Fisheries Resource Status and Management Alternatives for the Southeast Florida Region

Southeast Florida Coral Reef Initiative
Fishing, Diving, and Other Uses
Local Action Strategy Project 18 & 20A

Southeast Florida Coral Reef Initiative
Acting above to protect what's below.

Fisheries Resource Status and Management Alternatives for the Southeast Florida Region

Final Report

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August 10, 2011

Completed in Fulfillment of PO D01144525 for

Southeast Florida Coral Reef Initiative
Fishing, Diving and Other Uses
Local Action Strategy Project 18 & 20A

and

Florida Department of Environmental Protection
Coral Reef Conservation Program
1277 N.E. 79th Street Causeway
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This report should be cited as follows:

Ault, J.S. and E.C. Franklin. 2011. Fisheries Resource Status and Management Alternatives for the Southeast Florida Region. Report to Florida DEP. Miami Beach, FL. Pp 105.

This report was prepared for the Florida Department of Environmental Protection (DEP) by Jerald S. Ault and Erik C. Franklin. Funding for this report was provided in part by a Coral Reef Conservation Program grant from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and Coastal Resource Management Award No. NA06N0S4190100, and by the FDEP, through its Coral Reef Conservation Program. The total cost of the project was $24,000, of which 100 percent was provided by the NOAA. The views, statements, findings, conclusions and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida, U.S. Department of Commerce, NOAA, or any of its subagencies although these agencies did provide reviews and edits of the document.

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Acknowledgements

We thank D.E. Harper of NOAA Fisheries Southeast Fisheries Science Center for assistance in obtaining fishery-dependent databases. J. Monty of the Florida Department of Environmental Protection's Coral Reef Conservation Program provided exemplary grant management assistance and document editing throughout the life of the project.

Executive Summary

The sustainability of multispecies coral reef fisheries is a key conservation concern given their economic and ecological importance. Assessment of catch and effort trends and numerical model analyses were conducted to evaluate population status via resource trends and reference points (or sustainability benchmarks) for sixteen fish and one lobster species of the coral reef complex in the southeast Florida region (i.e., Miami-Dade, Broward, Palm Beach, and Martin counties). This report did not provide a stock assessment for any of the species but rather a synopsis of pertinent information on their status and trends for managers. Since the study was restricted to a limited area, results were not indicative of overall stock status throughout the geographic range of each species but rather reflect the condition of fisheries activities and fish populations within the southeast Florida region only. Although the study domain was confined to Florida state waters, the report provides analysis with both Florida state benchmarks and U. S. federal fisheries benchmarks to characterize the trends and condition of these species in the southeast Florida region in as much detail as possible.

For Florida state fisheries benchmarks, the status of the red grouper (*Epinephelus morio*), black grouper (*Mycteroperca bonaci*), mutton snapper (*Lutjanus analis*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyrus chrysurus*), hogfish (*Lachnolaimus maximus*), white grunt (*Haemulon plumeri*), tomtate (*Haemulon aurolineatum*), great barracuda (*Sphyraena barracuda*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), blue angelfish (*Holacanthus bermudensis*) queen angelfish (*Holacanthus ciliaris*) rock beauty (*Holacanthus tricolor*), French angelfish (*Pomacanthus paru*), gray angelfish (*Pomacanthus arcuatus*), and spiny lobster (*Panulirus argus*) was examined through an analysis of catch and effort data from fishery-dependent datasets for 1990-2008. General trends in fisheries-dependent data were examined for all species over approximately the same time period. Trends (increasing, decreasing, unchanging, or unknown) were used as indicators of the condition of fish populations and fisheries in the southeast Florida region. An examination of recreational and commercial fisheries-dependent data showed that the fishery species had predominantly declining or unchanged trends in fisheries landings and effort for 1990 to 2008. Estimated headboat landings for five of the eleven reef fish species declined significantly from 1990-2006 but headboat angler days (fishing effort) also declined over the same time period. No significant declines in estimated marine recreational landings were found for 1990-2008 but this data encompassed the entire Florida east coast, not just the southeast Florida region. Marine aquaria commercial landings and effort of angelfish declined significantly from 1994 to 2009. Spiny lobster commercial fishery landings and effort declined significantly from 1990 to 2009. Commercial fishery landings in the southeast Florida region declined 73% from 485,000 pounds in 1990 to

178,000 pounds in 2006. Black grouper, red grouper, mutton snapper, yellowtail snapper, hogfish, and angelfish experienced significant declines in commercial landings with associated declines in effort over that time period.

For U. S. federal fisheries benchmarks, levels of fishing mortality against fishing mortality at maximum sustainable yield (MSY) and spawning potential ratio (SPR) were used as indicators of population status for all species with adequate catch, size, and life history information. Mean size ($\bar{L}$, in length) of animals in the exploited part of the population was estimated from three fishery-dependent size composition data sets (Trip Interview Program (TIP), Headboat, and Marine Recreational Fisheries Statistics Survey (MRFSS)) and used as an indicator of exploitation rates and fish population condition. In application, fishing mortality rates estimated from $\bar{L}$ of various data sources were comparable. All species but the greater amberjack experienced a level of fishing effort exceeding a sustainable rate (where F/F_{MSY} ratio > 1.0). Of the 11 reef fish species assessed, eight were below 30% SPR and four were below 10% SPR. These findings suggest that a majority of these reef fish species in the southeast Florida region are experiencing overfishing and exist at unsustainable levels.

Reef fishery management currently employed in the southeast Florida region include: minimum size limits, bag limits, gear restrictions, and time closures. Spatial closures are not currently used in the southeast Florida region, although they are commonly used for reef fish management elsewhere, including the Florida Keys, the Dry Tortugas, and along Florida's east and west coasts for deeper water reef fishes. Fishery management alternatives specific to the southeast Florida region are most likely limited to effort restrictions in the form of spatial closures for the species in decline but any actions undertaken should be framed within the context of the entire fishery domain, not just the southeast Florida region. The most critical need is fisheries-independent surveys of the reef fish targeted by fisheries in the Florida region that integrates with existing survey efforts. A glossary of fishery management terminology and abbreviations in included in Appendix 6.1. A bibliography of coral reef fish and fishery-relevant citations for southeast Florida region is included in an Appendix 6.2.

1.0 Introduction

The sustainability of multispecies coral reef fisheries is a key conservation concern given their economic and ecological importance, the significant dependence of subsistence and artisanal fishers on reef fisheries for their livelihoods, and the considerable and growing threats to coral reef habitats (i.e. coral bleaching and disease, pollution and climate change). Sustainability refers to the ability of an exploited population of fish to produce goods and services, including yields at suitable levels in the short term, while maintaining sufficient reproductive capacity to continue providing these goods and services into the indefinite future (Walters & Martell 2004). Intensive exploitation and overfishing is perhaps the major threat to these ecosystems (Russ 1991; Haedrich & Barnes 1997; Ault *et al.* 1998, 2005*a*; Coleman *et al.* 2000). However, insufficient and poor quality data and lack of an appropriate modeling framework have prevented sophisticated evaluations of the sustainability of reef fisheries. Generally lacking are the data needed to conduct modern stock assessments, including demographic rates and historical time-series of age-size structured catches by species, and the associated fishing effort by gear and recreational or commercial sector (Quinn & Deriso 1999; Haddon 2001; Quinn 2003).

Assessment of catch and effort trends and numerical model analyses were conducted to evaluate fishery status via resource reference points (or sustainability benchmarks) for sixteen fish and one lobster species of the coral reef complex in the southeast Florida region (i.e., Miami-Dade, Broward, Palm Beach, and Martin counties). Since the study was restricted to this limited area, results were not indicative of overall stock condition throughout the geographic range of each species but rather reflect the condition of populations and fisheries activities within the southeast Florida region only. Although the study domain was confined to Florida state waters, the report provides analysis with both Florida state and U. S. federal fisheries benchmarks to characterize the condition of these species in the southeast Florida region in as much detail as possible.

For Florida state fisheries benchmarks, the status of the red grouper (*Epinephelus morio*), black grouper (*Mycteroperca bonaci*), mutton snapper (*Lutjanus analis*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyrus chrysurus*), hogfish (*Lachnolaimus maximus*), white grunt (*Haemulon plumeri*), tomtate (*Haemulon aurolineatum*), great barracuda (*Sphyraena barracuda*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), blue angelfish (*Holacanthus bermudensis*) queen angelfish (*Holacanthus ciliaris*) rock beauty (*Holacanthus tricolor*), French angelfish (*Pomacanthus paru*), gray angelfish (*Pomacanthus arcuatus*), and spiny lobster (*Panulirus argus*) was examined through an analysis of catch, effort, and length composition data from fishery-dependent datasets for 1990-2008. General trends in fisheries-dependent data (catch, effort, etc. as available) were examined for all species over approximately the same time period. Trends (increasing, decreasing, unchanging, or unknown) were used as indicators of the condition of fish populations and fisheries in the southeast Florida region.

For U. S. federal fisheries benchmarks, levels of fishing mortality against fishing mortality at maximum sustainable yield (MSY) and spawning potential ratios (SPR) were used as indicators of population status for all species with adequate catch, size, and life history information (11 fish species). Mean size ($\bar{L}$, in length) of animals in the exploited part of the population was estimated from three fishery-dependent size composition data sets (Trip Interview Program (TIP), Headboat, and Marine Recreational Fisheries Statistics Survey (MRFSS)) and used as an indicator of exploitation rates and fish population condition. In application, fishing mortality rates estimated from $\bar{L}$ of various data sources were comparable. The length-based assessment methods have been utilized for Florida Keys and Puerto Rico reef fish populations (Ault *et al*. 1998, 2005*a*, *b*, 2008) to quantify the reef-fish community response to exploitation in the southeast Florida region (i.e., Miami-Dade, Broward, Palm Beach, and Martin counties). This approach is novel in that it has relatively simple data requirements and provides a community-level perspective on exploitation effects, yet also enables evaluation of stock-specific sustainability. The principal data used in the assessment were abundance at size for 11 species: red grouper (*Epinephelus morio*), black grouper (*Mycteroperca bonaci*), mutton snapper (*Lutjanus analis*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyrus chrysurus*), hogfish (*Lachnolaimus maximus*), white grunt (*Haemulon plumeri*), tomtate (*Haemulon aurolineatum*), great barracuda (*Sphyraena barracuda*), gray triggerfish (*Balistes capriscus*), and greater amberjack (*Seriola dumerili*) from the exploited coral reef complex sampled by fishery-dependent surveys. This analysis was not performed for angelfish (Pomacanthidae) or lobster (*Panulirus argus*) due to data deficiencies. The objectives of these analyses were to: (1) estimate mortality rates from the length composition data; (2) use the estimated mortality rates and other population-dynamic parameters in a length-structured population model to compute sustainability reference points (benchmarks) for the exploited reef fish species in the southeast Florida region; and (3) as a first step in the fishery management process, evaluate the species-specific benchmarks with respect to resource sustainability standards in an exploited fish community context. Additionally, based upon the results of the analyses, for those species whose status is determined to be unknown, gaps in data were identified, and for those species determined to be in decline according to the benchmark, a brief summary of current and potential fishery management alternatives was discussed but a comprehensive treatment of this topic was beyond the scope of this work.

2.0 Methods
2.1 Study Area

The southeast Florida region includes the waters offshore of Martin, Palm Beach, Broward, and Miami-Dade counties between the northern boundary of Biscayne National Park and the St. Lucie Inlet in Martin County and out to the state limit of 3 nautical miles (Fig. 1). The coral reef tract is comprised of three linear, limestone ridges of coral reef and colonized hardbottom running parallel to the shore from south Miami (25º34') to offshore of West Palm Beach (26 º43') (Walker *et al.* 2008). The reef and hardbottom areas extend north of West Palm Beach into waters offshore of Martin County but are less common and lack the linear, ridge structure of the southern reef areas (Collier *et al.* 2008). Additional bathymetric mapping is underway to characterize these areas (Fig. 1). The Gulf Stream Current flows from the Caribbean Sea, Gulf of Mexico, and Florida Keys to bring warm water and larvae to this region. For an excellent overview of the physical environment and biological communities of the southeast Florida region see Banks *et al.* 2008.

This marine region is adjacent to the highly urbanized coastal zone of Miami and Fort Lauderdale which results in considerable human use of marine resources. For example, the number of vessel registrations in the southeast Florida region has steadily increased over the past 45 years from less than 40,000 registered vessels in the mid-1960's to over 150,000 vessels in 2010 (Fig. 2). Commercial vessel registrations have remained stable over the time period while recreational registrations have tripled. The steady increase in the number of recreational registered vessels is only punctuated by slight decreases in the late 1980's and 2000's that coincided with economic declines and/or fuel price increases. The continuation of this trend in the future will mean further demand to enjoy the marine environment and utilize marine resources for recreation.

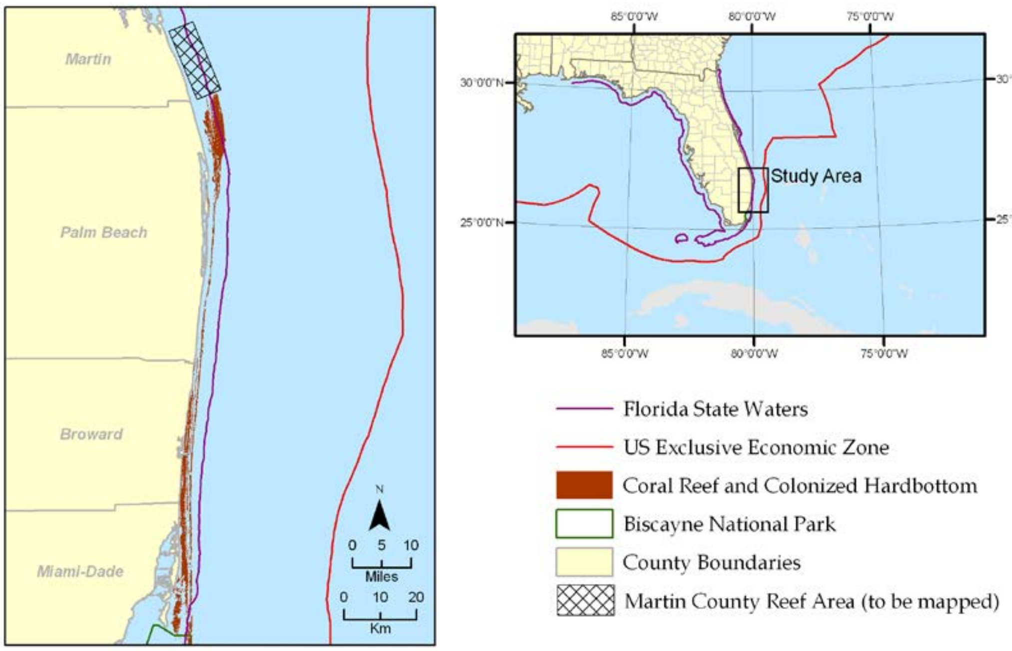

Figure 1. The southeast Florida region includes the waters offshore of Martin, Palm Beach, Broward, and Miami-Dade counties between the northern boundary of Biscayne National Park and the St. Lucie Inlet in Martin County out to the state limit of 3 nautical miles.

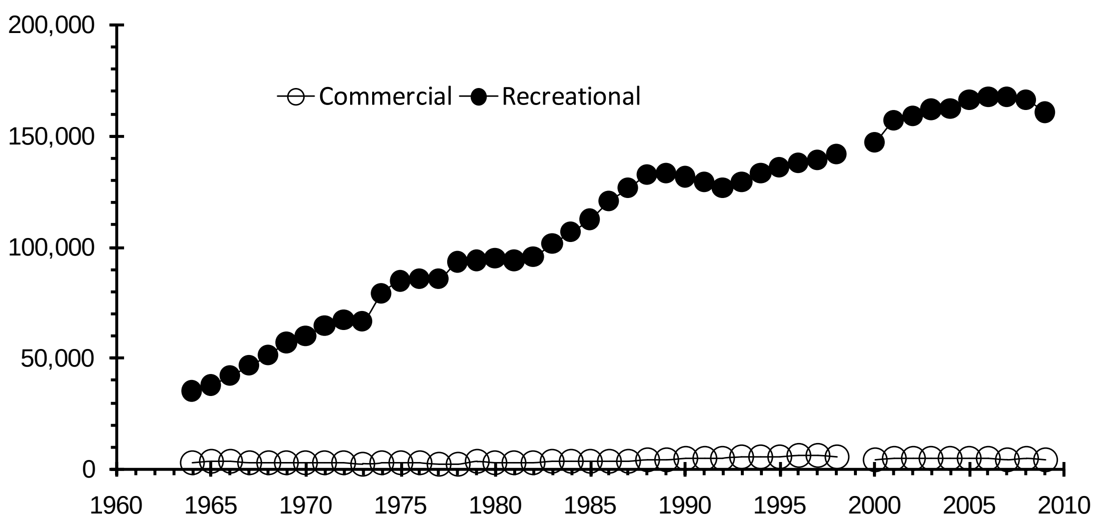

Figure 2. Number of recreational and commercial vessels registered in the southeast Florida region (i.e., Dade, Broward, Palm Beach and Martin counties, Florida) from 1964-2009. Years with missing values had no data available.

2.2 Data Sources

Fishery-dependent data sources for the recreational, headboat, and commercial fisheries were utilized in the study. Fishery-independent data sources were examined and found to lack adequate spatial extent and temporal frequency to provide a representative sample of reef fish populations of the southeast Florida region, and thus were not utilized in the following analyses.

2.2.1 Recreational Fishing

Two fishery-dependent data sources were included in the recreational fishing analysis, the Marine Recreational Fishing Statistical Survey (MRFSS) in section 2.2.1.1 and data from the National Marine Fisheries Service (NMFS) headboat fishery survey in section 2.2.1.2.

2.2.1.1 Marine Recreational Fishing Statistical Survey (MRFSS)

The National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistics Survey (MRFSS) collects data on recreational landings for shore-based fishing and from private vessels and charter boats in the United States. Begun in 1981, MRFSS estimates the catch, landings, and the combined total of releases and discards by state based on phone interviews and creel surveys. Phone surveys estimate marine recreational angler participation and effort while creel surveys document landings and collect information about catch composition, releases, discards, and fish used as bait. Fishing effort is the estimated number of fishing trips taken by individual anglers. We analyzed general trends in MRFSS estimated landings data for the east coast of Florida and length composition data for the eleven fish species in the southeast Florida region from 1990 through 2009. For more details on the MRFSS, visit the program website at the URL: http://www.st.nmfs.noaa.gov/st1/recreational/index.html.

2.2.1.2 NMFS Headboat Survey

The National Oceanic and Atmospheric Administration's (NOAA) Beaufort Laboratory's Southeast Region Headboat Survey collects fisheries and biological data to support stock management activities. Large fishing vessels that carry multiple recreational anglers who have paid "by the head" are called headboats. The Headboat Survey has collected data for Florida since 1978. We used headboat landings by species and angler days as a measure of fishing effort for 1990 through 2008 from Miami through Ft. Pierce, FL (St. Lucie County). For more information on the headboat survey program, visit their website at http://www.sefsc.noaa.gov/headboatsurveyprogram.jsp.

2.2.2 Commercial Fishing

The Accumulative Landings System (ALS) data consists of information on the quantity and value of seafood products caught by fishermen and sold to established seafood dealers or brokers. These data are monthly totals of the quantities landed and the value of the landings as well as biometric data (e.g., length, weight, etc.) for each species reported by dealers or brokers to the State fisheries agency. The Florida Trip Ticket Program and NMFS Trip Interview Program are both components of the ALS. For more information, visit the ALS at http://www.sefsc.noaa.gov/alsprogram.jsp.

2.2.2.1 Florida Trip Ticket

Commercial fisheries landings and fishing effort data have been collected by the state of Florida since November 1984. Florida law (Chapters 370.021, .06(2)(a), 370.07(6)(a), and Administrative Code 68E-5.002) requires that all sales of seafood products from the waters of Florida must be reported on a Marine Fisheries Trip Ticket at the time of sale. The state of Florida implemented the trip ticket program in 1985. This program collects information on the gear used to catch the fish and the area where the fishing occurred are also recorded in the data. Because the quantity and value data are collected from seafood dealers, the information on gear and fishing location are estimated and added to the data by data collection specialists. Trip tickets include information about the harvester, the dealer purchasing the product, the date of the transaction, the county in which the species was landed, time fished, and pounds of each species landed for each trip. Completed tickets are mailed to the Florida Fish and Wildlife Conservation Commission, where they are processed. We used trip ticket landings and length composition by species for 1990 through 2006 from Miami through St. Lucie Inlet. For more information, visit http://research.myfwc.com/features/view_article.asp?id=23423.

2.2.2.2 Trip Interview Program (TIP)

The Trip Interview Program (TIP) was developed and is maintained by the NOAA/NMFS Southeast Fisheries Science Center (SEFSC) as a shore-based sampling program that collects size frequency data and age at length data from commercial fisheries. Field biologists visit docks and fish houses to interview the fishermen and take length and weight samples from their catch. For some trips, the port agents are at the location when the fish are being unloaded and can measure and weigh individual fish as they are being unloaded. At other times, the fish have already been unloaded and the port agent is given permission to measure and weigh a sample of the catch from the storage containers at the fish houses. In addition to the length and weight data, the port agents also attempt to interview the captain or a crew member to collect data on the fishing trip (i.e., fishing area, type and quantity of gear, fishing time, etc.). We used trip interview program length composition by species for 1990 through 2008 from Miami through St. Lucie Inlet. For more information on the TIP, visit their website at http://www.sefsc.noaa.gov/tip.jsp.

2.2.3 Population Dynamics Parameters

Life history parameters for maximum age, growth and maturity for the 11 reef fish species considered (Table 1) were obtained from the literature syntheses of Ault *et al.* (1998, 2005b) and Claro *et al.* (2001). These parameters included the oldest age of a fish in the stock, a_λ the maximum observed length, L_λ, of a fish at a_λ, and the length at sexual maturity, L_m. Growth coefficient, K, the age at which length is zero, a_0, and ultimate or asymptotic length, L_∞, were parameters estimated from the von Bertalanffy growth equation. The ultimate or asymptotic weight, W_∞, is the weight of a fish at L_∞.

Table 2. Life-history parameters (Ault *et al.* 1998, Claro *et al.* 2001, Ault *et al.* 2005) for southeast Florida region reef fishes. Data not available for angelfish and lobster species.

		Parameters						
	Species	a_λ (y)	K (y^{-1})	L_∞ (mm)	a_0 (y)	W_∞ (kg)	L_m (mm)	L_λ (mm)
	Groupers							
1	Black	33	0.1432	1334.00	-0.9028	38.8619	856	1302
2	Red	26	0.2130	848.20	-0.6600	10.0822	488	845
	Snappers							
3	Mutton	40	0.1600	874.40	-1.3200	9.1509	402	918
4	Gray	28	0.1360	722.30	-0.8630	5.2478	230	708
5	Yellowtail	14	0.1700	483.80	-1.8700	1.6931	199	451
	Wrasses							
6	Hogfish	23	0.0798	912.57	-1.7760	14.1012	166	786
	Grunts							
7	White	18	0.1859	511.85	-0.7760	3.0623	180	496
8	Tomtate	9	0.2222	310.00	-1.2800	4.3058	130	307
	Barracuda							
9	Great Barracuda	32	0.0900	1780.00	-1.1900	42.9795	877	1690
	Triggerfish							
10	Gray triggerfish	16	0.2625	514.90	-0.0039	3.5321	330	507
	Jacks							
11	Greater amberjack	17	0.2500	1389.00	-0.7900	33.9969	684	1373

2.3 Fishery Regulations

A summary of the major fisheries regulations impacting southeast Florida marine fisheries landings and effective date from 1983-2009 is shown chronologically for pertinent species and gear in Table 2. The list is not meant to be comprehensive for fisheries regulations in the southeast Florida region but rather highlight those regulations that directly or indirectly affected the regulated harvest of the fish species examined in this report.

Table 3. Summary of major fisheries regulations impacting southeast Florida marine fisheries landings: 1983-2009. The designation of Florida Fish and Wildlife Conservation Commission (FFWCC) represents a Florida state regulation within three nautical miles of land and the South Atlantic Fishery Management Council (SAFMC) represents a U.S. federal regulation, which is applicable from three nautical miles to the Exclusive Economic Zone (EEZ). Total length abbreviated TL and fork length FL.

SPECIES/GEAR	EFFECTIVE DATE	RULES AND REGULATIONS DESCRIPTION	AGENCY
Nets	3/20/1991	Use of gill nets in state waters with mesh size greater than 6 inches prohibited.	FFWCC
	7/4/1991	Use of any gill or trammel net with a total length greater than 600 yards prohibited in all waters of Brevard Indian River, St. Lucie, Martin, and Palm Beach counties	FFWCC
	7/1/1995	Use of gill nets or other entangling nets prohibited for the purpose of catching or taking any saltwater finfish, shellfish or other marine animals in Florida waters (Florida constitution Article X, Section 16 - Limiting marine net fishing).	FFWCC
Marine Life (Pomacanthidae)	1/1/1991	Minimum size limits - gray, French angelfish 1.5 inches TL, blue and queen angelfish - 1.75 inches TL; Maximum size limits - gray, French, blue, queen angelfish - 10 inches TL, rock beauty - 6 inches TL; Recreational daily bag limit: 5 angelfish; Commercial daily vessel limit: 75 per person or 150 per vessel, the lesser	FFWCC

	1/1/1995	Maximum size limits - gray, French, blue, queen angelfish - 8 inches TL, rock beauty - 5 inches TL	FFWCC
	2/28/2002	Moratorium extended on new marine life endorsements until 6/30/2005	FFWCC
Reef Fish	9/28/1983	Minimum size limit - yellowtail snapper 12 inches TL	SAFMC
	7/29/1985	Minimum size limits - mutton, yellowtail snappers - 12 inches TL black, red groupers - 18 inches	FFWCC
	12/11/1986	Snapper bag limit: 10 per recreational fisherman daily for any combination of snapper, excluding lane, vermillion, and yelloweye Grouper bag limit: 5 per recreational fisherman daily for any combination of groupers, excluding rock hind and red hind	FFWCC
	2/1/1990	Minimum size limits - mutton, yellowtail snapper - 12 inches TL gray snapper - 10 inches TL black, red grouper - 20 inches TL amberjack - 28 inches fork length amberjack bag limit - 3 daily per recreational fisherman Recreational daily bag limit - 10 snapper per person (no more than 5 gray snapper), 5 grouper per person	FFWCC
	1/1/1992	Minimum size limits - gray, mutton, and yellowtail snapper - 12 inches (30.5 cm) TL black, red grouper - 20 inches (50.8 cm) TL greater amberjack - 28 inches (71.1 cm) FL fish traps banned in EEZ Recreational daily bag limit - 10 snappers, 5 groupers, 3 greater amberjack	SAFMC

	12/31/1992	Amberjack harvest limit restricted in April and May to the bag limit for this species; mutton snapper harvest restricted in May and June to the bag limit	FFWCC
	3/1/1994	Minimum size limits - mutton snapper - 16 inches; hogfish, gray triggerfish - 12 inches Recreational daily bag limit of 5 per person for hogfish	FFWCC
	3/1/1995	Minimum size limits - gray, yellowtail snapper - 12 inches (30.5 cm) TL, mutton snapper - 16 inches (40.6 cm) TL, hogfish - 12 inches (30.5 cm) FL	SAFMC
	1/1/1998	Recreational daily bag limit - greater amberjack 1 fish per fisherman	FFWCC
	12/31/1998	Minimum size limits - black grouper - 24 inches Recreational daily bag limits - black and gag grouper 2 per person	FFWCC
	2/24/1999	Daily bag limits - 1 greater amberjack per person, 10 mutton snapper in May and June (spawning season) per person, 5 grouper per person with no more than 2 black grouper, 20 snapper-grouper aggregate excluding tomtate and limits to greater amberjack and grouper per person Minimum size limits - gray triggerfish 12 inches (30.5 cm) TL, black grouper 24 inches (60.9cm) TL	SAFMC
	3/1/2001	Commercial vessel limit - greater amberjack - 1,000 pounds per vessel	FFWCC
	7/1/2006	Changes legal measurement of gray triggerfish from 12 inches (30.5 cm) TL to 12 inches (30.5 cm) FL	FFWCC

	7/1/2007	Prohibits commercial fishermen from harvesting recreational bag limit on commercial trips (already done for amberjack effective 12/31/1992)	FFWCC
	7/29/2009	Seasonal closure - black, red grouper in January through April Bag limits - 3 grouper, 1 black grouper	SAFMC
	1/19/2010	Seasonal closure - black, red grouper in January through April Bag limits - 3 grouper, 1 black grouper	FFWCC
Spiny lobster	7/2/1987	Minimum size - 3 inch carapace or 5.5 inch tail Recreational daily bag limit 6 per person or 24 per boat, the greater Two-day sport season last weekend prior to August 1, regular season is August 6 to March 31 Limits 2000 traps fished per person or boat Prohibits harvest of egg-bearing lobsters	FFWCC
	7/1/1992	Established the following rules for the special two-day recreational season: change the season to occur the last consecutive Wednesday and Thursday in July each year; during this two-day period, harvest methods will be limited to diving and to the use of bully nets or hoop nets; no more than 12 lobster may be harvested or possessed per person per day	FFWCC
	8/6/1993	Maximum number of spiny lobster traps allowed in commercial sector each season set at 10% fewer than were allowed the previous season	FFWCC
	8/1/1994	Established a daily vessel bag limit of 50 spiny lobster for special recreational crawfish license holders (or per person for such	FFWCC

		license holders who are not harvesting lobsters from a vessel)	
	6/3/1996	Suspends 10% trap reduction for 1996/97 season	FFWCC
	1/30/1997	Alternating trap reduction schedule: 0% reduction in 1997/98 and 1999/2000 seasons, 10% reduction in 1998/99 and 2000/01 seasons	FFWCC
	7/1/2000	Delays 10% trap reduction for one year to 2001/02 season	FFWCC
	7/1/2001	Reduces the lobster traps in Florida waters 4% annually until total number is 400,000 deletes 10% trap reduction for 2001/02 season	FFWCC
	7/2/2003	Recreational daily bag limit 6 per person (vessel limit eliminated)	FFWCC
	4/1/2004	Establishes a commercial dive harvest limit of 250 lobsters per day for Dade and Broward counties Applies the 250 lobster limit to lobsters caught with commercial bully nets statewide	FFWCC

2.4 Florida State Fisheries Benchmark Analysis

For the Florida state fisheries benchmark analysis, fisheries-dependent reported catch and effort data for the sixteen reef fish species and one lobster species were evaluated on the basis of the trend in data from southeast Florida-wide (Table 3). Trends were analyzed statistically using general linear models to categorize the slope of the fitted trend lines as increasing (positive) or decreasing (negative) at the $p < 0.05$ significance level; or unchanged (i.e., non-significant/ non-existent trends, $p > 0.05$) (n.s.). Status of data deficient species was categorized as unknown.

Table 4. Sources of fishery-dependent catch, effort, and length composition data for southeast Florida reef fishes (MRFSS, Marine Recreational Fisheries Statistics Survey; TIP, Trip Interview Program) with time period, fishery sector, and spatial domain of the data set in the analyses.

Database	Period	Sector	Spatial Domain
MRFSS	1990-2009	Recreational fishing fleet	Florida east coast, Miami to north
Headboat	1990-2006	Headboat fishing fleet	Florida, Miami to Ft. Pierce
TIP	1990-2008	Commercial fishing fleet	Florida, Miami to St. Lucie Inlet
Trip Ticket	1990-2006	Commercial fishing fleet	Florida, Miami to St. Lucie Inlet

2.5 U.S. Federal Fisheries Benchmark Analysis

For U.S. federal fisheries benchmark analysis, evaluation of benchmarks involved determination of fishing effort that generates maximum sustainable yield, F_{MSY}, and the spawning potential ratio (SPR) for the species. We defined F_{MSY} = M as a proxy for F_{MSY} (Quinn & Deriso 1999; Restrepo & Powers 1999). The ratio of fishing effort to the effort at MSY was used to evaluate if overfishing was occurring for a fishery. The ideal status for a fishery is not to experience overfishing. If the maximum fishing mortality threshold (MFMT, equivalent to the F_{MSY} limit in our analysis) is exceeded, then management alternatives in the form of reductions in F (or rebuilding plans) must be implemented to reverse the situation and move the stock to $F/F_{MSY} < 1$. SPR is a management benchmark that measures a stock's potential to produce yields on a sustainable basis. The methods used to determine these benchmarks are detailed in sections 2.5.1 to 2.5.4.

2.5.1 Length Composition Analysis

Fishery-dependent length composition data were obtained from southeast Florida-wide sampling of commercial, headboat, and recreational catches (Table 3). All datasets were from approximately the same geographic extent and time period. Length composition data for the species considered were used to estimate mean lengths and corresponding variances between lower L_c and upper L_λ bounds, applying standard statistical procedures. We set L_c to correspond to the minimum size at first capture imposed by Florida state regulations for each species (see Table 2 for details) with L_λ determined from observations of the largest individuals by species from fisheries-dependent data sets listed in Table 3. A graphical representation of the life history stanzas and associated parameters is in Fig. 3.

