2008 GRAY'S REEF NATIONAL MARINE SANCTUARY
CONDITION REPORT
REVIEWERS AND AFFILIATIONS

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The document that follows is a copy of the DRAFT Gray's Reef National Marine Sanctuary Condition Report that was disseminated to three individuals who served as peer reviewers. In December 2004, the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) establishing peer review standards that would enhance the quality and credibility of the federal government's scientific information. Among other information, these standards apply to Influential Scientific Information (ISI), which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." The Condition Reports are considered Influential Scientific Information. For this reason, these reports are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines. Therefore, following the completion of every report they are reviewed by a minimum of three individuals who are considered to be experts in the field, were not involved in the development of the report, and are not Office of National Marine Sanctuaries employees. Following the External Peer Review the comments and recommendations of the reviewers were considered by sanctuary staff and incorporated, as appropriate, into a final draft document. In some cases sanctuary staff reevaluated the status and trend ratings and when appropriate, the accompanying text in the document was edited to reflect the new ratings.

The comments and suggested edits that were received from the reviewers are embedded in the below draft. The final Gray's Reef NMS Condition Report may be downloaded from: http://sanctuaries.noaa.gov/.

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Gray's Reef National Marine Sanctuary

Condition Report

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Comment [kb1]: The report encompasses wide variety of style and detail both among and within sections and subsections. Some sub-sections are delightfully informative and well written and some diffuse, vague, and even confusing. I understand that I was not asked to review the entire document and that it is in, perhaps very preliminary form, however, you must understand that I am a compulsive editor. I have made comments and suggestions and edits throughout. Please forgive me. I've included comments, suggestions, and editing directly in the document as well as in summarized form (below).

In terms of content, the report is commendably information-rich and serves its purpose well in addressing the System-Wide Monitoring Questions, though unevenness in detail and scope. If done regularly, each iteration of the report should conserve all of the facts and references enhancing its value.

Comment [kb2]: The report for the 16 square mile Gray's Reef Sanctuary is quite good. We have no substantive concerns with the report.

Cover photo credits left to right:

Suggested Citation:
National Marine Sanctuary Program. 2007. Gray's Reef National Marine Sanctuary Condition Report 2007. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. ** pp.

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Table of Contents

Abstract
Gray's Reef National Marine Sanctuary Condition Summary Table
About This Report
Introduction
Site History and Resources
- Overview
- Geology
- Designation
- Water and Climate
- Habitat
- Living Resources
- Maritime Archaeological Resources

Pressures on the Sanctuary
- Anchoring
- Diver Impacts
- Recreational Fishing
- Marine Debris
- Research Activities
- Invasive Species
- Coastal Development
- Climate Change

State of the Sanctuary Resources
- Water
- Habitat
- Living Resources
- Maritime Archaeological Resources

Response to Pressures
- Anchoring
- Diver Impacts
- Recreational Fishing
- Marine Debris
- Research Activities
- Invasive Species
- Coastal Development
- Climate Change

In Summary
Acknowledgements
Cited Resources
Additional Resources
Appendix A: Rating Scheme for System-Wide Monitoring Questions

Comment [kb3]: The abstract really wasn't an abbreviated summary because it was incomplete and not reflective of the entire document. The 'Concluding Remarks' section looked like an incomplete summary. The purpose and background material that is in the 'About this Report' section should be in the 'Introduction'. I suggest that the best way to deal with this patchwork of information is to simply begin the report with an Executive Summary (a not-so-abbreviated summary but tightly written like an abstract; executive summaries appear to be most common in the important federal reports that I read because they combine the key content from the entire report), followed by a comprehensive Introduction, the report sections, references, and appendices.

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Executive Summary

This report of the on the status, trends and pressures at Gray's Reef National Marine Sanctuary represents a first attempt to describe the site with regard to the current health and condition of the resources contained therein. Additionally, this "condition" report helps to determine what causal factors exist which may require monitoring and potential remediation in the years to come.

Overall, the resources protected by Gray's Reef National Marine Sanctuary appear to be in relatively good shape. Of the seventeen resources or questions identified, seven appear to be in good condition, four appear to be in good/fair condition while four more appear to be in fair condition; none of the resources identified were listed in fair/poor or poor condition and two of the questions related to maritime archaeological resources were found not to be applicable.

In recent years, research conducted in Gray's Reef has recently become focused less on simple characterization and more on oceanographic processes, biogeographic distribution, sources and fates of individual organisms and their contribution to the ecosystem as a whole. What factors help to structure the resources and how uses of the resources may affect their health, viability and longevity is important to understand. This data generated as a result of this report will enable us to not only look back at the status of the resources to date but will provide guidance for our continued resource management as we face future challenges imposed by such potential threats as windfarming, dredge disposal, climate change, migrational pattern shifts and, artificial reefs.

Abstract

Gray's Reef National Marine Sanctuary protects particularly dense and nearshore patches of productive "live bottom habitat" that are sparsely distributed from Cape Hatteras, North Carolina and Cape Canaveral, Florida of the inner- and mid-shelf of the South Atlantic Bight. Influenced by complex ocean currents, the area protected by Gray's Reef National Marine Sanctuary serves as a crossroads to both temperate (colder water) and sub-tropical species. Located 17.5 nautical miles (nm) offshore of Sapelo Island, Georgia, the sanctuary encompasses 17 square nm. While most commercial fishing activities such as trawling, fish trapping and long-lining are prohibited, Gray's Reef offers some of the best recreational fishing and diving to be found in the region. The sanctuary is just 40 miles south of Savannah, Georgia, the second busiest port on the eastern seaboard.

Despite ever increasing coastal populations and recreational use of the sanctuary, the waters of Gray's Reef are relatively pristine though some human-produced and persistent pollutants and contaminants have reached the sediments and water-filtering organisms of the sanctuary. The contaminants which are present persist at levels that are not thought to cause any permanent harm to the organisms which thrive and propagate in sanctuary waters. The habitat of Gray's Reef is relatively undisturbed by human activity with the exception of inadvertently and intentionally deposited marine debris. Regulations have recently been implemented prohibiting anchoring in sanctuary waters which can cause damage to the non-regenerative limestone outcropping reef structures. Recreational fishing and spearfishing by divers continue to impact the living marine resources of Gray's Reef, and, emerging threats to the sanctuary appear to come from non-indigenous (invasive) species and contamination of organisms by waterborne chemicals. Though there are archaeological resources to be found in Gray's Reef, it is thought that there are few impacts to these resources and the impacts do not appear to have had a negative effect on maritime archaeological resource integrity.

The newest management plan for Gray's Reef National Marine Sanctuary was released July 2006 and became effective on February 16, 2007. The new plan includes changes that will further protect sanctuary resources while continuing to allow public access and use. The plan uses an ecosystem-based approach to management stressing consideration of ecological interrelationships not only within the sanctuary, but within the larger context of the South Atlantic Bight and the Carolinian Eco-region. Because Gray's Reef and the National Marine Sanctuary Program embrace regional governance and Ecosystem Approaches to Management, the new management plan contains activities which address the need for increased levels of cooperation with other management and research agencies in the region. We call this program "Latitude 31^{30}" because it considers the entire interrelated coastal ocean system from watershed to oceanic influences along the geographical latitudes that include Gray's Reef.

Finally, specific management changes include an "allowable gear" regulation which allows for recreational fishing through the use of only rod and reel, handline and spearfishing gear without powerheads, and prohibits vessels from anchoring within the sanctuary's boundaries. In addition, stronger research, monitoring and education plans are being implemented as well as a proposal to formally investigate the benefits of a research area within the sanctuary based on a Sanctuary Advisory Council recommended special workshop.

Comment [kb4]: suggested adding this "Executive Summary" text. He also suggests changing the header of "Abstract" to "Introduction". Gilligan also suggested the text edits to the Abstract.

Comment [kb5]: I'm not convinced that this is an abstract.

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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 (EEZ) 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, over 180 species of fish, and other important marine organisms*

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Gray's Reef National Marine Sanctuary
Condition Summary Table

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, please see Appendix A.)

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.
- N/A Question not applicable.

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	?	Insufficient information to make a determination. (see page 21)		Monitoring for nutrient levels and contaminants associated with increased coastal and inland development.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	?	Stable nutrients, chlorophyll, lack of HAB	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?	—	2000 baseline, 2005 indicators below FDA 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 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?	?	Insufficient information to make a determination (see page 27)		Anchoring prohibition in the Gray's Reef Final Management Plan and an associated outreach campaign is expected to result in improvements to the hard substrate (non-regenerative limestone ledges) and attached living marine resources associated with the bottom features. Outreach, education and monitoring programs increase awareness of the impacts of marine debris. Monitoring the ecological condition of benthic fauna and the sediment quality in the sanctuary.
6	What is the condition of biologically-structured habitats and how is it changing?	?	Evidence of anchor, fishing, and diving damage		
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.	
LIVING RESOURCES					

Comment [kb8]: Based on personal observation of Gray's Reef, the overall condition of GRNMS appears to be in good order. Exposed reef areas appear to be well colonized by live bottom organisms and generally teaming with life. In order to protect and manage the sanctuary, GRNMS personnel continuously conduct scientific studies to further understand the environment at Gray's Reef. The site will constantly be exposed to stressors such as recreational fishing, scuba divers, anchoring, marine debris, invasive species, coastal development, and research activities. A continued educational program and physical presence offshore by GRNMS and Georgia DNR personnel can help reduce some of the problems associated with human activities. Some marine debris does exist at GRNMS, but is generally not widespread. Continued efforts by NOAA and recreational divers to recover any marine debris encountered while conducting dives will help to keep the debris at a minimum.

