Florida Fish and Wildlife
Conservation Commission

National Park Service
U.S. Department of the Interior

South Florida Natural Resources Center
Everglades and Dry Tortugas National Parks

Implementing the Dry Tortugas National Park Research Natural Area Science Plan

The 3-Year Report

Prepared by the

National Park Service and the

Florida Fish and Wildlife Conservation Commission

2010

Docking, Mooring, Seaplanes, and More

Docking facilities are reserved for park-permitted ferries 10 am to 3 pm daily. Load, unload, and moor vessels only as designated on the public dock and for not over two hours between sunrise and sunset. Overnight mooring to docks or piers is prohibited (except in certain emergencies.) Anchor overnight only within one nautical mile of the fort.

Seaplane approaches, landings, and takeoffs must be within one nautical mile of the fort. Moor seaplanes only in the designated area at Garden Key.

To dump or litter on park grounds or in park waters or to pump holding tanks into park waters is prohibited.

Fishing is prohibited in the Research Natural Area (RNA). Anchoring on sand bottom in the RNA is allowed until mooring buoys are installed.

Warning: Submerged features like coral make navigating in park waters hazardous.

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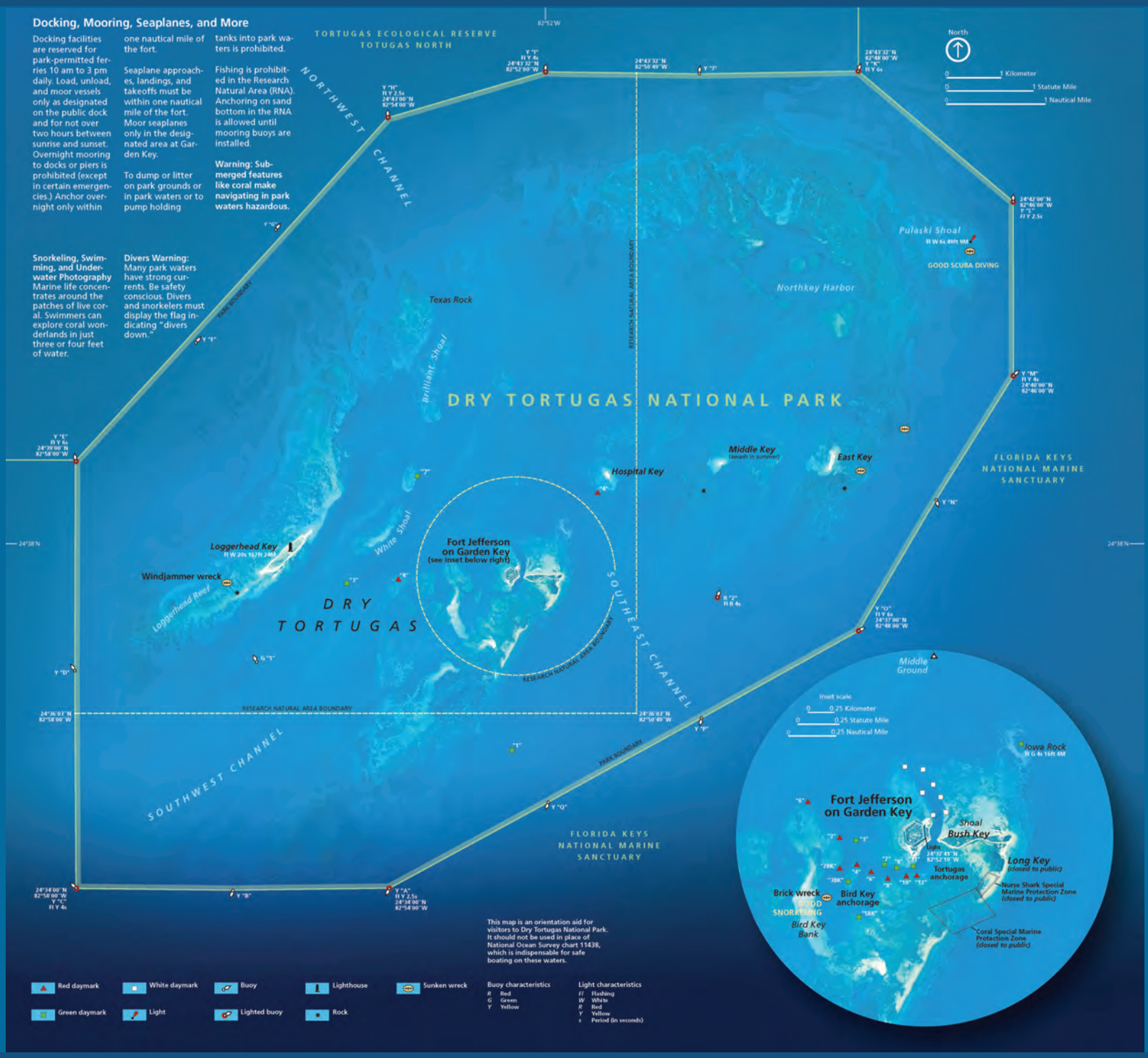
Marine life concentrates around the patches of live coral. Swimmers can explore coral wonderlands in just three or four feet of water.

Divers Warning:
Many park waters have strong currents. Be safety conscious. Divers and snorkelers must display the flag indicating "divers down."



This map is an orientation aid for visitors to Dry Tortugas National Park. It should not be used in place of National Ocean Survey chart 11438, which is indispensable for safe boating on these waters.

Red daymark · White daymark · Buoy · Lighthouse · Sunken wreck
Green daymark · Light · Lighted buoy · Rock

Buoy characteristics
R Red
G Green
Y Yellow

Light characteristics
Fl Flashing
W White
R Red
Y Yellow
s Period (in seconds)

Implementing the

Dry Tortugas National Park

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South Florida Natural Resources Center
Everglades and Dry Tortugas National Parks
Homestead, Florida

National Park Service
U.S. Department of the Interior

Florida Fish and Wildlife Conservation Commission
Tallahassee, Florida

Cover photograph of black grouper by Douglas Morrison, NPS.
Cover satellite photograph of the Dry Tortugas by NOAA.

Implementing the Dry Tortugas National Park Research Natural Area Science Plan: The 3-Year Report 2010

EXECUTIVE SUMMARY

In 2007, the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) developed a science plan, "Assessing the Conservation Efficacy of the Dry Tortugas National Park Research Natural Area," specifically to assess the effectiveness of a 46-mi^2 Research Natural Area (RNA). The Dry Tortugas National Park (DRTO) RNA is a no-take, no-anchoring marine reserve that was implemented to protect shallow water habitats and reef fish species in conjunction with two nearby existing marine reserves, the Tortugas Ecological Reserves, North and South. This three-year interim report summarizes the progress of the science plan activities to date. Progress in implementing the science plan has been facilitated by a number of cooperative relationships between federal and state agencies, academic scientists, and coordination by the FWC and NPS. While the results presented are part of a three-year effort, most contributing scientists went through the process of preparing project proposals and competing for grant funding prior to being able to initiate work. Nevertheless, work has begun on all 6 major topic areas described in the science plan. A total of 18 projects are underway. A summary of progress on each of these projects is provided here.

RNA Topic 1: Quantify changes in the abundance and size-structure of exploited species within the RNA relative to adjacent areas.

Fishery-independent visual assessment of resource status of the reef fish community in DRTO – Jerald S. Ault et al.

In 2008 and 2009, synoptic diver visual surveys were conducted at a number of random sites both inside and outside of the RNA. Divers collected biological and environmental data on reef fishes and associated habitats to serve as a baseline characterization of fish abundance and sizes inside and outside the RNA. After additional surveys are conducted in 2010 and 2011, data will be available to analyze changes in abundance and sizes of a variety of important reef fish species.

Examining the efficacy of the newly established RNA for protecting coral reef fishes within DRTO – Theodore S. Switzer et al.

Seasonal (spring and fall) fish trapping and hook-and-line surveys of reef habitat within DRTO were initiated in 2008 and will continue through 2011. Preliminary results indicate that non-lethal ageing methods may be generally effective for groupers and certain snappers. Numerous exploited reef fishes (primarily yellowtail snapper, lane snapper, red grouper, gray snapper, button snapper, and black grouper) were collected in both the RNA and adjacent open-use area; thus, indicating that the study methodology will be useful to monitor changes in the abundances and size structures of these species.

Characterization of fish assemblages associated with seagrasses within the newly established RNA and adjacent open-use zones at DRTO – Theodore S. Switzer et al.

Fish trapping surveys of seagrass habitat within DRTO were initiated during the spring and fall season in 2009 and will continue through 2010. Juveniles of several exploited reef fishes (yellowtail snapper, red grouper, and black grouper) have been collected in seagrass habitat as have numerous non-exploited fishes. Results from this project may help to capture early benefits for smaller size classes of fish in seagrass habitats.

RNA Topic 2: Monitor the immigration and emigration of targeted species in the RNA.

Fine-scale and net migration patterns of selected reef fish species from the RNA to adjacent fished areas in the DRTO region – Michael W. Feeley et al.

A study was initiated in May 2008 to determine patterns and essential habitat ranges of selected adult snapper and grouper species within the RNA using analysis of movement and habitat use from telemetry data. A total of 26 mutton snapper, 13 black grouper, and 18 yellowtail snapper were acoustically tagged within the RNA and DRTO in 2008 and 2009 and an array of acoustic receivers was deployed. Fish movements inside and outside the RNA may demonstrate the spillover benefits of the RNA in DRTO and throughout the region.

Reef fish movements and flux around the RNA – Nicholas A. Farmer and Jerald S. Ault

An array of hydroacoustic receivers was deployed along the northwestern boundary of the RNA to track movements of acoustically tagged grouper, snapper, and amberjack. Grouper tended to move less frequently than snapper. Home range estimates were made for each species. The study demonstrated that exploitable grouper and snapper crossed RNA boundaries, particularly when the boundaries were in contiguous coral reef habitats or near home range centers.

Use of protected areas by threatened and endangered marine turtles in the Dry Tortugas – Kristin M. Hart

To understand sea turtle movements and habitat use in DRTO, satellite and acoustic tracking of green, hawksbill, and loggerhead turtles were initiated in 2007. Movement data help to characterize the proportion of time tagged turtles spend in various areas of the park, including the RNA, while nesting, feeding, and migrating from one habitat to another. Satellite tracking results are also revealing connections between turtles tagged at DRTO and other nesting and feeding grounds in the Caribbean region.

RNA Topic 3: Monitor changes in species composition and catch rates of exploited species throughout the surrounding region.

Extended creel census development for DRTO – Jerald S. Ault and Steven G. Smith

A study to review the historical creel survey data for DRTO from 1981 to the present was initiated in fall 2009. Historical data will be used to refine the existing creel survey design to help estimate fishery statistics. The improved creel census will be calibrated with data collected through the reef visual census described under RNA Topic 1 and made compatible with the regional Marine Recreational Fisheries Statistics Survey.

DRTO vessel permit system – Dave Walton

A vessel permit system was developed in 2009 to help quantify boating and recreational activities in DRTO. Permit applications will be available online, in Key West, and at DRTO. Data from the permit system will be used to estimate total fishing effort (RNA Topic 3), understand the relative impacts of diving on designated dive sites (RNA Topic 4), and provide information for the social science survey that will be implemented in 2010 (RNA Topic 6).

