Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

GRAY'S REEF NATIONAL MARINE SANCTUARY

Gray's Reef National Marine Sanctuary

Research Area Monitoring Plan Development Workshop Report

December 18-19, 2007

U.S Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of National Marine Sanctuaries

ABSTRACT

In 1999, the concept of establishing a Research Area within the boundaries of Gray's Reef National Marine Sanctuary was raised during the early stages of the Management Plan Review Process. Since that time, sanctuary staff have undertaken a process to consider the concept and invited stakeholders, scientists and managers to assist in developing a proposal for a research area. As part of that effort, the sanctuary invited a variety of experts to assist with the development of a set of objectives for a research only area. Based on those recommendations, sanctuary staff developed a set of questions that could be addressed if a research area were established. In December 2007, a workshop was held to develop a Research Area Monitoring Plan that could be implemented to address those questions. This report is a summary of the Research Area Monitoring Plan that was proposed during that workshop.

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BACKGROUND

The concept of a research (control) area within Gray's Reef National Marine Sanctuary (GRNMS) has been under discussion for several years. The concept was first raised in 1999 during the early stages of the GRNMS Management Plan review process at public scoping meetings and was raised again during public research workshops. Subsequently, the Gray's Reef Sanctuary Advisory Council (SAC), with the approval of the Sanctuary superintendent, formed a research area working group (RAWG) to further consider the concept. The Advisory Council's recommendation to investigate the concept of a marine research area was adopted by GRNMS as a research and monitoring strategy for the Management Plan which was released in 2006.

The RAWG comprised representative constituents of Gray's Reef including: researchers, academics, conservation groups, recreational anglers and divers, educators, commercial fishing, law enforcement and sanctuaries representatives. The working group met initially in May 2004, and then periodically over the course of a year, to discuss the concept in detail. The working group employed a consensus driven, constituent-based process to address the concept of a marine research area. All participants discussed at length all issues, considerations, priorities and concerns for each step of the process.

The following recommendations were developed by the working group and were referred to the SAC. After reviewing and considering the recommendations, the SAC adopted and submitted them to NOAA GRNMS:

Recommendation #1
Significant research questions exist at Gray's Reef National Marine Sanctuary that can only be addressed by establishing a control (research) area. Therefore, the research area concept should be further explored by NOAA through a public review process.

Recommendation #2
As many appropriate tools as feasible, especially a GIS (Geographic Information System, geographic and spatial analysis software) site evaluation tool and a RAWG should be used to investigate a research area with proper siting criteria.

Recommendation #3
Diversity of habitat with emphasis on high relief habitat should be the primary siting criterion. The RAWG should be maintained to support NOAA GRNMS in consideration of these various criteria (e.g., habitat, size, existing research and monitoring sites, bottom fishing data) in developing proposed options for a draft environmental impact statement.

Recommendation #4
Minimizing impacts to user communities including fishing, diving, research and resource management should be a priority under the research area concept. Non-bottom impinging activities should not be viewed as conflicting with the primary objectives of a proposed research area.

Based on the recommendations of the Advisory Council, NOAA concluded that the research area concept should be further explored through a public review process. Part of that process would involve drafting a Research Area Monitoring Plan. To begin this task, GRNMS enlisted the support of a variety of experts to assist in the development of a monitoring plan to evaluate the effectiveness of the research area (see Appendix I for a list of attendees). On December 18 and 19, 2007, the National Marine Sanctuary Program (NMSP) and the GRNMS hosted a workshop to consider what activities should be undertaken to evaluate the effectiveness of a research area (see Appendix II for the workshop agenda). This document summarizes the outcomes of the Research Area Monitoring Planning workshop that was held in Savannah Georgia.

PROCESS

Dr. George Sedberry, Gray's Reef National Marine Sanctuary (GRNMS) Superintendent, opened the meeting by welcoming the group and thanking them for their participation in this effort to draft a monitoring plan for a proposed research area within GRNMS. Dr. Sedberry provided background on the Research Area process to date and provided context for the next two days' activities:

Gray's Reef needs to answer certain questions about human impacts in order to manage the sanctuary properly. Answering these questions requires that harvesting be stopped in the study area. The SAC and RAWG recommended that fishing closures be limited to an area required to answer priority questions. In addition, these advisors suggested that attempts be made to minimize displacement of fishing while including an adequate amount of habitat required to address priority research questions.

The SAC and RAWG also provided recommendations related to implementation of the research area. These included the suggestion that research area monitoring activities be coordinated with ongoing monitoring in the sanctuary. And, whenever possible, research area monitoring efforts should be integrated with existing data.

Workshop participants were given information on how sanctuary staff plans to report on research area results. GRNMS staff will provide regular evaluations of the research area and will prepare a five-year report on research area effectiveness. Interim information transfer meetings and status reports will also occur as needed. Further, sanctuary staff, in partnership with outside experts, will conduct periodic and formal program reviews. When justified, the research area monitoring plan will be adapted to reflect findings from these reviews.

Over the two days of this workshop, participants were asked to begin developing a monitoring plan that will allow NOAA to evaluate the impacts of closing part of the sanctuary. NOAA is looking to develop a research area monitoring plan that is practical and realistic, affordable and effective and that provides for timely information delivery. For the purposes of this workshop, participants were asked to focus on priority resources and questions, include socioeconomic monitoring and incorporate existing work and information sources whenever possible. Participants were asked to recognize that GRNMS will depend on partners, including fishing public and volunteers, to implement this research area monitoring plan.

Several challenges facing workshop participants were recognized as the group attempts to develop recommendations for a research area monitoring plan. Those include selecting priority questions, identifying practical approaches,

keeping the plan uncomplicated and understandable and resolving issues related to inconsistent support (i.e., vessels, contracts, weather, etc.).

Dr. Sedberry then introduced the GRNMS Research Coordinator, Greg McFall, who gave an overview of recent and ongoing research in the sanctuary. The goal of this presentation was to ensure that all participants had a clear understanding of what existing activities and information were available to contribute to a research area monitoring plan.

Presentation on existing research underway in Gray's Reef NMS – by Greg McFall

Gray's Reef NMS Research Coordinator Greg McFall provided the group with a brief overview of the research underway in the sanctuary. Because most of the workshop participants were either involved in or aware of these activities, the presentation was intended to be a broad representation of existing work.

