73686	25.98431	7.854036	5.91847	2.674526
1	1991	25	204.1712	429.8621	380.9281	240.65181	125.4167	62.43495	31.82659	11.70053	6.905953	5.099961
1	1992	25	299.4172	649.6174	557.9516	343.99012	175.938	91.81638	46.84962	16.35747	10.17757	7.882939
1	1993	25	136.4747	297.766	246.7135	143.60209	73.76489	38.88499	19.11463	6.714899	4.328258	2.635491
1	1994	25	183.1159	350.1557	267.5916	155.36889	82.61143	42.67374	20.02459	6.420062	4.929604	3.109059
1	1995	25	160.9987	340.6296	255.2023	137.58128	71.90313	38.45555	17.59014	5.710101	3.93704	1.992712
1	1996	25	116.6681	257.0968	200.7716	108.20571	54.18175	28.8908	13.41826	4.2366	2.812408	1.717871
1	1997	25	170.5544	370.4786	295.6585	173.42588	92.33329	47.65315	23.86941	7.484731	5.364065	3.17802
1	1998	25	292.6357	690.8389	540.5222	286.97132	142.7198	79.01015	37.66422	11.9715	7.591233	4.074114
1	1999	25	324.4544	783.6046	623.2016	330.54404	160.4864	87.17141	42.04689	13.71274	8.469533	5.307429
1	2000	25	304.7471	727.429	635.6375	382.59334	193.4004	97.14375	50.6322	17.15259	10.91044	6.351283
1	2001	25	381.862	893.3115	704.6439	388.95179	198.6706	105.1803	50.56173	16.96656	10.31893	5.531969
1	2002	25	377.7485	940.5624	773.9294	421.04542	211.4095	114.5846	57.40986	19.16064	11.54815	7.598442
1	2003	25	353.2094	850.1884	691.0708	385.17401	191.5441	101.3534	50.3486	16.11704	10.23873	5.75467
1	2004	25	368.1259	918.0599	769.2028	423.83612	204.467	109.6062	54.97446	18.06407	10.85488	6.806222
2	1981	1	0	0.02439	0.22147	1.38688	2.40068	2.49219	1.964	0.8144	0.37098	0.32506
2	1982	1	0.1	0.78328	0.82376	1.21632	1.84668	1.259	0.97096	0	0	0
2	1983	1	0	0	0.05506	0.27679	0.33185	0.45536	0.42411	0.28274	0.05506	0.11905
2	1984	3	0	0.02439	0.85605	1.75242	3.97362	5.38987	10.2954	3.87882	1.17946	1.65014
2	1985	1	0	0.02439	0.02439	0.14634	0.39024	0.21951	0.19512	0	0	0
2	1986	22	5.591276	19.81634	21.39219	36.251755	43.17054	42.44633	30.95531	8.980596	3.388802	4.007188
2	1987	24	4.983782	16.3795	18.42267	39.556984	52.39132	49.35746	35.28577	9.594876	3.031628	5.99618
2	1988	17	2.582747	15.16451	15.19125	30.095936	36.39325	32.59676	22.6764	6.318001	1.705891	4.275362
2	1989	25	2.260948	17.06062	20.2946	47.757383	64.05226	64.58842	38.17077	10.98458	3.011971	5.818565
2	1990	25	2.62216	17.66238	23.04167	59.816901	80.84969	83.91376	52.33052	17.59651	4.795701	9.370779
2	1991	25	1.107287	10.73989	16.57688	50.80844	72.12251	73.15469	51.76513	19.5431	5.201813	10.98091
2	1992	25	9.33545	47.53322	54.58139	126.46244	169.0177	165.7886	108.88	33.36381	9.402623	17.63554
2	1993	25	1.47559	12.00779	21.49249	62.411733	96.49948	101.2756	78.60541	29.74856	9.93158	12.52676
2	1994	25	3.325708	32.10039	45.05173	105.50355	155.0755	154.479	114.62	35.88974	11.63157	16.32305
2	1995	25	1.817169	19.09081	28.97476	89.68223	137.9308	138.6886	94.52591	30.80543	9.820216	14.66412
2	1996	25	2.338714	18.38168	27.43717	80.172516	121.5692	120.4059	77.01096	22.42297	6.666286	11.59475
2	1997	19	1.005982	8.613619	12.12966	28.707928	38.76528	43.95521	31.70517	12.18747	3.051064	4.8787
2	1998	25	1.40533	14.12528	20.35309	51.766045	79.09085	78.06189	56.20971	17.2914	6.112707	7.583795
2	1999	14	0.399998	4.56866	6.943022	21.573414	32.16997	32.84531	20.35465	6.793916	2.146123	3.205029
2	2000	6	0	1.533119	3.191339	7.0636873	13.14988	11.8594	11.89793	3.459279	1.418	1.42757
2	2001	11	0.302969	3.511307	5.182332	18.268734	28.32873	29.09136	17.28685	5.235766	1.331844	2.460155
2	2002	15	0.794001	2.824699	5.025956	24.522922	36.30256	39.41294	25.9285	10.08559	2.863372	5.23972
