View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by IssueLab

Economic Costs of Historic Overfishing on Recreational Fisheries: South Atlantic & Gulf of Mexico Regions

Report to The Pew Charitable Trusts

Taylor Hesselgrave
Kristen Sheeran, Ph.D.

26 July 2012

ecotrust

For questions or comments, please contact Dr. Kristen Sheeran at
Ecotrust
721 NW Ninth Ave., Suite 200
Portland, OR 97209
503-467-0811
ksheeran@ecotrust.org

EXECUTIVE SUMMARY

Ocean fish are a vital renewable resource for human populations, providing food, employment, and recreation. Many fish stocks worldwide, however, are in a state of serious decline due to overfishing, environmental degradation, climate change, and other stressors. Fishing effort worldwide has remained relatively constant with only slight increases recorded, while the global production of marine fisheries has decreased (Food and Agriculture Organization of the United Nations, 2010).

The South Atlantic and Gulf of Mexico regions of the United States have witnessed significant declines in fish stocks that are important to recreational and commercial fisheries. As of 2011, nine fish populations across the two regions were officially classified as “overfished.” An additional 12 populations were classified as “subject to overfishing.” Biological overfishing occurs when harvest rates from fishing exceed the growth rates of fish stocks. The resulting declines in fish populations can impact the economy at large.

This study examines an important component of the costs of overfishing in the South Atlantic and Gulf of Mexico regions — recreational catch losses from historic overfishing and their associated economic impacts. Our analysis covers nine federally managed overfished stocks in these two regions over the period 2005–2009, the most recent years for which the necessary data were available prior to the 2010 Deepwater Horizon oil spill in the Gulf. Those stocks are black sea bass, red grouper, red porgy, red snapper, and snowy grouper in the South Atlantic; and gag, gray triggerfish, greater amberjack, and red snapper in the Gulf of Mexico.

Recreational fishing has long been an important economic activity in these regions. The money spent by recreational fishermen on charter fishing excursions, tackle, bait, fuel, and other expenses supports employment and economic activity across those regions. Our analysis assumes that recreational fisheries could have contributed more to regional economic activity had the stocks been capable of producing greater yields over the study period of 2005–2009. We estimate the size of the recreational catch loss for each species for each year and the economic activity that could have resulted had that catch been available.

To arrive at our estimates of recreational catch loss, we compared average annual recreational harvests and effort for each stock for each year over the study period to potential estimated harvests and effort had the stocks been producing at optimum yield. We sourced our measures of optimum yield and maximum sustainable yield for each individual stock from regional stock assessments and fishery management plans. We valued the resulting catch loss by using data on trip expenditures by recreational fishermen in the South Atlantic and Gulf of Mexico. Effort and expenditure data were sourced from the Marine Recreational Fisheries Statistics Survey and includes trips that caught, targeted, or caught and/or targeted the stocks in our analysis.[1] Economic multipliers were used to estimate the total direct, indirect, and induced economic activity that could have been generated by those recreational fishing expenditures. Our estimates of catch loss and associated economic impacts are not additive across stocks since trips and their respective expenditures may be associated with multiple stocks.

Our analysis finds that recreational fisheries in the South Atlantic and Gulf of Mexico could have contributed millions of dollars more in additional recreational expenditures and associated economic activity had the fish species been producing at optimum yield over the study period. The greatest direct losses were associated with South Atlantic black sea bass and South Atlantic red snapper. Recreational fishermen in the South Atlantic spent $41.7 million on average annually to realize 44% of the total recreational catch that could have been available had the fish population been producing optimally. We estimate that recreational expenditures on South Atlantic black sea bass could have been $52.8 million greater each year over the five-year study period had the stock been producing at optimum yield. An additional $52.8 million in recreational expenditures each year could have generated an additional $138 million in economic output and $40.3 million in income, and supported 896 jobs annually for the region.

[1] We used the MRFSS because complete data from the more recent Marine Recreational Information Program (MRIP) database were not yet available at the time of this study.

In the case of South Atlantic red snapper, fishermen spent $9.2 million on average annually over the study period to catch 37% of the recreational catch that could have been available under optimum yield. We estimate that recreational expenditures on South Atlantic red snapper could have been $15.9 million greater each year and could have contributed an additional $41.6 million in economic output and $12.2 million in income, and supported 270 jobs for the region annually between 2005–2009.

In the Gulf region, the greatest losses were associated with red snapper, where recreational fishermen spent $22.4 million to realize 64% of the optimal catch that could have been available. We estimate that recreational expenditures on Gulf red snapper could have been $12.7 million greater each year had the stock been producing at optimum yield. An additional $12.7 million in recreational expenditures each year could have generated an additional $33.2 million in economic output and $9.7 million in income, and supported 215 jobs annually for the region.

Our findings support the conclusion that overfished stocks can lead to significant economic losses for regional economies through forgone recreational fishing expenditures. This is only one component of the cost of overfishing. Our analysis does not estimate the value of catch losses in commercial fisheries or the broader impacts on ecosystems and biodiversity. The total value of catch losses resulting from historic overfishing would be greater still if other impacts had been considered. Despite these limitations, this study provides strong economic evidence in support of maintaining healthy ocean fish populations and continuing efforts to rebuild stocks currently subject to overfishing or classified as overfished.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ABC	acceptable biological catch
ACL	annual catch limit
CPUE	catch per unit of effort
EEZ	exclusive economic zone
FSSI	Fish Stock Sustainability Index
GCG	Gentner Consulting Group
GMFMC	Gulf of Mexico Fishery Management Council
gw	gutted weight
HPUE	harvest per unit of effort
IFQ	individual fishing quota
MAFMC	Mid-Atlantic Fishery Management Council
MRFSS	Marine Recreational Fisheries Statistics Survey
MRIP	Marine Recreational Information Program
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OFL	overfishing level
OY	optimum yield
SAFMC	South Atlantic Fishery Management Council
SEDAR	SouthEast Data, Assessment, and Review
SEFSC	Southeast Fishery Science Center
SERO	Southeast Regional Office
SPR	spawning potential ratio
SSB	spawning stock biomass
SSC	Scientific and Statistical Committee
ww	whole weight

1. INTRODUCTION

Fish stocks are a vital resource to human populations. They are a renewable resource capable of sustaining ecological, livelihood, and recreational benefits if properly managed and supported.

In recent years, however, overfishing, climate change, shifts in land-use patterns, population growth, and other stressors have contributed to declines in fish stocks worldwide. Fishing efforts globally have remained relatively constant with only slight increases recorded, while the global production of marine fisheries has declined (Food and Agriculture Organization of the United Nations [FAO], 2010). As many experts have warned, the world is now witnessing the most crucial period in the history of fisheries, with so many species in a state of decline and threatened with extinction (Srinivasan *et al.,* 2010, citing Grainger and Garcia, 1996; Pauly *et al.*, 2002; Myers and Worm, 2003; Millennium Ecosystem Assessment, 2005; Lotze *et al.*, 2006; Worm *et al.*, 2006).

Biological overfishing, the standard definition of overfishing, occurs when fishing depletes stocks faster than they can reproduce. Catch levels that exceed sustainable harvest rates can yield higher returns in the short-term, but they eventually result in biologically overfished stocks with biomass levels below key biological thresholds. At worst, overfishing can lead to species extinction. In the meantime, however, human populations may experience consistent, substantial losses in subsistence catch and commercial landings, as well as lost recreational opportunities. Healthy fish stocks that have not been subject to overfishing, or have been replenished after years of overfishing, can provide abundant food, commercial landings, and recreational opportunities for the long-term.

If overfishing results in decreased recreational fishing opportunities, the economic consequences can be significant. Marine recreational fishing is a vital economic activity, particularly for coastal economies. In 2009, approximately 11 million recreational fishermen took 74 million saltwater fishing trips across the United States (National Oceanic and Atmospheric Administration [NOAA], 2010). It is estimated that these fishermen spent $4.5 billion on fishing trips and $15 billion on durable fishing-related equipment (NOAA, 2010). These expenditures likely contributed an additional $50 billion in sales impacts to the U.S. economy and $23 billion in value-added impacts, and supported more than 327,000 job impacts (NOAA, 2010a).

Expenditures on recreational fishing touch many sectors of the economy, including many not directly related to fishing activities. Recreational fishermen spend money on charter fees, bait and tackle, licenses, fuel and other equipment; but they also make purchases related to dining, lodging, transportation, and other retail. These businesses, in turn, hire labor and other inputs to meet the demands of recreational fishermen. Workers paid by the businesses that are directly or indirectly supported by recreational fishing expenditures spend a portion of their income on other goods and services in the economy. Recreational fishing, therefore, generates economic activity above and beyond the level of direct expenditures on fishing.

Recreational fishing has long been important to the Gulf of Mexico and South Atlantic regions. Many recreationally important species in these regions, however, are in a state of decline, classified as “overfished” or “subject to overfishing.” These stocks could have contributed more to regional economic activity had they been capable of sustaining greater yields. Unrealized opportunities for recreational fishing and forgone related economic activity account for some of the costs of overfishing in these regions.

This study examines recreational catch losses from historic overfishing and their associated economic impacts in the South Atlantic and Gulf of Mexico. We measure recreational catch loss as recreational trip expenditures that could have occurred had more fish been available to have been caught and/or targeted in a study fishery. We estimate the recreational catch loss for each species for each year and the economic activity that could have resulted had that catch been available.

Our analysis covers nine federally managed overfished stocks in these two regions over the period 2005–2009, the most recent years for which the necessary data were available prior to the 2010 Deepwater Horizon oil spill in the Gulf. Those stocks are black sea bass, red grouper, red porgy, red snapper, and snowy grouper in the South Atlantic; and gag, gray triggerfish, greater amberjack, and red snapper in the Gulf of Mexico.

Our analysis compares average annual recreational harvests and effort for each stock for each year over the study period to estimated potential harvests and effort had the stock been producing at optimum yield. We source our measures of optimum yield and maximum sustainable yield for each individual stock from regional stock assessments and fishery management plans. We value catch loss by using data on trip expenditures by recreational fishermen in the South Atlantic and Gulf of Mexico. These data, which come from the MRFSS, include trips that caught, targeted, or caught and/or targeted the stocks in our analysis.

NOAA has conducted the MRFSS since 1979; it is a national survey of recreational fishermen designed to generate a reliable database for estimating the impact of recreational fishing on marine resources. In recent years, NOAA updated, improved, and replaced the MRFSS with the Marine Recreational Information Program (MRIP). However, directed effort estimates from MRIP were still under development and unavailable at the time of this study, and our analysis thus uses the MRFSS database.

Economic multipliers are used to estimate the total direct, indirect, and induced economic activity that could have been generated by those recreational fishing expenditures. Estimates of catch loss and associated economic impacts are not additive across stocks since trips and their respective expenditures may be associated with multiple stocks.

2. PROJECT OVERVIEW

2.1. Methods

This study estimates recreational catch losses and associated economic impacts for nine federally managed overfished stocks in the South Atlantic and Gulf of Mexico regions. Our analysis covers the period from 2005–2009, the most recent years that complete data were available prior to the Deepwater Horizon oil spill in the Gulf in 2010. Though data were available for 2010 for some stocks, the year was decidedly anomalous because of the unknown effects of the oil spill, and it was excluded from the analysis. Unless otherwise noted, all monetary values are presented in 2010 dollars and pounds are quoted in whole weight (ww) values.

We define recreational catch loss as recreational trip expenditures that could have occurred had more fish been available to have been caught and/or targeted in a study fishery. We first estimate the size of the potential recreational catch had the stock not been overfished. We value the catch loss in dollars and project the additional economic activity that recreational catch could potentially have generated.

Valuing catch losses in recreational fisheries is more complicated than valuing catch losses in commercial fisheries. In commercial fisheries, catch loss can be valued directly using ex-vessel prices (Hesselgrave *et al.,* 2011). There is no direct market price, however, to value catch loss in recreational fisheries.

The value of recreational fishing is a function of the pleasure or satisfaction recreational fishermen derive from their activity. Economists typically use non-market valuation techniques, such as contingent valuation, to estimate this type of non-market value. Contingent valuation relies on surveys to elicit from respondents the amount they would theoretically be willing to pay for an incremental change in an activity — for example, how much a fisherman would be willing to pay to catch an additional fish or to take an additional fishing trip. Willingness to pay captures the incremental value individuals place on a given resource or activity, and it can be used as a proxy for market price. The results of willingness-to-pay surveys are generally highly dependent on survey design; the method requires careful survey design and extensive sampling to ensure reliable data collection.

In this analysis, we use an expenditure based approach to value recreational catch losses. Expenditures tell us how much individual fishermen spent, not what they theoretically would have been willing to spend, on recreational fishing. When actual expenditures are used, the direct, indirect, and induced economic activity related to those expenditures can be determined through the use of economic multipliers. This allows us to determine how a decline in recreational fishing opportunity affects businesses and communities across the supply chain.

As expenditures on recreational fishing decline, so too may expenditures by businesses that supply the recreational fishing industry. For example, charter boat operators may hire fewer crew members and purchase less fuel and equipment. Stores that rent or sell fishing equipment may stock fewer supplies. The combination of direct and indirect losses induces further economic impacts. Charter boat captains and their crew members have less income to spend at local restaurants and shops. Shop and restaurant owners, in turn, decrease their demands for labor and supplies. As expenditures on recreational fishing decline, the impacts multiply throughout the economy.

2.2. Scope

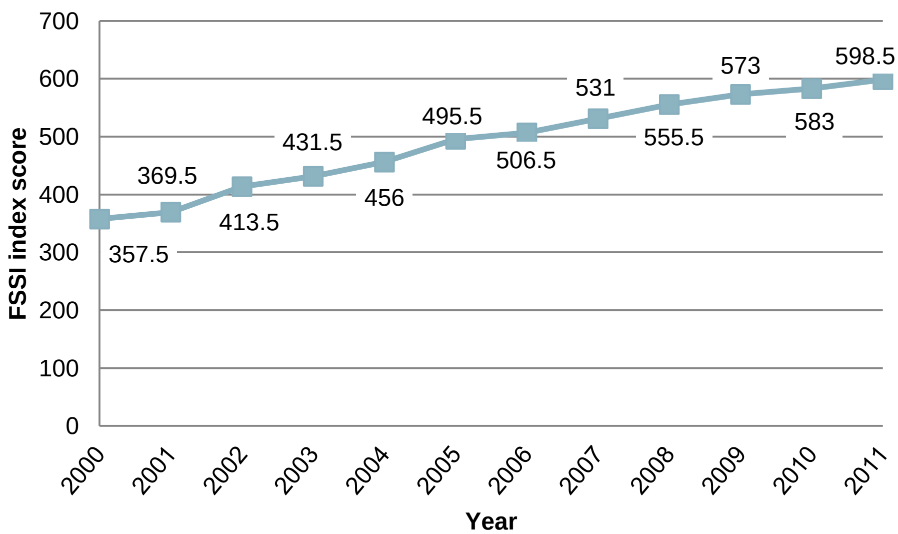
NOAA's National Marine Fisheries Service (NMFS) reviews more than 500 individual fish stocks and stock complexes and reports annually to Congress on the status of stocks. This is a requirement of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (Sec. 304[e][1]). Stock assessments are carried out often, although the frequency with which assessments occur varies by species. NMFS characterizes stocks as "unknown," "healthy," "subject to overfishing," or "overfished." A stock may be both "subject to overfishing" and "overfished" at the same time.

According to NMFS, a stock is subject to overfishing if its fishing mortality rate exceeds the level that provides for maximum sustainable yield (MSY). MSY is considered the largest average catch that can be taken from a stock on a continuing basis under prevailing environmental conditions without impairing its long-term productivity. NMFS defines a stock that is overfished as having a biomass level below the biological threshold specified in its fishery management plan. A fishery management plan is a set of science-based recommendations aimed at achieving specified management goals for a fishery. When a stock is classified as overfished, the MSA requires fishery managers to implement a plan to end overfishing and take actions to rebuild stocks.

NMFS measures progress in the management of national fisheries through the Fish Stock Sustainability Index (FSSI).The FSSI will increase if additional assessments are conducted, or if overfishing ends and stocks rebuild toward the level that provides MSY. The FSSI is comprised of 230 key U.S. fish stocks. Key stocks are selected for their importance to commercial and recreational fisheries. From 2000–2011, the index has increased approximately 67% (Figure 1).[2] The increase in the FSSI from 2010 to 2011 was primarily due to stocks with known statuses being classified as not subject to overfishing, not overfished, or rebuilt. The area of the FSSI with the greatest potential for growth is by increasing biomass levels for overfished stocks and stocks with low biomass levels.

[2] The maximum possible FSSI score is 920 points. The FSSI score reported in the last quarter update for 2011 was 598.5, which also explains the scoring methodology (NMFS, 2011). To reach the maximum score would require the stock to grow roughly another 54%; however, there are 298 additional stocks that currently are not considered in the FSSI. The statuses of these additional stocks are largely "not defined," "not applicable," or "unknown."

Figure 1. Fish Stock Sustainability Index scores, 2000–2011



Source: Adapted from NMFS 2011b and 2011c

In this study we targeted two of the eight fishery management council regions, the South Atlantic and the Gulf of Mexico. These regions are grappling with the effects of historic overfishing and are popular regions for recreational fishing. For this analysis, we considered only fish stocks classified as overfished in the fourth quarter assessment report for the NMFS Status of U.S. Fisheries, 2011(a). The one exception was South Atlantic black sea bass, which only recently was removed from the overfished list.

Table 1 lists the nine focus stocks included in our analysis by region and the first year in which they were officially listed as overfished in NOAA's annual Status of Stocks report to Congress, which should not be confused as the year stocks were actually overfished. The history and details of each stock are discussed further in Section 4. Most stocks approached overfished conditions by the mid-1970s, but were not formally classified as such until more recently.

Table 1. List of focus stocks for this study and original year of NOAA 'overfished' classification

South Atlantic	Scientific Name	Year
Black sea bass	*Centropristis striata*	2001
Red grouper	*Epinephelus morio*	2000
Red porgy	*Pagrus pagrus*	2000
Red snapper	*Lutjanus campechanus*	2000
Snowy grouper	*Epinephelus niveatus*	2000

Gulf of Mexico	Scientific Name	Year
Gag	*Mycteroperca microlepis*	2009
Gray triggerfish	*Balistes capriscus*	2008
Greater amberjack	*Seriola dumerili*	2001
Red snapper	*Lutjanus campechanus*	1988

Source: NMFS (2001,2002, 2009, 2010) and SouthEast Data, Assessment, and Review (SEDAR) (2009b)

Table 2 details the current status, management action required, and rebuilding program progress for each of the nine focus stocks as reported in the fourth quarter of NOAA's 2011 Status of the Stocks report (NMFS, 2011a). All overfished focus stocks, except for South Atlantic red porgy and South Atlantic black sea bass, were also classified as subject to overfishing.

For some stocks, such as South Atlantic red grouper, the fishery was listed as overfished in previous NOAA reports and later changed to unknown. This is because earlier definitions of overfished for some stocks were based on the spawning potential ratio (SPR), which was later deemed inadequate to determine overfished status. Such stocks maintained unknown status until a compliant biomass-based determination was made. In the case of South Atlantic red grouper, this was not until 10 years later, though the stock assessment indicates the stock had indeed been overfished for decades.