Recent research efforts in Gray's Reef includes:

- Paleo-archeological investigations, led by Dr. Irv Garrison
- Benthic macroinvertebrate investigations, led by Dr. Jeff Hyland
- Water Quality Monitoring program, led by Dr. Marc Frischer
- Larval Fish studies, led by Dr. Jon Hare
- Fish Tagging studies, led by Dr. George Sedberry
- Fish surveys, led by Reef Environmental Education Foundation
- Invertebrate monitoring program, led by Dr. Danny Gleason
- Biogeographic characterization, led by Drs. Mark Monaco and Matt Kendall

Gray's Reef also has a data buoy located within the sanctuary which provides information on wind direction, speed and gust; wave and swell height and period; current direction and velocity; surface temperature of air and water; dissolved oxygen, pH, salinity, chlorophyll A and turbidity. To support research and monitoring efforts in the sanctuary, Gray's Reef NMS has two small vessels available to scientists. The sanctuary also has ship time scheduled on the NOAA Ship *Nancy Foster* each year. Finally, the site maintains and operates a small Remotely Operated Vehicle (ROV) and several NOAA divers available to support research in the sanctuary.

Multiple Scale Assessment and Monitoring of Coral Reef and Hard-Bottom areas in the Florida Keys – by Dr. Mark Chiappone

Dr. Mark Chiappone of the University of North Carolina at Wilmington provided workshop participants with a presentation on the zoning effectiveness research he has been involved with in the Florida Keys. The objective of this program is to evaluate no take zones versus reference sites, looking at the status and trends of

coral reef and hard-bottom communities on multiple spatial scales and considering habitat and regional variations. The team visits a large number of sites in a small amount of time and selects target areas for more intensive monitoring.

Dr. Chiappone described the survey parameters of this "Protected Zone Assessment" which include zones not randomly selected, BACI (before-after-control-impact), some zones include more than one habitat type, and high intra- and inter-site variability. The marine zones comprise a very small percentage of the Florida Keys National Marine Sanctuary (FKNMS). The team considered what variables to record to assess community structure and condition, and developed essentially a system wide, hierarchical approach. The FKNMS Zone Performance Assessment Classification of hard-bottom and coral reef habitats identified what is out there and where it is located. The power of their approach is that the team does not spend a huge amount of time in one area. They survey 49 fixed stations, which is very expensive to visit each station every year. The researchers recognize that the problem with that approach is that they do not know how those stations relate to the rest of the sanctuary.

To address this, they have taken the randomized approach, which allows them to cover a large number of sites in a brief amount of time. Surveying one station can be done in 60-75 minutes. Having a small, committed team that is not tied to NOAA funding has been key to their success. They follow the "KISS principle" and try to leverage resources as much as possible.

<u>Presentation on benthic monitoring at Gray's Reef NMS and "J" Reef – by Dr. Danny Gleason</u>

Dr. Danny Gleason of Georgia Southern University gave a presentation to the workshop participants about his research on the recruitment and succession of sessile benthic invertebrates in the South Atlantic Bight. Dr. Gleason highlighted the importance of marine protected areas, using the example of Oculina banks off the east coast of Florida, where the difference between an unprotected control area and an experimental research reserve was established.

The remainder of the presentation focused on three ongoing projects inside of Gray's Reef National Marine Sanctuary: successional processes in sessile, benthic invertebrate communities, recruitment of *Oculina arbuscula* to artificial and natural substrata, and population genetic structure and recruitment in *O. arbuscula*.

The first project, successional processes in sessile benthic invertebrate communities, is being conducted to monitor sessile invertebrate populations on subtidal reefs of the South Atlantic Bight. This project has two objectives: follow establishment to bare reef substrata and monitor community structure of existing patches. Using twenty plots of hard bottom substrate, the project will compare

between control sites and cleared sites to determine early successional species and seasonal residents. During this study, Hurricane Charley came through Gray's Reef NMS in August 2004. This storm provided additional, unexpected data about how storms can damage reefs.

Next, Dr. Gleason discussed his investigations into the recruitment of *O. arbuscula* to artificial and natural substrate. This study aims to quantify through time the recruitment rates, death rates, and growth rates of *O. arbuscula*. After growth rates and recruitment rates were found to be higher than expected, Dr. Gleason aimed to answer the question "Why isn't *O. arbuscula* taking over temperate reefs?" This project has led to one extremely important take home message: "Long term monitoring enhances understanding of community dynamics. [It] allows short term or stochastic processes to be disentangled from those acting over longer timescales."

The final study looked at population genetic structure and recruitment in *O. arbuscula*. This project used amplified fragment length polymorphism (AFLP) to map the genetic structure of *O. arbuscula*. AFLP was used because it has a relatively short start-up time, is relatively inexpensive, assays the entire genome, is PCR based but does not require prior sequence information necessary for primer design, and is highly polymorphic (contains numerous markers). This study has determined that among adult samples there is support for one or more populations. Also, both allocation programs assign the majority of juveniles collected from "J" reef back to "J" reef, which suggests a fair amount of self seeding.

Introduction of Workshop Process – Dr. Steve Gittings

Dr. Steve Gittings, Chief Scientist for the Office of National Marine Sanctuaries, served as the facilitator for the remainder of the workshop. Dr. Gittings provided a group with an overview of the steps that the workshop planning team had outlined to help develop a monitoring plan.

As a starting point, Dr. Gittings introduced a series of questions (see Appendix III) that had been developed by sanctuary personnel. This set of questions is considered to be the most important that a research area needs to address. All of the questions relate to the impacts of bottom fishing. One set of questions has to do with sessile invertebrates, one with mobile invertebrates and one set of questions pertains to benthic fish.

Over the course of the workshop, participants will be attempting to develop the priority approaches to answering these questions. Participants were reminded that the goal was not to develop a comprehensive list of monitoring activities to address these questions, but rather to focus on the most important activities.

On the first day of the workshop, focus will be on talking about what needs to be measured to answer these priority questions and how those measurements should be made. On day two, the group will discuss how these projects can be implemented.

As a start, the group was asked to identify requirements; that is, to identify specific *hypotheses (sub-questions)* for each of the six primary questions; identify *resources* specifically relevant to those hypotheses; determine expected or potential *responses* to be measured or evaluated; and determine appropriate measurement *metrics.* Based on that effort, a "Requirements Matrix" would be developed.

The next step workshop participants would undertake involved developing specific project ideas that would answer the priority research area questions. To support this effort, the workshop planners developed templates that participants could complete as they discussed proposed monitoring activities. These templates included the following information: title, question(s) addressed, problem statement, objectives, statistical design, variables of interest, geography (locations), annual field needs, interval, existing information available, partners and roles, support requirements (equipment, vessels, etc.), cost, time to complete and additional comments.

The final task of the workshop would be to prioritize requirements. Prioritization was to be done considering the following criteria:

- Urgency
- Breadth - topics and questions addressed
- Ability to integrate with existing monitoring
- Ecosystem indicators
- Vulnerability of species
- Historical data availability
- Logistical feasibility (metrics, field time, equip, partnerships)
- Time to completion
- Cost

Following Dr. Gittings' introduction to the workshop process, participants discussed the list of questions and proposed sub questions that they believed were important to consider. The questions were modified accordingly and the group began work on the requirements matrix (see Appendix IV for the list of questions and sub questions developed by the participants).