2	2003	18	0.611716	7.061209	10.78633	28.637659	40.70334	43.90187	31.34596	11.07285	2.816449	5.062833
2	2004	12	0.1	3.417449	6.372952	18.543997	28.95136	29.17832	20.22771	7.128822	1.929466	3.150161
3	1981	0	0	0	0	0	0	0	0	0	0	0
3	1982	0	0	0	0	0	0	0	0	0	0	0
3	1983	0	0	0	0	0	0	0	0	0	0	0
3	1984	0	0	0	0	0	0	0	0	0	0	0
3	1985	0	0	0	0	0	0	0	0	0	0	0
3	1986	0	0	0	0	0	0	0	0	0	0	0
3	1987	0	0	0	0	0	0	0	0	0	0	0
3	1988	0	0	0	0	0	0	0	0	0	0	0
3	1989	1	0.08717	0.401937	0.263922	0.1452803	0.053267	0.026638	0.012108	0.009687	0	0
3	1990	7	3.223407	9.623322	12.35797	11.236006	9.087983	8.766192	4.093127	3.342451	1.814501	3.454747
3	1991	4	0.927806	1.428554	2.411908	5.037953	5.961932	7.114225	3.314033	3.135205	2.005321	4.662976
3	1992	5	2.540079	7.25546	9.242561	9.5551401	8.409575	6.419864	3.518082	2.517056	1.457359	3.08471
3	1993	25	52.34089	146.1499	167.2291	115.84978	61.15442	36.30718	19.4739	10.53481	5.468831	8.48897
3	1994	25	93.8867	242.8888	253.3765	179.87201	97.70492	52.67382	29.59293	13.16928	8.164492	8.668242

3	1995	25	94.54778	256.4688	264.0245	177.27583	92.28004	46.03134	26.24207	10.57459	6.319682	5.233185
3	1996	25	92.30825	236.7039	244.5612	163.37036	81.63231	42.79206	23.94791	9.86463	5.960975	5.855954
3	1997	25	82.35543	195.5767	195.7529	132.18528	65.6331	31.99752	17.51549	6.860957	3.947595	3.17332
3	1998	25	75.84935	183.8084	161.3491	98.080283	52.03049	30.7372	15.78697	7.378001	4.090488	5.889145
3	1999	25	48.66077	134.9053	145.8223	103.79679	56.57937	33.67083	18.91222	10.08299	5.131431	8.436479
3	2000	25	30.45848	88.99176	96.32543	65.183714	34.06245	19.67907	11.51744	5.719862	2.659451	4.401294
3	2001	25	82.69642	216.3159	224.6094	143.27417	71.31313	38.49329	20.43596	8.898379	5.136658	5.824159
3	2002	25	57.53503	145.6692	134.4771	84.572832	45.46871	26.0167	14.22372	6.490751	4.172445	6.372406
3	2003	25	34.69652	81.44614	79.33191	57.920221	37.21914	23.10775	12.2144	7.239466	3.722304	6.10139
3	2004	19	12.79279	38.78265	46.5092	36.885832	22.33516	12.768	7.427791	3.727102	2.090014	2.680931
4	1981	0	0	0	0	0	0	0	0	0	0	0
4	1982	0	0	0	0	0	0	0	0	0	0	0
4	1983	0	0	0	0	0	0	0	0	0	0	0
4	1984	0	0	0	0	0	0	0	0	0	0	0
4	1985	0	0	0	0	0	0	0	0	0	0	0
4	1986	0	0	0	0	0	0	0	0	0	0	0
4	1987	0	0	0	0	0	0	0	0	0	0	0
4	1988	0	0	0	0	0	0	0	0	0	0	0
4	1989	0	0	0	0	0	0	0	0	0	0	0
4	1990	25	0.3	3.33243	9.28439	29.86115	50.66102	57.17613	68.93896	26.529	8.57147	11.34705
4	1991	25	1.4	13.77083	27.65188	82.34424	134.2891	143.8223	137.1464	52.49309	18.41527	21.67027
4	1992	25	1.7	18.80012	44.07285	156.88276	258.6317	274.6359	239.1921	93.90986	34.31449	39.86634
4	1993	25	0.5	5.47739	20.07087	61.22433	109.0858	124.808	141.8139	58.74066	21.98465	21.29761
4	1994	25	1.8	14.49279	34.95952	88.9082	152.6647	173.3878	218.1225	83.99081	31.0788	34.60019
4	1995	25	0.6	5.7624	13.31641	44.3335	75.55197	82.39726	87.12224	33.63071	11.02511	13.26221
4	1996	25	0	1.50873	8.32633	27.21919	47.39304	51.31487	60.1971	25.68764	9.79453	10.56029
4	1997	25	0	0.60627	6.64874	25.3365	47.4027	53.94095	64.01243	25.37671	9.33828	10.33875
4	1998	12	0.664652	2.249573	4.84175	15.321409	26.78601	25.54883	23.64832	8.248703	3.970953	3.72041
4	1999	5	0	0.04878	1.41746	6.04058	10.00084	11.9494	11.63542	5.82904	2.06428	2.01454
4	2000	4	0	0.21603	1.02486	4.36068	7.56322	7.14625	8.50205	3.10815	1.32224	1.75677
4	2001	10	0.1	0.92962	3.54888	10.26101	19.50143	20.32304	25.21073	9.93736	4.14388	4.04461