Table 2. NOAA fourth quarter 2011 status determination of focus stocks

South Atlantic stocks	Overfished	Overfishing	Management action required	Rebuilding program progress
Black sea bass[3]	–	X	Reduce mortality, continue rebuilding	Year 6 of 10-year plan
Red grouper	X	X	Reduce mortality, rebuilding program	n/a*
Red porgy	X	–	Continue rebuilding	Year 12 of 18-year plan
Red snapper	X	X	Reduce mortality, continue rebuilding	Year 1 of 35-year plan
Snowy grouper	X	X	Reduce mortality, continue rebuilding	Year 6 of 34-year plan

Gulf of Mexico stocks	Overfished	Overfishing	Management action required	Rebuilding program progress
Gag	X	X	Reduce mortality, rebuilding program	n/a**
Gray triggerfish	X	X	Reduce mortality, continue rebuilding	Year 4 of 6-year plan
Greater amberjack	X	X	Reduce mortality, continue rebuilding	Year 9 of 10-year plan
Red snapper	X	X	Reduce mortality, continue rebuilding	Year 11 of 32-year plan

** The South Atlantic Fishery Management Council (SAFMC) was notified by the Southeast Regional Office on June 9, 2010, that red grouper was being overfished. The SAFMC has two years from this date to implement a rebuilding plan for red grouper.*[4]

*** The Southeast Regional Office notified the Gulf of Mexico Fishery Management Council (GMFMC) on Aug. 11, 2009, that gag was being overfished. A rebuilding plan was expected to be implemented in late 2011/early 2012.*[5]

Source: NMFS, 2011a

Our list of focus stocks does not include all stocks classified as overfished or subject to overfishing in each region. In the South Atlantic region, pink shrimp are also classified as overfished; however, the stock is not included in the analysis because the pink shrimp fishery is strictly commercial.[6]

---

[3] In the fourth-quarter report, South Atlantic black sea bass was no longer classified as overfished, but as in rebuilding status.

[4] Since the NMFS publication of

Table 2, Amendment 24, detailing the South Atlantic red grouper rebuilding plan, has been sent to NMFS for final review and approval.

[5] Since the NMFS publication of

Table 2, Amendment 32, detailing the Gulf of Mexico gag rebuilding plan, has been approved by NMFS and was implemented March 12, 2012.

[6] The South Atlantic pink shrimp stock is officially considered an annual crop, eliminating the requirement of a rebuilding plan (NMFS, 2010b). The South Atlantic fishery management plan for shrimp states that with favorable environmental conditions, high fecundity enables pink shrimp to rebound from a very low population size to a high population size in a short period (SAFMC, 1996). The Shrimp Review Advisory Panel concluded that the parent stock was in decline, not because of overfishing but rather due to environmental and climatic factors (NMFS, 2010b). It would seem that if favorable environmental conditions keep the stock relatively impervious to crashing, then a decline due to environmental factors should require attention.

The South Atlantic black sea bass stock was classified as overfished in 2002, and remained so until the fourth quarter 2011 Status of U.S. Fisheries report, when it was reclassified as “subject to overfishing, continuing rebuilding efforts,” but no longer overfished. Four additional stocks in the South Atlantic are determined to be subject to overfishing but are not classified as overfished: gag, speckled hind, vermillion snapper, and Warsaw grouper.

Except for the stocks detailed in Table 1 and the aforementioned exceptions, there are no additional overfished populations in the targeted regions; however, there are several FSSI and non-FSSI stocks for which overfished status is either unknown or undefined in the South Atlantic and the Gulf of Mexico regions. For a detailed list of these unknown or undefined stocks, please see NMFS Status of U.S. Fisheries (2011a). In the six council regions and the Highly Migratory Species management division outside the scope of this study, an additional total of 36 FSSI and non-FSSI stocks are classified as overfished as reported in the fourth quarter of 2011.

3. REGIONAL OVERVIEW

In 1976, the MSA created eight regional fishery management councils to govern and manage fishery resources within the 200-mile federal limit of the ocean, called the exclusive economic zone (EEZ), adjacent to its constituent states. Councils develop fishery management plans and management measures for the fisheries within their EEZ. NMFS approves and implements these plans and measures.

This study focuses on two of these regions, the South Atlantic and the Gulf of Mexico. In this section we briefly describe each region and their respective fishery management councils and examine basic regional harvest trends, including recreational effort data as sourced from NMFS’ Fishery Statistics Division’s databases.[7]

Our descriptions of the South Atlantic and Gulf of Mexico fishery management councils are succinct; for a more detailed overview of the regional fishery management councils, please see the U.S. Regional Fishery Management Council (2012).[8]

3.1. The South Atlantic

The South Atlantic Fishery Management Council (SAFMC) manages the region off the coasts of North Carolina, South Carolina, Georgia, and eastern Florida. Voting SAFMC members include the NMFS regional director, the official responsible for marine fisheries management in each South Atlantic state, and appointed knowledgeable citizens (usually fishermen) from each of the South Atlantic states. Nonvoting members include representatives of the U.S. Fish and Wildlife Service, U.S. Coast Guard, Department of State, and Atlantic States Marine Fisheries Commission.

The council meets four times a year, once in each of the southeastern states. Before final action on any proposed rule change, the council involves the public through informal scoping meetings, sets public hearings and receives input at council meetings; it also receives expert reviews. Proposed rule changes are then sent to NMFS for further review, public comment, and approval by the secretary of commerce before being implemented. Each regional management council has a Scientific and Statistical Committee (SSC) responsible for reviewing the scientific basis of council management plans and actions and developing fishing-level recommendations in accordance with national fisheries management guidelines.

Commercial fisheries in the South Atlantic landed an average of 207.6 million pounds annually in the 30 years from 1981–2010. Landings declined steadily until a large drop in 1999, when a total of only 15.6 million pounds were landed, after which landings remained depressed.

Over roughly the same period, recreational harvests remained mostly consistent, averaging 37.2 million pounds annually. Since 2005, the weight of recreational harvests likely exceeded commercial landings. The level of

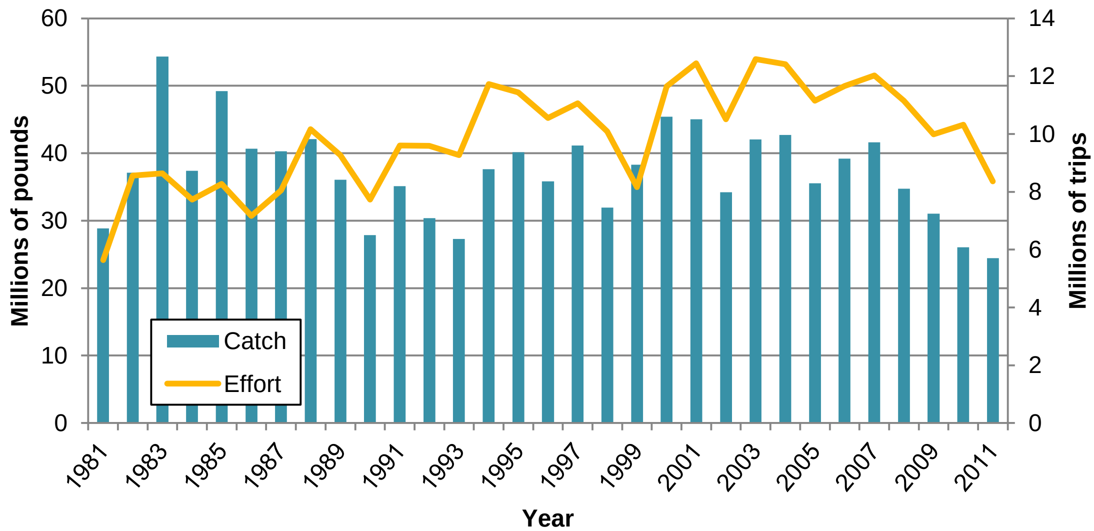
[7] Available online at http://www.st.nmfs.noaa.gov/st1/index.html.

[8] You can also visit its website at http://www.fisherycouncils.org.

recreational effort, defined as the number of trips taken, averaged approximately 9.9 million trips annually from 1981–2011; since 2000, 11.2 million trips were taken annually on average.

Figure 2 displays the total estimated ocean recreational catch and effort data for the South Atlantic from 1981–2011.[9] By comparing catch and effort levels, it is evident that recreational fishermen were no longer catching as much as they had, despite an overall increase in effort.

Figure 2. South Atlantic ocean recreational catch and effort, 1981–2011



Source: NMFS MRIP data[10]

3.2. The Gulf of Mexico

The Gulf of Mexico Fishery Management Council (GMFMC) manages the Gulf of Mexico region off the coasts of Texas, Louisiana, Mississippi, Alabama, and western Florida. Voting members include the regional NMFS administrator, the directors of the five Gulf state marine resource management agencies, and 11 appointed members who are nominated by the state governors and appointed by the secretary of commerce. Nonvoting members include representative from the U.S. Coast Guard, U.S. Fish and Wildlife Service, Department of State, and the Gulf States Marine Fisheries Commission.

The council meets five times a year at locations around the Gulf Coast. Before taking final action on any proposed rule change, public hearings are held throughout the region and include expert reviews. Proposed rule changes are then submitted to NMFS for further review and approval before implementation. It also has a Scientific and Statistical Committee (SSC) responsible for reviewing the scientific basis of council management plans and actions and developing fishing-level recommendations in accordance with national fisheries management guidelines.

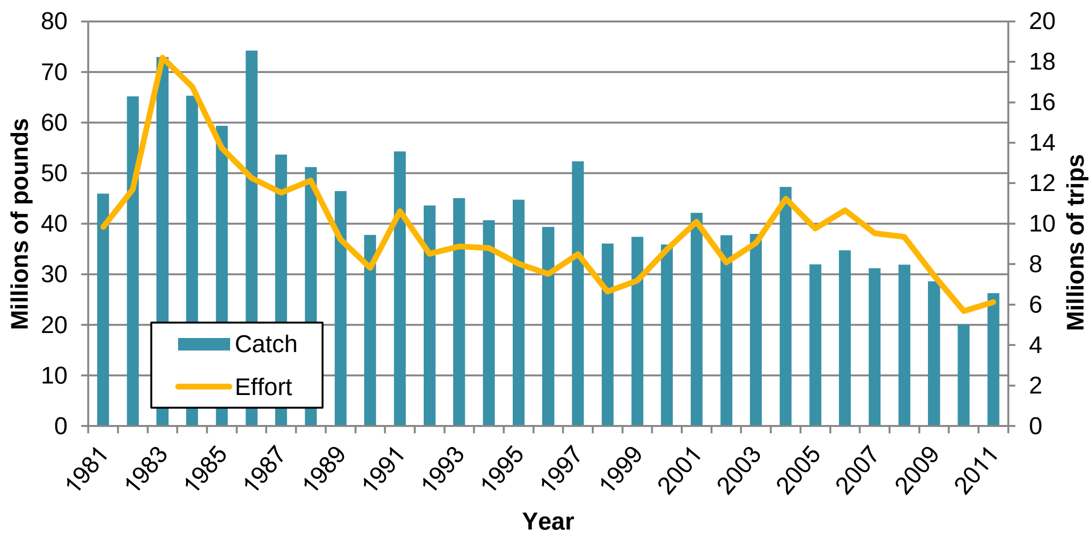
Commercial fisheries in the Gulf of Mexico landed an average of 1.8 billion pounds annually in the 30 years from 1981–2010. After landings reached their maximum level of 2.6 billion pounds in 1984, landings declined steadily. In 2010, a total of 1.3 billion pounds was landed.

[9] Ocean" refers to the State Territorial Sea (s a zone extending three nautical miles from shore for all states except for the Gulf coast of Florida where the seaward boundary is three marine leagues) and Federal EEZ and does not include inland saltwater or brackish water bodies.

[10] Our analysis sourced effort and expenditure estimates from the MRFSS dataset as complete stock-specific MRIP data were not available at the time of this study. However, the regional effort estimates presented in this figure are based off the new MRIP as the NMFS online database (http://www.st.nmfs.noaa.gov/st1/index.html) no longer queries from the MRFSS. Using the MRIP for this figure, which serves only to give context to historical trends in the region, does not affect our MRFSS-based analysis.

Over roughly the same time period, 1981–2011, recreational harvests followed similar trends and averaged 44.2 million pounds annually. Recreational effort levels averaged 9.8 million trips annually from 1981–2011; since 2000, 8.9 million trips were taken annually on average. Figure 3 displays the total estimated ocean recreational catch and effort data for the Gulf of Mexico for the years 1981–2011. Both catch and effort levels have declined over the time period.

Figure 3. Gulf of Mexico ocean recreational catch and effort, 1981–2011



Source: NMFS MRIP data[11]

4. FOCUS STOCKS

This section presents a brief biological description, summary of assessment and management history, and a glance at recent recreational harvest data over the period 2000–2010 for each of the nine focus stocks in this study.[12] This information was sourced from each species' individual stock assessment, its council's management plans, and NOAA's FishWatch.[13]

The SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and U.S. Caribbean. The process produces the stock assessments and update assessments that provided much of the background and data necessary to complete our study. For a more detailed description of the SEDAR process, see Appendix A

Stock assessments are publicly accessible through the SEDAR website.[14] Many stocks may have been initially assessed or managed through a grouped species management plan; those plans are not discussed thoroughly in the following summaries but are available on the regional council websites. For more detailed information regarding assessments, regulations, or landings and harvest history for any stock, please reference that stock's assessment and fishery management plan.

---

[11] *Ibid*.

[12] Catch and effort data for 2010 were included in the Gulf even though the Deepwater Horizon disaster occurred, affecting the northern Gulf for much of the fishing season. However, 2010 data were included because they were available and the effect on fisheries is not yet known.

[13] FishWatch is a website providing "easy-to-understand science-based facts to help consumers make smart sustainable seafood choices"; available online at http://www.fishwatch.gov.

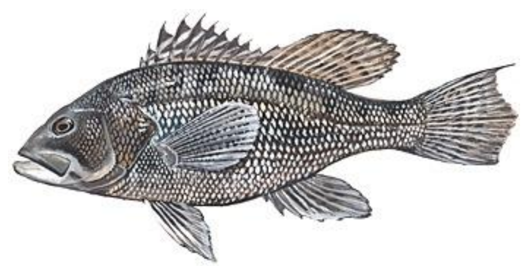
[14] Available online at http://www.sefsc.noaa.gov.

As data allow, we provide measures of biomass and recreational harvest. The following definitions are relevant to the biomass figures presented below:

- **MSY:** Maximum sustainable yield, the largest average catch that can be taken from a stock on a continuing basis under prevailing environmental conditions without impairing its long-term productivity.
- **F:** The fishing mortality rate, the rate at which fish are removed from the stock by harvesting.
- **F_{MSY}:** The F expected to achieve MSY under equilibrium conditions.
- **Biomass:** The total weight or volume of a species in a given area.
- **B_{MSY}:** The biomass of fish expected to exist under equilibrium conditions when fishing at F_{MSY}.
- **SSB:** Spawning stock biomass, the total weight or volume of all sexually mature fish in a population.
- **SSB_{MSY}:** The size SSB that will produce the MSY.

Images of the species were sourced from the SAFMC website.[15]

4.1. South Atlantic Black Sea Bass



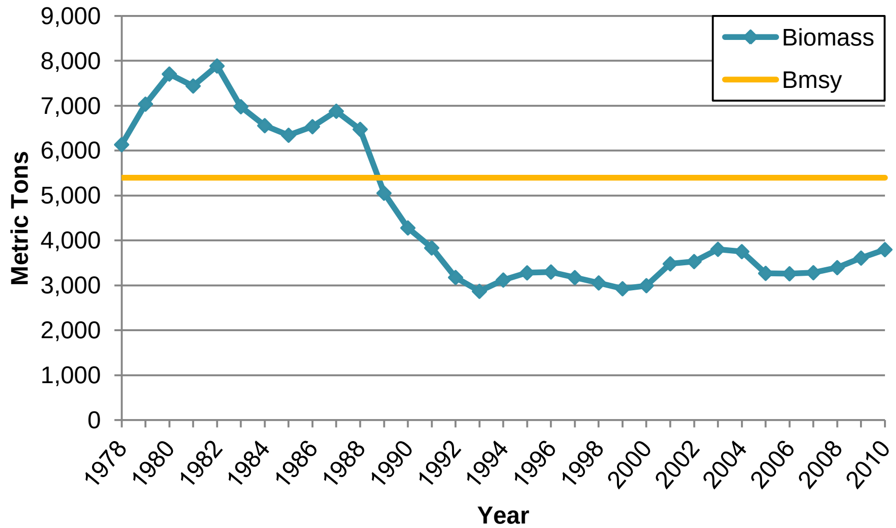
Black sea bass occur along the East Coast from Cape Cod in Massachusetts to the Gulf of Mexico. Black sea bass range from brown to black, with white spotting on the dorsal fins. They prefer structured, hard-bottom habitats such as reefs, wrecks, or oyster beds and are mostly found in depths of 50–200 feet. Black sea bass are opportunistic feeders, eating whatever is available, but prefer crabs, shrimp, worms, small fish, and clams. Black sea bass are protogynous hermaphrodites (i.e., they change from female to male) and primarily spawn from January through July.

In the United States, there are two stocks of black sea bass, managed respectively by the Mid-Atlantic Fishery Management Council (MAFMC) and the South Atlantic council. Figure 4 displays the South Atlantic stock's target biomass from a 2011 assessment, SEDAR 25, and the estimated stock biomass over time. Before the SEDAR process, the South Atlantic stock of black sea bass was first assessed by Vaughan *et al.* (1995), who concluded that overfishing had been occurring during the 1980s. Vaughan *et al.* (1996) estimated that the rate of overfishing had increased during the 1990s.

This stock's first assessment through the SEDAR process, in 2002, confirmed Vaughan *et al.*'s (1995, 1996) findings. That assessment was updated in 2005 (SEDAR, 2005a) after finding that the rate of overfishing continued to increase into the 2000s and that the stock remained overfished. A second 10-year rebuilding plan for South Atlantic black sea bass was implemented in 2006 by SAFMC Amendment 15A (2007). SAFMC Amendment 17B (2010b) established strict commercial and recreational annual catch limits (ACLs) for South Atlantic black sea bass at a combined total of 718,000 pounds gutted weight (gw). The latest SEDAR assessment was completed in 2011 and classified the stock as no longer overfished but still undergoing overfishing and not yet fully rebuilt (SEDAR, 2011a). For fishing years 2010-2011 and 2011-2012, the recreational ACLs were exceeded by 16% and 27%, respectively (NOAA, 2012).

[15] Available online at http://www.safmc.net.

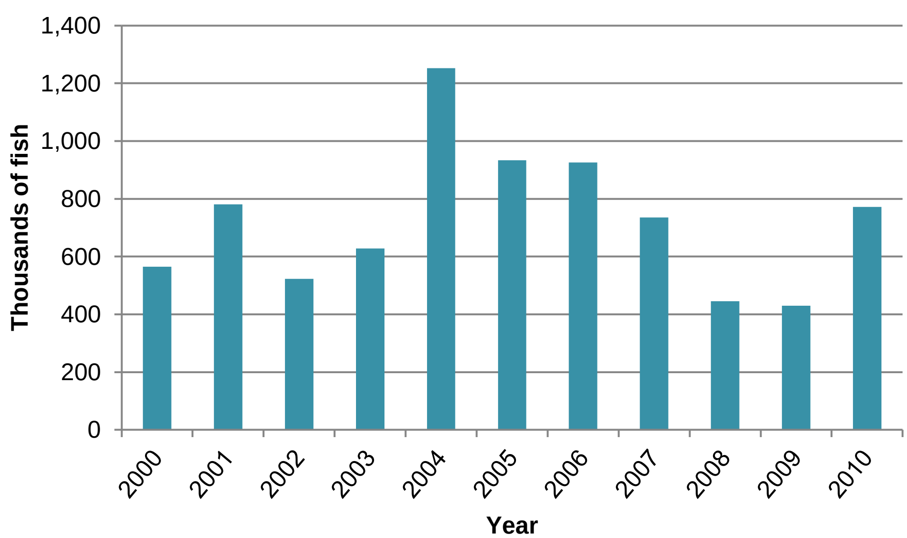
Figure 4. Biomass of South Atlantic black sea bass, 1978–2010



Source: SEDAR, 2011a

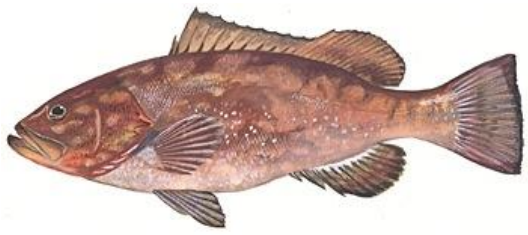
South Atlantic black sea bass is a popular commercial and recreational stock with allocations of 43% and 57%, respectively, of the total allowable catch (TAC) (SAFMC, 2006). The most common commercial gear has been traps (pots), with some fish taken by hand line. Historically, trawling for black sea bass was common, but it has been banned since 1989. Recreational fisheries use hook-and-line gear almost exclusively. At the time of this study, various restrictions were in place on this fishery, such as limited access, limited allowable sizes, and limited permissible gear. Figure 5 depicts recent recreational harvests of South Atlantic black sea bass as provided by request from NOAA's Southeast Regional Office (SERO).