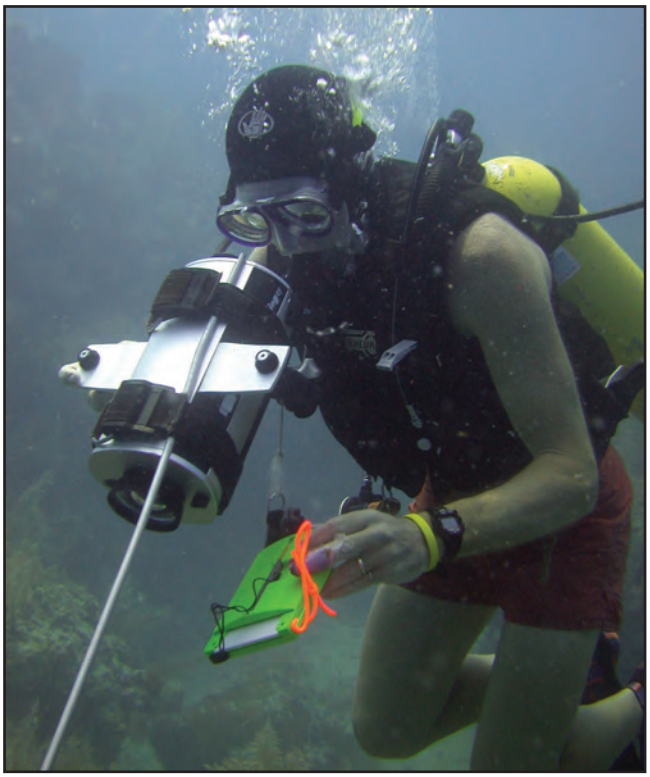
RNA Topic 4: Evaluate the effects of RNA implementation on marine benthic biological communities.

Assessing the effects on corals of SCUBA and snorkeling use at RNA designated (mooring buoy) dive sites – Douglas Morrison et al.

Using underwater video, transects were monitored for stony coral damage and coral loss at four RNA designated dives sites and three reference sites. Monitoring performed in 2009 will serve as a baseline to compare future levels of stony coral damage that may be induced by divers or natural causes. In 2010, mooring buoys will be installed at designated dive sites and the vessel permit system (RNA Topic 3) will be in place to assess total use of designated dive sites and analyze potential correlations between diver use and benthic impacts.

Coral reef community monitoring at Bird Key Reef and sites inside and outside the RNA at DRTO – Jeff Miller et al.

In 2004 and 2005, monitoring was initiated at Bird Key Reef to determine if percent cover of stony corals, algae, octocorals, sponges, coral species diversity, community structure, and rugosity are changing through time. Monitoring was recently expanded to include randomly selected sites inside and outside the RNA. Results will help determine long term trends in benthic cover at Bird Key Reef and random sites inside and outside the RNA.



Coral reef monitoring with underwater video camera. Photo by Rob Waara, NPS-SFCN.

Trophic relationships on coral reefs of DRTO: Inside and outside of the RNA – Ilsa B. Kuffner et al.

A study was initiated to examine the potential impacts of reduced abundance of exploited reef fish species on herbivores, macroalgae, and corals. Surveys were performed inside and outside of the RNA to characterize relationships between different trophic level organisms inhabiting the coral reef ecosystem. Additional surveys will be conducted in 2011 to determine if changes have occurred in the proportions of major coral reef ecosystem components and to help determine if the implementation of the RNA results in balanced benthic communities at DRTO.

Assessing the effects of creating the RNA no-anchor zone on seagrass beds – Douglas Morrison

Because the RNA does not allow anchoring, anchor impacts on seagrass should be minimized. A replicated sampling design with reference sites was implemented to monitor seagrass and macroalgae percent cover. Over time, monitoring results may demonstrate the benefits of no anchoring in maintaining high value seagrass habitats.

RNA Topic 5: Assess reproductive potential of exploited species by evaluating egg production and larval dispersal.

Reproductive potential of exploited reef fishes within the newly established Dry Tortugas RNA and adjacent open-use areas – Theodore S. Switzer et al.

An opportunistic examination of reproductive potential for exploited reef fishes was conducted on specimens obtained through trapping and hook-and-line surveys. To date, there has been no evidence of reproductively-active individuals within the RNA, although the probability of obtaining reproductively-active individuals was limited due to current levels of sampling effort as well as seasonal limitations of existing surveys (late spring and early fall only). The study may be expanded to collect reef fish during winter and early spring to increase the probability of capturing reproductively active animals.

Immigration and emigration of selected reef fish species from the RNA to the Tortugas South Ecological Reserve – Michael W. Feeley et al.

Spatial and temporal rates of movement of acoustically tagged snappers and groupers are being measured to observe movements during annual spawning migrations between Riley's Hump, the Tortugas Ecological Reserves, and DRTO, including the RNA, by a multi-agency managed array of approximately 80 acoustic receivers. Twenty-three mutton snapper, and 8 groupers, including 3 black grouper, 2 Nassau grouper, and 3 red grouper, were acoustically tagged within the Tortugas South Ecological Reserve in 2008 and 2009. Preliminary results indicate a possible corridor exists for the seasonal movements of mutton snapper between the DRTO/RNA and the Tortugas South Ecological Reserve, providing a link between marine protected areas.

Larval transport modeling from the Dry Tortugas – Jerald S. Ault et al.

A physical oceanographic model is being used to study physical transport and fate of reef fish eggs and larvae that are spawned in the DRTO region and transported to other areas of the Florida Keys and south Florida region. The study utilizes the Hybrid Miami Isopycnal Coordinate Ocean Model and information on spawning characteristics, e.g., timing locations, depths, and larval behavior of snapper and groupers species. Future model simulations will explore a full range of physical and biological conditions and results will help demonstrate the benefits of protecting reef fish species and spawning habitats in and around the RNA to fisheries throughout south Florida.

RNA Topic 6: Incorporate social sciences into the research and monitoring program.

A survey of visitor demographics, attitudes, perceptions, and experiences in the RNA – David Loomis

A survey was designed to help managers understand demographics, attitudes, perceptions, and experiences of park resources among visitors who boat, fish, dive, snorkel, and conduct other recreational activities at DRTO. The survey is now in the review process with the Office of Management and Budget. Once approved for use, the survey will be implemented through contacting visitors that received permits (RNA Topic 4) and results will help to improve education and outreach messages, encourage compliance with the RNA regulations, and enable visitors to help protect natural and cultural resources at DRTO.

Law enforcement in DRTO – Dave Walton

DRTO law enforcement staff works to enforce the special regulations associated with the RNA. Recent activities include collaboration with the U.S. Fish and Wildlife Service to stop illegal fishing activities and other illegal activities in the region including the largest lobster poaching case in Florida, "Operation Freezer Burn." Future activities include plans to establish cross deputization between National Park Service and Florida Fish and Wildlife Conservation Commission law enforcement personnel.

Submerged cultural resource condition assessment project – David I. Conlin et al.

Numerous submerged cultural resources exist inside and outside the DRTO RNA. A survey in 2009 relocated over 40 of 50 submerged cultural resources and condition assessments were performed at each site. Work in 2010 will include the investigation of magnetic anomalies and development of more detailed documentation techniques to help provide educational materials and assist in protection of sensitive submerged cultural resources.

Diver conducting visual survey. Red grouper in foreground. Photo by Jiangang Luo, Univ. of Miami/RSMAS.

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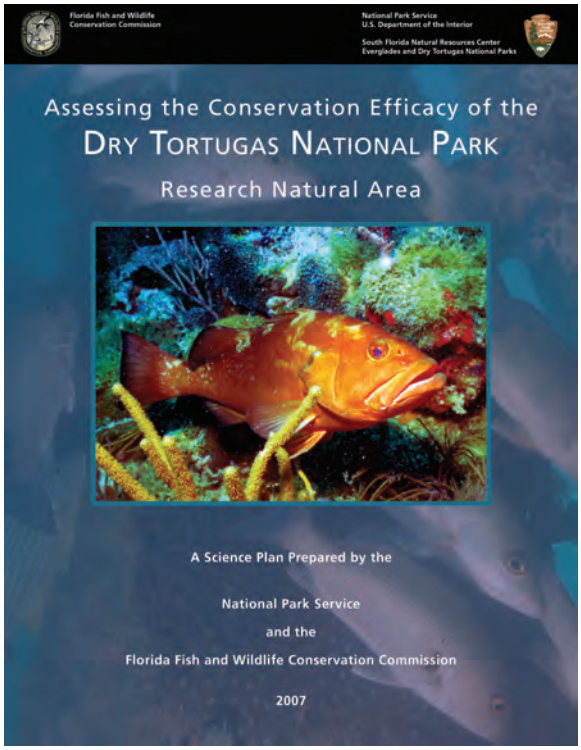

Science activities in the Dry Tortugas National Park Research Natural Area are guided by the science plan prepared in 2007 by the National Park Service and the Florida Fish and Wildlife Conservation Commission.

Comments and Questions on the RNA Science Plan and 3-Year Report:

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INTRODUCTION

In 2007, the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) established the 46-mi^2 Research Natural Area (RNA) of Dry Tortugas National Park (DRTO) and also developed a science plan specifically to assess the effectiveness of the marine reserve. This three-year interim report summarizes the progress of the science plan activities to date.

First established as Fort Jefferson National Momument in 1935, the site was reauthorized in 1992 as a national park. Congress established DRTO to "preserve and protect for the education, inspiration, and enjoyment of present and future generations nationally significant natural, historic, scenic, marine, and scientific values in south Florida." The enabling legislation stipulates that the park be managed to protect, among other values, "a pristine subtropical marine ecosystem, including an intact coral reef community." The RNA marine reserve directly supports the mission of the park as it is designed to restore ecological integrity and capacity for self-renewal by minimizing the effects of human activities on marine resources (see map of RNA on inside cover). Together, the RNA and the larger, adjacent Tortugas Ecological Reserve (TER) of the Florida Keys National Marine Sanctuary (FKNMS) will help to ensure the success of both marine and terrestrial ecosystems (see map of the regional reserve network on the inside back cover), and thereby contribute to a region-wide effort to strengthen resource protection.

The DRTO RNA was established to protect shallow water marine habitat, ensure species diversity, and enhance the productivity and sustainability of fish populations throughout the region. While boating, swimming, snorkeling, scuba diving, hiking, research, and education activities are allowed within the RNA, anchoring and fishing are prohibited.

The NPS and the FWC are committed to working together to conduct research, education, enforcement, and adaptive management of the Dry Tortugas ecosystem. The RNA provides a unique unexploited area that can be used to help assess the effects of fishing on exploited areas. Long-term studies and monitoring will serve to document existing baseline conditions and analyze how park natural resources respond to the protection provided.

The RNA science plan identifies six areas of RNA performance to be evaluated:

1. Quantify changes in the abundance and size-structure of exploited species within the RNA relative to adjacent areas;
2. Monitor the immigration and emigration of targeted species in the RNA;
3. Monitor changes in species composition and catch rates of exploited species throughout the surrounding region;
4. Evaluate the effects of RNA implementation on marine benthic biological communities;
5. Assess reproductive potential of exploited species by evaluating egg production and larval dispersal; and
6. Incorporate social sciences into the research and monitoring program.

Because ecosystems take time to respond to management actions, the developers of the assessment plan have included a variety of indicators that will help evaluate benefits both in short and long time-frames. Natural variability in sea temperature, weather events such as hurricanes, and other factors can affect many of the indicators described in the science plan and thereby have the potential to complicate RNA assessment. The full benefit of the RNA to the Tortugas region will only be measurable in the long-term. Therefore, this initial three-year assessment, reports primarily on progress implementing science projects that begin to monitor baseline conditions. A five-year assessment report will be prepared for release in the spring of 2012.

Black grouper. Photo by Douglas Morrison, NPS.

RNA Performance Topic 1

Fishery-independent visual assessment of resource status of the reef fish community in Dry Tortugas National Park

Investigators

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Project Description

The goal of this study is to monitor and statistically assess coral reef fish resource status (species composition, frequency-of-occurrence, size-structured abundance, and spatial distribution) in Dry Tortugas National Park. The study conducts synoptic diver visual surveys following a statistically robust stratified random sampling design to collect biological and environmental data on reef fishes and their habitats both inside and outside the Research Natural Area (RNA) in the park. Spatial and temporal trends in estimates of species-specific abundance metrics (e.g., occurrence, density, abundance, biomass, size composition) and fish community metrics (e.g., species diversity) are then statistically evaluated from surveys conducted before and after implementation of the RNA.