4	2002	15	0.1	1.52893	5.41801	17.18919	30.95911	32.34375	33.10108	13.47699	5.64968	5.23408
4	2003	21	0.563019	1.791486	7.408921	24.81121	40.73053	47.11034	45.68147	20.2789	7.706452	7.916424
4	2004	8	0	1.31709	3.28814	11.01523	17.66183	16.45391	16.19646	5.51711	1.91302	3.63776
5	1981	1	1	0	0	0	0	0	0	0	0	0
5	1982	1	1	0	0	0	0	0	0	0	0	0
5	1983	1	1	0	0	0	0	0	0	0	0	0
5	1984	1	1	0	0	0	0	0	0	0	0	0
5	1985	1	1	0	0	0	0	0	0	0	0	0
5	1986	1	1	0	0	0	0	0	0	0	0	0
5	1987	1	1	0	0	0	0	0	0	0	0	0
5	1988	1	1	0	0	0	0	0	0	0	0	0
5	1989	1	1	0	0	0	0	0	0	0	0	0
5	1990	1	1	0	0	0	0	0	0	0	0	0
5	1991	1	1	0	0	0	0	0	0	0	0	0
5	1992	1	1	0	0	0	0	0	0	0	0	0
5	1993	1	1	0	0	0	0	0	0	0	0	0
5	1994	1	1	0	0	0	0	0	0	0	0	0
5	1995	1	1	0	0	0	0	0	0	0	0	0
5	1996	1	1	0	0	0	0	0	0	0	0	0
5	1997	1	1	0	0	0	0	0	0	0	0	0
5	1998	1	1	0	0	0	0	0	0	0	0	0
5	1999	1	1	0	0	0	0	0	0	0	0	0
5	2000	1	1	0	0	0	0	0	0	0	0	0
5	2001	1	1	0	0	0	0	0	0	0	0	0
5	2002	1	1	0	0	0	0	0	0	0	0	0
5	2003	1	1	0	0	0	0	0	0	0	0	0
5	2004	1	1	0	0	0	0	0	0	0	0	0

```
##########################################################################################
# PARAMETER INPUT FILE--Gray Triggerfish September 2005          Modified     30-Mar-06
##########################################################################################
#
#================================================================================
# Total number of process parameters (must match number of entries in 'Specifications 1' section)
#================================================================================
      58
#================================================================================
# Number of sets of each class of parameters (must be at least 1)
#================================================================================
#       q (catchability)
#          |         Effort
#          |          |         Vulnerability (selectivity)
#          |          |          |         catch observation variance scalar
#          |          |          |          |        index variance scalar
#          |          |          |          |         |    effort variance scalar
#          |          |          |          |         |        |
#------------------------------------------------------------------------------------------------------------------------
                 13         5         8          2         1         1
#================================================================================
# Specifications 1: process parameters and observation error parameters
#================================================================================
#       class (nature) of parameter (1=constant, 2-4 = polynomial of degree x)
#          |         best estimate (or central tendency of prior)
#          |          |         lower bound  upper bound
#          |          |          |          |        phase to estimate (-1 = don't estimate)
#          |          |          |          |         |    prior density (1= lognormal, 2=normal, 3=uniform)
#          |          |          |          |         |        |    prior variance
#          |          |          |          |         |        |        |
#------------------------------------------------------------------------------------------------------------------------
# Natural mortality rate
                  1       0.27      0.19       0.41        -3         1      0.25
# Recruitment (10=Beverton/Holt, 11=Ricker)
                 10   20000000   1000000 1000000000         1         3         1