Figure 5. Recent recreational harvest of South Atlantic black sea bass, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

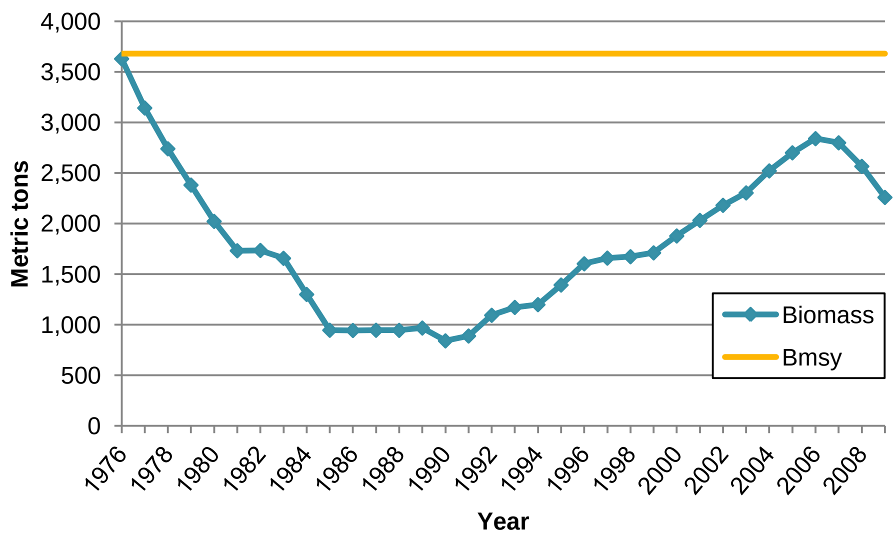
4.2. South Atlantic Red Grouper



Red grouper are found in the western Atlantic from Massachusetts through the Gulf of Mexico to as far south as Brazil. Red grouper, a deep-brownish-red fish with white spots on the sides, is a shallow-water grouper that moves offshore from shallower reef environments as it matures, most often found at depths of 80–400 feet. The red grouper is an opportunistic feeder and a top predator in the reef community, preferring crabs, shrimp, lobster, octopus, squid, and other fish that live close to reefs. Red grouper are also protogynous hermaphrodites. Their spawning season is from February through June, and they spawn frequently — close to 26 times a year. Coleman *et al.* (2010) of Florida State University recently discovered that red grouper help enhance biodiversity where they are found by creating and maintaining structural habitat for other marine life.

In the United States, red grouper stocks are managed by the South Atlantic and Gulf of Mexico fishery management councils. South Atlantic red grouper were examined in a trends report (Potts and Brennan, 2001), which estimated possible proxies for F_{MSY} and concluded that overfishing may be occurring. The South Atlantic red grouper stock was first formally assessed by the SEDAR process in SEDAR 19 (2010a), and in June 2010 it was officially classified as overfished. Figure 6 displays this stock's biomass over time; the B_{MSY} indicates that the stock has seriously declined since the mid-1970s. SAFMC Amendment 24 (2011a), under secretarial review at the time of this study, proposes measures to end overfishing and would establish a rebuilding plan for red grouper. The proposed 2012 recreational ACL for South Atlantic red grouper is 362,320 pounds (SAFMC, 2011a).

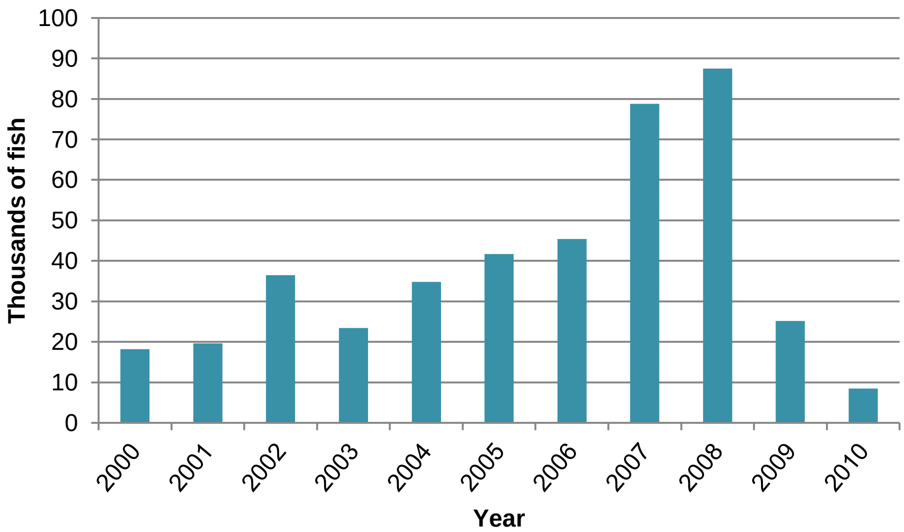
Figure 6. Biomass of South Atlantic red grouper, 1976–2009



Source: SEDAR, 2010a

The current allocation of South Atlantic red grouper between commercial and recreational fisheries is 44% and 56%, respectively (SAFMC, 2011a). Commercial and recreational fishermen mainly use hook-and-line gear to harvest red grouper. This stock's fishery management plan has implemented several limitations including gear restrictions and prohibitions, site closures, seasonal and other special closures, limited permitting, annual catch limits, and size limits. Figure 7 displays recent recreational harvests of South Atlantic red grouper as provided by SERO.

Figure 7. Recent recreational harvest of South Atlantic red grouper, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

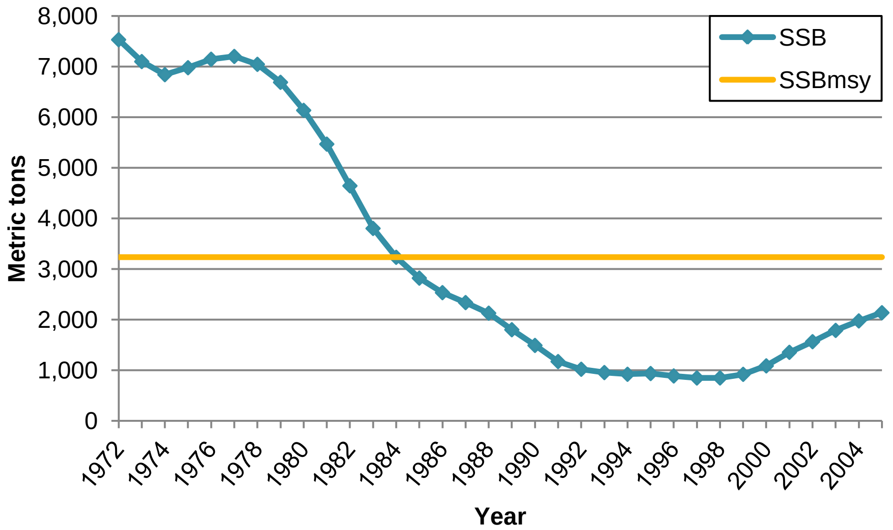
4.3. South Atlantic Red Porgy

Red porgy, a fish reddish on top, silvery-white on bottom, and highlighted by rows of small blue spots along the upper body, have an extensive range in warm waters of the Atlantic Ocean and adjacent seas from North American, South American, European, and African Atlantic coasts. Red porgy inhabit natural reefs, mainly in depths of 120–200 feet. They are bottom feeders consuming mostly snails, crabs, and sea urchins. Red porgy are also protogynous hermaphrodites, and their peak spawning period occurs in March and April.

In the United States, this species is managed by the SAFMC. Figure 8 displays the SSB and the target SSB, SSB_{MSY}, for South Atlantic red porgy. The SSB dropped below the SSB_{MSY} in 1984, and as of the most recent stock assessment (SEDAR, 2006a), had not yet recovered. Two original assessments of red porgy occurred in 1992, which first noted a decline in population beginning in the late 1970s (Vaughan *et al.*) and then noted a dramatic increase in exploitation of the stock and a simultaneous decline in abundance (Vaughan and Prager).

The very first assessment under the SEDAR process was of South Atlantic red porgy (SEDAR, 2001). That assessment found that the stock was officially overfished but that overfishing was no longer occurring. The council has undertaken a variety of management measures, such as size and harvest limitations, gear restrictions, and even a landings moratorium from fall 1999 to fall 2000. South Atlantic red porgy are currently in Year 12 of an 18-year rebuilding plan and have a total annual catch limit of 395,304 pounds (SAFMC, 2011b).

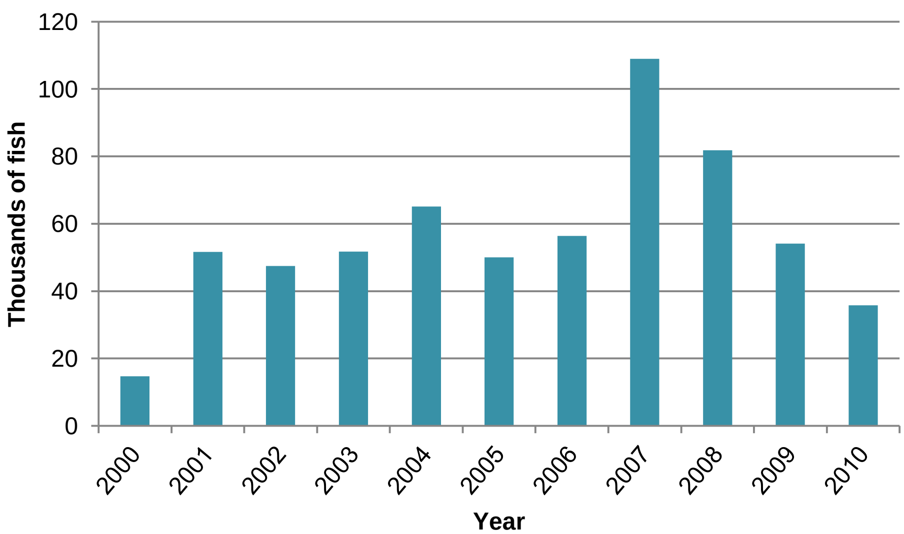
Figure 8. Spawning stock biomass of South Atlantic red porgy, 1972–2005



Source: SEDAR, 2006a

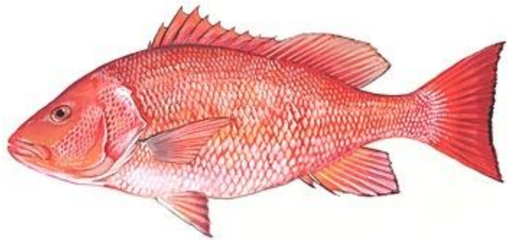
The current commercial and recreational allocation of this fishery is an even 50% each (SAFMC, 2008). The most common gear used to target red porgy has been hook and line for both commercial and recreational sectors. Occasional trawl and trap gear was used commercially, though trawling for red porgy has been banned since 1989. Figure 9 displays recent recreational harvests of South Atlantic red porgy.

Figure 9. Recent recreational harvest of South Atlantic red porgy, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

4.4. South Atlantic Red Snapper

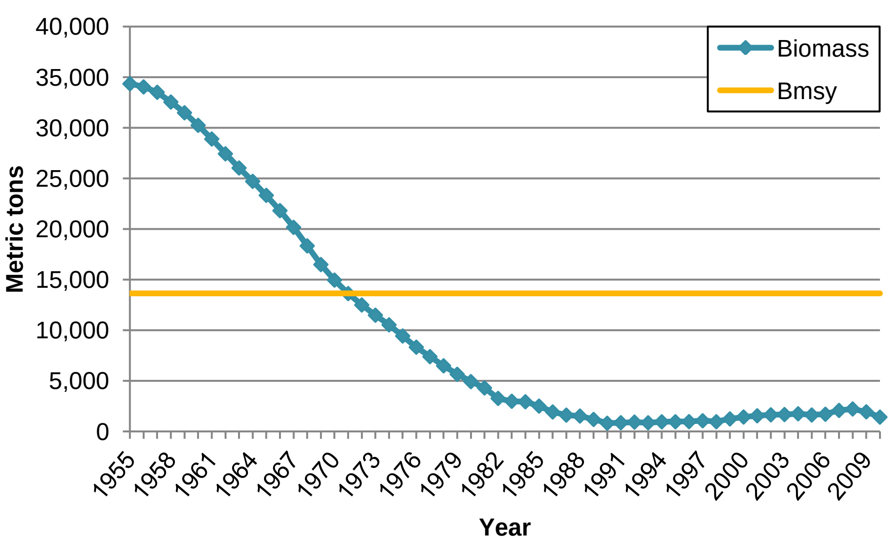


The red snapper is a red fish with enlarged “snapping” teeth and is generally found at depths from 30–620 feet along the eastern coast of North, Central, and northern South America and in the Gulf of Mexico. Young red snapper live in shallow sandy- or muddy-bottom habitat, while adults live on the bottom near hard structures such as reefs, ledges, and caves. Red snapper feed on fish, shrimp, crab, worms, cephalopods (octopus, squid, etc.), and some plankton. The red snapper’s spawning season spans May to October, and the oldest red snapper on record was 57 years old.

In the United States, red snapper is a popular fishery in both the South Atlantic and Gulf of Mexico regions, and the two management councils manage their respective red snapper stock. Figure 10 displays the biomass estimates of the South Atlantic red snapper stock over time, along with the stock’s target biomass, B_{MSY}. Overall biomass fell below B_{MSY} decades ago in the 1970s. The first formal assessment of red snapper in the U.S. Atlantic was conducted by Manooch *et al.* (1998) and then by Potts and Brennan (2001). Both suggested a sizable reduction in the stock’s fishing mortality rate.

This stock of red snapper was first assessed through the SEDAR process in 2007. The assessment found that since the 1960s, overfishing had been occurring and that the stock had been overfished (SEDAR, 2008). The management council set a variety of restrictions on the fishery, including area closures, through various amendments and through an interim rule that temporarily prohibited harvest altogether. The stock was assessed again through SEDAR in 2010. Shortly thereafter, the SAFMC extended the prohibition of both commercial and recreational harvest of South Atlantic red snapper from federal waters (SAFMC, 2010a). In other words, the current recreational ACL is effectively set at zero pounds. The South Atlantic red snapper stock is currently at the beginning of a 35-year rebuilding plan.

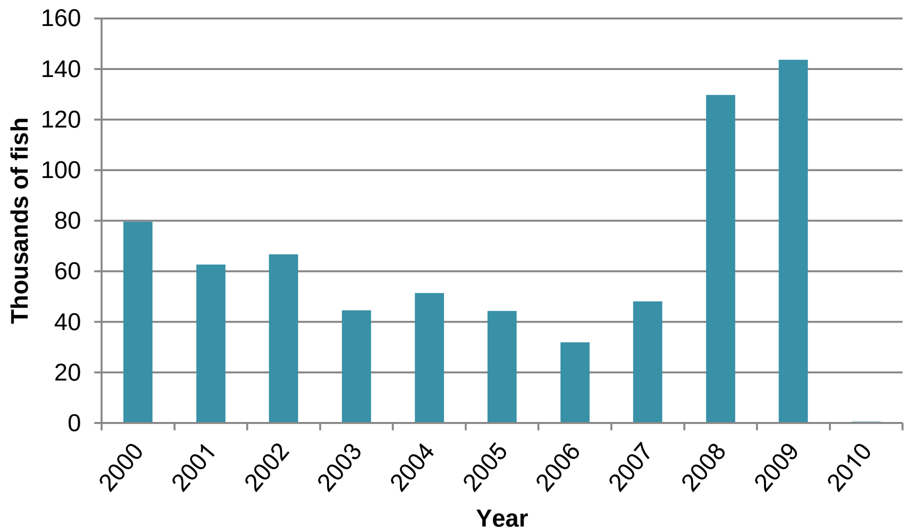
Figure 10. Biomass of South Atlantic red snapper, 1955–2010



Source: SEDAR, 2010b

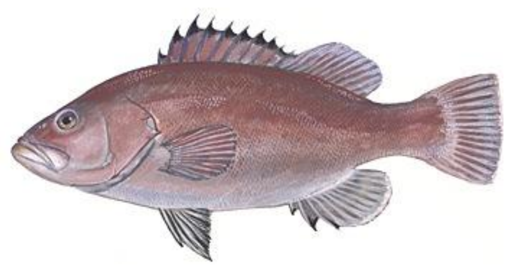
An allocation of South Atlantic red snapper between the commercial and recreational sector was recently set in the SAFMC's (2011b) Comprehensive Annual Catch Limit Amendment for the region at 28% and 72%, respectively. Hook-and-line gear is the primary gear type used to target this fishery. Figure 11, displaying recent South Atlantic red snapper recreational harvest, reflects the prohibition enacted in 2010, when only about 500 fish were caught, which was still current at the time of this study.

Figure 11. Recent recreational harvest of South Atlantic red snapper, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

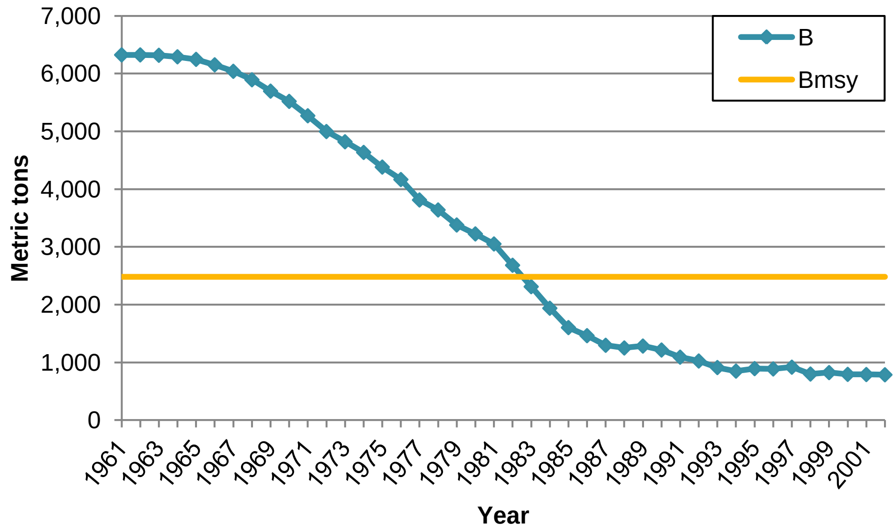
4.5. South Atlantic Snowy Grouper



Snowy grouper are dark brown, and the smaller fish have distinctive white spots and black markings that fade as they grow. They are a deep-dwelling grouper, found in depths of 380–800 feet generally along the outer continental shelf of the South Atlantic Bight, which is characterized by ridges, terraces, and precipitous cliffs. The species is distributed in the western Atlantic from Massachusetts to Brazil, including the Gulf of Mexico, the Lesser Antilles, and the northern coast of Cuba. Snowy grouper are protogynous hermaphrodites, spawning from May to June. They feed on crustaceans, fish, and squid and wait to ambush their prey.

Snowy grouper are managed as separate stocks in the SAFMC and the GMFMC. The South Atlantic snowy grouper stock was assessed (Staff, 1991; Huntsman *et al.,* 1992; Potts *et al.,* 1998; Potts and Brennan, 2001) before its SEDAR assessment in 2004 as part of the Deepwater Snapper-Grouper Complex in the South Atlantic. The snowy grouper SEDAR assessment suggested that fishing mortality first exceeded a sustainable rate in the mid-1970s, causing the population biomass to decrease below B_{MSY} in the early 1980s (Figure 12). While the SEDAR assessment has not been updated since 2004, Amendment 15A developed by the SAFMC (2007) updated management reference points for snowy grouper (along with South Atlantic black sea bass and red porgy) and further detailed the 34-year rebuilding plan for the stock.

