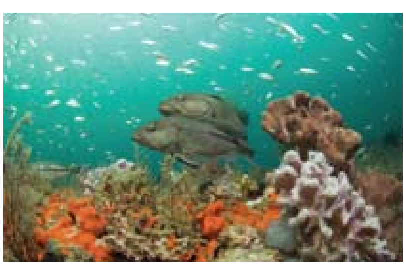
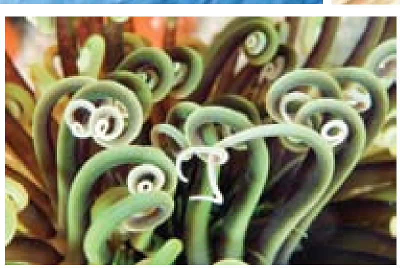
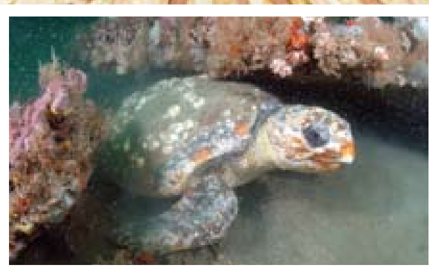
Gray's Reef
National Marine Sanctuary

CONDITION REPORT 2008







August 2008

National Marine Sanctuaries

Cover credits (Clockwise):

Map:
Bathymetric Grids provided by NOAA's NGDC Coastal Relief Model Vol. 2 and 2m gridded bathymetric data of Gray's Reef NMS provided by NOAA Ship Whiting.

Divins, D.L., and D. Metzger, NGDC Coastal Relief Model, Vol. 2, *http://www.ngdc.noaa.gov/mgg/coastal/coastal.html*

Gray's Reef NMS 2m gridded bathymetry – Survey H11055 – NOAA Ship Whiting, 2001.

Photos*:*
Cover Images: Clockwise from coastal graphic: spotfin butterfly fish taking refuge near a golden sea rod soft coral; close-up of an American tube anemone; loggerhead sea turtle resting under a ledge; close-up of tentacles of the American tube anemone; black sea bass over an invertebrate-covered ledge at Gray's Reef National Marine Sanctuary (all photos taken by Greg McFall, Gray's Reef National Marine Sanctuary).

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U.S. Department of Commerce
Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
VADM Conrad C. Lautenbacher, Jr. (USN-ret.)
Under Secretary of Commerce for Oceans and Atmosphere

National Ocean Service
John H. Dunnigan, Assistant Administrator

Office of National Marine Sanctuaries
Daniel J. Basta, Director

National Oceanic and Atmospheric Administration
Office of National Marine Sanctuaries
SSMC4, N/ORM62
1305 East-West Highway
Silver Spring, MD 20910
301-713-3125
http://sanctuaries.noaa.gov/

Gray's Reef National Marine Sanctuary
10 Ocean Science Circle
Savannah, GA. 31411
912- 598-2345
http://graysreef.noaa.gov/

Report Preparers:

Gray's Reef National Marine Sanctuary:
Greg McFall, George Sedberry, Becky Shortland

Office of National Marine Sanctuaries:
Kathy Broughton, Stephen R. Gittings

Southeast Atlantic, Gulf of Mexico, and Caribbean Region:
Sarah Fangman

Clancy Environmental Consultants, Inc.:
Karen Fox
http://clancyenv.com

Copy Editor: Matt Dozier

Graphic Designers: Matt Dozier, Matt McIntosh

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About this Report

This "condition report" provides a summary of resources in the National Oceanic and Atmospheric Administration's Gray's Reef National Marine Sanctuary, pressures on those resources, current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, the document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix A). Resource status of Gray's Reef is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years, unless otherwise specified.

Sanctuary staff consulted with a working group of outside experts familiar with the resources and with knowledge of previous and current scientific investigations. Evaluations of status and trends are based on interpretation of quantitative and, when necessary, non-quantitative assessments, and the observations of scientists, managers and users. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and outside experts based on their knowledge and perception of local problems. The final ratings were determined by sanctuary staff. This report has been peer reviewed and complies with the White House Office of Management and Budget's peer review standards as outlined in the Final Information Quality Bulletin for Peer Review.

This is the first attempt to describe comprehensively the status, pressures and trends of resources at Gray's Reef National Marine Sanctuary. Additionally, the report helps identify gaps in current monitoring efforts, as well as causal factors that may require monitoring and potential remediation in the years to come. The data discussed will enable us to not only acknowledge prior changes in resource status, but will provide guidance for future management as we face challenges imposed by such potential threats as increasing coastal populations, wind farming, artificial reefs and climate change.

Gray's Reef
National Marine Sanctuary

- *17 square miles (16.68 square nautical miles)*
- *Designated a national marine sanctuary in 1981 by President Jimmy Carter*
- *One of the largest nearshore rocky reefs in the southeastern United States*
- *The only marine protected area in federal waters in the South Atlantic Bight*
- *Named for University of Georgia taxonomist Milton B. Gray, who studied the area in the 1960s*
- *Contains rocky ridges with associated attached organisms known as a "live-bottom habitat"*
- *A complex habitat of caves, troughs, burrows and overhangs attracts sea turtles, an estimated 180 species of fish, and other important marine organisms*

Summary and Findings

Gray's Reef National Marine Sanctuary protects particularly dense and nearshore patches of productive "live-bottom habitat" that are sparsely distributed from Cape Hatteras, N.C., to Cape Canaveral, Fla., on the inner- and mid-shelf of the South Atlantic Bight. Influenced by complex ocean currents, this area serves as a crossroads for both temperate (colder water) and sub-tropical species. Located 17.5 nautical miles offshore of Sapelo Island, Ga., the sanctuary encompasses 17 square nautical miles. Gray's Reef offers some of the best recreational fishing and diving to be found in the region. Commercial fishing is very limited or non-existent due to gear restrictions. The sanctuary is just 40 miles south of Savannah, Ga., the second busiest port on the eastern seaboard.

The newest management plan for Gray's Reef National Marine Sanctuary was released in July 2006. The new plan includes changes and new regulations (effective February 2007) that will further protect sanctuary resources while continuing to allow public access and use. Because the Gray's Reef sanctuary and the National Marine Sanctuary System embrace regional governance and ecosystem approaches to management, the new management plan contains activities that address the need for increased levels of cooperation with other management and research agencies. These activities consider ecological interrelationships and the entire interrelated coastal ocean system from watershed to oceanic influences and within the larger context of the South Atlantic Bight and the Carolinian eco-region. In addition, stronger research, monitoring and education plans are being implemented along with a proposal to formally investigate the benefits of a research area within the sanctuary.

Overall, the resources protected by Gray's Reef National Marine Sanctuary appear to be in fair condition. Of the 17 resources or questions identified, three appear to be in good condition, four appear to be in "good/fair" condition, three more appear to be in fair condition, one appears to be in "fair/poor" condition, and four are undetermined. Two resource questions were found after investigation to be unimportant at Gray's Reef sanctuary. None of the resources identified were listed in poor condition. The habitat of Gray's Reef is somewhat disturbed by

A diver in the sanctuary observes a sea nettle (*Chrysaora quinquecirrha*). If you look closely, you will see a shrimp on the top portion of the sea nettle. Researchers at the sanctuary are investigating this symbiotic relationship.

human activity. Localized heavy recreational fishing in portions of the sanctuary seem to result in inadvertently and intentionally deposited marine debris. Anchoring, which can cause damage to the non-regenerative limestone outcropping reef structures and attached organisms, is now prohibited in sanctuary waters. Although allowable fishing gear is limited to rod and reel (the vast majority of users in the sanctuary) and spear, recreational fishing and spearfishing by divers continue to impact the living marine resources of Gray's Reef. The waters of Gray's Reef are relatively pristine at this time, although some human-produced and persistent pollutants and contaminants have reached the sediments and water-filtering organisms of the sanctuary. The contaminants persist at levels that are not thought to cause any permanent harm to the marine life that thrives in sanctuary waters. While there are archaeological resources to be found in Gray's Reef, it is believed that there are few impacts on these resources, and the impacts do not appear to have had a negative effect on maritime archaeological resource integrity. Emerging threats to the sanctuary include non-indigenous (and potentially invasive) species, contamination of organisms by waterborne chemicals from human coastal activities, and ever-increasing coastal populations and recreational use of the sanctuary.

National Marine Sanctuary System and System-Wide Monitoring

The National Marine Sanctuary System manages marine areas in both nearshore and open ocean waters that range in size from less than one to almost 140,000 square miles. Each area has its own concerns and requirements for environmental monitoring, but ecosystem structure and function in all these areas have similarities and are influenced by common factors that interact in comparable ways. Furthermore, the human influences that affect the structure and function of these sites are similar in a number of ways. For these reasons, in 2001 the program began to implement System-Wide Monitoring (SWiM). The monitoring framework (National Marine Sanctuary Program 2004) facilitates the development of effective, ecosystem-based monitoring programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types. It identifies four primary components common among marine ecosystems: water, habitats, living resources and maritime archaeological resources.

By assuming that a common marine ecosystem framework can be applied to all places, the National Marine Sanctuary System developed a series of questions that are posed to every sanctuary and used as evaluation criteria to assess resource condition and trends. The questions, which are shown on page iii and explained in Appendix A, are derived from both a generalized ecosystem framework and from the National Marine Sanctuary System's mission. They are widely applicable across the system of areas managed by the sanctuary program and provide a tool with which the program can measure its progress toward maintaining and improving natural and archaeological resource quality throughout the system.

Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. Although this report follows a new Gray's Reef sanctuary management plan, the information is intended to help set the stage for management plan reviews at each site. The report also helps sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats.

Gray's Reef National Marine Sanctuary Condition Summary Table

The following table summarizes the "State of Sanctuary Resources" section of this report. The first two columns list 17 questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Basis for Judgment column provides a short statement or list of criteria used to justify the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question. Please see the Appendix for further clarification of the questions and the Description of Findings statements.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends:
Conditions appear to be improving .... ▲
Conditions do not appear to be changing .... –
Conditions appear to be declining .... ▼
Undetermined trend .... ?
Question not applicable .... N/A

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?	?	2000 and 2005 monitoring data suggest good water quality, with some contaminants but below EPA guidelines; insufficient information to assess trend.	Undetermined status and trend.	Recognized challenges due to coastal and inland development, population increases and climate change. Continue monitoring for nutrient levels, contaminants and indicators of climate change.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	?	Stable nutrients, chlorophyll, lack of harmful algal blooms.	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	
3	Do sanctuary waters pose risks to human health and how are they changing?	–	2000 baseline, 2005 indicators below EPA Levels of Concern.	Selected conditions that have the potential to affect human health may exist, but human impacts have not been reported.	
4	What are the levels of human activities that may influence water quality and how are they changing?	–	Increasing, but little evidence of negative effects.	Few or no activities occur that are likely to negatively affect water quality.	
HABITAT					
5	What are the abundance and distribution of major habitat types and how are they changing?	?	Baseline data recently completed; assessment of trends will depend on future observations.	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.	Final management plan contains anchoring prohibition and outreach plans, and marine debris outreach, education and monitoring programs. Sanctuary will enhance ongoing science to better understand biologically-structured habitat, continue monitoring benthic fauna and sediment quality, and designate research area to discern between human-induced and natural changes.
6	What is the condition of biologically structured habitats and how is it changing?	?	Insufficient information on the complex biological structure of habitats to rate condition, though there is evidence of anchor, fishing and storm damage.	Undetermined status and trend.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	–	Low levels in 2000 and 2005.	Contaminants do not appear to have the potential to negatively affect living resources or water quality.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	?	Localized within areas of heavy use.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.	

Table is continued on the following page.

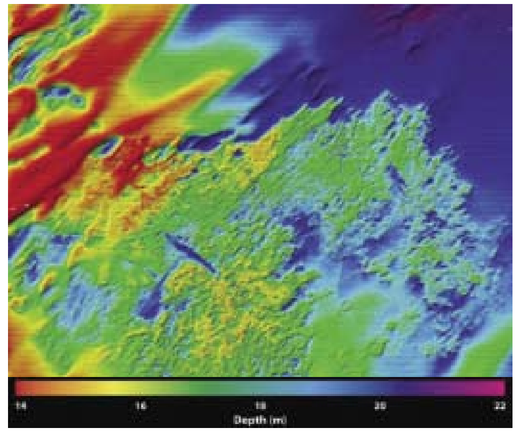
Gray's Reef National Marine Sanctuary Condition Summary Table (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Considerable benthic, epifauna and fish biodiversity monitoring and data, but insufficient at this time to rate status, trends and impacts as they relate to community development and function.	Undetermined status and trend.	Fishing is limited to rod and reel, handline, and spearfishing without powerheads. Spearfishing is under review. Regulations prohibit divers from taking marine organisms. A research area has been proposed to evaluate impacts of bottom fishing. Education and outreach programs are in place that promote good diving techniques. Monitoring will continue for invasive species. Sanctuary will confirm and characterize key species, conduct analysis of sponge mortality samples and monitor key species.
10	What is the status of environmentally sustainable fishing and how is it changing?	▼	Black sea bass, gag, red grouper, and red snapper regionally overfished and/or undergoing overfishing.	Extraction has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	▼	Two lionfish identified in sanctuary in fall 2007; three titan acorn barnacles found winter 2008.	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.	
12	What is the status of key species and how is it changing?	▼	Removal of key fish species and recent sponge mortality.	The reduced abundance of selected key species may inhibit full community development and function, and may cause measurable but not severe degradation of ecosystem integrity; or selected key species are at reduced levels, but recovery is possible.	
13	What is the condition or health of key species and how is it changing?	?	Key species tentatively identified but unable to determine condition and health; some contaminants detected in sponges, but cause of mortality undetermined	Undetermined status and trend.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	?	Localized within areas of heavy use.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.	
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	N/A	No archaeological evidence, though former human occupation remains a possibility based on paleontological data.	N/A	Anchoring has been banned, in part to reduce threat to archaeological resources.
16	Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?	N/A	No archaeological evidence, though former human occupation remains a possibility based on paleontological data.	N/A	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	–	Potential for diving, fishing and anchoring to damage sites.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.	

Site History and Resources

Source: ONMS

Figure 1. Georgia coastal map. The red box indicates the location of Gray's Reef National Marine Sanctuary.



Source: Gray's Reef National Marine Sanctuary

Figure 2. Multibeam sonar image of Gray's Reef bathymetry. This graphic represents the entirety of the sanctuary.