Accomplishments

Intensive sampling surveys were conducted in spring-summer of 2008 and 2009, one and two years post-implementation of the RNA. Divers using SCUBA collected biological data following a standard, non-destructive, and in-situ monitoring protocol in which a stationary diver records reef-fish data while centered in a randomly selected circular plot 15 m in diameter. The field research team was comprised of scientific personnel from NOAA Fisheries, the University of Miami, the National Park Service, and the State of Florida. The statistical field design partitioned Dry Tortugas National Park into subregions or strata based on reef habitat characteristics (i.e., complexity and patchiness of reef structures, depth) and spatial management zones (i.e., inside and outside the RNA). This habitat-based survey design was developed in 1999 and 2000, and has been shown to provide accurate and precise abundance metrics for reef fishes in the Tortugas region in a cost-effective manner. In 2008, 392 stations (i.e., statistical observations) were sampled, and 409 stations were sampled in 2009 (one station represents the pooled stationary plot counts for a buddy-pair of scientific divers). Sample sizes ranged from approximately 200-350 per survey conducted in 1999-2000, 2002, 2004, and 2006, prior to implementation of the RNA.

Gray angelfish, red grouper, and a bluehead wrasse swim beside great star coral in Dry Tortugas National Park. Photo by Jiangang Luo, Univ. of Miami/RSMAS.

Preliminary Results

In theory, establishment of a no-take marine reserve such as the RNA should reduce fishing pressure on exploited species, resulting in increases in relative abundance of fishes in the exploited life phase (i.e., individuals larger than the minimum legal length of capture) inside the reserve as compared to areas outside the reserve. For long-lived species such as snappers and groupers, these changes in abundance and size/age-structure are expected to take 10 to 20 years to reach their full potential. However, our previous research in the Florida Keys and Dry Tortugas regions has been able to statistically detect these changes in as little as 3 to 5 years after reserve implementation.

As an example, preliminary results are shown in Figures 1 and 2 for red grouper (*Epinephelus morio*), a highly prized species by both commercial and recreational fishers. For the pre-exploited life phase (length<50 cm), average density (number per unit area) has been stable since 2004, but appears to have declined somewhat from the 1999-2002 period (Fig. 1, top panel). Abundance of pre-exploited animals generally depends on the status of the spawning stock along with general environmental conditions. For the exploited life phase (>50 cm), average density fluctuated to some extent inside and outside the RNA prior to implementation in 2007 (Fig. 1, bottom panel). Post-implementation, densities were not statistically different inside and outside the RNA, but the average has been consistently higher inside the RNA compared to outside. The proportion of individuals larger than 50 cm, the legal minimum capture size, has also generally increased throughout the park post-implementation of the RNA, with an even higher proportion of exploited phase red grouper inside the RNA in 2009 compared to outside (Fig. 2). Although our results are not conclusive at this early stage of RNA establishment, the changes in relative abundance and size structure for red grouper seem to be moving in the expected direction.

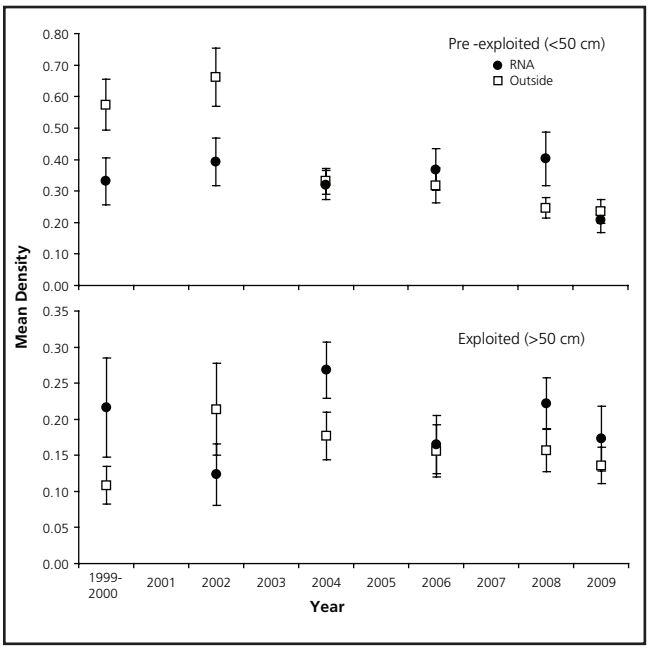

Figure 1. Visual survey time-series of red grouper mean density and associated standard error inside (dark circles) and outside (white squares) the RNA in Dry Tortugas National Park for pre-exploited (top panel) and exploited (bottom panel) life phases. The RNA was established in 2007.

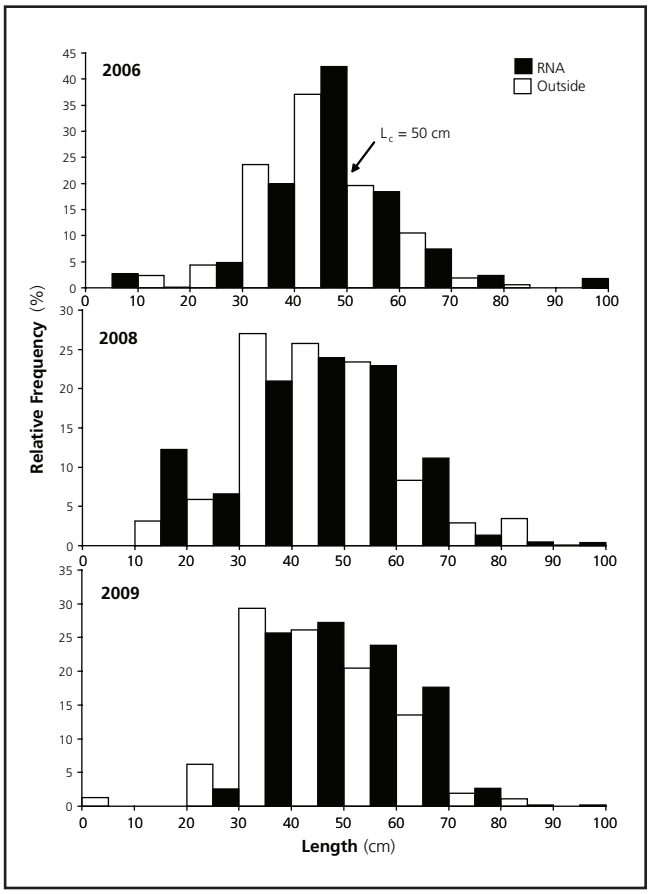

Figure 2. Relative length-frequency histograms for red grouper inside (dark bars) and outside (white bars) the RNA in Dry Tortugas National Park for surveys conducted in 2006, 2008, and 2009. The RNA was established in 2007. L_c denotes the minimum legal capture length.

Future Work

A robust monitoring and assessment program has been firmly established to track changes, should they occur, in reef fish species abundance and community metrics in response to implementation of the RNA in Dry Tortugas National Park. An intensive 20-day regional cruise of visual surveys is scheduled for the Tortugas during spring-summer 2010. Cruises should also occur in 2011 and 2012 to ensure that the final analyses are rigorous and detect all possible states of regional resource condition and ultimately determine the effectiveness of the RNA in building a sustainable recreational reef fishery within the park. In addition, complementary analyses will be conducted to compare the state of park resources with those of the broader Tortugas region, and the entire south Florida coral reef ecosystem.

RNA Performance Topic 1

Examining the efficacy of the newly established Research Natural Area for protecting coral reef fishes within Dry Tortugas National Park

Investigators

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Project Description

This study was designed to address explicitly several priority research areas identified by the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) in the Research Natural Area (RNA) science plan, including (1) the implementation of a stratified-random sampling survey using baited fish traps and hook-and-line gear to evaluate changes in the relative abundance, frequency of occurrence, and size structure of exploited reef fishes within the RNA and adjacent open-use areas, (2) the development of an external tagging study to monitor broad-scale ingress/egress of exploited reef fishes across RNA boundaries, and (3) the examination of size-age structure of exploited reef fishes within the RNA and adjacent open-use areas. Sampling methods follow a seasonal (spring and fall) stratified-random survey (SRS) approach within the southern portion of Dry Tortugas National Park (DRTO) (south of 24° 40' N; Fig. 1) in which sampling effort is randomly allocated among three generalized reef habitat types (isolated reef, continuous reef – spur and groove, continuous reef – non-spur and groove) common to both the RNA and adjacent open-use areas. At each sampling station, a survey of structure-oriented fishes is conducted through the use of baited chevron traps; an ancillary hook-and-line survey targeting exploited reef fishes is also conducted at a subset of trapping sites. Each individual collected is identified, enumerated, and measured. For exploited reef fishes, a small number of individuals (n = 10 per family per season) are sacrificed for life-history studies; the remainder are implanted with an external dart tag prior to release. Data from seasonal SRS trapping surveys will be used to compare overall community structure between the RNA and open-use areas as well as among habitat types. Data from both the SRS trapping and hook-and-line surveys will be used to compare abundance, frequency of occurrence, size structure, and habitat use of exploited reef fishes between the RNA and open-use areas. Data from life-history studies will be used to validate non-lethal ageing methods and conduct comparisons of age-structure for exploited reef fishes between the RNA and open-use areas. In addition, this study will provide data that can be compared to the reef visual census techniques that are also being used to understand changes in abundance and size structure of exploited reef fish species in the RNA.

Accomplishments

To date, seasonal stratified-random surveys, using both baited chevron traps and hook-and-line gear, were successfully conducted during both spring and fall in 2008 and 2009. In 2008, trapping surveys were conducted at a total of 112 stations including 58 stations within the RNA and 54 stations within adjacent, open-use areas of DRTO. Hook-and-line surveys were conducted at a total of 65 stations, including 30 stations within the RNA and 35 stations within open-use areas. In 2009, trapping surveys were conducted at a total of 121 stations, while hook-and-line surveys were conducted at a total of 57 stations.

Red grouper. Photo by Douglas Morrison, NPS.

Preliminary Results

During 2008, a total of 3,392 individuals was collected, including 1,784 within the RNA and 1,608 within open-use areas. Among exploited reef species, the most frequently collected taxa in the trapping surveys were yellowtail snapper, lane snapper, red grouper, and gray snapper. Within hook-and-line surveys, 522 individuals were collected, including 209 within the RNA and 313 within open-use areas. Among exploited reef species, the most frequently collected taxa in the hook-and-line surveys were yellowtail snapper, red grouper, mutton snapper, and black grouper. In 2008, a total of 2,641 individuals was tagged with external dart tags and released, including 1,200 within the RNA and 1,441 within open-use areas. Preliminary results indicate that non-lethal ageing methods may be effective at ageing groupers collected within DRTO. Results from non-lethal ageing methods have been mixed for snappers and will require additional data before making definitive conclusions. Data entry and processing for 2009 data are ongoing at present; therefore preliminary results from 2009 are unavailable.

Future Work

Stratified-random trapping and hook-and-line surveys will be conducted in the RNA and open-use areas in spring and fall during both 2010 and 2011. We will continue to tag released individuals. During future sampling, continued effort will be directed toward informing recreational anglers of our reef-fish tagging program with the hopes of increasing the numbers of recaptured individuals reported by recreational anglers. We will also begin to conduct more comprehensive and rigorous statistical analyses of collected data to compare habitat-specific community structure, size structure, and catch rates between the RNA and open-use areas.