After reviewing this report, I felt that the summary and status/trends tables did not appropriately reflect the current conditions at Gray's Reef. There seemed to be too many undetermined (gray) ratings when the text had discussed specific studies that should have been sufficient to make a judgment. The following comments discuss areas of concern that I think should be reviewed before finalizing this report.

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9	What is the status of biodiversity and how is it changing?	?	Insufficient information to make a determination (see page 28)		NOAA promulgated an "allowable gear" regulation for Gray's Reef that limits fishing to use of rod and reel, handline, and spearfishing gear without powerheads. Regulations prohibit divers from taking by hand any marine organism. Education and outreach programs increase public awareness of the importance of good diving techniques. Research areas within the sanctuary have been proposed to answer other management and research questions, including the potential impacts of bottom fishing on the sanctuary's living marine resources. Monitoring for signs of invasive 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	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 and keystone fish species	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.	
13	What is the condition or health of key species and how is it changing?	?	Insufficient information to make a determination (see page …)		
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 documented underwater archeological sites		
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	N/A	No documented underwater archeological sites		
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 undocumented artifacts	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.	

Comment [kb9]: technically, gag are undergoing overfishing but are not overfished, as of the latest NFMS report to Congress. The latest stock assessment in 06 said the same, but it had problems and has not been accepted. It is thought that by the time is is accepted, gag will be overfished. Scamp are not overfished or undergoing overfishing.

Deleted: scamp,

Comment [kb10]: There was some concern expressed about the green indicating good condition of invasive species considering occurrence of two exotic lionfish in GRNMS and establishment of lionfish in the U.S. South Atlantic region. However, finding two fish in GRNMS does not constitute establishment in our opinion and certainly is not currently a problem justifying a lower rating.

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About This Report

This report provides a summary of resources in the National Oceanic and Atmospheric Administration's Gray's Reef National Marine Sanctuary, pressures on those resources, the current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, this 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 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. Evaluations of status and trends were made by sanctuary staff, based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users. In many cases, sanctuary staff consulted outside experts familiar with the resources and with knowledge of previous and current scientific investigations. 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 perceptions of local problems, but the final ratings were determined by sanctuary staff. Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. This information is intended to help set the stage for management plan reviews at each site and to help sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats. 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.

Comment [kb11]: This section should be incorporated into the Introduction and abbreviated in the Executive Summary

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Introduction

The National Marine Sanctuary Program 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. Nevertheless, 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 Program 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 Program'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.

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Site History and Resources

Overview

Gray's Reef National Marine Sanctuary is one of the largest nearshore live-bottom reefs in the southeastern United States, and is the only marine protected area in Federal waters (EEZ) in the South Atlantic Bight, an area of continental shelf stretching from Cape Hatteras, North Carolina to Cape Canaveral, Florida. Located 17.5 nautical miles offshore of Sapelo Island and 16.68 square nautical miles in size, the sanctuary contains both rocky ledges and sandy flats (Figure 1). 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.

Gray's Reef sanctuary is one of the most popular recreational fishing and sport diving 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 dive, the staff at 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. (State of the Sanctuary Report)

http://graysreef.noaa.gov/sos_05.pdf

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

Comment [kb12]: I could not find the sanctuary boundary coordinates at the website. I think they should be included in all publication and reports as well as prominently available at the website:

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Datum: NAD83
    Geographic Coordinate System
    (a) N 31.362732 degrees W
80.921200 degrees
    (b) N 31.421064 degrees W
80.921201 degrees
    (c) N 31.421064 degrees W
80.828145 degrees
    (d) N 31.362732 degrees W
80.828145 degrees
    (e) N 31.362732 degrees W
80.921200 degrees
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These DEC DEG coordinates are from from 15 CFR Part 922 (why 5?)

I also found at http://law.justia.com/us/cfr/title15/15-3.1.2.2.11.9.html :
§ 922.90 Boundary.
The Gray's Reef National Marine Sanctuary (Sanctuary) consists of 16.68 square nautical miles (NM) of high sea waters off the coast of Georgia. The Sanctuary boundary includes all waters within a rectangle starting at coordinate 31°21'45"N, 80°55'17"W, commencing to coordinate 31°25'15"N, 80°55'17"W, thence to coordinate 31°25'15"N, 80°49'42"W, thence to coordinate 31°21'45"N, 80°49'42"W, thence back to the point of origin.

A chart illustrating the coordinates would be helpful as well.

Finally, DOC/NOAA/NOS/Sanctuaries should submit all sanctuary coordinates to Google Earth since that is rapidly becoming the standard for public geo-referenced information (like the NPS currently does with land-based parks.

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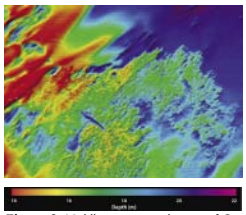

Figure 2. Multibeam sonar image of Gray's Reef bathymetry. This graphic represents the entirety of the Gray's Reef National Marine Sanctuary.

Geology

Gray's Reef sanctuary is a consolidation of marine and terrestrial sediments (sand, shell, and mud) that was laid down as loose aggregate between six and two 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. During this time, the area that is now Gray's Reef, was periodically exposed land and the shoreline was at times as much as 80 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 (Figure 3).

http://graysreef.noaa.gov/geology.html
http://sherpaguides.com/georgia/barrier_islands/natural_history/

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

Comment [kb15]: It would be nice to be able to reference an annotated bibliography of both white and gray literature research reports based upon work at the sanctuary. Currently, some research reports from the sanctuary are available online and some include references.

Comment [kb16]: are these nautical miles? Be consistent throughout.

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Designation

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

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."

http://graysreef.noaa.gov/samgraybio.html

In June 1978, the Coastal Resources Division of the Georgia Department of Natural Resources nominated Gray's Reef for consideration as a national marine sanctuary. Designation was approved and signed by President Jimmy Carter on January 16, 1981. (Gray's Reef National Marine Sanctuary Management Plan)

http://graysreef.noaa.gov/contents.html

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, North Carolina to Cape Canaveral, Florida. 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. 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 that 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 transport fish and invertebrate eggs and larvae from other areas, linking this special place to reefs north and south. (MP/EIS 2006, Monthly Climatology – http://www.unc.edu/~hseim/sablam/climatology/)

http://www.skio.peachnet.edu/research/sabsoon/
http://oceanexplorer.noaa.gov/explorations/islands01/background/bight/bight.html
http://www.unc.edu/~hseim/sablam/climatology/

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Comment [kb17]: Link to congressional record might be nice as well.

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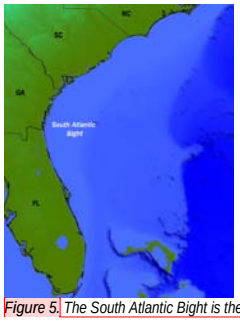

Figure 5. The South Atlantic Bight is the term used to describe the U.S. coastal ocean from North Carolina to the east coast of Florida.

Primary productivity at Gray's Reef sanctuary is likely supported by input of nutrients from freshwater land runoff, as well as deep, nutrient-rich water that is upwelled along the western edge of the Gulf Stream, and, surprisingly, nutrient-rich rainwater. 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. (MP/EIS 2006)

Habitat

Gray's Reef National Marine Sanctuary is underlain by a single rock unit made of 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 sparse live bottom. In addition, total percent cover and cover of macroalgae, sponges, and other organisms is significantly lower on short ledges in comparison to medium and tall ledges (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. (MP/EIS 2006)

http://graysreef.noaa.gov/information.html

Comment [kb21]: Need to get map that goes up to Hatteras, and label the two capes, to be consistent with text

Comment [kb22]: This is probably not very important. Upwelling occurs at the shelf edge off Daytona and off Onslow Bay, and I don't think the eddies carry that water to the inner shelf very often--should probably check with an oceanographer.

Comment [kb23]: Need correct citation

Comment [kb24]: Uniform type?

Comment [kb25]: Somewhere define what defines short, medium and tall ledges.

Comment [kb26]: Need correct citation

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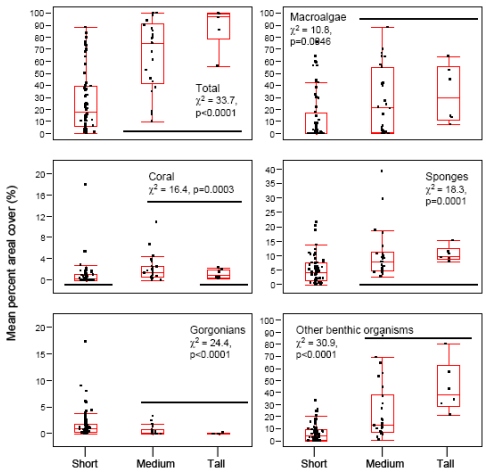

Figure 6. Box plots of percent cover of benthic organisms on three ledge groups determined by cluster analysis. Results of nonparametric ANOVAs (Kruskal-Wallis tests) and Dunn's multiple comparison tests to determine significant differences among mean ranks are provided (df = 2, alpha = 0.05). Solid horizontal lines join groups that are not significantly different from each other. Source: Kendall et al. 2007

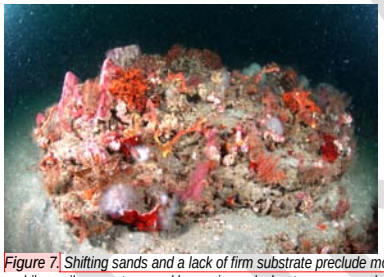

Figure 7. Shifting sands and a lack of firm substrate preclude most sessile forms from settling in sandy areas of the reef. Burrowing clams and crustaceans,, mobile snails, sea stars, and burrowing polycheate worms are better adapted to life in these loose sediments. (Photo: Greg McFall/Gray's Reef sanctuary)

Comment [kb27]: the photo is of reef, and the text desribes sand. Wouldn't a photo of sand be better?