                 10         32       1.1        100         2         1    0.0098
# Growth (type 8 = von Bertalanfy/Richards, Linf, K, t0, m, a, b (weight=al^b))
                  8      423.4    0.0001    1000000        -1         0         1
                  8     0.4269         0          2        -1         0         1
                  8    -0.6292        -5          5        -1         0         1
                  8          1         0         10        -1         0         1
                  8 4.4858E-08         0        100        -1         0         1
                  8     3.0203         0          5        -1         0         1
# catchability
                  1          1     1E-10         10        -1         0         1 # Rec-E
                  1          1     1E-10         10        -1         0         1 # Rec-W
                  1          1     1E-10         10        -1         0         1 # Comm-E
                  1          1     1E-10         10        -1         0         1 # Comm-W
                  1          1     1E-10         10        -1         0         1 # Shrimp
                  1        0.1     0.001       1000         1         0         1 # MRFSSE
                  1        0.1     0.001       1000         1         0         1 # HBE
                  1        0.1     0.001       1000         1         0         1 # HBW
                  1        0.1     0.001       1000         1         0         1 # CmHLE
                  1        0.1     0.001       1000         1         0         1 # CmHLW
                  1        0.1     0.001       1000         1         0         1 # Larval
```

```
1      0.1         0.001      1000    1    0    1 # Trawl
1      0.1         0.001      1000    1    0    1 # Video
# effort for 'prehistoric' period when data is sparse (Fix at anything if linear estimation is used)
1      0.0001      -1E-32     1.1     -4   0    1 # Rec-E
1      0.0001      -1E-32     1.1     -4   0    1 # Rec-W
1      0.0001      0.000001   1.1     4    0    1 # Comm-E
1      0.0001      0.000001   1.1     4    0    1 # Comm-W
1      0.0001      -1E-32     1.1     -4   0    1 # Shr
# effort for period with useful data
1      0.001       0.00001    0.3     1    0    1 # Rec-E
1      0.001       0.00001    0.3     1    0    1 # Rec-W
1      0.001       0.00001    0.3     1    0    1 # Comm-E
1      0.001       0.00001    0.3     1    0    1 # Comm-W
1      0.001       0.00001    0.3     1    0    1 # Shr
# vulnerability (selectivity) (5=knife edge, 6=logistic, 7=gamma, 15 = double logistic)
6      0.4         0          2       3    0    1 # Rec-E
6      1.65        0.5        10      4    0    0.0625
6      0.7         0          2       3    0    1 # Rec-W
6      1.2         0.5        10      4    0    0.0625
6      0.5         0          2       3    0    1 # Comm-E
6      1.2         0.5        10      4    0    0.0625
6      0.7         0          2       3    0    1 # Comm-W
6      1.7         0.5        10      4    0    0.0625
15     0           -1         10      -3   0    0.0625 #Shrimp
15     0.01        0          2       -4   0    1
15     2.1         -1         10      -3   0    0.0625
15     0.2         0          2       -4   0    1
15     0.99592986  0          1       -4   0    1
6      0.7         0          2       -3   0    0.0625 #Larval
6      8           0          10      -4   0    1