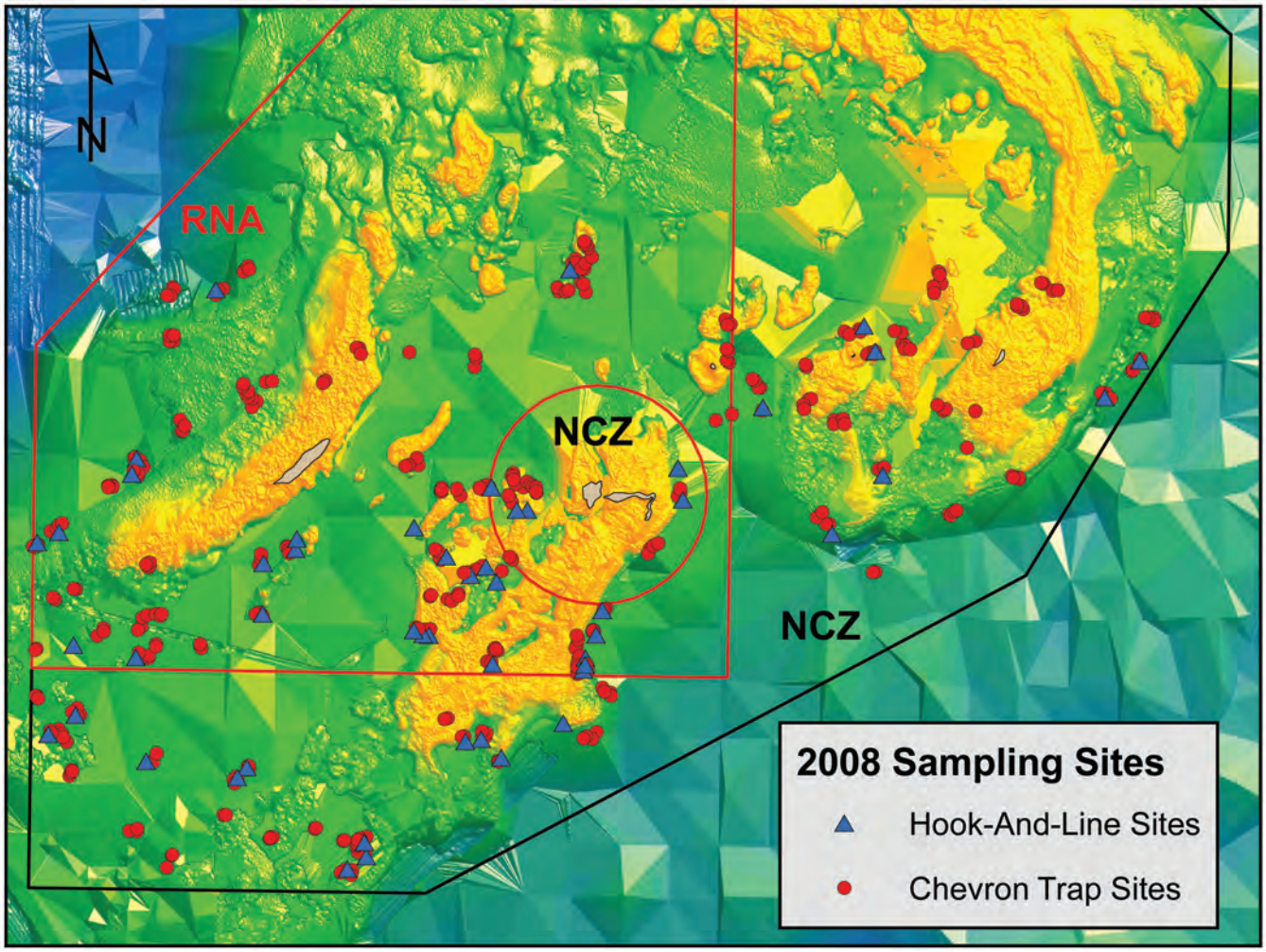

Figure 1. Hook-and-line and fish trap sampling sites during fall 2008.

RNA Performance Topic 1

Characterization of fish assemblages associated with seagrasses within the newly established Research Natural Area and adjacent open-use zones at Dry Tortugas National Park

Investigators

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Project Description

This project is designed to fill acknowledged data gaps regarding fish assemblages associated with seagrasses within Dry Tortugas National Park (DRTO). The primary objective of the study is to characterize community structure of seagrass-associated fish within the DRTO Research Natural Area (RNA) and adjacent open-use areas. The newly established RNA is the first protected area established in the DRTO region to offer direct protection to seagrasses, a habitat known to support numerous resident and transient fishes. The relative contribution of these protected seagrass areas related to recruitment of reef-associated fish is currently understudied in the Dry Tortugas. Additionally, baseline data from which long-term changes in community structure in association with the establishment of the DRTO RNA will be assembled. Potential benefits of the RNA would likely first be detectable in either the recruitment of reef fishes or alternately trophic cascades; accordingly, it is critical to obtain baseline data for these smaller individuals as soon as possible following the 2007 establishment of the DRTO RNA. Sampling methods follow a seasonal (spring and fall) stratified-random survey approach within the southern portion of DRTO (south of 24° 40' N; Fig. 1) in which sampling effort is randomly allocated to areas of known seagrass within both the RNA and adjacent open-use areas. At each sampling station, a survey of seagrass-associated fish is conducted through the use of baited Antillean Z-traps. Each individual collected is identified, enumerated, and measured. Data from these seasonal surveys will be used to compare overall community structure as well as habitat use by exploited reef fishes associated with seagrasses within the RNA and adjacent open-use areas.

Accomplishments

In spring 2009, we conducted an exploratory survey to test the utility of two sampling alternatives that were chosen based on minimizing the potential for damage to seagrass and associated coral habitat: a small diver-deployed seine (DDS) and Antillean Z-traps. The DDS has been used effectively in collecting structure-oriented fishes associated with kelp forests along the Oregon coast, while Antillean Z-traps have been used effectively in monitoring structure-oriented assemblages in Australia. A total of 26 stations was sampled in spring 2009, including 12 within the RNA and 14 within open-use areas. Preliminary results indicated that the DDS was ineffective at capturing seagrass-associated fish in the clear Dry Tortugas waters. The Antillean Z-traps were much more effective, capturing juveniles of several exploited reef fish taxa (black grouper, red grouper, and yellowtail snapper) along with numerous other fishes. Beginning in fall 2009, sampling was conducted solely with the use of Antillean Z-traps, although additional effort was allocated among shallow (less than 10 m deep) reef sites to compare relative abundances between seagrass and reef habitats. During fall sampling, we sampled 14 seagrass stations within the RNA, 12 seagrass stations within open-use areas, and 10 reef stations.

Preliminary Results

Data entry and processing for 2009 data are currently ongoing. Qualitatively, catches were greater during fall than spring and have been dominated numerically by yellowtail snapper, slippery dicks, and white grunt. In addition, Z-traps have collected numerous red grouper and graysby.

Future Work

Stratified-random trapping surveys will be conducted in seagrass and shallow reef habitats in the RNA and open-use areas in spring and fall 2010. We will also begin to conduct more comprehensive and rigorous statistical analyses to compare habitat-specific community structure and catch rates between the RNA and open-use areas. This project will assess the value of seagrass habitat for juvenile fishes in DRTO.

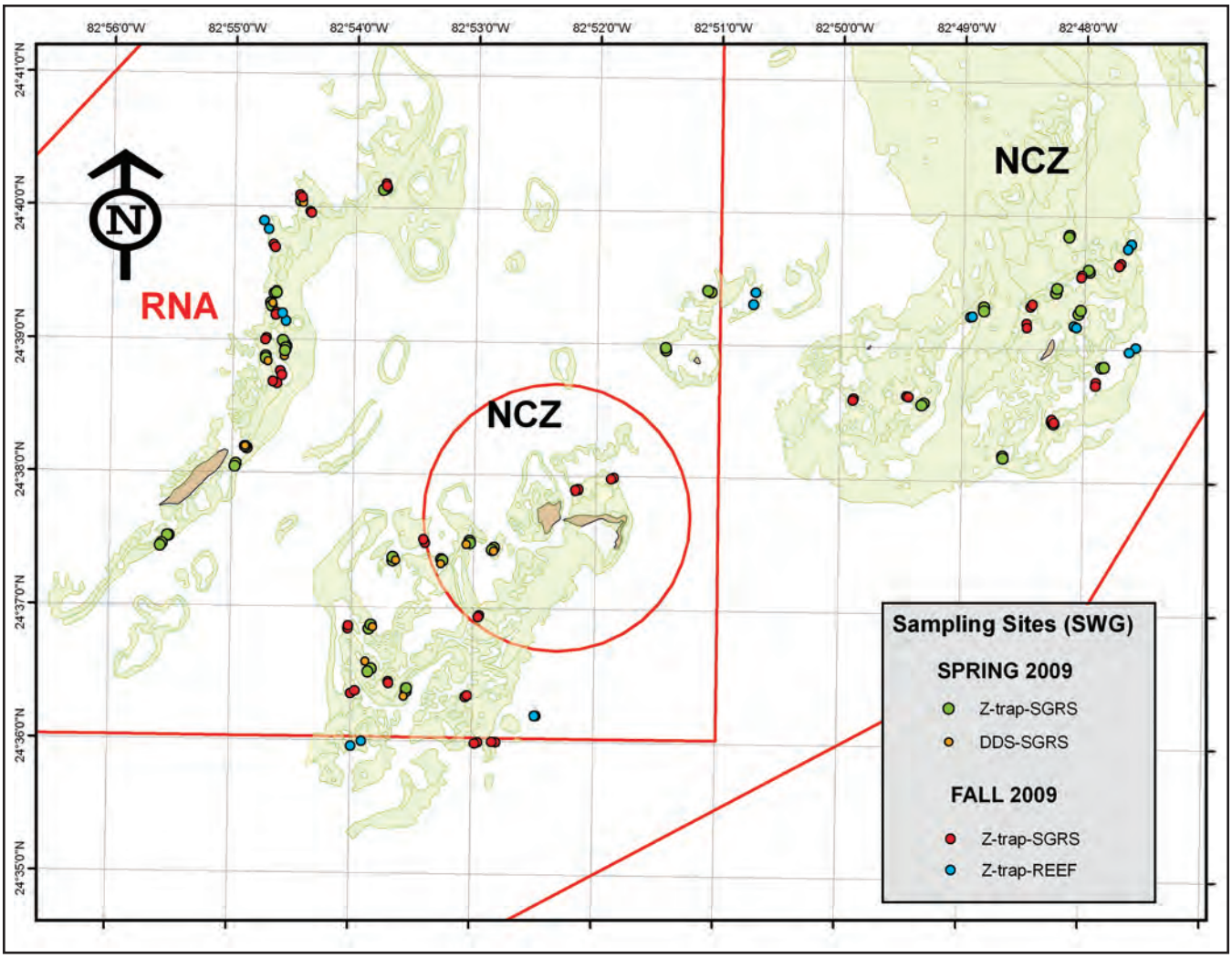

Figure 1. Fish assemblage sampling sites within seagrass and reef habitats, spring and fall 2009.

Yellowtail snapper and school of silverside fish. Photo by Douglas Morrison, NPS.

RNA Performance Topic 2

Fine-scale and net migration patterns of selected reef fish species from the Research Natural Area to adjacent fished areas in the Dry Tortugas National Park region

Investigators

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Project Description

The first marine protected area in the Florida Keys was established in 1963. Since then, numerous protected areas have been established and these are widely recognized as valuable tools in an ecosystem-based approach to marine resource management. However, to establish biologically relevant boundaries and eventually define management benefits, the scale on which ecological processes function must be determined. Therefore, a study using analysis of movement and habitat use from telemetry data was initiated in May 2008 to determine patterns and essential spatial range of selected adult snapper and grouper species. Ongoing research efforts are focused in the southern half of Dry Tortugas National Park (DRTO; south of 24º 40' N) with an array of Vemco VR2 receivers positioned in the southeastern corner of a newly established no-take marine reserve, the Research Natural Area (RNA), including coverage within both the RNA and adjacent open-use areas (Fig. 1). The receiver array covers a total area of approximately 10 km^2 and is centralized along the low-relief/high-relief spur and groove habitat within and adjacent to the southeastern corner of the RNA, a habitat known to support a rich and diverse assemblage of exploited reef fishes. This low-relief and high-relief spur and groove habitat borders low-relief hard bottom and seagrass habitats to the northwest and sand habitat to the south, allowing for the examination of fine-scale patterns of habitat use among a variety of habitats. Additionally, the array comprises both a western and an eastern component separated by a deep (30 meters sea water) sand plain. The area covered by the western component of the array straddles both the RNA and adjacent open-use areas of the Special Use Zone (SUZ) and southern Natural Cultural Zone (NCZ), while the eastern component is concentrated within the eastern NCZ and adjacent sand plain. Combined, these two components will allow us to examine fine-scale rates of movement across RNA boundaries as well as test for potential movement across two separate RNA boundaries: one with a natural barrier and another with uninterrupted contiguous habitat.