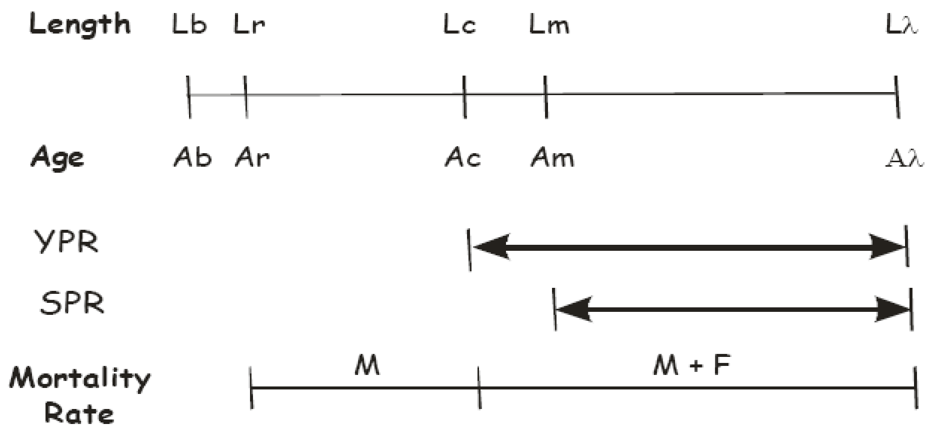

Figure 3. To evaluate fishery metrics in terms of sustainability benchmarks, the life history stanzas of a fish must be considered between birth (a_b), the age (a_r) or size (L_r) of recruitment to the fishery, to the maximum age (a_λ) or size (L_λ) in the fishery. Animals are reproductive between the size of maturity (L_m) and maximum size/age. Natural mortality (M) operates throughout all stanzas and fishing mortality (F) occurs with knife-edged selectivity between the minimum size of first capture (L_c) and L_λ. Yield-per-recruit (YPR) analyses include fish from the size at first capture to the maximum size in the fishery. Spawning potential ratio (SPR) analyses are determined from fish between the size at first sexual maturity to maximum size. During the exploited period, total mortality (Z) is the sum of the competing risks of death, i.e., Z = M + F.

2.5.2 Mortality Estimation

We used average length ($\bar{L}$) of the exploited part of the population, which is a metabolic-based indicator that is highly correlated with population size, to quantify population status for the southeast Florida reef fishes (Beverton & Holt 1957; Ricker 1963; Pauly & Morgan 1987; Ehrhardt & Ault 1992; Kerr & Dickie 2001; Jennings *et al.* 2007). For exploited species, $\bar{L}$ directly reflects the rate of fishing mortality through alterations of the population size structure (Beverton & Holt 1957; Quinn & Deriso 1999). Theoretically, $\bar{L}$ at time t is expressed as

$$\bar{L}(t) = \frac{F(t)\int_{a_c}^{a_\lambda} N(a,t)\, L(a,t)\, da}{F(t)\int_{a_c}^{a_\lambda} N(a,t)\, da} \quad , \qquad [1]$$

where a_c is the minimum age at first capture, a_λ the oldest age in the stock, N(a,t) the abundance for age class a, L(a,t) the length at age, and F(t) is the instantaneous fishing mortality rate at time t. In practice, $\bar{L}$ is usually estimated from lengths in the range of length at first capture L_c (or recruitment to the exploited phase of the stock) to the maximum observed length L_λ, the length of a fish at a_λ. F(t) could also be the viewing power of divers in fishery-independent visual surveys of reef fish populations (Ault *et al.* 1998).

Using estimates of $\overline{L}$ in time *t*, total instantaneous mortality rate $\hat{Z}(t)$ was estimated using the method of Ehrhardt and Ault (1992)

$$\left[\frac{L_\infty - L_\lambda}{L_\infty - L_c}\right]^{\frac{\hat{Z}(t)}{K}} = \frac{\hat{Z}(t)\left(L_c - \overline{L}(t)\right) + K\left(L_\infty - \overline{L}(t)\right)}{\hat{Z}(t)\left(L_\lambda - \overline{L}(t)\right) + \left(L_\infty - \overline{L}(t)\right)} \quad , \qquad [2]$$

where K and L_∞ are parameters of the von Bertalanffy growth equation. Estimates of Z were computed using an iterative numerical algorithm (Ault *et al.* 1996; FAO 2003). Life history parameters for maximum age, growth and maturity for the reef fish species considered (Table 1) were obtained from the literature syntheses of Ault *et al.* (1998, 2005b) and Claro *et al.* (2001).

2.5.3 Numerical Population Model

A stochastic, length-based numerical population model (Ault & Olson 1996; Ault *et al.* 1998) was used for computing ensemble numbers at given lengths $\tilde{N}_\gamma$ over time for a given cohort γ, generalized as

$$\tilde{N}_\gamma(L_\gamma, t) = \int_{a_r}^{a_\lambda} R_\gamma(\tau - a) S(a) \theta(a) P(L \mid a) da \qquad [3]$$

where $R_\gamma(\tau - a)$ is cohort recruitment lagged back to birth date, *S(a)* is survivorship to age *a*, $\theta(a)$ is a logistic model of sex ratio at age to account for hermaphroditic life histories common to tropical reef fishes, and *P(L|a)* is the probability of being length *L* given the fish is age *a* (Denney *et al.* 2002). This population model simulates the time-transition of recruits to mature adults to maximum size-age using a number of dynamic functions to regulate population birth, growth, and survivorship processes, including fishery harvests. Details of the numerical population model can be found in Ault *et al*. (1998).

The numerical model (equation 3) was calibrated through a consistency check between model estimates of $\overline{L}$, using $\hat{Z}$ from equation (2) as the input, and the $\hat{\overline{L}}$ estimated from data. Additionally, the two major components of Z, fishing mortality rate F and natural mortality rate M, were evaluated. In this process, M was estimated from lifespan applying the procedure of Alagaraja (1984; *sensu* Hoenig 1983) assuming that 5% of a cohort survives to the maximum age/size, and F was estimated by subtracting M from Z (Ault *et al.* 1998). The calibrated model was then used to compute management benchmarks of stock status to evaluate sustainability in the following analytical process.

2.5.4 Sustainability Analyses

Populations were evaluated at current levels of fishing mortality against U.S. federal fishery management sustainability benchmarks. The simulation model was configured to assess two U.S. federal reference points to address several sustainability risks: spawning potential ratio (SPR; Clark 1991) and the ratio of **F/ FMSY** (e.g., Restrepo & Powers 1999). Since population biomass *B(a,t)* is the product of numbers-at-age times weight-at-age W(a,t), yield in weight Y_w from a species during an instant t was calculated as

$$Y_w(F, L_c, t) = F(t)\int_{L_c}^{L_\lambda} B(L \mid a,t)dL = F(t)\int_{L_c}^{L_\lambda} N(L \mid a,t)W(L \mid a,t)dL \qquad [4]$$

An important measure of stock reproductive potential, spawning stock biomass (SSB) at a given level of fishing mortality, was obtained by integrating over individuals in the population between the size of sexual maturity (L_m; 50% maturity, assumed knife-edged) and the maximum size (L_λ)

.
$$SSB(t) = \int_{L_m}^{L_\lambda} B(L \mid a,t)dL \qquad [5]$$

Maximum spawning biomass is obtained under conditions of no fishing mortality. Spawning potential ratio (SPR) is a management benchmark that measures a stock's potential to produce yields on a sustainable basis, and is computed as the ratio of current SSB(t) relative to that of an unexploited stock

.
$$SPR = \frac{SSB_{exploited}}{SSB_{unexploited}} \qquad [6]$$

Estimated SPRs were compared to U.S. federal standards which define 30% SPR as the threshold below which a stock is no longer sustainable at current exploitation levels (e.g., Gabriel *et al.* 1989; Restrepo et al. 1998).

3.0 Results
3.1 Fishery Trends
3.1.1 Recreational Fishery

Trends in the Marine Recreational Fishing Statistical Survey (MRFSS) recreational type A + B1 harvest (landings + discards) for eight of the 16 species were examined for 1990-2009 from the east coast of Florida. Recreational landings and discard data from MRFSS were not available for black grouper, hogfish, tomtate, angelfish, or spiny lobster. Total harvest for the eight species did not significantly decline, nor did the total recreational effort for all finfish species in the east Florida coast from 1990-2009 (Fig. 4). None of the eight species individually experienced significant declines in estimated combined landings and discards over the study period and thus their harvest trends could be characterized as unchanged (Fig. 5-13; Table 4). Recreational harvest status of the eight data deficient species was classified as unknown.

The annual mean length in the exploited phase, $\bar{L}$, was estimated for ten species the southeast Florida region (Fig. 14-23). Recreational length data from MRFSS were not available for tomtate, angelfish, or spiny lobster. None of the species had a significant trend in $\bar{L}$. Caution should be exercised with the interpretation of annual $\bar{L}$ estimates given the low sample sizes (n < 10) observed during some years for some species.

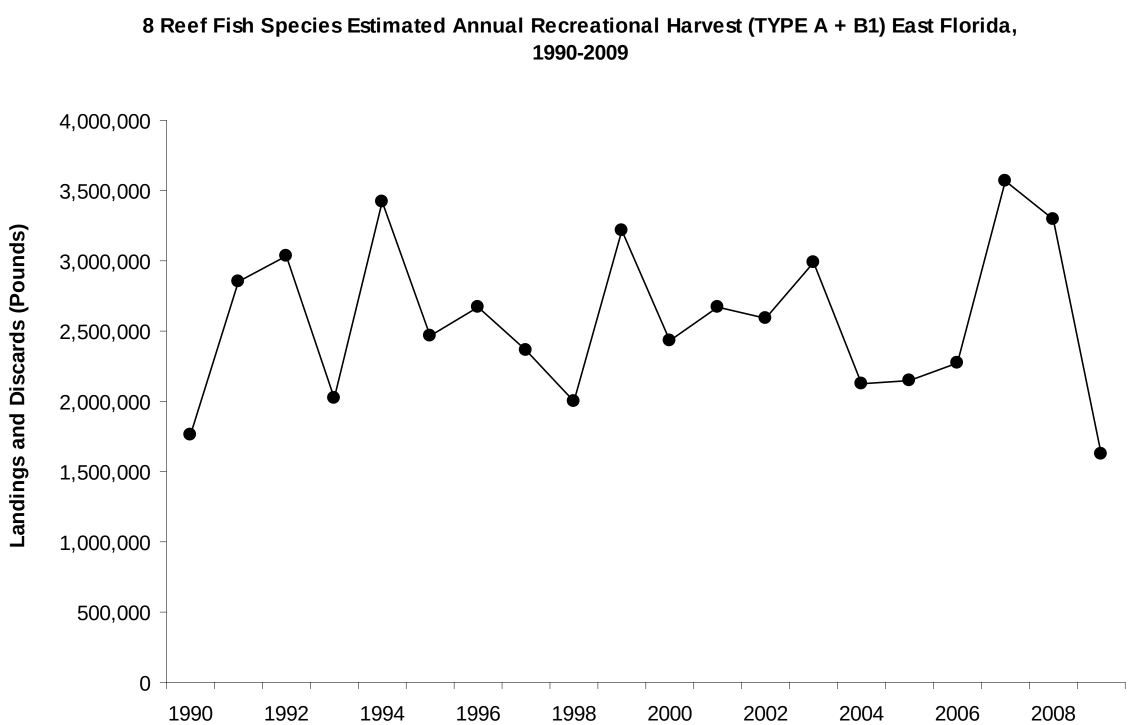

Figure 4. Estimated harvest (TYPE A + B1) of 8 reef fish species (red grouper, mutton snapper, gray snapper, yellowtail snapper, white grunt, great barracuda, gray triggerfish, and greater amberjack) by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

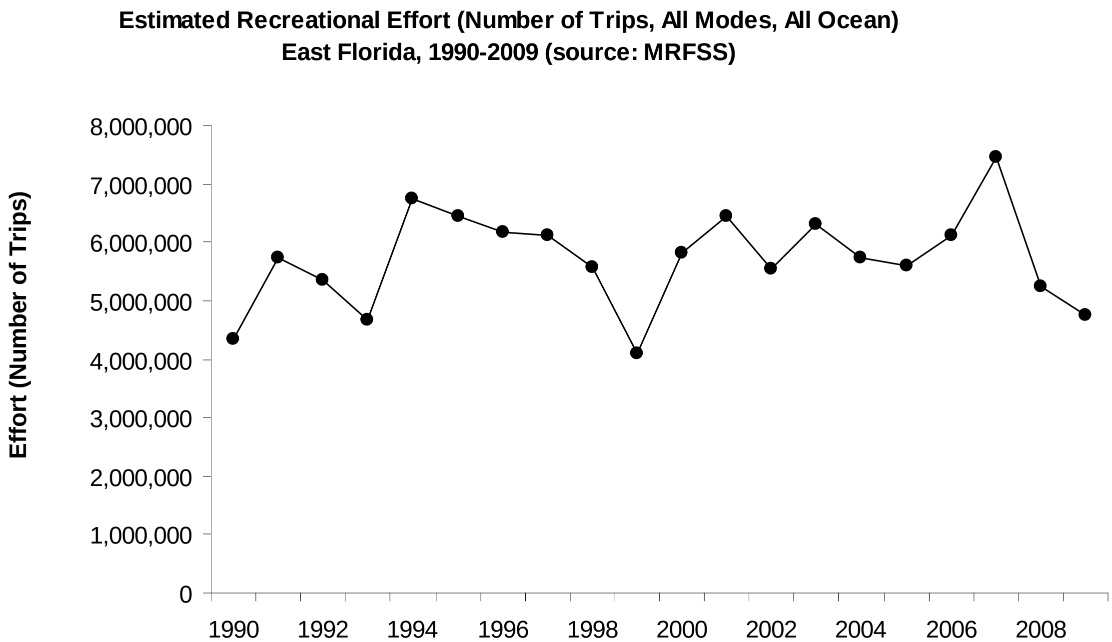

Figure 5. Number of trips estimated for recreational fishery in east Florida coast, all modes, all ocean areas from 1990-2009 from NOAA/NMFS MRFSS.

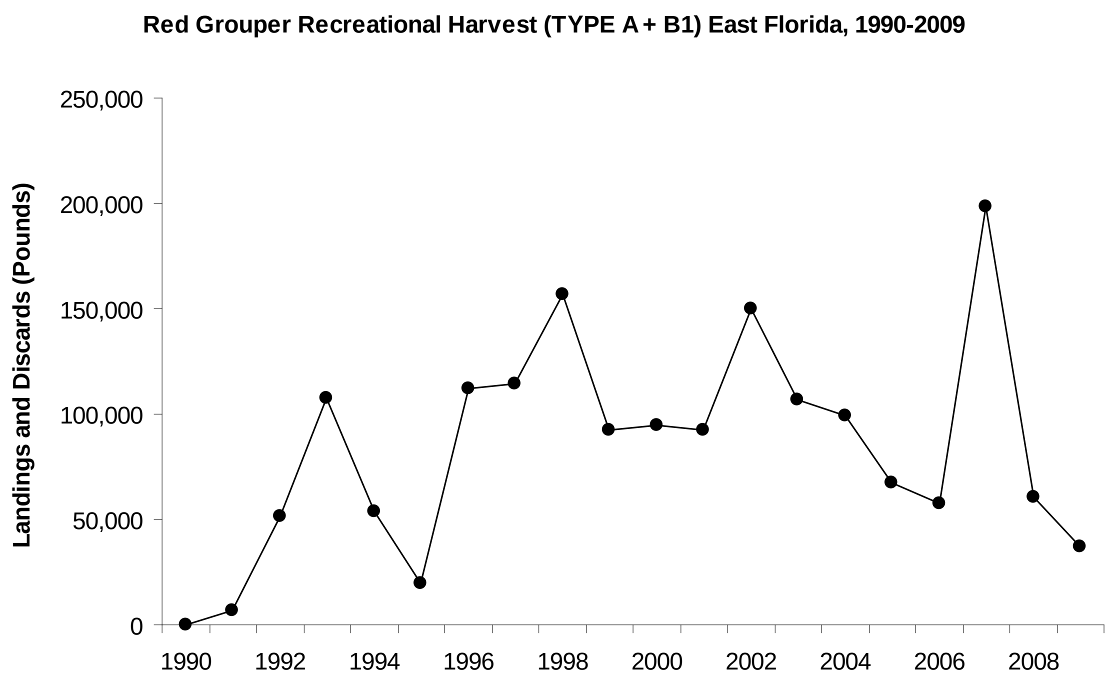

Figure 6. Estimated harvest (TYPE A + B1) of red grouper by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

Gray Snapper Estimated Annual Recreational Harvest (TYPE A + B1) East Florida, 1990-2009

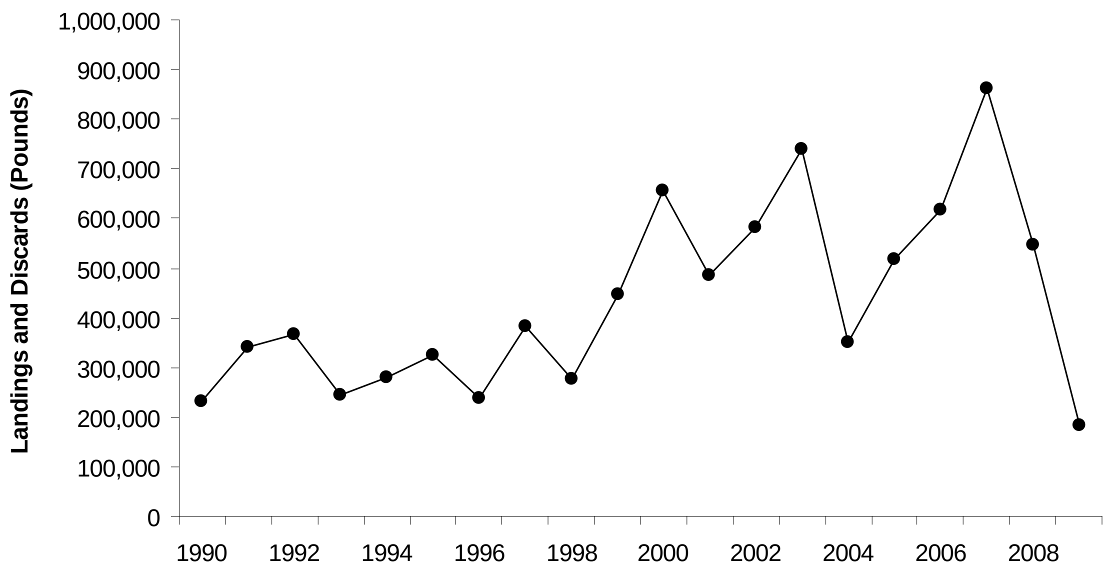

Figure 7. Estimated harvest (TYPE A + B1) of gray snapper by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

Mutton Snapper Recreational Harvest (TYPE A + B1) East Florida, 1990-2009 (source: MRFSS)

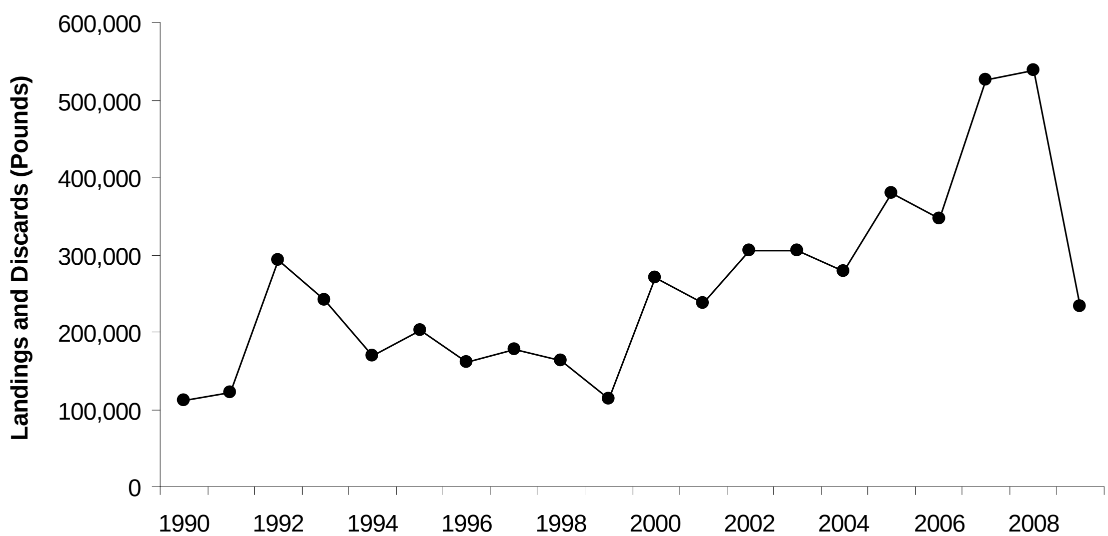

Figure 8. Estimated harvest (TYPE A + B1) of mutton snapper by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

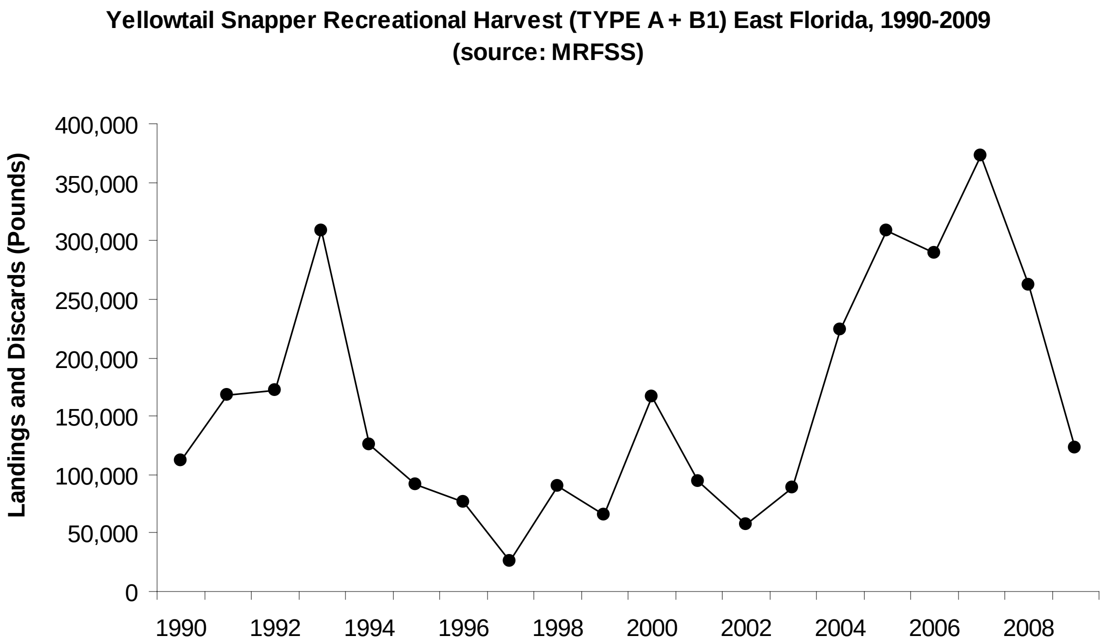

Figure 9. Estimated harvest (TYPE A + B1) of yellowtail snapper by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

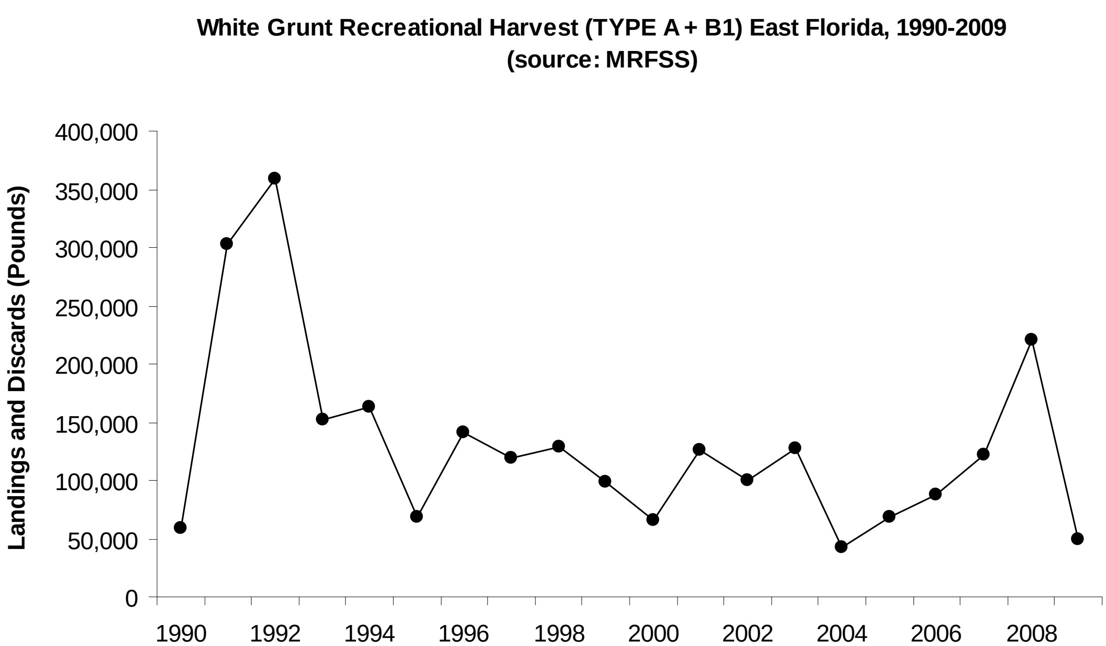

Figure 10. Estimated harvest (TYPE A + B1) of white grunt by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

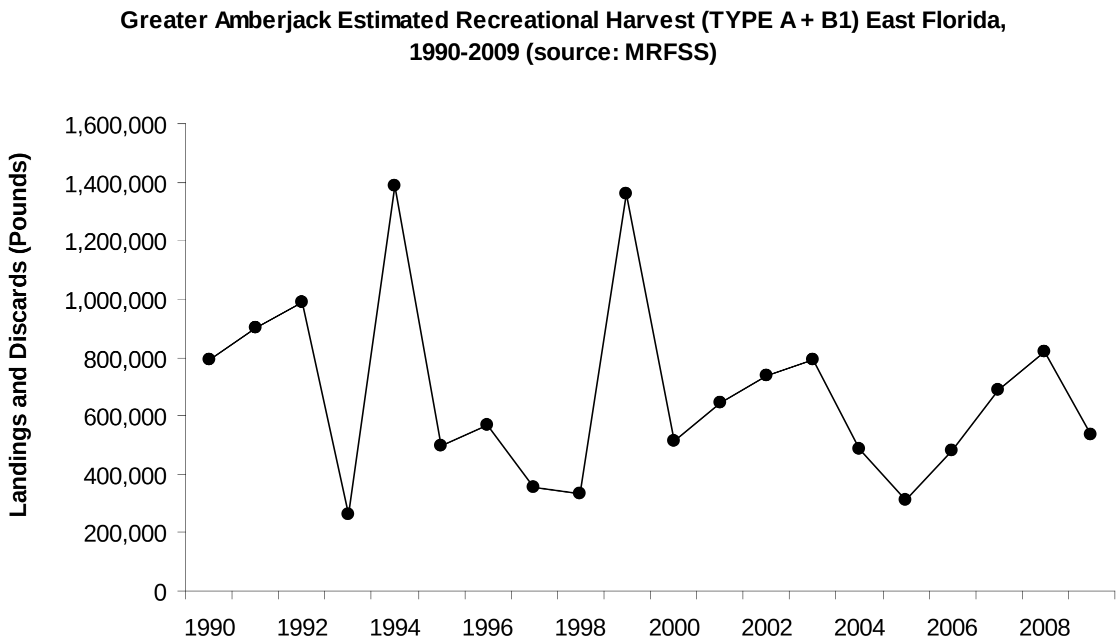

Figure 11. Estimated harvest (TYPE A + B1) of greater amberjack by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

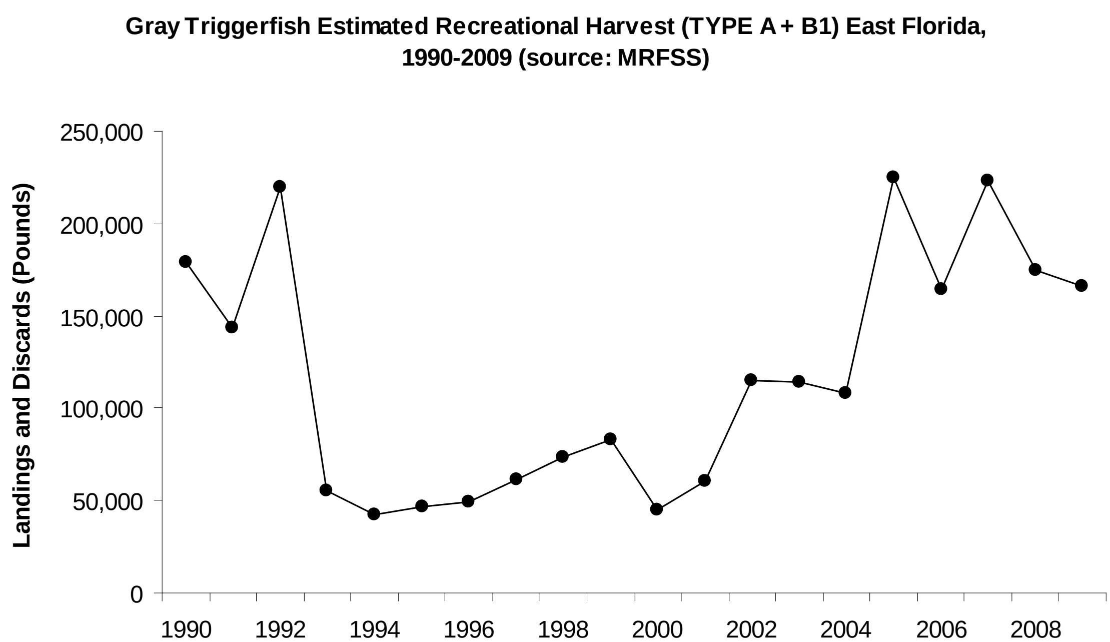

Figure 12. Estimated harvest (TYPE A + B1) of gray triggerfish by the recreational fishery in east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

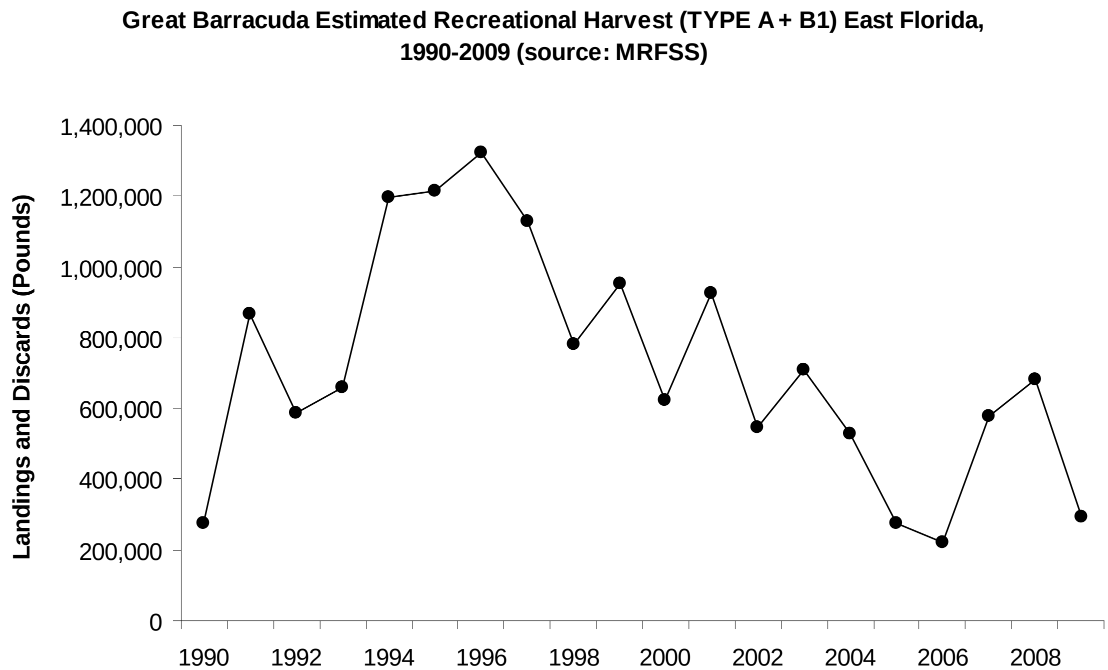

Figure 13. Estimated harvest (TYPE A + B1) of great barracuda by the recreational fishery in the east Florida coast, 1990-2009 from NOAA/NMFS MRFSS.

Table 5. Annual estimated recreational harvest (landings and discards) in thousands of pounds for East Florida coast from 1990-2009.

Common name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Trend*
Gray snapper	231	340	367	243	281	323	237	381	276	446	657	485	581	739	351	517	617	861	545	184	n.s.
Gray triggerfish	179	143	219	56	43	47	49	62	73	83	45	61	115	115	108	225	165	223	175	166	n.s.
Great barracuda	277	866	585	657	1199	1213	1323	1130	783	952	625	925	547	710	530	275	224	579	680	292	n.s.
Greater amberjack	794	902	987	260	1387	499	566	355	334	1361	513	645	735	794	486	312	482	691	819	537	n.s.
Mutton snapper	111	121	293	241	169	201	162	177	163	114	271	237	305	305	279	380	347	526	538	233	n.s.
Red grouper	0	6	51	107	54	19	112	114	157	93	95	93	150	107	100	67	57	198	61	37	n.s.
White grunt	59	303	359	152	163	69	142	119	129	99	66	127	100	127	43	68	87	122	220	50	n.s.
Yellowtail snapper	112	167	172	309	126	91	76	26	90	65	166	94	58	89	224	309	290	372	262	123	n.s.
TOTAL 8 SPP.	1762	2850	3032	2025	3421	2462	2666	2364	2005	3213	2437	2667	2591	2985	2120	2153	2268	3572	3300	1622	n.s.