QUESTIONS ADDRESSED DURING THE WORKSHOP

Sessile Invertebrates/Gear Impacts

1. Does bottom fishing gear affect benthic invertebrate populations?
    a. What is the severity of impact of bottom fishing gear (individual and cumulative)?
    b. What is the frequency and spatial distribution of the fishing that affects bottom habitats?
    c. What are the differences in frequency and comparative severity for different gear types?
    d. How big a problem is fishing gear effects relative to natural variations in live bottom invertebrate species?

Sessile Invertebrates/Recovery Rates

2. What are the rates of recovery of populations of sessile invertebrates following various levels of disturbance by bottom fishing gear?
    a. At what rate do dominant space competitors recover?

Sessile Invertebrates/Indirect Effects

3. What are the effects (e.g., changes in benthic food webs) of changes in benthic communities due to bottom fishing?
    a. How does distribution and abundance of sessile invertebrates change with changes in predation pressure?
    b. How do changes in fish community feeding activity affect invertebrate trophic structure?

Mobile Invertebrates/Predator Effects

4. How do infaunal and mobile invertebrate communities look in the absence of fishing?
    a. How do infaunal communities living in adjacent sands affected by changes in fishing pressure?
    b. How are motile epifaunal communities affected by changes in fishing pressure?

Bottom Fish/Effects and Recovery

5. How much are benthic fish populations affected by fishing?
    a. What are the targeted and by-catch species?
    b. Are other species affected by the removal of targeted and by-catch species?
    c. How much is caught and what is the effort?
    d. How much do fish move in and out of the Research Area?
    e. How does fishing affect diversity and community structure?

REQUIREMENTS

Workshop participants were asked to consider the priority research questions and identify the resources that would have to be assessed to address them. They were also asked to identify the specific metrics that would have to be measured when answering the priority questions.

At the end of this exercise, a “Requirements Matrix” (Appendix V) was assembled based on the workshop participants’ discussions. This is a matrix of priority resources and metrics, with the information in the cells representing the question(s) to which each combination applies. The matrix allows participants to see the entire list of resources considered relevant to each question and the associated measurement requirements. This information can be used to determine which combinations are the most important based on the resources themselves or the number of questions addressed by a specific resource-metric combination.

WORKSHOP RECOMMENDATIONS

After completing the "Requirements Matrix" workshop participants broke into three groups to develop project templates to answer the priority research questions (see Appendix VI for the project templates). During the breakouts, workshop participants identified seven projects for inclusion in the Research Area Monitoring plan. Each of these proposed projects is described below.

Marine Debris Distribution and Abundance

Understanding how marine debris from fishing and other human activities affects Gray's Reef resources requires assessment of the spatial distribution of debris and the abundance of various gear and trash types present in the area. Workshop attendees proposed a marine debris distribution and abundance study to answer the following questions:

1) What is the severity of impact of bottom fishing gear (individual and cumulative)?
2) What is the frequency and spatial distribution of the fishing that affects bottom habitats?
3) What are the differences in frequency and comparative severity for different gear types?
4) How big a problem is fishing gear effects relative to natural variations in live bottom invertebrate species?

Workshop participants proposed that this study build upon existing plans to conduct a marine debris assessment in the sanctuary, both within and outside the research area. Participants recommended that sampling should include immediately after fishing tournaments (among other times), even though tournaments target pelagic fish. Ideally, this study would include data on location of vessel during tournaments and at other times. The proposed statistical design would be probabilistic, with randomly stratified samples across habitats (excluding sand habitats), while distinguishing between various strata along ledges. The variables of interest are the distribution and frequency of occurrence of marine debris within and among ledges for each gear type and other trash types.

Participants proposed that this study be conducted on an annual basis around all ledge habitats both inside and outside of the research area, requiring approximately 10 field days per year. Workshop participants estimated that this project would take three years to complete. GRNMS support requirements would include vessel support, dive support, dive gear and cameras.

Entanglement Impacts of Lost Gear

Understanding how marine debris from fishing and other human activities affects Gray's Reef resources requires assessment of the effects of gear on individual organism, and the potential for recovery after injury. Workshop attendees proposed study to evaluate the impacts of lost gear study to answer the following questions:

1) What is the severity of impact of bottom fishing gear (individual and cumulative)?
2) What are the differences in frequency and comparative severity for different gear types?
3) How big a problem is fishing gear effects relative to natural variations in live bottom invertebrate species?

This proposed study would involve tracking the survivorship and recovery rates of animals entangled in fishing gear (either actual or intentional). Researchers would record the severity of injury by various fishing gear types, the fate of entangled colonies, and the rate of recovery of colonies from which gear is removed. Focal species would include *Oculina* and octocorals. The statistical design would be a time series analysis at permanent stations with manipulations or opportunistic stations with pre-entangled animals and repeated observations to assess fate. The variables of interest are how animal conditions change over time for entangled and disentangled animals for each gear type encountered.

This study is proposed to be conducted on a quarterly basis and would need seven field days each year and require three years to complete. GRNMS support requirements will include vessel support, dive support, dive gear and cameras from the sanctuary.

Effects of Changes in Fish Foraging Pressure on the Composition of Infaunal and Epifaunal Benthic Invertebrate Communities

A number of benthic communities may exhibit changes as a result of closing even a small area to fishing. These may include infauna, epifauna, epibenthos, and cryptofauna; any or all of which may show changes in distribution, abundance, or size, among other characteristics. These changes can, in turn, influence habitat characteristics such as structure and chemistry. Workshop attendees proposed a study to investigate the effects of changes in fish foraging pressure on the composition of infaunal and epifaunal benthic invertebrate communities. This study would answer the following questions:

1) How does distribution and abundance of sessile invertebrates change with changes in predation pressure?
2) How do changes in fish community feeding activity affect invertebrate trophic structure?

3) How do infaunal communities living in adjacent sands affected by changes in fishing pressure?
4) How are motile epifaunal communities affected by changes in fishing pressure?

The proposed objectives of this study are to characterize and quantify changes in the benthic community structure resulting from shifts in fish foraging pressures after creation of the research area. This project would also assess the changes in softbottom seafloor microhabitats (e.g., biogenic structures and geochemical characteristics) resulting from shifts in benthic community structure and assess the changes in hardbottom topographic complexity that result from changes in sessile macroinvertebrates. The variables of interest are species composition and abundance per unit area, as well as biogenic structure (observations and/ or photographs), geochemistry, and topographic complexity. The statistical design will require repeated sampling at fixed stations inside and outside the research area (with replication).