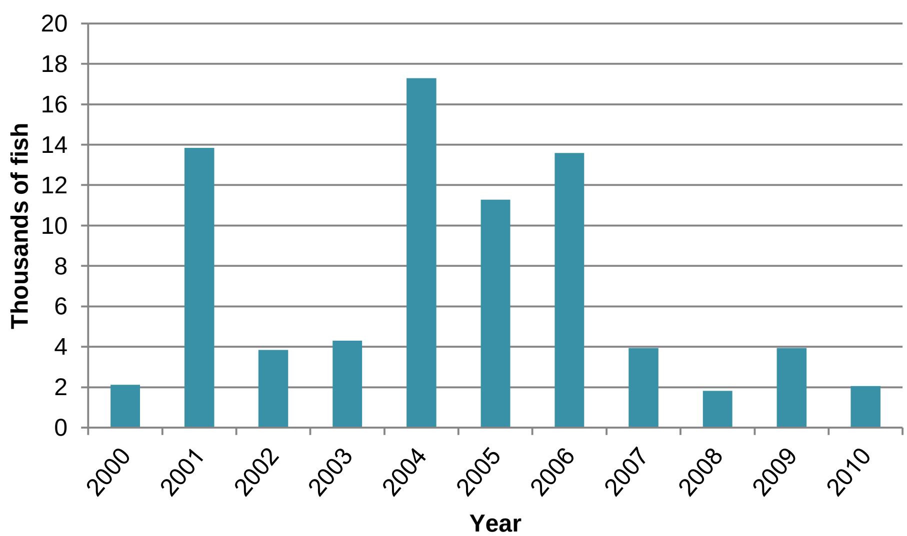
Figure 12. Biomass of South Atlantic snowy grouper, 1961–2002



Source: SEDAR, 2004

At the time of this study, the fishery was 95% allocated to the commercial sector, and 5% allocated to the recreational sector (SAFMC, 2007); this allocation is further discussed in Section 7.1. Both commercially and recreationally, handlines are the dominant gear type in this fishery. Figure 13 displays recent recreational harvest of South Atlantic snowy grouper from 2000–2010. Both gear and bag limits exist on this fishery, and Amendment 17B (2010b) set a strict recreational catch limit of 523 fish, which is significantly lower than recent recreational harvests, see Figure 13. This ACL was enforced in 2011 and was only 23% realized that year (NOAA, 2012).

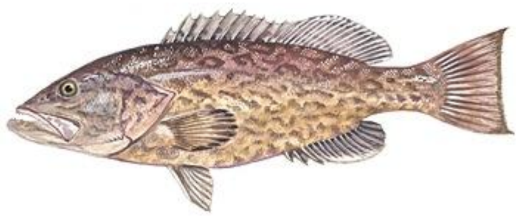
Figure 13. Recent recreational harvest of South Atlantic snowy grouper, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

4.6. Gulf of Mexico Gag

Gag have long, compressed bodies that are generally brownish-gray with pale underbellies and traces of dark wavy markings on their sides. Gag are found in the western Atlantic at depths of 60–250 feet. Young gag live in estuaries

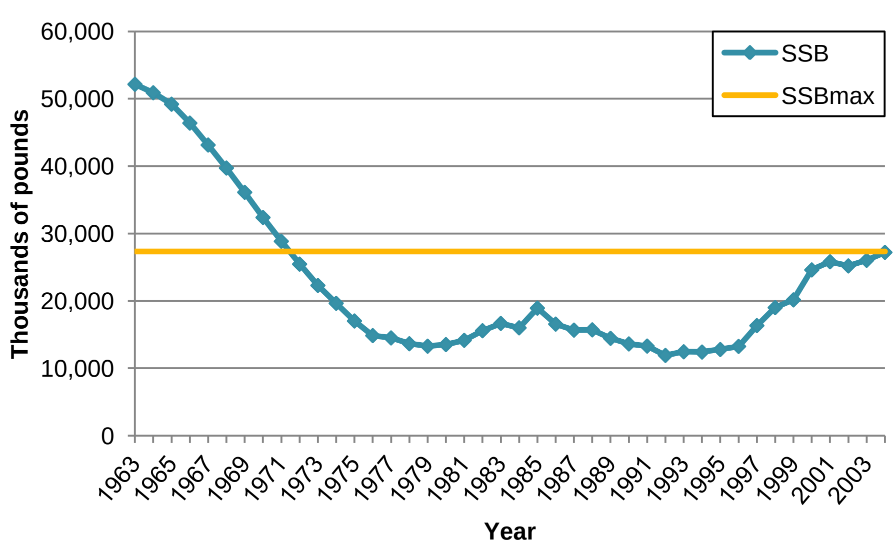


in sea-grass beds and structured habitats, while adults live offshore and prefer hard-bottom habitats. Gag grow slowly, up to more than 3 feet and 50 pounds, and can live up to about 30 years. Gag are protogynous hermaphrodites and spawn from late January to mid-April in the Gulf of Mexico. Gag eat a variety of fish, crabs, shrimp, and squid.

Gag are managed as two separate stocks by the GMFMC and the SAFMC in the United States. The Gulf of Mexico gag stock, originally included as part of the Reef Fish Fishery Management Unit, was first individually assessed in 1994 (Schirripa and Goodyear). While that assessment concluded the stock was not overfished, the 1997 gag stock assessment (Schirripa and Legault) indicated overfishing may have been occurring. In response, seasonal and spatial closures as well as size limitations were implemented for both commercial and recreational fisheries. A 2001 assessment indicated that gag was not overfished or undergoing overfishing (Turner *et al.*, 2001).

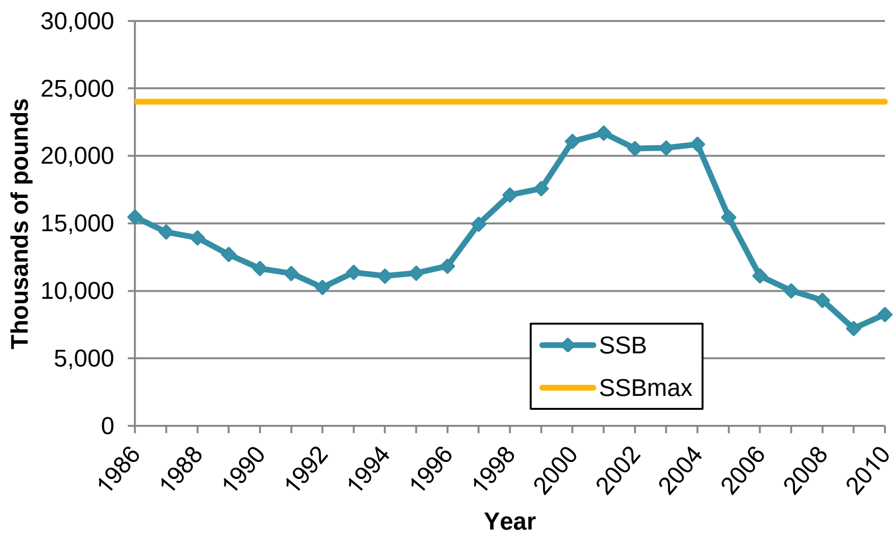
The first SEDAR assessment of Gulf of Mexico gag was in 2006 (SEDAR, 2006d) revealing suboptimal biomass levels since the mid-1970s. While this assessment found the SSB largely recovered from previous declines (Figure 14), when the stock was last assessed by SEDAR in 2009 scientists found abundance had declined again and the SSB was estimated to be at 47% of the minimum standing stock threshold (Figure 15). It is likely the population declines were due to a major red tide event, an algal bloom that releases potent neurotoxins, in 2005. It is thought that red tide contributed about 20% additional mortality to the population on top of fishing mortality (GMFMC, 2011). The stock was officially classified as overfished in 2009, and in Amendment 32, the GMFMC (2011) implemented fishing regulations, setting an ACL of 2.02 million pounds for 2012 and establishing a 10-year rebuilding plan for Gulf of Mexico gag.

Figure 14. Biomass of Gulf of Mexico gag, 1963–2004



Source: SEDAR, 2006d

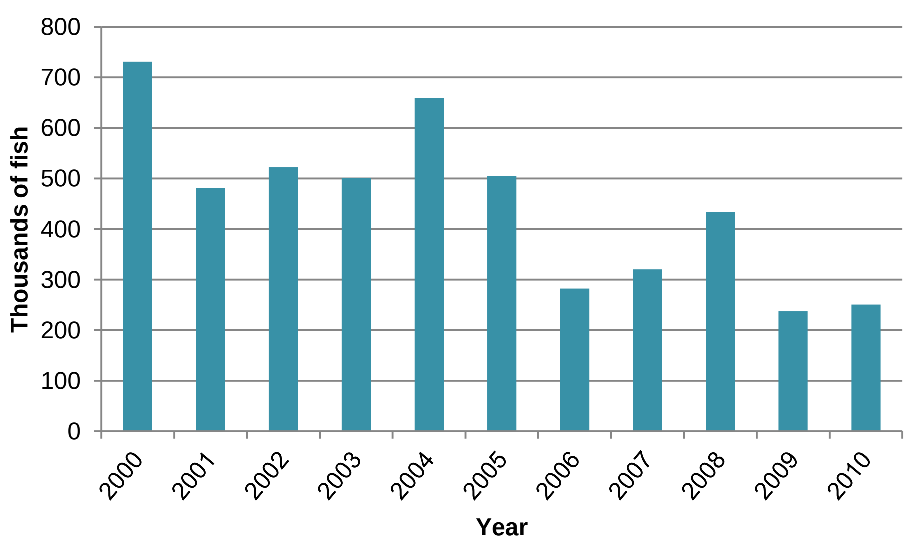
Figure 15. Biomass of Gulf of Mexico gag, 1986–2010



Source: Values based on a 2010 rerun of SEDAR, 2009a; provided by personal communication with B. Linton, Jan. 3, 2012.

The commercial and recreational Gulf of Mexico gag fisheries are allocated 39% and 61% of total harvest, respectively (GMFMC, 2008b). This stock is mainly targeted by vertical hook-and-line gear, though longlines and spears are also used. As mentioned above, an ACL is allocated between the commercial and recreational fisheries; an individual fishing quota (IFQ) program, which began in 2010, allocates the commercial catch among commercial fishermen. There are various other regulations managing the fishery such as gear restrictions, area closures, and size limits. Figure 16 displays recent recreational harvest of Gulf of Mexico gag.

Figure 16. Recent recreational harvest of Gulf of Mexico gag, 2000–2010



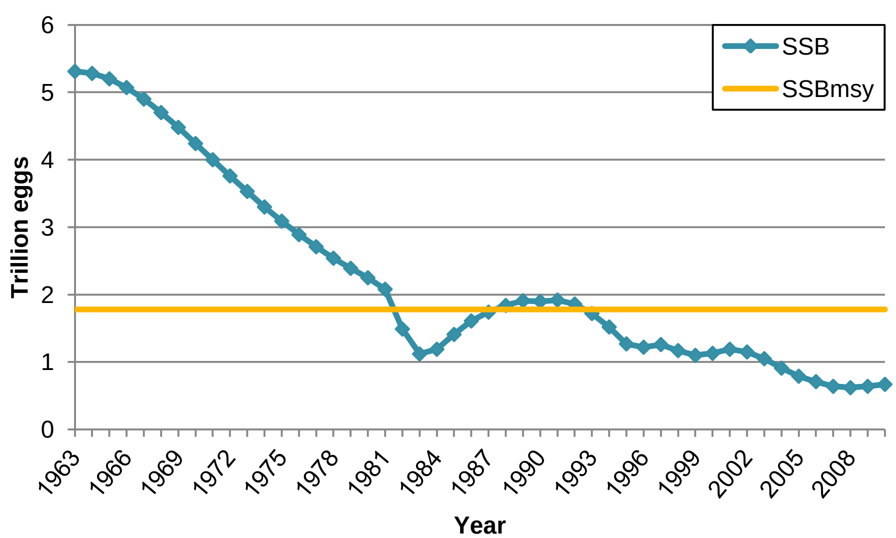
Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

4.7. Gulf of Mexico Gray Triggerfish

Gray triggerfish have large incisor teeth and laterally compressed bodies covered with tough, sandpaper like gray skin. The triggerfish got its name because when its second spine is depressed, it acts as a trigger, unlocking the first spine. Gray triggerfish are found on both sides of the tropical and temperate Atlantic, from Massachusetts to Brazil and from England southward along the coast of Africa. Along the southwestern United States, gray triggerfish typically inhabit structured hard-bottom areas at depths of 80–300 feet. Spawning occurs offshore during the spring and summer, and unlike most reef fish, triggerfish have demersal eggs that are deposited in guarded nests. The fish uses its powerful teeth to dislodge and crush small mussels, sea urchins, and barnacles, and may also feed on plankton.

In the United States, the SAFMC and the GMFMC manage gray triggerfish stocks. Gray triggerfish were first part of the Reef Fish Fishery Management Plan implemented in 1984. Individually, Gulf of Mexico gray triggerfish were first assessed with SEDAR 9 in 2006. That assessment found that the stock was both overfished and experiencing overfishing. Allocations and catch limits were implemented by GMFMC Amendment 30A in 2008, and an update assessment was completed in 2011 (SEDAR, 2011b). Figure 17 displays SSB levels over time, expressed in trillions of eggs. This fishery is currently under a six-year rebuilding plan beginning in 2008. Recently, the Gulf council's scientific advisers recommended a significant decrease in gray triggerfish's acceptable biological catch (ABC) at a total of 305,300 pounds, which is less than half of the current stock ACL of 793,000; these new limits will likely take effect in 2012 and be codified in Amendment 37.[16]

Figure 17. Biomass of Gulf of Mexico gray triggerfish, 1963–2010

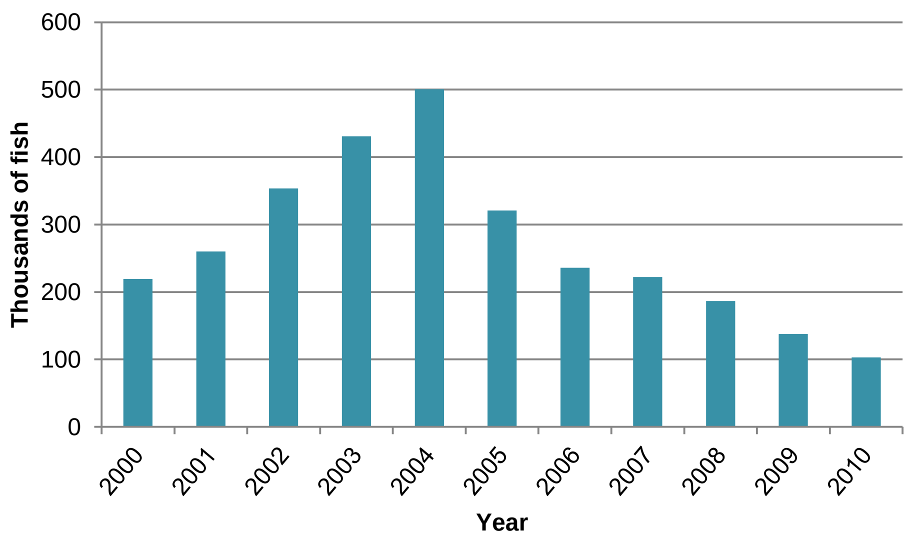


Source: SEDAR, 2011b

[16] Published on the GMFMC blog: http://gulfcouncil.blogspot.com/2012/04/may-council-meeting-preview.html.

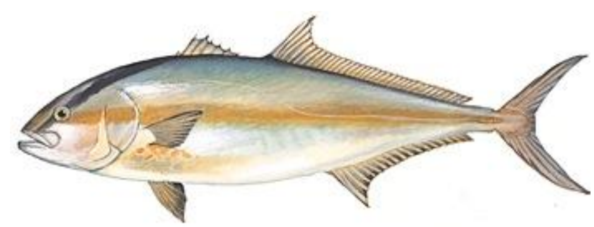
Allocations of Gulf of Mexico gray triggerfish are set at 21% commercial and 79% recreational (GMFMC, 2008a). Hand line and longline are the most prevalent gear types for this fishery. At the time of this study, there were various restrictions on this fishery, such as limited access, limited allowable sizes, and limited permissible gear. Figure 18 displays recent recreational harvest of Gulf of Mexico gray triggerfish from 2000–2010.

Figure 18. Recent recreational harvest of Gulf of Mexico gray triggerfish, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

4.8. Gulf of Mexico Greater Amberjack



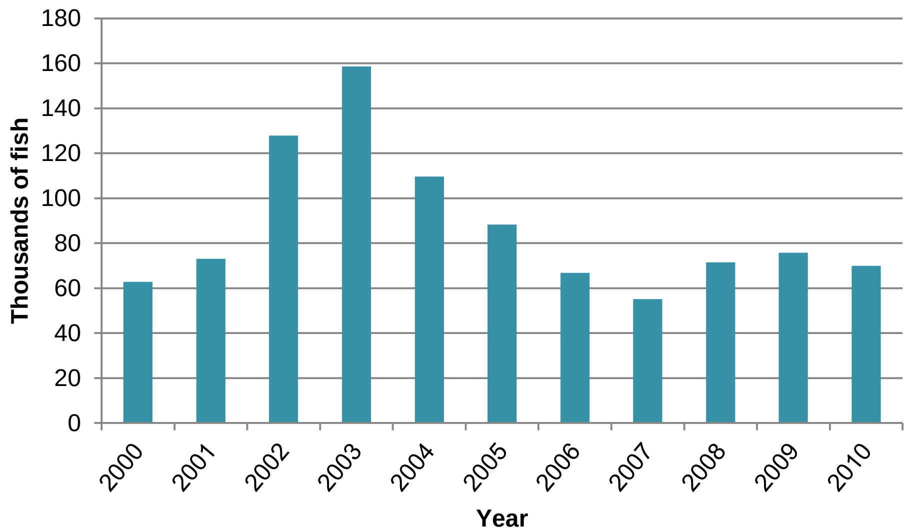
Greater amberjack are a silvery-blue fish with a dark stripe extending along the top of their bodies through their eyes. Greater amberjack are found in the Mediterranean Sea and the Atlantic, Pacific, and Indian oceans. They prefer structured habitat, such as reefs, rock outcrops, and wrecks. Greater amberjack spawn from March through July and may grow to 6 feet and nearly 200 pounds. Greater amberjacks eat mostly crab, squid, and other reef fishes.

In the United States, the SAFMC and the GMFMC manage greater amberjack stocks. The Gulf of Mexico stock was first assessed by the SEDAR process in 2006 (SEDAR, 2006c). This assessment found that the stock likely experienced overfishing conditions in the late 1980s and became overfished in the early 1990s. In 2003 the GMFMC set a 10-year rebuilding plan for the stock. GMFMC Amendment 30A established a recreational quota, modified the greater amberjack rebuilding plan, and established commercial and recreational accountability measures that are triggered when a quota is exceeded. The current recreational allocation is set at 1.4 million pounds, though, once approved, GMFMC Amendment 35 would reduce the recreational quota to 1.3 million pounds (GMFMC, 2012).

While yearly tabulated biomass data were not available for this stock at the time of this study, the Gulf of Mexico greater amberjack fishery had a SEDAR update assessment completed in 2011(c). Unfortunately, the GMFMC's SSC rejected the reference points presented in the recent update assessment and recommended that a new assessment be undertaken. However, the assessment did provide a graph showing the ratio of biomass over time to the B_{MSY} (Appendix B). The figure shows that this stock was most likely overfished by 1992.

The current proportional allocation of the TAC for Gulf of Mexico greater amberjack is 73% recreational and 27% commercial (GMFMC, 2008a). This stock is primarily targeted with longline gear and vertical lines. At the time of this study, there were various restrictions on this fishery, such as limited access, limited allowable sizes, and limited permissible gear. Figure 19 displays the recent recreational harvest of Gulf of Mexico greater amberjack over 2000–2010.

Figure 19. Recent recreational harvest of Gulf of Mexico greater amberjack, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

4.9. Gulf of Mexico Red Snapper

Please see the previous section (4.4) on South Atlantic red snapper for the biological description of this fish.