Overview

Gray's Reef National Marine Sanctuary is one of the largest nearshore live-bottom reefs in the southeastern United States, and it is the only marine protected area in federal waters (U.S. Exclusive Economic Zone) in the South Atlantic Bight, an area of continental shelf stretching from Cape Hatteras, N.C., to Cape Canaveral, Fla. Located 17.5 nautical miles offshore of Sapelo Island, Ga., the 16.68-square-nautical-mile sanctuary contains both rocky ledges and sandy flats (Figures 1 and 2). Unlike reefs built by corals, Gray's Reef comprises scattered limestone rock outcroppings that stand above the sandy substrate of the nearly flat continental shelf. The reef also supports soft corals, non-reef building hard corals, bivalves and sponges, as well as associated fishes and sea turtles.

The Gray's Reef sanctuary is one of the most popular recreational fishing destinations along the Georgia coast. Sportfishing occurs year-round but at different levels of intensity. Fishing for pelagic species, such as king mackerel, is one of the most popular activities. For divers, access to the reef itself requires experience in open-ocean diving; currents can be strong and visibility varies greatly. For those who do not scuba dive, the staff at the Gray's Reef sanctuary engages the public through extensive land-based education and outreach programs. For scientists, the sanctuary is a living laboratory for a variety of marine research and monitoring projects (GRNMS 2006).

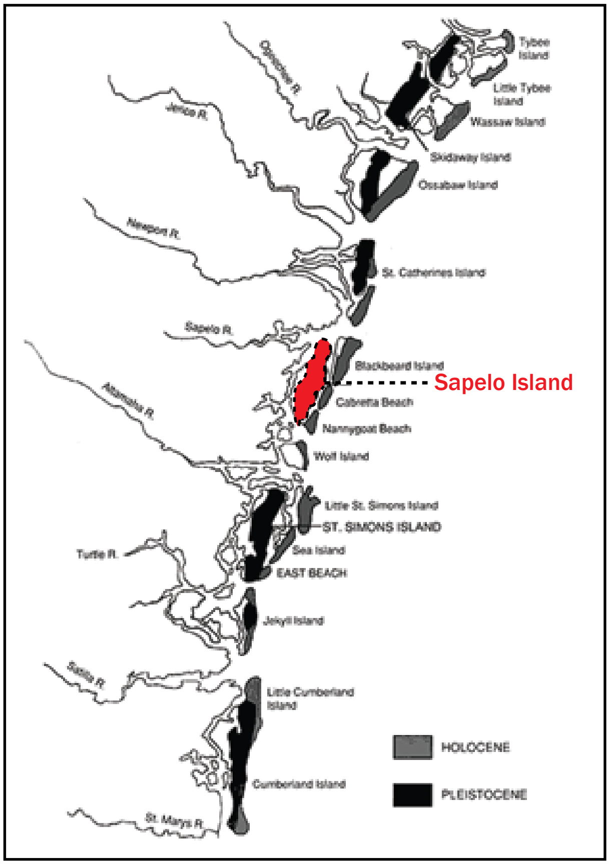
Geology

The Gray's Reef sanctuary is a consolidation of marine and terrestrial sediments (sand, shell and mud) that was laid down as loose aggregate between 6 and 2 million years ago. Some of these sediments were likely brought down by coastal rivers draining into the Atlantic and others were delivered by currents from other areas. These sediments continued to accumulate until a dramatic change began to take place on Earth during the Pleistocene Epoch, between 2 million and 10,000 years ago (Figure 3). During this time, the area that is now Gray's Reef was periodically exposed land and the shoreline was at times as much as 70 nautical miles east of its present location, as sea levels rose and fell at least seven times. As the glacial ice melted for the last time starting 18,000 years ago, the water flowed back into the sea, filling the ocean basins back to their original levels.

Designation

In the 1960s, extensive biological surveys of the ocean floor off the Georgia coast were conducted by Milton "Sam" Gray, a biological collector and curator at the University of Georgia Marine Institute on Sapelo Island, Ga. (Figure 4). In 1961, Gray first recognized this unique, near-shore hard-bottom reef off Sapelo Island. In 1974, the name "Gray's Reef" was proposed for this live-bottom habitat to commemorate Gray's valuable contribution to the understanding of offshore habitats and marine organisms, especially those of the near-shore continental shelf of Georgia. Collections made during the surveys still remain under the protective supervision of the University of Georgia Natural History Museum and maintained as the "Gray's Reef Collection."

In June 1978, the Coastal Resources Division of the Georgia Department of Natural Resources nominated Gray's Reef for consider-

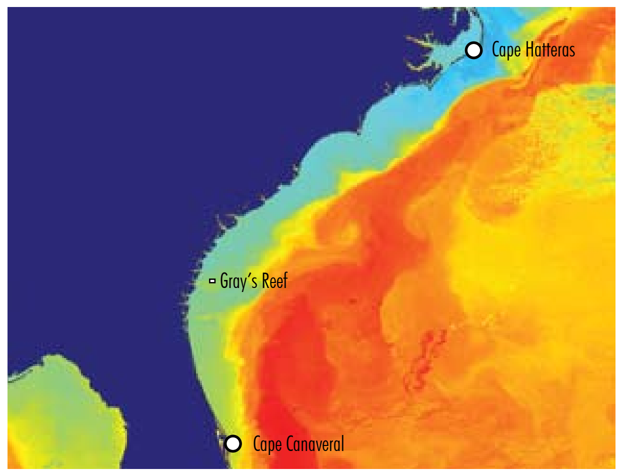


Source: Taylor Schoettle

Figure 3. The older and westward set of islands, the Pleistocene islands, sheltered Georgia's mainland beaches 40,000 to 60,000 years ago before the last great ice age. St. Simons, Sapelo, and Skidaway islands are examples.

Source: Georgia Marine Institute

Figure 4. Gray's Reef was named after Milton "Sam" Gray, who conducted extensive biological surveys of the ocean floor off the Georgia coast.



Source: NOAA Coastal Services Center

Figure 5. The South Atlantic Bight is the term used to describe the U.S. coastal ocean from Cape Hatteras, N.C., to Cape Canaveral, Fla.

ation as a national marine sanctuary. The designation was approved and signed by President Jimmy Carter on Jan. 16, 1981, and was publicly announced in the Federal Register (46 FR 7942).

Water and Climate

Gray's Reef National Marine Sanctuary is a small but very important part of the broad continental shelf off the southeastern coast of the United States, sometimes known as the South Atlantic Bight (Figure 5). The South Atlantic Bight extends from Cape Hatteras, N.C., to Cape Canaveral, Fla. The outer reaches are dominated by the Gulf Stream flowing northeastward. The inner area is defined by the cuspate curves of the coastline between the two capes and is dominated by tidal currents, river runoff, local winds, seasonal storms, hurricanes and seasonal atmospheric changes. The Gray's Reef sanctuary lies at the break between the inner- and mid-shelf zone of the South Atlantic Bight and is subject to seasonal variations in temperature, salinity and water clarity. It is also influenced by the Gulf Stream, which draws deep, nutrient-rich water to the region, and carries and supports many of the tropical fish species and other animals found seasonally in the sanctuary. Ocean currents and eddies also transport fish and invertebrate eggs and larvae from other areas, linking this special place to reefs north and south (NMSP 2006, Blanton et al. 2003).

Primary productivity at the Gray's Reef sanctuary is likely supported by input of nutrients from freshwater land runoff, as well as deep, nutrient-rich water from upwelling along the western edge of the Gulf Stream. Due to agitation from periodic high seas, re-suspension of organic material in the sediment adds to the productivity of sanctuary waters. Water column and benthic primary production are both important contributors to the overall productivity of the sanctuary, though benthic primary productivity is thought to be an order of magnitude higher than that of the water column. In addition, the Gulf Stream likely supplies planktonic larvae of invertebrates and fishes originating in the Caribbean and Gulf of Mexico (NMSP 2006).

Habitat

Gray's Reef National Marine Sanctuary is underlain by aragonitic limestone. These rocky features vary from flat, smooth surfaces to exposed vertical scarps and ledges with numerous overhangs, crevices and slopes (Riggs et al. 1996). The irregularities of the bathymetry can be attributed to the easily erodable limestone that has dissolved and pitted, creating the appearance of isolated ledges and patches of hard bottom. Exposed surfaces are colonized to varying extents by algae and sessile and burrowing invertebrates, which in turn provide shelter, foraging habitat and nursery areas for a large diversity of fish. Interestingly, percent cover of benthic species, with the exception of gorgonians, is significantly greater on ledges in comparison to the sparse live bottom. In addition, total percent cover and cover of macroalgae, sponges and other organisms is significantly lower on short ledges (<58.5 cm height) in comparison to medium (58.5-89.2 cm) and tall ledges (>89.2 cm) (Figure 6) (Kendall et al. 2007). The series of rock ledges and sand expanses has produced a complex habitat of caves, burrows, troughs and overhangs that provide a solid base upon which temperate and tropical marine flora and fauna attach and grow. This rocky platform, with its rich carpet of attached invertebrate and plant organisms, is known locally as a "live-bottom" habitat (NMSP 2006).

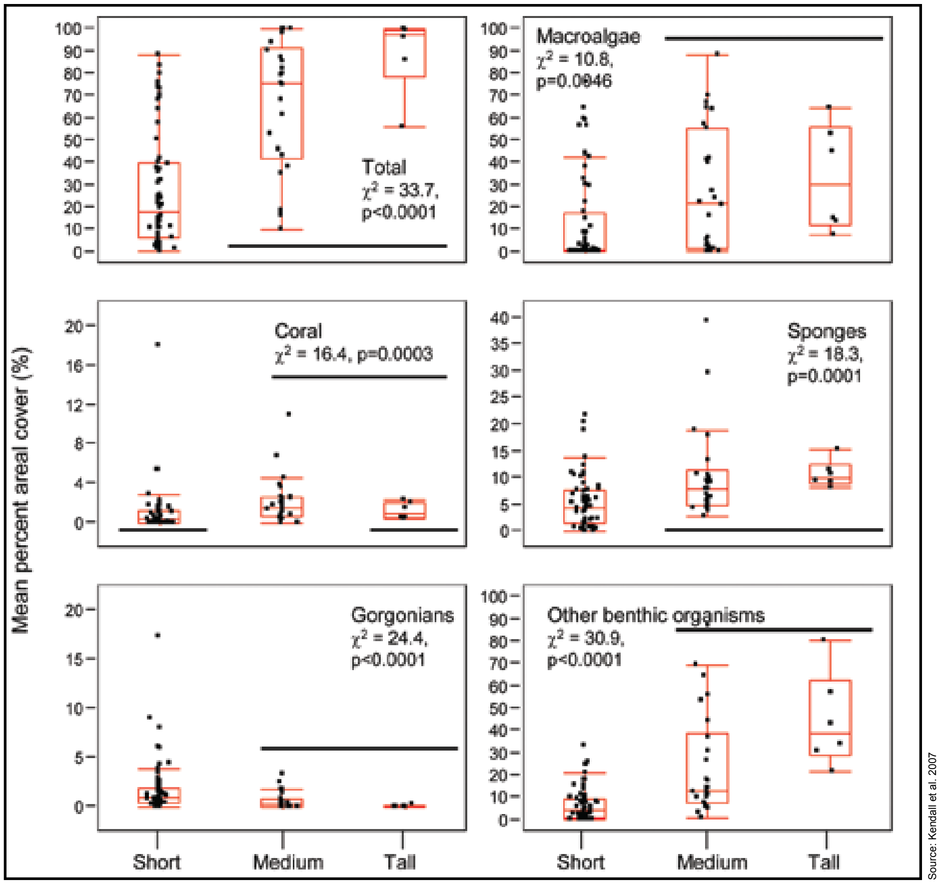


Figure 6. Box plots of percent cover of benthic organisms on three ledge groups determined by cluster analysis (note that each graph has a different vertical scale). Results of nonparametric ANOVAs (Kruskal-Wallis tests) and Dunn's multiple comparison tests to determine significant differences among mean ranks are provided (df = 2, alpha = 0.05). Solid horizontal lines join groups that are not significantly different from each other.

Live-bottom habitats are structurally complex and provide a number of microhabitats. Although the Gray's Reef sanctuary is the most intensely surveyed live-bottom feature in the region, diver-focused survey methods have provided only basic information on the extent and distribution of the live-bottom areas within the sanctuary. Video transects, coupled with side-scan and multi-beam sonar mapping suggest that sand habitats (rippled sand and flat sand) dominate, accounting for 75% of the sanctuary area. Approximately 24% of the sanctuary is sparsely or moderately colonized live bottom, and less than 1% of the sanctuary is considered densely colonized live bottom (Kendall et al. 2005).

Sediments covering the vast areas of sand in the sanctuary are probably re-suspended and redistributed during times of high wave action that accompanies winter and tropical storms. These shifting sands can uncover barely emergent limestone rock areas or, conversely, cover areas that were previously exposed (Figure 7). The effect of storm-suspended sediments has even been observed to scour entire low-relief ledges, removing all but the hardiest of attached marine organisms (McFall pers. comm.).

Living Resources

The live-bottom habitat of the Gray's Reef sanctuary is of particular biological importance, given the extensive sands that cover most of the broad continental shelf. The sanctuary contains biological assemblages consisting of sessile invertebrates such as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans and corals living upon and attached to naturally occurring hard or rocky formations with rough, broken or smooth topography, and whose structural complexity favors the aggregation of turtles, fishes and other fauna (Figure 8) (McFall 1998).

Gray's Reef National Marine Sanctuary attracts reef-associated fishes including bottom-dwelling and mid-water fish species such as sea bass, snapper, grouper and mackerel, as well as their prey. An estimated 180 species of fish, encompassing a wide variety of sizes, forms and ecological roles, have been recorded at Gray's Reef. Some fish species are dependent upon the reef for food and shelter, and rarely venture away from it during their life. Many of these fishes are nocturnal seeking refuge within the structure of the reef during the day and emerging at night to feed. Some species of reef-dwelling fish disperse to sandy habitats or to other reef areas north and south or offshore for feeding and spawning. Other reef residents, such as gag and black sea bass, rely on the inshore areas and estuaries in early life stages.

In addition to reef-associated fishes, Gray's Reef serves as habitat for a number of other fish species. King mackerel, Spanish mackerel, great barracuda, Atlantic spadefish and cobia make up the majority of pelagic species that are targeted for recreational angling. The high abundance of schooling baitfishes, such as Spanish sardine and round scad, likely attracts these pelagic predators to sanctuary waters. Approximately 30 species spawn in the vicinity of the sanctuary and only a third of these are reef-associated (Walsh et al. 2006, Sedberry et al. 2006). The large areas of sandy habitat in the sanctuary form another habitat that is not as rich in fish species, and is not targeted by recreational fishermen. These sandy areas support a number of species including flounders, tonguefishes, cusk eels, stargazers, and lizardfishes (Walsh et al. 2006, Gilligan 1989).