Live-bottom habitats are structurally complex and provide a number of microhabitats. Although 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 sidescan sonar and multibeam mapping suggest that sand habitats (rippled sand and flat sand) dominate, accounting for 75% of the sanctuary. 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).

The vast areas of sand in the sanctuary are probably re-suspended and redistributed during times of high wave action which accompany winter and tropical storms. These shifting sands can uncover barely emergent limestone rock areas or conversely cover areas that were previously exposed. 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 (Figure 7).

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Comment [kb28]: Need a citation for this statement.

Living Resources

The live-bottom habitat of 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

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turtles, fishes, and other fauna. (Identification and Species Diversity of Sessile Invertebrate Fauna Indigenous to the Natural Rock Formations of Gray's Reef sanctuary – http://graysreef.noaa.gov/mcfall.html)

http://graysreef.noaa.gov/mcfall.html

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. (Photo : Greg McFall/Gray's Reef sanctuary)

Gray's Reef 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 National Marine Sanctuary. 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 by nature, seeking refuge within the structure of the reef during the day and emerging at night to feed. Some species of reef resident fish disperse to sandy habitats or to other reef areas north and south for feeding and spawning. Other reef residents, such as gag (grouper) and black sea bass, rely on the inshore areas and estuaries in early life stages.

Figure 9. Gray's Reef is an important area for loggerhead seea turtles to rest and forage throughout the year. (Photo: Flip Nicklin – National Geographic Society)

In addition to reef-associated fishes, Gray's Reef is habitat to 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. 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, toungefishes, cusk eels, stargazers, and lizardfish. (Gray's Reef Common Fish Identification Guide - http://graysreef.noaa.gov/fishes.html)

http://graysreef.noaa.gov/fishes.html

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 loggerhead sea turtle is the most abundant sea turtle in the South Atlantic Bight and is federally listed as a 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.

Comment [kb29]: Need correct citation

Comment [kb30]: Page 27 mentions 181 species with a citation. Numbers, citations and even graphs are used in the habitat section above. I'm a little confused about the level of detail, referencing, and consistency throughout the document.

Comment [kb31]: use AFS common names throughout

Comment [kb32]: This is awkward as it was worded. I don't think the productivity of the reef attracts pelagic forage fishes--they live and feed in the water column. They are attracted to things like reefs or boats or junk (thigmotaxis), which may not have anything to do with productivity, but which are probably a predator avoidance behavior.

Deleted: productivity of live-bottom reefs, which in turn provides necessary food for an

Comment [kb33]: Need a citation for this statement.

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Comment [kb34]: References or a link to reports resulting from studies done at the sanctuary would be helpful and would improve consistency among sections of this report

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Marine mammals on the southeast United States continental shelf include cetaceans (whales and dolphins), occasional pinnipeds (harbor seals and sea lions), and sirenians (West Indian manatee). Atlantic spotted dolphin (Figure 10) and Western North Atlantic coastal bottlenose dolphin, which have been designated as depleted under the Marine Mammal Protection Act, are the most often encountered marine mammals at Gray's Reef National Marine Sanctuary. 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 coastal Georgia and northern Florida, has been observed in the vicinity of the sanctuary during the winter.

Comment [kb36]: is this really the name of this animal?

Comment [kb37]: is this an official designation?

Figure 10. Atlantic spotted dolphins are relatively small and live in both coastal and offshore waters feeding primarily on fish and squid. (Photo: Greg McFall/Gray's Reef sanctuary)

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. Sea birds observed in the sanctuary area include gulls, petrels, shearwaters, gannets, phalaropes, jaegers, and terns. (MP/EIS 2006)

Comment [kb38]: Need correct citation

Maritime Archaeological Resources

To date, there are no documented downed aircraft or shipwrecks 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 at the sanctuary may indicate that the current reef area could have been inhabited by ancient Paleoamericans (ancient peoples of the Americas who were present at the end of the last Ice Age) when it was above sea level. (MP/EIS 2006)

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Figure 11. Ancient scallop bed at Gray's Reef with shells embedded in sediments that were deposited thirty thousand yeas ago. (Photo: Greg McFall/Gray's Reef sanctuary)

Pressures on the Sanctuary

Comment [kb40]: Change 'Pressures on the Sanctuary' section to 'Human Activities Affecting the Sanctuary'. Within each of the subsections it would have been very helpful to have an explanation of how the human activity impacts have been measured in the past (if it has and to what degree), how it currently being measured (if it is and to what degree), and how it will be measured in the future (if it will and to what degree). As written, it is hard to get a clear picture of the human influences and trends. The responses to the State of Sanctuary questions in the following section would be similarly bolstered by such knowledge.

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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 influences upon 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.

Figure 12. Anchors were 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. (Photo: Greg McFall/Gray's Reef sanctuary)

Anchoring may also have a negative effect on biodiversity as changes to the live-bottom composition can adversely affect either the habitat or the marine organisms of the reef. Bottom-dwelling invertebrates that inhabit 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 to this "foundation" of the reef can be passed along the food chain to adversely affect the overall integrity of the reef ecosystem. (Strategy MRP-1: Prevent Damage to Benthic Habitats from Anchoring - MP/EIS 2006)

Diver Impacts

Weather, sea conditions, and diver proficiency tend to limit the number of people who dive at 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.

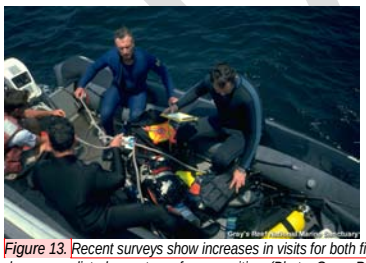

Figure 13. Recent surveys show increases in visits for both fishing and diving in the sanctuary since its designation in 1981. Diving can result in inadvertent damage or disturbance to reef communities. (Photo: Grays Reef sanctuary)

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

Comment [kb41]: 1.It would seem that visitation/use estimates and enforcement data would be of value in making conclusions about human activities and sanctuary condition. Changes in direct human use should be monitored and reported in terms of visitation/ uses and enforcement in the condition report. It reminds me of how the difference between a conservationist and a rabid environmentalist has been described: a conservationist wants laws to protect natural resources. A rabid environmentalist wants them enforced. Enforcement effort should be reported regardless of availability (e.g. Coast Guard) or current needs assessments (low use estimates).

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Comment [kb42]: Within each of these categories it would have been very helpful to have an explanation of how the human activity impacts have been measured in the past (if it has and to what degree), how it is currently being measured (if it is and to what degree), and how it will be measured in the future (if it will and to what degree). As written, it is hard to get a clear picture of the human influences and trends. The responses to the State of Sanctuary questions in the next section would be similarly bolstered by such knowledge.

Comment [kb43]: Advise not using the terms positive or negative because they can be misleading unless they refer to an actual scale. For example anchoring could be increasing (a positive trend) but with adverse or detrimental results, not beneficial. Recommend changing first line to read: **"Anchoring may also adversely effect biodiversity by changing live-bottom composition through damage to either …."**.
Also replace "negative in line 4, paragraph 1, with adverse.

Comment [kb44]: Need correct citation

Comment [kb45]: Shorten text by replacing "result in inadvertent damage or disturbance to reef …" with '…inadvertently damage or disturb reef …'.

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. (Overview of the Conservation of Australian Marine Invertebrates – http://www.amonline.net.au/invertebrates/marine_overview/chapt6dz.html, MP/EIS)

http://www.amonline.net.au/invertebrates/marine_overview/chapt6dz.html

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 (Figure 14). 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 since 1981.The trends in use are expected to continue as population increases along the Georgia coast (Figure 15) and the popularity of recreational fishing and diving grows. Increase in use, coupled with declines in fish populations and degradation of coastal habitats could result in negative impacts on fish populations and sanctuary habitat (Ehler and Leeworthy 2002). (MP/EIS 2006)

http://graysreef.noaa.gov/newdraftplan/socioeconomic.pdf

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 and because ledges are structurally complex and are often densely colonized by biota.

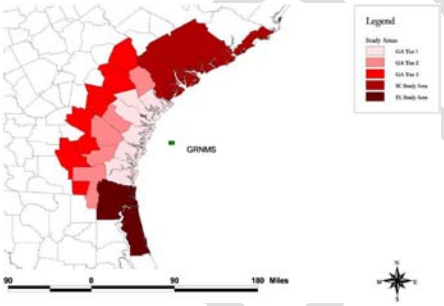

Figure 14. Gray's Reef National Marine Sanctuary Socioeconomic Study Area. The map indicates the counties in which the socioeconomic survey was conducted. NOAA Office of National Marine Sanctuaries

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Comment [kb48]: Replace "negative" with detrimental or adverse.