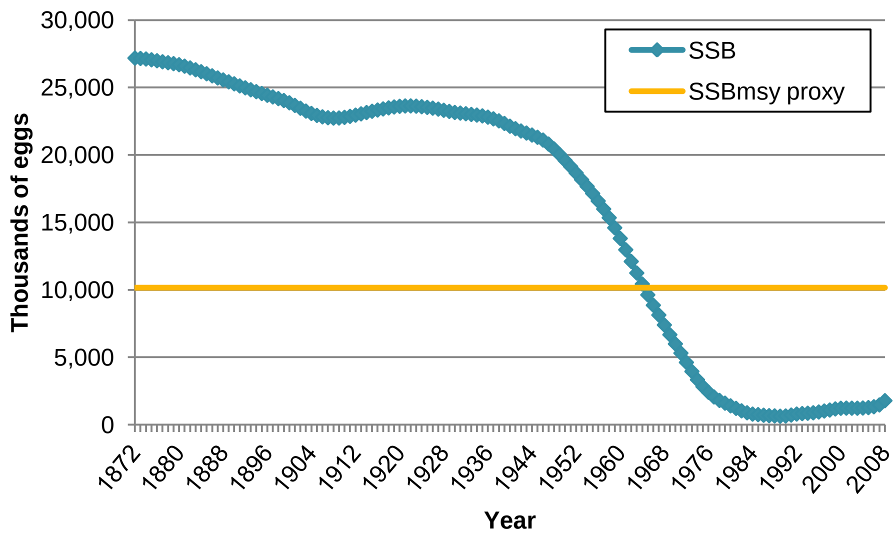
The first Gulf of Mexico red snapper stock assessment was conducted in 1988 (Goodyear); the stock was determined to be so overfished that reductions in fishing mortality of 60–70% would be required to rebuild the stock. The overfished status of the red snapper fishery was the result not only of an excessive amount of effort in the directed fishery, but also of a high level of bycatch mortality of juvenile red snapper associated with shrimp trawling. A regulatory amendment in 2001 set the timeline for the rebuilding plan for Gulf of Mexico red snapper at 32 years. Additionally, the council implemented various and extensive management measures, including strict catch limits for the commercial fishery and soft catch targets for the recreational fishery, size and gear restrictions, shortened fishing seasons, permitting moratoriums, and fishery closures. However, actual catches often exceeded set catch limits; as the stock continued to be overfished, following amendments (22 and 27/14) and an interim rule revised and expanded the rebuilding plan (GMFMC, 2004; GMFMC, 2007).

The SEDAR process first reviewed Gulf of Mexico red snapper in 2005 (SEDAR, 2005b) and concluded that the stock continued to be overfished and undergoing overfishing. In 2007, an IFQ system was established for the red snapper commercial fishery through Amendment 26 (GMFMC, 2006), effectively creating a continuous closed red snapper season for vessels without IFQ share and a year-round fishery for those with shares. In the few years the program has been in place, commercial catches are closer to catch limits and contain fewer juvenile snapper. The recreational sector, however, has continuously exceeded the TAC in recent years (Bonini *et al.*, 2011). In response, Amendment 27/14 (GMFMC, 2007), implemented in 2008, imposed "hard" catch limits with accountability, measures which have greatly contributed to rebuilding efforts.

SEDAR completed an update assessment for the stock in 2009(b), confirming that, while still overfished, the Gulf red snapper stock is rebuilding as planned with 2032 as the target end year. The stock is scheduled to be assessed by the SEDAR process again starting in August 2012 and ending in May 2013.

Figure 20 displays Gulf of Mexico red snapper SSB, calculated as the number of eggs produced by the spawning population relative to the number of eggs produced if all spawners were 30 years old, and a proxy for SSB_{MSY}.[17] Over more than a century, the stock has faced huge declines beginning by about 1970, with SSB levels decreasing approximately 93% from 1872 to 2008.

Figure 20. Biomass of Gulf of Mexico red snapper, 1872–2008

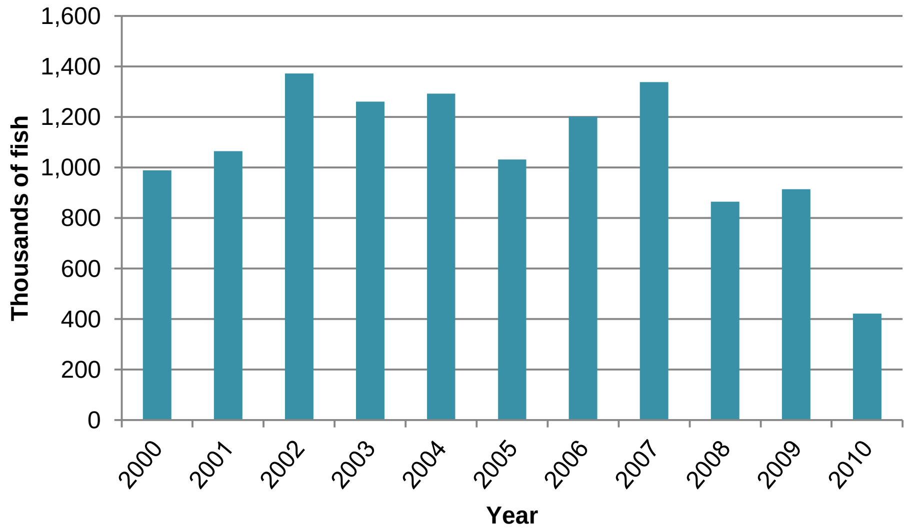


Source: Values provided by personal communication with B. Linton, May 31, 2012.

In the Gulf of Mexico, 51% and 49% of the TAC is allotted to the commercial and recreational red snapper fisheries, respectively (GMFMC, 2007). Commercial and recreational fishermen mainly use hook-and-line gear, and recreational fishermen are required to use certain devices to improve the chance of survival of any unintentionally caught fish. At the time of this study, there were various further restrictions on this fishery, such as limited access, strict catch limits, recreational seasonal closures, and size limits. Figure 21 displays recent recreational harvest of Gulf of Mexico red snapper.

[17] The SSB_{MSY} proxy (F26% SPR) represents the relative number of spawning females when the stock is at equilibrium. F26% SPR refers to yield associated with the fishing rate when the spawning potential ratio is at 26%, the management benchmark for Gulf of Mexico red snapper indicating a rebuilt population. The spawning potential ratio is a common management benchmark measurement that estimates spawning potential of a population relative to an unfished population.

Figure 21. Recent recreational harvest of Gulf of Mexico red snapper, 2000–2010



Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

5. DATA AND METHODS

Overfishing means fewer fish are available to catch in subsequent years due to lower population levels. If reduced fish populations diminish recreational fishing opportunities, those catch losses can be quantified and valued. We describe the process for collecting and analyzing the necessary data for this analysis below.

5.1. Data Collection

To conduct our analysis, we assembled the following data for each of the nine focus stocks in the South Atlantic and Gulf of Mexico (see Table 1):

- Scientifically determined MSY and OY reference points.
- Council-determined recreational allocations.
- Recreational harvests for each stock for years 2005–2009.
- Stock-specific estimates of recreational effort and expenditure data for years 2005–2009.

Data were gathered from individual stock assessments, fishery management plans and amendments, the NOAA Fisheries Service's SERO, and the MRFSS. All estimates are reported in 2010 dollars, and pounds are quoted in whole weight unless otherwise noted.

Stock-Specific Measurements

Potential harvests could be estimated on the basis of equilibrium optimum yield (OY) or maximum sustainable yield (MSY).[18] The MSA (Section 3 [33] MSA, 2007) defines OY as the amount of fish that:

(a) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;
(b) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and
(c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery.

[18] As defined previously, MSY is the largest average catch that can be taken from a stock on a continuing basis under prevailing environmental conditions without impairing its long-term productivity.

Many have debated the appropriateness of using MSY or OY as a management tool for fisheries (Roughgarden and Smith, 1996; Jennings *et al.,* 2001; Heneman, 2002; Walters *et al.,* 2005; Legovic *et al.,* 2010). MSY, however, is still the most readily understood and operational concept within fisheries management (Mace, 2004). Since MSY is larger than OY, estimating potential harvests based on MSY would have led to higher estimates of recreational catch loss. We chose instead to base our analysis on OY, on the grounds that the MSA requires fishery councils to set management levels at OY.

There are equilibrium OY values, which correspond with a stock whose population is in equilibrium, and rebuilding OY values, which are set conservatively low as part of a plan to return stocks to equilibrium levels. The rebuilding OY values are often set equal to levels of acceptable biological catch (ABC). The ABC is the range of estimated allowable catch for a stock and is used to establish a limit or target fishing level designed so that management actions become more conservative as biomass estimates, or other proxies, for a stock or stock complex decline and as science and management uncertainty increases. Some of the focus stocks in our analysis have rebuilding OYs in addition to equilibrium OYs. Because we are interested in measuring potential catch at healthy fish stock levels, we use equilibrium OY values in our analysis.

Measures of MSY and equilibrium OY for each focus stock were sourced from each stock's regional stock assessment and fishery management plan. These documents are available publicly from the SEDAR, SAFMC, and GMFMC websites.[19] Sector allocation percentages were also obtained from the regional councils. Appendix C references the exact years and sources from which MSY, OY, and allocation percentages were taken for each stock in our analysis.

We used published estimates of MSY and OY that were available during the study period, 2005–2009. These are the values of MSY and OY that likely influenced regulatory decisions over that period. More recent MSY and OY values have been published for some stocks, such as South Atlantic black sea bass, South Atlantic red snapper, Gulf of Mexico gag, and Gulf of Mexico greater amberjack. We chose not to use those most recent estimates, because they did not pertain to our study period.[20]

Although we preferred to source the MSY values, OY values, and the allocation percentages from assessments, amendments, and regulations that were current over the study period, in some cases we were not able to because the data were not available for those stocks until 2010 or later. For South Atlantic red grouper, there was no MSY, OY, or allocation percentage until after 2010. There also were no allocation percentages for South Atlantic red snapper and snowy grouper stocks until after 2010.

In the case of Gulf of Mexico greater amberjack, an equilibrium OY value was not available, because the council staff could not determine one during its 2006 SEDAR assessment or in related amendments. This remains an issue in recent assessments of this stock, as the recently updated estimates of MSY and OY from the 2011 SEDAR update stock assessment of Gulf of Mexico greater amberjack were rejected by the GMFMC's SSC as "unreliable" (GMFMC, 2012, p. 1). The GMFMC has emphasized the need for a new benchmark stock assessment as soon as possible to address issues in the 2011 update assessment. Because we needed a proxy for the Gulf of Mexico greater amberjack OY value for this analysis, we took the average of the annual yields associated with the standard definition of the equilibrium OY for this stock over the years 2005–2009 from the 2006 assessment presented in Amendment 30A, Table 2.1.1 (GMFMC, 2008a).[21]

SERO Catch Data

Recreational harvest values for 2005–2009 for the SAFMC and GMFMC regions were provided by request from the Southeast Regional Office (SERO) of NOAA using the Southeast Fishery Science Center's (SEFSC) Recreational ACL

[19] Available online at http://www.sefsc.noaa.gov, http://www.safmc.net, and http://www.gulfcouncil.org respectively.

[20] We present these more recent MSY values in Table 13, alongside a discussion about the general decline of MSY estimates over time in Section 7.3.

[21] Current management criteria and Gulf of Mexico greater amberjack stock benchmarks set OY as the yield associated with an F40% SPR when the stock is at equilibrium; F40% SPR refers to yield associated with the fishing rate when the spawning potential ratio is at 40%.

Dataset (personal communication with N. Farmer, Mar. 21, 2012). The SEFSC compiled this dataset from Southeast Headboat Survey, MRFSS, and Texas Parks and Wildlife Creel Survey data. It is a more comprehensive dataset and includes improved weight estimates.[22] Table 3 and Table 4 display the pounds (whole weight) and number of fish, respectively, landed recreationally in the South Atlantic and Gulf of Mexico regions over 2005–2009. These harvest numbers do not include fish caught and released alive.

Table 3. Annual and averaged recreational harvest (lbs. ww), 2005–2009

South Atlantic Stocks	2005	2006	2007	2008	2009	Average 2005–2009
Black sea bass	826,012	835,967	788,899	521,828	478,070	**690,155**
Red grouper	299,116	505,311	633,933	1,099,141	283,565	**564,213**
Red porgy	80,424	97,299	176,180	142,365	95,772	**118,408**
Red snapper	314,953	282,952	357,902	809,135	1,019,988	**556,986**
Snowy grouper	105,116	169,337	60,985	16,909	77,173	**85,904**

Gulf of Mexico Stocks	2005	2006	2007	2008	2009	Average 2005–2009
Gag	3,624,259	1,989,632	2,609,995	3,148,641	1,663,718	**2,607,249**
Gray triggerfish	583,715	451,936	427,824	419,210	401,026	**456,742**
Greater amberjack	1,440,850	1,372,419	1,065,839	1,279,199	1,592,857	**1,350,233**
Red snapper	4,083,766	4,021,293	4,440,015	3,711,658	4,624,577	**4,176,262**

Source: SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

Of our focus stocks in the South Atlantic, black sea bass was the most recreationally harvested stock, at an annual average of 690,155 pounds, or 693,981 fish, over the study period. In the Gulf of Mexico region, red snapper was the most recreationally harvested stock, with recreational harvests averaging approximately 4.1 million pounds, or 1.1 million fish, over the study period.

Table 4. Annual and averaged recreational harvest (number of fish), 2005–2009

South Atlantic Stocks	2005	2006	2007	2008	2009	Average 2005–2009
Black sea bass	933,349	925,803	735,603	445,337	429,823	**693,983**
Red grouper	41,709	45,443	78,801	87,478	25,150	**55,716**
Red porgy	50,043	56,352	108,930	81,840	54,063	**70,246**
Red snapper	44,256	31,863	48,141	129,725	143,681	**79,533**
Snowy grouper	11,282	13,584	3,944	1,823	3,933	**6,913**

Gulf of Mexico Stocks	2005	2006	2007	2008	2009	Average 2005–2009
Gag	504,932	282,424	320,043	434,078	237,229	**355,741**
Gray triggerfish	320,995	235,805	221,976	186,488	137,549	**220,563**
Greater amberjack	88,291	66,790	55,161	71,457	75,747	**71,489**
Red snapper	1,031,350	1,201,348	1,338,082	864,815	913,777	**1,069,874**

Source: Data from SERO, 2012

[22] While MRFSS landings from Monroe County are assigned to the Gulf of Mexico by default, SERO took additional steps to post-stratify these data and reassign those landings to the South Atlantic for several species in the ACL Amendments. Additionally, greater amberjack landings are post-stratified when quota monitoring, so the landings presented in greater amberjack quota notices may not correspond exactly with those presented here.

Effort and Expenditure Data

Effort and expenditure data used in this analysis were produced by Gentner Consulting Group (2012) for Ecotrust upon request (see Appendix D). Gentner Consulting Group (GCG) generated these data from the MRFSS, a national survey of recreational fishing expenditures.[23]

The MRFSS collected data such as a fisherman's residence, hours fished, primary areas fished, target species, gear used, and days fished in the last two and 12 months. An intercept add-on survey also collected data on recreational fishermen's trip expenditures. Because the MRFSS does not estimate directed effort for specific stocks, GCG developed code in cooperation with the MRFSS program to derive stock-specific effort and expenditure data for the nine focus stocks.[24] GCG's (2012) estimation procedure post-stratified the MRFSS state-level effort estimates by the proportion of anglers that caught and/or targeted the species. This means that these estimates are not additive across species groups because an angler could have caught or targeted more than one species on a given trip. For example, an angler who states that she is targeting red snapper could catch a snowy grouper on the same trip. That single trip would be captured in directed effort estimates for red snapper as well as snowy grouper (GCG, 2012).

Directed effort, therefore, includes any trip where the target species was caught, targeted, or caught and/or targeted. From a behavioral standpoint, targeted trips may be the preferred measure of directed effort. Bycatch, however, is a serious management concern affecting many of the focus stocks in this analysis. The GCG (2012) raises three additional concerns with defining directed effort exclusively in terms of targeted trips:

1) The survey targeting question is asked after the trip has occurred, raising questions about whether the fisherman's answer gauges an actual ex-ante targeting decision or simply an ex-post measure of what the fisherman had success catching.
2) The MRFSS survey allows only a primary and secondary target choice, not groups or assemblages, raising concerns in cases where it is more likely that fishermen are targeting "reef fish" or "bottom fish."
3) Item non-response is very high for the targeting question; in 2010, 55% of all intercepted recreational fishermen in the South Atlantic gave no primary or secondary target; this lack of response may be a reflection of the inability to indicate a group of species that were targeted.

Expenditures were estimated from the add-on survey by summing expenditures across all categories and calculating mean total expenditure by species, mode, and region using the same estimation code used for Gentner and Steinbeck's (2008) report for NOAA. Because of the optional nature of the add-on survey, sample size was sometimes insufficient to provide robust estimates of trip expenditures for each species. In these cases, species-specific estimates were discarded in favor of estimates of expenditures across a group of species. Because the focus stocks in this analysis included both reef and bottom fish, GCG estimated trip expenditures across all species together in each region (GCG, 2012).

The MRFSS survey is not conducted in the state of Texas. Current and potential effort and expenditure estimates for Texas, therefore, are not included in this analysis. However, recreational catch data from Texas is included; excluding Texas catch would directly overestimate catch losses for the region. Appendix E further explores the implications of excluding Texas effort and expenditure data from the analysis.

Table 5 presents GCG's (2012) data on the average annual number of charter, private boat, and shore recreational fishing trips by stock. Table 6 presents GCG's per-trip estimates of expenditures by mode and by stock. Table 7 presents average annual expenditures by stock and by mode over the period 2005–2009.

---

[23] Effort and expenditure data sourced and derived from MRFSS not MRIP. This is because the necessary data from MRIP were not available at the time of this study.

[24] Species-specific effort was estimated by post-stratifying the MRFSS state-level effort estimates by the proportion of fishermen who caught and/or targeted the species above (GCG, 2012).

Table 5. Average annual number of trips by stock and by mode, 2005–2009

South Atlantic Stocks	Charter	Private boat	Shore	Total average # of trips per year
Black sea bass	69,335	512,533	94,392	**676,260**
Red grouper	12,866	69,872	2,154	**84,892**
Red porgy	15,611	13,666	0	**29,277**
Red snapper	17,148	98,230	2,878	**118,255**
Snowy grouper	3,088	2,705	0	**5,792**

Gulf of Mexico Stocks	Charter	Private boat	Shore	Total average # of trips per year
Gag	21,804	361,579	127,076	**510,458**
Gray triggerfish	32,404	37,718	583	**70,705**
Greater amberjack	15,546	22,134	308	**37,988**
Red snapper	56,903	189,020	2,344	**248,267**

Source: Estimates provided by GCG (2012) using MRFSS data

Table 6. Per trip expenditures by mode and by stock, 2005–2009

South Atlantic Stocks	Charter	Private boat	Shore
Black sea bass	$225	$47	$20
Red grouper	$225	$47	$20
Red porgy	$219	$56	--
Red snapper	$213	$56	$19
Snowy grouper	$170	$67	--

Gulf of Mexico Stocks	Charter	Private boat	Shore
Gag	$164	$73	$29
Gray triggerfish	$136	$43	$29
Greater amberjack	$164	$76	$29
Red snapper	$170	$67	$29

Source: Estimates provided by GCG (2012) using MRFSS data

Table 7. Average annual expenditures by stock and by mode, 2005–2009

South Atlantic Stocks	Charter	Private boat	Shore	Total average annual expenditures
Black sea bass	$15,625,870	$24,209,138	$1,877,486	**$41,712,494**
Red grouper	$2,899,536	$3,300,348	$42,851	**$6,242,735**
Red porgy	$3,419,457	$770,789	$0	**$4,190,246**
Red snapper	$3,647,024	$5,540,423	$54,334	**$9,241,782**
Snowy grouper	$525,101	$180,806	$0	**$705,907**

Gulf of Mexico Stocks	Charter	Private boat	Shore	Total average annual expenditures
Gag	$3,576,303	$26,243,261	$3,629,276	**$33,448,841**
Gray triggerfish	$4,391,974	$1,605,801	$16,646	**$6,014,420**
Greater amberjack	$2,549,882	$1,689,931	$8,806	**$4,248,619**
Red snapper	$9,677,710	$12,635,111	$66,945	**$22,379,766**

Source: Estimates provided by GCG (2012) using MRFSS data

In the South Atlantic, black sea bass had the highest average effort, estimated at 676,260 trips annually over 2005–2009. This corresponds with the high recreational harvest values of this stock over the same period as presented in Table 4. In the Gulf of Mexico, directed effort is not highest for red snapper, the region's most-harvested focus stock. Gulf of Mexico gag averaged 510,458 trips annually over the study period, while Gulf of Mexico red snapper had the second highest of that region's stocks at 248,267 trips annually on average.