Sea turtles known to occur in the South Atlantic Bight include the Kemp's ridley, hawksbill, leatherback, green and loggerhead. Except for the loggerhead, all these species are federally listed as endangered. The

Photo: Matt Kendall/NOAA

Figure 7. Shifting sands and a lack of firm substrate preclude most sessile forms from settling in sandy areas of the reef. Burrowing clams and crustaceans, mobile snails, sea stars and burrowing polychaete worms are better adapted to life in these loose sediments.

Photo: Greg McFall/NOAA

Figure 8. Hydroid photographed in Gray's Reef. Hydroids are usually colonial and have a branched skeleton that generally grows in patterns resembling feathers or ferns.

Figure 9. Gray's Reef is an important area for loggerhead sea turtles to rest and forage throughout the year.

Figure 10. Atlantic spotted dolphins are relatively small and live in both coastal and offshore waters, feeding primarily on fish and squid.

loggerhead sea turtle is the most abundant sea turtle in the South Atlantic Bight and is federally listed as threatened (Figure 9). Gray's Reef is an important area for loggerheads to rest and forage throughout the year, especially during the summer nesting season, when females may nest two to four times on area beaches, laying approximately 120 eggs per nest.

Marine mammals on the southeastern United States continental shelf include cetaceans, occasional pinnipeds (harbor seals and sea lions) and sirenians (West Indian manatees). Atlantic spotted dolphins (Figure 10) and bottlenose dolphins (most likely from the Western North Atlantic coastal stock, see Torres et al. 2003), are the most common marine mammals at the Gray's Reef sanctuary. Both species have been designated as depleted under the Marine Mammal Protection Act. There are four species of federally listed endangered whales in the region: northern right, humpback, sperm and fin. Of these, only the highly endangered northern right whale — whose only known calving grounds are off coastal Georgia and northern Florida — has been observed in the vicinity of the sanctuary during the winter.

Figure 11. Ancient scallop bed at Gray's Reef with shells embedded in sediments that were deposited 30,000 years ago.

Pelagic birds, many of which are seasonal migratory species, occur on the middle and outer shelf regions of the South Atlantic Bight, particularly along the western edge of the Gulf Stream. More than 30 species of marine birds occur off the southeastern coast of the United States. Seabirds observed in the sanctuary area include gulls, petrels, shearwaters, Northern Gannet, phalaropes, jaegers and terns (NMSP 2006).

Maritime Archaeological Resources

To date, no downed aircraft or shipwrecks have been documented within Gray's Reef National Marine Sanctuary. However, Gray's Reef is an area of great interest for submerged archaeological and historical resources. Fossil oysters, scallops and snails embedded in the sandstone at the sanctuary indicate that the reef was once a shallow coastal environment (Figure 11). Fragments of mammal bones and a projectile point located in the sanctuary may indicate that the current reef area could have been inhabited by Paleoamericans — ancient peoples of the Americas who were present at the end of the last ice age — when it was above sea level (NMSP 2006).

Pressures on Sanctuary Resources

Human activities and natural processes both affect the condition of natural and archaeological resources in marine sanctuaries. This section describes the nature and extent of the most prominent human impacts on Gray's Reef National Marine Sanctuary.

Anchoring

Anchor damage can pose a serious threat to sanctuary marine resources as anchors and anchor chains can damage or destroy hard bottom and the marine organisms that are dependent on the substrate (Figure 12). Some visitors to Gray's Reef sanctuary once used anchors to secure their boats for fishing, diving and research. Given the nature of hard substrate in the sanctuary, it is difficult to secure anchorage unless anchors snag crevices or overhanging ledges. Boats would also typically anchor over live-bottom substrate because it is the habitat of interest for fishing and diving. Anchor contact can physically damage or modify habitat by scraping, cracking, displacing, breaking or removing substrate, or otherwise harming marine life attached to this substrate.

Anchoring may also adversely affect biodiversity by changing live-bottom composition through damage to either the habitat or the marine organisms of the reef. For example, coral that inhabits the hard-bottom areas of the reef provide either food or shelter to many species of fish and other invertebrates upon which larger reef and pelagic species of fishes feed. Any negative impact on this "foundation" of the reef can be passed along the food chain and may adversely affect the overall integrity of the reef ecosystem (NMSP 2006).

Photo: Greg McFall/NOAA

Figure 12. Anchors were once used by some visitors to Gray's Reef to secure boats for fishing, diving and research. Such anchoring can pose a serious threat to sanctuary marine resources.

Diver Impacts

Weather, sea conditions and diver proficiency tend to limit the number of people who dive at the Gray's Reef sanctuary. However, recent surveys show increases in visits for both fishing and diving in the sanctuary since its designation in 1981 (Figure 13). Coastal population increases, new diving and navigation technologies and the public's enhanced awareness of Gray's Reef as a diving destination may continue to increase diving activities and the probability of inadvertent damage or disturbance to reef communities.

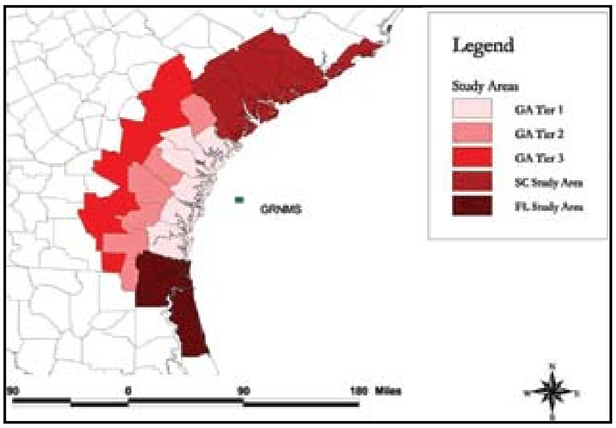
Studies have been conducted that show the impacts of dive activities. For example, divers in Australia were followed for 30 minutes and all direct contacts with the reef were recorded. Most divers damaged no coral while a small minority damaged between 10 and 15 corals each per 30-minute dive; fins caused the most damage (Harriott et al. 1997). A similar study in the Florida Keys showed that "… divers with gloves have significantly higher numbers of interactions with corals than divers without gloves…" (Talge 1990). Data also indicate that contacts may not change the percent of coral coverage, but may change composition from slower growing, older species, to faster growing, "weedy," opportunistic species. Other evidence indicates that most diving contacts may be tolerable and sustainable. In combination with other environmental stresses, such as poor water quality from sedimentation, improperly treated organic wastes, or nutrient pollution from terrestrial runoff, diving contacts can be part of a significant deleterious cumulative effect in reef communities (Ponder et al. 2002, NMSP 2006).

Photo: Grays Reef NMS

Figure 13. Recent surveys show increases in visits for both fishing and diving in the sanctuary since its designation in 1981. Diving can inadvertently damage or disturb reef communities.

Recreational Fishing

Based on socioeconomic studies from Georgia coastal counties and sanctuary surveys of visitor use, recreational fishing activities have increased significantly at Gray's Reef in the past 20 years. The data also indicate that the majority of users in the sanctuary are fishing with rod and reel fishing gear. Recreational fishing with spearguns is also a growing concern, although powerheads have been prohibited in the sanctuary since 1981. The trends in use are expected to continue as population increases along the Georgia coast (Figures 14 and 15) and the popularity of recreational fishing and diving grows. Increases in use, coupled with declines in fish populations and degradation of coastal habitats could result in adverse impacts on fish populations and sanctuary habitat (Ehler and Leeworthy 2002, NMSP 2006).



Source: NOAA Office of National Marine Sanctuaries

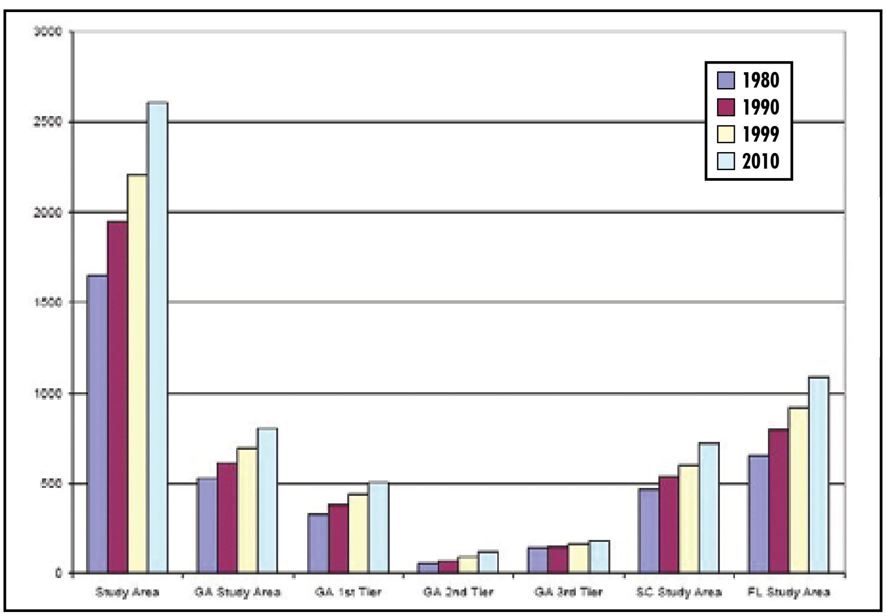
Figure 14. Gray's Reef National Marine Sanctuary Socioeconomic Study Area. The map indicates the counties in which the socioeconomic study was conducted.

Research by Kendall et al. (2007) indicates that ledges within the sanctuary are often targeted by fishermen due to the association of recreationally important fish species with this bottom type (Figure 16); ledges are structurally complex and are often densely colonized by biota.

Marine Debris

Marine debris may be any object of wood, metal, glass, rubber, plastic, cloth or paper that has been lost or discarded in the marine environment. Marine debris is a direct result of human activities on land and at sea, either intentional or accidental dumping within the sanctuary, or indirectly deposited from areas outside the sanctuary. Debris can pose serious threats to marine wildlife via entanglement or ingestion of plastics, cause impairment of navigation by obstructing propellers and clogging cooling intakes, and negatively impact the aesthetic qualities of the sanctuary. The abundance and spatial distribution of marine debris is dependent upon several factors, including its origin (terrestrial or maritime), ocean currents, wind patterns and physiographic char¬acteristics. Depending upon their composition, individual debris items may persist for a long time in the marine environment. Plastics, which are the dominant debris type in numerous marine systems, are of particular concern because they break down slower in the ocean than items on land due to lower temperatures and fouling by marine organisms.

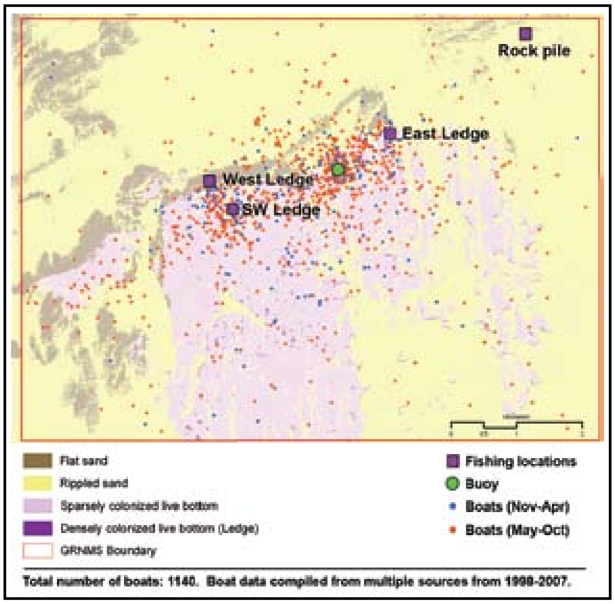
Use of the Gray's Reef sanctuary and surrounding areas has increased since the designation of the sanctuary in 1981. There has been a substantial increase in the human population within the coastal region of Georgia in recent years. As coastal populations rise and boating, fishing and offshore shipping increase in the region, an increase in the volume of refuse materials entering the waters of the sanctuary from coastal and offshore areas can be anticipated (Ehler and Leeworthy 2002, NMSP 2006).



Source: NOAA Office of National Marine Sanctuaries

Figure 15. Population Growth and Projected Growth for the Gray's Reef Study Area. The graph shows the projected increase in population growth in coastal counties.

A recent study by Kendall et al. (2007) showed that approximately two-thirds of all observed debris items found

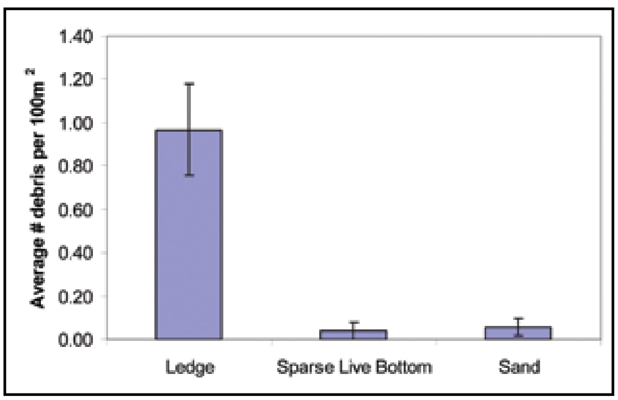


Source: NOAA Biogeography Team

Figure 16. Concentration of boats at Gray's Reef National Marine Sanctuary from 1998-2007 superimposed on the habitat distribution map.

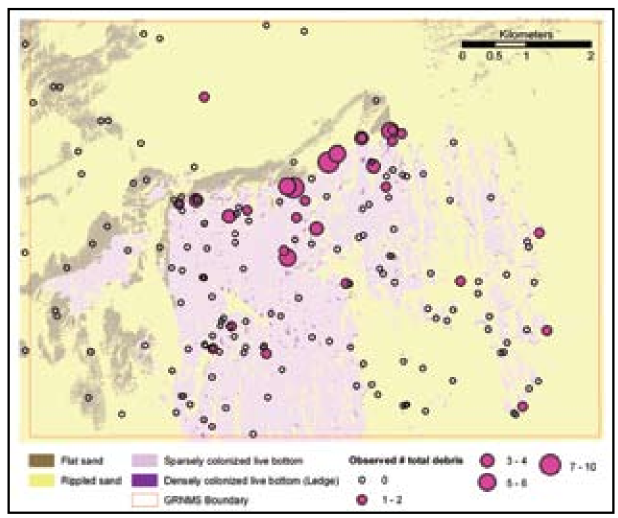
Photo: Greg McFall/NOAA

Figure 17. Example of fouled fishing line (out of water).



Source: Kendall et al. 2007

Figure 18. Average number of debris items at surveyed locations in the sanctuary (+/-SE_ per 100 m^2 transect by bottom type).