*1990-2009 Trends

n.s. non-significant or non-existent landings trend; trendslope = 0 ($p > 0.05$)

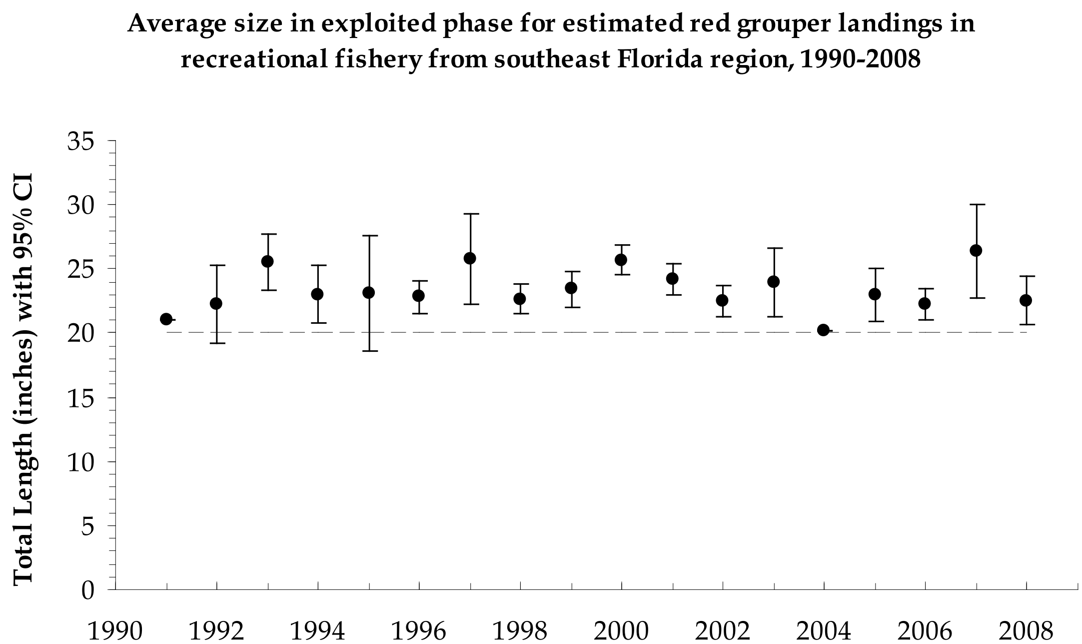

Figure 14. Average size in the exploited phase ( ) of red grouper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dotted line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

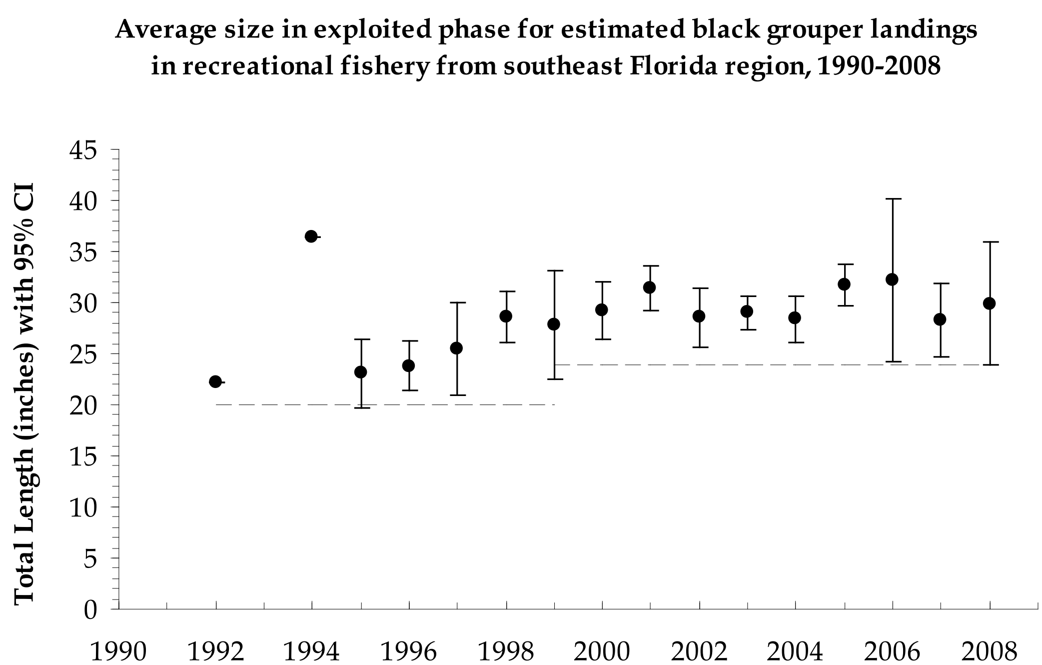

Figure 15. Average size in the exploited phase ($\overline{L}$) of black grouper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dotted line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

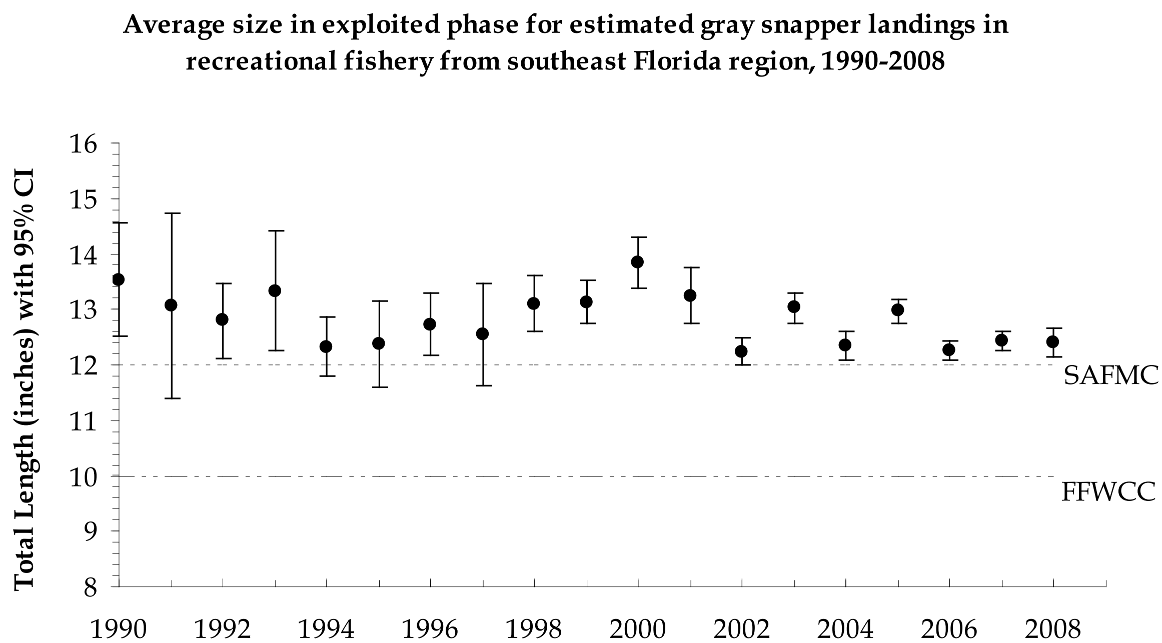

Figure 16. Average size in the exploited phase ($\overline{L}$) of gray snapper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dotted line (SAFMC) and dash/dotted line (FFWCC) shows minimum size at first capture for federal and state waters.

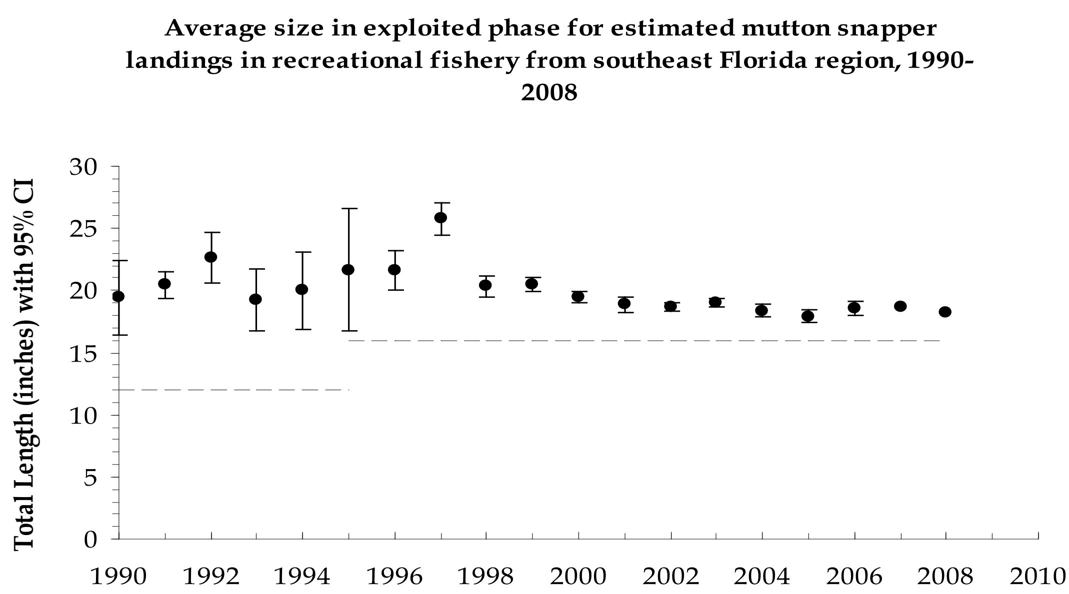

Figure 17. Average size in the exploited phase ($\overline{L}$) of gray snapper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dotted line (SAFMC) and dash/dotted line (FFWCC) shows minimum size at first capture for federal and state waters.

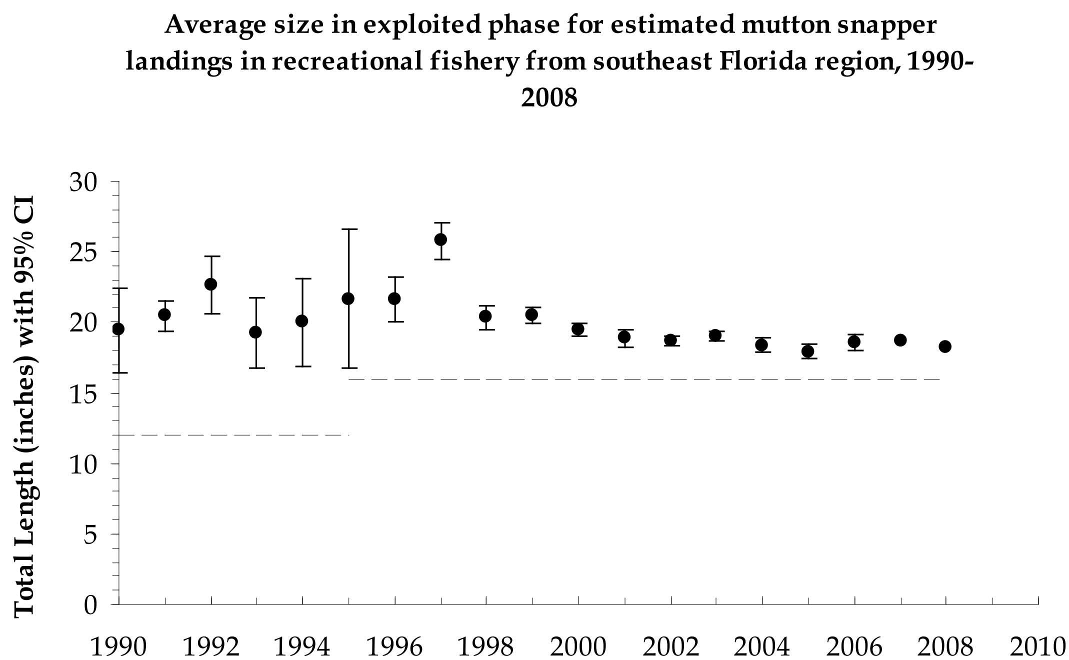

Figure 18. Average size in the exploited phase ($\overline{L}$) of mutton snapper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

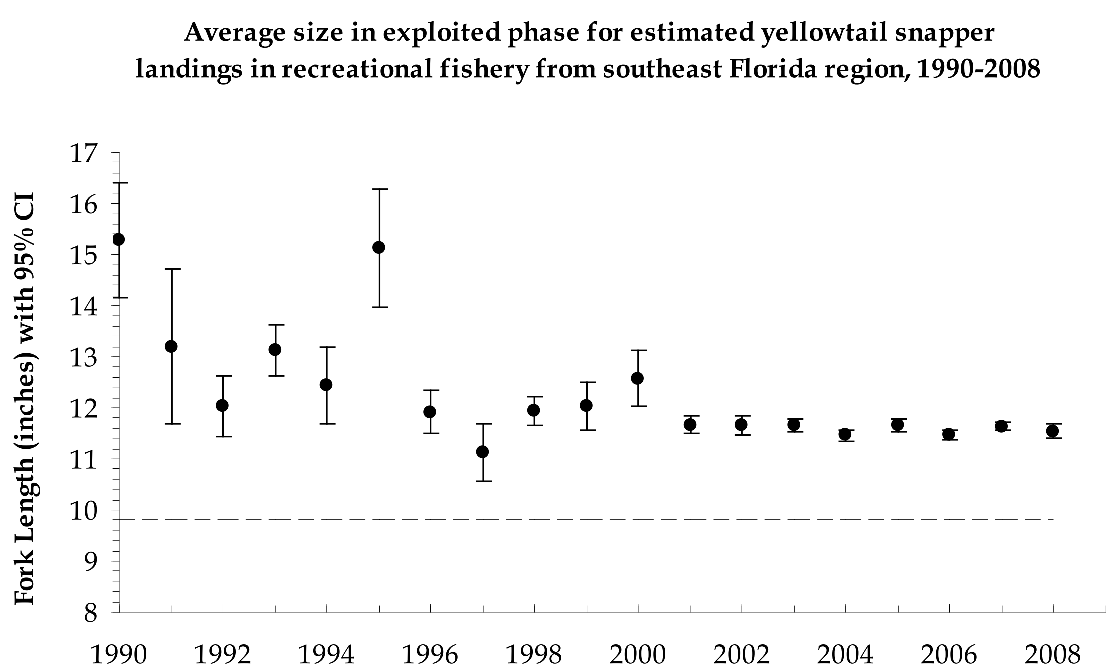

Figure 19. Average size in the exploited phase ($\overline{L}$) of yellowtail snapper estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

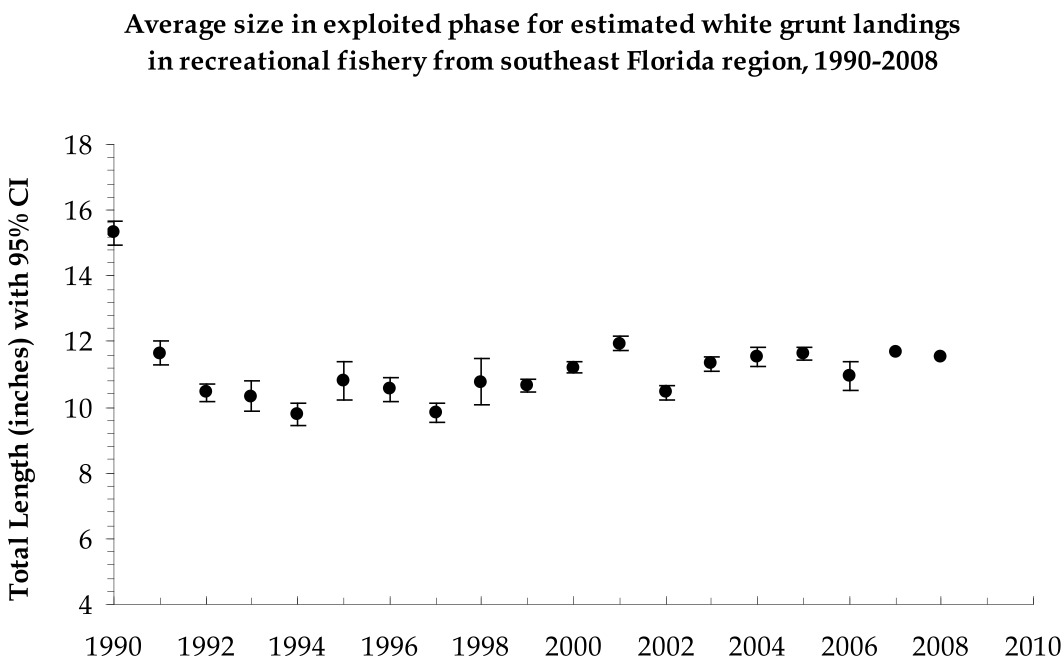

Figure 20. Average size in the exploited phase ($\overline{L}$) of white grunt estimated for the recreational fishery in the southeast Florida region, 1990-2008. There is no minimum size regulation by SAFMC or FFWCC.

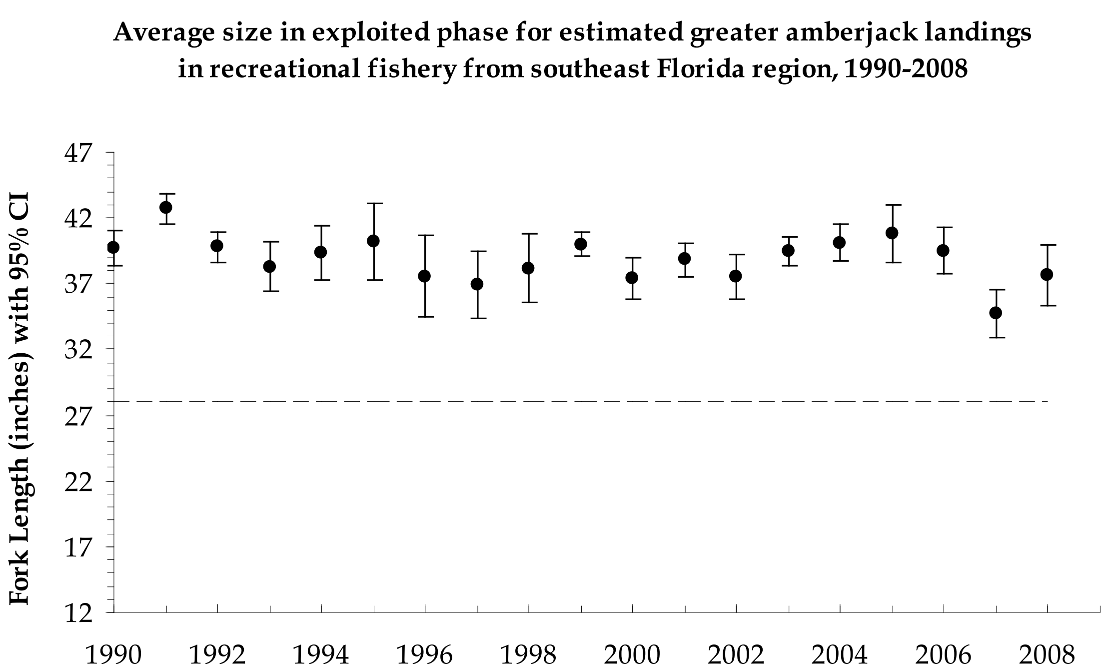

Figure 21. Average size in the exploited phase ($\overline{L}$) of greater amberjack estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

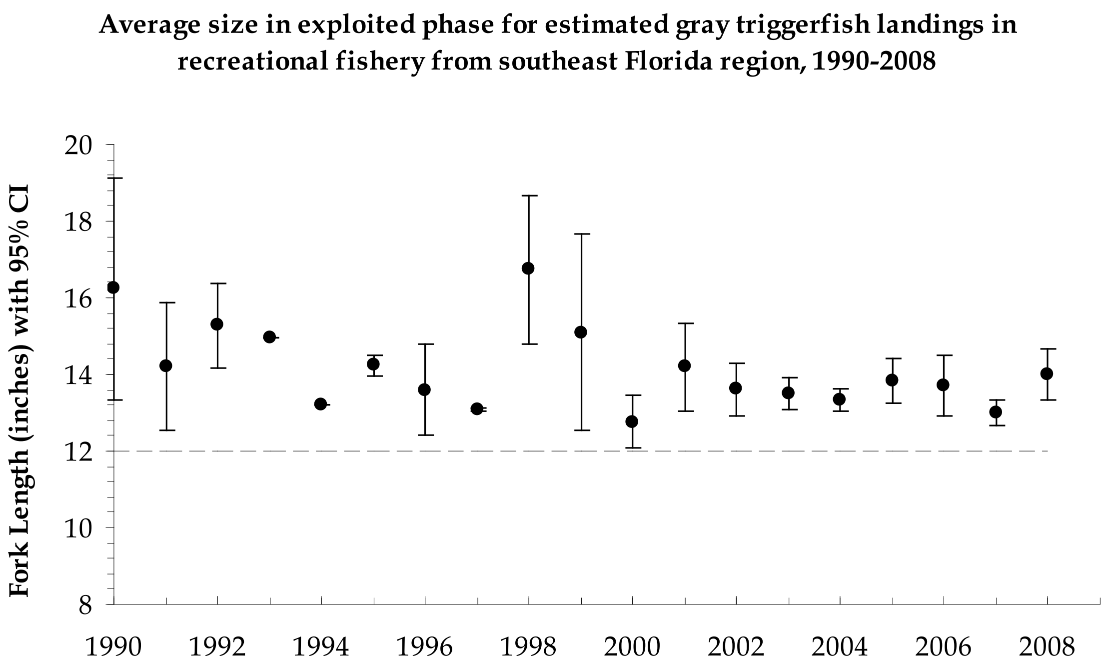

Figure 22. Average size in the exploited phase ($\overline{L}$) of gray triggerfish estimated for the recreational fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

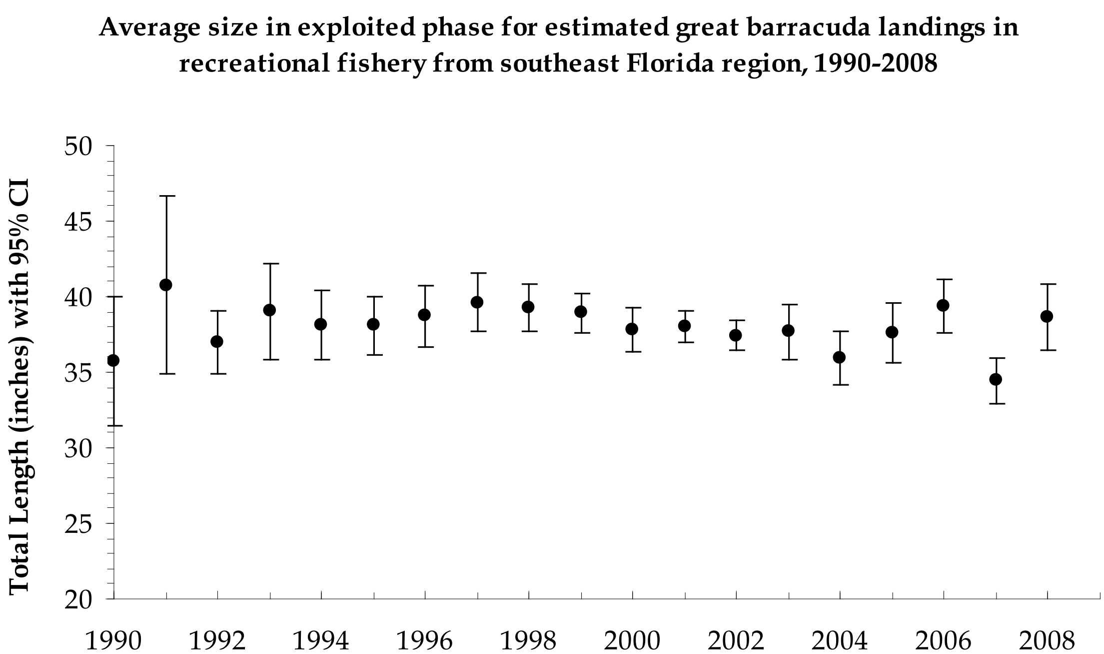

Figure 23. Average size in the exploited phase ($\overline{L}$) of great barracuda estimated for the recreational fishery in the southeast Florida region, 1990-2008. There is no minimum size regulation by SAFMC or FFWCC.

3.1.2 Headboat Fishery

Landings of the 11 reef fish species (angelfish and lobster and not targeted by headboats) from the headboat fishery in the southeast Florida region declined 85% from 196,000 pounds in 1990 to 30,000 pounds in 2006 ($p < 0.001$) (Fig. 24). The decline in landings coincided with a 50% reduction in effort from approximately 147,000 angler days in 1990 to almost 74,000 angler days in 2006 (Fig. 25). Five of the eleven fish species experienced statistically significant declines in landings (Fig. 26-36, Table 5). Mutton snapper, yellowtail snapper, white grunt, greater amberjack, and great barracuda were the five species with significant declines in headboat landings. It is unclear if the decline in landings reflects the solely the decreasing effort in the fishery. In contrast to the landings data, none of the eleven species experienced significant declining trends in the mean length of exploited phase over the study period (Fig. 37-47). Caution should be exercised with the interpretation of annual $\bar{L}$ estimates given the low sample sizes ($n < 10$) observed during some years for some species.

11 Reef fish species landings from headboat fishery in southeast Florida region, 1990-2006

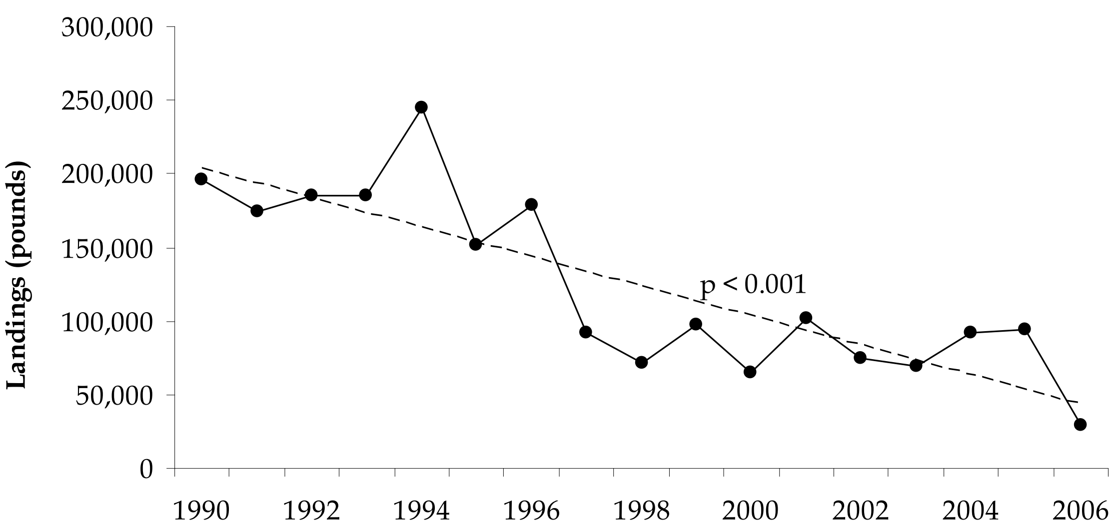

Figure 24. Total landings of 11 reef fish species (red grouper, black grouper, mutton snapper, gray snapper, yellowtail snapper, hogfish, white grunt, tomtate, great barracuda, gray triggerfish, and greater amberjack) analyzed in this report estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

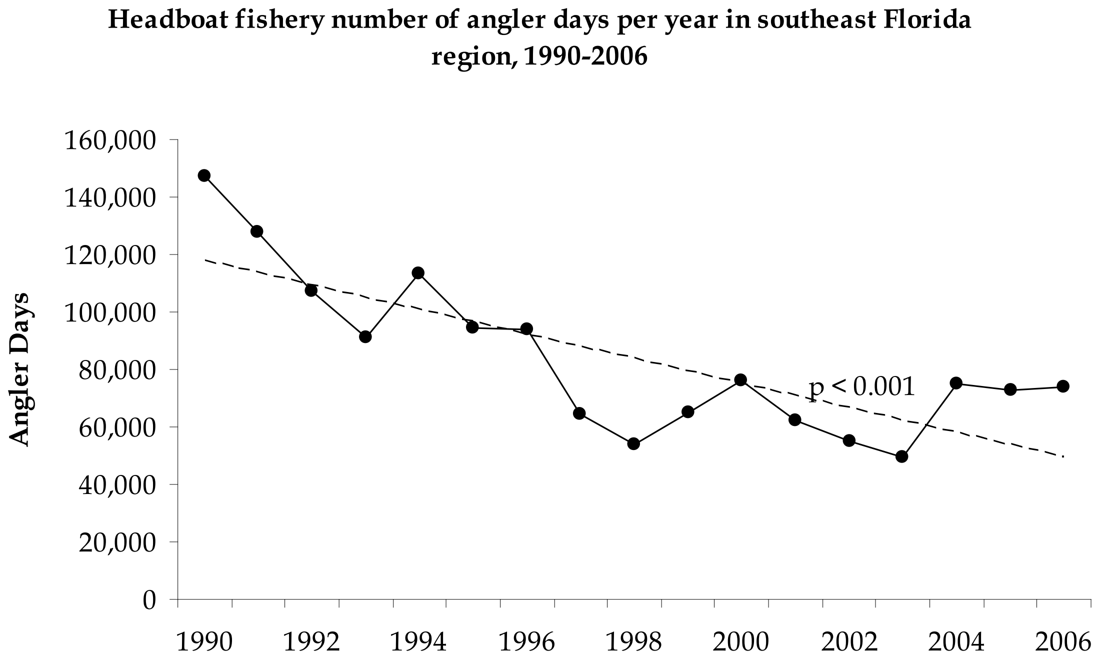

Figure 25. Number of angler days per year estimated for the recreational headboat fishery in the southeast Florida region 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

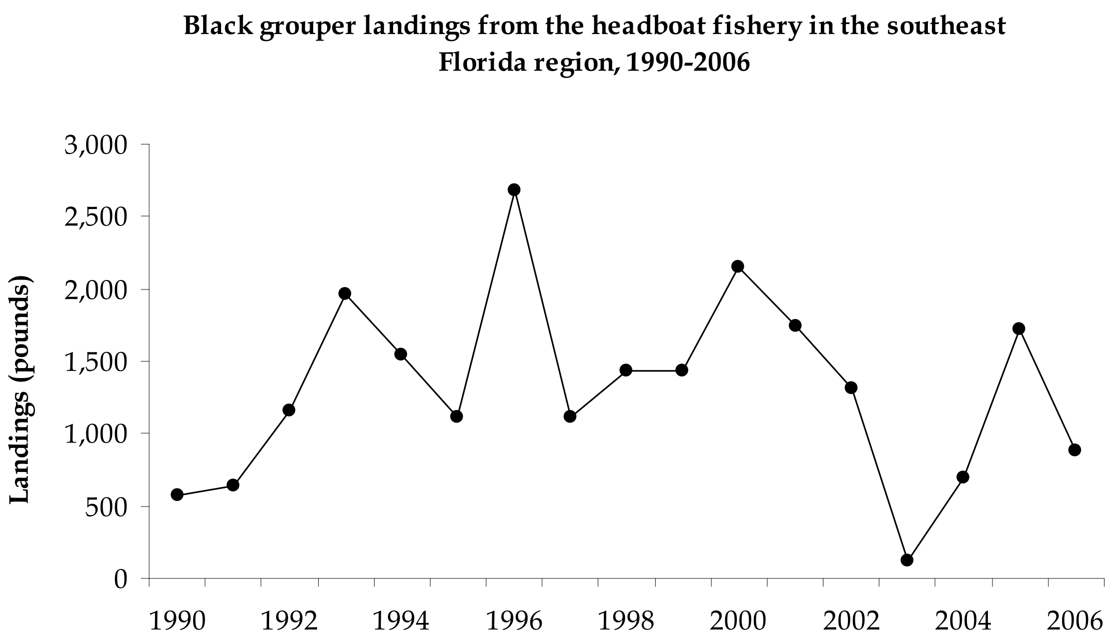

Figure 26. Landings of black grouper estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

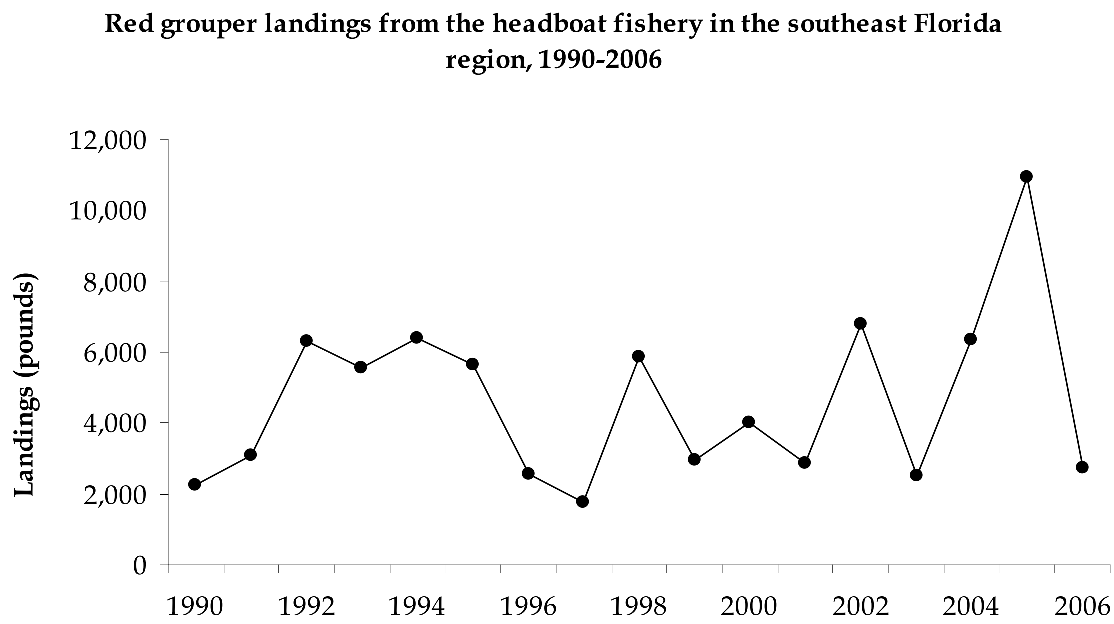

Figure 27. Landings of red grouper estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