This study will be conducted on a quarterly basis initially and then on an annual basis. It will take more than five years to complete and require two weeks of field work per year. The habits of interest are all ledge and sand habitats inside of and outside of the research area. GRNMS would provide support through the use of the research vessels *Nancy Foster* and *Joe Ferguson*.

Fishery-Dependent Creel Survey

It is important to know the level of mortality from fishing activities in GRNMS, both prior to and after the establishment of the research area. This will allow investigators to more accurately interpret the results of studies conducted in both areas. Workshop attendees proposed a fishery-dependent creel survey to answer the following questions:

1) What are the targeted and by-catch species?
2) How much is caught and what is the effort?
3) How does fishing affect diversity and community structure?
4) How does fishing intensity vary with location in the sanctuary?

The proposed objective of this study is to determine fishery catch and effort prior to and after designation of research area. The variables of interest are to determine what is landed, caught, released, discarded, or used at sea (i.e., bait). What is the total amount of catch per person, per hour/per trip, and per gear/method, by location (inside the sanctuary and outside)? What is the level of related lost tackle or “break offs”? Possible approaches to the statistical design would involve creel surveys, questionnaires, observations, volunteer monitoring fishermen (sentinel/ volunteer program), law enforcement reporting, remote sensing and acoustic sensing.

The proposed study would consider all available habitats inside and outside of the sanctuary. It would be completed quarterly for two years, but the workshop participants suggested that the annual field needs would need to be determined. GRNMS support requirements include providing satellite data, NMSP personnel, survey instruments, vessels, computing/data analysis and volunteer support.

Diver Visual Fishery-Independent Survey

Assuming current fishing effects reef fish populations, one would expect changes in abundance, species composition and size structure of the community with the implementation of the research area. Over time, these changes would provide a reasonable estimate of the extent to which current fishing affects the community. Workshop attendees proposed a fishery-independent diver visual survey to answer the following questions:

1) What are the targeted and by-catch species?
2) Are other species affected by the removal of targeted and by-catch species?
3) How does fishing affect diversity and community structure?

The proposed objective for this study is to track populations and other characteristics of targeted and non-targeted fish species, both inside and outside of the research area. The variables of interest include the number and length of all fish by species and habitat characteristics (e.g., ledge height). The design of the study will focus on a few selected species, including black sea bass. The allocation of samples among strata will be based on stratum size, variance of target species, and overall precision goal.

Workshop participants suggested that this study be conducted three times per year (annually at a minimum and quarterly at a maximum) and would require at least five years to complete. All hard bottom habitats (high ledge, medium-high ledge, low ledge, and flat hardbottom) should be considered. GRNMS would supply vessel support, dive support, dive gear, and cameras from the sanctuary.

Tagging of Fishes to Determine Movement in Relation to Closed Fishing Area

It is important to understand how reef fish move in order to determine the extent to which an area closed to fishing encompasses their home range. If the closure represents only a small fraction of a fish's home range, eliminating fishing in only one part of that range may not offer much protection to the fish. In this case, observations of species with large home ranges within a small study area may yield little information about human impacts that are controlled within that area. To investigate these issues relative to the Research Area, workshop participants recommended a study to evaluate site fidelity and provide information about the dynamics of populations within what is, in effect, a small marine protected area.

This activity involves conducting a fish tagging study to answer the following question: How much do fish move in and out of the research area?

The objectives for this proposed study are to determine the daily movements of fish relative to the research area and how the movement patterns change with time. Investigators would examine the seasonal/annual patterns of migration and determine if the research area will exhibit spillover. The species of interest include black sea bass, grouper, tomtate and red snapper. This activity would involve two components: traditional tagging and acoustic tagging. Workshop participants recommended that as many as 1000 external tags will be placed on each target species and be tracked through a variety of methods including traps and diver visual censuses. In addition, 100 acoustic tags would be surgically implanted in the target species to track fish movement. Acoustic receivers would be placed within and outside the research area to track fish within the sanctuary. GRNMS would provide funding, vessel support, dive support, traps, receivers and acoustic tags.

Comparative Life History of Fishes in Protected and Fished Areas

Life history characteristics can be altered by fishing and by closures to fishing. These changes ultimately affect overall productivity in a given area, resulting in community level influences. Understanding these dynamics, and whether they manifest in small closed area like that proposed for Gray's Reef, inform managers about the effectiveness and consequences of their actions. How does fishing and protective management affect life history? How does protection affect the production of fish biomass? Workshop attendees proposed a comparative life history of fishes in protected and fished areas study to answer the following questions:

1) What are the targeted and by-catch species?
2) Are other species affected by the removal of targeted and by-catch species?
3) How does fishing affect diversity and community structure?

The proposed objectives are to compare life history (size and age structure; population fecundity; mortality; feeding habits) in fished and unfished areas. Also, to compare abundance, biomass and length-specific fecundity of fishes in the research area to fished areas to determine the potential reproductive output of fish populations in a shallow inner shelf live bottom area in the absence of fishing, and what might be exported to fished areas. There are several variables of interest with this study, including length frequency, age structure, size at age and maturity, and size/age specific fecundity (from existing data or fished area). All data can be extrapolated to unfished area using length frequency estimates (visual census). Also, workshop participants recommended that sex/maturity can be estimated from blood hormone analysis and natural mortality can be estimated from length frequency in the absence of fishing. The statistical design will be developed around standard life/fisheries methods in fished area of

sanctuary or nearby live bottom in the region (MARMAP data). Also, length frequency data will be collected from unfished area and use age/length keys/existing data to extrapolate age, mortality and fecundity from length. Study of feeding in unfished area may be a problem, but can be done using gut lavage or chemical and isotopic methods.

This study will be conducted on a monthly basis for three years and will look at all habitat types inside and outside of the study area. GRNMS will help with the field needs of 60 days per year (5 per month).

Prioritization

Workshop organizers had intended to ask the group to prioritize the requirements developed during the meeting. However the group was not able to complete this step due to time constraints. It was agreed that the workshop organizers would attempt to complete this independently and solicit feedback from the group at a later date.

NEXT STEPS

The Office of National Marine Sanctuaries and Gray's Reef National Marine Sanctuary, in collaboration with appropriate partners, will use the information provided at this Research Area Monitoring Planning Workshop to draft a more detailed and complete Research Area Monitoring Plan. In addition to providing further details on monitoring projects themselves, the draft plan will include information on projected staffing, funding, information management and delivery and implementation, including a timeline. The plan will incorporate ongoing investigations that can address portions of the identified priorities. Sanctuary staff will also propose prioritization for the suggested projects. The Draft Research Area Monitoring Plan will be made available for review and comment, updated based on those comments, and finalized for implementation.