Accomplishments

Thirty-two VR2 acoustic receivers were placed in DRTO, within and outside the borders of the RNA in May 2008. Receivers were deployed using a subsurface buoy system to minimize the probability of receiver loss. These receivers were first downloaded and redeployed in October 2008. Following the passage of Hurricane Ike in September 2008, all receivers were recovered with the exception of those located along RNA boundary lines in less than 15 m of water. These stations were subsequently repositioned in deeper water (greater than 20 m) and 100%of all receivers were downloaded and redeployed in May and October 2009. Selected reef fish were caught by hook-and-line or fish trap within DRTO and the RNA and surgically implanted with coded transmitters (Vemco V9 or V16) in May and October 2008 and 2009. This study is complemented by ongoing research being conducted by Mote Marine Laboratory, the U.S. Geological Survey, and Florida Fish and Wildlife Conservation Commission that includes: a nurse shark project (Principal Investigator (PI): Dr. W. Pratt/Mote); a sea turtle project (PI: Dr. K. Hart/USGS) and our spawning aggregation project (see RNA Topic 5). We are coordinating closely with these organizations with respect to exchange of data obtained from the various arrays. These complementary studies extend regional coverage to the east and north within DRTO and throughout the region, including the Tortugas North Ecological Reserve (TNER) and the Tortugas South Ecological Reserve (TSER), located 25 km southeast of Garden Key.

Mutton snapper. Photo by Douglas Morrison, NPS.

Preliminary Results

A total of 26 mutton snapper (*Lutjanus analis*), 13 black grouper (*Mycteroperca bonaci*), and 18 yellowtail snapper (*Ocyurus chrysurus*) was acoustically tagged within the RNA and DRTO in 2008 and 2009. The telemetry database is currently under review and will be used to elucidate fine- and broad-scale habitat utilization patterns. We are tracking a significant number of mutton and yellowtail snapper; however, we presently can account for only 3 of the total black grouper tagged within the array. Preliminary analyses in 2008 determined that one mutton snapper tagged inside the RNA migrated 25 km during a 10-day period. This fish returned to the RNA after it was detected on a receiver approximately 6 km east of the TSER. An array of offshore receivers established at Riley's Hump, within the TSER, later confirmed that mutton snapper tagged within DRTO and the RNA repeatedly undertake seasonal spawning migrations to the TSER. The final measure of conservation benefits of the RNA likely will depend on data collected with acoustic receivers throughout the region in order to understand fully the spatial patterns and habitat utilization of selected species within the region.

Future Work

We will continue our acoustic tagging efforts within DRTO and the RNA through May 2010. Although extensive efforts are ongoing to describe habitat utilization patterns across protected and non-protected zones through spatially explicit randomized sampling designs, life history and seasonal movement patterns still remain to be determined. During 2010, additional field efforts will be directed toward acoustically tagging black grouper to complement static habitat utilization studies (PI. T. Switzer/FWC; PI. J. Ault & J. Bohnsack/UMiami & NOAA) and our acoustic spawning aggregation study (see RNA Topic 5). Since multi-year transmitters were implanted in fish, we will continue to download data semiannually on receivers through 2011. Data analyses will establish the degree of connectivity between habitats and the network of management areas in the Dry Tortugas and determine the efficacy of current management zones on commercially and recreationally valuable reef fish. Data collected on fish species from DRTO and the RNA will be evaluated from a seascape perspective at a scale appropriate to regional ecosystem processes.

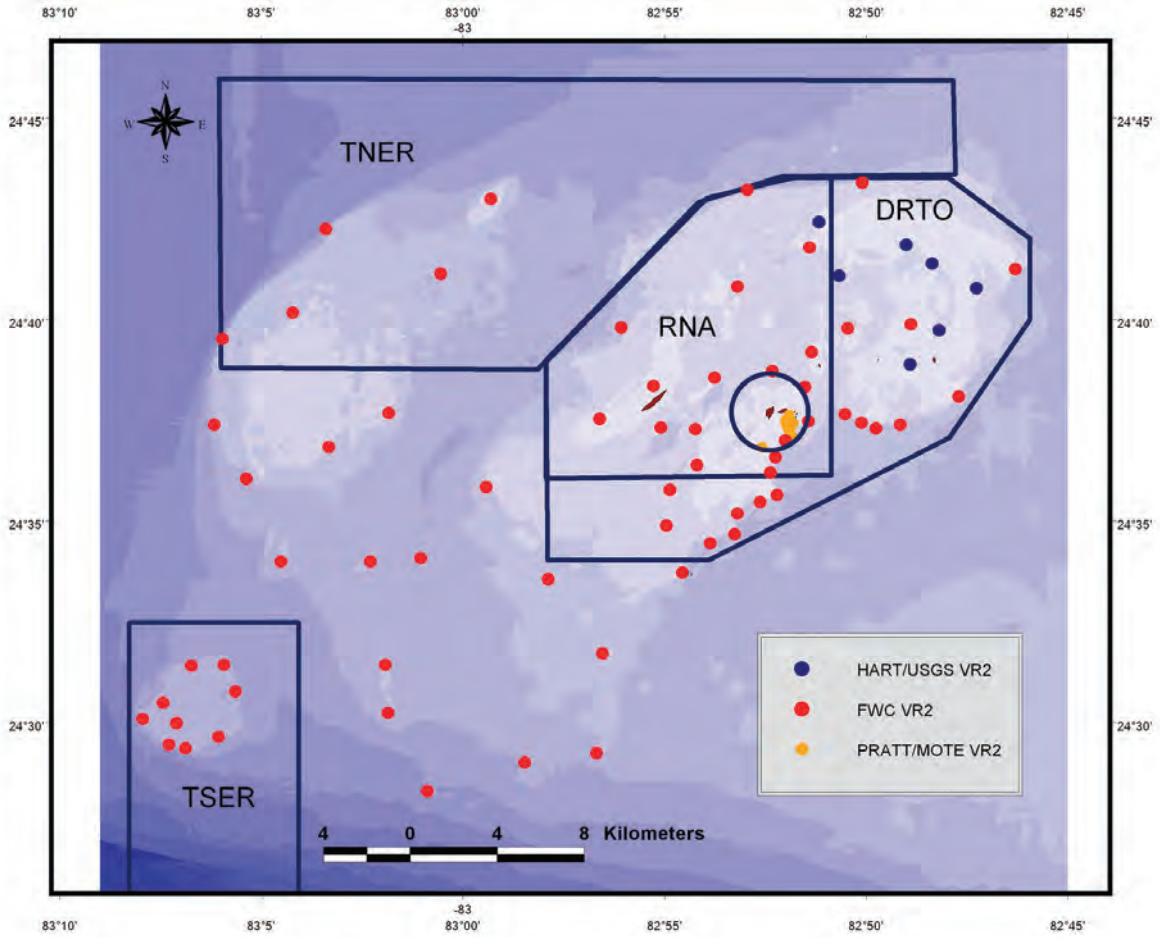

Figure 1. Locations of acoustic receivers in the Dry Tortugas region during summer 2009.

RNA Performance Topic 2

Reef fish movements and flux around the Research Natural Area

Investigators

Nicholas A. Farmer and Jerald S. Ault

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Project Description

Quantifying reef fish movement patterns and space use is critical in determining the effectiveness of no-take marine reserves (NTMR) in conserving adult spawning stock biomass for subsequent recruitment, and providing exploitable biomass to adjacent fisheries areas. Movements of exploited coral reef fishes are largely unknown, but knowledge of the distance and frequency of movement in and out of reserves is essential for management decision-making. To better understand population flux for exploited reef fishes and evaluate the contention that reserves are a sink for fisheries production, a multi-year acoustic telemetry study was conducted in the Research Natural Area (RNA) of Dry Tortugas National Park. Empirical data on long-term movement patterns and space requirements are essential in assessing resource protection and to account for the scale of animal movements and the locations of core habitats that may lead to high levels of spillover that prevent the reserve from functioning effectively as a buffer against fishing mortality.

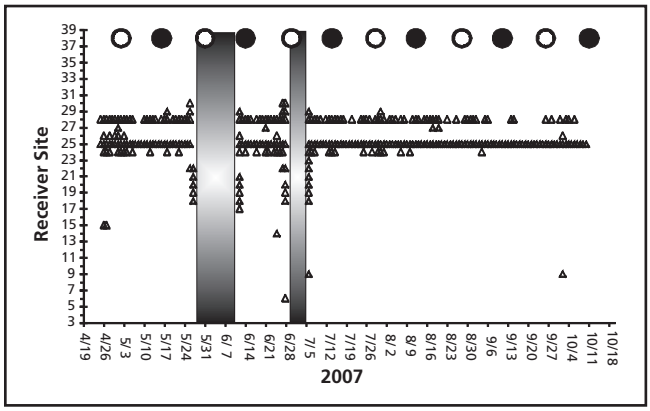

Figure 1. Acoustic receiver detections by site (triangles) during 2007 for a sexually-mature mutton snapper tagged on April 25, 2007, relative to new (closed circles) and full (open circles) moon periods. Note lack of detections (shaded vertical bars) between May 27 and June 13, and then again during June 28 – July 6. Also of interest is the great amount of movements detected prior to and immediately following apparent spawning migrations, relative to the remainder of the tracking days.

Accomplishments

A calibrated array of 75-80 omnidirectional hydroacoustic receivers were used to examine home range, activity patterns, site fidelity, and habitat preferences for acoustically-tagged adult reef fish in Dry Tortugas National Park. The receiver array was located near the northwestern section of the RNA and covered about 50 km^2. Acoustic tagging included black grouper (*Mycteroperca bonaci*), red grouper (*Epinephelus morio*), mutton snapper (*Lutjanus analis*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chyrsurus*), tiger shark (*Galeocerdo cuvier*), and greater amberjack (*Seriola dumerili*).

Preliminary Results

In general, grouper movements detected in this study were relatively small and infrequent, whereas mutton snapper and yellowtail snapper moved more frequently, and the gray snapper made daily movements associated with an apparent nocturnal migration. Relative frequency of detected movement varied between species. Distances moved, presented here as mean distance with standard errors (SE), varied significantly between species, with significant ($p < 0.001$) differences for all interspecies comparisons except for red grouper and mutton snapper. The majority of yellowtail snapper (mean: 137.5 ± 0.11 m) movements were less than 400 m in distance. The majority of movements by black grouper (mean: 210.71 ± 0.35 m), red grouper (mean: 400.63 ± 0.02 m), and mutton snapper (mean: 363.42 ± 0.14 m) were less than 600 m in distance. All observed movements by gray snapper (mean: 1215.16 ± 0.13 m) exceeded 1,000 m. A 274 cm total length (TL) female tiger shark ranged broadly, but was detected in the array on a daily basis for two months prior to disappearing. Of particular note, a 125 cm greater amberjack tagged in Dry Tortugas National Park in February 2007 was detected about 30 times between February and May, and then left the array permanently in mid-May 2007. Surprisingly, that fish was recaptured off Cancun, Mexico in October 2009, at a size of approximately 145 cm.