Source: Kendall et al. 2007

Figure 19. Spatial distribution of total debris (number per 100 m^2).

during field surveys was fishing gear, and about half of the fishing-related debris was monofilament fishing line (Figure 17). Other fishing-related debris included leaders and spear gun parts, and non-gear debris included cans, bottles and rope. The distribution and abundance of marine debris in the Gray's Reef sanctuary is related to the bottom type (Figure 18), the level of boating and fishing activity (Figure 16), and local characteristics of benthic features. The spatial distribution of debris is concentrated in the center of the sanctuary and is most frequently associated with ledges rather than other bottom types (Figure 19). On ledges, the presence and abundance of debris is significantly related to observed boat density and physiographic features including ledge height and ledge area. While it is likely that most fishing-related debris originates from boats inside the sanctuary, preliminary investigation of ocean current data indicate that currents may influence the distribution and local retention of more mobile items (Kendall et al. 2007).

Research Activities

The sanctuary is actively promoting research activities by university and government scientists. Current studies are mapping the sanctuary, quantifying fish and invertebrate populations on various temporal and spatial scales, documenting the presence of marine debris and monitoring physical factors. In some cases, these research activities involve extensive diving operations, manipulative experiments and long-term deployment of monitoring equipment. While these research programs are providing valuable information to the sanctuary, some habitat damage invariably occurs. Studies being conducted on the benthos appear to present additional threats to habitat quality due to diver impacts and alteration of the bottom via deployment of experimental apparatus. The impacts of research activities tend to be localized and concentrated on portions of the sanctuary with densely and sparsely colonized live bottom.

Invasive Species

Introduced non-indigenous species can be invasive if they become common and have significant ecosystem impacts, like assuming a keystone species role. The Indo-Pacific red lionfishes (*Pterois volitans* and *P. miles*) have become well established along the eastern coast (Whitfield et al. 2002), and in September 2007 two specimens of red lionfish were sighted within Gray's Reef sanctuary boundaries (however, because very few physical characteristics distinguish these two species it is unknown which species was actually sighted). In January 2008, three barnacles of the invasive species *Megabalanus coccopoma* (titan acorn barnacle) were found in Gray's Reef attached to the data buoy. This species is not native to the Atlantic but now occurs along the U.S. Atlantic coast and in the Gulf of Mexico. Potential impacts as a result of establishments of these and other organisms include competition with native species for food and space, predation, and disease.

Coastal Development

Human population growth and use of the coastal zone have increased dramatically in recent years, particularly along the U.S. southeastern coast. In coastal Georgia, populations have increased 62% from 1970-2000 and are projected to increase by another 51% to 844,161 by 2030 (Georgia Institute of Technology 2006). Human activities associated with such growth bring ensuing pressures on the coastal zone, including pollutant impacts arising from a variety of sources. Chemical contaminants may enter from industrial point-source discharges, oil spills, and nonpoint-source agricultural and urban runoff. Microbial contaminants may arrive from leaking septic tanks, sewage treatment plant overflows and wildlife and pet wastes. Chemical contaminants can cause toxicity in resident biota and pose a risk to human consumers of fish and shellfish. Microbial contamination can also lead to contamination of shellfish consumed by humans. In addition, eutrophication of our coastal waters from over-enrichment of nutrients and organic matter can lead to harmful effects from oxygen reduction, buildup of toxic levels of ammonia and sulfide, and other adverse conditions (such as high turbidity and reduced light penetration). Such pollutants, in addition to affecting estuarine and inland systems, may in some cases ultimately reach the offshore sanctuary environment by various mechanisms, including atmospheric deposition and underwater cross-shelf transport of materials outwelled through coastal sounds (Cooksey et al. 2004, Hyland et al. 2006).

Climate Change

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems. Climate change is having significant effects on sea temperature, sea level, storm intensity and currents. This could result in more damaging storms and more extreme floods and droughts. Sea level rise can cause beach erosion, dune and bank erosion, wetland loss, alteration of species assemblages, impacts on infrastructure flooding and island re-sizing, and can have groundwater implications (Ocean Management Task Force 2004).

State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: water, habitat, living resources and maritime archaeological resources. For each, sanctuary staff and selected outside experts considered a series of questions about each resource area. The set of questions is derived from the National Marine Sanctuary System's mission, and a system-wide monitoring framework (National Marine Sanctuary Program 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sanctuary sites and combined. The appendix (Rating Scheme for System-Wide Monitoring Questions) clarifies the set of questions and presents statements that were used to judge the status and assign a corresponding color code on a scale from "good" to "poor." These statements are customized for each question. In addition, the following options are available for all questions: "N/A" — the question does not apply; and "undetermined" – resource status is undetermined. In addition, symbols are used to indicate trends: "▲" — conditions appear to be improving; "—" — conditions do not appear to be changing; "▼" — conditions appear to be declining; and "?" — the trend is undetermined.


Photo: Greg McFall/NOAA

School of Greater Amberjack swimming by a branching finger sponge

This section of the report provides answers to the set of questions. Answers are supported by specific examples of data, investigations, monitoring and observations, and the basis for judgment is provided in the text and summarized in the table for each resource area. Where published or additional information exists, the reader is provided with appropriate references and Web links.

Water

Contaminants may be transported from land across the inner shelf to Gray's Reef National Marine Sanctuary, but the quantity of material from this process is affected by the trapping efficiency of salt marsh estuaries. The concentration of nutrients in the water not only varies with outwelling events, which are affected by freshwater inputs and oceanographic events, but also with the rates of exchange of contaminants between the water and silt-clay particles in the sediments.

NOAA's National Ocean Service has conducted sampling along three cross-shelf transects, extending from the mouths of Sapelo, Doboy and Altamaha sounds, and showed a general pattern of decreasing trace concentrations of contaminants with increasing distance from shore, suggesting possible sources from outwelling through coastal sounds. Data also revealed higher percentages of silt-clay fractions in sediments at stations closest to the sounds. These finer-grained particles represent a potential source for adsorption of chemical contaminants entering these systems. Cross-shelf differences in salinity and temperature provided additional evidence of the influence of the sounds, especially the Altamaha, on the adjacent shelf environment. The atmosphere is also considered a pathway of contaminants such as heavy metals, persistent organic contaminants and nutrients to the reef (NMSP 2006, Harris et al. 2004).

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?*** Water quality in the sanctuary is considered to be good based on assessments during spring 2000 and 2005. The trend, however, is undetermined. Unfortunately, there is insufficient information to determine whether changing oceanographic and atmospheric conditions are affecting water quality. In 2005, sanctuary staff in collaboration with the Skidaway Institute of Oceanography developed a more extensive water quality monitoring plan to assess whether trends observable in the coastal region are being reflected in water quality at Gray's Reef. Measurements include temperature, salinity, dissolved oxygen, inorganic nutrients (NO_2/NO_3, NH_4, PO_4, $Si(OH)_4$), organic nutrients (DON, urea, DOC), chlorophyll-a, and a number of bacteriological parameters including total bacteria counts, total and fecal coliforms, enterococci, and the ratio of bioluminescent to total heterotrophic bacteria. Harmful algal bloom species are not currently being examined at the Gray's Reef sanctuary.

    Specific chemical contaminants have not been measured in the water column, but are expected to be very low or undetectable because of the low concentrations found in sediments and biota. In addition, a bacterial indicator of chemical contamination (ratio of bioluminescence to total bacteria; Frischer et al. 2005) suggests an absence of chemical contaminants in the water column at the Gray's Reef sanctuary (Frischer unpublished data). Dissolved oxygen levels, a primary indicator of water quality, are high throughout the sanctuary. Results of a baseline characterization conducted in 2000 (Hyland et al. 2006, Cooksey et al. 2004) indicated that dissolved oxygen values ranged from 7.6-8.4 mg l^{-1}, which are well above a reported benthic hypoxic effect threshold of about 1.4 mg l^{-1} (Diaz and Rosenberg 1995) and most state standards of 5 mg l^{-1} or lower. A follow-up survey conducted in 2005 and ongoing monitoring showed consistent values in this same range (Balthis et al. 2007, Frischer unpublished data). All nutrient, chlorophyll-a, and total bacterial abundance indicate that water quality at Gray's Reef, in terms of those parameters, is good and not changing.

    Currently, anthropogenic stressors that may affect the water quality in the sanctuary — including increasing human activity in the coastal zone — are relatively low. Although some contaminants have been identified in fish and benthic organisms, to date, all have been below EPA guidelines. However, this does not mean that potential problems do not exist. As coastal development and population density continues to increase, offshore water quality will be impacted. This is an area that the sanctuary needs to continuously monitor in order to determine if conditions are changing. In the future, baseline data will help determine whether stressors such as population increases in the coastal zone are influencing water quality at Gray's Reef.

    Changing salinity patterns on the continental shelf off Georgia are also a potential stressor for coastal and shelf species that currently inhabit Gray's Reef. Natural drought (currently at the highest level of "exceptional" in the southeast U.S.) and increasing human freshwater extraction from dwindling watersheds that feed the coastal zone have had dramatic effects on coastal ecosystems recently (Visser et al. 2002). This freshwater runoff has historically penetrated across the shelf to the edge of the Gulf Stream, and is particularly strong during winter and early spring (Li 2001) when many reef fish spawn (Sedberry et al. 2006). The runoff typically carries nutrients from terrestrial sources to ocean waters that serve as the habitat for very young fish larvae (Atkinson et al. 1978), and reduced runoff could result in poor survival of reef fish larvae on the shelf. In addition, the levels of freshwater runoff can have an effect on overall shelf circulation, and their penetration across the shelf can affect Gulf Stream meanders (Atkinson et al. 1978, Blanton 1981) that influence the kinds of organisms found at Gray's Reef. Because Gray's Reef is located within the influence of a massive estuarine/riverine system, it has typically had salinities less than the open ocean, and species typical of coastal and estuarine habitats have occurred here. Changing freshwater runoff may influence the fauna of Gray's Reef, as oceanic and Gulf Stream species replace those coastal species that are less tolerant of higher salinities.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** At present, eutrophication does not appear to have the potential to negatively affect living resources or habitat quality. The trend, however, has not been determined. There is no evidence of eutrophication or incipient eutrophication at Gray's Reef National Marine Sanctuary as is occurring in the South Atlantic Bight coastal zone (Verity et al. 2006). This finding is based on low and stable nutrient concentrations, seasonal estimates of chlorophyll-a concentrations, the absence of harmful algal bloom events — with the exception of a subsurface bloom of *Phaeocystis globosa* in 1999 associated with stratified water (Long et al. 2007) — and high and stable dissolved oxygen concentrations in surface and near-bottom waters.

3. ***Do sanctuary waters pose risks to human health and how are they changing?*** While conditions that have the potential to affect human health may exist at Gray's Reef, human impacts have not been reported. Furthermore, there is

no evidence that the threat is changing. Risks to human health in Gray's Reef sanctuary have been undergoing assessment based on the use of bacterial indicators of fecal contamination. Indicators have included total and fecal coliform bacteria and enterococci bacteria. All indicators were below detection limits in eight samples collected throughout 2005 (Frischer unpublished data), suggesting minimal risks to human health.

Results of a baseline characterization of benthic communities and sediment quality conducted in 2000 (Hyland et al. 2006, Cooksey et al. 2004) also suggested that chemical contaminants in tissues of target benthic species within the sanctuary were below EPA human health guidelines (where available), based on a limited sample population of 10 fillets of black seabass and nine arc shell composites. Moderate concentrations of lead, however, just below the EPA Level of Concern value of 3 µg/g dry weight, were found in one fish sample (2.6 µg/g) and one arc shell sample (2.9 µg/g). Also, similar to sediments (see Question 7), tissues of both species contained trace concentrations of man-made pesticides (DDT, chlorpyrifos, dieldrin, lindane, heptachlor epoxide) and other chemical substances associated with human sources (PCBs, PAHs). The fact that immobile organisms like the arcs picked up these contaminants, albeit at low concentrations, provides evidence that such materials have made their way to the offshore sanctuary environment, either by air or cross-shelf transport by water from land. Results of a follow-up monitoring survey conducted in 2005 (Balthis et al. 2007) show a similar persistent trend of low yet detectable levels of chemical contaminants in tissues of these same species. Also, migratory species of fish like king mackerel that are currently under contaminant warnings (i.e., for mercury) are actively fished within sanctuary waters.

4. *What are the levels of human activities that may influence water quality and how are they changing?*

Because of the remote location of Gray's Reef National Marine Sanctuary from the coastal zone, human activities that may potentially negatively affect water quality in the sanctuary are believed to be limited. Human activities have increased dramatically along the southeastern coastal zone, but based on chemical contaminant and nutrient concentrations measured in the sanctuary there is no evidence of impact from these sources and no evidence that the trends observed in the coastal zone during the past 20 years (Verity et al. 2006) are mirrored in the sanctuary. However, the continued development of the coastal zone is inevitable, and therefore continued monitoring of the Gray's Reef sanctuary for evidence of this impact should be a continuing research priority.

The following information provides an assessment by sanctuary staff and the Gray's Reef Research Advisory Panel of the status and trends pertaining to water quality and its effects on the environment:

Water Quality Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
1	Stressors	?	2000 and 2005 monitoring data suggest good water quality, with some contaminants but below EPA guidelines; insufficient information to assess trend.	N/A
2	Eutrophic Condition	?	Stable nutrients, chlorophyll, lack of harmful algal blooms.	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
3	Human Health	–	2000 baseline, 2005 indicators below EPA Levels of Concern.	Selected conditions that have the potential to affect human health may exist, but human impacts have not been reported.
4	Human Activities	–	Increasing, but little evidence of negative effects.	Few or no activities occur that are likely to negatively affect water quality.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Getting Worse (▼), Undetermined Trend (?), Question not applicable (**N/A**)

Habitat

Gray's Reef is a submerged hard-bottom (limestone) area that, compared to surrounding areas, contains extensive but discontinuous rock outcroppings of moderate (6-10 feet) height with sandy, flat-bottomed troughs between. The series of rock ledges and sand expanses has produced a complex habitat of caves, burrows, troughs and overhangs that provide a solid base upon which the sanctuary's abundant sessile invertebrates can attach and grow. This rocky platform, with its carpet of attached organisms, is known as a "live-bottom habitat". This topography supports an unusual assemblage of temperate and tropical marine flora and fauna. Algae and invertebrates grow on the exposed rock surfaces; dominant invertebrates include sponges, barnacles, sea fans, hard corals, sea stars, crabs, lobsters, snails and shrimps. The reef attracts numerous species of benthic and pelagic fishes, including black seabass, snapper, groupers and mackerels.