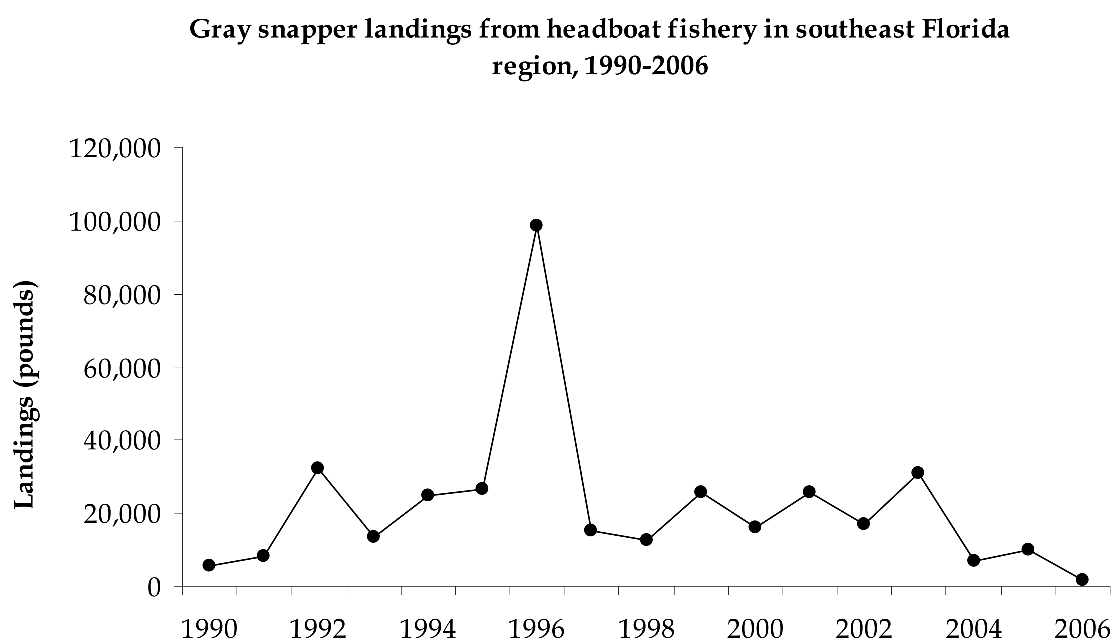

Figure 28. Landings of gray snapper estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

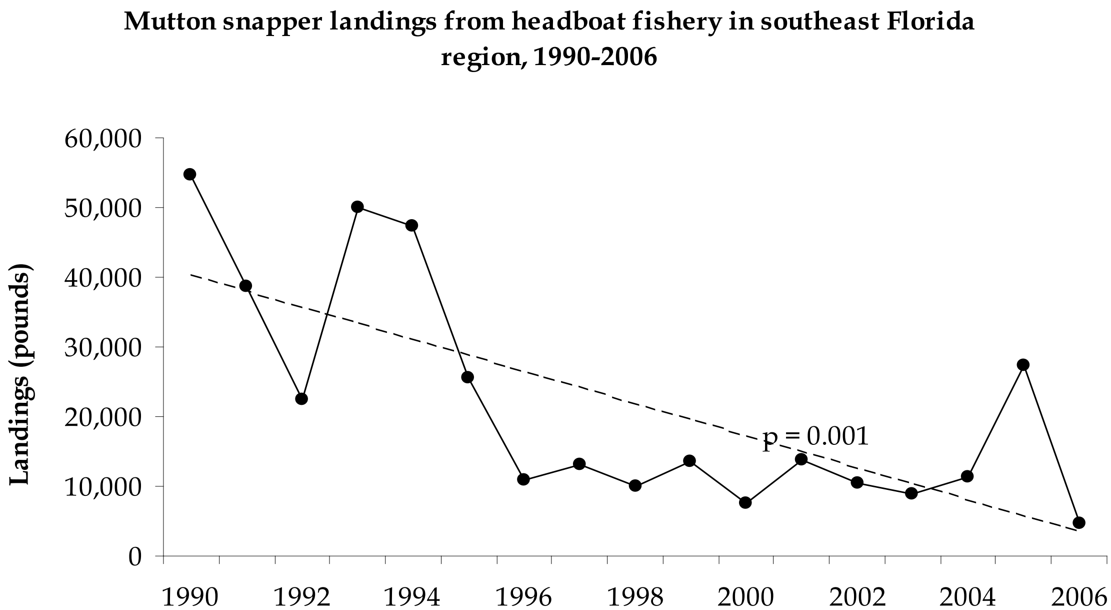

Figure 29. Landings of mutton snapper estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p = 0.001$) negative linear trend.

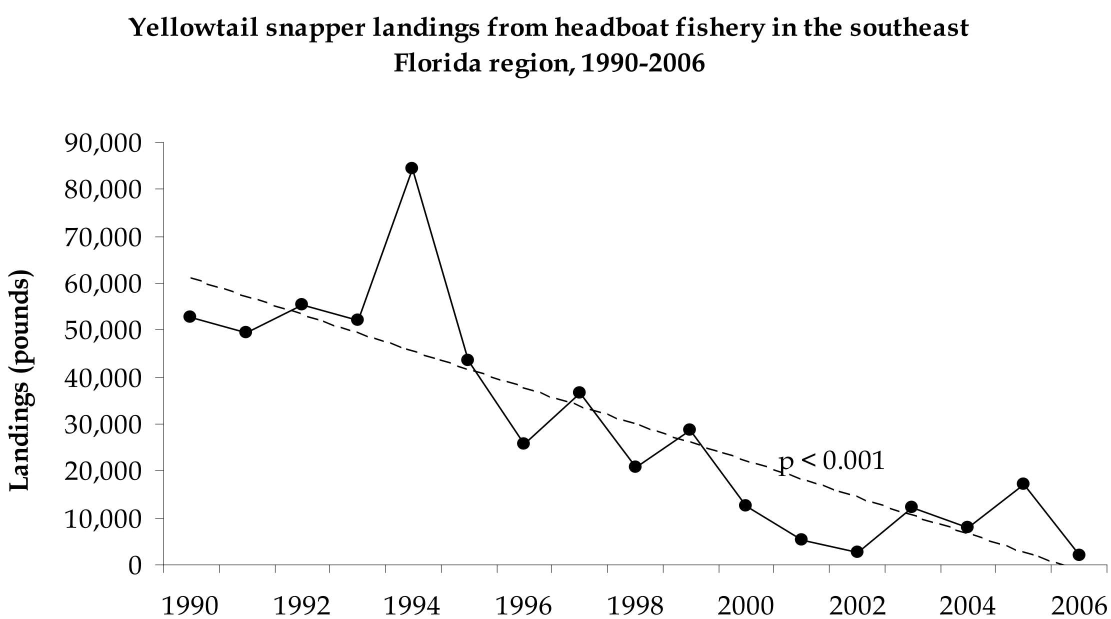

Figure 30. Landings of yellowtail snapper estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

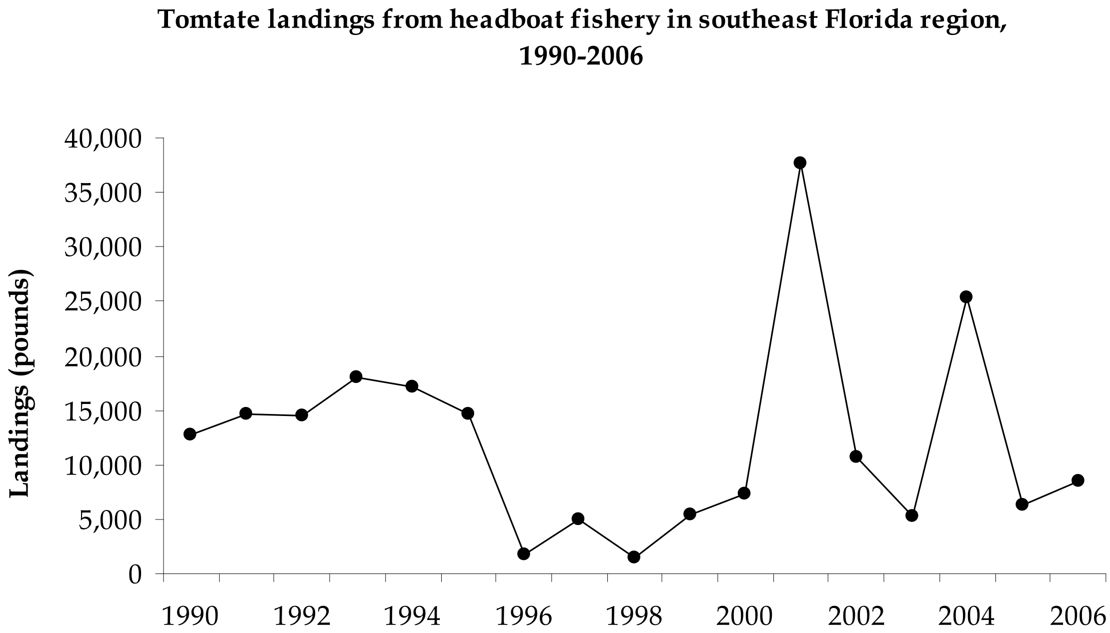

Figure 31. Landings of tomtate estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

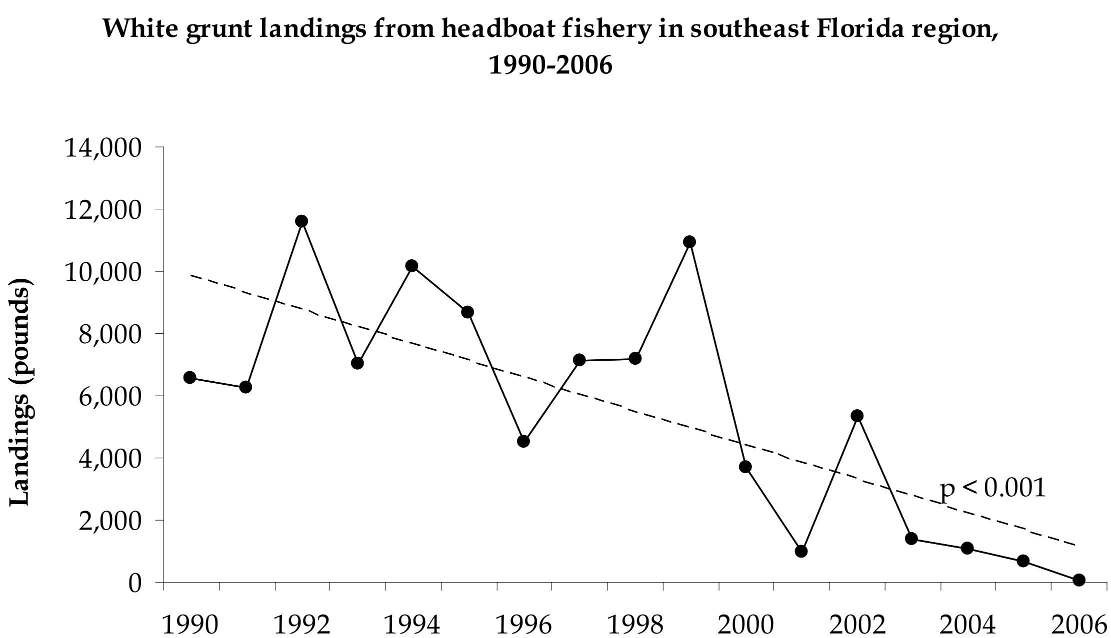

Figure 32. Landings of white grunt estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

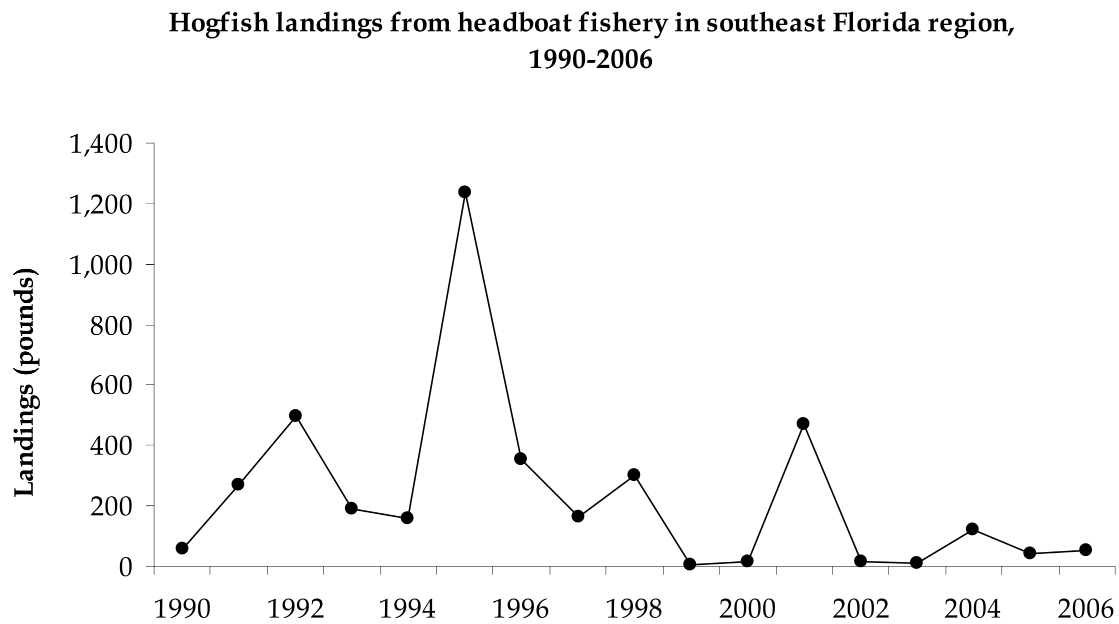

Figure 33. Landings of hogfish estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

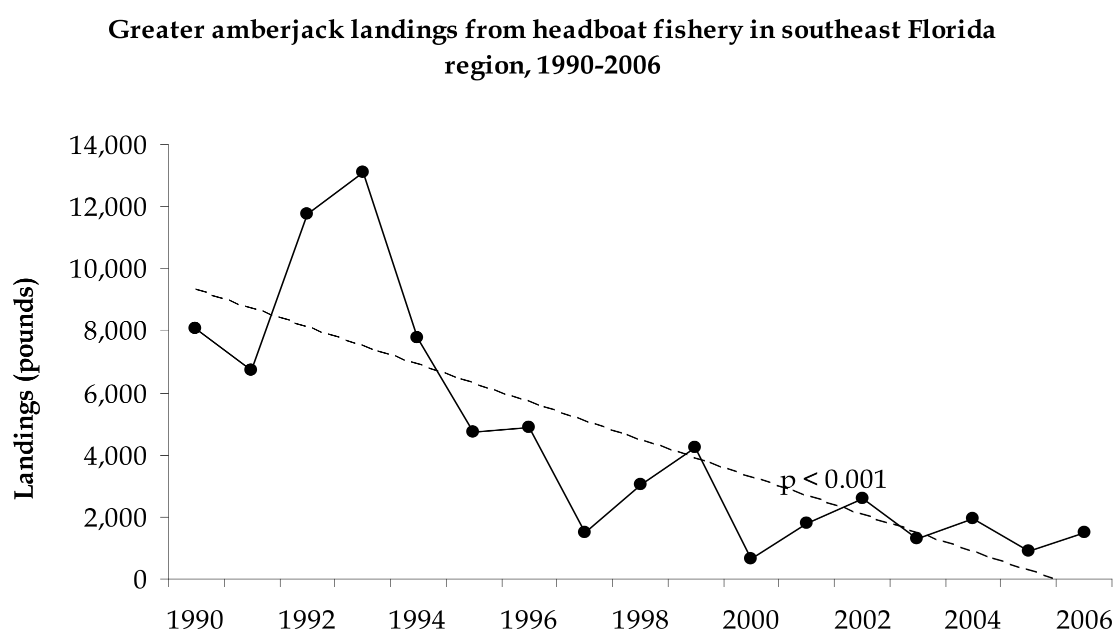

Figure 34. Landings of greater amberjack estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

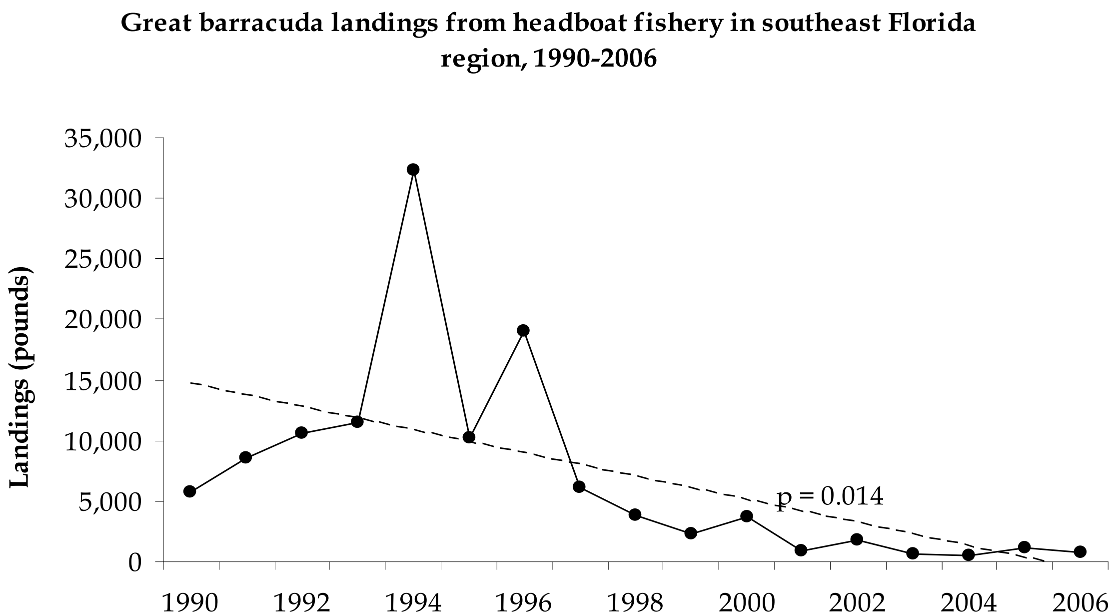

Figure 35. Great barracuda landings estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006. Dashed line shows significant (p = 0.014) negative linear trend.

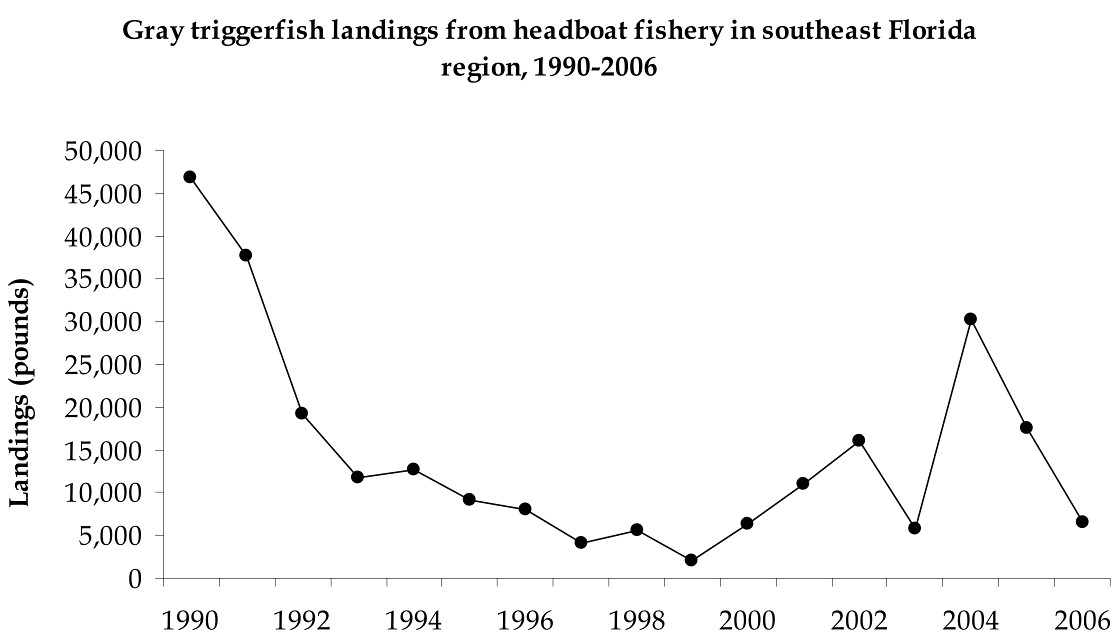

Figure 36. Landings of gray triggerfish estimated for the recreational headboat fishery in the southeast Florida region, 1990-2006.

Table 5. Annual estimated headboat landings in pounds (for Miami to Ft. Pierce) from 1990-2006 with linear trend and p-value of signficant trends.

Common name	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Trend*	P-value
Black grouper	569	643	1,155	1,959	1,549	1,112	2,678	1,113	1,438	1,438	2,155	1,747	1,312	125	696	1,717	883	n.s.	
Gray snapper	5,634	8,194	32,312	13,640	24,889	26,765	98,595	15,490	12,717	25,868	16,309	25,612	17,059	30,816	7,177	10,115	1,945	n.s.	
Gray triggerfish	46,749	37,625	19,158	11,667	12,642	9,057	8,101	4,043	5,548	2,119	6,338	10,980	16,137	5,810	30,250	17,605	6,473	n.s.	
Great barracuda	5,718	8,620	10,583	11,519	32,318	10,169	19,054	6,194	3,823	2,354	3,740	855	1,763	624	547	1,147	795	**neg**	0.014
Greater amberjack	8,083	6,708	11,747	13,128	7,774	4,747	4,874	1,478	3,025	4,239	626	1,810	2,584	1,275	1,923	872	1,472	**neg**	<0.001
Hogfish	56	269	495	190	159	1,237	355	166	300	5	14	468	15	11	121	41	53	n.s.	
Mutton snapper	54,753	38,600	22,412	49,929	47,391	25,572	10,819	13,150	9,933	13,632	7,662	13,712	10,392	8,865	11,296	27,426	4,646	**neg**	0.001
Red grouper	2,238	3,070	6,295	5,552	6,401	5,631	2,547	1,779	5,875	2,968	4,012	2,882	6,814	2,527	6,332	10,932	2,725	n.s.	
Tomtate	12,779	14,633	14,524	17,953	17,184	14,682	1,703	5,051	1,408	5,370	7,266	37,697	10,764	5,313	25,402	6,271	8,532	n.s.	
White grunt	6,580	6,274	11,600	7,049	10,176	8,685	4,489	7,149	7,161	10,931	3,715	970	5,331	1,365	1,072	671	42	**neg**	<0.001
Yellowtail snapper	52,661	49,299	55,413	52,205	84,503	43,434	25,804	36,500	20,677	28,688	12,627	5,210	2,731	12,055	7,770	17,193	2,105	**neg**	<0.001
TOTAL 11 SPP.	195,820	173,935	185,694	184,791	244,986	151,091	179,019	92,113	71,905	97,612	64,464	101,943	74,902	68,786	92,586	93,990	29,671	**neg**	<0.001

*1990-2006 Trends

pos increasing landings trend; trendline slope > 0 (p<0.05)
neg decreasing landings trend; trendline slope <0 (p<0.05)
n.s. non-significant or non-existent landings trend; trendslope = 0 (p>0.05)

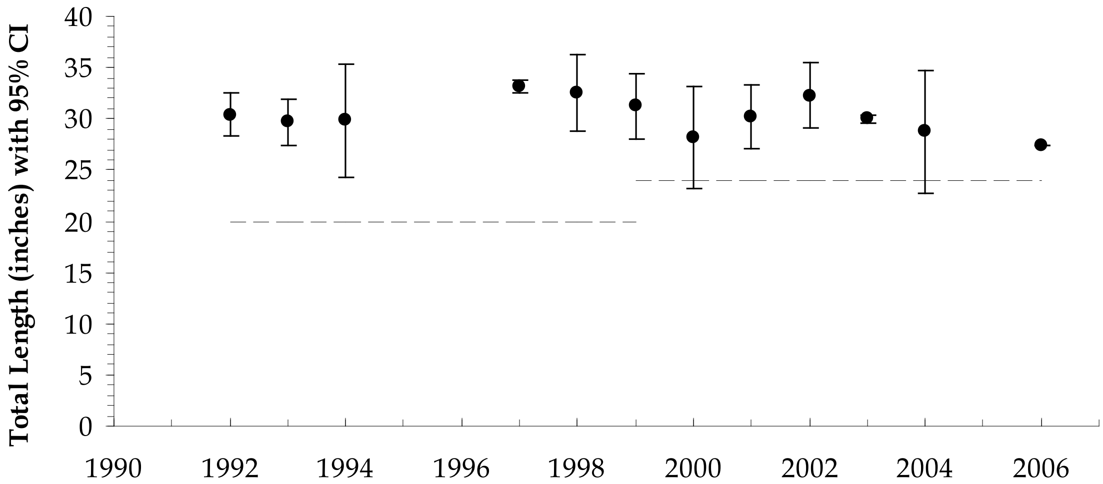

Figure 37. Average size in the exploited phase ($\overline{L}$) of black grouper estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no

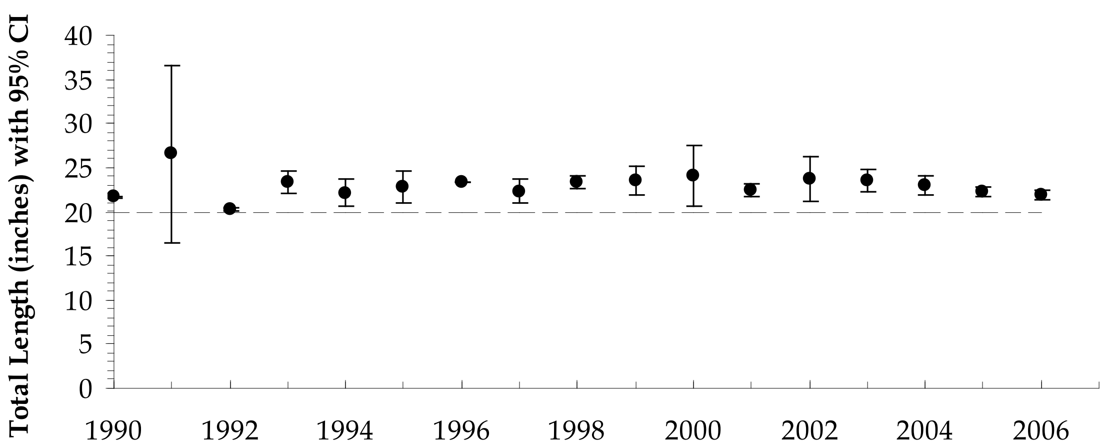

Figure 38. Average size in the exploited phase ($\overline{L}$) of red grouper estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

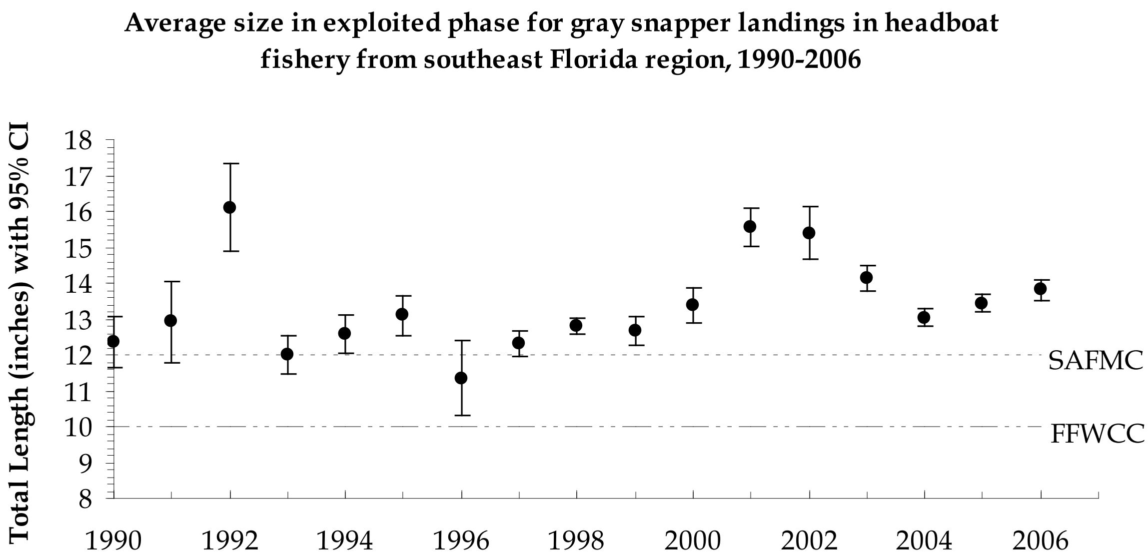

Figure 39. Average size in the exploited phase ($\overline{L}$) of gray snapper estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dotted line (SAFMC) and dash/dotted line (FFWCC) represents legal minimum size at first capture for federal and state waters, respectively.

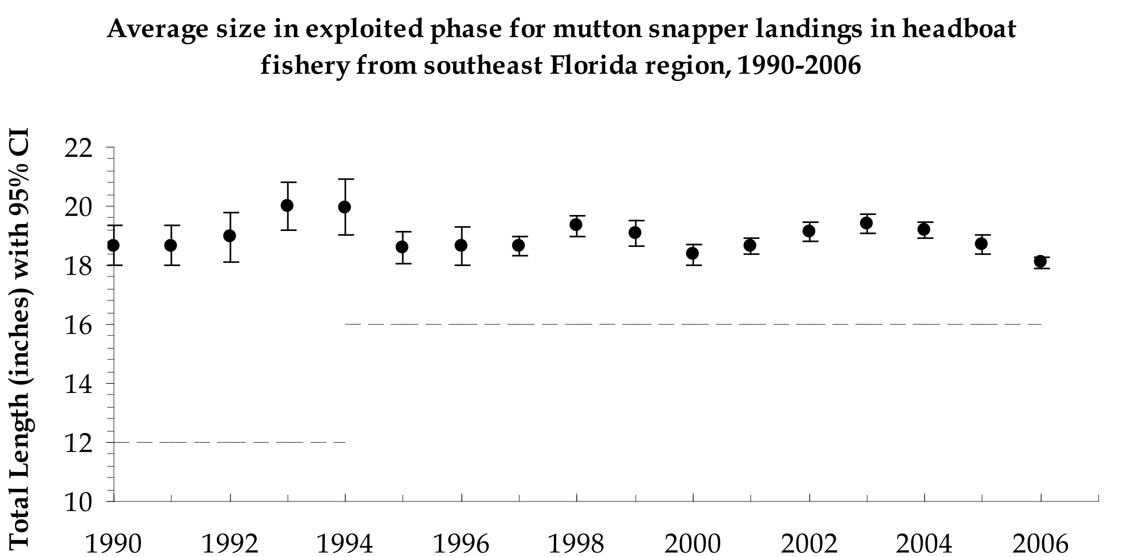

Figure 40. Average size in the exploited phase ($\overline{L}$) of mutton snapper estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

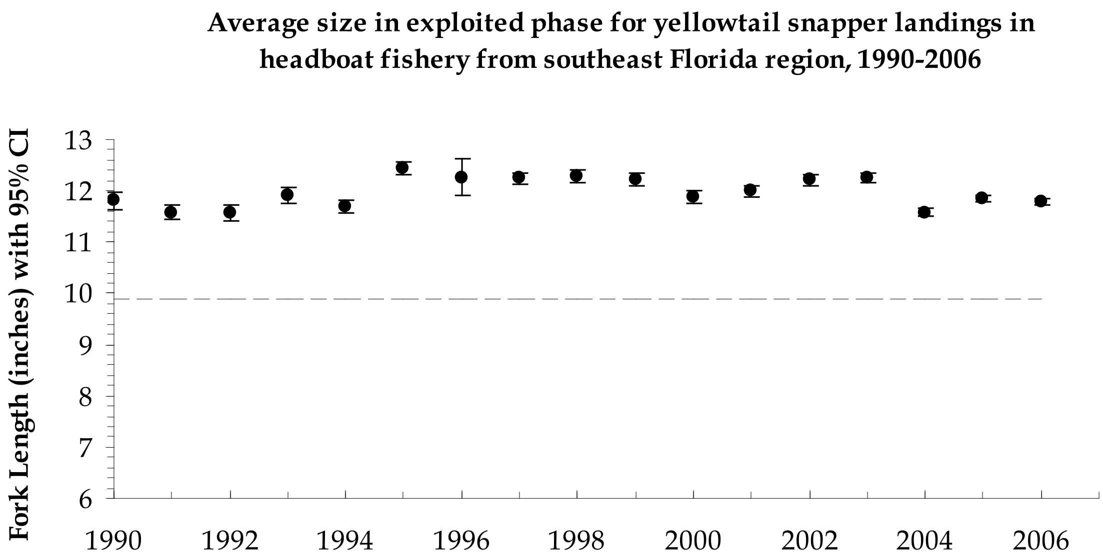

Figure 41. Average size in the exploited phase ($\overline{L}$) of yellowtail snapper estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dotted line represents legal minimum size at first capture (SAFMC and FFWCC same).