We found that exploited-phase groupers and snappers occasionally crossed RNA boundaries. They were generally more likely to do so where boundaries overlay contiguous reef, and when home range centers were close to reserve boundaries. Flux rates across reserve boundaries detected by acoustic telemetry varied by species and by year. In 2006, only 2 of 31 (6%) grouper were detected moving across RNA boundaries. During 2007, 4 of 14 (29%) red grouper moved across RNA boundaries. No black grouper (but sample size was small) were detected moving across reserve boundaries in either year. Only 1 of 5 of the tagged yellowtail snapper moved

across the reserve boundary; notably, one fish crossed the reserve boundary 62 times, but spent less than 2% of its total time outside the RNA. A gray snapper crossed the boundary 10 times, spending 3.4% of its time outside the RNA. Only 1 of 2 mutton snapper moved across reserve boundaries, but it did so 702 times, spending more than 9% of its time outside the RNA. This sexually-mature fish was continuously tracked for 168 d, with two extended absences during the full moon in summer presumably related to spawning migrations (Fig. 1). Direction of travel is implied by the receiver detection patterns relative to the full moon (open circles). During this period there were spawning aggregations of mutton snapper over Riley's Hump in the Tortugas South Ecological Reserve (TSER) during full moons May-July, which strongly suggests these absences were associated with spawning activity (Fig. 2).

Linear regression analysis revealed that log-transformed proximity of home range center to RNA boundaries was a significant predictor of time spent outside of the RNA for red grouper, accounting for 40% of the variance in time spent outside the reserve. Average home range sizes were 1.13 ± 0.86 km^2 (±SE) for black grouper (n = 2, 57-75 cm TL), 1.95 ± 0.33 km^2 for red grouper (n = 33, 45-66 cm TL), 3.19 km^2 for gray snapper (n = 1, 54 cm TL), 7.64 km^2 for mutton snapper (n = 1, 70 cm TL), and 2.51 ± 0.17 km^2 (n = 4, 48-55 cm TL) for yellowtail snapper. Estimated home range size varied considerably between individuals for red grouper (0.01 to 5.76 km^2) and black grouper (0.27 to 1.99 km^2), but was relatively consistent for yellowtail snapper (2.17 to 2.91 km^2).

The majority of observed movements of groupers and snappers out of the RNA were into the North TER, suggesting the importance of this reserve network as a buffer against fishing pressure. The detected movements were biphasic: off spawning period; and, during spawning. Generally, the distance and frequency of movements were greater during spawning suggesting an increased vulnerability of fishes during this time. The RNA may provide some protection to mutton snapper that subsequently spawn in the TSER. Finally, our observations of extensive movement by both a greater amberjack and a tiger shark suggest that the RNA may afford important short-term protection for these mobile species. A spatially synoptic network of NTMRs would be required to protect for these species throughout their lifetimes.

Future Work

Refinement and publication of an individual-based localizing tendency model of reef fish movement is needed. It should be parameterized from the fine-scale acoustic telemetry data and integrated into a Spatial Management Performance Assessment simulation model for reef fish populations developed to evaluate quantitatively performance of no-take marine reserves in the Dry Tortugas, Florida.

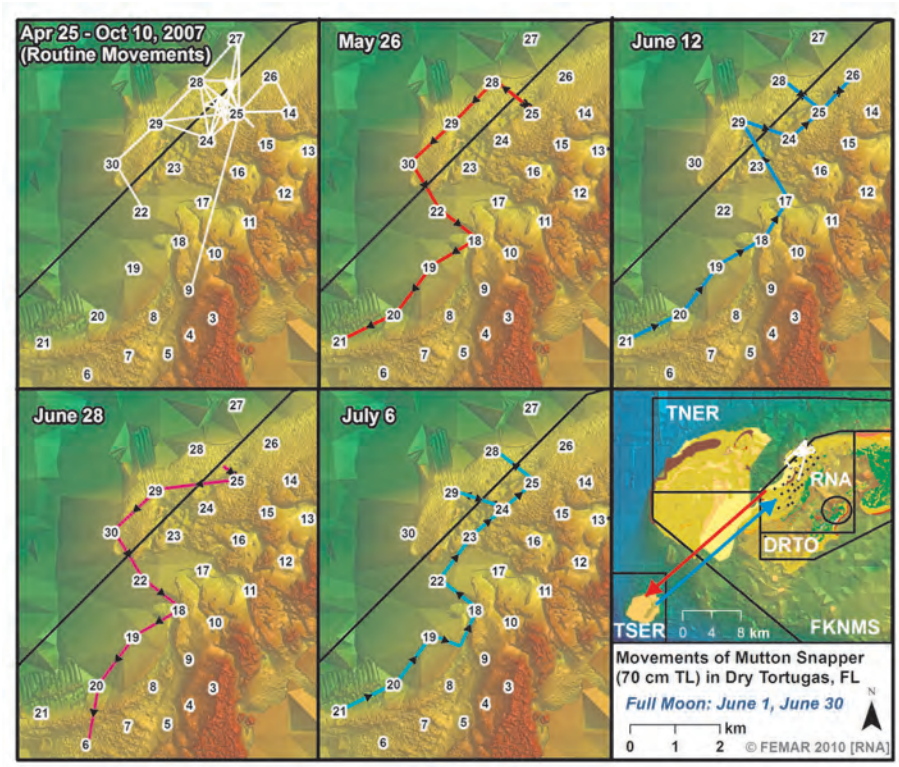

Figure 2. Receiver detections of an acoustically-tagged 70 cm TL mutton snapper in the RNA portion of Dry Tortugas National Park. Routine movements are shown during the period of April 25 to October 10, 2007. Specific spatial movements out of and back into the array are shown for the periods May 26-June 12 and June 28-July 6, 2007. These two periods correspond to the vertical bars highlighted in Figure 1.

RNA Performance Topic 2

Use of protected areas by threatened and endangered marine turtles in the Dry Tortugas

Investigator

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Project Description

Dry Tortugas National Park (DRTO) harbors several key foraging and nesting habitats that are important for endangered marine species, including federally protected marine turtles. Threatened loggerheads (*Caretta caretta*) forage in hard bottom areas on spiny lobsters and crabs, endangered hawksbills (*Eretmochelys imbricata*) forage on reefs and consume sponges, and endangered green turtles (*Chelonia mydas*) graze on seagrasses and marine algae.

To characterize the population of sea turtles in DRTO and quantify the proportion of time individuals of each species spend in the RNA compared to other areas of the park, I am conducting a turtle capture, tagging, and tracking project. Turtle captures are accomplished by intercepting reproductive females on nesting beaches and capturing turtles in the water. Using satellite and acoustic telemetry techniques, I am determining daily locations and movement patterns for tagged turtles, calculating home ranges and core use areas, and statistically summarizing the extent of overlap of these areas with that of the RNA.

Accomplishments

During 2008, I tagged six turtles (three loggerheads on East Key, three hawksbills from Bird/Long Key flat) with satellite and acoustic tags; three of these tags are still transmitting daily location data as of November 11, 2009. I also captured, tagged, and sampled 23 juvenile green turtles on the Bird/Long Key flat. In May 2009, I delineated the 50% core use areas for loggerheads and hawksbills tagged in 2008 to create transects through these areas to be photographed in June 2009 using the USGS's underwater Along Track Reef Imaging System (ATRIS). In June 2009, I satellite-tagged four reproductive female loggerheads and six subadult and adult green turtles. To date, I have satellite tagged 16 sea turtles (seven loggerheads, six greens, three hawksbills) and acoustic tagged 25 turtles (10 loggerheads, 13 greens, two hawksbills); 14 of these turtles are double-tagged with both satellite and acoustic tags (seven loggerheads, five greens, two hawksbills).

Preliminary Results

The size distribution for all 63 sea turtles captured (Fig. 1) in the park includes juvenile, subadult, and adult greens of both sexes; subadult and adult loggerheads of both sexes; and juvenile, subadult, and adult hawksbills (unknown sex). Green turtles were the most common species captured (N=49), followed by loggerheads (N=10) and hawksbills (N=4) (Fig. 1). From October 2007 through August 2009, I observed more than 325 georeferenced sightings of sea turtles in various areas of the park. Satellite-tracking results indicated that loggerhead females tagged on East Key use core areas outside the RNA more frequently than areas within the RNA, and hawksbills captured near the Bird/Long Key flat used a core area that overlaps with the Natural/Cultural zone "bubble" (Fig. 2). Subadult and adult green turtles of both sexes were park residents, using an area of lush seagrass near North Key Harbor outside the RNA (Fig. 2). In contrast, adult female loggerheads were part-time residents in the park only from about May through July/early August. Juvenile/subadult hawksbills appeared to be full-time residents of the park, as two tagged individuals are each still resident after approximately 460 tracking days. Migratory pathways and destination points

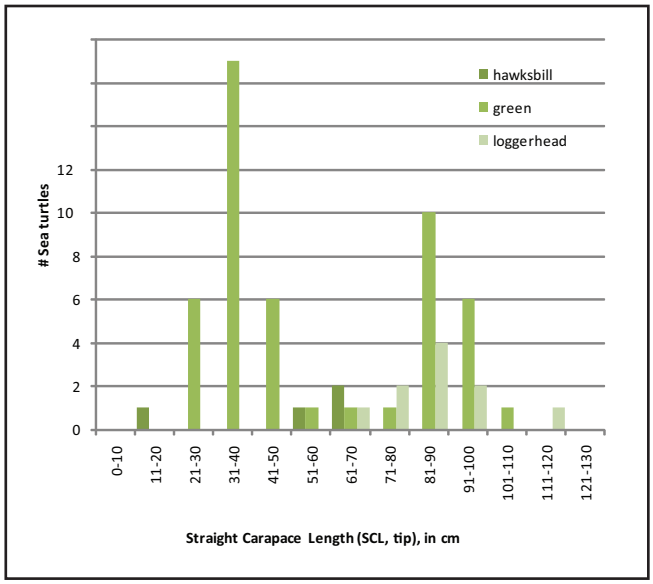

Figure 1. Size distribution of sea turtles captured and sampled May 2008-August 2009 in Dry Tortugas National Park (N=63).

of satellite-tagged loggerhead females indicated that three of seven tagged turtles migrated to and took up residence in the Bahamas, whereas four migrated to the southwest coast of Florida. One hawksbill departed DRTO after 265 days of residence and travelled to the north coast of Cuba, where it was harvested by fishermen. As of November 11, 2009, I have logged 3,262 turtle tracking days (1,446 days for loggerheads, 618 days for greens, and 1,198 days for hawksbills). In 2009, I recaptured 13/29 or 44.8% of juvenile greens (21-50 cm straight carapace length (SCL) size class) that were originally captured and tagged in August 2008. For these 13 juveniles, mean SCL at initial capture was 34.8 cm (5.01 SD; range 26.8-42.6 cm) and mean annual growth rate was 3.7 cm SCL (2.56 SD; range 0.9-10.2 cm). Diet of juvenile greens was primarily *Thalassia testudinum*.

Future Work

In 2010-2011, I plan to conduct nesting beach work and in-water turtle captures to increase the sample sizes of tagged/sampled individuals for all three species and study the internesting habitat where reproductive females spend their time between nesting events. I will specifically plan capture and tagging efforts to assess (1) whether reproductively mature female loggerheads nesting on Loggerhead Key use the same internesting habitat (50% core use area) outside the RNA as that used by the seven loggerheads previously tagged on East Key in 2008 and 2009, (2) where nesting green turtles from both East Key and Loggerhead Key spend their time in the internesting interval (and whether this area is in the RNA), and (3) where additional hawksbills may be found. I also expect to be able to determine, through satellite tracking, whether reproductive female green turtles nesting at DRTO are resident within the park, or instead migrate elsewhere after the nesting season. I have three acoustic data-downloading trips planned each year for the next 2 years to service and maintain my seven deployed acoustic receivers. I will continue catching juvenile greens (and hopefully more hawksbills) in the shallow flat around Bird/Long Key and refine growth rate estimates for these young turtles. Additionally, I will process all lavage samples, conduct isotope analysis, and conduct genetic analysis to determine stock structure for each species. I will continue to update information on residence times for turtles residing in and using DRTO. I will also continue to work with ATRIS to plan mapping and habitat characterization efforts in turtle internesting habitat and other turtle core use areas in the park. The combined data sets will provide insight into (1) the effectiveness of the RNA for protecting threatened and endangered marine turtles and their requisite habitats, (2) the condition of those habitats (i.e., seagrass beds), and (3) the development of more effective decision-support tools to manage coral ecosystems adaptively.