Stocks with the highest effort numbers also had the highest associated trip expenditures. For example, recreational fishermen who caught and/or targeted South Atlantic black sea bass and Gulf of Mexico gag spent $41.7 million and $33.4 million on average per year, respectively, over the study period. These expenditures go toward lodging, food and dining, charter fees, bait and tackle, and transportation, among other things.[25]

To determine average annual trip expenditures for each stock, we divided total average annual expenditures by the total average annual number of trips for each stock. Results are summarized in Table 8. Across the focus stocks, trip expenditure estimates ranged from approximately $62 for South Atlantic black sea bass to $143 for South Atlantic red porgy.

Trip expenditures for each stock varied depending on a few factors. First, bottom-dwelling species and species caught farther out from shore, such as red grouper, require more fuel to reach them. Second, fishing mode affects trip expenditures; charter fishermen generally have higher trip expenditures than private boat or shore-based fishermen. Private boat was the most popular mode of fishing for the stocks in this analysis. Relative to other focus stocks, however, Gulf of Mexico gag and South Atlantic black sea bass had higher levels of shore-based effort over the study period, which may be why they also had the lowest trip expenditures on average. Gulf of Mexico gag in particular are caught in high numbers from shore, when fishermen are likely targeting other species. Most shore-caught gag are released alive. We included shore mode in this study to capture all expenditure possibilities and to be consistent with how the trip and expenditure data were treated for this analysis. Additionally, some species, such as red porgy and gray triggerfish, are not popular target fisheries, yet they are caught often while targeting another fishery, like red snapper.

Table 8. Average annual number of trips, total expenditures, and trip expenditures by stock, 2005–2009

South Atlantic Stocks	Total average annual # of trips	Total average annual expenditures	Average annual trip expenditures
Black sea bass	676,260	$41,712,494	**$61.68**
Red grouper	84,892	$6,242,735	**$73.54**
Red porgy	29,277	$4,190,246	**$143.13**
Red snapper	118,255	$9,241,782	**$78.15**
Snowy grouper	5,792	$705,907	**$121.87**

Gulf of Mexico Stocks	Total average annual # of trips	Total average annual expenditures	Average annual trip expenditures
Gag	510,458	$33,448,841	**$65.53**
Gray triggerfish	70,705	$6,014,420	**$85.06**
Greater amberjack	37,988	$4,248,619	**$111.84**
Red snapper	248,267	$22,379,766	**$90.14**

Source: Current study, using estimates provided by GCG (2012) using MRFSS data

A single trip and its associated expenditures may be attributed to more than one species as fishermen on the MRFSS survey could have indicated up to two target species and could have caught a third or fourth species as well. The estimates presented above in Table 8 include trips during which no fish were caught as well as trips in

[25] See http://www.st.nmfs.noaa.gov/st5/RecEcon/Expend_RP_Special/2006_exp_int.pdf for a copy of the add-on intercept expenditure survey.

which multiple species were caught in a single outing. Therefore, it is important to note that effort and expenditure estimates **cannot** be added across stocks.

5.2. Methods

We define a catch loss as recreational trip expenditures that could have occurred if more fish had been available to be recreationally caught or targeted in a study fishery. To estimate catch losses, we compared recent average annual recreational trip expenditures for each focus stock to estimated *potential* annual recreational trip expenditures had the fisheries not been overfished. The catch loss for each stock (CL) is estimated in three steps.

First, we estimated a harvest per unit of effort (HPUE) number for each stock(s) by dividing average annual recreational pounds harvested (F) by the stock-specific average annual recreational effort data (E_c) over 2005–2009. This measurement differs from the standard catch per unit of effort (CPUE) measurement in that it does not include fish caught but released alive. Live releases are common on recreational fishing trips, but because the fish are released alive, we cannot count them against the available fish stock for harvest. At the same time, we cannot exclude fishing effort where no fish were harvested, as associated expenditures still occurred. Therefore, the HPUE is a good proxy associating trip effort with actual harvest.

$$HPUE = \frac{F}{E_c}$$

HPUE allowed us to translate total potential catch available into a measure of potential effort (E_p) should the stocks be at healthy levels. This is estimated by dividing each stock's total potential catch available, which is the stock's OY multiplied by its set recreational allocation (a), by the HPUE. We assumed that potential effort would increase proportionately with the increased availability of the fish stock. This assumption is discussed further in Section 7.

$$E_p = \frac{OY(a)}{HPUE}$$

The catch loss (*CL*) for each stock is then estimated by subtracting the current effort level (E_c) from the estimated potential effort (E_p), multiplied by average per trip expenditures (χ) for each stock over 2005–2009.[26]

$$CL = \chi(E_p - E_c)$$

6. RESULTS

In Section 6.1, we present our estimates of catch loss, the recreational trip expenditures that could have occurred had more fish been available to be recreationally caught and/or targeted in each of our focus fisheries. The dollars that could have been spent on recreational fishing could have supported additional economic activity in and around the study regions. In Section 6.2, we apply the relevant economic multipliers to our estimates of catch loss to project the amount of indirect and induced economic activity that could have occurred had the fisheries not been overfished.

6.1. Catch Loss

Table 9 presents our estimates of potential annual expenditures per stock had fishermen been able to harvest the recreational allocation at equilibrium optimum yield. Table 10 estimates the difference between annual average expenditures between 2005–2009 (Table 7) and potential expenditures (Table 9) to arrive at our estimates of catch loss for each stock.

[26] We assume that per trip expenditures are independent of the size of fish stocks.

Table 9. Potential annual recreational expenditures per stock

South Atlantic Stocks	MSY (lbs. ww)	OY (lbs. ww)	Rec. allocation %	Estimated # annual of trips	Average exp/trip ($)	Estimated potential annual expenditures (millions $)
Black sea bass	2,777,824	2,742,551	57%	1,531,779	$61.68	**$94.5**
Red grouper	1,110,000	1,089,000	56%	91,757	$73.54	**$6.7**
Red porgy	625,699	608,099	50%	75,177	$143.13	**$10.8**
Red snapper	2,314,000	2,104,000	72%	321,629	$78.15	**$25.1**
Snowy grouper	313,056	303,871	5%	1,024	$121.87	**$0.1**

Gulf of Mexico Stocks	MSY (lbs. ww)	OY (lbs. ww)	Rec. allocation %	Estimated # annual of trips	Average exp/trip ($)	Estimated potential annual expenditures (millions $)
Gag*	5,050,400	4,920,600	61%	587,659	$65.53	**$38.5**
Gray triggerfish	1,638,000	976,000	79%	119,359	$85.06	**$10.2**
Greater amberjack	5,039,000	2,718,800	73%	55,840	$111.84	**$6.2**
Red snapper	14,960,000	13,350,000	49%	388,873	$90.14	**$35.1**

** The MSY and OY values for this stock have been converted from gutted weight to whole weight using a conversion factor of 1.18 provided by SERO.*

Source: Authors' estimates, using data referenced in Appendix C

Table 10. Estimated annual catch loss and percent realized

South Atlantic Stocks	Expenditures (millions $)		ESTIMATED ANNUAL CATCH LOSS (millions $)	% realized
	Estimated annual potential	Average annual 2005–2009		
Black sea bass	$94.5	$41.7	**$52.8**	44%
Red grouper	$6.7	$6.2	**$0.5**	93%
Red porgy	$10.8	$4.2	**$6.6**	39%
Red snapper	$25.1	$9.2	**$15.9**	37%
Snowy grouper	$0.1	$0.7	**-$0.6**	n/a

Gulf of Mexico Stocks	Expenditures (millions $)		ESTIMATED ANNUAL CATCH LOSS (millions $)	% realized
	Estimated annual potential	Average annual 2005–2009		
Gag	$38.5	$33.4	**$5.1**	87%
Gray triggerfish	$10.2	$6.0	**$4.1**	59%
Greater amberjack	$6.2	$4.2	**$2.0**	68%
Red snapper	$35.1	$22.4	**$12.7**	64%

Source: Authors' estimates

In the South Atlantic, the largest estimated catch loss was for black sea bass, with $52.8 million annually in unrealized potential expenditures. This was followed by South Atlantic red snapper with an estimated annual catch loss of $15.9 million. In the Gulf of Mexico, red snapper had the largest catch loss estimated at $12.7 million annually, followed by gag at $5.1 million.

The final column in Table 10 displays the percentage of estimated potential expenditures realized by current expenditures. For example, in the South Atlantic, red snapper 2005–2009 average annual expenditures were $9.2 million compared with estimated potential expenditures of $25.1 million; thus, approximately 37% of estimated potential expenditures were realized. This measure allows for interesting comparisons; while South Atlantic red snapper had the lowest percentage of potential expenditures realized, it was not the largest catch loss in the region.

In the cases of Gulf of Mexico gag and gray triggerfish, delays in management response to overfishing may have contributed to smaller catch loss estimates. Gag weren't declared overfished until 2009, the last year of the study period. Regulations and catch limits were not implemented until after 2009. Gray triggerfish were not declared overfished until 2006 and catch levels were reduced in 2008. The delay in management of these stocks likely meant that more fish were caught recreationally during that period than was sustainable. Had harvests over that period been more in line with what regulations would eventually dictate, catch losses would have been greater than estimated above.

The negative catch loss estimated for South Atlantic snowy grouper suggests that actual harvests, on average, exceeded our estimates of potential harvests over the study period. The recreational allocation for snowy grouper over that time period was only 5%. In comparison, the stock with the next lowest recreational allocation was Gulf of Mexico red snapper at 49%. Given its low recreational allocation, it may be that the number of trips that targeted and/or caught snowy grouper exceeded the prescriptions of the management council over that period. This would explain the anomalous result for snowy grouper. This is discussed in further detail in Section 7.1.

6.2. Additional Economic Impact

When an angler purchases bait, hires a charter boat captain, or purchases a room at a nearby lodge, he/she injects money into the local economy. Those businesses, in turn, purchase labor and other inputs to supply the demands of recreational fishermen. As those expenditures move along the supply chain, other businesses are impacted as well. For example, a charter boat crew member may spend his wages at the local tavern. This means that every dollar in expenditure on recreational fishing can lead to a more than proportionate increase in economic activity. This is known as the multiplier effect. If recreational fishing diminishes because of overfishing, it is not only the direct expenditures that are lost. The economy also forgoes the benefits of the indirect and induced economic activity that could have occurred.

We used economic multipliers to estimate the total amount of economic output, personal income, and jobs that could have been created through expenditures on recreational fishing. The purpose of applying multipliers is to capture the ripple effects of economic activity; simply, a direct change in one sector affects other sectors. Multipliers are derived from input-output models that describe the industrial structure of an economy, the inputs to various sectors and the distribution of outputs, at a particular scale.[27] For example, a multiplier of 1.5 implies that $1 of direct expenditures on recreational fishing generates an additional $0.50 in indirect and induced economic activity, for a total economic output of $1.50. Personal income multipliers can also be used to measure the portion of direct, indirect, and induced economic activity that accrues to households in the study area in the form of wages, salaries, and profits.[28] Typically, the larger the region is, the greater the multiplier effect. Multipliers specific to the recreational fishing sectors in the South Atlantic or Gulf of Mexico regions could not be identified. We chose instead the national multipliers for recreational fisheries applied by Gentner and Steinback (2008) in their analysis of the national economic impacts of recreational fishing expenditures in the United States, see Table 11.[29]

[27] Economic multipliers, invaluable tools in economic analyses, are derived from input-output (I-O) models that describe the structure of an economy in terms of the inputs to its various industry sectors and the distribution of the outputs from those sectors. I-O models are the most comprehensive economic accounts at the level of the whole economy. In the United States, it is common to use multipliers derived through IMPLAN (IMpact analysis for PLANning, a privately owned, computer-based I-O modeling system developed by the Minnesota IMPLAN Group Inc. (MIG). See http://implan.com for more information); the multipliers used in this report were derived from IMPLAN.

[28] An increase in economic output does not necessarily imply income in the form of wages, salaries, and profits for the regional economy. For example, when anglers purchase gas, a large percentage of that expenditure benefits gas suppliers in other regions/countries.

[29] Typically, the larger the region is, the greater the multiplier effect. Using national rather than regional multipliers, therefore, may overestimate the multiplier effect.

Table 11. Multipliers from Gentner and Steinback (2008)

Per dollar of final demand			
Economic output	**Income**	**Value added**	**Jobs per $1 million**
2.62	0.76	1.21	17

Source: Gentner and Steinback (2008)

To estimate the total economic impact of South Atlantic and Gulf of Mexico recreational catch losses from historic overfishing, we multiplied the direct loss in expenditures – the catch loss – by output, income, and jobs multipliers, see Table 12.[30]

Table 12. Estimated economic impacts of recreational catch losses

	Estimated			
South Atlantic Stocks	**Catch loss (millions $)**	**Economic output (millions $)**	**Income (millions $)**	**Jobs (#)**
Black sea bass	$52.8	$138.2	$40.3	896
Red grouper	$0.5	$1.3	$0.4	9
Red porgy	$6.6	$17.2	$5.0	112
Red snapper	$15.9	$41.6	$12.2	270
Snowy grouper	-$0.6	n/a	n/a	n/a

	Estimated			
Gulf of Mexico Stocks	**Catch loss (millions $)**	**Economic output (millions $)**	**Income (millions $)**	**Jobs (#)**
Gag	$5.1	$13.2	$3.9	86
Gray triggerfish	$4.1	$10.8	$3.2	70
Greater amberjack	$2.0	$5.2	$1.5	34
Red snapper	$12.7	$33.2	$9.7	215

Source: Authors' estimates using multipliers from Gentner and Steinback (2008)

7. DISCUSSION

Our analysis finds that recreational fisheries in the South Atlantic and Gulf of Mexico could have contributed millions of dollars more in additional recreational expenditures and associated economic activity had the stocks been producing at optimum yield over the study period. The greatest catch losses were associated with South Atlantic black sea bass and South Atlantic red snapper. Recreational fishermen in the South Atlantic spent $41.7 million on average annually to realize 44% of the total recreational catch that could have been available had the stock been producing at optimum yield. We estimate that recreational expenditures on South Atlantic black sea bass could have been $52.8 million greater each year over the five-year study period had the stock been producing at optimum yield. An additional $52.8 million in recreational expenditures each year could have generated an additional $138 million in economic output and $40.3 million in income, and supported 896 jobs annually for the region.

In the case of South Atlantic red snapper, fishermen spent $9.2 million on average annually over the study period to catch 37% of the recreational catch that could have been available had the stock been at healthy levels. We estimate that recreational expenditures on South Atlantic red snapper could have been $15.9 million greater each year and could have contributed an additional $41.6 million in economic output and $12.2 million in income, and supported 270 jobs for the region annually between 2005–2009.

[30] The values in Table 12 are not additive across stocks nor within stocks, economic output includes income and the two categories cannot be combined.

In the Gulf region, the greatest losses were associated with red snapper, where recreational fishermen spent $22.4 million to realize 64% of the optimal catch that could have been available. We estimate that recreational expenditures on Gulf red snapper could have been $12.7 million greater each year had the stock been at healthy levels. An additional $12.7 million in recreational expenditures each year could have generated an additional $33.2 million in economic output and $9.7 million in income, and supported 215 jobs annually for the region.

It is no surprise that greater catch numbers contribute more to economic activity. But this can only be sustained if stocks are maintained at healthy levels and are not in decline due to overfishing. The South Atlantic and Gulf of Mexico regions could have benefited more from their recreational fisheries between 2005–2009 had stocks not been so depleted in the past. Maintaining and rebuilding population levels that support higher catch levels over time should induce increased expenditures by recreational fishermen and result in greater economic activity.

In the remainder of this section we discuss some of the key assumptions of the analysis and limitations of data collection that may have affected our results.

7.1. Snowy Grouper Allocation

The South Atlantic snowy grouper stock analysis resulted in a negative catch loss. In other words, the analysis shows a decrease in overall regional expenditures should fishermen catch the estimated potential available catch as opposed to current levels. This occurred because average annual catch levels over the study period exceeded our estimates of potential recreational snowy grouper harvests for a healthy fishery. To explain this, we hypothesize that the actual recreational portion of total South Atlantic snowy grouper harvest is appreciably higher than the council-set recreational allocation we used, 5%, to estimate potential catch levels.

The snowy grouper allocation of 95% to commercial fisheries and 5% to recreational fisheries was originally proposed in SAFMC Amendment 15B in 2008. This division was based on commercial and recreational landings data from 1986–2005. That amendment also explored two alternatives basing the allocation on landings data: 1) over the years 1992–2005 or 2) from only the year 2005. In those alternative proposals, snowy grouper's recreational allocation would have been 7% or 12%, respectively, indicating the rising recreational percentage of total harvest in more recent years. Moreover, the amendment included a comment concerned that given the small proposed allocation and the low monitoring capability of the quota system, recreational overages of snowy grouper would be highly likely.[31]

To gain a better understanding of recent observed commercial and recreational percentages of total South Atlantic snowy grouper harvest, we examined the NMFS Fishery Statistics Division's commercial and recreational databases.[32] We queried commercial landings and recreational harvest data for the stock for 1986–2010 to directly compare observed percentages with the set 5% allocation (Figure 22). The blue line presents the observed recreational portion of total harvest, while the red line is set at the council-mandated 5% allocation.

It should be noted, however, that the comparison is not perfect. First, NMFS commercial landings and recreational harvest data are collected differently. Furthermore, the division's online database protects confidentiality for fishermen by excluding commercial landings data from states with fewer than three dealers for any fishery. For

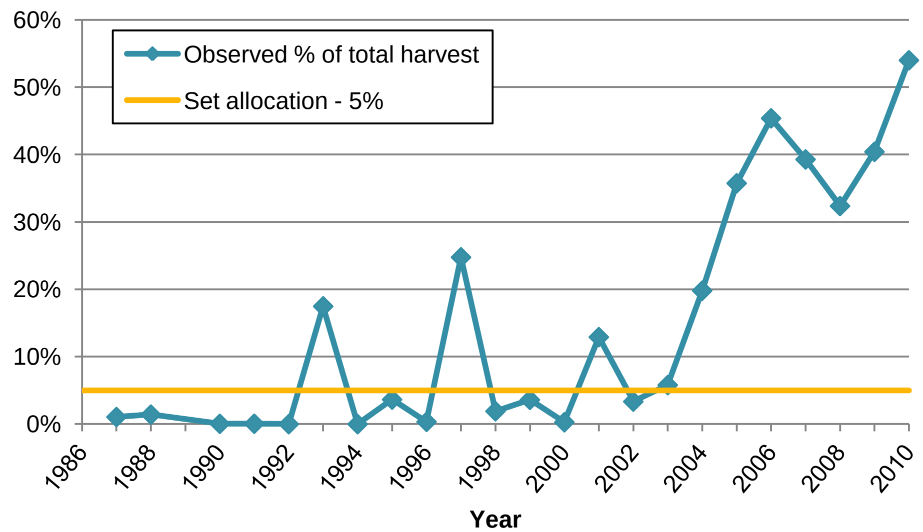
[31] The amendment also published a comment from the North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, which stated: "The current system is **unable to monitor when the recreational quota has been met**. Without some kind of real time monitoring of the recreational fishery and given the small quota for the recreational sector**, it is highly likely there will be recreational overages in the landings of snowy grouper**" (emphasis added, SAFMC, 2008, p. VII). The amendment's published response was as follows: "The Council's intent is to establish the allocations in Amendment 15B for snowy grouper…as **interim allocations** until the implementation of more permanent allocations. The Council has formed an Allocation Committee that will develop recommendations for the Snapper Grouper Committee. The Allocation Committee will investigate ways to divide allowable future harvest amongst the commercial and recreational sectors for all species currently managed by the Council" (emphasis added, SAFMC, 2008, p. VIII). A comprehensive ACL amendment implemented in 2012 (SAFMC, 2011b) maintained the historical South Atlantic snowy grouper allocations; while the Council could change the allocations for species in the future and has discussed this possibility, no amendments are currently under development at the time of this study to do so (personal communication with J. McGovern, June 6, 2012).