15     0           -1         10      -3   0    0.0625 #Trawl
15     0.01        0          2       -4   0    1
15     2.1         -1         10      -3   0    0.0625
15     0.2         0          2       -4   0    1
15     0.99592986  0          1       -4   0    1
6      0.5         0          2       -3   0    1 #Video
6      1           0.5        10      -4   0    0.0625
# catch observation error variance scalar
1      1           0.01       5       -1   0    1 # All others
1      2           0.01       5       -1   0    1 # Shrimp
# index observation error variance scalar
1      1.5         0.1        5       -1   0    1
# effort observation error variance scalar
1      1           0.1        5       -1   0    1
#==============================================================================
# Specifications 2: process ERROR parameters
#==============================================================================
#     best estimate (or central tendency of prior)
#       |       lower bound  upper bound
#       |       |            phase to estimate (<0 = don't estimate)
#       |       |       |       |       prior density (1=lognormal, 2=normal, 3=uniform)
#       |       |       |       |       |   prior variance
#       |       |       |       |       |       |
#------------------------------------------------------------------------------------------------------------------------
# overall variance (negative value indicates a CV)
```

```
        -0.2        -2     -0.01       3       0       1
# recruitment process variation parameters (allows year to year fluctuations)
#   correlation coefficient
           0    -1E-32      0.99      -1       0       1
#   variance scalar (multiplied by overall variance)
        0.15         0     1E+20      -1       0       1
#   annual deviation parameters (last entry is arbitrary for deviations)
           0        -5         5       4       1       1
# catchability process variation parameters (allows year to year fluctuations)
#   correlation coefficients
           0    -1E-32      0.99      -1       0       1       # Rec-E
           0    -1E-32      0.99      -1       0       1       # Rec-W
           0    -1E-32      0.99      -1       0       1       # Comm-E
           0    -1E-32      0.99      -1       0       1       # Comm-W
           0    -1E-32      0.99      -1       0       1       # Shrimp
           0    -1E-32      0.99      -1       0       1       # MRFSSE
           0    -1E-32      0.99      -1       0       1       # HBE
           0    -1E-32      0.99      -1       0       1       # HBW
           0    -1E-32      0.99      -1       0       1       # CmHLE
           0    -1E-32      0.99      -1       0       1       # CmHLW
           0    -1E-32      0.99      -1       0       1       # Larval
           0    -1E-32      0.99      -1       0       1       # Trawl
           0    -1E-32      0.99      -1       0       1       # Video
#   variance scalars (multiplied by overall variance)
           0    -1E-32     1E+20      -1       0       1       # Rec-E
           0    -1E-32     1E+20      -1       0       1       # Rec-W
           0    -1E-32     1E+20      -1       0       1       # Comm-E
           0    -1E-32     1E+20      -1       0       1       # Comm-W
           0    -1E-32     1E+20      -1       0       1       # Shrimp
           0    -1E-32     1E+20      -1       0       1       # MRFSSE