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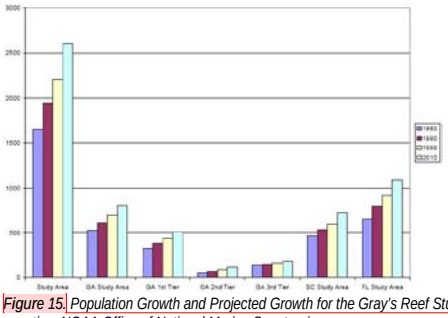

Figure 15. Population Growth and Projected Growth for the Gray's Reef Study Area. The graph shows the projected increase in population growth in coastal counties. NOAA Office of National Marine Sanctuaries

Comment [kb50]: We need our graphic designer to make this more legible. Make sure you find the original high res version of this image.

Marine Debris

Marine debris may be any object of wood, metal, glass, rubber, plastic, cloth, paper, or other artificial item that has been lost or discarded in the marine environment (Figure 16). 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, ingestion of plastics, impairment to navigation by obstructing propellers and clogging cooling intakes, and to the aesthetic qualities of the sanctuary. The abundance and spatial distribution of marine debris is dependent upon several factors, including its origin/source (e.g., terrestrial vs. maritime), ocean currents, wind patterns, and physiographic characteristics. 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, or of particular concern because they, break down slower in the ocean than items on land due to lower temperatures and fouling by marine organisms.

Comment [kb51]: Delete "artificial" since it is not necessary and "non-artificial" items can be debris.

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Figure 16. Marine debris is a direct result of human activities on land and at sea. Photo: Greg McFall/Gray's Reef sanctuary

Use of Gray's Reef sanctuary and surrounding areas has increased since the designation of the sanctuary in 1981. There has been a substantial increase in human population within the coastal region of Georgia in recent years. As coastal populations rise and boating, fishing, and offshore shipping increases 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). (MP/EIS 2006)

Comment [kb52]: Need correct citation

http://graysreef.noaa.gov/newdraftplan/socioeconomic.pdf
http://marinedebris.noaa.gov/

A recent study by Kendall et al. (2007) showed that approximately two-thirds of all observed debris items found during field surveys were 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 Gray's Reef sanctuary is related to the bottom type (Figure 18), the level of boating and fishing activity (Figure 19), 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 20). On ledges, the presence

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and abundance of debris is significantly related to observed boat density and physiographic features including ledge height, ledge area, and percent cover. 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).

Figure 17. *Example of fouled fishing line (out of water). Source: Kendall et al. 2007*

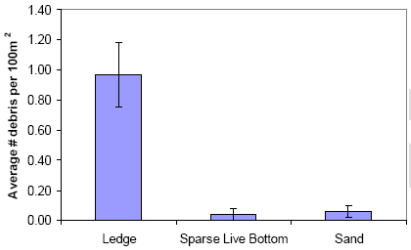

Figure 18. *Average number of debris items at surveyed locations in the sanctuary (+/-SE_ per 100 m² transect by bottom type. Source: Kendall et al. 2007*

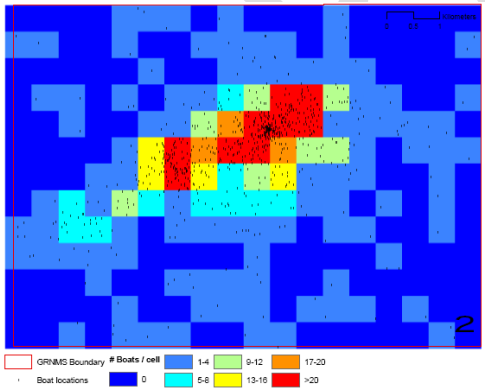

Figure 19. *Locations of observed boats and density of boats per 0.25 km² cell. Source: Kendall et al. 2007*

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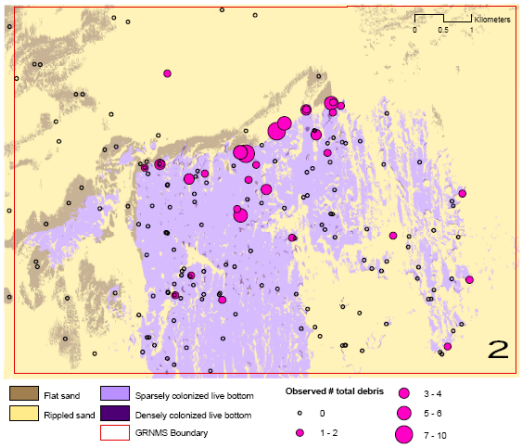

Figure 20. *Spatial distribution of total debris (number per 100 m². Source: Kendall et al. 2007*

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 provide 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. There are numerous examples of established species at other national marine sanctuaries around the country and in waters near the Gray's Reef sanctuary. The red lionfish (*Pterois volitans*) has become well established along the eastern coast and in September 2007, were first documented inside Gray's Reef sanctuary boundaries. Titan acorn barnacles (*Megabalanus coccopoma*) have recently been found as close as Chatam County, Georgia. Potential 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 also 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).

Deleted: Exotic invasive species can cause significant impacts and alter natural systems.

Comment [kb53]: This sentence is confusing and not informative.

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Comment [kb54]: Since these sub-sections occur within the human effects section, it would be helpful to mention that the introduction of both of these species were probably the result of human activity (aquarium trade releases/escapes – red lionfish, and ship ballast water release – giant barnacle).

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Climate Change

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems. Climate change can have significant effects on sea level and currents. This could result in more intense 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, island re-sizing, and have ground water implications. (Mass. Office of Coastal Zone Management: Oceanography, Weather Patterns and Climate Change: http://www.mass.gov/czm/oceanmanagement/waves_of_change/pdf/troceancc.pdf)

http://www.mass.gov/czm/oceanmanagement/waves_of_change/pdf/troceancc.pdf

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 derive from the National Marine Sanctuary Program 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. Appendix A (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 "?" – trend is undetermined.

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 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, thus 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. (MP/EIS 2006, Harris et al. 2004)

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

It is unclear at this point if changing oceanographic and atmospheric conditions are affecting water quality at Gray's Reef. However, the correlation between recent sponge mortality and warm water temperatures suggests there may be some affects from changing conditions. Water quality at Gray's Reef was assessed during the spring of 2000 and 2005. 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 Grays Reef. Measurements include temperature, salinity, dissolved oxygen (DO), 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. Specific chemical contaminants have not been

Comment [kb55]: Need correct citation

Comment [kb56]: The ratings of Good-Good/Fair with "no change" or "undetermined" may be reflective of the current status of the hydro-habitat at GRNMS. One observation, by this reviewer, is that the water masses that move across GRNMS and the inner-to-mid-shelf are quite complex. While not directly on the axis of the Gulf Stream, the site is not far west of this important current system. Much is made of GRNMS as a "convergence" locale for south-flowing currents and those that are more tropical.

Circulation models do not contradict this general picture but the inner shelf-to-near shore fresh water flux is a significant actor influencing the reef area. "Stressors" that impact water quality at GRNMS will arise from this inshore area more so than from Gulf Stream-related influences.

The response listed in this Condition Report is reasonable. It focuses on nutrient levels and contaminants that are rightly presumed to be of anthropogenic in origin. What the baseline data cited in this report does not reflect is the relationship of contaminants/nutrients to circulation across the site over an annual cycle. Clearly these parameters change according to the seasonal changes in circulation. These patterns—both contaminant/nutrient ***and*** circulation must be taken together and treated as such.

Comment [kb57]: Need correct citation

Comment [kb58]: As a water quality parameter, salinity should be mentioned as potential stressor for coastal species that currently inhabit Gray's Reef. Natural drought and human freshwater extraction from watersheds that feed the coastal zone have had dramatic effects on coastal ecosystems recently (e.g. salt marsh dieback, parasite-caused blue crab die offs). Because Gray's Reef is located within the influence of a massive estuarine/riverine system, it has typically had salinities less than open ocean and species typical of coastal and estuarine habitats have occurred here. If increasing salinity of the coastal waters persists, we might expect fewer coastal species and more oceanic species to become resident. I think this should be mentioned somewhere (here, questions 9-11, 14, or elsewhere).

Comment [kb59]: At this point, the anthropogenic stresses that may affect GRNMS are most likely low. Some contaminants have been identified in fish and benthic organisms, but to date, all have been below FDA guidelines. However, this does not mean that potential problems do not exist. As coastal development and population continues to increase, offshore water quality will be challenged. This is an area that GRNMS needs to be watching continuously to determine if conditions are stable or degrading. However, it seems the current information should relate to a "good" overall condition for stress impact.

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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 Gray's Reef sanctuary (Frischer unpublished data). DO 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 DO 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 (Hyland unpublished data, Frischer unpublished data). In summary, all nutrient, chlorophyll a, and total bacterial abundance indicate that water quality at Gray's Reef is high. However, there is insufficient information to determine if changing oceanographic and atmospheric conditions are affecting water quality. In the future, these baseline data will help determine whether stressors such as population increases in the coastal zone will affect water quality in Gray's Reef.

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

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 2005). This finding is based on low and stable nutrient concentrations, seasonal estimates of chlorophyll-a concentrations, the absence of HAB events, with the exception of a subsurface bloom of *Phaeocystis globosa* in 1999 associated with stratified water (Long et al. in prep), and high and stable DO concentrations in surface and near bottom waters.