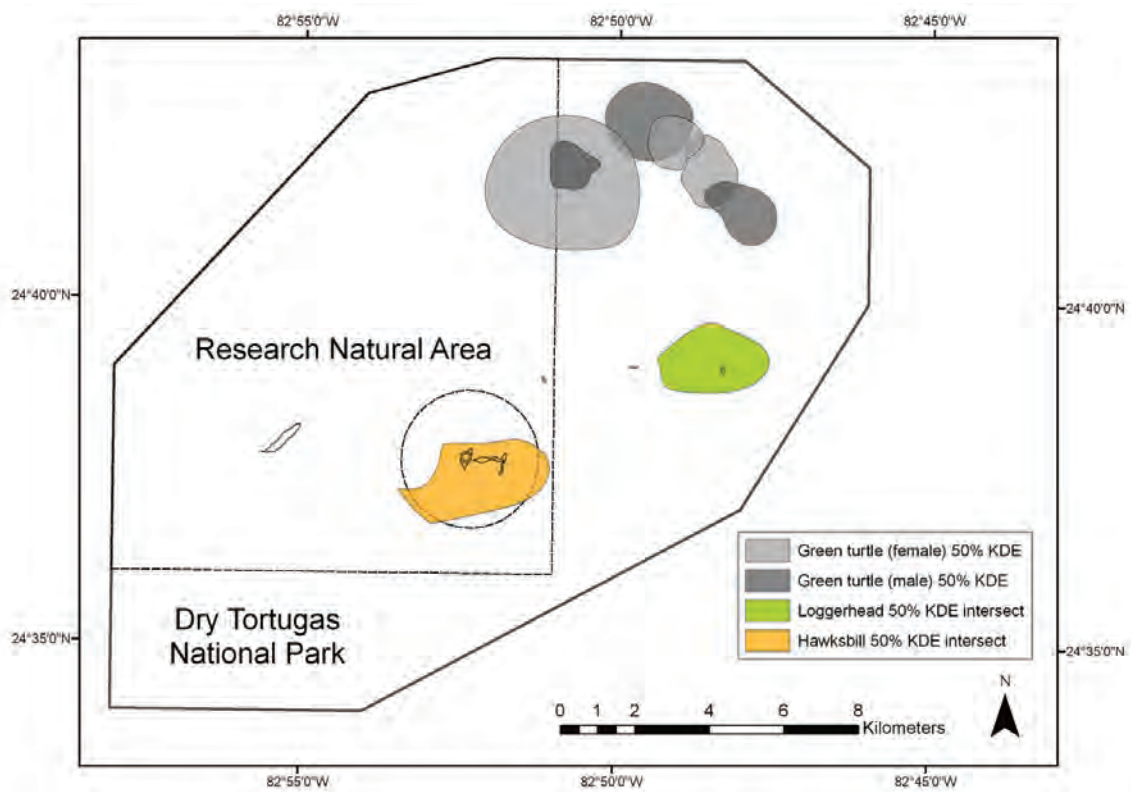

Figure 2. Core use areas (50% kernel density estimates, KDE) for satellite-tagged sea turtles in Dry Tortugas National Park, 2008-2009. Colored zones represent the overlap of core use areas for N=3 hawksbills (orange) and N=7 loggerheads (green). Gray zones represent individual turtle 50% KDEs for male (dark gray) and female (light gray) green turtles tagged in August 2009. Green turtle core use areas are shown for individuals because there was no overlap of all six individual 50% core use areas for this species.

RNA Performance Topic 3

Extended creel census development for Dry Tortugas National Park

Investigators

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Project Description

The goal of this study is to improve creel census design performance and evaluate regional fishery-dependent and independent databases as they relate to Research Natural Area (RNA) implementation in Dry Tortugas National Park (DRTO).

Accomplishments

This study commenced in the fall of 2009. Working with park personnel we have obtained the historical creel survey database for DRTO dating back to 1981. These data have been preliminarily analyzed for trends in catch-per-unit-effort, a measure of abundance, for reef fish taxa. These historical data will be used to refine the creel survey design to allow efficient estimation of fishery statistics and trends as they relate to RNA implementation. The new design will be compatible with the regional Marine Recreational Fisheries Statistics Survey program and further calibrated against fishery-independent reef visual census data.

Graysby. Photo by Jiangang Luo, Univ. of Miami/RSMAS.

Most recreational fishing data are collected from interviews of anglers (creel surveys) who land or fish at Garden Key, Dry Tortugas National Park. NPS photo.

Preliminary Results

Data have been organized to evaluate the following conditions to facilitate design developments:

- Spatial and temporal distribution of recreational fishing effort in the park
- Relationship of catches to the distribution of reef habitats within the park
- Range of vessel sizes and efficiencies operating within park waters
- Range of species targeted by anglers.

Recreational fishers in DRTO captured a wide variety of reef fish taxa during the time periods of 1981-84 and 2000-04 (Table 1). Catches were dominated by grouper and snapper species. Historically, creel observers recorded catches of two types: (1) captured and kept; and, (2) captured and released. The percentage of positive catch trips in which individuals were captured and then released increased between the two time periods for grouper and snapper taxa. This may be related to management implementation and subsequent changes in legal capture size for these taxa in the intervening years between the two time periods.

Future Work

We expect these analyses to be completed by fall of 2010 and will include recommendations for implementing the improved creel survey design in DRTO.

Table 1. Preliminary analyses of the percentage of reef fishing trips sampled in the Dry Tortugas National Park creel survey that captured fishes of a variety of taxa groups. Positive catch trips were categorized as follows: caught and kept, caught and released, and the combined total.

	1981-84 (n=484 reef trips) % of Positive Catch Trips			**2000-04 (n=229 reef trips)** % of Positive Catch Trips		
Taxa	**Total**	**Kept**	**Released**	**Total**	**Kept**	**Released**
Groupers						
Graysby	0.6	0.4	0.6	0.0	0.0	0.0
Coney	0.2	0.0	0.2	0.0	0.0	0.0
Rock hind	0.0	0.0	0.0	0.9	0.4	0.4
Red hind	0.4	0.2	0.2	0.0	0.0	0.0
Goliath grouper	0.8	0.0	0.8	1.8	0.0	1.8
Red grouper	19.0	16.9	14.1	69.9	63.8	59.8
Nassau grouper	1.2	1.0	0.6	0.9	0.9	0.9
Black grouper	8.5	6.8	3.5	26.6	21.8	21.0
Gag	1.0	0.8	0.4	4.4	3.1	2.6
Scamp	0.8	0.8	0.2	3.1	2.6	1.3
Yellowfin grouper	0.6	0.4	0.2	0.0	0.0	0.0
Unidentified groupers	32.0	28.5	17.8	1.3	1.3	0.4
Snappers						
Mutton snapper	9.7	9.5	0.4	27.5	27.1	9.6
Schoolmaster	0.0	0.0	0.0	0.9	0.4	0.4
Gray snapper	46.7	41.9	22.1	18.8	17.0	10.5
Lane snapper	0.8	0.8	0.0	4.8	3.9	3.1
Yellowtail snapper	25.6	21.7	15.9	65.5	56.3	54.6
Unidentified snappers	11.8	9.3	6.8	3.9	3.1	0.9
Grunts						
Margate	0.4	0.4	0.0	0.9	0.9	0.0
French grunt	0.8	0.0	0.8	1.3	0.0	1.3
Spanish grunt	0.4	0.0	0.4	0.4	0.4	0.0
Sailors choice	0.2	0.2	0.0	0.0	0.0	0.0
White grunt	1.7	1.2	0.6	4.4	3.1	2.2
Bluestriped grunt	3.9	2.7	2.3	0.9	0.0	0.9
Unidentified grunts	16.3	7.0	13.2	3.1	1.3	2.2
Other Reef Fishes						
Boxfish spp.	1.0	0.0	1.0	0.0	0.0	0.0
Damselfish spp.	1.0	1.0	0.0	0.0	0.0	0.0
Great barracuda	18.8	3.9	17.2	16.2	0.9	15.7
Jack spp.	15.1	9.1	10.1	18.3	8.7	13.1
Parrotfish spp.	1.7	0.2	1.5	1.3	0.0	1.3
Porgy spp.	13.6	9.7	7.0	3.9	2.6	1.8
Shark spp.	6.2	1.7	5.4	14.9	0.4	14.4
Triggerfish spp.	1.0	0.8	0.4	1.8	0.4	1.3
Wrasse spp.	3.3	2.1	1.5	0.4	0.4	0.0

RNA Performance Topic 3

Dry Tortugas National Park vessel permit system

Investigator

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Project Description

The General Management Plan Amendment of Dry Tortugas National Park (DRTO) dictates that a vessel permit plan be instituted to protect the resource, minimize human impacts, and monitor use. The goal and purpose of the plan is to provide increased protection specifically to the Research Natural Area (RNA), the visitor, and to the marine resources outside the RNA. The permit system will achieve this goal by providing reliable information to the public about the significance of the delicate resources and appropriate practices for RNA visitation. The permit system will afford a greater level of staff and visitor interaction that will enhance safe boating practices, resulting in a reduction of incidents. The system will provide park managers reliable information about public use and the ability to articulate carrying capacity at recreational dive and snorkel sites. Permit requirements apply to all recreational vessels, commercial fishing vessels, and vessels operating under a Commercial Use Authorization. It does not apply to vessels that are simply transiting through the park. It also does not apply to vessels greater than 50 m that require a Special Use Permit. Free of charge, a permit application can be obtained over the internet through the DRTO website, in person at the Key West Eco-Discovery Center or Garden Key administrative office, or on the water from park patrol staff.

Accomplishments

The permit system was instituted in September 2009. DRTO staff developed an electronic permit system that is utilized by the park to generate permits and maintain user statistics. DRTO staff has been contacting vessels in the park and issuing permits. A press release has been drafted to inform the public of the new requirement. It will be released when the electronic permit application is added to the DRTO website. The permit will identify park users as well as their activities in the park. Presently, every permit holder is a given pamphlet concerning the significance of the Research Natural Area, as well as a pamphlet that contains the rules and regulations of the park.

Preliminary Results

The program has just begun but has support from the boating public. A social science investigation will be conducted using names and addresses that are obtained via the permit database.

Future Work

Funding to manage the permit system is being pursued. A position to be located at the Eco-Discovery Center on Key West is being sought to manage the system.

Commercial fishing vessels anchored in the harbor near Garden Key, Dry Tortugas National Park. Photo by Joy Brunk, NPS.

Snorkelers over a coral reef near Garden Key, Dry Tortugas National Park. Photo by Brett Seymour, NPS.

RNA Performance Topic 4

Assessing the effects on corals of SCUBA and snorkeling use at Research Natural Area designated (mooring buoy) dive sites

Investigators

Douglas Morrison[1], Meredith Meyers[2], and Rob Ruzicka[3]

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Project Description

Boat anchoring will not be permitted in the Research Natural Area (RNA). Therefore, SCUBA diving and snorkeling activities in the RNA will be concentrated at designated dive sites with mooring buoys. Multiple assessments around the world have determined that heavy diving activity on coral reefs, in most cases greater than 5,000-6,000 divers per year per site, have damaged corals. Monitoring the potential effects of diving activity on corals at RNA dive sites is needed.