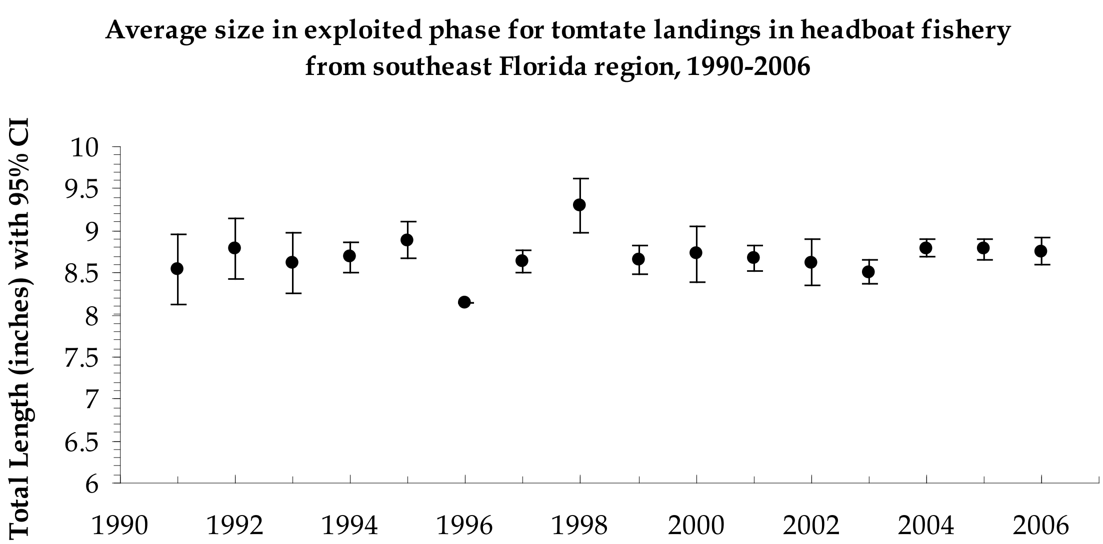

Figure 42. Average size in the exploited phase ($\overline{L}$) of tomtate estimated for the headboat fishery in the southeast Florida region, 1990-2006. Years with missing values had no data available. There is no minimum size regulation by SAFMC or FFWCC.

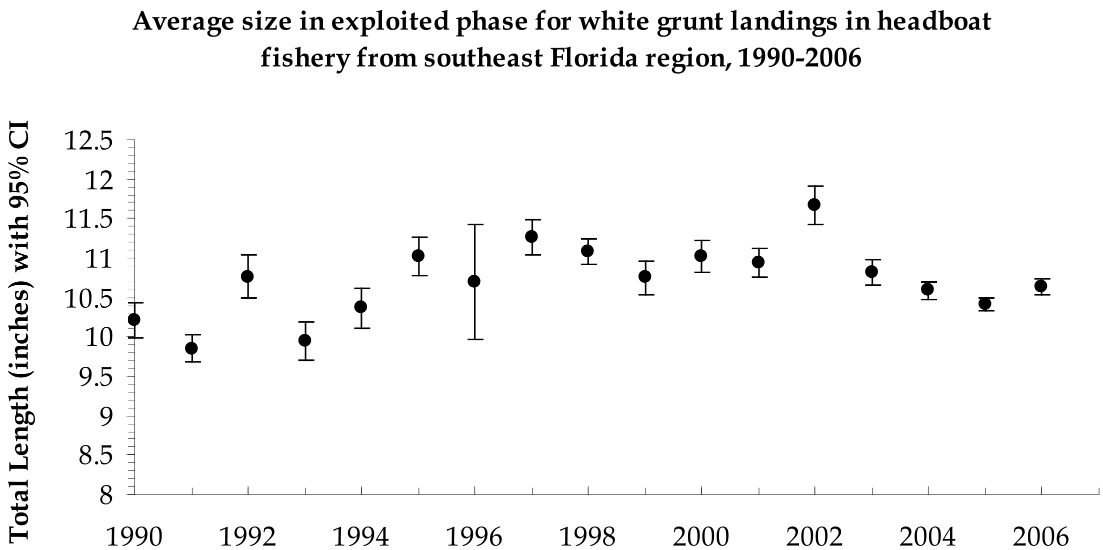

Figure 43. Average size in the exploited phase ($\bar{L}$) of white grunt estimated for the headboat fishery in the southeast Florida region, 1990-2006. There is no minimum size regulation by SAFMC or FFWCC.

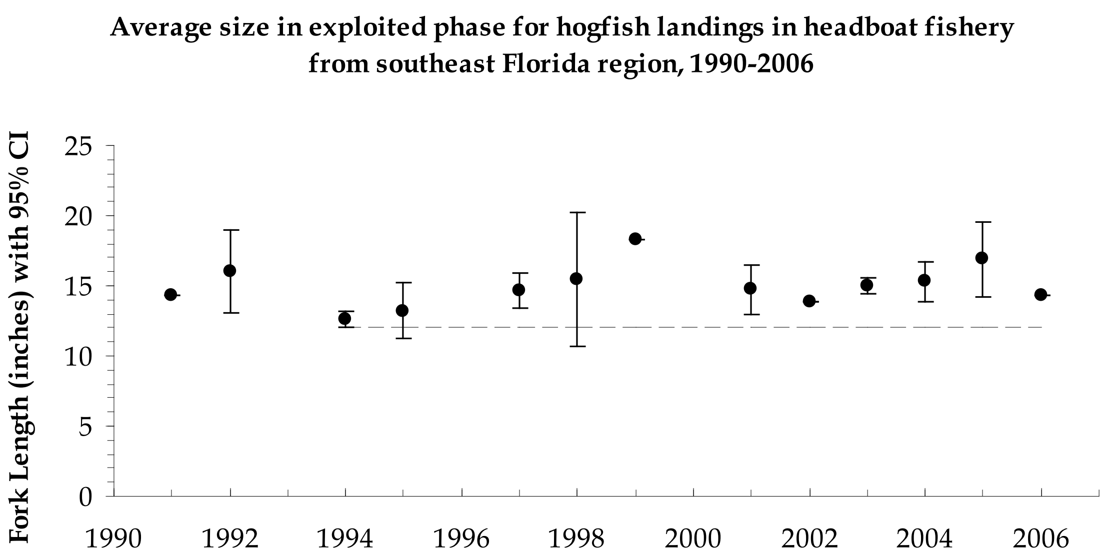

Figure 44. Average size in the exploited phase ($\bar{L}$) of hogfish estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

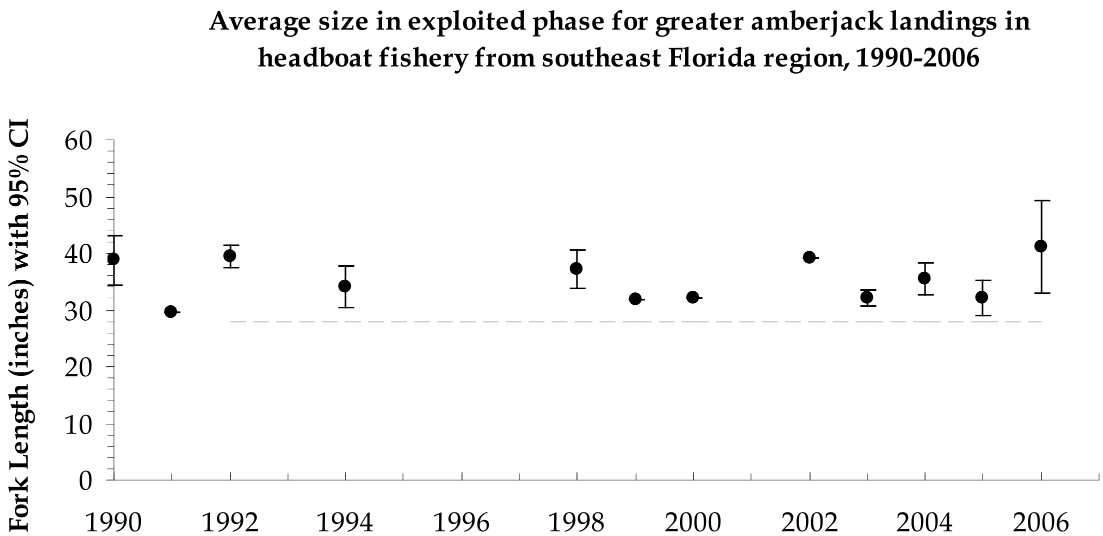

Figure 45. Average size in the exploited phase ($\bar{L}$) of greater amberjack estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

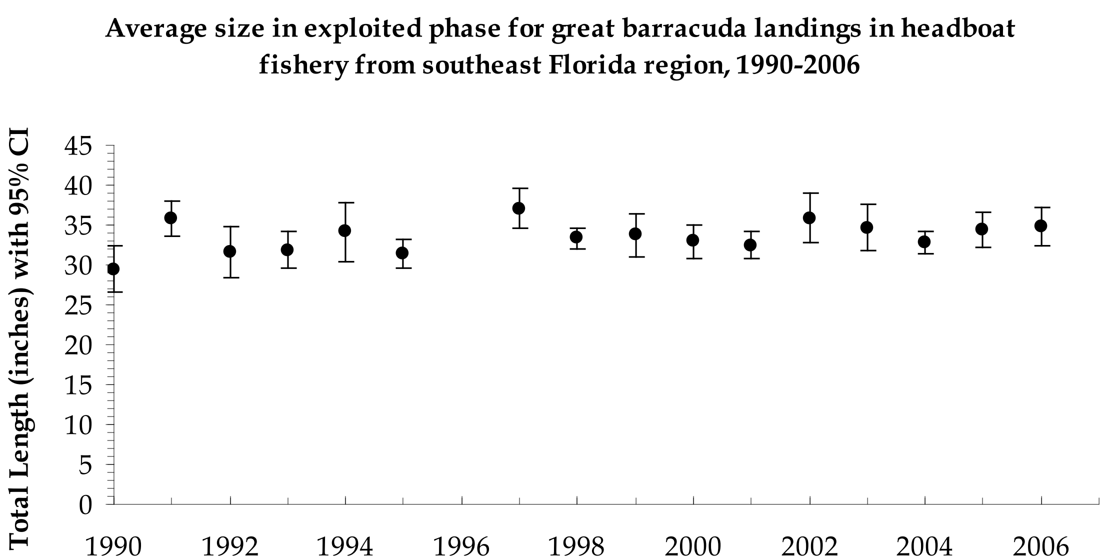

Figure 46. Average size in the exploited phase ($\bar{L}$) of great barracuda estimated for the headboat fishery in the southeast Florida region, 1990-2006. Years with missing values had no data available. There is no minimum size regulation by SAFMC or FFWCC.

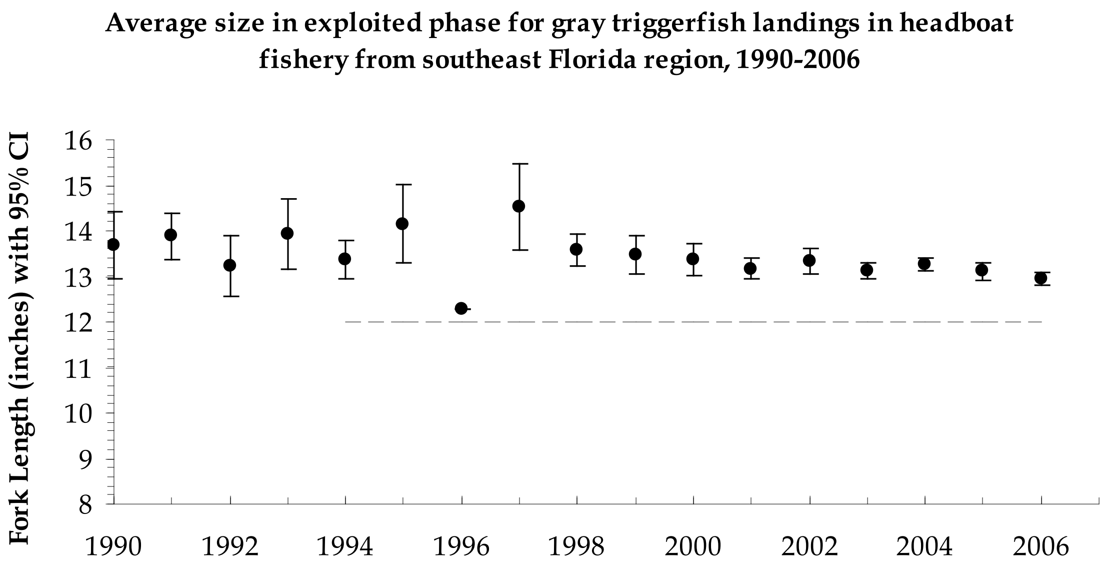

Figure 47. Average size in the exploited phase ($\overline{L}$) of gray triggerfish estimated for the headboat fishery in the southeast Florida region, 1990-2006. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

3.1.3 Commercial Fishery

Landings of six reef fish species and the aggregate category of "grunts" from the commercial fishery in the southeast Florida region declined 73% from 485,000 pounds in 1990 to 178,000 pounds in 2006 ($p < 0.0001$) (Fig. 48). Commercial landings data were not available for great barracuda, gray triggerfish, and greater amberjack. Five of the seven fish species experienced statistically significant declines in landings over the same time period (Fig. 49-55). Gray snapper and grunts did not decline. Black grouper, red grouper, mutton snapper, yellowtail snapper, and hogfish were the five species with significant declines in commercial landings. It is unclear if the decline in landings reflects decreasing fish populations or a decrease in effort in the commercial fishery since effort was not included due to difficulties in accurately partitioning effort for a multi-species, multigear fleet.

For the southeast Florida region, landings and number of trips for spiny lobsters declined significantly from 1990-2009, with a maximum catch of 916,654 pounds in 1991 decreasing to 266,616 pounds in 2009 (Fig. 56-57). These results suggest an unchanged trend in landings per trip for spiny lobster.

From the marine aquaria fishery, angelfish (family Pomacanthidae) landings and number of trips declined significantly for all Florida state waters from 1994 to 2009 (Fig. 58-59). Data were unavailable to characterize the southeast Florida region alone, but most marine aquaria activity occurs in Monroe County and southeast Florida. These results suggest an unchanged trend in landings per trip for angelfish.

In contrast to the landings data, none of the seven species experienced significant declining trends in the mean length of exploited phase from 1990-2008 (Fig. 60-70). Caution should be exercised with the interpretation of annual $\bar{L}$ estimates given the low sample sizes ($n < 10$) observed during some years for some species. Estimated monthly landings and value ($USD) of eight fish species demonstrate the within-year temporal fishery dynamics of each species (Fig. 71-86). For example, landings of the gray snapper (Fig. 75) and great barracuda (Fig. 85) peak in summer while greater amberjack landings are highest in spring (Fig. 83).

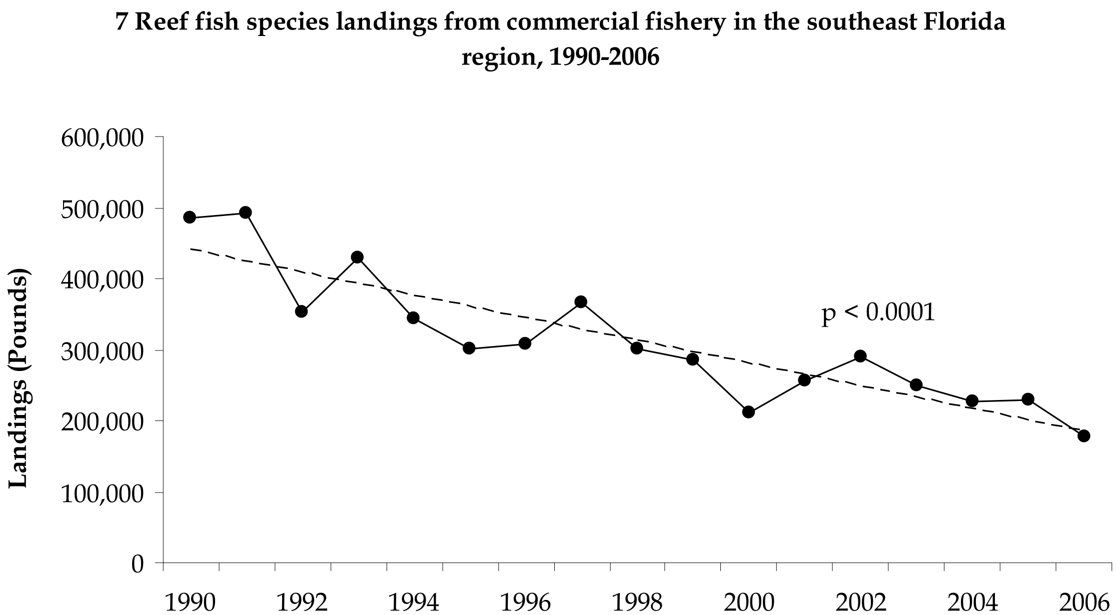

Figure 48. Total landings of 7 reef fish species (red grouper, black grouper, mutton snapper, gray snapper, yellowtail snapper, hogfish, and grunts) analyzed in this report estimated for the commercial fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.0001$) negative linear trend.

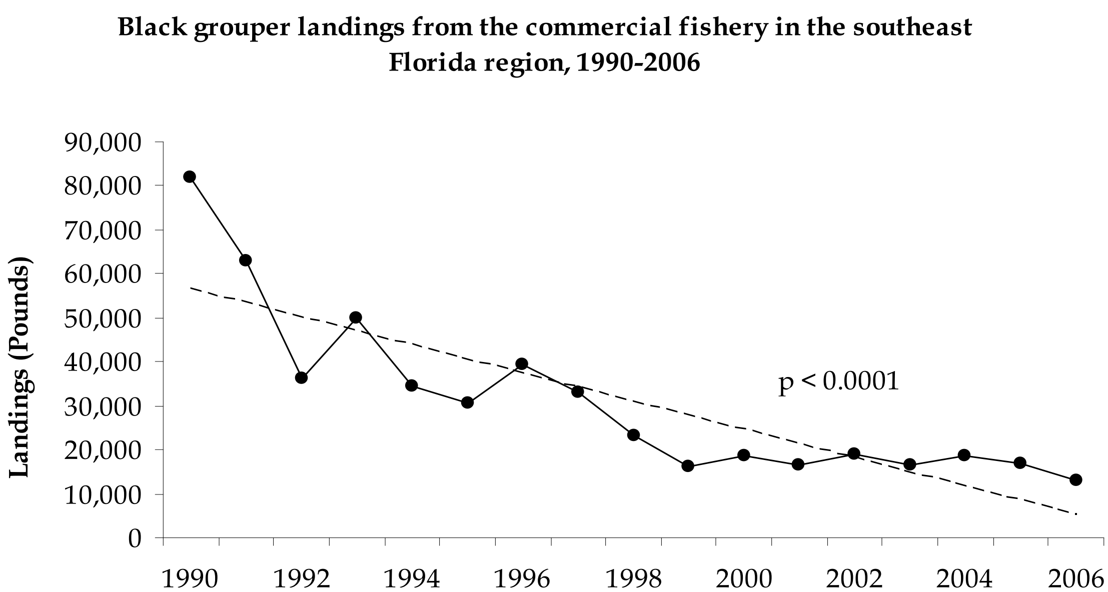

Figure 49. Landings of black grouper reported for the commercial fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.0001$) negative linear trend.

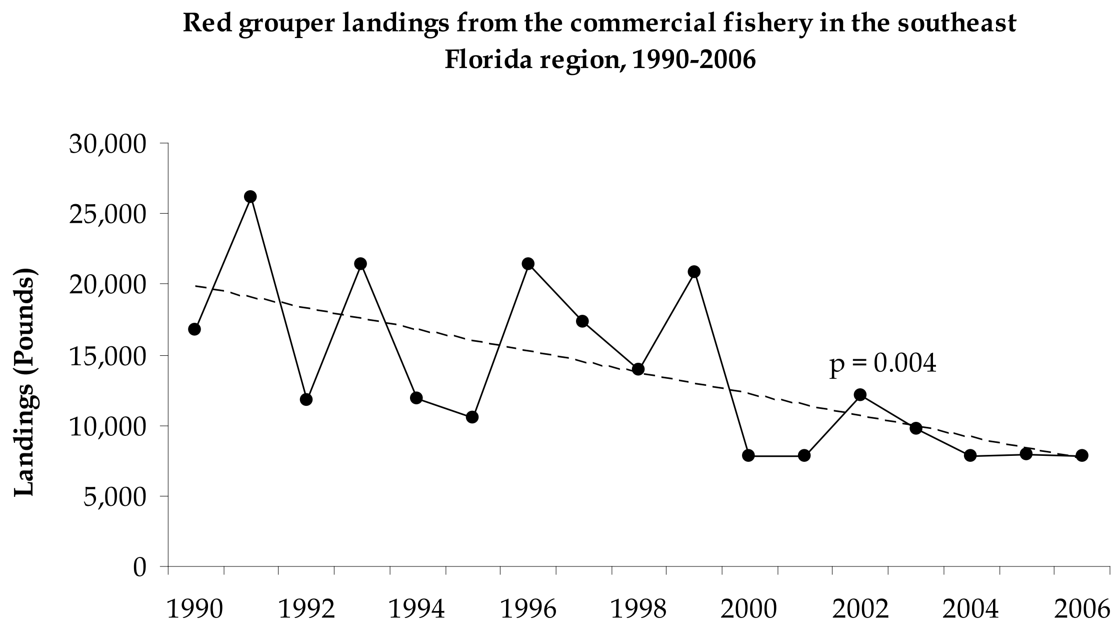

Figure 50. Landings of red grouper reported for the commercial fishery in the southeast Florida region, 1990-2006. Dashed line shows significant (p = 0.004) negative linear trend.

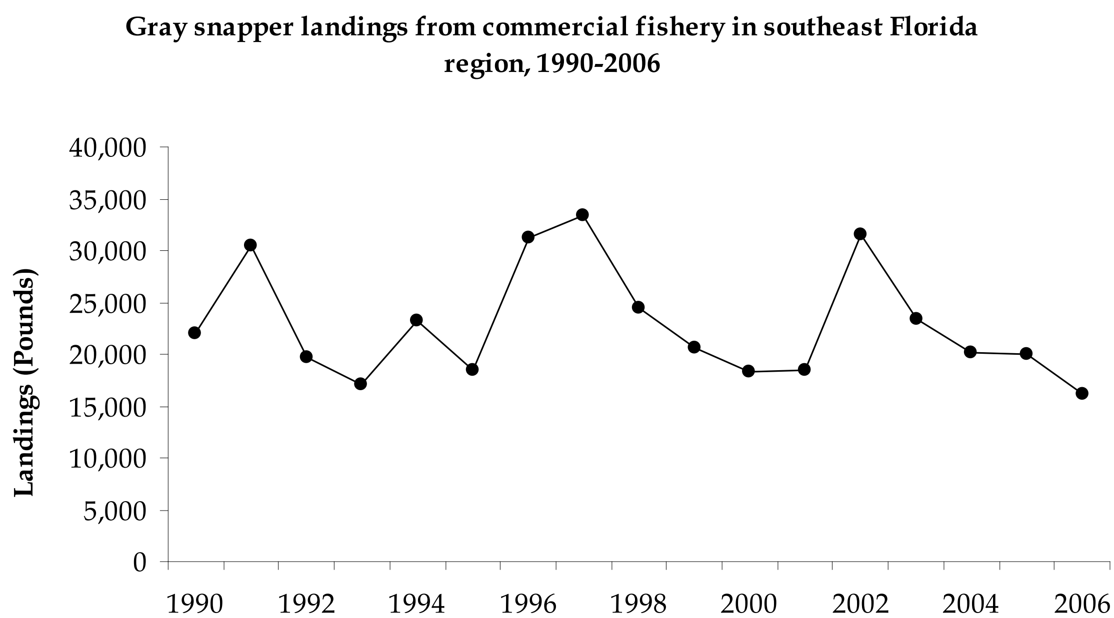

Figure 51. Landings of gray snapper reported for the commercial fishery in the southeast Florida region, 1990-2006.

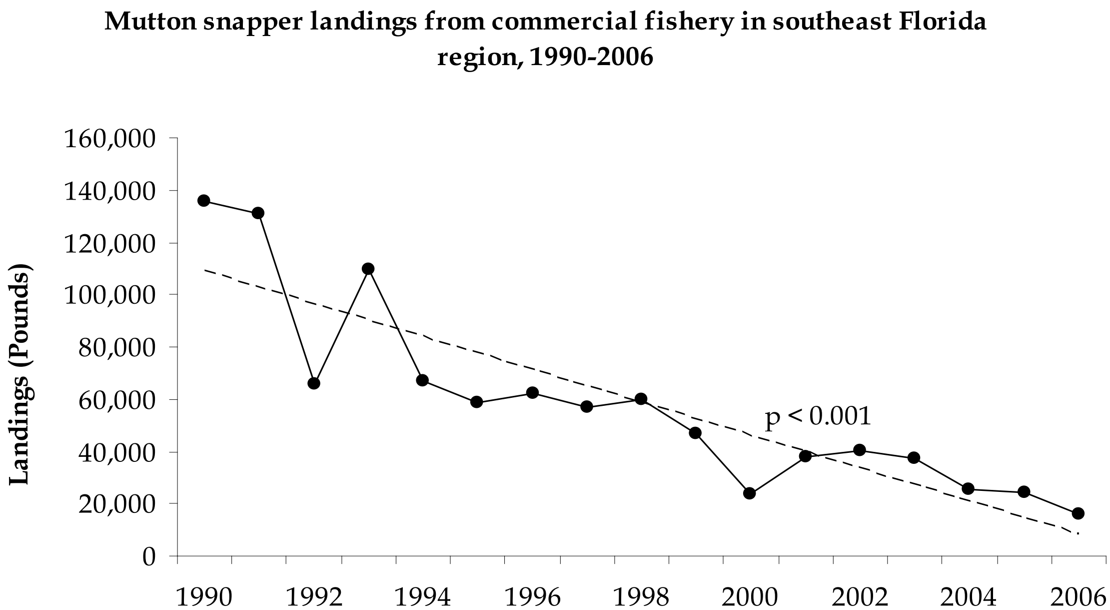

Figure 52. Landings of mutton snapper reported for the commercial fishery in the southeast Florida region, 1990-2006. Dashed line shows significant ($p < 0.001$) negative linear trend.

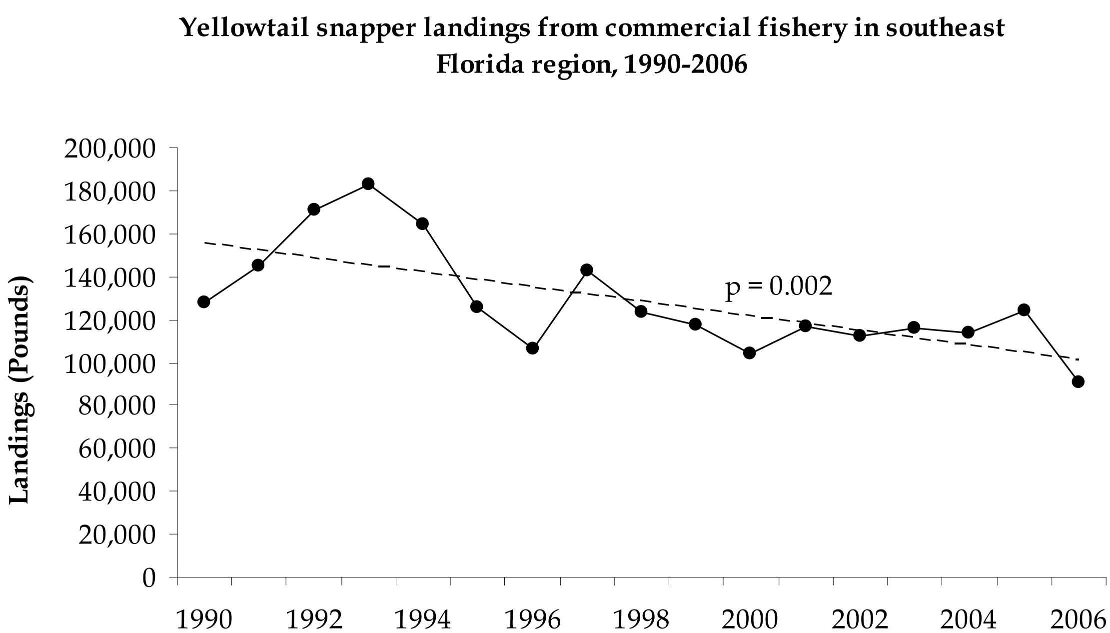

Figure 53. Landings of yellowtail snapper reported for the commercial fishery in the southeast Florida region, 1990-2006. Dotted line shows significant ($p = 0.002$) negative linear trend.

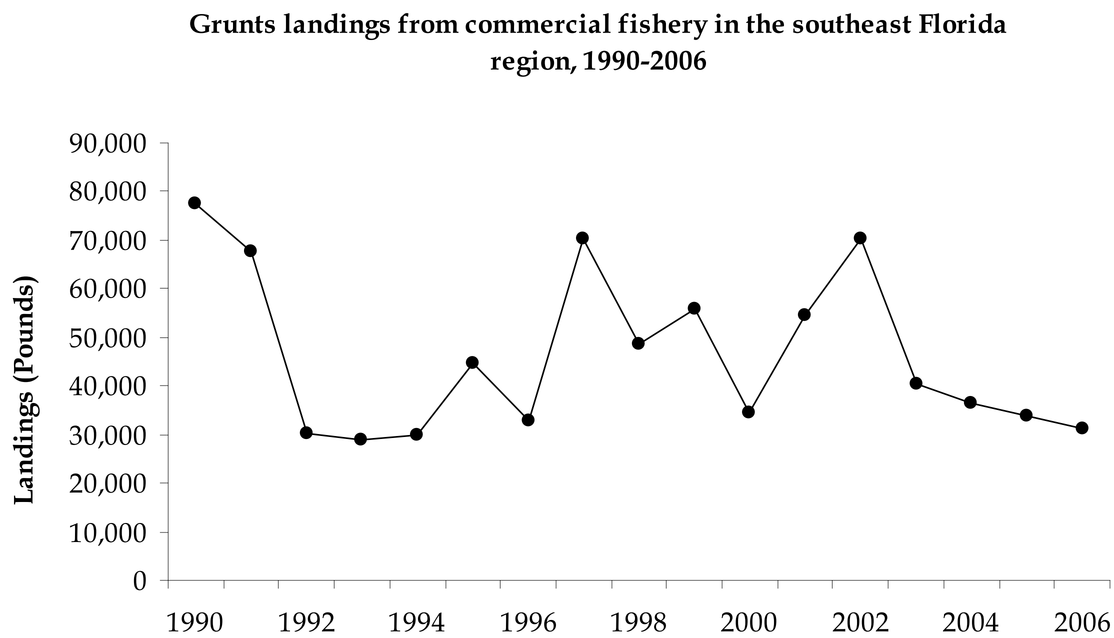

Figure 54. Landings of grunts reported for the commercial fishery in the southeast Florida region, 1990-2006.

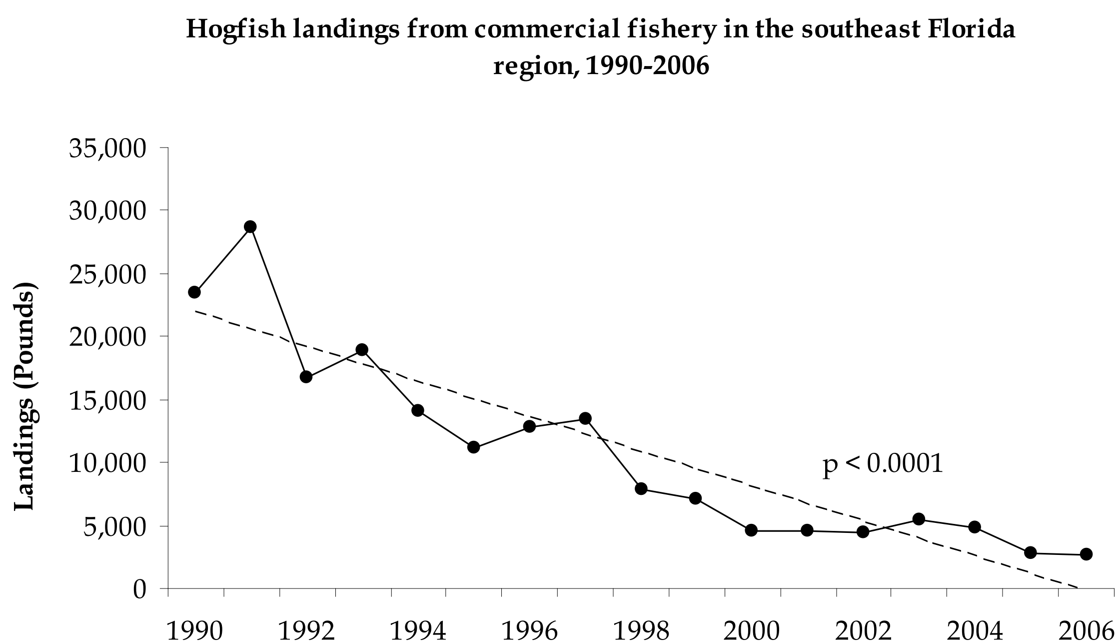

Figure 55. Landings of hogfish reported for the commercial fishery in the southeast Florida region, 1990-2006. Dotted line shows significant ($p < 0.0001$) negative linear trend.