3. Do sanctuary waters pose risks to human health?

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 8 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 suggest that chemical contaminants in tissues of target benthic species within the sanctuary are below FDA human-health guidelines (where available) based on a limited sample population (10 fillets of black sea bass and 9 arc shell composites). Moderate concentrations of lead, however, just below the FDA 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 are picking up these contaminants, albeit at low concentrations, provides evidence that such materials are making their way to the offshore sanctuary environment, either by air or underwater cross-shelf transport from land. Results of a follow-up monitoring survey conducted in 2005 (Hyland unpublished data) show a similar persistent trend of low yet detectable levels of chemical contaminants in tissues of these same species. Moreover, migratory species of fish like king mackerel that are currently under contaminant warnings (e.g., for mercury) are actively fished within sanctuary waters.

Comment [kb60]: highly migratory fish are oceanic things like tunas and billfishes; king mackerl are in the coastal migratory management unit

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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 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 2005) is replicated in the sanctuary. However, the continued development of the coastal zone is inevitable and therefore continued monitoring of Gray's Reef National Marine 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:

- There is not enough information at this time to determine if changing oceanographic and atmospheric conditions are affecting water quality in the sanctuary.
- There is no evidence of eutrophication or changing status of eutrophication in the sanctuary.

- The risks to human health at the sanctuary are considered to be low and unchanging. However, the detection of bioaccumulating chemical contaminants and some regional fish consumption warnings are indicative of potential human health risks that should be monitored to ensure that future problems do not occur.
- The levels of human activities that may influence water quality, although numerous and increasing in the southeastern coastal zone, are not currently adversely affecting water quality conditions, and appear to be stable.

Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Declining
? = Undetermined trend N/A = Question not applicable

	Status	Rating	Basis for Judgment
1	Stressors	—	Insufficient information to make a determination
2	Eutrophic Condition	?	Stable nutrients, chlorophyll, lack of HAB
3	Human Health	—	2000 baseline, 2005 indicators below FDA Levels of Concern
4	Human Activities	—	Increasing, but little evidence of effects

Habitat

Gray's Reef is a submerged hard bottom (limestone) area that, as compared to surrounding areas, contains extensive but discontinuous rock outcropping of moderate (6 to 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 for the abundant sessile invertebrates to attach and grow. This rocky platform with its carpet of attached organisms is known locally 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 coral, sea stars, crabs, lobsters, snails, and shrimp. The reef attracts numerous species of benthic and pelagic fish, including black sea bass, snapper, grouper, and mackerel.

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

There is presently an inadequate dataset from 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. The first comprehensive habitat classification of Gray's Reef was completed in 2001 using multibeam and sidescan 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 21). Previous sidescan surveys of the sanctuary in the 1980s were used to characterize bottom type. Direct comparisons are not straightforward with the new, multiple datasets because of differences in available data types and survey 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 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).

Comment [kb61]: The ratings for items #5-#8 are reasonable. The conclusion that "habitats are in pristine or near-pristine condition" (#5) may be supportable. The sand fields at GRNMS are quite dynamic while the hard bottom rock ledges are reasonably stable in a geological sense. Benthic organisms—burrowing and otherwise—have large areas to colonize and inhabit. One can take issue with the assessment of item #7. If the only data are those for 2000 and 2005, then some doubt can be expressed for an assessment of "no change." Item #8 may be underestimated but it is difficult to correlate use and location without a real census of vessel locations in the sanctuary. This should be done during monitoring visits to the site when vessel concentrations are observed. Sanctuary personnel can document the vessel density ***and*** obtain exact GPS coordinates by simply coming alongside these vessels.

Comment [kb62]: GRNMS completed an extensive habitat survey of the site which has provided detailed information of the seafloor (Kendall et al, 2005). Because of this study, GRNMS has GIS based maps showing the abundance and distribution of habitats within the site boundaries. It seems that this information should relate to a "good" rating on the status and trends table. Natural forces offshore are constantly shifting sands causing erosion and deposition so it may be difficult to determine a trend as such for this category.

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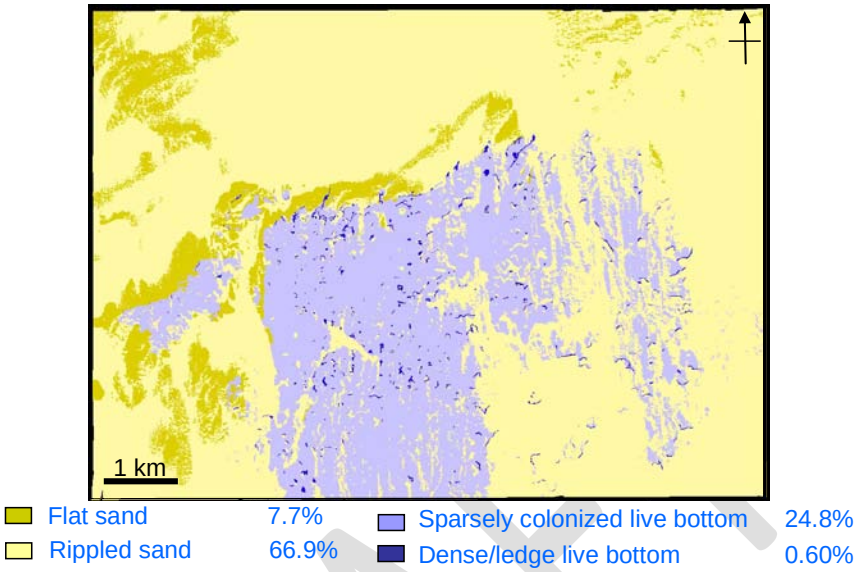

Figure 21. Gray's Reef National Marine Sanctuary Benthic Habitat Map. Source: (Kendall et al. 2005)

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

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). Insufficient information currently exists to determine the condition of biologically structured habitats, however 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 improper scuba diving techniques and anchoring. Recreational fishing may also impact biologically-structured habitats through marine debris, especially through entanglement in monofilament line (Kendall et al. 2007). 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 indicate that changes in biologically-structured habitats may also occur due to storm impacts (i.e., movement of sediment) or on seasonal cycles (Gleason in prep). The inability to decipher changes resulting from human impacts versus natural processes makes the trend undetermined. Additionally, at present we only have baseline data on the condition of biologically-structured habitats in the sanctuary therefore continued monitoring at a range of spatial and temporal scales is required to assess condition and establish the trend.

Comment [kb63]: The bottom structure was also well defined in Kendall's Gray's Reef study. Due to the relatively shallow depths at GRNMS, storm damage is the most likely cause of disturbance on the seafloor. Also, due to the distance offshore, GRNMS is not that heavily utilized by divers (as compared to the Keys). Disturbances by divers are most likely occurring, but compared to what a large storm can produce, would be small in comparison. The status and trends for structure should be "good" since GRNMS has a
good concept of bottom structure and for the most part, it is in good condition. Any trends would be difficult to determine and would certainly be dependent on weather patterns for any given year.

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

Results of a baseline characterization of benthic communities and sediment quality conducted in 2000 (Hyland et al. 2006, Cooksey et al. 2004) suggest that chemical contaminants in sediments (including pesticides, PCBs, PAHs, and metals) are generally at low background concentrations, below probable bioeffect threshold levels. The 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 underwater cross-shelf transport from land (Figure 22). Total organic carbon (TOC) in sediments is also at low levels, <2 % throughout the sanctuary and <1% at most stations (Hyland et al. 2006), typical of shelf waters in this region (Tenore et al. 1978) and well below a reported range (> 3.6%) 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 (Hyland unpublished data) show a similar persistent trend of low background levels of such sediment-associated stressors. Nonetheless, the presence of chemical contaminants in

Comment [kb64]: Contaminants are making their way out to GRNMS, but at this time have not reached bioeffect levels. According to the report, numerous studies have produced data so that a generalized determination for the status and trends part of this report could be selected. GRNMS should continue to investigate and monitor potential water, sediment and biological contamination as part of their site management duties.

sediments at low yet detectable levels in both surveys suggests that such pollutants are reaching the sanctuary and thus should continue to be monitored to ensure that future problems do not develop. (Harris et al. 2004, MP/EIS 2006)

Comment [kb65]: Need correct citation

http://www.nbi.noaa.gov/products/others/GRNATIONAL MARINE SANCTUARY_Benthic_FY02Rpt.pdf

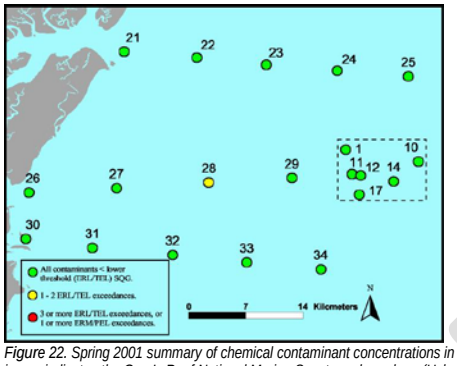

Figure 22. Spring 2001 summary of chemical contaminant concentrations in sediments relative to sediment quality guidelines. The outlined box to the right of the image indicates the Gray's Reef National Marine Sanctuary boundary. (Hyland et al. 2006)

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

Comment [kb66]: Marine debris is the most visible human impact to the site and is primarily composed of aluminum cans, bottles and fishing gear, but does not adversely impact the site. Continued efforts by divers to retrieve any debris encountered would certainly be of help. Anchoring probably produces the greatest impact to the site, and now has been officially banned under the new sanctuary management plan.