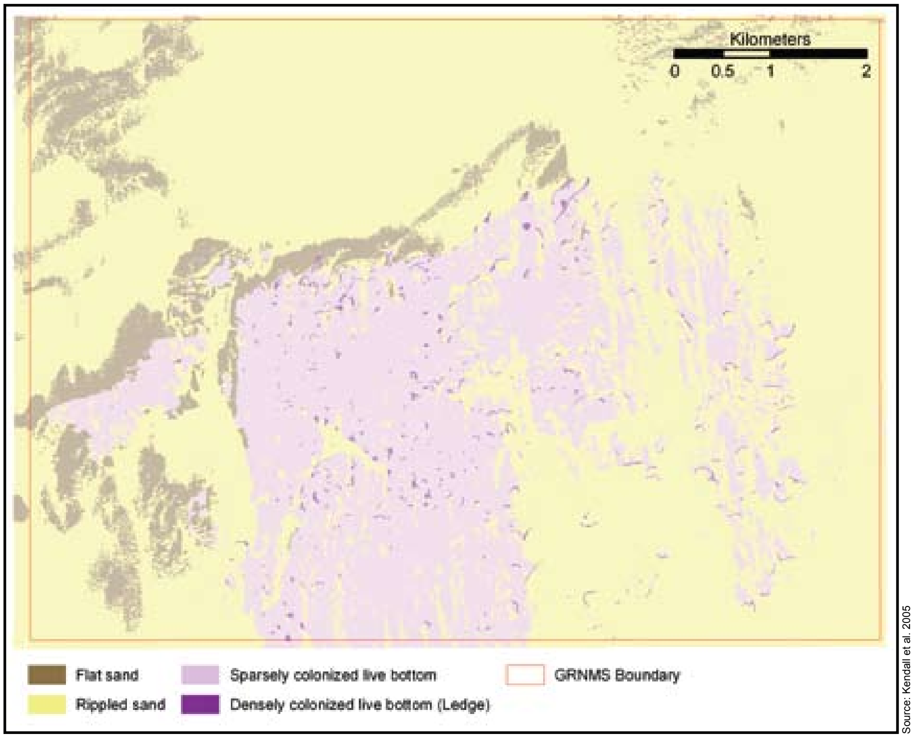


Figure 20. Gray's Reef National Marine Sanctuary benthic habitat map.

5. ***What are the abundance and distribution of major habitat types and how are they changing?*** Selected habitat loss or alteration has taken place at Gray's Reef, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality. The trend is undetermined. The sanctuary completed the first comprehensive habitat classification in 2001 using multibeam and side-scan sonar surveys ground truthed by diver observations and ROV video and still photography (Kendall et al. 2005). The sonar imagery, which completely covers the sanctuary, was mosaiced and georeferenced for use in GIS analysis of bottom type and benthic habitats. This analysis documents the four major habitat types and their spatial extent in the sanctuary: densely colonized live bottom (0.6%), sparsely colonized live bottom (24.8%), rippled sand (66.9%) and flat sand (7.7%) (Figure 20). Previous side-scan surveys of the sanctuary in the 1980s were used to characterize bottom types. Direct comparisons are not straightforward with the new, multiple datasets because of differences in available data types and line spacing. However, efforts to quantify the level of error in older data are ongoing so that decadal changes in habitat distribution can potentially be determined. Preliminary comparisons suggest that areas of low relief in the southeastern quadrant of the sanctuary have been buried by influx of sand on these timescales.

A recent survey of 179 sites within the Gray's Reef sanctuary indicates that the four bottom types have distinct physical and biological characteristics (Kendall et al. 2007). Sparse live bottom and ledges are colonized by macroalgae and numerous invertebrates, including coral, gorgonians, sponges, tunicates, anemones and bryozoans. Biotic cover on sparse live bottom is less in comparison to ledges, likely because colonization is inhibited by shifting sands. In addition, percent cover of biota on ledges is positively related to ledge height (Kendall et al. 2007). The densely colonized live bottom, although comprising a small percentage of the total sanctuary area, is the critical habitat impacted by pressures and is disproportionate in its importance. Thus, small impacts to a very spatially limited habitat are a particular management concern for this sanctuary. Anthropogenic pressures are not significantly affecting the abundance or distribution of habitat types based on diver observations. Although flat and rippled sand bottom have a low percent cover of epibenthic organisms, these bottom types harbor diverse infaunal assemblages (Hyland et al. 2006).

There is presently an inadequate time series of data with which to determine trends in habitat abundance and distribution. However, the sanctuary now has a comprehensive baseline survey from which future change can be confidently assessed.

6. ***What is the condition of biologically structured habitats and how is it changing?*** Currently, there is insufficient information on the complex biological structure of habitats to rate the condition. There is, however, evidence of anchor, fishing and storm damage. The trend is undetermined. Gray's Reef National Marine Sanctuary is composed of four main bottom types: flat sand, rippled sand, sparsely colonized live bottom and densely colonized live bottom (ledges). Non-quantitative assessments and observations (e.g., dislodgement of sponges, corals and other invertebrates) by scientists, sanctuary staff and users indicates that damage to densely and sparsely colonized live

bottom is primarily associated with anchoring. Recreational fishing may also impact biologically structured habitats through marine debris, especially through entanglement in monofilament line (Kendall et al. 2007). Although the impact is minimal, disturbances by divers are also occurring. Damage to biologically structured habitats is disproportionate on a spatial scale and is probably concentrated in areas of highest fishing and diving activity. Recently established long-term monitoring of the benthos indicates that changes in biologically structured habitats at shallow depths also occur due to storm impacts (i.e., movement of sediment) or on seasonal cycles (Freeman et al. 2007). The inability to decipher changes resulting from human impacts versus natural processes makes the trend undetermined at present. Continued monitoring at a range of spatial and temporal scales is required to establish the trend.

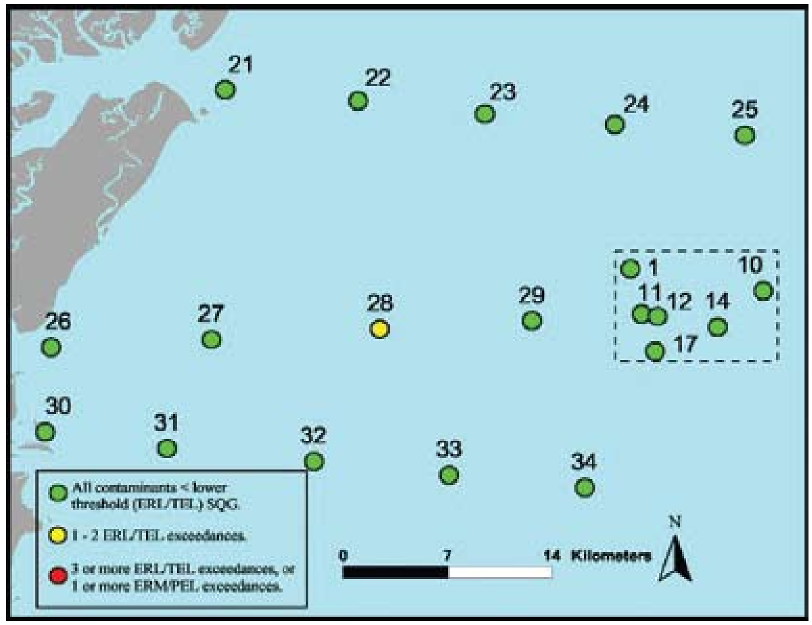


Figure 21. Spring 2001 summary of chemical contaminant concentrations in sediments relative to sediment quality guidelines. The outlined box to the right of the image indicates the Gray's Reef National Marine Sanctuary boundary.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Contaminant concentrations in sanctuary habitats do not appear to have the potential to negatively affect living resources or water quality, and conditions do not appear to be changing. Results of a baseline characterization of benthic communities and sediment quality conducted in 2000 (Hyland et al. 2006, Cooksey et al. 2004) suggested that chemical contaminants in sediments (including pesticides, PCBs, PAHs, and metals) were generally at low background concentrations, below probable bioeffect threshold levels. The historically low sediment contamination is most likely attributable to the remote location of this offshore environment and the sandy nature of the substrate (e.g., absence of a silt-clay fraction). However, sediments contain trace concentrations of contaminants associated with human sources (pesticides, PCBs, PAHs), demonstrating that such materials are making their way to the offshore sanctuary environment, either by air or aquatic cross-shelf transport from land (Figure 21). Total organic carbon in sediments is also at low levels — less than 2 percent throughout the sanctuary and less than 1 percent at most stations (Hyland et al. 2006) — typical of shelf waters in this region (Tenore et al. 1978). This is well below a reported range (less than 3.6 percent) associated with a high risk of disturbance from organic over-enrichment (Hyland et al. 2005). Results of a follow-up monitoring survey conducted in 2005 (Balthis et al. 2007) showed a similar persistent trend of low background levels of such sediment-associated stressors. Nonetheless, the presence of chemical contaminants in sediments at low yet detectable levels in both surveys suggests that such pollutants have reached the sanctuary and thus should continue to be monitored to ensure that future problems do not develop (Harris et al. 2004, NMSP 2006).

8. ***What are the levels of human activities that may influence habitat quality and how are they changing?*** Selected human activities in the sanctuary have resulted in measurable habitat impacts, but evidence suggests the effects are localized and not widespread. The trend is undetermined. Fishing, anchoring, marine debris, divers and research activities are suspected or known causes of damage to habitats within Gray's Reef National Marine Sanctuary (Figure 22). Based on boat counts and fishing tournament participation data, visitation to Gray's Reef has increased over the last 25 years, and this increase is likely responsible for some documented habitat impacts. Anchor damage and entangled fishing line has been observed. The spatial distribution of debris is concentrated in the center of the sanctuary and is most frequently associated with biologically structured habitats (i.e., habitats created by

sponges and other upright organisms) and along ledges, rather than at other bottom types (see Figure 19). Approximately 90% of debris encountered at the Gray's Reef sanctuary has been found along ledges (Kendall et al. 2007). This is probably more a result of bottom fishers than tournament fishing (which targets mackerel and involves bait drifting or trolling). Data are not currently available to discern the trend in the number of visitors participating in destructive activities. Nevertheless, continued increases in human use will probably add to habitat alteration. A combination of improved monitoring and enhanced education and enforcement of regulations would be appropriate management actions.

The following information provides an assessment by sanctuary staff and the Gray's Reef Research Advisory Panel of the status and trends pertaining to the current state of the marine habitat:

Habitat Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	?	Baseline data recently completed; assessment of trends will depend on future observations.	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
6	Structure	?	Insufficient information on the complex biological structure of habitats to rate condition, though there is evidence of anchor, fishing, and storm damage.	N/A
7	Contaminants	–	Low levels in 2000 and 2005.	Contaminants do not appear to have the potential to negatively affect living resources or water quality.
8	Human Activities	–	Localized within areas of heavy use.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Getting Worse (▼), Undetermined Trend (?), Question not applicable (N/A)

Living Resources

Fishes

The highest fish species richness, diversity, abundance and biomass at Gray's Reef National Marine Sanctuary is found on and near reef structure ('live bottom'). Resident and non resident reef fishes normally associate with hard structure, and even coastal migratory pelagic species such as mackerels are attracted to and orient themselves near structures. Flat and rippled sand sites have the lowest value in fish species richness, diversity, abundance and biomass. Analysis of fish assemblages at ledges (high-relief hard structure areas) indicates that species richness and total abundance of fish are positively related to total percent cover of sessile invertebrates and ledge height (Kendall et al. 2007, Kendall et al. 2008). As a result, ledges within the sanctuary are often targeted by fishermen due to the association of recreationally important fish species with this bottom type and because ledges are structurally complex and are often densely colonized by biota. In addition, pelagic predators like king mackerel feed on schools of pelagic baitfish that concentrate down current from bottom structure.

Currently, recreational fishing pressure on reef-associated fishes is thought to be less intense than it is for pelagic species, although studies conducted at the Gray's Reef sanctuary indicate that fishing mortality for black sea bass is the same or higher within the sanctuary than it is regionally or at inner-shelf reefs off South Carolina (Harris et al. 2005). The most intensive fishing pressure occurs in conjunction with offshore fishing tournaments, which target king mackerel. Weekends experience more fishing activity than weekdays. On an annual basis, fishing pressure is patterned around meteorological events and migratory patterns of the targeted species. Fishing pressure is probably lowest in mid-winter with low tempera-

Photo: Kendall et al. 2007

Figure 22. Marine debris is a direct result of human activities on land and at sea.

tures and winter storms. By late winter or early spring, recreational fishing pressure increases as the anglers target black sea bass. In late spring to early summer, fishing pressure peaks as anglers target the pelagic cobia, bluefish, Spanish mackerel and king mackerel. Late summer experiences a slump in fishing pressure as target species are widely scattered and difficult to catch. By fall, fishing pressure increases again as the pelagic species return. This is sustained until the water temperature drops low enough to cause the target species to migrate out of the area.

In 1993, NOAA's National Marine Fisheries Service's Marine Resources Monitoring Assessment and Prediction Program established sampling stations at Gray's Reef sanctuary to monitor reef fish populations. During the trapping periods (July 1993-1995 and July 1998-2001), catches were dominated by black sea bass (50 percent), followed by scup (34 percent) and tomtate (12 percent). Other species caught included pinfish, blue runner, gray triggerfish, northern puffer and leopard toadfish.

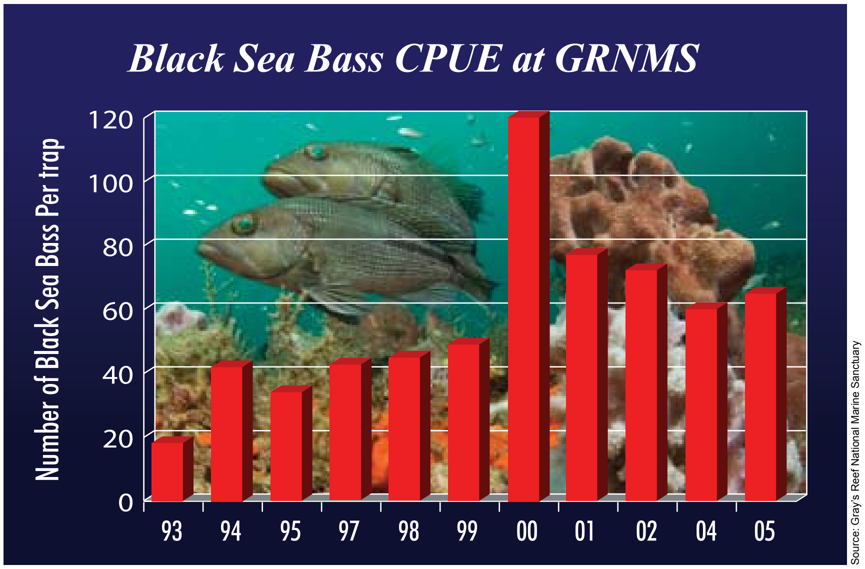


Figure 23. Black sea bass catch at Gray's Reef National Marine Sanctuary through the Marine Monitoring, Assessment and Prediction Program – South Carolina Department of Natural Resources.