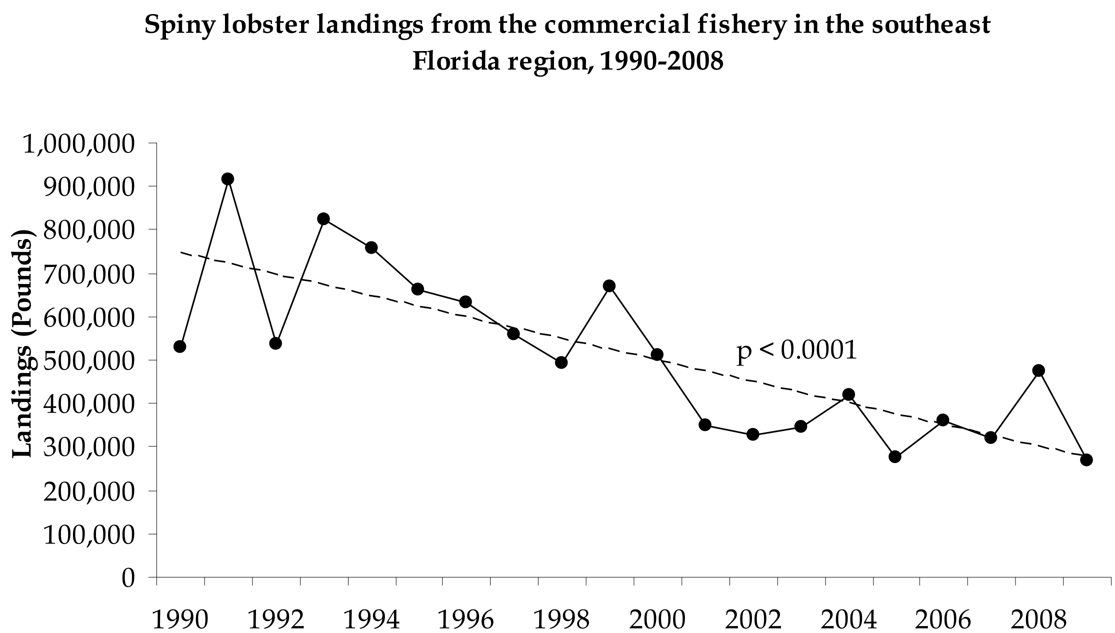

Figure 56. Landings of spiny lobster reported for the commercial fishery in the southeast Florida region, 1990-2009. Dotted line shows significant ($p < 0.0001$) negative linear trend.

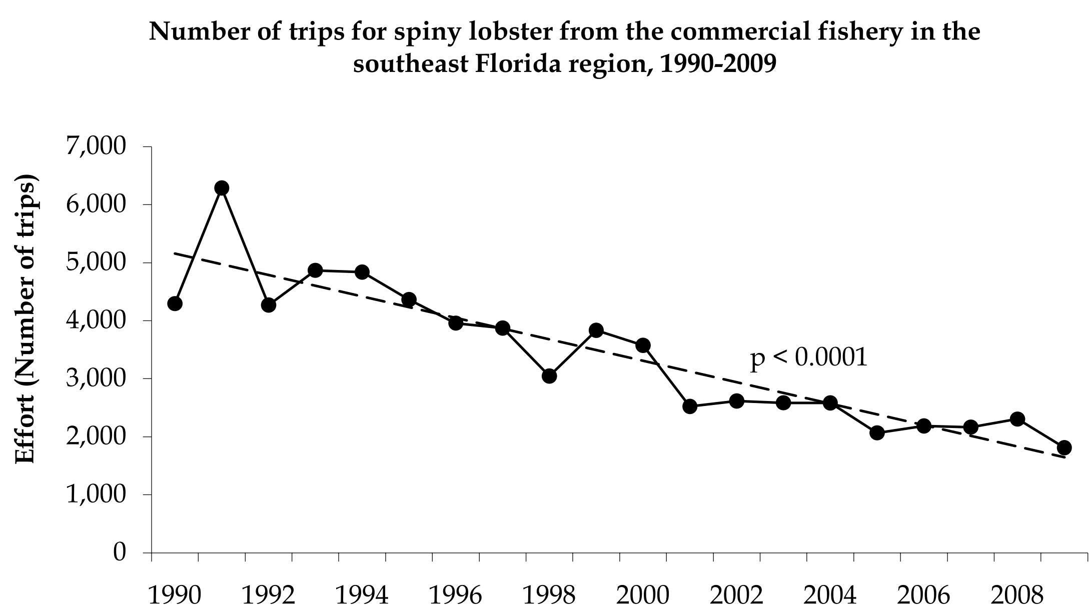

Figure 57. Number of trips per year for spiny lobster from the commercial fishery in the southeast Florida region 1990-2009. Dashed line shows significant ($p < 0.0001$) negative linear trend.

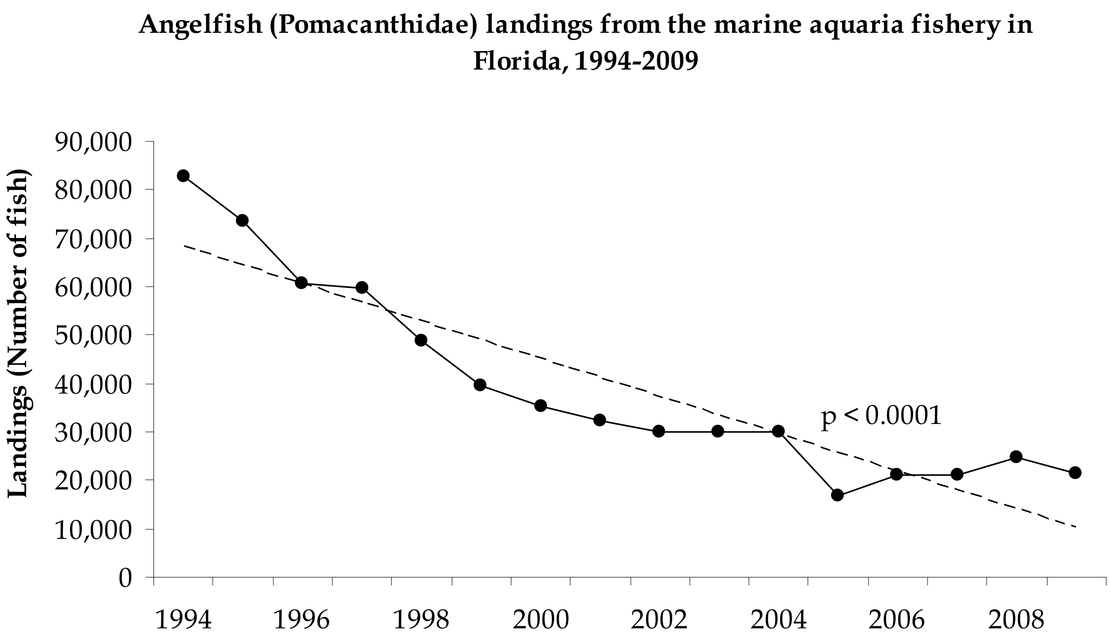

Figure 58. Landings of angelfish (Pomacanthidae) reported for the commercial marine aquaria fishery in Florida, 1994-2009. Dotted line shows significant ($p < 0.0001$) negative linear trend.

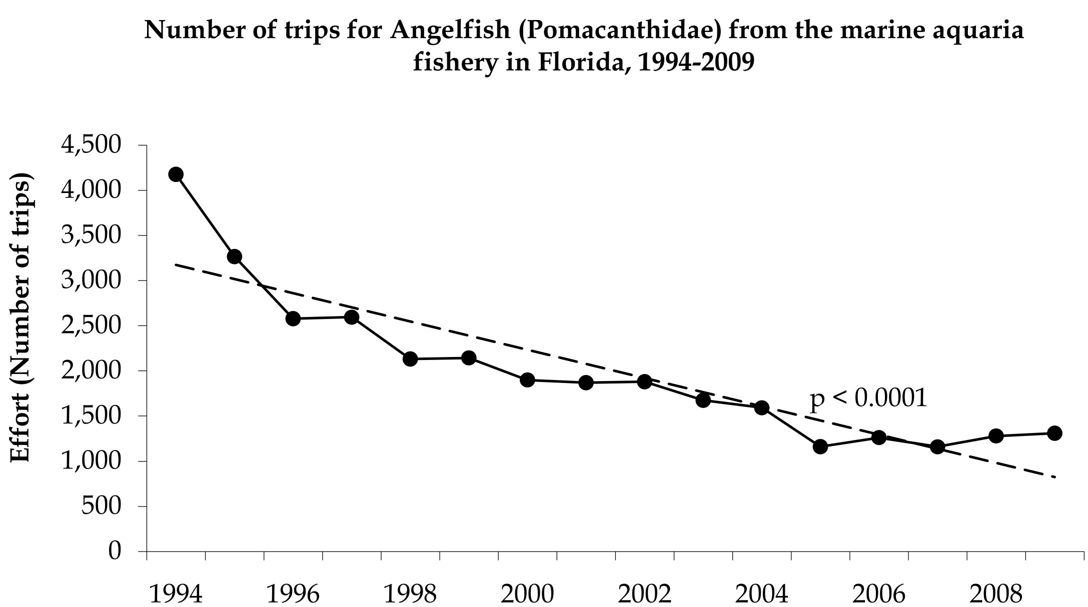

Figure 59. Number of trips per year for angelfish (Pomacanthidae) from the commercial marine aquaria fishery in Florida from 1994-2009. Dashed line shows significant ($p < 0.0001$) negative linear trend.

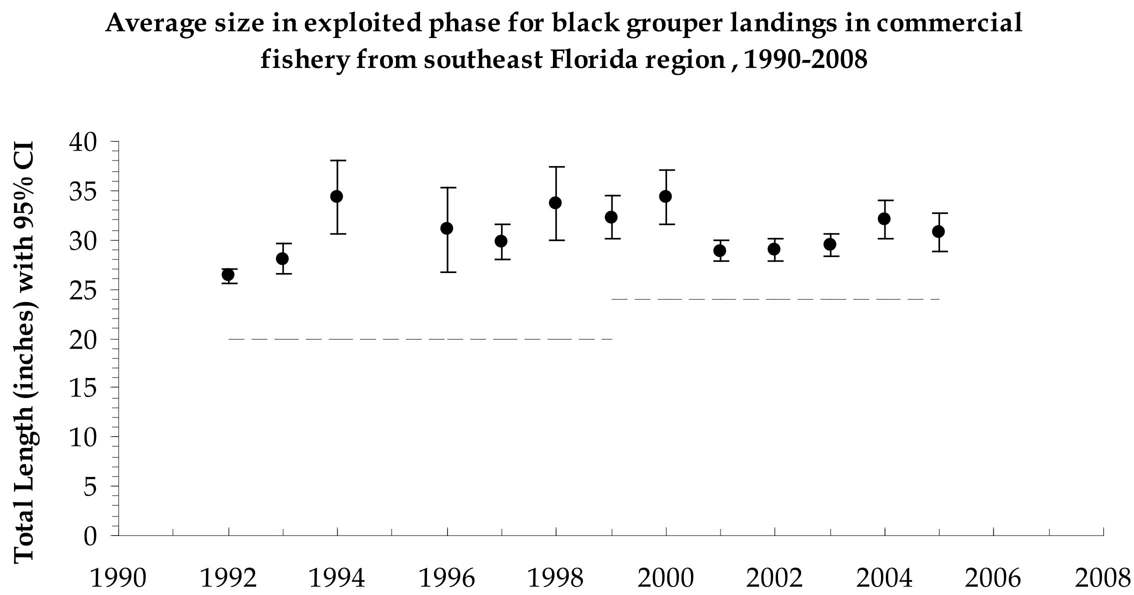

Figure 60. Average size in the exploited phase ($\bar{L}$) of black grouper estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

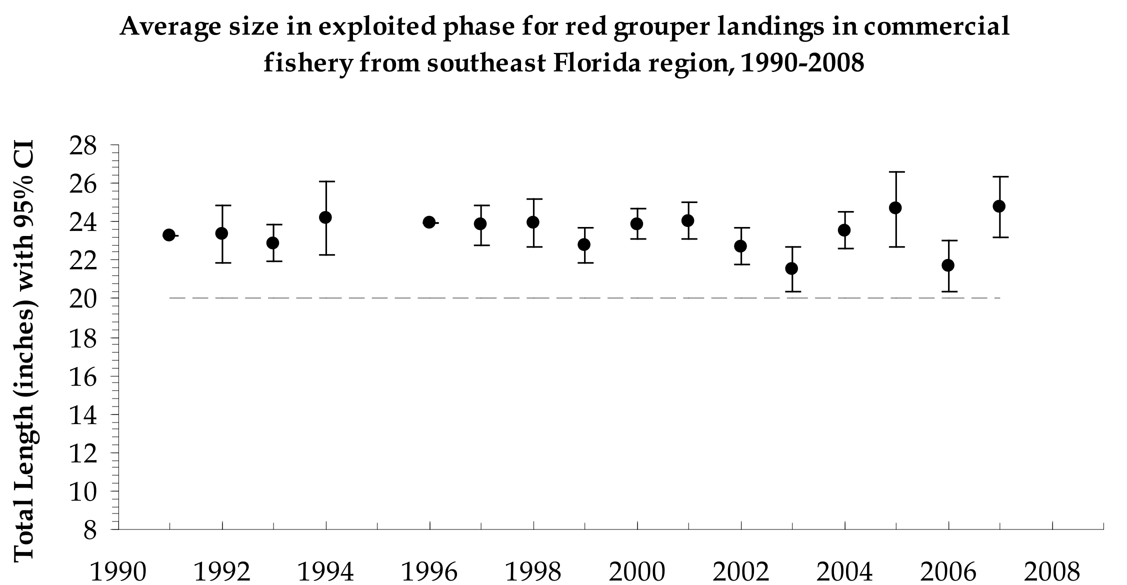

Figure 61. Average size in the exploited phase ($\bar{L}$) of red grouper estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

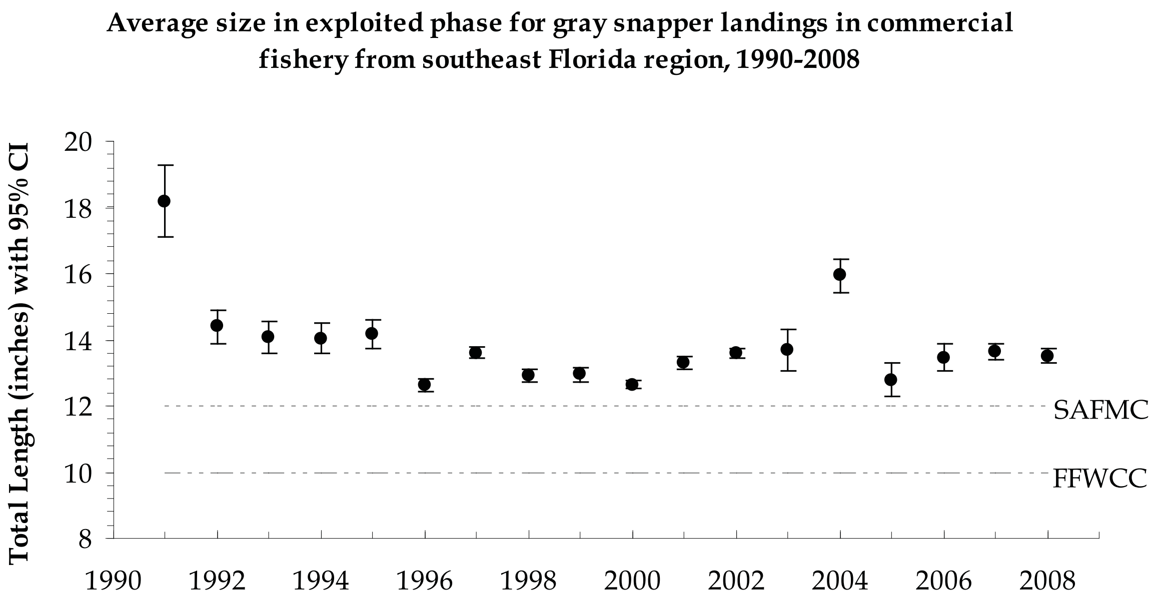

Figure 62. Average size in the exploited phase ($\overline{L}$) of gray snapper estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dotted line (SAFMC) and dash/dotted line (FFWCC) represents legal minimum size at first capture for federal and state waters, respectively.

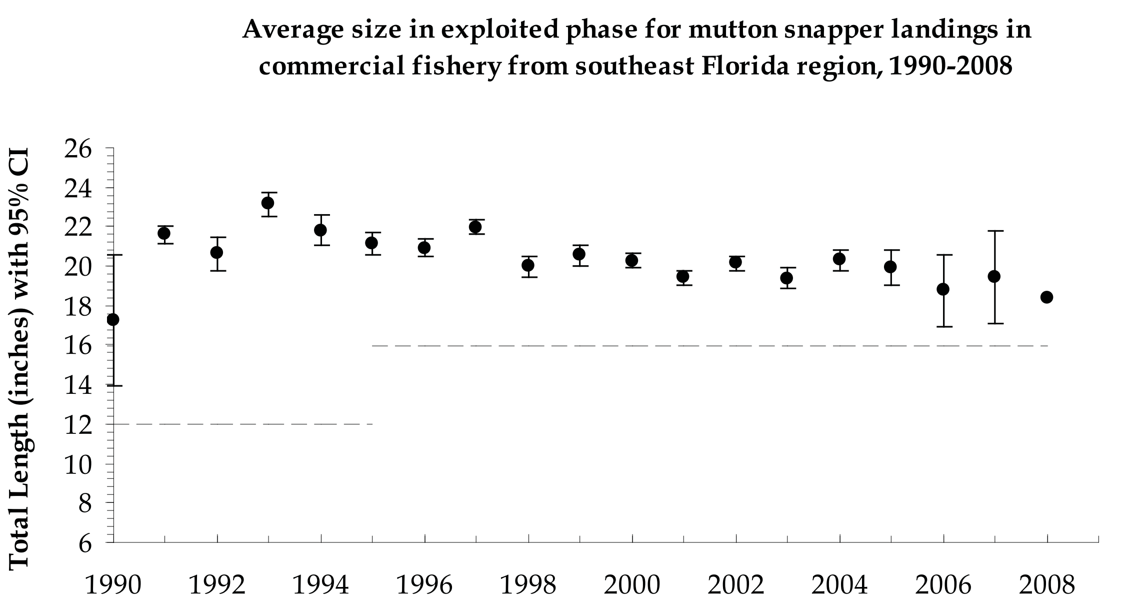

Figure 63. Average size in the exploited phase ($\overline{L}$) of mutton snapper estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

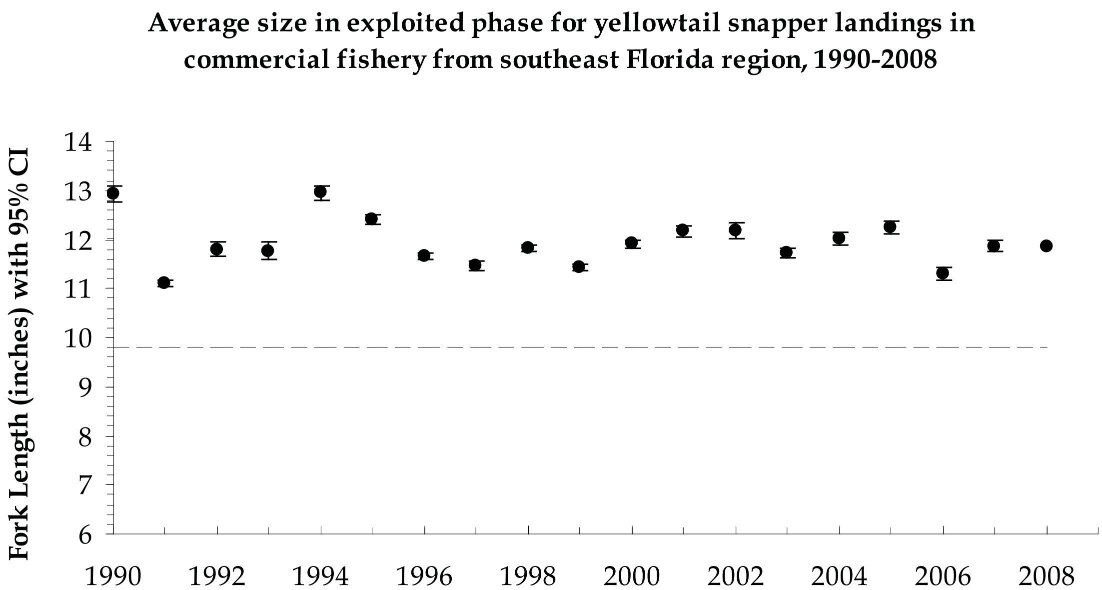

Figure 64. Average size in the exploited phase ($\bar{L}$) of yellowtail snapper estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same).

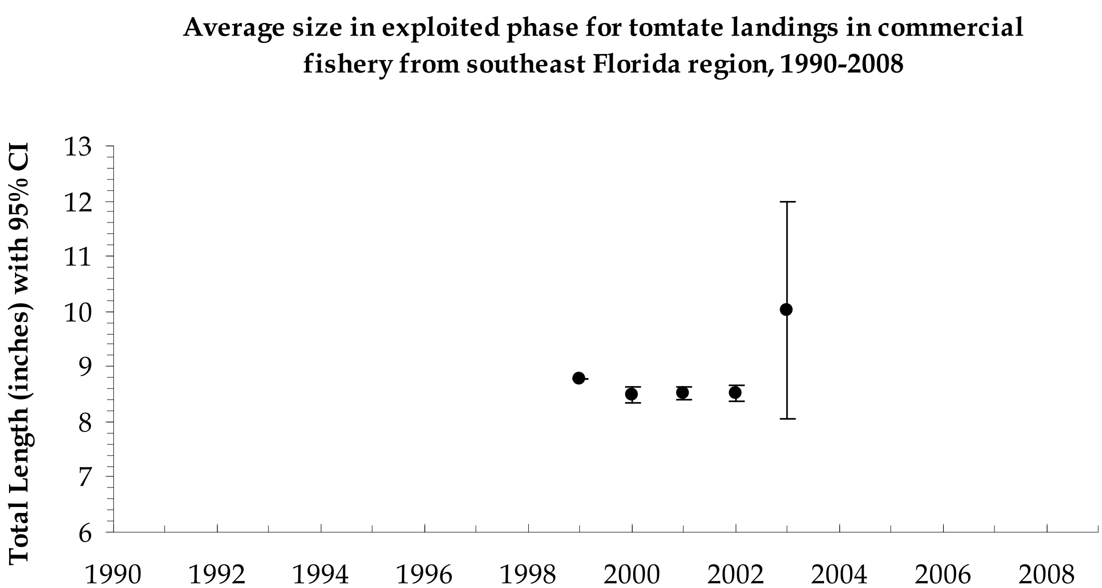

Figure 65. Average size in the exploited phase ($\bar{L}$) of tomtate estimated for the commercial fishery in the southeast Florida region, 1990-2008. Years with missing values had no data available. There is no minimum size regulation by SAFMC or FFWCC.

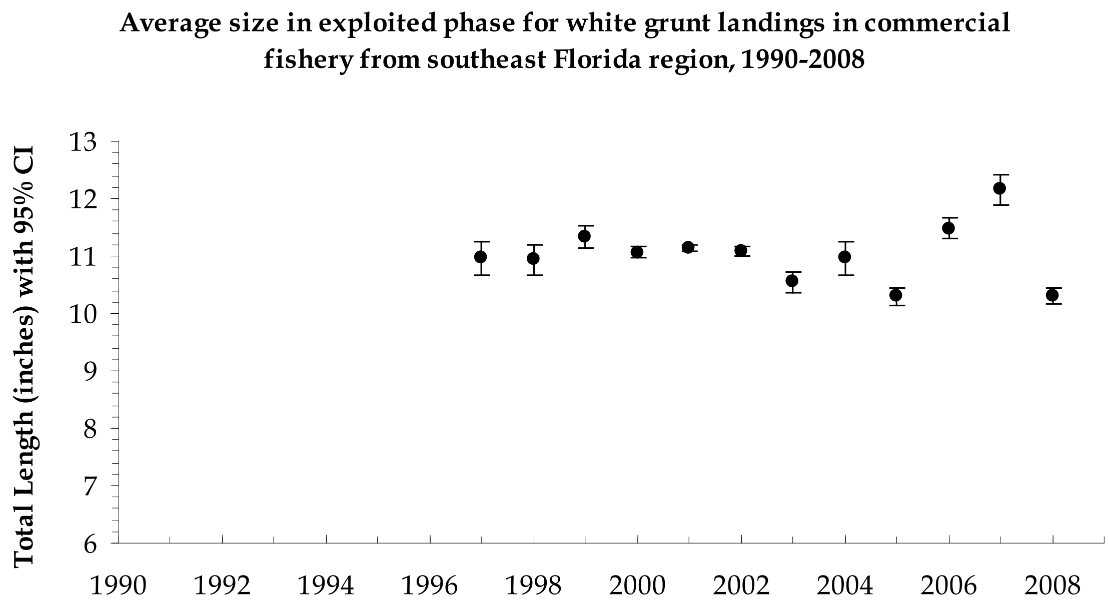

Figure 66. Average size in the exploited phase ($\bar{L}$) of white grunt estimated for the commercial fishery in the southeast Florida region, 1990-2008. Years with missing values had no data available. There is no minimum size regulation by SAFMC or FFWCC.

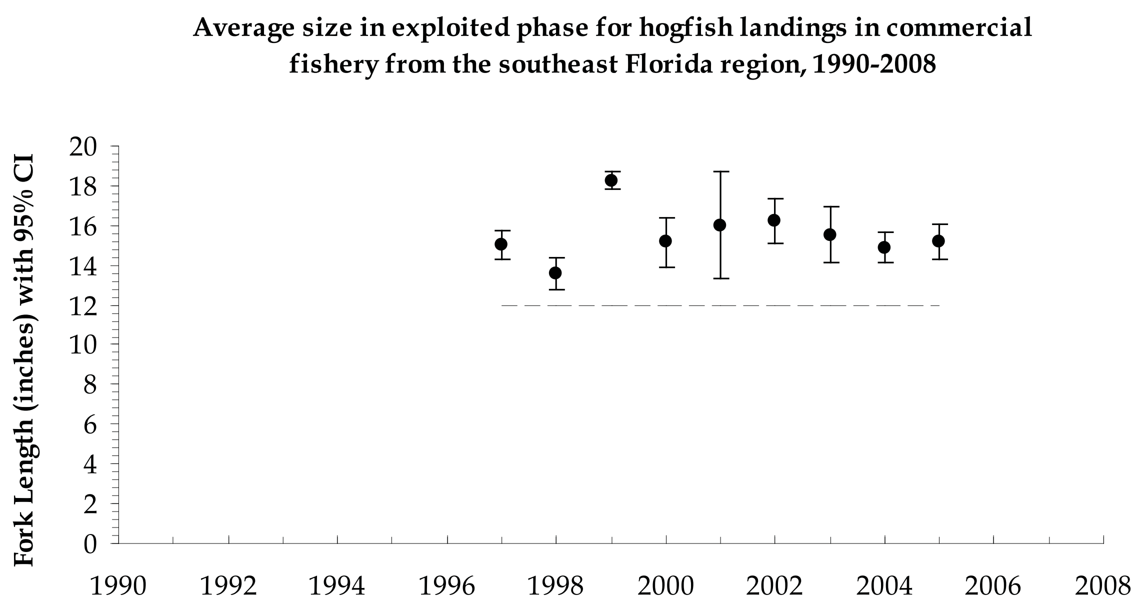

Figure 67. Average size in the exploited phase ($\bar{L}$) of hogfish estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

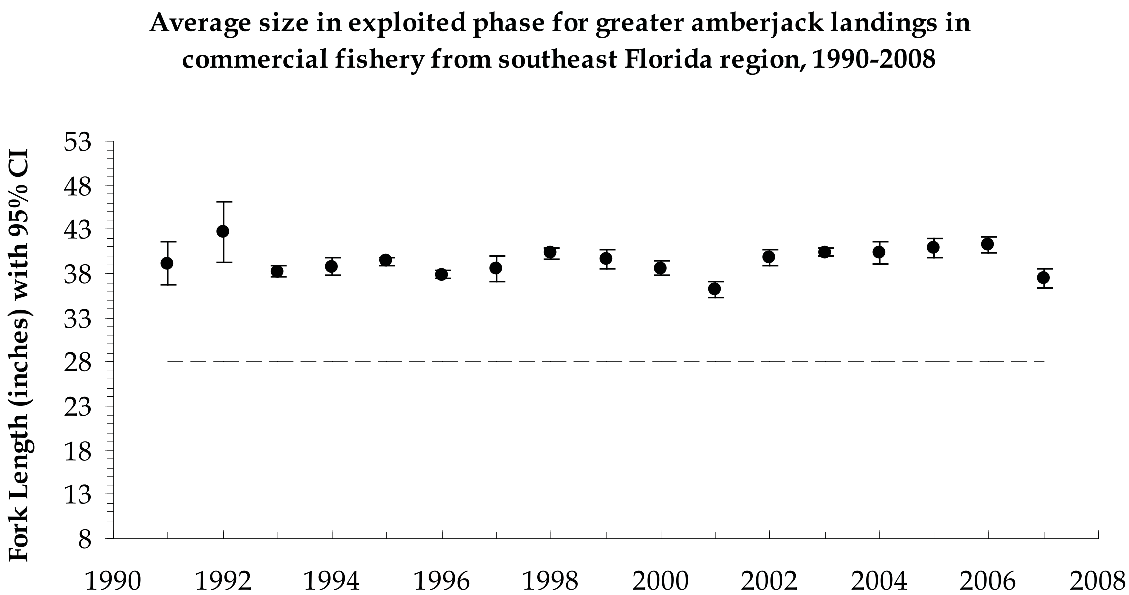

Figure 68. Average size in the exploited phase ($\overline{L}$) of greater amberjack estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

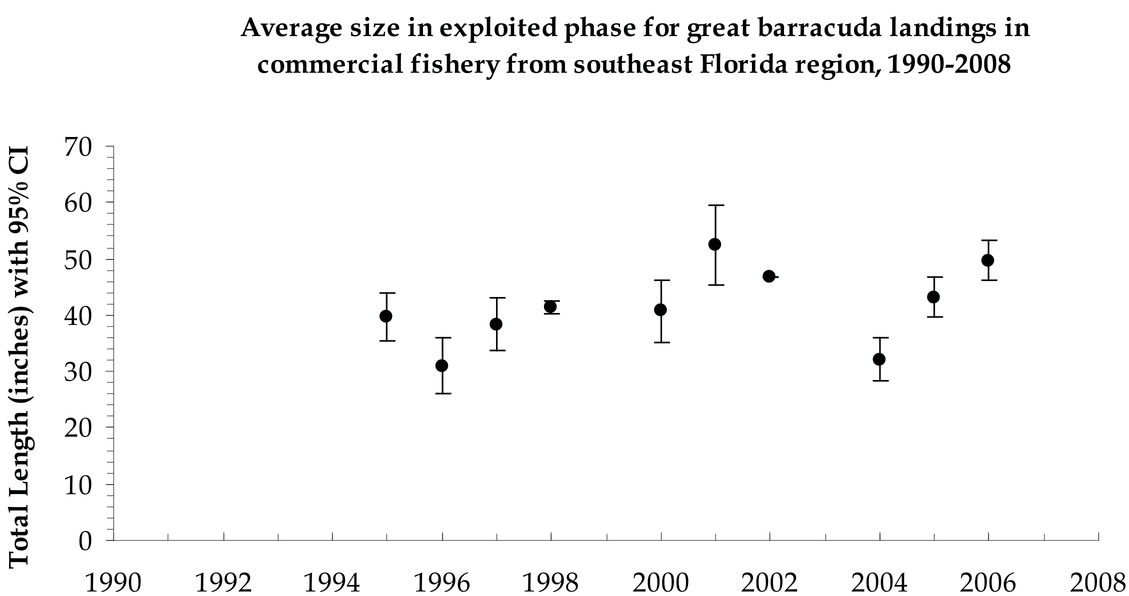

Figure 69. Average size in the exploited phase ($\overline{L}$) of great barracuda estimated for the commercial fishery in the southeast Florida region, 1990-2008. Years with missing values had no data available. There is no minimum size regulation by SAFMC or FFWCC.

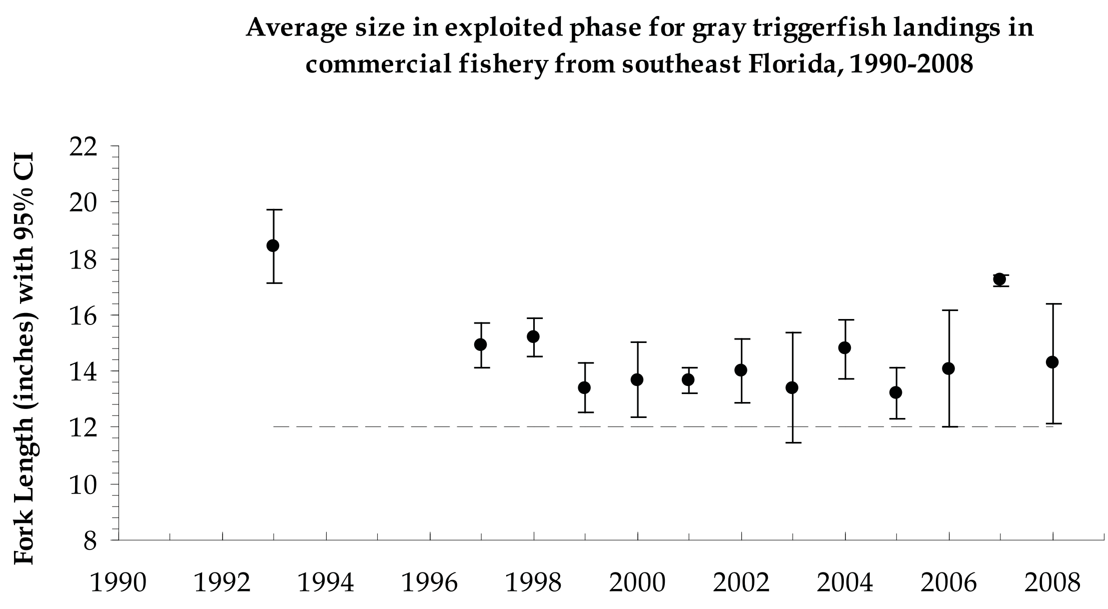

Figure 70. Average size in the exploited phase ($\bar{L}$) of gray triggerfish estimated for the commercial fishery in the southeast Florida region, 1990-2008. Dashed line represents legal minimum size at first capture (SAFMC and FFWCC same). Years with missing values had no data available.