Fishing, anchoring, marine debris, divers, and research activities are suspected or known causes of damage to habitats within Gray's Reef National Marine Sanctuary. 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. Approximately 90% of debris encountered at 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 drift fishing or trolling). Data are not currently available, however, 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 is relatively intact, however insufficient information exists to adequately determine status and trends; densely colonized live bottom, although only 0.6% of the sanctuary, is disproportionate in its importance as habitat and is the focus of most of the pressures of concern; baseline data now exist against which to potentially measure habitat variability, change and trends.
- Observations indicate that biologically-structured habitats within sanctuary boundaries appear to be moderately affected by human activities; damage to biologically-structured habitats is disproportionate on a spatial scale and is probably concentrated in areas of highest fishing and scuba diving activity; additional data is needed to more clearly delineate the effects of human activities and natural processes on biologically-structured habitats.
- Chemical contaminants in sediments are present at persistently low yet detectable levels throughout the sanctuary and should be monitored to ensure that future problems do not develop.
- Selected activities, including recreational fishing and diving, and anchoring, have resulted in measurable habitat impacts within areas of high use (particularly in biologically structured habitats), but evidence suggests effects are localized, not widespread.

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Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving ▬ = Not changing ▼ = Declining
? = Undetermined trend N/A = Question not applicable

	Status	Rating	Basis for Judgment
5	Abundance/Distribution	?	Insufficient information to make a determination
6	Structure	?	Insufficient information to make a determination
7	Contaminants	▬	Low levels in 2000 and 2005
8	Human Impacts	?	Localized within areas of heavy use

Living Resources

Fishes

The highest fish species richness, diversity, abundance, and biomass of fishes at Gray's Reef 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 mackerel are attracted to 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). 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.

Deleted: Fish communities at Gray's Reef sanctuary are closely linked to benthic habitats.

Deleted: In comparison, ledge sites have significantly higher species richness, abundance, and biomass.

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Currently, recreational fishing pressure for reef-associated fishes is thought to be less intense than it is for pelagic species, although studies conducted at GRNMS 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 temperatures 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 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. (Gray's Reef National Marine Sanctuary Overflight Summary Report: Visitor Use at Gray's Reef National Marine Sanctuary - http://www.graysreef.nos.noaa.gov/flight.html)

Comment [kb67]: Need correct citation

http://www.graysreef.nos.noaa.gov/flight.html

In 1993, NOAA's National Marine Fisheries Service's Marine Resources Monitoring Assessment and Prediction (MARMAP) program established sampling stations at Gray's Reef sanctuary to monitor reef fish populations. During the trapping periods (July 1993-95 and July 1998-2001), catches were dominated by black sea bass (50 percent) (Figure 23), followed by scup (34 percent) and tomtate (12 percent). Other species caught included pinfish, blue runner, gray triggerfish, northern puffer, and leopard toadfish.

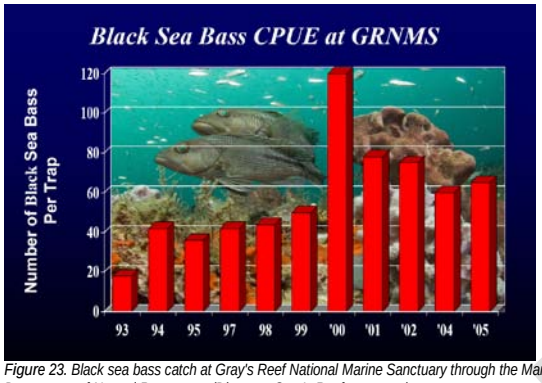

Figure 23. Black sea bass catch at Gray's Reef National Marine Sanctuary through the Marine Monitoring, Assessment and Prediction Program – South Carolina Department of Natural Resources (Diagram: Gray's Reef sanctuary)

In Gray's Reef sanctuary, the number of black sea bass caught per trap has increased since 1993 with a significant increase occurring in 2000. Estimated abundance of black sea bass at Gray's Reef 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, is resident on reefs and other structures as adults. Black sea bass are estuarine-dependent as juveniles, and relatively little is known about their spawning behaviors on or near the sanctuary. Tagging data indicated that after three months 93 percent of the fish were recaptured in 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, A Summary of Monitoring and Tagging Work by the Marine Resources Monitoring and Assessment Program at Gray's Reef sanctuary During 2002 - http://ocean.floridamarine.org/efh_coral/pdfs/GraysMarmap.pdf).

http://www.nbi.noaa.gov/products/others/GRNATIONAL_MARINE_SANCTUARY_Benthic_FY02Rpt.pdf
http://ocean.floridamarine.org/efh_coral/pdfs/GraysMarmap.pdf

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

There is not an adequate historical dataset from which to compare the current status of biodiversity in Gray's Reef, and to determine trends. However researchers have determined that benthic infaunal invertebrate diversity at Gray's Reef sanctuary is very high, and is higher than comparable depths off mid-Atlantic and northeastern states. However 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/or recreational fishing) to a follow-up in 2005 (Cooksey et al. 2004; Hyland et al. 2006). Samples collected with a Young grab had a mean diversity of 45 (± 11) species per grab (0.04 m^2) in 2000 and 47 (± 12) in 2005. 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 important in the food chain.

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

Diversity at Gray's Reef National Marine Sanctuary is very high compared to shelf sites at similar depths south of Cape Hatteras, but there are no baseline data to determine if diversity has changed in response to fishing pressure exerted since the 1970s.

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

According to NMFS (2006), red snapper, gag, red grouper and black sea bass are overfished and these species and gag are undergoing overfishing throughout the region. Gray triggerfish, sheepshead and greater amberjack are not currently overfished in the region.

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Comment [kb68]: Need correct citation

Comment [kb69]: Items #9 and #11 have missed one key addition to the faunal diversity at GRNMS—the recently observed Red Lionfish (*Pterois volitans*). While its discovery is serendipitous and its presence is clearly anthropogenic in origin, the "invasive" nature of this species points to a more obvious change at GRNMS—habitat change such that a tropical invader can readily survive in this environment. A caveat should be entered here; the Lionfish's range may have a significantly broader temperature tolerance (62-82° F; 17-28° C) than originally suspected for the species.

Comment [kb70]: The report states that fish diversity is high, yet the color scale states that not enough data is present to determine diversity. The Sam Gray collection currently housed at The University of Georgia has thousands of specimens from GRNMS. REEF has also conducted fish census surveys for about 8 years. Both of these data sets should give an idea of diversity and indicate some trend about population. The report also states that the benthic diversity at GRNMS is higher than comparable depths off mid-Atlantic and northeastern states. It seems that given this information, the biodiversity status for GRNMS should be in good condition (green). The REEF census and NOAA diver observations on the benthic community should be utilized to determine a basic trend.

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Comment [kb71]: This seems to be more of a regional problem than a reflection of GRNMS conditions.

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Monitoring of the abundance and size of black sea bass (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 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 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 on black sea bass at 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 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.

Comment [kb72]: It would be informative for the reader to note the year that the SAFMC implemented minimum size increases.

Gag and scamp have decreased in abundance in visual census transects, and length-frequency measurements of black sea bass, 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.

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

The red lionfish (*Pterois volitans*), formerly a resident of the western Pacific and eastern Indian oceans only, has become well established in the western Atlantic along the eastern coast of the U.S. (Whitfield et al, 2002) and was recently documented at sites in close proximity to the Gray's Reef sanctuary boundaries. In the fall of 2007 NOAA's National Centers for Coastal Ocean Science reported the first sighting of two lionfish in the sanctuary (Figure 24). The range and abundance of this species is continuing to increase (Whitfield 2006). Titan acron barnacles (*Megabalanus coccopoma*), native to the western Pacific have been recently found as close as Charleston Harbor (Sedberry, pers. comm.), and are reported from Chatam County, Georgia (http://nas.er.usgs.gov/).

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Comment [kb73]: Need correction citation

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

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

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

Comment [kb74]: Likewise, items #12 and #13 seem to focus on sessile epifauna—sponges—as keystone species to the detriment of fish/mammalian taxa. NOAA is to be commended for the annual census of fish taxa. If there is one category where good, teleological data exists ant GRNMS, it is in this area of assessment. These data should be evaluated for trends that bear of both species diversity and species richness at GRNMS. Such studies should allow a more confident assessment of items #9-#13.

Comment [kb75]: This seems to be more of a regional problem than a reflection of GRNMS conditions.

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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 and Harvey http://www.bio.georgiasouthern.edu/gr-inverts/index.html). 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 (Gleason in prep).

Key species of fishes in the sanctuary include gag and scamp, king mackerel, black sea bass and red snapper. 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 only occurring on 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% of the ledges surveyed and appeared evenly distributed throughout 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.

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

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

Sponges, identified as key species at Gray's Reef, 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 Gray's Reef (Hyland 2006) but the amounts present in the sponge tissue 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). The combinations of local and high levels of recruitment reflect a reproductively healthy *O. arbuscula* population in the sanctuary. However, insufficient data exist to determine if the contaminant levels found in fish and invertebrates within Gray's Reef are precluding full community development and function.