APPENDIX 1 List of workshop participants and roles

Name	Institution	Role
Akins, Lad	Reef Environmental Education Foundation	Participant
Alexander, Clark	Skidaway Institute of Oceanography	Participant
Bohnsack, Jim	National Marine Fisheries Service	Participant
Cavanaugh, Joe	Reef Environmental Education Foundation	Participant
Chiappone, Mark	University of North Carolina at Wilmington	Participant
Debose, Jennifer	Flower Garden Banks National Marine Sanctuary	Participant
Fangman, Sarah	Southeast and Gulf of Mexico Region of the Office of National Marine Sanctuaries	Participant
Frischer, Marc	Skidaway Institute of Oceanography	Participant
Gleason, Danny	Georgia Southern University	Participant
Gittings, Steve	Office of National Marine Sanctuaries	Facilitator
Hyland, Jeff	NOAA Center for Coastal Environmental Health and Biomolecular Research (CCEHBR)	Participant
Kimmel, Joe	National Marine Fisheries Service	Chair
Krueger, Gail	Gray's Reef National Marine Sanctuary	Participant
McFall, Greg	Gray's Reef National Marine Sanctuary	Participant
Olmi, Geno	Coastal Services Center	Participant
Sedberry, George	Gray's Reef National Marine Sanctuary	Participant
Shortland, Becky	Gray's Reef National Marine Sanctuary	Participant
Smith, Steve	University of Miami's Rosenstiel School of Marine and Atmospheric Science	Participant
Woodward, Spud	Georgia Department of Natural Resources	Participant

APPENDIX II Workshop Agenda

Gray's Reef Research Area Working Group

Research & Monitoring Project Development Workshop

December 18-19, 2007

Day 1

8:30 Introduction and goals (George Sedberry)
8:45 Current monitoring, including REEF and NCCOS (Greg McFall)
9:15 Presentation on SCREAM (Mark Chiappone)
9:45 Benthic monitoring at GR and J Reef (Danny Gleason)

10:15 Break

10:30 Recommended process (Gittings)
- Matrix 4 as a starting point for question templates
- Requirements matrix
- Project templates
- Prioritization

11:00 First question template

12:00 Lunch

1:00 Breakouts to complete question templates
3:00 Requirements matrix
4:00 First project template
5:00 Adjourn

Day 2

8:30 Review requirements matrix and first project template
9:00 Breakouts to complete project templates
11:00 Prioritization and implementation options
12:00 Adjourn

APPENDIX III Research Area Questions

Sessile Invertebrates

Gear Impacts
Does bottom fishing gear affect benthic invertebrate populations?

Recovery Rates
What are the rates of recovery of populations of sessile invertebrates following various levels of disturbance by bottom fishing gear?

Indirect Effects
What are the indirect effects (e.g., changes in benthic food webs) of changes in benthic communities due to bottom fishing?

Mobile Invertebrates

Predator Effects
How do mobile invertebrate communities look in the absence of fishing?

Bottom Fish

Direct Effects
How much are benthic fish populations reduced by bottom fishing effort?

Recovery Rates
What is the rate of recovery for species targeted by bottom fishing?

APPENDIX IV. Revised Research Area Questions

Sessile Invertebrates/Gear Impacts: 1. Does Bottom Fishing gear affect benthic invertebrate populations?

Sub-question(s)	Key Resources	Potential Responses	Metrics
1a. What is the severity of impact of bottom fishing gear (individual and cumulative)?	• Sponges • Polychaete colonies • Gorgonians • Tunicates • Bryozoans • *Oculina* • Ark shells	• Changes in cover • Changes in relative abundance • Abrasions and lesions • Disease • Entanglement • Changes in size composition • Organisms dislodged by divers • Note: must be weighed against changes due to natural events	• Percent cover (area of coverage) for each key resource • Number of colonies • Size composition of certain species (e.g., gorgonians, *Oculina)* • Rating of entanglement impact (1-3; passive, abrasive, lethal) • Number of dislodged sponges
1b. What is the frequency and spatial distribution of the fishing that affects bottom habitats?	• Same as above • Ledge habitat	• Higher accumulation rates (frequency of recent entanglement) in fished areas • Larger amount of recently lost fishing gear in fished areas (not necessarily entangled on organisms) • Larger amount of recent trash in fished areas	• Frequency of entanglement of organisms • Abundance of recently lost gear • Abundance of trash

Sessile Invertebrates/Gear Impacts: 1. Does Bottom Fishing gear affect benthic invertebrate populations? (*continued*)

Sub-question(s)	Key Resources	Potential Responses	Metrics
1c. What are the differences in frequency and comparative severity for different gear types?	• Different gear types (spear, monofilament, bottom tackle, pelagic tackle) • Sponges bryozoans, polychaete colonies, gorgonians, tunicates, *Oculina*, ark shells	• Differences in relative abundance of different gear types listed • Different severity of impacts associated with the different gear types on different organisms	• Encounters/survey for each gear type • Rating of impact severity for each gear type (e.g., 1-3 for lethal, abrasive, passive) for each affected colony type
1d. How big a problem are fishing gear effects relative to natural variations in live bottom invertebrate species?	• Different gear types (spear, monofilament, bottom tackle, pelagic tackle) • Sponges bryozoans, polychaete colonies, gorgonians, tunicates, *Oculina*, ark shells	• Burial and dislodgement	• Sedimentation • Physical turbulence • Sponge bleaching • Changes in water quality properties (turbidity, temperature, DO) • Light attenuation

Sessile Inverts/Recovery Rates: 2. What are the rates of recovery of populations of sessile invertebrates following various levels of disturbance by bottom fishing gear?

Sub-question(s)	Key Resources	Potential Responses	Metrics
2a. At what rate do dominant space competitors recover?	• Sponges • Bryozoans • Polychaetes • Gorgonians • Tunicates • *Oculina* • Ark shells	• Changes in abundance or cover • Changing diversity measures (e.g. , evenness) • Changes in size frequency • Healing of abrasions after removal of gear	• Recruitment in cleared plots • Abundance in cleared plots • Cover in cleared plots • Size frequency in cleared plots • Recruitment in disturbed areas • Cover in disturbed areas • Size in disturbed areas • Occurrence of abrasions over time • Diversity measures

Sessile Inverts/Indirect Effects: 3. What are the effects (e.g., changes in benthic food webs) of changes in benthic communities due to bottom fishing?

Sub-question(s)	Key Resources	Potential Responses	Metrics
3a. How does distribution & abundance of sessile invertebrates change with changes in predation pressure?	• Attached sessile epifaunal invertebrates • Cryptic fauna associated with larger host invertebrates	• Changes in species diversity, abundance, age-size structure, biomass and productivity	• Species diversity • Abundance • Age-size structure • Biomass • Productivity
3b. How do changes in fish community feeding activity affect invertebrate trophic structure?	• Attached sessile epifaunal invertebrates • Cryptic fauna associated with larger host invertebrates	• Changes in feeding preferences of fishes • Changes in prey community (see above)	• Stable isotopes • Gut content • Direct observation of feeding behavior

Mobile Inverts/Predator Effects: 4. How do infaunal and mobile invertebrate communities look in the absence of fishing?