           0    -1E-32     1E+20      -1       0       1       # HBE
           0    -1E-32     1E+20      -1       0       1       # HBW
           0    -1E-32     1E+20      -1       0       1       # CmHLE
           0    -1E-32     1E+20      -1       0       1       # CmHLW
           0    -1E-32     1E+20      -1       0       1       # Larval
           0    -1E-32     1E+20      -1       0       1       # Trawl
           0    -1E-32     1E+20      -1       0       1       # Video
#   annual deviation parameters (last entry is arbitrary for deviations)
           0        -5         5      -1       0       1       # Rec-E
           0        -5         5      -1       0       1       # Rec-W
           0        -5         5      -1       0       1       # Comm-E
           0        -5         5      -1       0       1       # Comm-W
           0        -5         5      -1       0       1       # Shrimp
           0        -5         5      -1       0       1       # MRFSSE
           0        -5         5      -1       0       1       # HBE
           0        -5         5      -1       0       1       # HBW
           0        -5         5      -1       0       1       # CmHLE
           0        -5         5      -1       0       1       # CmHLW
           0        -5         5      -1       0       1       # Larval
           0        -5         5      -1       0       1       # Trawl
           0        -5         5      -1       0       1       # Video
# effort process variation parameters (allows year to year fluctuations)
#   correlation coefficients
         0.5         0      0.99      -1       0       1       # Rec-E
         0.5         0      0.99      -1       0       1       # Rec-W
```

	0.5	0	0.99	-1	0	1	# Comm-E
	0.5	0	0.99	-1	0	1	# Comm-W
	0.5	0	0.99	-1	0	1	# Shr
#	variance scalars (multiplied by overall variance)						
	0.223	0	1E+20	-1	0	1	# Rec-E
	0.223	0	1E+20	-1	0	1	# Rec-W
	0.223	0	1E+20	-1	0	1	# Comm-E
	0.223	0	1E+20	-1	0	1	# Comm-W
	0.0392	0	1E+20	-1	0	1	# Shr
#	annual deviation parameters (last entry is arbitrary for deviations)						
	0.0001	-5	5	2	1	1	# Rec-E
	0.0001	-5	5	2	1	1	# Rec-W
	0.0001	-5	5	2	1	1	# Comm-E
	0.0001	-5	5	2	1	1	# Comm-W
	0.0001	-5	5	2	1	1	# Shr

Appendix 3.

Gray Triggerfish Population Trajectory.

Year	SSB (trillion eggs)	Abundance (millions of fish)	Recruits (millions of fish)	F
1963	7.51	9.07	2.15	0.00
1964	7.46	9.07	2.15	0.01
1965	7.33	8.98	2.15	0.03
1966	7.11	8.83	2.14	0.04
1967	6.83	8.63	2.14	0.06
1968	6.51	8.41	2.14	0.07
1969	6.15	8.16	2.14	0.09
1970	5.77	7.91	2.13	0.10
1971	5.39	7.66	2.13	0.11
1972	5.01	7.40	2.12	0.13
1973	4.64	7.16	2.11	0.14
1974	4.30	6.92	2.11	0.16
1975	3.98	6.70	2.10	0.17
1976	3.69	6.48	2.09	0.19
1977	3.42	6.27	2.08	0.20
1978	3.18	6.08	2.07	0.22
1979	2.96	5.89	2.06	0.23
1980	2.76	5.72	2.05	0.24
1981	2.59	5.64	2.13	0.26
1982	2.24	5.36	1.94	0.49
1983	1.89	4.95	2.10	0.52
1984	1.77	5.19	2.47	0.60
1985	1.80	5.72	2.73	0.55
1986	1.92	6.24	2.89	0.40
1987	2.11	6.92	3.22	0.39
1988	2.28	7.44	3.35	0.38
1989	2.40	7.63	3.27	0.39
1990	2.53	8.01	3.55	0.39
1991	2.67	8.57	3.97	0.43
1992	2.58	8.10	3.28	0.52
1993	2.24	6.82	2.57	0.57
1994	2.01	6.14	2.50	0.55
1995	1.71	5.28	2.07	0.66
1996	1.47	4.56	1.93	0.62
1997	1.31	4.10	1.77	0.53
1998	1.18	3.58	1.46	0.47
1999	1.18	3.58	1.66	0.39
2000	1.33	4.26	2.21	0.37
2001	1.58	5.43	2.98	0.40
2002	1.59	5.17	2.12	0.41
2003	1.47	4.55	1.78	0.43
2004	1.35	3.96	1.49	0.43