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

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 abundance, fecundity, and their availability as food for other species. Additional information exists to show a regional trend for other species as well (e.g. gag and scamp). Existing data suggest that approximately 20% 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 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 evidence of accumulation for certain organocontaminants 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:

Comment [kb76]: Since criteria for keystone and key species are described in Appendix A: Rating Scheme for System-Wide Monitoring Questions, there should be some explanation for why those so identified at Gray's reef (citations, other reference documents of verbal descriptions). For example, sponges are offered as key species but it is not clear why. Does the dimension of physical habitat complexity that they contribute maintain species diversity? Does their presence/size/type or changes indicate persistence of reef habitat, lack of disturbance, or climate changes? The process for designating key and keystone species at GRNMS should be included in the discussion.

Comment [kb77]: Need correct citation

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Deleted: grouper

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Comment [kb78]: The key species health is listed as undetermined in the report. The report mentions that gag and scamp grouper are not found evenly dispersed throughout GRNMS and the reason for the uneven distribution is not known. However, black sea bass seem to
be found throughout GRNMS and in good abundance. Therefore, the fish distribution may not be a sanctuary related issue, but possibly regional or habitat preference.

The only benthic organisms that appeared to indicate a potential problem were the sponges. Sponges are not a known food source, but the organo contaminants found in the sponge tissues could be an early indicator for anthropogenic stresses. It seems that a more realistic condition status would be "good/fair" with possible a downward trend or at least a notation that conditions are being closely monitored.

Comment [kb79]: Should this be Hyland **et al.**?

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- There is presently an inadequate historical dataset from which to compare the current status of biodiversity in Gray's Reef, and to determine trends
- Fish stocks show similar evidence of overfishing as regional stocks, based on periodic sampling with fish traps as part of region-wide MARMAP sampling, annual visual census, NMFS stock assessments and some socio-economic surveys conducted by the sanctuary staff.
- For the first time, two lionfish were observed in the sanctuary in the fall of 2007; conditions exist for continued and increased occurrence and potential impact from both fish and invertebrate species.
- Changes in benthic assemblages, while attributable to some human activities, have not been substantial, but the over-fishing of several key and keystone fish species could lead to additional future changes.
- While most assessments at Gray's Reef indicate healthy and viable populations, evidence of accumulation of contaminants in sponges raises concern about the possibility for environmental degradation.
- Selected activities such as fishing, diving, anchoring, have resulted in measurable living resource impacts, but evidence suggests effects are localized within areas of high use, not widespread.

Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Declining
? = Undetermined trend N/A = Question not applicable

	Status	Rating	Basis for Judgment
9	Biodiversity	?	Insufficient information to make a determination
10	Extracted Species	▼	Black sea bass, gag, red grouper, and red snapper regionally overfished and/or undergoing overfishing
11	Invasive Species	▼	Two lionfish identified in sanctuary in Fall 2007
12	Key Species Status	▼	Removal of key and keystone fish species
13	Key Species Condition	?	Insufficient information to make a determination
14	Human Activities	?	Localized within areas of heavy use

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Maritime Archaeological Resources

There are no shipwrecks in the sanctuary and only a few scattered artifacts suggesting a human presence at lower sea level stands have been found within Sanctuary boundaries. However, these are not considered a known resource; rather these finds are serendipitous and are not explicit sites that can be degraded by human activities. Nevertheless, human activities, such as anchoring, bottom fishing, and diving in the sanctuary could damage artifacts yet to be discovered, and do occur at levels that raise some concern.

Comment [kb80]: It is true that archaeologically speaking GRNMS is lacking with only a few artifacts recovered to date, but the site makes up any deficiencies with the abundance of fossilized scallop beds and bone fragments. GRNMS has already provided considerable insight to both its ancient marine and terrestrial environment. It is also possible that human activities could degrade these resources through scuba diving and anchoring, but evidence at known sites has not been documented to date.

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:

- Although research and recreational diving, bottom fishing and anchoring could impact artifacts on the bottom, there have been no documented impacts.

Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Declining
? = Undetermined trend N/A = Question not applicable

	Status	Rating	Basis for Judgment
15	Integrity	N/A	No documented underwater archeological sites
16	Threat to Environment	N/A	No documented underwater archeological sites
17	Human Activities	—	Potential for diving, fishing, and anchoring to damage undocumented artifacts

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Response to Pressures

This section describes current or proposed responses to pressures. 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 which 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. 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 contacts on land with user groups, marinas, the media, and on-water patrols. Because these are new regulations, an enforcement "soft-start" will also be employed whereby education and interpretive enforcement will occur for a period prior to issuing citations.

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 (e.g., 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, the public's enhanced 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 program will be initiated to include printed materials and radio spots to increase public awareness about the importance of good diving techniques, Gray's Reef regulations that guide diver activities, and marine animal interactions. The campaign will coordinate with PADI's Project Aware and 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 ecosystem. Based on current socioeconomic studies (Ehler and Leeworthy, 2002; Bird et al., 2001) and sanctuary surveys (Gray's Reef, 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 Gray's Reef that limits fishing to use of rod and reel, handline, 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 Gray's Reef in the draft management plan, but deferred that decision until additional socioeconomic information could be gathered. While use of powerheads with spearguns will continue to be prohibited, regulation of all spearfishing will be revisited in two years. Additional research studies will be conducted to determine the potential for spearfishing impacts on sanctuary resources.

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 will be further explored through a public process beginning in 2007. Among the research questions that may be addressed with establishment of a control/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 activities to address this issue will be through outreach, education and monitoring. Gray's Reef 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 (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 for 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 Program 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 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. Gray's Reef 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 to native species Gray's Reef will continue monitoring and looking for signs of invasive species (e.g. lionfish) 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. Gray's Reef will also continue collaboration with Reef Environmental Education Foundation (REEF), which conducts annual fish surveys and helps to monitor for invasive species.

Coastal Development

As coastal development increases in coming years, a potential exists for continued and increasing levels of land-based chemical pollutants to impact sanctuary resources. Gray's Reef 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

This report of the status, trends and pressures at Gray's Reef National Marine Sanctuary represents a first attempt to describe the site with regard to the current health and condition of the resources contained therein. Additionally, this "condition" report helps to determine what causal factors exist which may require monitoring and potential remediation in the years to come.

Overall, the resources protected by Gray's Reef National Marine Sanctuary appear to be in relatively good shape. Of the seventeen resources or questions identified, seven appear to be in good condition, four appear to be in good/fair condition while four more appear to be in fair condition; none of the resources identified were listed in fair/poor or poor condition and two of the questions related to maritime archaeological resources were found not to be applicable.

In recent years, research conducted in Gray's Reef has recently become focused less on simple characterization and more on oceanographic processes, biogeographic distribution, sources and fates of individual organisms and their contribution to the ecosystem as a whole. What factors help to structure the resources and how uses of the resources may affect their health, viability and longevity is important to understand. This data generated as a result of this report will enable us to not only look back at the status of the resources to date but will provide guidance for our continued resource management as we face future challenges imposed by such potential threats as wind farming, dredge disposal, climate change, migrational pattern shifts and, artificial reefs.

Comment [kb81]: Pg 32 paragraph 2 on Invasive Species discusses monitoring trends. However, is there no plan yet to remove exotics if found?

Comment [kb82]: Recommendations by the GRNMS Sanctuary Advisory Council (SAC), including: (1) establishment of a control (research) area; (2) GIS evaluative tools; (3) use of habitat diversity as primary criterion; and (4) reduction of user impacts should be implemented. These recommendations would improve the Condition Report process by providing habitat data across several categories, under controlled conditions and evaluated in a consistent format and fashion. This is particularly true for recommendations 1-3.

The control area designated for GRNMS must cross-cut all the habitat diversity at GRNMS to include hard bottom and non-hard bottom areas. Geological studies have clearly demonstrated that the hard substrate at GRNS is less pervasive and more deeply buried to the south and east of the mid-site area. Such a variation in edaphic conditions must, without question, dramatically influence ecology at GRNMS.

Comment [kb83]: A research area has been proposed within GRNMS for approved projects. Currently, much of the offshore (benthic) research is conducted at J Reef, a small live-bottom habitat located to the northeast of GRNMS. J Reef is very similar in appearance to GRNMS on the surface, but geologically speaking it is very different. J Reef is actually formed by the an ancient scallop bed outcrop that had been loosely cemented to form a solid body while GRNMS is composed of limestone/sandstone outcroppings and often topped by fossilized scallops. A question that could be raised is that if the geology is different, what about the benthic community? This question could be answered by allowing a research area within GRNMS. However, research can be destructive so projects would need to be evaluated and monitored in order to preserve the integrity of the Gray's Reef.

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Acknowledgements

Gray's Reef National Marine Sanctuary would like to acknowledge the assistance of Clancy Environmental Consultants, Inc. who was instrumental in developing the template for this document and providing the initial material under contract to NOAA. We would particularly like to thank Karen Fox for drafting content. We would additionally like to thank the members of the Research Advisory Panel under the guidance of Drs. Danny Gleason and Clark Alexander who agreed to chair the panel on the advice and suggestion of the Gray's Reef National Marine Sanctuary Advisory Council. Our grateful thanks are also extended to the reviewers of this document: Dr. Ervan Garrison (University of Georgia, Department of Anthropology), Dr. Matt Gilligan (Savannah State University), and Dr. Scott Noakes (University of Georgia, Center for Applied Isotope Studies).