In the Gray's Reef sanctuary, the number of black sea bass caught per trap has increased since 1993, with a significant increase occurring in 2000 (Figure 23). Estimated abundance of black sea bass at the sanctuary showed a large increase from 1993 to 2001, followed by a decrease through 2004. Due in part to a high year of larval recruitment, the population size estimate increased in 2005, and is the second highest estimate since 1993. This species, like many in the snapper-grouper complex, resides on reefs and other structures as adults. Black sea bass are estuarine-dependent as juveniles, and relatively little is known about their spawning behaviors in or near the sanctuary. Tagging data indicated that after three months, 93 percent of the fish were recaptured at Gray's Reef, suggesting that these fishes show relatively low rates of movement. Tags returns from recreational fishermen outside the boundaries indicate that many of the larger fish move out of the sanctuary (Harris et al. 2004, McGovern et al. 2002).

9. ***What is the status of biodiversity and how is it changing?*** Diversity at Gray's Reef National Marine Sanctuary is very high compared to shelf sites at similar depths north of Cape Hatteras, but there are no baseline data to determine if diversity has changed in response to fishing pressure exerted since the 1970s.

There is considerable benthic, epifauna and fish biodiversity monitoring and data, but data is insufficient at this time to rate the status of the resources and impacts on full community development and function. Benthic infaunal invertebrate diversity in the Gray's Reef sanctuary is very high, and is higher than comparable depths off mid-Atlantic and northeastern states. The complexity of these structures, however, is not completely understood, and there are no baseline data (i.e., pre-fishing years) to compare with present diversity measures. Diversity of benthic infauna did not change from one study in 2000 (after at least 30 years of commercial and recreational fishing) to a follow-up in 2005 (Cooksey et al. 2004, Hyland et al. 2006). Samples collected had a mean diversity of 45 (+ 11) species per grab (0.04 m^2) in 2000 and 47 (+ 12) in 2005. The total number of infauna collected was about 350 taxa. Benthic infauna are an important food source for forage fishes and some fishery species and are an important link in the food chain.

Fish diversity is also quite high in the sanctuary, with 181 species recorded, including 46 managed species (Hare et al. in press). Annual monitoring by visual census has indicated no change in fish diversity (REEF, unpublished). The Gray's Reef sanctuary is in a transitional zone between cold temperate and warm temperate waters. Because of this, the fish community likely changes considerably in response to episodic hydrographic events like cold water intrusions and Gulf Stream eddies, and may be in a constant state of succession toward full community development.

10. *What is the status of environmentally sustainable fishing and how is it changing?* Regional fishing has caused or is likely to cause severe declines in some but not all ecosystem components at Gray's Reef and reduce ecosystem integrity. Furthermore, this condition appears to be getting worse. According to NOAA's National Marine Fisheries Service (2006), red snapper, gag, red grouper and black seabass are overfished. Gray triggerfish, sheepshead and greater amberjack are not currently overfished in the region.

Monitoring of the abundance and size of black seabass (the dominant reef-associated fishery species at the sanctuary) in trap surveys indicates trends in abundance and size that are similar to trends found throughout the region, where this species is classified as overfished and is undergoing overfishing. This may indicate that federal region-wide fishery management measures have a greater influence on status of stock than do sanctuary regulations. Tagging studies of black seabass indicate high rates of tag returns from recreational fishermen, resulting from high fishing effort within the sanctuary. Tagging and catch curve analysis from trap survey catches indicate that fishing mortality of black seabass at the Gray's Reef sanctuary is as high as or higher than that on other reefs throughout the region. Mean length of black seabass in trap surveys at the sanctuary has increased since 1993, following similar trends throughout the region, and is likely influenced by increases in minimum size imposed by the South Atlantic Fishery Management Council (Harris et al. 2005). There is good and consistent annual recruitment of small black seabass in trap catches.

Gag and scamp have decreased in abundance in visual census transects, and length-frequency measurements of black seabass, gag and scamp (from trap and visual census data) indicate that a large portion of the population is removed upon reaching minimum size, either by fishing or by migration out of the sanctuary.

There is considerable but unmeasured fishing effort on coastal pelagic species (king and Spanish mackerel) during mackerel tournaments and at other times. Federal management of coastal pelagic species has resulted in sustainable fisheries for king mackerel and the stock is not currently overfished.

11. *What is the status of non-indigenous species and how is it changing?* The status of non-indigenous species in the sanctuary is considered to be "good/fair" — non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity. This trend is declining. Two species of lionfish (*Pterois volitans* and *P. miles*), formerly residents of the western Pacific and eastern Indian oceans only, have become well established in the western Atlantic along the eastern coast of the U.S. (Whitfield et al. 2002) and have been documented at sites in close proximity to the Gray's Reef sanctuary boundaries. In fall 2007, NOAA's National Centers for Coastal Ocean Science reported the first sighting of two red lionfish in the sanctuary (Figure 24). Because very few physical characteristics distinguish the two species of lionfish it is unknown which species was actually sighted. The range and abundance of this species is continuing to increase (Ruiz-Carus 2006). In January 2008, three barnacles of the invasive species *Megabalanus coccopoma* (titan acorn barnacle) were found in Gray's Reef attached to the data buoy. These barnacles, native to the western Pacific, have been found throughout the southeast Atlantic.Marine biologists at NOAA's

Photo: Matt Kendall/NOAA

Figure 24. One of the two lionfish that were observed for the first time in the sanctuary in fall 2007.

Center for Coastal Fisheries and Habitat Research in Beaufort, N.C., are currently conducting research on the red lionfish. It is the first marine invasive fish suspected to have established itself in the sanctuary (Private Research Permit MNMS-01-2007).

Potential impacts of these and other organisms include competition with native species for food and space, predation on native species, and diseases to which native species have no resistance (Ruiz-Carus 2006). Impacts from red lionfish could include direct competition with large groupers (*Mycteroperca* spp.) for food and predation on smaller seabasses (*Serranidae* spp.) and other benthic fish and crustaceans (Ruiz-Carus 2006). Potential human impacts could result from fishers or divers coming in contact with venomous spines. Impacts from titan barnacles could include spatial dominance of available habitat. Titan acorn barnacles could exclude other epifaunal species, including local barnacles, mussels, oysters, corals and sponges. Cold seasonal water temperatures could hinder year-round establishment of red lionfish (Kimball et al. 2004) and titan acorn barnacles.

12. What is the status of key species and how is it changing? The status of key species in the sanctuary is considered to be fair, as selected key species are at reduced levels, but recovery is possible. The condition, however, may be getting worse. Key species of fishes in the sanctuary include gag and scamp, king mackerel, black sea bass and red snapper, all of which are targeted by fishers and are dominant predators in the ecosystem. While gag and scamp can be found at the sanctuary, they are not found in the numbers that might be anticipated based on the abundance of suitable habitat and available resources. Of the 92 ledges surveyed by Kendall et al. (2007), only 20 had occurrences of these species, with the majority of the species occurring on just 10 ledges. The spatial distribution of both species was quite clumped on ledges in the north central and south central regions of the sanctuary. In addition, both species were often observed together at the same ledge and were rarely observed as lone individuals. In contrast, black sea bass occurred at 98 percent of the ledges surveyed and appeared evenly distributed through¬out the sanctuary. Pressure on king mackerel has been steadily increasing at Gray's Reef in the recent past, with the majority of effort coming from fishing tournaments.

Benthic cover of invertebrates on live-bottom areas in the sanctuary is dominated by various species of sponges (primarily in the genera *Ircinia* and *Chondrilla*), corals (predominately *Oculina arbuscula*), tunicates (including *Styela*, *Aplidium* and *Symplegma*), arborescent bryozoans (primarily *Schizoporella*) and gorgonians (dominated by *Telesto* and *Leptogorgia*) (Ruzicka 2005, Gleason et al. 2007). No evidence of disease has been observed on these key benthic species, although recent mortalities in *Ircinia* seem to correlate with warmer water temperatures. Recently established long-term monitoring of the benthos has noted some decline in percent cover and species diversity, but these changes appear to be due to storm impacts (i.e., movement of sediment) or represent seasonal cycles (Freeman et al. 2007).

According to NMFS (2008) and SEDAR (2008), red snapper, gag, red grouper and black sea bass are overfished and/or undergoing overfishing throughout the region. Tagging studies of black sea bass indicate high rates of tag returns from recreational fishermen, resulting from high fishing effort within the sanctuary. Tagging and catch curve analysis from trap survey catches indicate that fishing mortality for black sea bass at the Gray's Reef sanctuary is as high as or higher than that on other reefs throughout the region. Mean length of black sea bass in trap surveys at the sanctuary has increased since 1993, following similar trends throughout the region, and is likely influenced by increases in minimum size imposed by the South Atlantic Fishery Management Council (Harris et al. 2005). There is good and consistent annual recruitment of small black sea bass in trap catches.

Based on the above information, the status of key species is determined to be fair and the trend appears to be decreasing.

13. What is the condition or health of key species and how is it changing? The condition of key species at the Gray's Reef sanctuary has not been systematically assessed, nor have trends been identified. Sponges, recognized as key species at Gray's Reef due to their importance in structuring habitat, however, have been found to contain organic contaminants (PCBs, PAHs etc.) in their tissues. These filtering organisms appear to be accumulating contaminants from the water column (McFall pers. comm.). Tissues from mussels and fish and sediments have been used recently to determine the level of contaminants in the sanctuary (Cooksey et al. 2004, Hyland at al. 2006), but the amounts present in the sponge tissues appear to be higher than levels reported from these other sources. Coral has also been identified as a key species at Gray's Reef, with the most prominent species being *Oculina arbuscula*. This species shows high recruitment rates (Gleason in prep.) and genetic studies indicate that new individuals result from "local" recruitment (Wagner 2006),reflecting a reproductively healthy *O. arbuscula* population in the sanctuary. Insufficient data exist to determine a trend.

14. What are the levels of human activities that may influence living resource quality and how are they changing? Certain human activities have resulted in measurable living resource impacts, but evidence suggests effects are localized and not widespread. The trend, however, is undetermined. Activities that are most likely to affect living resources at Gray's Reef are recreational bottom fishing (from boats and perhaps spearfishing), diving (recreational and research), certain research activities (e.g., collecting, coring, data collection), anchoring, disposal of marine debris, and coastal development. Observational data suggest that the activity having the most measurable effect on living resources is recreational bottom fishing. Aside from creating some of the marine debris at Gray's Reef, fishing appears to depress the size-frequency distribution for black sea bass, potentially affecting their abundance, fecundity and availability as food for other species. Additional information exists to show a regional trend for other species, such as gag and scamp, as well. Existing data suggest that approximately 20 percent of fishers at Gray's Reef participate in bottom fishing, but time-series data that might be used for assessing trends are not currently available.

Diver impacts, whether they result from research, recreation or spearfishing, are intermittent and generally limited to specific study locations. Similarly, anchoring and marine debris are concentrated in locations with high visitation, and most impacts have been observed in areas with the highest relief and cover. Of the marine debris surveyed at Gray's Reef, two-thirds is composed of fishing line (usually entangled), which, like other visitation-related activities, is most heavily concentrated in areas of high relief. Data on levels for most of these activities, and for any impacts they might be causing, are generally lacking, as are data on trends.

Preliminary data from one on-going study suggest that evidence of accumulation of certain organic contaminants in sponges likely results from coastal development, but it is not known whether these are at high enough levels to be of concern. Coastal development is certain to continue to increase, making this an activity that should be monitored closely.

The following information provides an assessment by sanctuary staff and the Gray's Reef Research Advisory Panel of the status and trends pertaining to the current state of the sanctuary's living resources:

Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
9	Biodiversity	?	Considerable benthic, epifauna and fish biodiversity monitoring and data, but insufficient at this time to rate status, trends and impacts as they relate to community development and function.	N/A
10	Extracted Species	▼	Black seabass, gag, red grouper, and red snapper regionally overfished and/or undergoing overfishing.	Extraction has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.
11	Non-indigenous Species	▼	Two lionfish identified in sanctuary in fall 2007.	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.
12	Key Species Status	▼	Removal of key fish species and recent sponge mortality.	The reduced abundance of selected key species may inhibit full community development and function, and may cause measurable but not severe degradation of ecosystem integrity; or selected key species are at reduced levels, but recovery is possible.
13	Key Species Condition	?	Key species tentatively identified but unable to determine condition and health; some contaminants detected in sponges, but cause of mortality undetermined.	N/A
14	Human Activities	?	Localized within areas of heavy use.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Getting Worse (▼), Undetermined Trend (?), Question not applicable (N/A)

Maritime Archaeological Resources

There are currently no known shipwrecks in the sanctuary, but Gray's Reef National Marine Sanctuary does contain considerable paleontological resources of both marine and terrestrial origin. This may have important implications with regard to former human occupation of the area, and the potential for future archaeological finds.

Within the sanctuary boundaries, two research stations have been well documented to contain large areas of ancient scallop (Placopecten magellanicus) beds. These scallops have been dated to approximately 42,000 to 44,000 years before present and range in size up to 20 centimeters in diameter. In addition to the two research stations, the scallops have also been documented at several other sites throughout the sanctuary.

The primary importance of the ancient scallop beds is that they shed some light on past climate change at Gray's Reef. The presence of these scallops dictates a much colder environment than what is currently found at Gray's Reef today. The death assemblage also indicates a potentially rapid rise in the ocean temperature at Gray's Reef that makes the shells proxies for the timing and rate of climate shifts. In the scientific community today, there is great interest in accurate hindcasts for Earth's climate that provide real context by which to measure and assess modern climate change. These resources may provide a significant role in understanding future climate change, which makes it a vital task to preserve and monitor these "maritime archaeological, paleontological and prehistoric resources" in the sanctuary, as set forth in the enabling legislation of the National Marine Sanctuary System.

Also frequently discovered at the sanctuary are fossilized terrestrial and marine mammal bone fragments. These bone fragments help to piece together the changes at Gray's Reef as Georgia's shoreline advanced and retreated over geologic time. It has been well documented that Gray's Reef was last exposed approximately 7,000 years ago and prior to that had been submerged and exposed many times, allowing both marine and terrestrial animals to live there.

A recent discovery near Gray's Reef, dated by radiocarbon methods to 38,000 years ago, is that of a northern right whale (*Eubalaena glacialis*) cranial bone. This discovery alone suggests that the Georgia Bight was a favored ground for this endangered species long before the modern era.