Sub-question(s)	Key Resources	Potential Responses	Metrics
4a. How are infaunal communities living in adjacent sands affected by changes in fishing pressure	• Infaunal communities (e.g., polychaetes, crustaceans, mollusks, other	• Changes in diversity • Abundances, species composition (i.e., halo effects)	• Diversity • Abundance
4b. How are motile epifaunal communities affected by changes in fishing pressure?	• Crustaceans, echinoderms (e.g., brittle stars, sea cucumbers, sea urchins and sea stars), gastropods	• Changes in diversity • Abundances, species composition • Changes in biogenic seafloor structure and rate of depth bioturbation	• Diversity • Abundance • Presence and persistence of mounds, burrows, ripples, fecal material, tubes • Benthic primary productivity

Bottom Fish/Effects & Recovery: 5. How much are benthic fish populations affected by fishing?

Sub-question(s)	Key Resources	Potential Responses	Metrics
5a. What are the targeted and by-catch species?	• Black sea bass • Gag • Scamp • Red snapper • Sheepshead • Round scad • Tomtate • Scup • Bank sea bass • White grunt • Spanish sardines • Atlantic thread herring • Grey trigger • White bone porgy • Jolthead porgy • Saucereye porgy • Atlantic spadefish • Sharks • Red drum • Goliath grouper • Red Grouper	• Change in abundance and size • Change in species composition and diversity • Age structure • Change in diet • Change in reproductive potential/output • Change in habitat preference/site fidelity • RA edge effects • Potential response in increased poaching	• Proportion occurrence • Per unit abundance • Species composition • Size structure • Age size maturity/length • Age size fecundity • Gut contents • Poaching events • Home range/site fidelity • Spillover • Distribution of effort

Bottom Fish/Effects & Recovery: 5. How much are benthic fish populations affected by fishing? (*continued*)

Sub-question(s)	Key Resources	Potential Responses	Metrics
5b. Are other species affected by the removal of targeted and by-catch species?	• Prey, predator and competitor species	• Same as 5a (above)	• Same as 5a (above) except poaching and effort
5c. How much is caught and what is the effort?	• Same as 5a (above)	• Same as 5a (above)	• Same as 5a (above) • CPUE
5d. How much do fish move in and out of the RA?	• Subset of 5a (above)	• Change in habitat preference/site fidelity • RA edge effects	• Home range/site fidelity • Spillover • Catch outside RA
5e. How does fishing affect diversity and community structure?	• Same as 5a (above) *and* • Prey, predator and competitor species	• Change in species composition and diversity	• Species composition and diversity

Metrics

Resource Ecosystem/Attributes	Percent cover	Abundance/Encounter rate	Relative abundance	Size composition	Species Diversity	Recruitment	Biomass	Productivity	Age/size maturity	Age/size fecundity	Age/size length	Home range	Site fidelity	Spillover	Distribution of fishing effort	CPUE	Number of dislodged sponges	Abrasions	Bleaching	Entanglement (1-3; passive, abrasive, lethal)	Frequency of entanglement of organisms	Stable isotopes	Gut content	Feeding behavior observation	Persistence	Burial	Sedimentation	Turbulence (water movement)	Turbidity	Temperature	Light attenuation	Poaching events
Habitat																																
Quality								4b																			1d	1d	1d	1d	1d	
Mounds		4b																							4b							
Burrows		4b																							4b							
Ripples		4b																							4b							
Fecal material		4b																							4b							
Tubes		4b																							4b							
Invertebrates																																
Sponges	1a, 2a	1a, 2a		2a		2a										1a	2a	1d	1a,1c	1a						1d						
Polychaete colonies	1a, 2a	1a, 2a		2a		2a											2a		1a,1c	1a												
Bryozoans	1a, 2a	1a, 2a		2a		2a											2a		1a,1c	1a												
Gorgonians	1a, 2a	1a, 2a		1a,2a		2a											2a		1a,1c	1a												
Oculina	1a, 2a	1a, 2a		1a,2a		2a											2a		1a,1c	1a												
Tunicates	1a, 2a	1a, 2a		2a		2a											2a		1a,1c	1a												
Ark shells	1a, 2a	1a, 2a		2a		2a													1a,1c	1a												
Infauna in sessile benthos		3a		3a	3a		3a	3a													3b	3b	3b									
Attached sessile epifauna		3a		3a	3a		3a	3a													3b	3b	3b									
Sediment polychaetes		4a			4a																											
Sediment crustaceans		4a			4a																											
Sediment molluscs		4a			4a																											
Brittle stars		4b			4b																											
Sea cucumbers		4b			4b																											
Sea urchins		4b			4b																											
Sea stars		4b			4b																											
Shelled gastropods		4b			4b																											
Nudibranchs		4b			4b																											
Managed Fish Species																																
Black sea bass		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Gag		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Scamp		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Red snapper		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Sheepshead		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Round scad		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Tomtate		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Scup		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Bank sea bass		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
White grunt		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Spanish sardines		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Atlantic thread herring		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Grey trigger fish		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
White bone porgy		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Jolthead porgy		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Saucer eye porgy		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Atlantic spadefish		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Sharks		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Red drum		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Goliath grouper		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Red grouper		5a,5c	5a,5c	5a,5c,5e	5e				5a,5c	5a,5c	5a,5c	5d	5d	5a,5c,5d	5a,5c	5c							5a,5c									5a,5c
Other Fish																																
Non-targeted prey fish		5b	5b	5b					5b	5b	5b			5b									5b									
Non-targeted predators		5b	5b	5b					5b	5b	5b			5b									5b									
Anthropogenic																																
Fishing gear		1b																														
Trash		1b																														
Spearfishing gear		1c																														
Monofilament		1c																														
Bottom tackle		1c																														
Pelagic tackle		1c																														

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Element 1: Marine Debris Distribution and Abundance**

	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)	**1a, 1b, 1c, 1d**		

Problem Statement/Questions	**Understanding how marine debris from fishing and other human activities affects Gray's Reef resources requires assessment of the spatial distribution of debris, and the abundance of the various gear and trash types present in the area.**
Objectives	**Build on plans to conduct a marine debris assessment in the sanctuary, both within and outside the research area. Sampling should include immediately post-fishing tournament, even though the tournament is for pelagic fish. The study would also benefit from data on location of vessel during tournaments and at other times.**
Statistical Design (describe)	**Probablistic, randomly stratified across habitats, excluding sand habitats and distinguishing between various strata along ledges**
Variables of Interest or other Information Needs	**Distribution and frequency of occurrences within and among ledges, for each gear type and other trash types**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)	x	x	x				x	x	x			