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Cited Resources

A Summary of Monitoring and Tagging Work by the Marine Resources Monitoring and Assessment Program at Gray's Reef National Marine Sanctuary During 2002 - http://ocean.floridamarine.org/efh_coral/pdfs/GraysMarmap.pdf

Bird et al. 2001

Cooksey, C. J. Hyland, W. L. Balthis, M. Fulton, G. Scott, and D. Bearden. 2004. Soft-bottom benthic assemblages and levels of contaminants in sediments and biota at Gray's Reef National Marine Sanctuary and nearby shelf waters off the coast of Georgia (2000 and 2001). *NOAA Tech. Memo. NOS NCCOS 6*. NOAA National Ocean Service, National Center for Coastal Environmental Health and Bimolecular Research, Charleston, SC. 55p.

Diaz and Rosenberg 1995

Ehler, Rod and V. R. Leeworthy. May 2002. A Socioeconomic Overview of Georgia's Marine Related Industries and Activities; NOAA, U.S. Department of Commerce. http://graysreef.noaa.gov/newdraftplan/socioeconomic.pdf

Frischer unpublished data

Georgia Institute of Technology 2006

Gleason and Harvey http://www.bio.georgiasouthern.edu/gr-inverts/index.html

Gleason in prep.

Gray's Reef Common Fish Identification Guide - http://graysreef.noaa.gov/fishes.html

Gray's Reef National Marine Sanctuary Management Plan - http://graysreef.noaa.gov/contents.html

Gray's Reef National Marine Sanctuary Overflight Summary Report: Visitor Use at Gray's Reef National Marine Sanctuary: http://www.graysreef.nos.noaa.gov/flight.html

Hare et al. in press

Harriott et al. 1997

Harris et al. 2005

Harris, P.J., G.R. Sedberry, H.S. Meister and D.M. Wyanski. 2004. A Summary of Monitoring and Tagging Work by the Marine Resources Monitoring and Assessment Program at Gray's Reef National Marine Sanctuary During 2004. Annual Report FY2004 Submitted to Gray's Reef National Marine Sanctuary. 9 pp. http://www.nbi.noaa.gov/products/others/GRNATIONAL MARINE SANCTUARY_Benthic_FY02Rpt.pdf

http://nas.er.usgs.gov

Hyland unpublished data

Hyland, J., C. Cooksey, W.L. Balthis, M. Fulton, D. Bearden, G. McFall, and M. Kendall. 2006. The soft-bottom macrobenthos of Gray's Reef National Marine Sanctuary and nearby shelf waters off the coast of Georgia, USA. *J. Exper. Mar. Biol. Ecol.*, 330: 307-326.

Hyland, J.L., Balthis, L., Karakassis, I., Magni, P., Petrov, A.N., Shine, J.P., Vestergaard, O., Warwick, R.M., 2005. Organic carbon content of sediments as an indicator of stress in the marine benthos. Mar Ecol. Progr. Ser., 295, 91-103.

Comment [kb84]: I suggest a single comprehensive 'References' section with 'Literature Cited' (since there are citations for published material) and 'Other Resources' (unpublished material) sub-sections. Listing references by section and sub-section is not economical for the writers or readers, in my view.

Comment [kb85]: Need correct citation

Comment [kb86]: Need full citation. Reference found in Response/Recreational fishing section.

Comment [kb87]: Need full citation. Reference found in State/Water/Question 1 section.

Comment [kb88]: Need full citation. Reference found in State/Water/Question 1&2

Comment [kb89]: Need full citation. Reference found in Pressures/Coastal Development section.

Comment [kb90]: Need correct citation. Reference found in State/LR/Q12.

Comment [kb91]: Need full citation. Reference found in State/Habitat/Question 6 section.

Comment [kb92]: Need correct citation

Comment [kb93]: Need correct citation

Comment [kb94]: Need correction citation. Reference found in State/LR/intro section.

Comment [kb95]: Need full citation. Reference found in State/LR/Q9

Comment [kb96]: Need full citation (reference found in Pressures/Diver impacts section and Response/Diver impacts section)

Comment [kb97]: Need full citation. Reference found in State/LR/Q10

Comment [kb98]: Need correction citation. Found in State/LR/Q11

Comment [kb99]: Need full citation. Reference found in State/Water/Question 1 and Habitat Question 7 sections.

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Identification and Species Diversity of Sessile Invertebrate Fauna Indigenous to the Natural Rock Formations of Gray's Reef sanctuary - http://graysreef.noaa.gov/mcfall.html

Long et al. in prep

Kendall, M.S., L.J. Bauer and C.F.G. Jeffrey. 2007. Characterization of the Benthos, Marine Debris and Bottom Fish at Gray's Reef National Marine Sanctuary. Prepared by National Centers for Coastal Ocean Science (NCCOS) Biogeography Team in cooperation with the National Marine Sanctuary Program. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 50. 82 pp. + Appendices.

Kendall, MS, OP Jensen, C Alexander, D field, G McFall, R Bohne, and ME Monaco. 2005. Benthic mapping using sonar video transects, and an innovative approach to accuract assessment: A characterization of bottom features in the Georgia Bight. Journal of Coastal Research. 21 (6): 1154-1165.

Mass. Office of Coastal Zone Management: Oceanography, Weather Patterns and Climate Change - http://www.mass.gov/czm/oceanmanagement/waves_of_change/pdf/troceancc.pdf

Monthly Climatology - http://www.unc.edu/~hseim/sablam/climatology/

MP/EIS 2006

Munoz 2006 ICAIS

National Marine Sanctuary Program. 2004. A monitoring framework for the National Marine Sanctuary System. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 22 pp.
NMFS 2006

NMFS 2006

Overview of the Conservation of Australian Marine Invertebrates - http://www.amonline.net.au/invertebrates/marine_overview/chapt6dz.html

REEF, unpublished

Riggs, SR, SW Snyder, AC hine, and DL Mearns. 1996. Hardbottom morphology and relationships to the geologic framework: Mid-Atlantic continental shelf. Journal of Sedimentary Research 66(4): 830-846.

Ruzicka 2005

State of the Sanctuary Report - http://graysreef.noaa.gov/sos_05.pdf

Strategy MRP-1: Prevent Damage to Benthic Habitats from Anchoring - MP/EIS 2006
Strategy MRP-2: Prevent Diver Impacts on Benthic Habitat - MP/EIS 2006
Strategy MRP-3: Remove Marine Debris from the Sanctuary and Prevent New Debris from Accumulating - MP/EIS 2005
Strategy MRP-4: Increase Protection for Fish and Invertebrate Species - MP/EIS 2006

Talge,H. Impact of recreational divers on coral reefs in the Florida Keys. Diving for science 1990. Proceedings of the American Academy of Underwater Sciences Tenth Annual Scientific Diving Symposium. October 4-7 1990. University of South Florida – St. Petersburg, Fla. Jaap,-.C. ed. 1990. pp. 365-374. http://www.coral.noaa.gov/bib/abstracts/author-t/talge.html

Tenore, K.R., Chamberlain, C.F., Dunstan, W.M., Hanson, R.B., Sherr, B., Tietjen J.H., 1978. Possible effects of Gulf Stream intrusions and coastal runoff on the benthos of the continental shelf of the Georgia Bight. In: Wiley, M.L. (Ed), Estuarine Interactions. Academic Press, New York, pp. 577-598.

Verity 2005

Comment [kb100]: Need correct citation

Comment [kb101]: Need full citation. Reference found in State/Water/Question 2 section.

Comment [kb102]: Need correct citation. Reference found in Pressures/Climate change section.

Comment [kb103]: Need correct citation

Comment [kb104]: Need correct citation

Comment [kb105]: Need correction Citation. Reference found in State/LR/Q11.

Comment [kb106]: Need full citation. Reference found in State/LR/Q10

Comment [kb107]: Need correct citation

Comment [kb108]: Need correct citation. Reference found in State/LR/Q9

Comment [kb109]: Need full citation. Reference found in State/LR/Q12.

Comment [kb110]: Need correction citation

Comment [kb111]: Need full citation. Reference found in State/Water/Question 2&4 section.

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Wagner 2006

Whitfield 2006 International Conference on Aquatic Invasive Species

Whitfield P.E., Gardner T., Vives S.P., Gilligan M.R., Coutenay, W.R., Jr., Ray, G.C., and J.A. Hare. 2002. Biological invasion of the Indo-Pacific lionfish *Pterois volitans* along the Atlantic coast of North America. Marine Ecology Progress Series 235:289-297.

Comment [kb112]: Need full citation. Reference found in State/LR/Q13

Comment [kb113]: Need full citation. Reference found in State/LR/Q11

Additional Resources

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

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

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

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

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

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

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

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/

<<<The below references were in the "original" Cited Resources Section, however, they are not found anywhere in the text. I suggest we delete them, unless you want to insert their citation into the text>>>

Affected Environment

Endangered Species Act of 1973 - http://www.nmfs.noaa.gov/pr/laws/esa.htm

Frischer et al. 1995

Gray's Reef National Marine Sanctuary Regulations - http://graysreef.noaa.gov/regs.html

Introduction and Overview

Marine Mammal Protection Act of 1972 - http://www.nmfs.noaa.gov/pr/laws/mmpa.htm

McFall

Migratory Bird Treaty Act - http://www.eh.doe.gov/oepa/laws/mbta.html

Sedberry

South Atlantic Fishery Management Council Fishing Regulations - http://www.safmc.net/fishid/SAFMCregs05.pdf

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<<<The below web sites were in the "original" Additional Resources Section, however, they are not found anywhere in the text. I suggest that we can keep them since they don't really need to be referenced>>>>

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

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

NOAA's National Marine Fisheries Service Web site: http://www.nmfs.noaa.gov/

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/

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

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