To date, only a few manmade prehistoric artifacts have been recovered at Gray's Reef. These artifacts have been points of interest and discussion over the years, but no archaeological sites have been discovered in association with these finds. However, since Gray's Reef was last exposed approximately 7,000 years ago, it is possible that humans once lived and hunted in the area before submergence in post-glacial time (Holocene). It thus remains a possibility that important undiscovered archaeological evidence exists at Gray's Reef.

Natural oceanographic forces pose the main danger to the Gray's Reef sanctuary's prehistoric, archaeological and paleontological resources. Erosion due to storms and natural currents continuously occurs at the bottom, as moving sand exposes and buries the scallop beds and bone fragments. Little can be done to prevent damage to sanctuary resources from these forces except monitor the sites and recover and document any finds as they become exposed. Recreational diving and anchoring at the sanctuary could potentially impact the resources, but since anchoring has been banned within the sanctuary, it is not expected that this will be a major problem.

The following information provides an assessment by sanctuary staff and the Gray's Reef Research Advisory Panel of the status and trends pertaining to the current state of the sanctuary's maritime archaeological resources:

Maritime Archaeological Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
15	Integrity	**N/A**	No archaeological evidence, though former human occupation remains a possibility based on paleontological data.	N/A
16	Threat to Environment	**N/A**	No archaeological evidence, though former human occupation remains a possibility based on paleontological data.	N/A
17	Human Activities	**–**	Potential for diving, fishing and anchoring to damage sites.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Getting Worse (▼), Undetermined Trend (**?**), Question not applicable (**N/A**)

Response to Pressures

This section describes current or proposed responses to pressures on the sanctuary. Current responses are based on implementation of the sanctuary's 2006 management plan, which encompasses those specific strategies.

Anchoring

Anchoring can adversely impact not only the non-regenerative limestone ledges, but can harm the benthic fauna that are attached to it. Many of the large and well-established invertebrates (corals and sponges) are the most reproductively viable members of the population and can be easily removed by an anchor or chain. In response to these threats, NOAA established an anchoring prohibition in the Gray's Reef Final Management Plan that became effective in February 2007. Anchoring is now prohibited in the sanctuary, except in emergencies. Compliance is expected to result in improvements to the hard substrate and attached living marine resources associated with the bottom features. Gray's Reef is also undertaking an outreach campaign to alert the public and users to the new regulations through communication with user groups, marinas the media, and on-water patrols.


Photo: Greg McFall/NOAA

Schooling baitfishes swimming over a vase sponge with a diver in the background

Diver Impacts

Along with anchoring, improper scuba diving techniques may be responsible for damage to densely and sparsely colonized live bottom at Gray's Reef, such as dislodgement of sponges, corals and other invertebrates. Studies in Australia (Harriott et al. 1997) and the Florida Keys (Talge 1990) have documented diver impacts including reef-damaging contacts with flippers and gloves. While the impacts do not seem to be significant at this time for Gray's Reef, growing public awareness of the sanctuary as a diving destination may continue to increase diving activities and the probability of inadvertent damage or disturbance to reef communities.

In addition to the allowable gear fishing regulation, which prohibits "taking by hand, any marine organism, or any part thereof living or dead," reducing diver impacts through educational efforts will help protect marine resources at Gray's Reef. Education and outreach programs featuring printed materials and radio spots will be initiated to increase public awareness about the importance of good diving techniques, Gray's Reef regulations that guide diver activities, and etiquette for interacting with marine animals. The campaign will coordinate with PADI's Project Aware and will include information about the value of the reef, rules and regulations, and diver responsibilities. Materials will be distributed at dive shops and at public events and presentations.

Recreational Fishing

The abundance and diversity of marine fish species at Gray's Reef are critical components of the sanctuary's ecosystem. Based on current socioeconomic studies (Ehler and Leeworthy 2002, Bird et al. 2001) and sanctuary surveys (GRNMS unpublished data) of visitor use, recreational fishing activities have increased significantly at the sanctuary in the past 25 years. The trends in use are expected to continue as population increases along the Georgia coast, the popularity of recreational fishing grows and boating and fish-finding technology improves. In response to this, NOAA promulgated an "allowable gear" regulation for the Gray's Reef sanctuary that limits fishing to use of rod and reel, hand line, and spearfishing gear without powerheads. The intent of the regulation is to eliminate future use of a variety of allowed fishing gear that would have detrimental effects on habitats and marine resources (e.g., traps, bandit gear, pots and nets of various kinds).

NOAA proposed prohibiting all spearfishing in the Gray's Reef sanctuary in the draft management plan, but deferred that decision until additional information could be gathered. A socioeconomic assessment of georgia offshore spearfishing was conducted in fall 2007. Results from the study indicate that no dive charters made spearfishing trips to the sanctuary in recent years and none were planned in the future. A scuba club reported one spearfishing trip (one day, six divers) a year to the sanctuary. A small amount (no more than 1 percent of all fishing) of private boat-based spearfishing at the sanctuary can be assumed, but has not been documented. The combination of no charter spearfishing activity at the sanctuary and the abundant substitution opportunities lead to the conclusion that a prohibition on spearfishing at the sanctuary would result in no measurable economic impact (Ehler pers. comm.). The sanctuary is currently reassessing spearfishing in light of this new information.

Significant management and research questions still exist, however, that can only be addressed by establishing a control (research) area within the boundaries. The concept of a marine research area was evaluated by a working group of the Sanctuary Advisory Council and NOAA. The proposal was further explored through a public process in 2008 and the public comments are being considered by the Sanctuary Advisory Council for recommendations to NOAA. Among the research questions that may be addressed with establishment of a research area are the potential impacts of bottom fishing (recreational rod and reel) on the sanctuary's living marine resources. The research area may allow only restricted use, such as fishing for coastal pelagic species, which would allow science to be conducted in a marine environment free of most extractive activities.

Marine Debris

The accumulation of debris in the marine environment is an increasing problem worldwide. Marine debris is aesthetically displeasing, can be a nuisance to boaters and the shipping industry, and can negatively impact marine biota. The primary focus of Gray's Reef sanctuary activities to address this issue will be through outreach, education and monitoring. The sanctuary will continue outreach to the public and users on the impacts of marine debris. Outreach efforts will focus on developing and distributing printed materials and targeted radio messaging during peak boating activity in the spring and summer months. In addition, scientists with NOAA will continue quantifying and characterizing marine debris in Gray's Reef and addressing other gaps in information needed to allow the site to better manage these impacts. Focused removal of marine debris will continue using the efforts of volunteer and staff divers. Scientific divers are already noting, photographing and removing, whenever possible, debris found in the sanctuary.

Because there is increased concern about materials deposited outside Gray's Reef drifting into and damaging sanctuary resources, regulatory authority has been clarified in the final management plan, but no new regulations are anticipated at this time.

Research Activities

Numerous research activities take place in Gray's Reef National Marine Sanctuary and in some cases these activities may result in impacts to sanctuary resources. Regulations give the National Marine Sanctuary System the authority to allow certain activities that would otherwise be prohibited (but offer some other benefit to the sanctuary) through the issuance of permits. New Gray's Reef sanctuary regulations make the permitting process clearer in terms of the scope, purpose, manner, terms and conditions of permits issued. The sanctuary will continue the permitting program in order to monitor and address any impacts on sanctuary resources from research activities. Sanctuary staff will also continue to recommend locations outside the sanctuary for research projects that are incompatible with the site's mission of resource protection.

Invasive Species

Because of the potential impact on native species, Gray's Reef sanctuary staff will continue monitoring and looking for signs of invasive species (i.e., lionfishes) in the sanctuary or encroachment of species known to be outside the sanctuary. Due to the increased potential for invasive larval organisms to travel directly to the bottom on a buoy line, the sanctuary is also considering means to prevent encroachment by using chain instead of natural or synthetic mooring lines on the corner marker buoys. Sanctuary staff will also continue collaboration with Reef Environmental Education Foundation (REEF), which conducts annual fish surveys and helps to monitor for invasive species. The sanctuary will also consider removal of invasive species while they are still in low enough abundance to allow an effective response.

Coastal Development

As coastal development increases in coming years, the potential exists for continued and increasing levels of land-based pollutants to impact sanctuary resources. Gray's Reef sanctuary staff will continue to monitor for nutrient levels and contaminants associated with increased coastal and inland development. NOAA scientists will also continue monitoring the ecological condition of benthic fauna and the sediment quality in the sanctuary.

Concluding Remarks

An oyster toadfish heading for the cover of a rock outcropping

This report is the first attempt to describe the relationship between human pressures and the status and trends of natural resources within Gray's Reef National Marine Sanctuary. By doing so, this condition report helps to identify the pressures and their impacts that may warrant monitoring and remediation in the years to come.

Overall, the resources protected by Gray's Reef National Marine Sanctuary appear to be in fair condition. Of the 17 resources or questions identified, three appear to be in good condition, four appear to be in "good/fair" condition, three more appear to be in fair condition, one appears to be in "fair/poor" condition. Two of the resources or questions that were considered do not apply. None of the resources identified were listed in poor condition. The trends for four of the resources or questions were undetermined, although rapidly growing coastal populations are considered emerging threats to all of the resources of Gray's Reef over time. In recent years, research conducted at Gray's Reef has become focused less on simple characterization and more on oceanographic processes, biogeographic distribution, and sources and fates of individual organisms and their contributions to the ecosystem as a whole. The establishment of a research area within the sanctuary boundaries is a step that would immediately allow for studies of specific questions related to the impacts of particular fishing practices on benthic invertebrate and fish communities. For questions within this report that were not sufficiently answered due to uncertainty or a lack of sufficient information to judge status or trends, it is hoped that the research area will facilitate research and monitoring that better resolves them.

It is important to understand the factors that help to structure the resources of the sanctuary, and how uses of its resources may affect their health, viability and longevity. The information presented in this report enables managers to look back and consider past changes in the status of the resources, and provides guidance for continued resource management as future challenges are presented.

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Additional Resources

Georgia Department of Natural Resources Web site: http://www.gadnr.org/

Gray's Reef National Marine Sanctuary Web site: http://graysreef.noaa.gov/

Gray's Reef sanctuary Web site, General Information About Gray's Reef sanctuary: http://graysreef.noaa.gov/information.html

Gray's Reef sanctuary Web site, Geological History of Gray's Reef sanctuary: http://graysreef.noaa.gov/geology.html

Gray's Reef sanctuary Web site, Reflections on Milton B. "Sam" Gray: http://graysreef.noaa.gov/samgraybio.html

Gray's Reef sanctuary Web site, Research: http://graysreef.noaa.gov/research.html

Marine Protected Areas of the United States Web site: http://www.mpa.gov/

NOAA National Marine Sanctuary Program Web site: http://sanctuaries.noaa.gov/

NOAA Ocean Explore Web site, South Atlantic Bight: http://oceanexplorer.noaa.gov/explorations/islands01/background/bight/bight.html

NOAA Ocean Explorer Web site: http://www.oceanexplorer.noaa.gov/welcome.html

NOAA's Marine Debris Program Web site: http://marinedebris.noaa.gov/

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Sherpa Guides Web site, The Natural History of Georgia's Barrier Islands: http://sherpaguides.com/georgia/barrier_islands/natural_history/

Skidaway Institute of Oceanography Web site: http://www.skio.peachnet.edu/

South Atlantic Bight Synoptic Offshore Observational Network Web site: http://www.skio.peachnet.edu/research/sabsoon/

South Atlantic Fishery Management Council Web site: http://www.safmc.net/

Southeast Fisheries Science Center Web site: http://www.sefsc.noaa.gov/home.jsp

The Reef Environmental Education Foundation Web site: http://www.reef.org/

USGS Nonindigenous Aquatic Species Web site: http://nas.er.usgs.gov

Woods Hole Oceanographic Institution Web site: http://www.whoi.edu/

Appendix: Rating Scheme for System-Wide Monitoring Questions

The purpose of this appendix is to clarify the 17 questions and possible responses used to report the condition of sanctuary resources in "Condition Reports" for all national marine sanctuaries. Individual staff and partners utilized this guidance, as well as their own informed and detailed understanding of the site to make judgments about the status and trends of sanctuary resources.

The questions derive from the Office of National Marine Sanctuaries' mission, and a system-wide monitoring framework (National Marine Sanctuary Program 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on and study the ecosystems encompassed by the sanctuaries. They are being used to guide staff and partners at each of the 14 sites in the sanctuary system in the development of this first periodic sanctuary condition report. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sites and combined. Evaluations of status and trends may be based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

Following a brief discussion about each question, statements are presented that were used to judge the status and assign a corresponding color code. These statements are customized for each question. In addition, the following options are available for all questions: "N/A" — the question does not apply; and "Undet." — resource status is undetermined.

Symbols used to indicate trends are the same for all questions: "▲" — conditions appear to be improving; "▬" — conditions do not appear to be changing; "▼" — conditions appear to be declining; and "**?**" — trend is undetermined.

Water Stressors

1. Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?

This is meant to capture shifts in condition arising from certain changing physical processes and anthropogenic inputs. Factors resulting in regionally accelerated rates of change in water temperature, salinity, dissolved oxygen or water clarity could all be judged to reduce water quality. Localized changes in circulation or sedimentation resulting, for example, from coastal construction or dredge spoil disposal, can affect light penetration, salinity regimes, oxygen levels, productivity, waste transport and other factors that influence habitat and living resource quality. Human inputs, generally in the form of contaminants from point or non-point sources, including fertilizers, pesticides, hydrocarbons, heavy metals and sewage, are common causes of environmental degradation, often in combination rather than alone. Certain biotoxins, such as domoic acid, may be of particular interest to specific sanctuaries. When present in the water column, any of these contaminants can affect marine life by direct contact or ingestion, or through bioaccumulation via the food chain.

[Note: Over time, accumulation in sediments can sequester and concentrate contaminants. Their effects may manifest only when the sediments are resuspended during storm or other energetic events. In such cases, reports of status should be made under Question 7 – Habitat contaminants.]

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most if not all living resources and habitats.

Water
Eutrophic Condition

2. What is the eutrophic condition of sanctuary waters and how is it changing?

Nutrient enrichment often leads to planktonic and/or benthic algae blooms. Some affect benthic communities directly through space competition. Overgrowth and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage. Disease incidence and frequency can also be affected by algae competition and the resulting chemistry along competitive boundaries. Blooms can also affect water column conditions, including light penetration and plankton availability, which can alter pelagic food webs. Harmful algal blooms often affect resources, as biotoxins are released into the water and air, and oxygen can be depleted.

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most if not all living resources and habitats.

Water
Human Health

3. Do sanctuary waters pose risks to human health and how are they changing?

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or fish intended for consumption. They also emerge when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to harmful algal blooms increase dramatically. Any of these conditions should be considered in the course of judging the risk to humans posed by waters in a marine sanctuary.