[32] Available online at http://www.st.nmfs.noaa.gov/st1/index.html.

some of the years from 1986–2010 for South Atlantic snowy grouper, it does appear as though some Georgia data may have been withheld. This may mean that actual commercial landings may be greater than those shown, and thus the actual recreational percentages may be lower than those presented in Figure 22.

Even *if* to an exaggerated degree, however, the trends observable in Figure 22 align with the alternative rising allocation proposals that Amendment 15B (SAFMC, 2008) presented as it averaged more recent harvest data up to 2005. The NMFS Fishery Statistics Division data indicate that, assuming no significantly withheld snowy grouper commercial landings, **recreational portions of total harvest are recently much higher than the set allocation of 5%**, and may even be as high as 50%, as shown for 2010.

Figure 22. Observed vs. set recreational allocation of South Atlantic snowy grouper, 1986–2010



Source: Current study using data from NMFS' Fishery Statistics Division

All considered, while our analysis estimated a negative catch loss for this fishery, it may very well be because we limited the potential catch, and therefore total potential trips and regional expenditures, of South Atlantic snowy grouper to only the set allocation of 5% of the equilibrium optimum yield. Had we used the observed recreational portion of total harvest over the study period of 2005–2009, which is closer to 40%, in our analysis, we would have estimated this stock's average catch loss at approximately $275,000 annually.

Because, as noted above, this observed recreational percentage may be overestimated, we chose instead to keep the analysis consistent and, as we did for the rest of the focus stocks, used the SAFMC set allocation of 5%. However, we thought it important to discuss the likelihood that the set recreational allocation of South Atlantic snowy grouper is likely being exceeded.

The SAFMC set a strict recreational annual catch limit for this fishery in 2010 at a mere 523 fish. This ACL is less than 8% of the average number of fish caught over the duration of our analysis, 2005–2009, which was 6,913 fish annually. The negative catch loss expenditures found in our main analysis above may represent the short term gains of overfishing, which often do not begin to compare with the long-term consequential losses.

7.2. Recreational Fishing Effort Elasticity

Our analysis assumed that effort was perfectly elastic with respect to available catch; that is, the change in recreational effort, or number of trips, is proportionally equal to the change in recreational catch available. This assumption may or may not be accurate.

It seems plausible that an increase in the amount of fish available for recreational harvest would encourage greater recreational fishing effort. But the change may or may not be proportionate. Fishermen cite many motivations for fishing other than catching fish: time with family and friends, venturing outdoors, traveling, etc. There is likely a degree of substitutability between species; some fishermen who were already taking trips targeting one stock may switch targets to another stock without increasing their overall effort or trip expenditures. If it were the case that fishermen switched targets to a different species that was not their most preferred, the result would be a welfare loss of a different kind not captured by expenditures. If there is significant substitutability among species, catch losses may be overestimated. But it may also be the case that as stocks are rebuilt and overfished stocks recover, the quality of fish, such as the average size caught, may increase, enticing greater effort.

To more precisely determine fishing elasticity with respect to available catch in our focus stocks, more research would need to be conducted that was beyond the scope of this report.[33] If effort increases less than proportionately with stock size, our analysis overestimates catch loss. If effort increases more than proportionately with stock size, our analysis underestimates catch loss.

7.3. Declining MSY

Catch losses for some of the focus stocks in our analysis seemed surprisingly small, given the fact that all of these species are overfished. South Atlantic red grouper, for example, realized 93% of potential expenditures on average over the study period. But catch losses for South Atlantic red grouper and other species may be underestimated if we consider how MSY has been changing over time.

The definition of MSY is the largest average catch that can be taken from a stock on a continuing basis under prevailing environmental conditions without impairing its long-term productivity. This reference point changes over time as levels of biomass, or overall stock size, decrease. When biomass levels are low, as they are for all of the focus stocks of this analysis (see figures in Section 4), the average sustainable catch is low as well. When stocks historically were at higher levels and had higher biomasses, they also had higher MSY estimates.

Table 13 presents MSY levels found in recent and previous assessments of two stocks from the South Atlantic, black sea bass and red snapper, and three stocks from the Gulf of Mexico, gag, greater amberjack, and red snapper. Although in some cases the process of estimating stock-specific MSYs changed over time, the definition of MSY as the largest average catch sustainably removed from the population remained the same. The MSYs reported at the time represented the best available science.

Table 13. Changes in MSY for select focus stocks

Stock	MSY	Source Year	MSY	Year	% Change
South Atlantic black sea bass	2,777,825	SEDAR 5, 2005	1,767,000	SEDAR 25, 2011	**-36%**
South Atlantic red snapper	2,431,000	SEDAR 15, 2008	1,842,000	SEDAR 24, 2011	**-24%**
Gulf of Mexico gag	5,500,000	Turner, 2001	4,190,000	Interim Rule, 2011	**-24%**
Gulf of Mexico greater amberjack	9,500,000	GMFMC, 2001	5,039,000	SEDAR 9, 2006	**-47%**
Gulf of Mexico red snapper	41,130,000	SEDAR 7, 2005	14,960,000	SAR Update, 2009	**-64%**

Source: Current study, references cited within table

Across all stocks, MSY decreased by as much as 24–64% over a 10-year period. Most striking is the decrease observable for Gulf of Mexico red snapper; over a four-year period, from a 2005 SEDAR assessment to a 2009 assessment, the MSY fell by 64%. As shown in Section 4, biomass levels for all of the focus stocks were significantly higher in years past; had they been sustained, they might be producing larger available catches today than is indicated by today's scientifically determined MSY estimates around which our analysis is based. This implies that catch losses may be even greater than indicated by our analysis.

[33] There has been some research on recreational fishing elasticities. See Loomis and Fix (1998), Bergstrom *et al.* (2004), and Gentner (2004).

8. CONCLUSION

Our case study analysis of nine overfished stocks in the South Atlantic and Gulf of Mexico demonstrates the economic significance of forgone recreational fishing opportunities to the regional economy due to historic overfishing. The inability of the focus stocks to produce at optimum yield lost the South Atlantic and Gulf of Mexico regional economies millions of dollars of potential economic activity. Decades of overfishing have reduced the stocks to fractions of their historic levels. For one stock, South Atlantic red snapper, the extent of overfishing has reached the point where commercial and recreational fishing is, at least temporarily, prohibited.

The impacts of overfishing extend well beyond the loss in recreational fishing expenditures and associated economic activity. The loss of recreational fishing opportunities may incur greater welfare losses for recreational fishermen than is implied by the amount of money they spend on recreational fishing. Moreover, as fish stocks decline, commercial fisheries and the businesses that rely directly or indirectly on commercial fishing activity are also hurt. Lastly, catch losses do not capture the impacts to ecosystems and biodiversity. Despite these limitations, this study provides strong economic evidence in support of maintaining healthy ocean fish populations and continuing efforts to rebuild stocks currently subject to overfishing or classified as overfished.

REFERENCES

Bergstrom, J.C., J.H. Dorfman, and J.B. Loomis. 2004. “Estuary Management and Recreational Fishing Benefits.” *Coastal Management* 32(4):417-432.

Bonini, S., N. Saran, and L. Stein. 2011. Design for Sustainable Fisheries: Modeling Fishery Economics. Miami: McKinsey & Co.

Coleman, F.C., C.C. Koenig, K.M. Scanlon, S. Heppell, S. Heppell, and M.W. Miller. 2010. “Benthic Habitat Modification through Excavation by Red Grouper, Epinephelus morio, in the Northeastern Gulf of Mexico.” *Open Fish Science Journal* (3):1–15.

Gentner, B. 2004. Examining Target Species Substitution in the Face of Changing Recreational Fishing Policies. In: What Are Responsible Fisheries? Proceedings of the Twelfth Biennial Conference of the International Institute of Fisheries Economics and Trade. July 20–30, 2004. Tokyo.

Gentner, B., and S. Steinback. 2008. The Economic Contribution of Marine Angler Expenditures in the United States, 2006. U.S. Department of Commerce, NOAA Tech. Memo. NMFS F/SPO-94.

Gentner Consulting Group (GCG). 2012. Directed Effort and Expenditures: Prepared for Ecotrust. Silver Spring, Md.: Gentner Consulting Group. Available as Appendix D.

Goodyear, C.P. 1988. Recent Trends in Red Snapper Fishery of the Gulf of Mexico. NMFS. SEFSC. Miami. CRD 87/88-16. Memo. Rpt.

Grainger, R.J., and S.M. Garcia. 1996. Chronicles of Marine Fishery Landings (1950–1994): Trend Analysis and Fisheries Potential. FAO Fisheries Technical Paper 359. Rome: FAO.

Gulf of Mexico Fishery Management Council (GMFMC). 2001. Secretarial Amendment 2: Re-building plan for amberjack for the Reef Fish Fishery FMP. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2004. Final Amendment 22 to the Reef Fish Fishery Management Plan to Set Red Snapper Sustainable Fisheries Act Targets and Thresholds, Set a Rebuilding Plan, and Establish Bycatch Reporting Methodologies for the Reef Fish Fishery. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2006. Final Amendment 26 to the Gulf of Mexico Reef Fish Fishery Management Plan to Establish a Red Snapper Individual Fishing Quota Program. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2007. Amendment 27 to the Reef Fishery Management Plan. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2008a. Reef Fish Amendment 30A: Greater Amberjack, Gray Triggerfish, Including Supplemental Environmental Impact Statement, Regulatory Impact Review, and Regulatory Flexibility Act Analysis. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2008b. Reef Fish Amendment 30B: Gag, Red Grouper, Including Supplemental Environmental Impact Statement, Regulatory Impact Review, and Regulatory Flexibility Act Analysis. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2011. Reef Fish Amendment 32 Gag Grouper: Rebuilding Plan, Annual Catch Limits, Management Measures and Red Grouper Annual Catch Limits, Management Measures Grouper Accountability Measures. Tampa, Fla.; St. Petersburg, Fla.: GMFMC; NOAA.

GMFMC. 2012. Public Hearing Draft of Amendment 35 to Reef Fish Fishery Management Plan Addressing Changes to the Greater Amberjack Rebuilding Plan and Adjustments to the Stock Annual Catch Limit. Tampa, Fla.: St. Petersburg, Fla.: GMFMC; NOAA.

Heneman, B. 2002. Federal Fishery Laws: New Model Needed to Sustain Fisheries and Ecosystems. Pp. 1-5. In: Managing Marine Fisheries in the United States, Proceedings of the Pew Oceans Commission Workshop on Marine Fishery Management. Arlington, Va.: Pew Oceans Commission.

Hesselgrave, T., S. Kruse, and K.A. Sheeran. 2011. The Hidden Cost of Overfishing to Commercial Fishermen: A 2009 Snapshot of Lost Revenues. Report to The Pew Charitable Trusts. Portland, Ore.: Ecotrust.

Huntsman, G.R., J.C. Potts, R. Mays, R.L. Dixon, P.W. Willis, M. Burton, and B.W. Harvey. 1992. A Stock Assessment of the Snapper-Grouper Complex in the U.S. South Atlantic Based on the Fish Caught in 1990. Report to the South Atlantic Fishery Management Council, 1 Southpark Circle, Suite 306, Charleston, S.C. 29407.

Jennings, S., M.J. Kaiser, and J.D. Reynolds. 2001. *Marine Fisheries Ecology*. Malden, Mass.: Blackwell Science Ltd.

Legovic, T., J. Klanjscek, and S. Gecek. 2010. “Maximum Sustainable Yield and Species Extinction in Ecosystems.” *Ecological Modelling* 221:1569-1574.

Loomis, J.B. and P. Fix. 1998. Testing the Importance of Fish Stocking as a Determinant of the Demand for Fishing Licenses and Fishing Effort in Colorado. *Human Dimensions of Wildlife* 3(3):46–61.

Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Perterson, C.H. and J.B.C. Jackson. 2006. “Depletion, Degradation, and Recovery Potential of Estuaries and Coastal Seas.” *Science* 312:1806–1809.

Mace, P.M. 2004. “In Defense of Fisheries Scientists, Single-Species Models and Other Scapegoats: Confronting the Real Problems.” *Marine Ecological Progress Series* 274: 285-291.

Manooch, C.S., III, J.C. Potts, D.S. Vaughan, and M.L. Burton. 1998. Population assessment of the red snapper from the southeastern United States. *Fisheries Research* 38:19−32.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Current State and Trends: Findings of the Condition and Trends Working Group. Washington: Island Press.

MSA, Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006, Pub. L. No. 109-479, 120 Stat. 3575 (2007).

Myers, R.A., and B. Worm. 2003. “Rapid Worldwide Depletion of Predatory Fish Communities.” *Nature* 423: 280–283.

National Marine Fisheries Service (NMFS). 2001. Report to Congress: Status of Fisheries of the United States, 2000. Silver Spring, Md.: NMFS.

NMFS. 2002. Toward Rebuilding America’s Marine Fisheries: Annual Report to Congress on the Status of U.S. Fisheries, 2001. Silver Spring, Md.: U.S. Department of Commerce, NOAA, NMFS Office of Sustainable Fisheries.

NMFS. 2009. National Marine Fisheries Service: 2008 Report to Congress: The Status of U.S. Fisheries. Silver Spring, Md.: U.S. Department of Commerce, NOAA, NMFS Office of Sustainable Fisheries.

NMFS. 2010a. National Marine Fisheries Service: 2009 Report to Congress: The Status of U.S. Fisheries. Silver Spring, Md.: U.S. Department of Commerce, NOAA, NMFS Office of Sustainable Fisheries.

NMFS. 2010b. Summary of Stock Status for FSSI and Non-FSSI Stocks—Fourth Quarter 2010. www.nmfs.noaa.gov/sfa/statusoffisheries/2010/fourth/Q4%202010%20FSSInonFSSIStockStatus.pdf.

NMFS. 2011a. National Marine Fisheries Service: 4th Quarter 2011 Summary of Stock Status for FSSI Stocks. NMFS. http://www.nmfs.noaa.gov/sfa/statusoffisheries/2011/fourth/Q4%202011%20FSSI%20and%20nonFSSI%20StockStatus.pdf.

NMFS. 2011b. National Marine Fisheries Service 2010 Report to Congress: The Status of U.S. Fisheries. U.S. Department of Commerce, NOAA.

NMFS. 2011c. Fish Stock Sustainability Index: 2011 Quarter 1 Update through March 31, 2011. http://www.nmfs.noaa.gov/sfa/statusoffisheries/2011/first/FSSI_SummaryChanges_Q1_2011.pdf.

NMFS; SERO. 2011. Draft Environmental Assessment, Regulatory Impact Review, and Regulatory Flexibility Act Analysis for a Temporary Rule to set the 2011 Gulf of Mexico Gag Recreational and Commercial Management Measures. St. Petersburg, Fla.: NMFS, SERO.

National Oceanic and Atmospheric Administration (NOAA). 2012. Recreational Landings and Annual Catch Limits. NOAA Fisheries Service, Southeast Regional Office – St. Petersburg, Fla. Last updated April 3, 2012. http://sero.nmfs.noaa.gov/sf/RecreationalLandingsandCatchLimits.html.

NOAA. 2010. Fisheries economics of the United States 2009: Economics and sociocultural status and trends series. Silver Spring, Md.: NOAA, NMFS, U.S. Department of Commerce.

Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J.., Sumaila, U.R., Walters, C.J., Watson, R. and D. Zeller. 2002. "Towards Sustainability in World Fisheries." *Nature* 418: 689–695.

Potts, J.C., M.L. Burton, and C.S. Manooch III. 1998. Trends in Catch Data and Estimated Static SPR Values for Fifteen Species of Reef Fish Landed Along the Southeastern United States. Report to the South Atlantic Fishery Management Council, 1 Southpark Circle, Suite 306, Charleston, S.C. 29407. 45 pp.

Potts, J.C., and K. Brennan. 2001. Trends in Catch Data and Estimated Static SPR Values for Fifteen Species of Reef Fish Landed Along the Southeastern United States. Report prepared for the SAFMC.

Regional Fishery Management Councils. 2012. U.S. Regional Fishery Management Councils: Opportunities and Challenges. Regional Fishery Management Councils under NOAA Award #NA05NMF4410033. http://www.fisherycouncils.org/USFMCsections/USRFMCweb.pdf.

Roughgarden, J., and F. Smith. 1996. "Why Fisheries Collapse and What to Do About It." *Proceedings of the National Academy of Sciences* 93:5078-5083.

Schirripa, M.J., and C.M. Legault. 1997. Status of the Gag Stocks of the Gulf of Mexico: Assessment 2.0. Oct. 1, 1997. NOAA; SEFSC, Miami Laboratory.

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

South Atlantic Fishery Management Council (SAFMC). 1996. Final Amendment 2 (Bycatch Reduction) to the Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region with Final Supplemental Environmental Impact Statement, Regulatory Impact Review, and Social Impact Assessment. Charleston, S.C. SAFMC.

SAFMC. 2006. Snapper Grouper Amendment 13C. Charleston, S.C.; St. Petersburg, Fla.: SAFMC; NMFS.

SAFMC. 2007. Snapper Grouper Amendment 15A and Environmental Assessment. North Charleston, S.C.; St. Petersburg, Fla.: SAFMC; NMFS.

SAFMC. 2008. Final Snapper Grouper Amendment 15B and Environmental Assessment. North Charleston, S.C.: SAFMC.

SAFMC. 2010a. Amendment 17A to the Fishery Management Plan for the Snapper Grouper Fishery of the South Atlantic Region with Final Environmental Impact Statement, Initial Regulatory Flexibility Act Analysis, Regulatory Impact Review, and Social Impact Assessment/Fishery Impact Statement. North Charleston, S.C.: SAFMC.

SAFMC. 2010b. Amendment 17B to the Fishery Management Plan for the Snapper-Grouper Fishery of the South Atlantic Region with Environmental Assessment, Initial Regulatory Flexibility Act Analysis, Regulatory Impact Review and Social Impact Assessment/Fishery Impact Statement. North Charleston, S.C.: SAFMC.

SAFMC. 2011a. Amendment 24: To the Snapper Grouper Fishery Management Plan of the South Atlantic Region. Red Grouper Rebuilding Plan. North Charleston, S.C.; St. Petersburg, Fla.: SAFMC; NOAA.

SAFMC. 2011b. Comprehensive Annual Catch Limit (ACL) Amendment for the South Atlantic Region. North Charleston, S.C.; St. Petersburg, Fla.: SAFMC; NMFS.

SouthEast Data, Assessment, and Review (SEDAR). 2001. SEDAR 1. Stock Assessment of South Atlantic Red Porgy. Charleston, S.C.: SEDAR, SAFMC.

SEDAR. 2002. SEDAR 2. South Atlantic Black Sea Bass; Stock Assessment Report 1. Charleston, S.C.: SEDAR, SAFMC.

SEDAR. 2004. SEDAR 4. Stock Assessment Report 1: Deepwater Snapper-Grouper Complex in the South Atlantic. Charleston, S.C.: SEDAR, SAFMC.

SEDAR. 2005a. SEDAR Report of Stock Assessment: Black Sea Bass Update Process #1. Beaufort, N.C.: SEDAR, SAFMC.

SEDAR. 2005b. SEDAR 7. Stock Assessment Report of SEDAR 7: Gulf of Mexico Red Snapper: Assessment Report 1. Charleston, S.C.: SEDAR.

SEDAR. 2006a. Stock Assessment of Red Porgy off the Southeastern United States. SEDAR Update Assessment. Beaufort, N.C.: SEDAR, SAFMC.

SEDAR. 2006b. SEDAR 9. Stock Assessment Report of Gulf of Mexico Gray Triggerfish: SEDAR 9 Assessment Report 1. Charleston, S.C.: SEDAR, GMFMC.