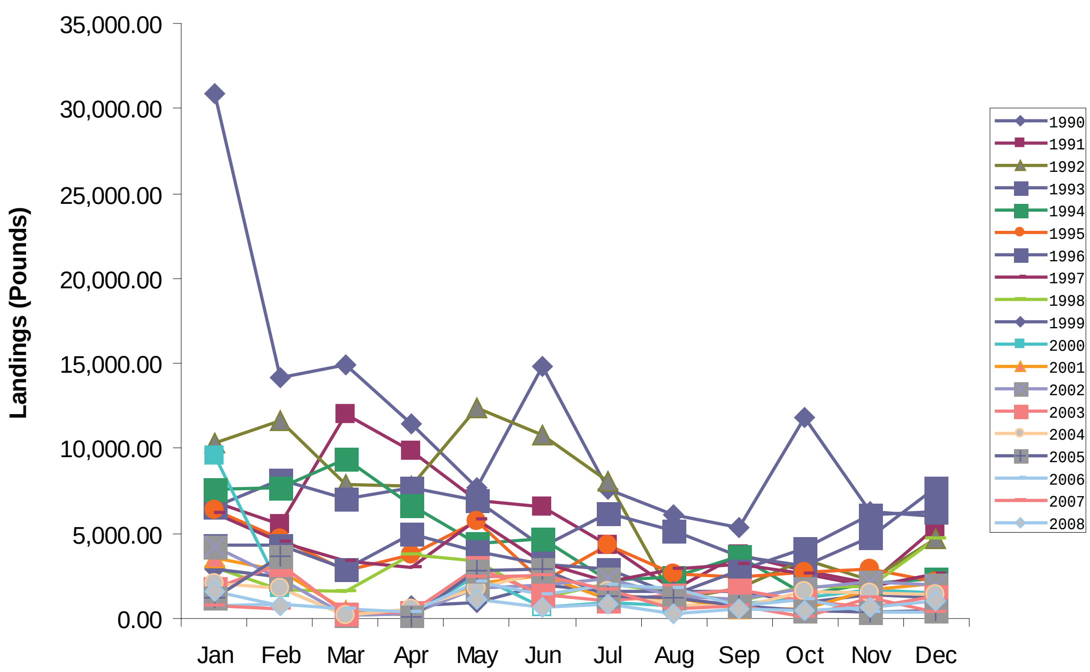

Figure 71. Estimated monthly landings of black grouper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

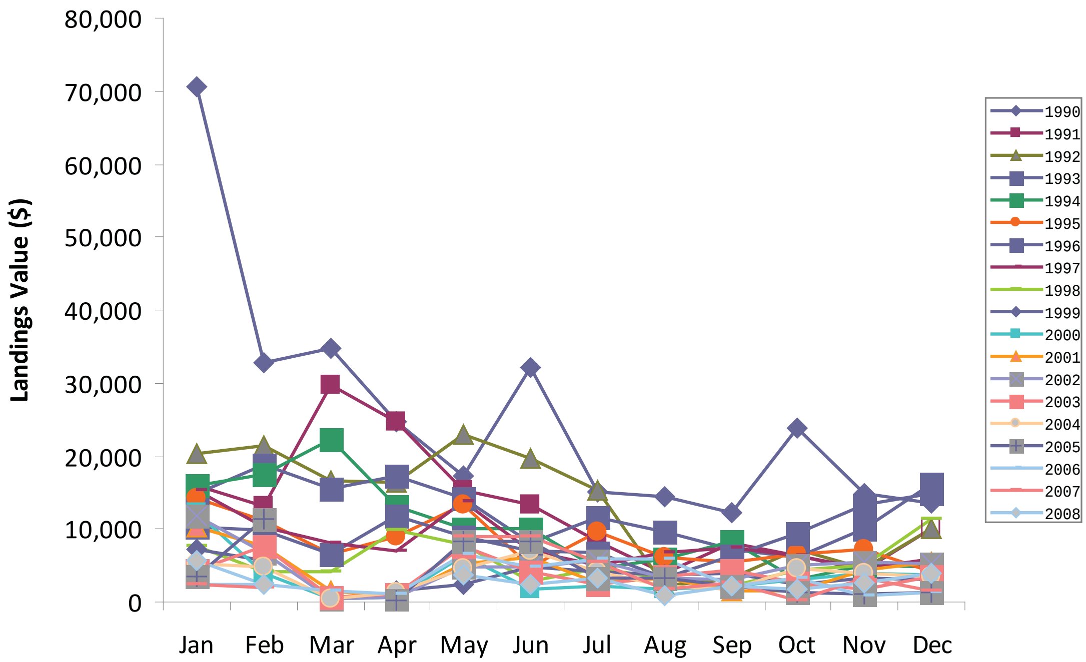

Figure 72. Estimated monthly value ($USD) of landings of black grouper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

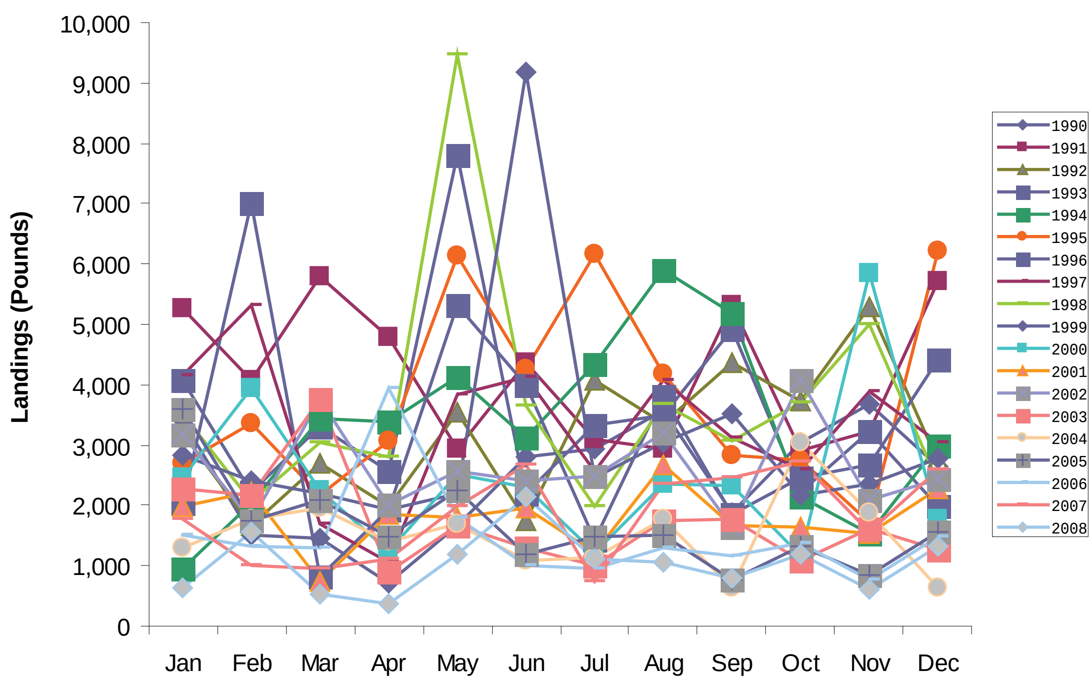

Figure 73. Estimated monthly landings of red grouper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

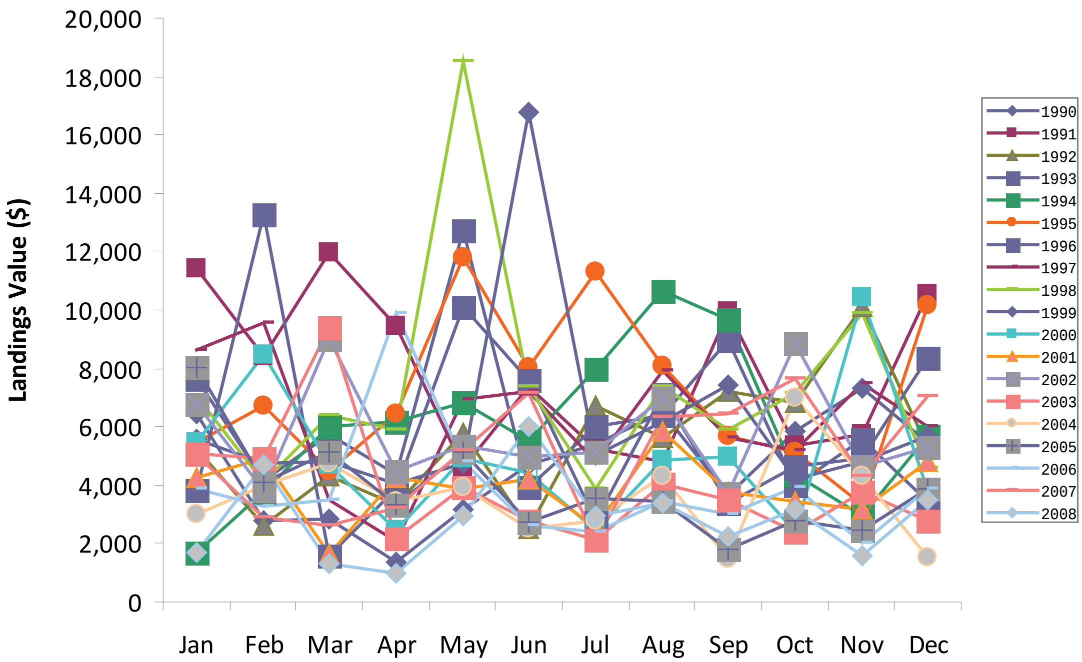

Figure 74. Estimated monthly value ($USD) of landings of red grouper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

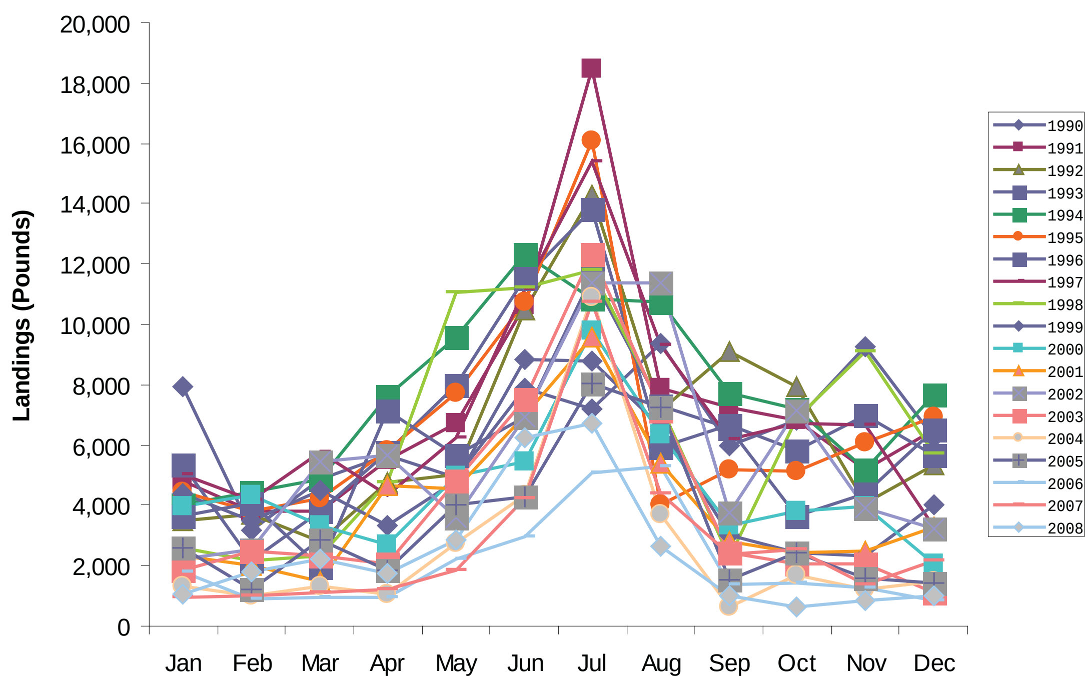

Figure 75. Estimated monthly landings of gray snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

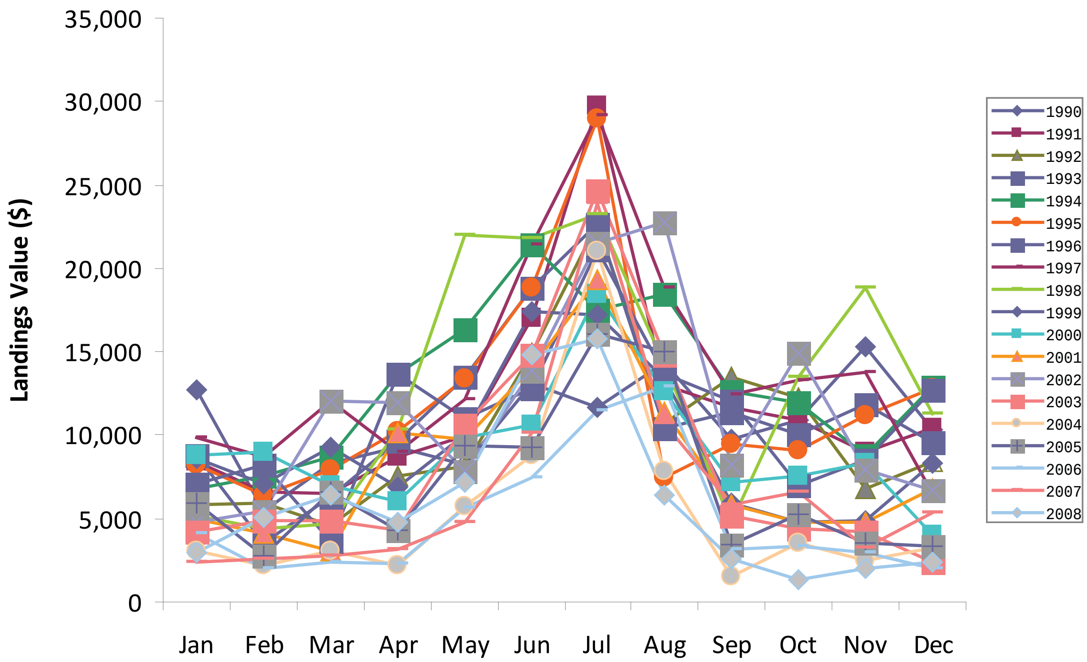

Figure 76. Estimated monthly value ($USD) of landings of gray snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

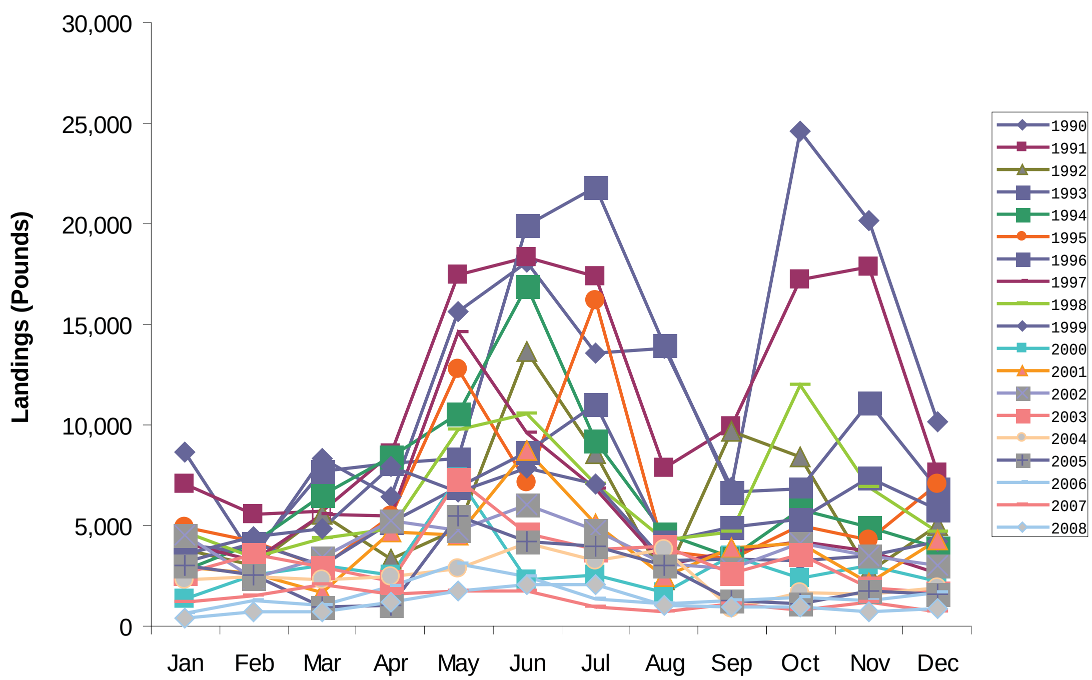

Figure 77. Estimated monthly landings of mutton snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

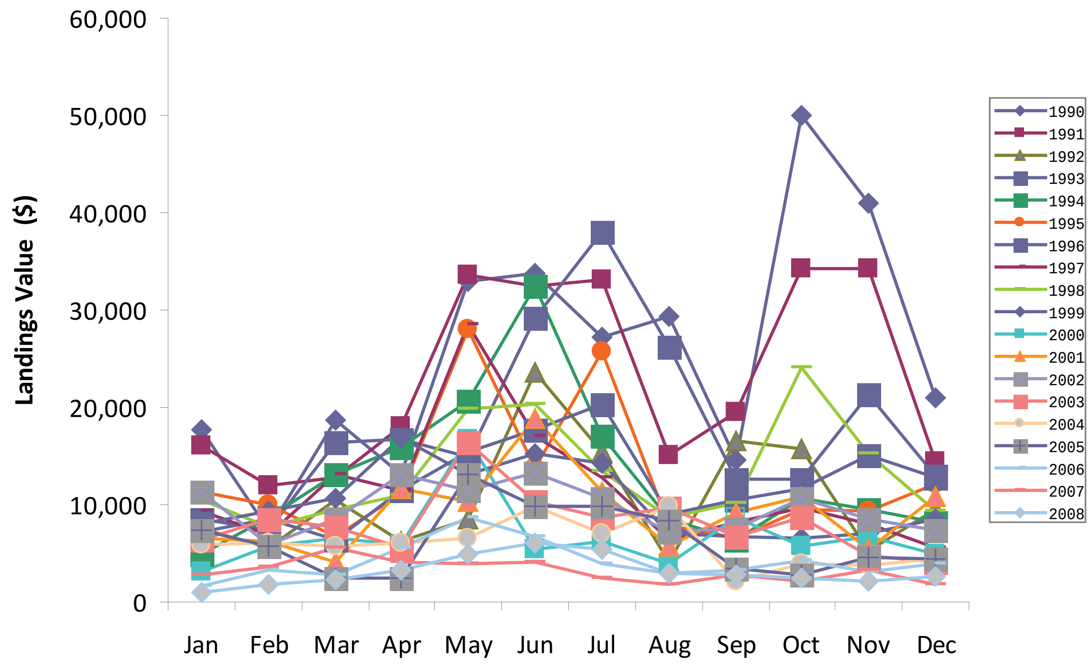

Figure 78. Estimated monthly value ($USD) of landings of mutton snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

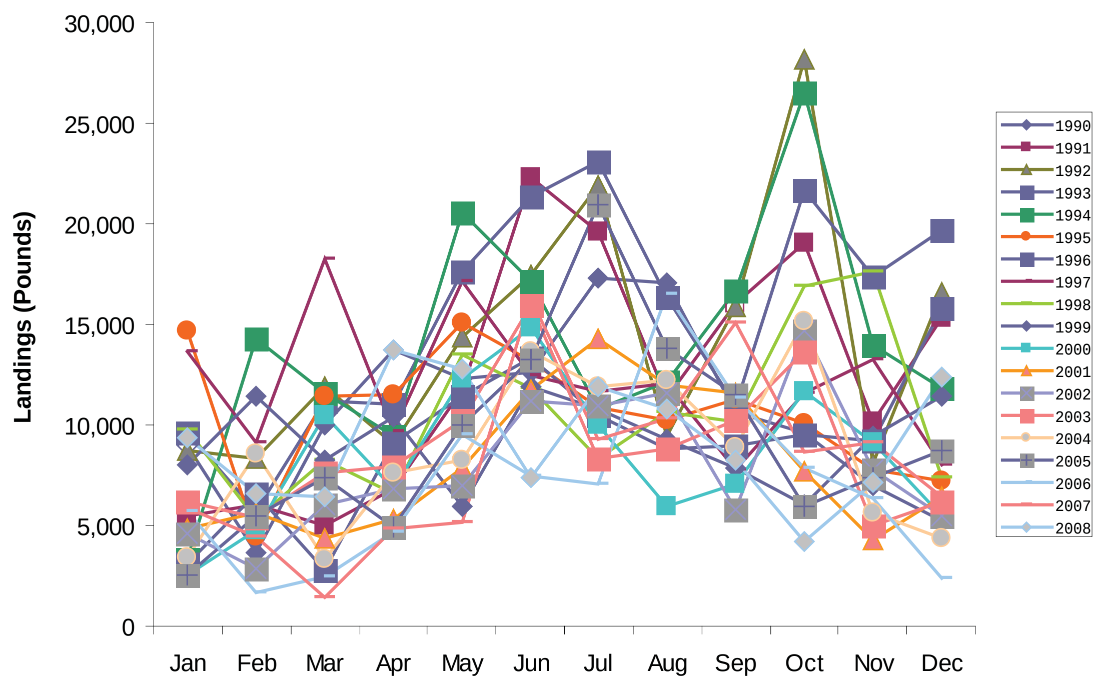

Figure 79. Estimated monthly landings of yellowtail snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

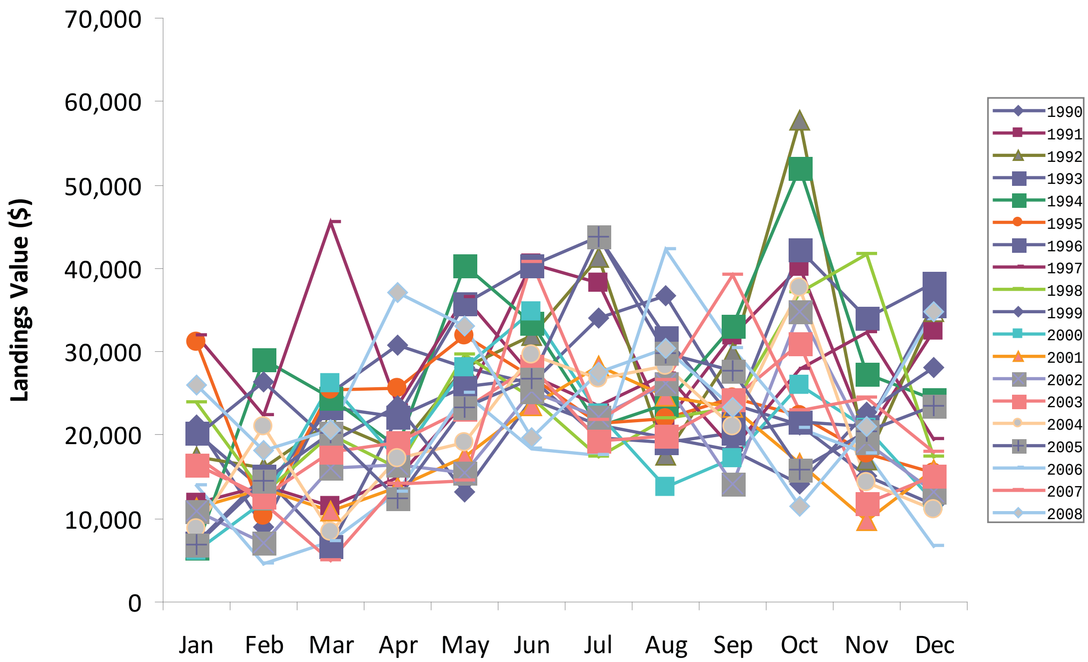

Figure 80. Estimated monthly value ($USD) of landings of yellowtail snapper by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

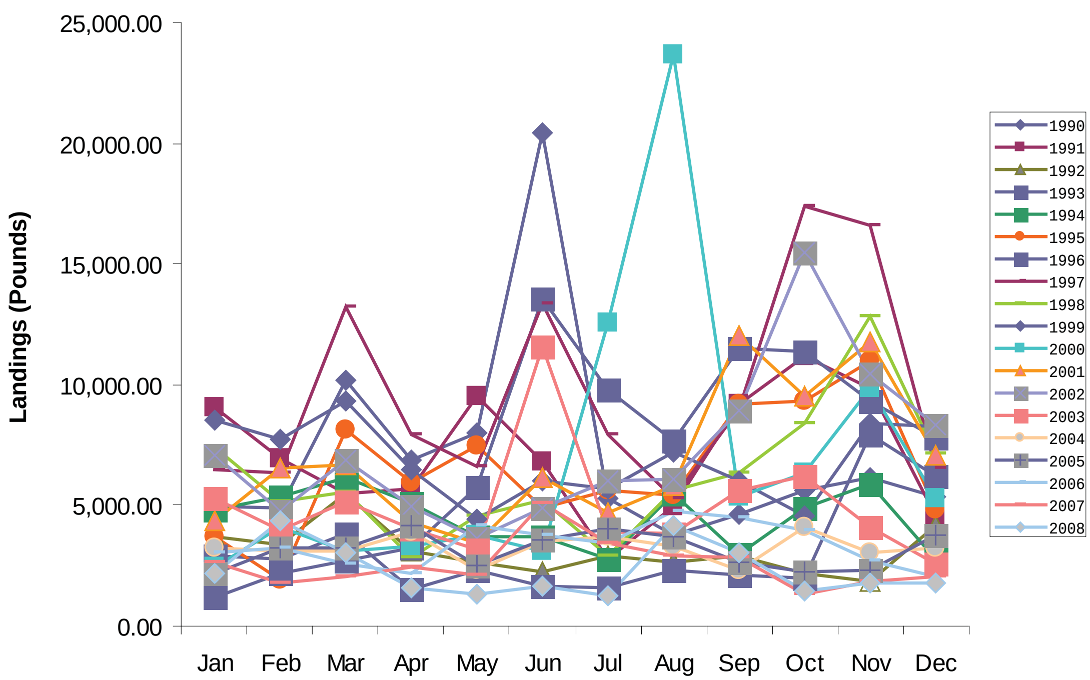

Figure 81. Estimated monthly landings of grunts by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

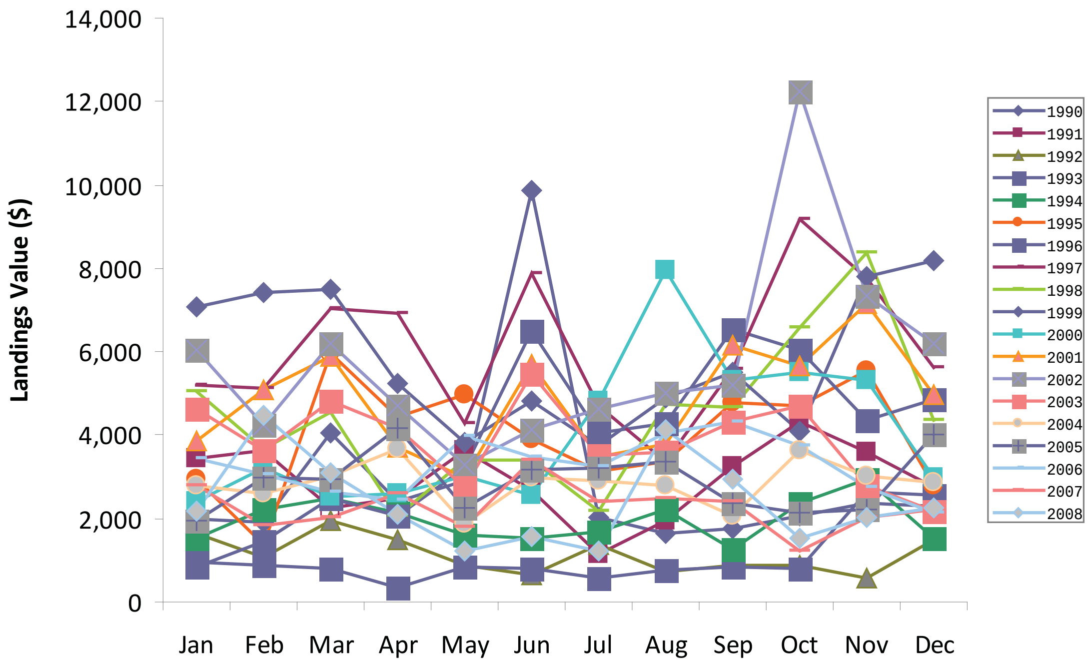

Figure 82. Estimated monthly value ($USD) of landings of grunts by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division.

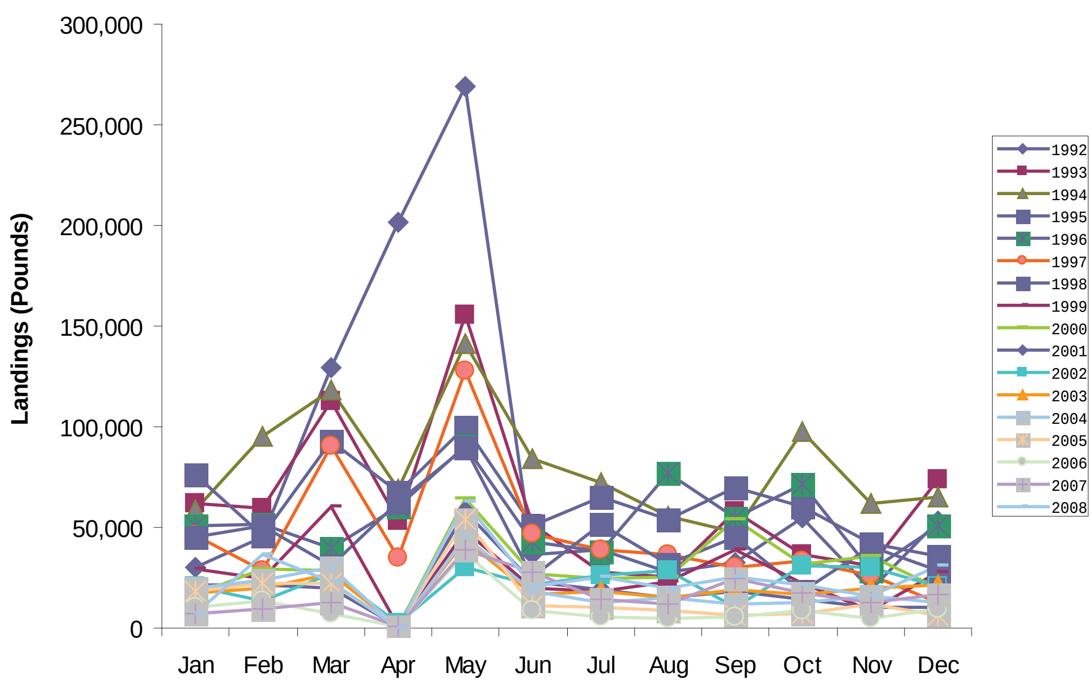

Figure 83. Estimated monthly landings of greater amberjack by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division. Years with missing values had no data available.

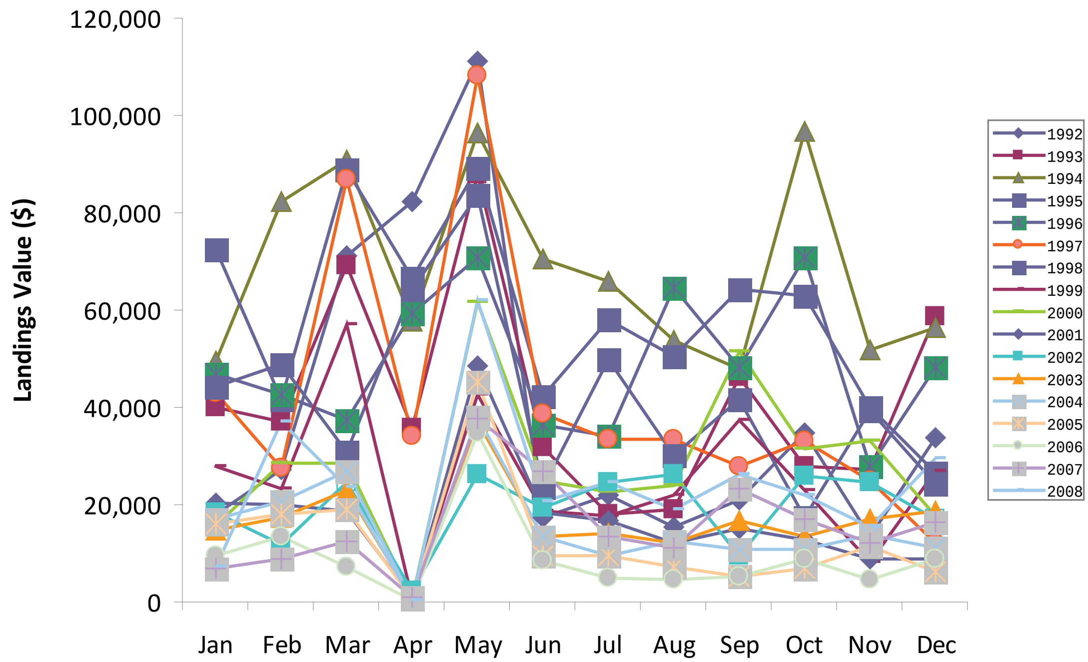

Figure 84. Estimated monthly value ($USD) of landings of greater amberjack by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division. Years with missing values had no data available.