	Days	Weeks	Months
Annual Field Needs	**10**		

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval			x			

	Type	Where	Time Period	Collector	Availability
Existing Information	**Kendall report**	**NOAA**		**Matt Kendall**	**Yes**

	Partner	Roles (e.g., on-going, field surveys, data analysis)
Partners & Roles	**Team Ocean Divers** **NOAA/NCCOS/Biogeography**	**Majority of field work** **Data analysis**

Support Requirements (e.g., equipment types, vessels)	**Vessel support, dive support, dive gear, and cameras from sanctuary**

	0-10	<25	<50	<75	<100	>100
Annual Cost (K)	x					

	1	2	3	4	5	>5
Time to Complete (years)			x			

Additional Comments	**Use of radar data to track vessel activity would provide use data to correlate with debris.**

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Element 2: Entanglement Impacts of Lost Gear**

	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)	**1a, 1c, 1d**		

Problem Statement/Questions	**Understanding how marine debris from fishing and other human activities affects Gray's Reef resources requires assessment of the effects of gear on individual organisms, and the potential for recovery after injury.**
Objectives	**This study would involve tracking the survivorship and recovery rates of animals entanged in fishing gear (either actual or intentional). It would record the severity of injury by various fishing gear types, the fate of entangled colonies, and the rate of recovery of colonies from which gear is removed. Focal species would include *Oculina* and gorgonian corals**
Statistical Design (describe)	**Time series at permanent stations with manipulations, or opportunistic station with pre-entangled animals, with repeated observations to assess fate**
Variables of Interest or other Information Needs	**Changing animal condition over time for entangled and disentangled animals for each gear type encountered**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)												

	Days	Weeks	Months
Annual Field Needs	**7**		

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval	**x**					

	Type	Where	Time Period	Collector	Availability
Existing Information	**Kendall work**	**NOAA/NCCOS**		**Matt Kendall**	**Yes**

	Partner	Roles (e.g., on-going, field surveys, data analysis)
Partners & Roles	**Team Ocean Divers** **REEF**	**Majority of field work** **Locating fouled colonies**

Support Requirements (e.g., equipment types, vessels)	**Vessel support, dive support, dive gear, and cameras from sanctuary**

	0-10	<25	<50	<75	<100	>100
Annual Cost (K)	**x**					

	1	2	3	4	5	>5
Time to Complete (years)			**x**			

Additional Comments	

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Effects of Changes in Fish Foraging Pressure on the Composition of Infaunal and Epifaunal Benthic Invertebrate Communities**

	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)	**3a, 3b, 4a, 4b**	**3a, 3b, 4a, 4b**	

Problem Statement	**A number of benthic communities may exhibit changes as a result of closing even a small area to fishing. These may include infauna, epibenthos, and cryptofauna, any or all of which may show changes in distribution, abundance, or size, among other characteristics. These changes can, in turn, influence habitat characteristics, including structure and chemistry.**
Objectives	**1) Characterize and quantify changes the benthic community structure resulting from shifts in fish foraging pressures after creation of the research area; 2) Assess changes in softbottom seafloor microhabitats (e.g. biogenic structures and geochemical characteristics) resulting from shifts in benthic community structure; 3) assess changes in hardbottom topographic complexity that result from changes in sessile macroinvertebrates.**
Statistical Design (describe)	**Repeated sampling at fixed stations inside & outside the research area, with replication**
Variables of Interest or other Information Needs	**Species composition and abundance per unit area; biogenic structure (observations and/or photographs), geochemistry, and topographic complexity**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)	X	X	X	X	X	X	X	X	X	X	X	X

	Days	Weeks	Months
Annual Field Needs		**2**	

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval	**initially**		**X**			

	Type	Where	Time Period	Collector	Availability
Existing Information	**Kendall et al; Gleason, Hyland (infauna), Alexander (geology)**				

	Partner	Roles (e.g., on-going, field surveys, data analysis)
Partners & Roles	**GSU** **NCCOS** **SKIO**	

Support Requirements (e.g., equipment types, vessels)	**Foster, Ferguson**

	0-10	<25	<50	<75	<100	>100
Annual Cost (K)						**X**

	1	2	3	4	5	>5
Time to Complete (years)						**X**

Additional Comments	***significant*** **post-processing time**

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Fishery Dependent Creel Survey**

	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)			**5a 5c 5e**

Problem Statement/Questions	**It is important to know the level of fishing mortality from fishing activities in GRNMS, both prior to and after the establishment of the research area. This will allow investigators to more accurately interpret the results of studies conducted both areas.**
Objectives	**Determine fishery catch and effort prior to and after designation of research area.**
Statistical Design (describe)	**Possible approaches would involve creel surveys, questionnaires, observations, volunteer monitoring fishermen (sentinel/volunteer program), law enforcement reporting, remote sensing, and acoustic sensing.**
Variables of Interest or other Information Needs	**Determine what is landed, caught, released, discarded, or used at sea (i.e., bait). What is the total amount of catch per person, per hour/per trip, and per gear/method, by location (inside the sanctuary and outside)? What is the level of related lost tackle/"break offs"? The latter would support the marine debris project.**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)	x	x	x	x	x	x	x	x	x	x	x	x

	Days	Weeks	Months
Annual Field Needs	**TBD**	**TBD**	**TBD**

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval	**quarterly**				**TBD**	

	Type	Where	Time Period	Collector	Availability
Existing Information	**existing socioeconomic surveys**	**in house**	**1999-present**	**NMSP and others**	**yes**

	Partner	Roles (e.g., on-going, field surveys, data analysis)
Partners & Roles	**NOAA OLE, GADNR, volunteers, students, interns, tournaments, fishing clubs/CCA,**	**ongoing (LE partners); NMSP (OMB survey); informal/outside surveys (volunteers, interns, CCA); NOAA Fisheries (MRFSS)**

Support Requirements (e.g., equipment types, vessels)	**satellite data; NMSP personnel; survey instruments; vessels et al; computing/data analysis; volunteer support/recognition**

	0-10	<25	<50	<75	<100	>100
Annual Cost (K)				x		

	1	2	3	4	5	>5
Time to Complete (years)		x				

Additional Comments	**ongoing; explore use of MRFSS data with financial support to NOAA Fisheries**

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Diver Visual Fishery Independent Survey**