SEDAR. 2006c. SEDAR 9. Stock Assessment Report Gulf of Mexico Greater Amberjack: SEDAR 9 Assessment Report 2. Charleston, S.C.: SEDAR, GMFMC.

SEDAR. 2006d. SEDAR 10. Stock Assessment Report Gulf of Mexico Gag Grouper: SEDAR 10 Stock Assessment Report 2. Charleston, S.C.: SEDAR, GMFMC.

SEDAR. 2008. SEDAR 15. Stock Assessment Report 1 (SAR 1) South Atlantic Red Snapper. North Charleston, S.C.: SEDAR, SAFMC.

SEDAR. 2009a. Stock Assessment of Gag in the Gulf of Mexico: SEDAR Update Assessment. Miami: SEDAR, GMFMC.

SEDAR. 2009b. Stock Assessment of Red Snapper in the Gulf of Mexico: SEDAR Update Assessment. Miami: SEDAR, GMFMC.

SEDAR. 2010a. SEDAR 19. Stock Assessment Report: South Atlantic Red Grouper. North Charleston, S.C.: SEDAR, SAFMC.

SEDAR. 2010b. SEDAR 24. Stock Assessment Report, South Atlantic Red Snapper. North Charleston, S.C.: SEDAR.

SEDAR. 2011a. SEDAR 25. Stock Assessment Report: South Atlantic Black Sea Bass. North Charleston, N.C.: SEDAR.

SEDAR. 2011b. Stock Assessment of Gray Triggerfish in the Gulf of Mexico: SEDAR Update Assessment. Miami: SEDAR.

SEDAR. 2011c. SEDAR 9 Stock Assessment Update Report: Gulf of Mexico Greater Amberjack. North Charleston, S.C.: SEDAR.

Srinivasan, U.T., W.L. Cheung, R. Watson and U.R. Sumaila. 2010. "Food Security Implications of Global Marine Catch Losses Due to Overfishing." *Journal of Bioeconomics* 12(3):179-182.

Staff of Beaufort Laboratory, Southeast Fisheries Science Center. 1991. South Atlantic Snapper Grouper Assessment 1991. Report to the South Atlantic Fishery Management Council, 1 Southpark Circle, Suite 306, Charleston, S.C. 29407. 21 pp., 4 tables, 39 figures.

Turner, S.C., C.E. Porch, D. Heinemann, G.P. Scott, and M. Ortiz. 2001. Status of the gag stocks of the Gulf of Mexico: Assessment 3.0. August 2001. NOAA; SEFSC, Miami Laboratory, Sustainable Fisheries Division contribution SFD-01/02-134.

Vaughan, D.S. and M.H. Prager. 2002. Severe Decline in Abundance of the Red Porgy (*Pagrus Pagrus*) Population off the Southeastern United States. *Fishery Bulletin* 100:351–375.

Vaughan, D.S., G.R. Huntsman, C.S. Manooch III, F.C. Rohde, and G.F. Ulrich. 1992. Population Characteristics of the Red Porgy, *Pagrus Pagrus*, Stock off the Carolinas. *Bulletin of Marine Science* 50:1–20.

Vaughan, D.S., M.R. Collins, and D.J. Schmidt. 1995. Population Characteristics of the Black Sea Bass *Centropristis Striata* from the Southeastern U.S. *Bulletin of Marine Science* 56:250−267.

Vaughan, D.S. 1996. Population Characteristics of the Black Sea Bass *Centropristis Striata* from the U.S. Southern Atlantic Coast. Report to the South Atlantic Fishery Management Council, Charleston, S.C., 59 pp.

Walters, C.J., V. Christensen, S.J. Martell, and J.F. Kitchell. 2005. "Possible Ecosystem Impacts of Applying MSY Policies from Single-Species Assessment." *ICES Journal of Marine Science* 62:558-568.

Worm, B., *et al*. 2006. "Impacts of Biodiversity Loss on Ocean Ecosystem Services." *Science* 314: 787–790.

Appendix A. SEDAR Process

The following description of the SEDAR process, included in many of the SEDAR assessments, is quoted from SEDAR (2010b).

SouthEast Data, Assessment, and Review (SEDAR) is a cooperative Fishery Management Council process initiated in 2002 to improve the quality and reliability of fishery stock assessments in the South Atlantic, Gulf of Mexico, and U.S. Caribbean. The improved stock assessments from the SEDAR process provide higher quality information to address fishery management issues. SEDAR emphasizes constituent and stakeholder participation in assessment development, transparency in the assessment process, and a rigorous and independent scientific review of completed stock assessments.

SEDAR is managed by the Caribbean, Gulf of Mexico, and South Atlantic Regional Fishery Management Councils in coordination with NOAA Fisheries and the Atlantic and Gulf States Marine Fisheries Commissions. Oversight is provided by a Steering Committee composed of NOAA Fisheries representatives: Southeast Fisheries Science Center Director and the Southeast Regional Administrator; Regional Council representatives: Executive Directors and Chairs of the South Atlantic, Gulf of Mexico, and Caribbean Fishery Management Councils; and Interstate Commission representatives: 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 process, which is conducted via webinars, 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. The completed assessment, including the reports of all 3 workshops and all supporting documentation, is then forwarded to the Council SSC for certification as 'appropriate for management' and development of specific management recommendations.

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

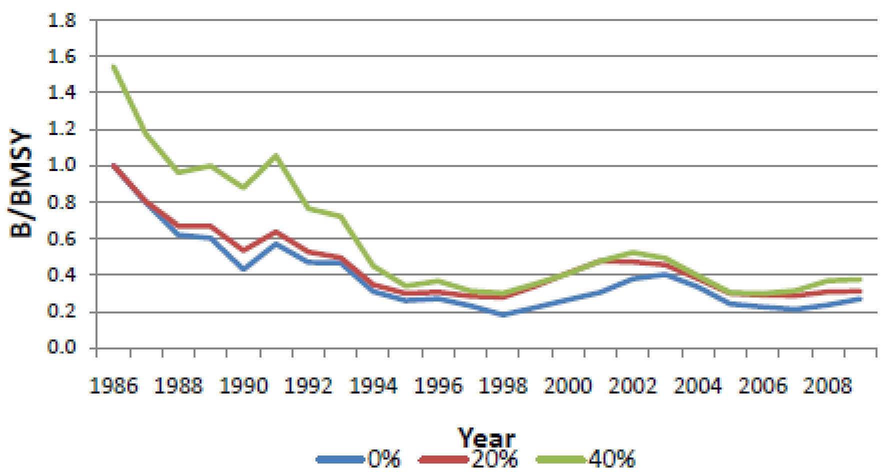
SEDAR Review Workshop Panels consist of a chair, three reviewers appointed by the Center for Independent Experts (CIE), and one or more SSC representatives appointed by each council having jurisdiction over the stocks assessed. The Review Workshop Chair is appointed by the council having jurisdiction over the stocks assessed and is a member of that council's SSC. Participating councils may appoint representatives of their SSC, Advisory, and other panels as observers.

Appendix B. SEDAR Gulf of Mexico Greater Amberjack Biomass Figure

Tabulated biomass data for the Gulf of Mexico greater amberjack stock was not presented in the stock's assessments allowing for the creation of figures like those presented in Section 4. However, a related figure was available and is presented in this appendix for context on the stock's abundance levels.

The Gulf of Mexico greater amberjack stock assessment was updated in 2011 (SEDAR, 2011c), and while not tabulated, a figure showing the ratio of total biomass to B_{MSY} over time was presented (Figure B.1). Anytime the value of B/B_{MSY} is less than one, it means the biomass at that time is below the B_{MSY} value. The three differently colored trajectories in Figure B.2. represent three levels of discard mortality when input into the biomass model. In all cases, the B/B_{MSY} ratio is consistently below one after about 1992, but may have been so as early as 1986.

Figure B.1. Gulf of Mexico greater amberjack B/B_{MSY} Trajectory



Source: SEDAR, 2011c, p. 111

Appendix C. Data Reference Table

Table C.1. Data sources for MSY, OY, and recreational allocation values used in this analysis

South Atlantic stocks	MSY value source	OY value source	Rec. allocation % source
Black sea bass	SEDAR Update (SEDAR, 2005)	Amendment 15A (SAFMC, 2007)	Amendment 13C (SAFMC, 2006)
Red grouper	SEDAR 19 (SEDAR, 2010a)	Amendment 24 (SAFMC, 2011a)	Amendment 24 (SAFMC, 2011a)
Red porgy	SEDAR Update (SEDAR, 2006a)	Amendment 15A (SAFMC, 2007)	Amendment 15B (SAFMC, 2008)
Red snapper	SEDAR 15 (SEDAR, 2008)	SEDAR 15 (SEDAR, 2008)	Comp. ACL Amendment (SAFMC, 2011b)
Snowy grouper	SEDAR 4 (SEDAR, 2004)	Amendment 15A (SAFMC, 2007)	Amendment 17B (SAFMC, 2010b)

Gulf of Mexico stocks	MSY value source	OY value source	Rec. allocation % source
Gag	SEDAR Update (SEDAR, 2009a)	SEDAR Update (SEDAR, 2009a)	Amendment 30B (GMFMC, 2008b)
Gray triggerfish	SEDAR 9 (SEDAR, 2006b)	Amendment 30A (GMFMC, 2008a)	Amendment 30A (GMFMC, 2008a)
Greater amberjack	SEDAR 9 (SEDAR, 2006c)	Average based on values found in Amendment 30A (GMFMC, 2008a)	Amendment 30A (GMFMC, 2008a)
Red snapper	SEDAR Update (SEDAR, 2009b)	SEDAR Update (SEDAR, 2009b)	Amendment 27 (GMFMC, 2007)

Appendix D: Directed Effort and Expenditures (Gentner Consulting Group, 2012)

Report for Ecotrust: 2012

Silver Spring, Md. 20901

Directed Effort

The analysis presented here will utilize data collected by the Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS consists of two independent and complementary surveys: a field intercept survey and a random digit dial (RDD) survey of coastal households. The intercept survey is a creel survey used to estimate mean catch-per-trip by species across several strata, including fishing wave (two-month period), fishing mode (shore, private or rental boat, or for-hire fishing vessel), and state. Data elements collected during the base part of the intercept survey include state, county, and ZIP code of residence, hours fished, primary area fished, target species, gear used, and days fished in the last two and 12 months. The creel portion of the survey collects length and weight of all fish species retained by the angler and the species and disposition of all catch not retained by the angler. The intercept data will be used for this analysis.

Directed effort can be defined as any trip where the target species was caught, targeted or caught and/or targeted. This analysis includes any trip where the target species was caught and/or targeted. While targeted trips may be preferred from a behavioral standpoint, many of the species included in this examination are bycatch species that are rarely targeted. Also, the targeting question is asked after the trip has occurred, raising questions about whether the angler's answer gauges an actual ex post targeting decision or simply an ex ante measure of what the angler had success catching. Additionally, the MRFSS survey only allows a primary and secondary target choice, not groups or assemblages, raising concerns in cases where it is more likely that anglers are targeting "reef fish" or "bottom fish." Finally item non-response is very high for the targeting question. In 2010, 55.3% of all intercepted anglers in the South Atlantic gave no primary or secondary target. This lack of response may be a reflection of the inability to indicate a group of species that were targeted.

In the South Atlantic region, this analysis focused on black sea bass (*Centropristis striata*), red grouper (*Epinephelus morio*), red porgy (*Pagrus pagrus*), red snapper (*Lutjanus campechanus*) and snowy grouper (*Epinephelus niveatus*). In the Gulf of Mexico region this analysis focused on gag grouper (*Mycteroperca microlepis*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*) and red snapper (*Lutjanus campechanus*). Because the MRFSS survey is not conducted in the state of Texas, Texas effort is not included in the effort, expenditure or impact estimates.

The MRFSS program does not estimate directed effort for specific species. Instead this examination uses code developed by GCG in cooperation with the MRFSS program. This estimation routine post-stratifies the MRFSS state-level effort estimates by the proportion of anglers who caught and/or targeted the species above. These estimates are not additive across species groups because an angler could have caught or targeted more than one species on a given trip. For example, an angler with a stated preference for targeting red snapper could catch a snowy grouper and a red porgy on the same trip. That single trip would show up in directed effort estimates for red snapper, snowy grouper, and red porgy.

Directed Expenditures

Because the MRFSS constitutes the best nationwide sample frame for marine recreational angling and offers considerable savings over implementing a new program, economic data collection is added-on to the MRFSS effort. During March through December of 2006, an intercept add-on survey was conducted to obtain data on angler trip expenditures. These data were used to estimate total trip expenditures across the nine species that are the focus of this analysis.

Expenditures were estimated by summing expenditures across all expenditure categories and calculating mean total expenditure by species, mode and region using the same estimation code used for Gentner and Steinback (2008). Because anglers can opt out of participating in the add-on survey, sample is lost. As a result, it is more difficult to estimate species-specific mean total trip expenditures than directed effort estimates because there is less sample. To address this problem, if the proportion of standard error (PSE) of the species, mode and region-specific expenditure estimate was above 20%, the species-specific estimate was discarded in favor of expenditure estimates generated across a group of species. In this case, because the list of species includes reef or bottom fish species in each region, the replacement expenditure group was generated by estimating the expenditures across all species together in each region.

Economic Impacts

It was beyond the scope of this project to estimate new regional-level multipliers. Instead, U.S. national-level multipliers were taken from Gentner and Steinback (2008) and applied to the expenditure estimates. This analysis yields estimates of total economic output, income, value added (contribution to gross domestic product) and employment.

References

Gentner, B., and S. Steinback (2008). The Economic Contribution of Marine Angler Expenditures in the United States, 2006. U.S. Department of Commerce, NOAA Tech. Memo. NMFS F/SPO-94, 301 pp. http://www.st.nmfs.noaa.gov/st5/publication/AnglerExpenditureReport/AnglerExpendituresReport_ALL.pdf

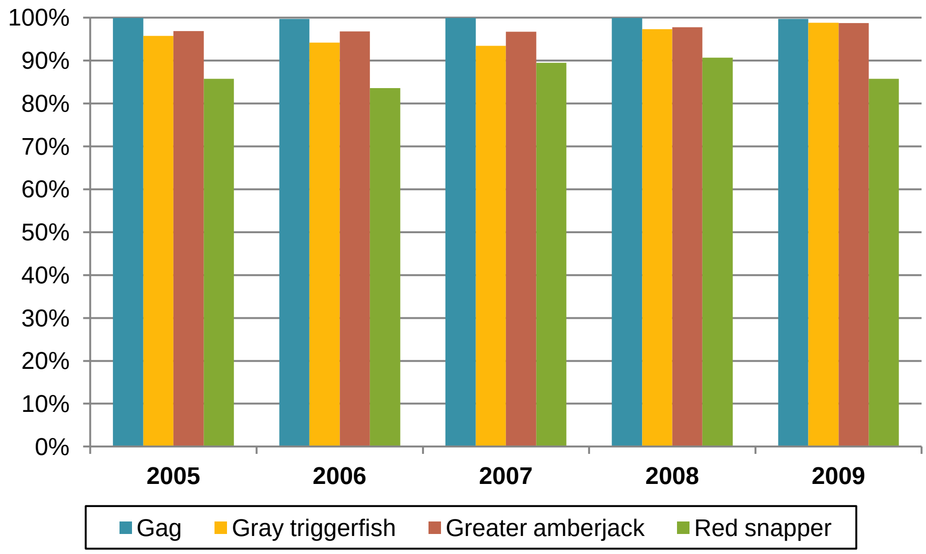
GENTNER CONSULTING GROUP

Appendix E. Texas Sensitivity Analysis

Because the MRFSS survey is not conducted in Texas, current and potential effort and expenditure estimates for that state are not presented in this analysis. To estimate the impact of those exclusions on our final estimates, we performed a brief sensitivity analysis.

Figure E.1. displays the recreational harvest of the four Gulf of Mexico focus stocks in this analysis—gag, gray triggerfish, greater amberjack, and red snapper, *excluding* Texas harvest data. The purpose of this figure is to demonstrate the extent to which Texas recreational effort and expenditures data may be missing in the main analysis presented in this study and to determine which stocks may be more sensitive to their exclusion.

Figure E.1. Gulf of Mexico recreational harvest of focus stocks excluding Texas, 2005–2009



Source: Current study using SERO catch data SERO catch data provided by personal communication with N. Farmer, Mar. 21, 2012

Out of the four stocks, Gulf of Mexico red snapper may be most sensitive to the exclusion of Texas effort and expenditure data. Over the five-year period of 2005–2009, the contribution of recreational harvests made in Texas to total GMFMC recreational harvests averaged 13% for that stock while averaging less than 5% for the other three stocks (4.1% for gray triggerfish, 2.7% for greater amberjack, and 0.2% for gag).

To perform our sensitivity analysis, we ran the catch loss analysis for Gulf of Mexico red snapper under three different case studies:

1.) including Texas catch data and estimates of Texas effort and expenditures;
2.) including Texas catch data but excluding Texas effort and expenditures; and
3.) excluding all Texas contributions to catch, effort, and expenditures.

Because the MRFSS survey is not conducted in Texas, we had to create our own estimates of Texas effort and expenditure data to run Case Study #1. To do so, we assumed that if Texas harvests are 13% of total harvests, similarly Texan contributions to total effort and expenditures would likely constitute 13% of total regional effort and expenditures. Estimates of average expenditure per red snapper trip for the Gulf region ($91.37) remained consistent across case studies as these are likely similar across GMFMC region states, including Texas.

Table E.1. presents the three case study runs detailing data inputs and estimated results. Case Study #2 is our preferred method and how the analysis was conducted for this report.

Table E.1. Texas case study sensitivity analysis for Gulf of Mexico red snapper

Assumptions	Average harvest 2005–09 (lbs. ww)	Average effort 2005–09	HPUE lbs./ effort	Average expenditures 2005–09 ($)	Average exp/ trip	Estimated # of potential trips	Estimated potential expenditures ($)	ESTIMATED CATCH LOSS ($)	% realized
1. TX catch and estimates of effort and expenditures included	4,176,262	314,606	13.27	$28,746,547	$91.37	492,785	$45,027,238	**$16,280,690**	**64%**
2. ***PREFERRED*** TX catch included. TX effort and expenditures excluded	4,176,262	273,694	15.26	$25,008,252	$91.37	428,701	$39,171,748	**$14,163,496**	**64%**
3. TX catch, effort, and expenditures excluded	3,633,167	273,694	13.27	$25,008,252	$91.37	492,785	$45,027,238	**$20,018,985**	**56%**

Source: Authors' estimates

Case Study #1 is likely most accurate, estimating a $16.3 million catch loss annually for 2005–2009, with current expenditure levels realizing approximately 64% of their estimated potential. However, our method of altering the effort and expenditure data to include estimates of Texan contributions is very simple; actual Texas effort and expenditure data may not mirror the state's harvest ratio to the region. Some actual Texas effort data is obtainable from each stock's stock assessment, however it could not be used in this analysis as the data were, first, not consistent with the MRFSS data we used, and second, were not consistent across stocks or years.

Case Study #2, the preferred method, does not alter any of the available source data for harvest, efforts, or expenditures, and achieves the same % realized estimate, 64%, as Case Study #1. This case study results in a catch loss estimate just under that of Case Study #1 at approximately $14.2 million.

Case Study #3, excluding Texas catch data, directly overestimates catch losses for the region by ignoring fish that were already caught by Texas and their associated trip expenditures, and results in the highest estimated average catch loss of $20 million annually over 2005–2008, with approximately only 56% of that amount estimated to be realized each year.

Excluding Texas effort and expenditure data, preferred method Case Study #2 has three significant implications:

1) The harvest per unit of effort (HPUE) estimates are likely slightly inflated for the GMFMC region stocks, as they attribute total region harvests to incomplete (missing Texas) effort counts.
2) Estimated potential trips and expenditures for the Gulf of Mexico region are likely underestimated,
3) Catch loss estimates for the Gulf of Mexico stocks may thus be underestimated.

Overall, we believe that electing the methods used for Case Study #2 are most defensible and at worst may result in catch loss estimates for the Gulf of Mexico stocks to be underestimated.