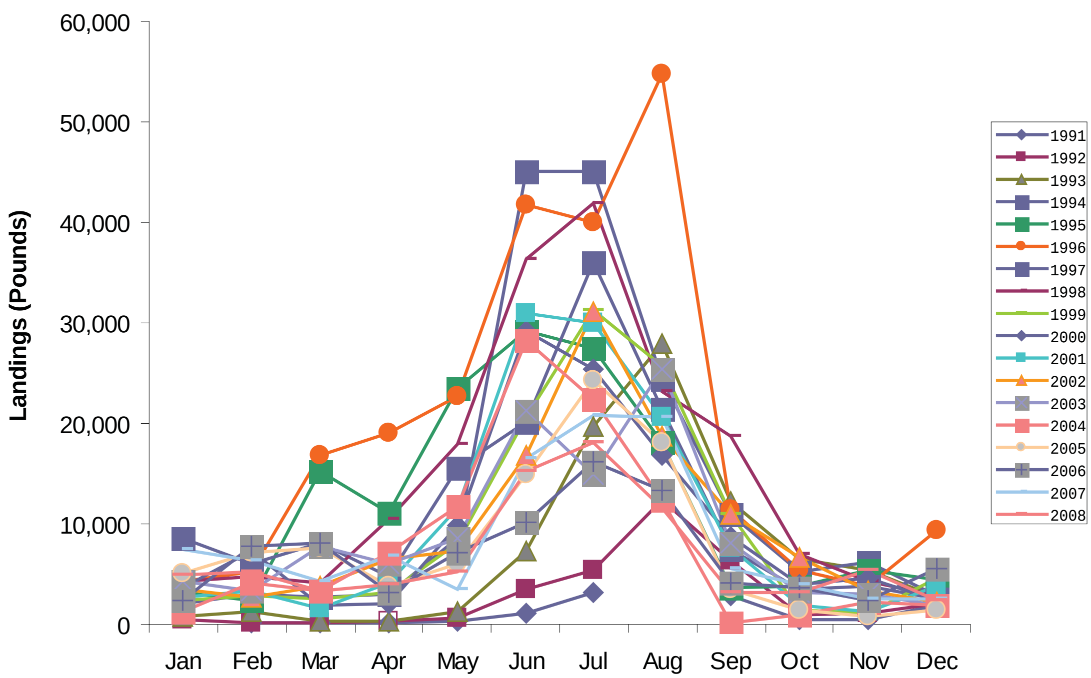

Figure 85. Estimated monthly landings of great barracuda by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division. Years with missing values had no data available.

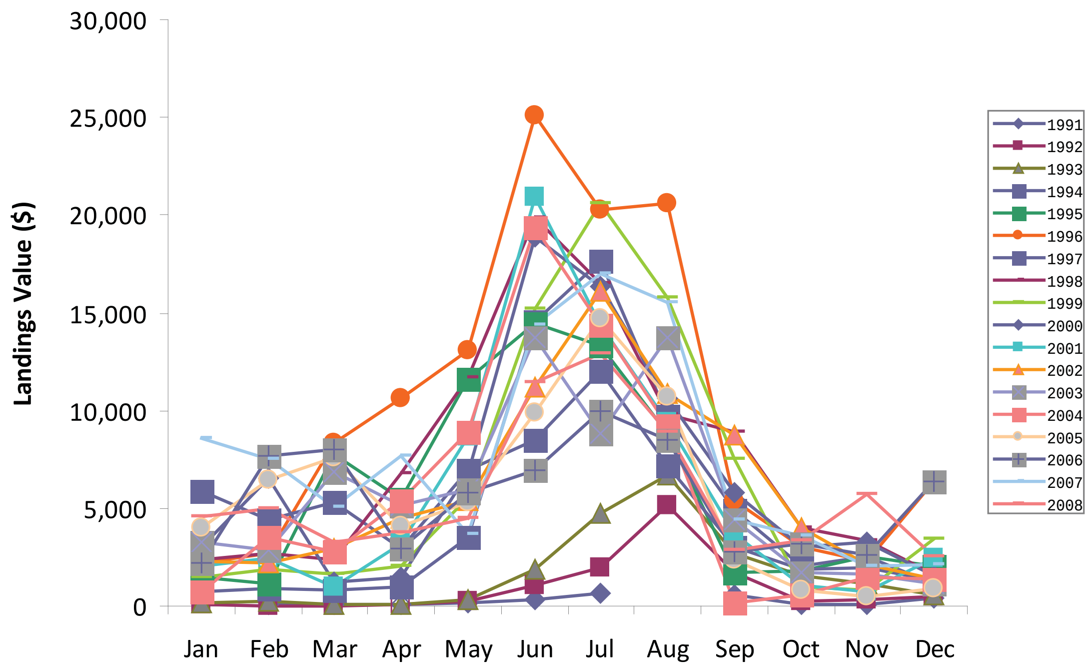

Figure 86. Estimated monthly value ($USD) of landings of great barracuda by the commercial fishery in the Florida, East Coast from 1990-2008 from NOAA/NMFS Fisheries Statistics Division. Years with missing values had no data available.

3.2 Fishing Mortality Estimates

An indicator variable we used to quantify population status for U. S. federal benchmarks for southeast Florida reef fishes was average length ($\bar{L}$) of the exploited part of the population. A total of 61,679 specimens from eleven species collected from 1990 through 2008 were analyzed. Angelfish and lobster were not included in this analysis due to data deficiencies. Values of $\bar{L}$ estimated from the three fishery-dependent data sources (Headboat, TIP, and MRFSS) were generally similar for each species (Fig. 87). Exceptions to the trend of similar $\bar{L}$ estimates were observed for the greater amberjack and great barracuda which both had significantly lower Headboat $\bar{L}$ estimates. $\bar{L}$ estimates from MRFSS were lower for black grouper and higher for tomtate than the other fisheries. Finally, mutton snapper $\bar{L}$ estimates were higher from the TIP than the Headboat and MRFSS data sets. An estimate of $\bar{L}$ for each species was used for the fishery benchmark analysis (bold values in Table 6). Fishing mortality estimates and fishing mortality at MSY are shown in Table 7.

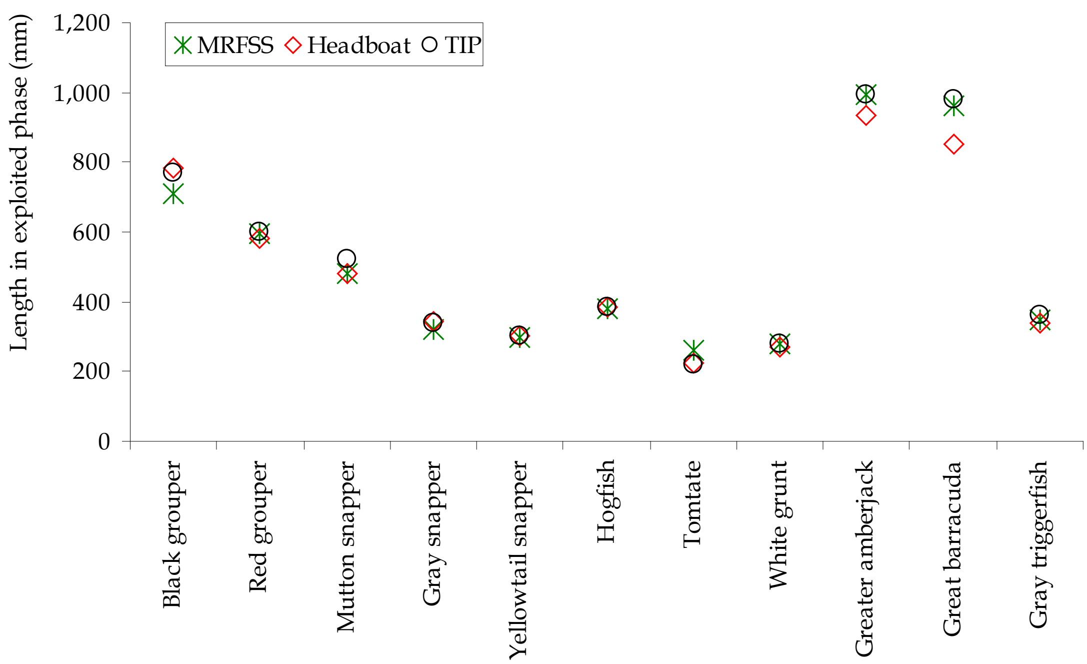

Figure 87. Mean length in the exploited phase, $\bar{L}$, for eleven reef fish species in the southeast Florida region for 1990-2008 from three fishery-dependent data programs: the NMFS Headboat survey, the Trip Interview Program, and the Marine Recreational Fishing Statistical Survey. Confidence intervals have been left off the estimates for clarity; see Table 4 for values.

Table 6. Average size in exploited phase, $\overline{L}$, and 95% confidence interval (CI) estimates for 11 targeted reef fishes in the southeast Florida region. Type: total length (TL) or fork length (FL). L_c is the minimum size of first capture (full selection) observed in the fishery-dependent data. The sample size *n* for each $\overline{L}$ calculation is given. Average size in exploited phase, $\overline{L}$, values in bold were used for fishery management benchmark analysis.

Species	Type	L_c (*mm*)	MRFSS 1990-2006 *n*	MRFSS 1990-2006 $\overline{L}$ (95% CI) (*mm*)	NMFS Headboat 1990-2006 *n*	NMFS Headboat 1990-2006 $\overline{L}$ (95% CI) (*mm*)	TIP 1990-2008 *n*	TIP 1990-2008 $\overline{L}$ (95% CI) (*mm*)
Groupers (Serranidae)								
Black Grouper (*Mycteroperca bonaci*)	TL	609	124	711 (686, 735)	37	784 (756, 812)	**234**	**769 (755, 784)**
Red grouper (*Epinephelus morio*)	TL	508	114	596 (583, 608)	**257**	**580 (573, 588)**	218	598 (589, 606)
Snappers (Lutjanidae)								
Mutton snapper (*Lutjanus analis*)	TL	406	1192	480 (475, 484)	3298	481 (478, 483)	**3009**	**520 (517, 523)**
Gray snapper (*L. griseus*)	TL	254	2561	322 (320, 324)	3449	344 (342, 347)	**4766**	**340 (339, 342)**
Yellowtail snapper (*Ocyurus chrysurus*)	FL	249	3794	296 (295, 298)	**11699**	**304 (303, 304)**	12751	302 (301, 302)
Wrasses (Labridae)								
Hogfish (*Lachnolaimus maximus*)	FL	305	**303**	**378 (371, 384)**	33	384 (365, 404)	172	386 (376, 396)
Grunts (Haemulidae)								
Tomtate (*Haemulon aurolineatum*)	TL	203	15	263 (232, 295)	**450**	**223 (222, 225)**	103	218 (215, 221)
White grunt (*H. plumieri*)	TL	203	1291	279 (277, 281)	**3594**	**272 (271, 273)**	2697	280 (280, 281)
Jacks (Carangidae)								
Greater amberjack (*Seriola dumerili*)	FL	711	517	995 (985, 1005)	88	934 (903, 965)	**946**	**992 (986, 998)**
Barracuda (Sphyraenidae)								
Great barracuda (*Sphyraena barracuda*)	TL	619	**1447**	**963 (953, 973)**	552	854 (840, 868)	51	980 (921, 1038)
Triggerfish (Balistidae)								
Gray triggerfish (*Balistes capriscus*)	FL	305	**324**	**348 (343, 352)**	1409	338 (336, 339)	184	364 (356, 372)

Table 7. Fishing mortality estimates for the southeast Florida region, 1990-2008.

Species	F_{MSY} (y^{-1})	F (y^{-1})
Groupers		
Black (*Mycteroperca bonaci*)	0.0908	0.4149
Red (*Epinephelus morio*)	0.1152	0.6783
Snappers		
Mutton (*Lutjanus analis*)	0.0749	0.4226
Gray (*L. griseus*)	0.1070	0.4976
Yellowtail (*Ocyurus chrysurus*)	0.2140	0.3385
Wrasses		
Hogfish (*Lachnolaimus maximus*)	0.1302	0.4542
Grunts		
White (*Haemulon plumieri*)	0.1664	0.4798
Tomtate (*H. aurolineatum*)	0.3329	0.6139
Barracuda		
Great Barracuda (*Sphyraena barracuda*)	0.0936	0.1186
Triggerfish		
Gray triggerfish (*Balistes capriscus*)	0.1872	0.8317
Jacks		
Greater amberjack (*Seriola dumerili*)	0.1762	0.1725

3.3 Fishery Management and Sustainability Benchmarks

Indicators are needed to assess the status and trends of reef fisheries and to support the implementation of an ecosystem approach to fisheries (Jennings 2005; Cury & Christensen 2005). Fishery management and sustainability benchmarks for the reef fish and lobster species in the southeast Florida region demonstrated general patterns of either unchanged or declining landings and fishery effort. These results do not constitute a formal stock assessment for these species but instead provides a summary of observed patterns for the coral reef associated fisheries of the southeast Florida region. More detail is provided in the following sections specific to the southeast Florida region state fishery benchmarks and the U. S. federal fishery benchmarks.

3.3.1 Florida State Benchmarks

Florida state benchmarks for fishery status were primarily based on trends in catch and effort for recreational, headboat, and commercial fisheries. Trends in the Marine Recreational Fishing Statistical Survey (MRFSS) recreational type A +

B1 harvest (landings + discards) for eight of the 11 species were examined for 1990-2009 from the east coast of Florida. None of the eight species experienced significant declines in estimated combined landings and discards or effort over the study period (Fig. 5-13; Table 2). These results represent the entire east coast of Florida, not just the southeast Florida region.

Landings of the 11 reef fish species from the headboat fishery in the southeast Florida region declined 85% from 196,000 pounds in 1990 to 30,000 pounds in 2006 ($p < 0.001$) (Fig. 24). The decline in landings coincided with a 50% reduction in effort from approximately 147,000 angler days in 1990 to almost 74,000 angler days in 2006 (Figure 25). Five of the eleven fish species experienced statistically significant declines in landings (Fig. 26-36, Table 3). Mutton snapper, yellowtail snapper, white grunt, greater amberjack, and great barracuda were the five species with significant declines in headboat landings. It is unclear if the decline in landings reflects decreasing fish populations or a decrease in effort in the headboat fishery.

Landings of six reef fish species and the aggregate category of “grunts” from the commercial fishery in the southeast Florida region declined 73% from 485,000 pounds in 1990 to 178,000 pounds in 2006 ($p < 0.0001$) (Fig. 48). Five of the seven fish species experienced statistically significant declines in landings over the same time period (Fig. 49-55). Gray snapper and grunts did not decline. Black grouper, red grouper, mutton snapper, yellowtail snapper, and hogfish were the five species with significant declines in commercial landings. It is unclear if the decline in landings reflects decreasing fish populations or a decrease in effort in the commercial fishery.

3.3.2 U.S. Federal Benchmarks

Spawning potential ratios were below the 30% threshold for all species except yellowtail snapper, tomtate, and greater amberjack (Fig. 88). All species but one (greater amberjack) had F/F_{MSY} ratios that indicated high levels of local fishing effort (Table 8). In addition, the SPRs for four of these five species are under 10% (exception is red grouper at 16%). Values of F/F_{MSY} and SPRs for all species are in Table 8.

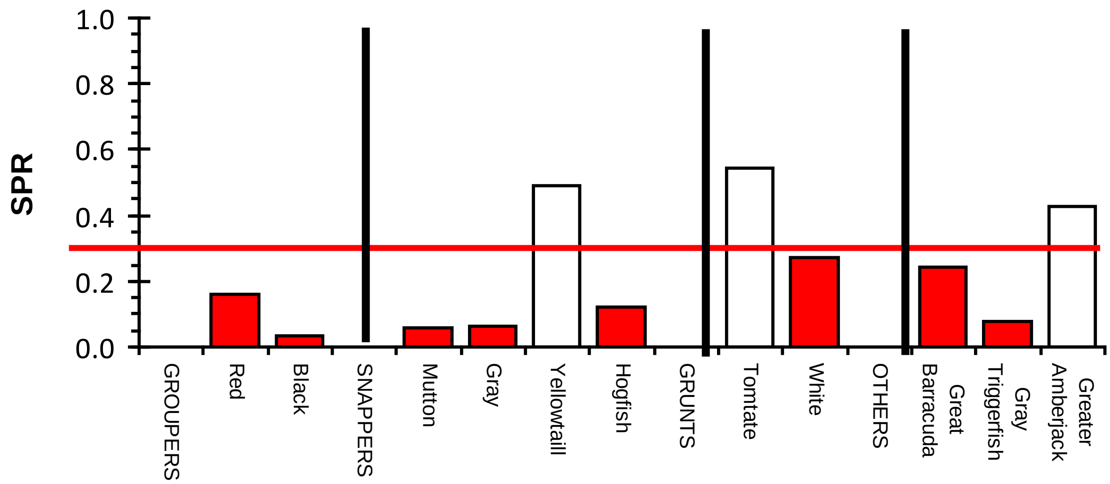

Figure 88. Spawning potential ratios (SPR) for eleven reef fish species in the southeast Florida region for 1990-2008.

Table 8. U.S. federal fishery management and sustainability benchmarks (F/FMSY and SPR) for 11 reef fish species in the southeast Florida region, 1990-2008.

Species	F/F_{MSY}	SPR
Groupers		
Black (*Mycteroperca bonaci*)	4.5704	0.0350
Red (*Epinephelus morio*)	5.8870	0.1607
Snappers		
Mutton (*Lutjanus analis*)	5.6427	0.0598
Gray (*L. griseus*)	4.6509	0.0607
Yellowtail (*Ocyurus chrysurus*)	1.5819	0.4926
Wrasses		
Hogfish (*Lachnolaimus maximus*)	3.4872	0.1206
Grunts		
White (*Haemulon plumieri*)	2.8829	0.2703
Tomtate (*H. aurolineatum*)	1.8443	0.5421
Barracuda		
Great Barracuda (*Sphyraena barracuda*)	1.2669	0.2432
Triggerfish		
Gray triggerfish (*Balistes capriscus*)	4.4421	0.0780
Jacks		
Greater amberjack (*Seriola dumerili*)	0.9789	0.4248

4.0 Discussion and Conclusions

An examination of recreational and commercial fisheries-dependent data showed that the sixteen reef fish species and 1 lobster species in the southeast Florida region had predominantly declining or unchanged trends in fisheries landings and effort for 1990 to 2008 (Table 9). Florida state benchmarks were based on trends in fishery landings over the study period which declined for several of the target fish species such as groupers, snappers, and hogfish but these trends were accompanied by decreases in fishery effort and reflect a diminished participation in the headboat and commercial fisheries, in particular. The recreational landings data were mostly unchanged but reflected catch and effort from the entire east Florida coast so may not accurately reflect the fishery dynamics of the southeast Florida region. More weight should be given to the results of the headboat fishery and commercial fishery landings. Given the significant decline in effort for the headboat fishery, the lack of an associated decline in landings for black grouper, red grouper, gray snapper, and hogfish could be viewed positively. A majority of species experienced declines in commercial landings and effort with the greatest decreases among black grouper, mutton snapper, and hogfish. Overall, these trends should be interpreted cautiously as they provide only a general summary of fisheries activities within the region for a subset of fish species.

In contrast, the U.S. federal management and sustainability benchmarks indicated that all the reef fish species but one (greater amberjack) experienced overfishing, and had low spawning potential ratios with black grouper, mutton snapper, gray snapper, and gray triggerfish in the poorest condition. Three species (yellowtail snapper, tomtate, and greater amberjack) had SPRs greater than 30% and low relative fishing effort ratios which would reflect more sustainable population status. The highest fishing effort ratios were estimated for mutton snapper (5.6) and red grouper (5.9). These results, based on length composition in the catch, provide a detailed complement to the landings and effort data and suggest a lack of consensus between the benchmark methods and a need for further study. Fisheries-dependent data primarily reflect the fishery, not necessarily the status of the fished populations. Fisheries-independent data are needed to better evaluate the condition of reef fish and lobster populations for the southeast Florida region. Currently, no comprehensive fisheries-independent survey program exists.

The intent of these analyses was to characterize the condition of fish populations in the southeast Florida region alone, not to describe the status of the overall stocks of these species. Thus, results must be interpreted cautiously as these data refer to a subset of biological and fisheries dynamics that are acting at much broader geographical scales.

Table 9. Comparison of Florida and U. S. federal fisheries management benchmarks of the fishery status of eleven reef fish species in the southeast Florida region, 1990-2008. For Florida State Benchmarks, a "YES" indicates a significant (at least $p < 0.05$) negative linear trend over the study period, a "NO" indicates an unchanging trend, and a "N/A" indicates that data was not available. None of the trends were significantly increasing.

Species	Florida State Benchmarks			US Federal Benchmarks	
	Recreational Landings/Effort Declining?[1]	Headboat Landings/Effort Declining?	Commercial Landings/Effort Declining?	Fishing Effort $F > F_{MSY}$?	SPR below 30%?
Groupers					
Black	N/A / N/A	NO / YES	YES	YES	YES
Red	NO / NO	NO / YES	YES	YES	YES
Snappers					
Mutton	NO / NO	YES / YES	YES	YES	YES
Gray	NO / NO	NO / YES	NO	YES	YES
Yellowtail	NO / NO	YES / YES	YES	YES	NO
Wrasses					
Hogfish	N/A / N/A	NO / YES	YES	YES	YES
Grunts					
White	NO / NO	YES / YES	NO[2]	YES	YES
Tomtate	N/A / N/A	NO / YES	NO[2]	YES	NO
Barracuda					
Great Barracuda	NO / NO	YES / YES	N/A	YES	YES
Triggerfish					
Gray triggerfish	NO / NO	NO / YES	N/A	YES	YES
Jacks					
Greater amberjack	NO / NO	YES / YES	N/A	NO	NO
Angelfish	N/A / N/A	N/A	YES / YES	N/A	N/A
Lobster					
Spiny lobster	N/A / N/A	N/A	YES / YES	N/A	N/A

[1]Recreational landings trends are for the entire east Florida coast.

[2]Commercial landings do not identify grunts (family Haemulidae) to species but only report landings of "grunts". Results for both white grunt and tomtate are identical from the aggregate "grunts" category.

4.1 Identification of Data Gaps

Insufficient and poor quality data and lack of an appropriate modeling framework have prevented sophisticated evaluations of the sustainability of reef fisheries. Generally lacking are the data needed to conduct modern stock assessments, including demographic rates, life history parameters, and historical time-series of age-size structured catches by species, and the associated fishing effort by gear and recreational or commercial sector (Quinn & Deriso 1999; Haddon 2001; Quinn 2003). During the course of this study, we encountered several areas that could benefit from further attention and resources. The most critical need is fisheries-independent surveys of the reef fish targeted by fisheries in the southeast Florida region. The analysis is based entirely on fishery-dependent data which may not adequately represent population status. A more accurate assessment of the status of reef fish populations could be provided by implementing a fisheries-independent monitoring program with a robust sampling design for the southeast Florida region. The most logical plan would be to extend the efforts of the ongoing NMFS Southeast Fisheries Science Center and University of Miami's Rosenstiel School of Marine and Atmospheric Science reef fish visual diver census program in the Florida Keys through Miami-Dade, Broward, Palm Beach, and Martin counties. This approach would not only provide unbiased estimates of population status in the region of interest but also establish a framework for comparisons of reef fish throughout the Florida Reef Tract. In conjuction with studies to collect detailed life history parameters (such as in Table 1) for coral reef associated fishery species, this approach can provide a robust analysis framework to evaluate the biological status of fishery species. Furthermore, an understanding of population connectivity from tracking studies and genetic research is necessary to describe the spatial population dynamics of the reef fish fishery species.

4.2 Management Alternatives

Any evaluation of the status of the reef fish and lobster species in the southeast Florida region must acknowledge the connectivity of these subpopulations with other subpopulations in adjacent areas such as Biscayne Bay and the Florida Keys. Management actions taken to address the sustainability of the southeast Florida region subpopulations also occur within the broader framework of state-wide actions implemented by Florida and U.S. fishery management agencies. A variety of regulations currently exist to manage the minimum size, bag limit, restrict gear and time of capture for the species of the study (Table 10). Given the limited geographic domain of this work, our conclusions are not applicable to the status of entire populations of these species in Florida waters but just the subpopulations in the southeast Florida region. Thus, the scope of this report does not allow us to speculate on the effectiveness of broader fishery management actions for these stocks including size and bag limits, catch limits, rights-based approaches, or effort management for these stocks which depend on an understanding of fish populations and fishers beyond the waters of the southeast Florida region. This is the role fulfilled by a formal stock assessment process which is not the intent of this report.

With these caveats in mind, there are some general guidelines that can be recommended. For minimum size limits, the length should be large enough to ensure that a fish has an opportunity to reproduce at least once prior to capture. As a rule of thumb, minimum sizes at first capture should be increased to facilitate reproductive opportunities but this management action can require a lag time for the mean size of the exploited phase of the fish to reach a mature size thus decreasing the yield. Bag limits are approaching, or like those for black grouper are at, a single fish per day (Table 2). Thus, there may be limited improvements in population condition from further decreases in bag limits for several of the species unless the limit reaches zero.

A significant management action not currently implemented in the region is a spatial closure or, as they are more commonly referred to, a no-take marine reserve. Both state and federal fishery management agencies possess the authority to establish no-take zones. Priority areas for spatial closures should be identified through population connectivity studies as well as the characterization of particular locations. An effective network of no-take zones may require closure of areas outside of the southeast Florida region to support fisheries management goals. No-take marine reserves have been shown to increase fish number and biomass (Halpern and Warner 2002; Ault *et al.* 2005a) but often represent a threat to fisherman who are concerned about the loss of fishing grounds. The southeast Florida region has been fished recreationally and commercially for decades (Fig. 89) so an ethic of open fishery access is culturally ingrained and would make spatial closures difficult to establish. These difficulties can be overcome, especially with community support, and provide localized refugia within the marine reserves as well as limited spillover of fish outside the reserve.

Table 10. Summary of current fishery management actions for the eleven reef fish species in the southeast Florida region.

Species	Size restriction?	Bag limit?	Gear restriction?	Temporal Restriction?	Spatial Closure?
Groupers					
Black	**YES**	**YES**	**YES**	**YES**	**NO**
Red	**YES**	**YES**	**YES**	**YES**	**NO**
Snappers					
Mutton	**YES**	**YES**	**YES**	**NO**	**NO**
Gray	**YES**	**YES**	**YES**	**NO**	**NO**
Yellowtail	**YES**	**YES**	**YES**	**NO**	**NO**
Wrasses					
Hogfish	**YES**	**YES**	**YES**	**NO**	**NO**
Grunts					
White	**NO**	**NO**	**YES**	**NO**	**NO**
Tomtate	**NO**	**NO**	**YES**	**NO**	**NO**
Barracuda					
Great Barracuda	**NO**	**NO**	**YES**	**NO**	**NO**
Triggerfish					
Gray triggerfish	**YES**	**YES**	**YES**	**NO**	**NO**
Jacks					
Greater amberjack	**YES**	**YES**	**YES**	**YES**	**NO**
Angelfish	**YES**	**YES**	**YES**	**NO**	**NO**
Lobster					
Spiny lobster	**YES**	**YES**	**YES**	**YES**	**NO**

Figure 89. Historic (1939; unknown) photos of reef fish catch from the southeast Florida region (courtesy of IGFA).

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6.0 Appendices

6.1 Glossary

a_0: the symbol for a life history parameter that represents the age of a fish at which length is zero in years.

a_b: the symbol for a life history parameter that represents the age of a fish at birth in years.

a_c: the symbol for a life history parameter that represents the minimum age of first capture of a fish by a fishery in years.

a_m: the symbol for a life history parameter that represents the age of sexual maturity of a fish in years.

a_r: the symbol for a life history parameter that represents the age of first recruitment of a fish to a fishery in years.

a_λ: the symbol for a life history parameter that represents the oldest age of a fish in the stock in years.

Angler days: A measure of fishing effort that reflects a typical day of fishing for an angler aboard a headboat. See section 2.2.1.2 for more details.

Biomass: The mass of fish in a population or landings usually quantified in pounds, tons, or kilograms.

Biomass ratio (B/B_{MSY}): A level of biomass compared to the biomass that would generate a maximum sustainable yield for the fishery.

Catch: An amount of fish caught during fishing usually expressed as the weight of fish or the number. Some catch may be discarded or released. See also Landings.

Creel survey: A direct survey of a fisherman's catch that can provide information on the type of fish, size, and quantity that are caught or landed.

Discards: Fish that are caught but are not kept.

Exclusive Economic Zone (EEZ): A seazone over which a state has special rights over the exploration and use of marine resources. It stretches from the seaward edge of the state's territorial sea out to 200 nautical miles from its coast.

Exploited Phase ($\bar{L}$): In the context of fishing, the harvest or catch of fish.

F: A life history parameter that represents the instantaneous rate of fishing mortality of a stock.

FFWCC: Florida Fish and Wildlife Conservation Commission

Fishery-dependent data: Information collected directly from the fisherman, fishing fleet, or dealer.

Fishery-independent data: Information collected from surveys conducted by scientists independently of the fishery.

Fishery yield: The cumulative landings of fish within a fishery for a given time period (usually annually).

Fishing effort: A measure of effort expended to catch fish, often characterized by gear, duration, and area.

Fishing effort ratio (F/F_{MSY}): A level of fishing effort compared to the fishing effort that would generate a maximum sustainable yield for the fishery.

Headboat: Large fishing vessels that carry multiple recreational anglers who have paid "by the head" are called headboats.

K: the symbol for a life history parameter that represents the Brody growth coefficient in years^{-1}.

L_b: the symbol for a life history parameter that represents the length of a fish at birth in millimeters.

L_c: the symbol for a life history parameter that represents the minimum length of first capture of a fish by a fishery in millimeters.

L_m: the symbol for a life history parameter that represents the length of sexual maturity of a fish in millimeters.

L_r: the symbol for a life history parameter that represents the length of first recruitment of a fish to a fishery in millimeters.

L_λ: the symbol for a life history parameter that represents the maximum observed length of a fish in millimeters.

L_∞**:** the symbol for a life history parameter that represents the ultimate or asymptotic length of a fish in millimeters.

Landings: An amount of fish caught and brought back to land during fishing usually expressed as the weight of fish or the number. See also Catch.

Limit control rule: A fisheries benchmark which represents a cut-off beyond which there is considerable risk to the condition of the fish population and fishery. See maximum sustainable yield.

M: A life history parameter that represents the instantaneous rate of natural mortality of a stock.

Mean length in exploited phase ($\overline{L}$): The average length of fish in a population that are captured in a fishery.

MFMT: Maximum fishing mortality threshold, a threshold for fishing effort that if exceeded should result in a management actions to decrease fishing effort (or stock rebuilding plans).

MRFSS: Marine Recreational Fisheries Statistics Survey, see Section 2.2.1.1 for a description.

MSFCMA: Magnuson-Stevens Fishery Conservation Management Act

MSY: Maximum sustainable yield; the maximum amount of landings that can be harvested over an indefinite period.

NMFS: National Marine Fisheries Service

NOAA Fisheries: The U. S. federal agency, a division of the Department of Commerce, responsible for the stewardship of the nation's living marine resources and their habitat. NOAA Fisheries is responsible for the management, conservation and protection of living marine resources within the United States' Exclusive Economic Zone (water three to 200 mile offshore). Synonymous with NMFS or National Marine Fisheries Service.

Optimum yield: The desirable level of landings for a fish population that decreases the risk of overexploitation compared to the maximum sustainable yield.

Overfished: Fish population biomass is below an acceptable level.

Overfishing: Fishing at a rate that is unsustainable and reduces a fish population below acceptable levels.

Precautionary control rules: The fishing effort and biomass ratios represent the two control rules utilized in this study.

RSMAS: Rosenstiel School of Marine and Atmospheric Science at the University of Miami.

SAFMC: South Atlantic Fishery Management Council

SEFSC: Southeast Fisheries Science Center of the National Marine Fisheries Service

Spawning potential ratio (SPR): Spawning potential ratio compares the spawning ability of a stock in the fished condition to the stock's spawning ability in the pristine or unfished condition.

Sustainability: The capacity to remain productive through time.

TIP: Trip Interview Program, see Section 2.2.2.2 for a description.

W_∞: the symbol for a life history parameter that represents the weight of a fish in kilograms at the ultimate or asymptotic length (L_∞).

Z: A life history parameter that represents the instantaneous rate of total mortality which is the summation of the instantaneous rate of natural mortality (M) and the instantaneous rate of fishing mortality (F).

6.2 Additional Fisheries Literature

The following references pertain to coral reef fish and fisheries in the southeast Florida region. This is not meant to be a comprehensive list but rather a useful starting point for interested investigators. The list was collected as a preliminary activity for this project. An Endnote library file (.enl) with these references is available from the Florida Department of Environmental Protection Coral Reef Conservation Program office.

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