	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)		**5a, 5b, 5e**

Problem Statement/Questions	**Assuming current fishing affects reef fish populations, one would expecting changes in abundance, species composition, and size structure of the community with the implementation of research area. Over time, these changes would provide a reasonable estimate of the extent to which current fishing affects the community.**
Objectives	**Track populations and other characteristics of of targeted and non-targeted fish species, both inside and outside Research Area**
Statistical Design (describe)	**Stratified random design with habitat-based strata, both inside and outside research area**
Variables of Interest or other Information Needs	**Number and length of all fish by species; habitat characteristics (e.g. ledge height); conduct power analysis of current Kendall method for select species; use design-based statistics; avoid binning - record to closest centimeter.**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)	**~10**	**~10**	**~10**	**~10**			**~30**	**~30**	**~30**	**~30**		

	Days	Weeks	Months
Annual Field Needs	**20 - (2 person team)**		

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval	**Max**		**Min**		**3x per year**	

	Type	Where	Time Period	Collector	Availability
Existing Information	**REEF; Kendall**	**Gray's Reef**	**2000-Present**		

	Partner	Roles (e.g., on-going, field surveys, data analysis)
Partners & Roles	**NCCOS; REEF**	

Support Requirements (e.g., equipment types, vessels)	**Vessel support, dive support, dive gear, and cameras from sanctuary**

	0-10	<25	<50	<75	<100	>100	
Annual Cost (K)				**X**			Larger "startup" and reduced costs in outyears

	1	2	3	4	5	>5
Time to Complete (years)						**X**

Additional Comments	**Design will focus on a few selected species, including black sea bass. Allocation of samples among strata based on stratum size, variance of target species, and overall precision goal; can use data from previous studies to conduct analyses.**

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Tagging of Fishes to Determine Movements in Relation to Closed Fishing Area**

	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
Question(s) addressed (e.g. 1b, 5a)			**5d**

Problem Statement	**It is important to understand how reef fish move in order to determine the extent to which closing an area to fishing affects observations within studies of human impacts on the fish community. For example, observations of species with large home ranges within a small study area may yield little information about human impacts that are controlled within that area. This project will evaluate site fidelity and its effects on studies with the research area and provide information about the dynamics of populations within what is, in effect, a small marine protected area.**
Objectives/Questions	**What is the daily movement of fish relative to the research area?** **How do movement patterns change with age?** **What are the seasonal/annual patterns of migration?** **Does a closed area on this scale (in this case the research area) exhibit spillover?**
Statistical Design (describe)	**Acoustic tagging within the research area (ideally place receivers within entire research area); acoustic tags on tomtate, red snapper, gag and black sea bass; traditional tagging on black sea bass, red snapper & gag; initiate both inside and outside of research area; 100 acoustic tags (total for all species); 1000 traditional tags (total per species)**
Variables of Interest or other Information Needs	**Black Sea Bass, gag (annual migrations), tomtate, red snapper**

	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
Geography (habitats and # sites)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

	Days	Weeks	Months
Annual Field Needs		**5**	

	Quarterly	Semi-annually	Annually	Bi-annually	Other	
Interval	**Acoustic**		**Traditional**			

	Type	Where	Time Period	Collector	Availability
Existing Information	**MARMAP** **GRNMS Tagging Study - planned**	**SCDNR** **GRNMS/NCCOS**	**1993-2007** **2007-2009**	**SCDNR** **GRNMS/NCCOS**	**Yes**

Partner	Roles (e.g., on-going, field surveys, data analysis)
MARMAP **NCCOS**	**field surveys & data analysis**

Support Requirements (e.g., equipment types, vessels)	**Vessel support (100' minimum for traditional tagging), dive support, dive gear, and traps, receivers and acoustic tags (could use FOSTER for traditional tagging)**

	0-10	<25	<50	<75	<100	>100
Annual Cost (K)						**X**

	1	2	3	4	5	>5
Time to Complete (years)			**acoustic**			**traditional**

Additional Comments	**Costs are inclusive of contracted labor to support data collection & analysis; after year two, costs are reduced significantly - years one and two include significant costs for acoustic tagging effort**

APPENDIX VI

Project Template - GRNMS Study Area Research Program

Title	**Comparative Life History of Fishes in Protected and Fished Areas**

Question(s) addressed (e.g. 1b, 5a)	Sessile Invertebrates	Mobile Invertebrates	Bottom Fish
			5a,b,e

Problem Statement/Questions	**Life history characteristics can be altered by fishing and by closures to fishing. These changes ultimately affect overall productivity in a given area, resulting in community level influences. Understanding these dynamics, and whether they manifest in small closed area like that proposed for Gray's Reef, inform managers about the effectiveness and consequences of their actions. How does fishing and protective management affect life history? How does protection affect the production of fish biomass?**
Objectives	**Compare life history (size and age structure; population fecundity; mortality; feeding habits) in fished and unfished areas. Compare abundance, biomass and length-specific fecundity of fishes in RA to fished area to determine the potential reproductive output of fish populations in a shallow inner shelf live bottom area in the absence of fishing, and what might be exported to fished areas.**
Statistical Design (describe)	**Standard life history/fisheries methods in fished area of sanctuary or nearby live bottom in the region (MARMAP data). Collect length frequency data from unfished area and use age/length keys/existing data to extrapolate age and fecundity from length. Study of feeding in unfished areas may be a problem, but can be done.**
Variables of Interest or other Information Needs	**Length frequency; age structure; size at age and maturity; size/age specific fecundity from existing data or fished area; extrapolate to unfished area using length frequency estimates (visual census). Sex/maturity can be done from blood hormone analyses. Natural mortality can be estimated from length frequency in the absence of fishing.**

Geography (habitats and # sites)	High Ledge Inside	Med Ledge Inside	Low Ledge Inside	Flat HB Inside	Flat Sand Inside	Rippled Sand Inside	High Ledge Outside	Med Ledge Outside	Low Ledge Outside	Flat HB Outside	Flat Sand Outside	Rippled Sand Outside
	X	X	X	X	X	X	X	X	X	X	X	X

Annual Field Needs	Days	Weeks	Months
	60 (5/mo)		

Interval	Quarterly	Semi-annually	Annually	Bi-annually	Other	
					Monthly	

Existing Information	Type	Where	Time Period	Collector	Availability
	Age/length keys; size-specific fecundity	**MARMAP (SCDNR); NMFS Beaufort**	**1970-present**	**SCDNR, NMFS**	**yes**

Partners & Roles	Partner	Roles (e.g., on-going, field surveys, data analysis)
	SCDNR; NMFS Beaufort	**partners, field surveys, data source, data analysis**

Support Requirements (e.g., equipment types, vessels)	**Can be conducted in conjunction with creel survey and MARMAP**

Annual Cost (K)	0-10	<25	<50	<75	<100	>100
						X

Time to Complete (years)	1	2	3	4	5	>5
			X			

Additional Comments	**We have ignored "diver effect"; could have two-tiered closure with fishing excluded and diving allowed in part or initially prior to full closure. This could be a MARMAP deliverable at no cost to NMSP; or funded by NOAA Fisheries (MARFIN) or SAFMC.**