Some sites may have access to specific information on beach and shellfish conditions. In particular, beaches may be closed when criteria for safe water body contact are exceeded, or shellfish harvesting may be prohibited when contaminant loads or infection rates exceed certain levels. These conditions can be evaluated in the context of the descriptions below.

Good	Conditions do not appear to have the potential to negatively affect human health.
Good/Fair	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.
Fair	Selected conditions have resulted in isolated human impacts, but evidence does not justify widespread or persistent concern.
Fair/Poor	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
Poor	Selected conditions warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts are likely or have occurred.

Water
Human Activities

4. What are the levels of human activities that may influence water quality and how are they changing?

Among the human activities in or near sanctuaries that affect water quality are those involving direct discharges (transiting vessels, visiting vessels, onshore and offshore industrial facilities, public wastewater facilities), those that contribute contaminants to stream, river, and water control discharges (agriculture, runoff from impermeable surfaces through storm drains, conversion of land use), and those releasing airborne chemicals that subsequently deposit via particulates at sea (vessels, land-based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can cause resuspension of contaminants in sediments.

Good	Few or no activities occur that are likely to negatively affect water quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.
Fair	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Habitat
Abundance & Distribution

5. What are the abundance and distribution of major habitat types and how are they changing?

Habitat loss is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes caused, either directly or indirectly, by human activities. The loss of shoreline is recognized as a problem indirectly caused by human activities. Habitats with submerged aquatic vegetation are often altered by changes in water conditions in estuaries, bays, and nearshore waters. Intertidal zones can be affected for long periods by spills or by chronic pollutant exposure. Beaches and haul-out areas can be littered with dangerous marine debris, as can the water column or benthic habitats. Sandy subtidal areas and hardbottoms are frequently disturbed or destroyed by trawling. Even rocky areas several hundred meters deep are increasingly affected by certain types of trawls, bottom longlines and fish traps. Groundings, anchors and divers damage submerged reefs. Cables and pipelines disturb corridors across numerous habitat types and can be destructive if they become mobile. Shellfish dredging removes, alters and fragments habitats.

The result of these activities is the gradual reduction of the extent and quality of marine habitats. Losses can often be quantified through visual surveys and to some extent using high-resolution mapping. This question asks about the quality of habitats compared to those that would be expected without human impacts. The status depends on comparison to a baseline that existed in the past - one toward which restoration efforts might aim.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.

Habitat Structure

6. What is the condition of biologically structured habitats and how is it changing?

Many organisms depend on the integrity of their habitats and that integrity is largely determined by the condition of particular living organisms. Coral reefs may be the best known examples of such biologically-structured habitats. Not only is the substrate itself biogenic, but the diverse assemblages residing within and on the reefs depend on and interact with each other in tightly linked food webs. They also depend on each other for the recycling of wastes, hygiene and the maintenance of water quality, among other requirements.

Kelp beds may not be biogenic habitats to the extent of coral reefs, but kelp provides essential habitat for assemblages that would not reside or function together without it. There are other communities of organisms that are also similarly co-dependent, such as hard-bottom communities, which may be structured by bivalves, octocorals, coralline algae or other groups that generate essential habitat for other species. Intertidal assemblages structured by mussels, barnacles and algae are another example, seagrass beds another. This question is intended to address these types of places where organisms form structures (habitats) on which other organisms depend.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resources, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of living resources and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.

Habitat Contaminants

7. What are the contaminant concentrations in sanctuary habitats and how are they changing?

This question addresses the need to understand the risk posed by contaminants within benthic formations, such as soft sediments, hard bottoms, or biogenic organisms. In the first two cases, the contaminants can become available when released via disturbance. They can also pass upwards through the food chain after being ingested by bottom dwelling prey species. The contaminants of concern generally include pesticides, hydrocarbons and heavy metals, but the specific concerns of individual sanctuaries may differ substantially.

Good	Contaminants do not appear to have the potential to negatively affect living resources or water quality.
Good/Fair	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.
Fair	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected contaminants have caused or are likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected contaminants have caused or are likely to cause severe declines in most if not all living resources or water quality.

Habitat
Human Activities

8. What are the levels of human activities that may influence habitat quality and how are they changing?

Human activities that degrade habitat quality do so by affecting structural (geological), biological, oceanographic, acoustic or chemical characteristics. Structural impacts include removal or mechanical alteration, including various fishing techniques (trawls, traps, dredges, longlines and even hook-and-line in some habitats), dredging channels and harbors and dumping spoil, vessel groundings, anchoring, laying pipelines and cables, installing offshore structures, discharging drill cuttings, dragging tow cables, and placing artificial reefs. Removal or alteration of critical biological components of habitats can occur along with several of the above activities, most notably trawling, groundings and cable drags. Marine debris, particularly in large quantities (e.g., lost gill nets and other types of fishing gear), can affect both biological and structural habitat components. Changes in water circulation often occur when channels are dredged, fill is added, coastal areas are reinforced, or other construction takes place. These activities affect habitat by changing food delivery, waste removal, water quality (e.g., salinity, clarity and sedimentation), recruitment patterns and a host of other factors. Acoustic impacts can occur to water column habitats and organisms from acute and chronic sources of anthropogenic noise (e.g., shipping, boating, construction). Chemical alterations most commonly occur following spills and can have both acute and chronic impacts.

- **Good** Few or no activities occur that are likely to negatively affect habitat quality.
- **Good/Fair** Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.
- **Fair** Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.
- **Fair/Poor** Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
- **Poor** Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Living Resources
Biodiversity

9. What is the status of biodiversity and how is it changing?

This is intended to elicit thought and assessment of the condition of living resources based on expected biodiversity levels and the interactions between species. Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition and predator-prey relationships. Community integrity, resistance and resilience all depend on these relationships. Abundance, relative abundance, trophic structure, richness, H' diversity, evenness and other measures are often used to assess these attributes.

- **Good** Biodiversity appears to reflect pristine or near-pristine conditions and promotes ecosystem integrity (full community development and function).
- **Good/Fair** Selected biodiversity loss has taken place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.
- **Fair** Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
- **Fair/Poor** Selected biodiversity loss has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.
- **Poor** Selected biodiversity loss has caused or is likely to cause severe declines in ecosystem integrity.

Living Resources Extracted Species

10. What is the status of environmentally sustainable fishing and how is it changing?

Commercial and recreational harvesting are highly selective activities, for which fishers and collectors target a limited number of species, and often remove high proportions of populations. In addition to removing significant amounts of biomass from the ecosystem, reducing its availability to other consumers, these activities tend to disrupt specific and often critical food web links. When too much extraction occurs (i.e. ecologically unsustainable harvesting), trophic cascades ensue, resulting in changes in the abundance of non-targeted species as well. It also reduces the ability of the targeted species to replenish populations at a rate that supports continued ecosystem integrity.

It is essential to understand whether removals are occurring at ecologically sustainable levels. Knowing extraction levels and determining the impacts of removal are both ways that help gain this understanding. Measures for target species of abundance, catch amounts or rates (e.g., catch per unit effort), trophic structure and changes in non-target species abundance are all generally used to assess these conditions.

Other issues related to this question include whether fishers are using gear that is compatible with the habitats being fished and whether that gear minimizes by-catch and incidental take of marine mammals. For example, bottom-tending gear often destroys or alters both benthic structure and non-targeted animal and plant communities. "Ghost fishing" occurs when lost traps continue to capture organisms. Lost or active nets, as well as lines used to mark and tend traps and other fishing gear, can entangle marine mammals. Any of these could be considered indications of environmentally unsustainable fishing techniques.

Good Extraction does not appear to affect ecosystem integrity (full community development and function).

Good/Fair Extraction takes place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.

Fair Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.

Fair/Poor Extraction has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.

Poor Extraction has caused or is likely to cause severe declines in ecosystem integrity.

Living Resources Non-Indigenous Species

11. What is the status of non-indigenous species and how is it changing?

Non-indigenous species are generally considered problematic and candidates for rapid response, if found soon after invasion. For those that become established, their impacts can sometimes be assessed by quantifying changes in the affected native species. This question allows sanctuaries to report on the threat posed by non-indigenous species. In some cases, the presence of a species alone constitutes a significant threat (certain invasive algae). In other cases, impacts have been measured and may or may not significantly affect ecosystem integrity.

Good Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).

Good/Fair Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.

Fair Non-indigenous species may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.

Fair/Poor Non-indigenous species have caused or are likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.

Poor Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.

Living Resources
Key Species

12. What is the status of key species and how is it changing?

Certain species can be defined as “key” within a marine sanctuary. Some might be keystone species, that is, species on which the persistence of a large number of other species in the ecosystem depends - the pillar of community stability. Their functional contribution to ecosystem function is disproportionate to their numerical abundance or biomass and their impact is therefore important at the community or ecosystem level. Their removal initiates changes in ecosystem structure and sometimes the disappearance of or dramatic increase in the abundance of dependent species. Keystone species may include certain habitat modifiers, predators, herbivores and those involved in critical symbiotic relationships (e.g. cleaning or co-habitating species).

Other key species may include those that are indicators of ecosystem condition or change (e.g., particularly sensitive species), those targeted for special protection efforts, or charismatic species that are identified with certain areas or ecosystems. These may or may not meet the definition of keystone, but do require assessments of status and trends.

Good	Key and keystone species appear to reflect pristine or near-pristine conditions and may promote ecosystem integrity (full community development and function).
Good/Fair	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
Fair	The reduced abundance of selected keystone species may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity; or selected key species are at reduced levels, but recovery is possible.
Fair/Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components, and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in ecosystem integrity; or selected key species are at severely reduced levels, and recovery is unlikely.

Living Resources
Health of Key Species

13. What is the condition or health of key species and how is it changing?

For those species considered essential to ecosystem integrity, measures of their condition can be important to determining the likelihood that they will persist and continue to provide vital ecosystem functions. Measures of condition may include growth rates, fecundity, recruitment, age-specific survival, tissue contaminant levels, pathologies (disease incidence tumors, deformities), the presence and abundance of critical symbionts, or parasite loads. Similar measures of condition may also be appropriate for other key species (indicator, protected or charismatic species). In contrast to the question about keystone species (#12 above), the impact of changes in the abundance or condition of key species is more likely to be observed at the population or individual level and less likely to result in ecosystem or community effects.

Good	The condition of key resources appears to reflect pristine or near-pristine conditions.
Good/Fair	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
Fair	The diminished condition of selected key resources may cause a measurable but not severe reduction in ecological function, but recovery is possible.
Fair/Poor	The comparatively poor condition of selected key resources makes prospects for recovery uncertain.
Poor	The poor condition of selected key resources makes recovery unlikely.

Living Resources
Human Activities

14. What are the levels of human activities that may influence living resource quality and how are they changing?

Human activities that degrade living resource quality do so by causing a loss or reduction of one or more species, by disrupting critical life stages, by impairing various physiological processes, or by promoting the introduction of non-indigenous species or pathogens. (Note: Activities that impact habitat and water quality may also affect living resources. These activities are dealt with in Questions 4 and 8, and many are repeated here as they also have direct effect on living resources).

Fishing and collecting are the primary means of removing resources. Bottom trawling, seine-fishing and the collection of ornamental species for the aquarium trade are all common examples, some being more selective than others. Chronic mortality can be caused by marine debris derived from commercial or recreational vessel traffic, lost fishing gear and excess visitation, resulting in the gradual loss of some species.

Critical life stages can be affected in various ways. Mortality to adult stages is often caused by trawling and other fishing techniques, cable drags, dumping spoil or drill cuttings, vessel groundings or persistent anchoring. Contamination of areas by acute or chronic spills, discharges by vessels, or municipal and industrial facilities can make them unsuitable for recruitment; the same activities can make nursery habitats unsuitable. Although coastal armoring and construction can increase the availability of surfaces suitable for the recruitment and growth of hard bottom species, the activity may disrupt recruitment patterns for other species (e.g., intertidal soft bottom animals) and habitat may be lost.

Spills, discharges, and contaminants released from sediments (e.g., by dredging and dumping) can all cause physiological impairment and tissue contamination. Such activities can affect all life stages by reducing fecundity, increasing larval, juvenile, and adult mortality, reducing disease resistance, and increasing susceptibility to predation. Bioaccumulation allows some contaminants to move upward through the food chain, disproportionately affecting certain species.

Activities that promote introductions include bilge discharges and ballast water exchange, commercial shipping and vessel transportation. Releases of aquarium fish can also lead to species introductions.

Good	Few or no activities occur that are likely to negatively affect living resource quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on living resource quality.
Fair	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Maritime Archaeological Resources Integrity

15. What is the integrity of known maritime archaeological resources and how is it changing?

The condition of archaeological resources in a marine sanctuary significantly affects their value for science and education, as well as the resource's eligibility for listing in the National Register of Historic Places. Assessments of archaeological sites include evaluation of the apparent levels of site integrity, which are based on levels of previous human disturbance and the level of natural deterioration. The historical, scientific and educational values of sites are also evaluated and are substantially determined and affected by site condition.

Good	Known archaeological resources appear to reflect little or no unexpected disturbance.
Good/Fair	Selected archaeological resources exhibit indications of disturbance, but there appears to have been little or no reduction in historical, scientific or educational value.
Fair	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.
Fair/Poor	The diminished condition of selected archaeological resources has substantially reduced their historical, scientific or educational value, and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known archaeological resources in general makes them ineffective in terms of historical, scientific or educational value, and precludes their listing in the National Register of Historic Places.

Maritime Archaeological Resources Threat to Environment

16. Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?

The sinking of a ship potentially introduces hazardous materials into the marine environment. This danger is true for historic shipwrecks as well. The issue is complicated by the fact that shipwrecks older than 50 years may be considered historical resources and must, by federal mandate, be protected. Many historic shipwrecks, particularly early to mid-20th century, still have the potential to retain oil and fuel in tanks and bunkers. As shipwrecks age and deteriorate, the potential for release of these materials into the environment increases.

Good	Known maritime archaeological resources pose few or no environmental threats.
Good/Fair	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.
Fair	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
Fair/Poor	Selected maritime archaeological resources pose substantial threats to certain sanctuary resources or areas, and prospects for recovery are uncertain.
Poor	Selected maritime archaeological resources pose serious threats to sanctuary resources, and recovery is unlikely.

Maritime Archaeological Resources
Human Activities

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?

Some human maritime activities threaten the physical integrity of submerged archaeological resources. Archaeological site integrity is compromised when elements are moved, removed or otherwise damaged. Threats come from looting by divers, inadvertent damage by scuba diving visitors, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities, among others.

Good	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.
Good/Fair	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.
Fair	Selected activities have resulted in measurable impacts to maritime archaeological resources, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Notes

Notes

Gray's Reef

National Marine Sanctuary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

NATIONAL MARINE SANCTUARIES