A RNA resource stewardship target is to have no long-term effects of diving activities on corals. The primary performance measures are damage to and loss of branching stony coral species, especially Endangered Species Act (ESA)-listed *Acropora* species. Secondary performance measures are damage to and loss of plating and foliose (leaf) type and mound, boulder, and encrusting type stony coral species. Stony coral species with branching morphology (e.g., *Acropora* species) are most susceptible to damage by diving activities. *Acropora* species were once very abundant but are now relatively uncommon in Dry Tortugas National Park (DRTO), and thus are at highest risk. Foliose and plating stony corals (e.g., *Agaricia* species) are more susceptible than mound, boulder, and encrusting type stony corals (e.g., star and brain corals).

This project is an element of the DRTO Coral Reef Benthic Communities Assessment Program and is conducted jointly with the Fish and Wildlife Research Institute (FWRI) of the Florida Fish and Wildlife Conservation Commission and the University of Georgia as a FWRI subcontractor, via a National Park Service cooperative agreement.

A fully replicated Before–After-Reference–Impact sampling design is used to measure and compare contemporaneous changes at RNA reef dive sites and equivalent reference sites with no or little diving activity. Four RNA dive sites, Texas Rock, Davis Rock, The Maze, and Off-Ramp, and three reference sites, Mayer's Peak, Temptation Rock, and Perfection, will be assessed annually for stony coral damage and annually or biennially for coral loss. Damage, a near-term effects measure, is quantified as the percentage of sampled coral colonies broken or abraded. Two coral damage survey methods are used at most sites: eight randomly located 10- x 2-m belt transects and four fixed 22- x 2-m belt transects. Coral loss, a longer-term measure, is determined by calculating changes in live coral percent cover with videographic techniques at the four fixed 22- x 2-m belt transects at each site, except Perfection and Off-Ramp. The fixed transects were not used at Perfection and Off-Ramp sites because of their small size. Separate *Acropora* species colony damage surveys are also conducted.

Damaged finger coral colony. Photo by Douglas Morrison, NPS.

Accomplishments

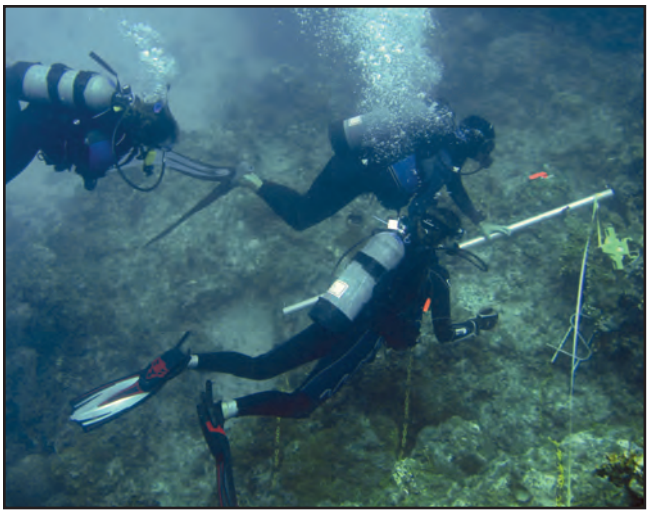
Stony coral damage and percent cover data were collected at all sites in 2009, before dive site mooring buoys were installed and the RNA no-anchor regulation was instituted. Thus, pre-implementation baseline data at all sites has been established.

Preliminary Results

Pre-implementation stony coral damage data collected in 2009 are summarized in Tables 1, 2, and 3; 4,500 coral colonies were surveyed. Coral damage, most likely due to storms, was observed at all sites. ESA-listed *Acropora cervicornis* (staghorn coral) is relatively common at Perfection and Off Ramp sites. None of the 50 staghorn colonies surveyed at Perfection were damaged (0.0% damage); one of the 44 staghorn colonies observed at Off Ramp was damaged (2.3% damage). The 2009 videography used to determine live coral percent cover is still being analyzed.

Future Work

RNA dive site mooring buoys will be installed, and the RNA no-anchor regulation will be implemented before the 2010 dive season (May through September). Stony coral damage surveys will be conducted in 2010, 2011, and future years, preferably near the end of the dive season. Currently we have only two years of funding for the more expensive, time-consuming, and logistically complex video surveys used to measure live coral percent cover. We will use these funds judiciously. For example, if the video surveys cannot be performed near the end of the 2010 dive season for logistic reasons, we will wait until 2011 to do them (this is a longer-term effects measure). Diver/visitor use data for the RNA dive sites are essential for evaluating potential ecological effects of diving. These data will be collected via the permit system (see Topic 6). This system will need to be operating by the 2010 dive season.



Setting up a fixed belt transect for coral damage survey on RNA designated dive reef/site (Davis Rock). Photo by Douglas Morrison, NPS.

Table 1. Percent damaged stony coral colonies, by growth form, at future RNA dive sites and RNA reference sites in 2009 pre-implementation random belt transect surveys. Values are mean ± SD.

Stony Coral Growth Form	RNA Dive Sites			RNA Reference Sites			
	Texas Rock	Davis Rock	The Maze	Off Ramp	Mayer's Peak	Temptation Rock	Perfection
Branching	5.0 ± 6.6	14.8 ± 3.6	3.5 ± 4.4	5.7 ± 2.7	3.8 ± 3.0	2.3 ± 2.8	3.4 ± 4.7
Plating/ Foliose	None	0.0 ± 0.0	0.0 ± 0.0	None	None	None	None
Mound/ Encrust	0.6 ± 1.6	0.0 ± 0.0	0.0 ± 0.0	1.4 ± 3.8	0.0 ± 0.0	0.0 ± 0.0	1.6 ± 4.2
Total	3.1 ± 3.8	5.4 ± 2.7	1.1 ± 1.5	4.4 ± 2.6	2.0 ± 1.7	1.7 ± 2.0	3.0 ± 3.8

Table 2. Cumulative data from 2009 pre-implementation stony coral damage surveys, using random transect method, at future RNA dive sites and RNA reference sites.

Stony Coral Colonies Surveyed	RNA Dive Sites				RNA Reference Sites		
	Texas Rock	Davis Rock	The Maze	Off Ramp	Mayer's Peak	Temptation Rock	Perfection
Damaged	14	17	5	8	8	8	7
Total	475	315	359	162	406	379	224
% Damaged	2.9	5.4	1.4	4.9	2.0	2.1	3.1

Table 3. Cumulative data from 2009 pre-implementation stony coral damage surveys, using fixed transect method, at future RNA dive sites and RNA reference sites.

Stony Coral Colonies Surveyed	RNA Dive Sites			RNA Reference Sites	
	Texas Rock	Davis Rock	The Maze	Mayer's Peak	Temptation Rock
Damaged	9	9	4	8	5
Total	503	441	415	423	330
% Damaged	1.8	2.0	1.0	1.9	1.5

RNA Performance Topic 4

Coral reef community monitoring at Bird Key Reef and sites inside and outside the Research Natural Area at Dry Tortugas National Park

Investigators

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Project Description

The South Florida / Caribbean Network (SFCN) is monitoring coral reef communities within Dry Tortugas National Park to determine whether the percent cover of stony corals, algae (turf, coralline, macroalgae), octocorals, and sponges; coral species diversity; coral community structure; and rugosity are changing through time within selected coral reef sites and inside and outside the newly created Research Natural Area (RNA).

SFCN began monitoring a site at Bird Key Reef in 2004 and added a second adjacent site in 2005 (Fig. 1). The Bird Key (19,765 m^2) and Bird Key-North (25,642 m^2) sites are located within a 2-km-long spur-and-groove reef structure and were selected for management interest and to compare with historical work. Each site consists of 20 permanent, randomly selected 10-m transects that are monitored with underwater video, capturing 25-35 non-overlapping video images, and identifying 10 random points per image (250-350 points/transect). Percent cover of living coral by species, macroalgae, turf algae, crustose coralline algae, octocorals, and sponges are calculated. Data on coral disease, long-spined sea urchins (an important algal grazer), rugosity, and water temperature also are collected. The Bird Key site straddles a boundary with 12 transects falling within the RNA and 8 transects plus 20 transects from Bird Key-North site falling inside the traditional Adaptive Use Area.

Monitoring has been expanded to include randomly selected sites to complement monitoring at Bird Key Reef. The expansion allows a broader assessment of trends in coral reef communities (with an initial 5% stony coral cover in waters from 2 to 20 m in depth) in the park and comparison of trends inside and outside the Research Natural Area. These sites are smaller, consisting of four 10-m transects providing a cost-effective trade-off between evaluating more sites throughout the park with effort at a site.

Accomplishments

SFCN staff have annually monitored the 40 transects across the two Bird Key and Bird Key-North sites and analyzed the results. SFCN investigated 157 randomly selected, potential sites using a rapid habitat assessment method that involved recording benthic cover in the field every 0.5 m along four 20-m transect tapes. In 2008, SFCN installed 18 sites that met the criteria of having a minimum of 5% initial stony coral cover (as determined by the rapid habitat assessment) and being from 2 to 20 m in depth. Nine sites are inside the newly established Research Natural Area and nine are outside. Video monitoring on these transects was conducted in 2008 and 2009.

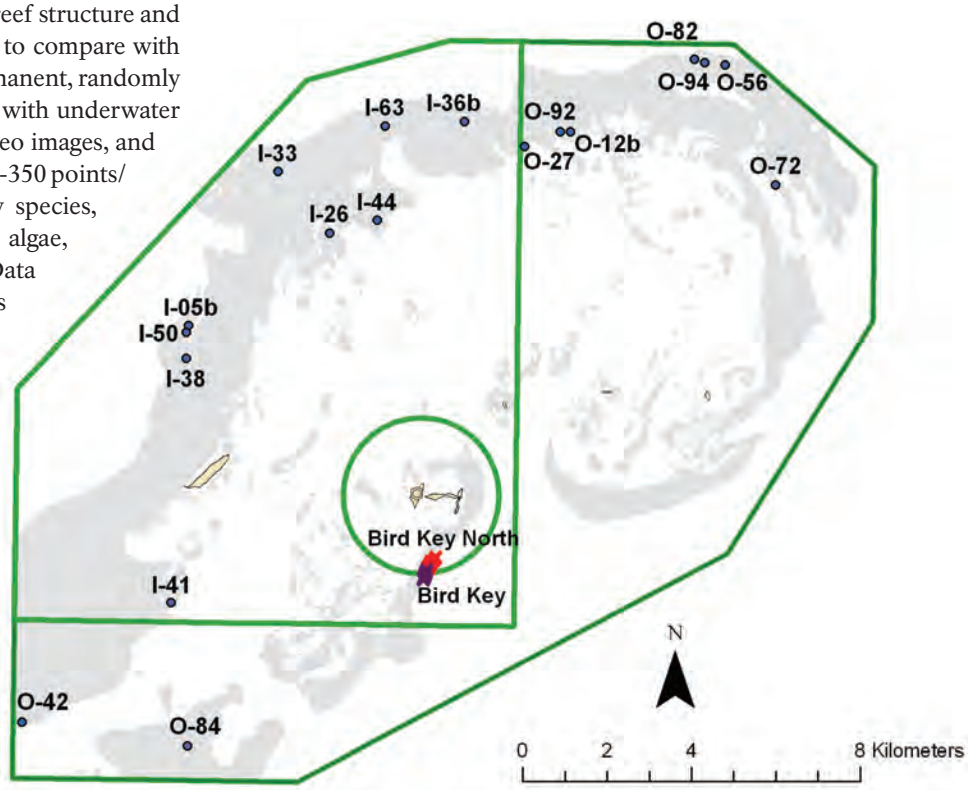

Figure 1. Map of SFCN coral monitoring sites in Dry Tortugas National Park showing sites at Bird Key and Bird Key-North installed in 2004 and 2005 respectively and 18 random sites installed in 2008.

Staff from SFCN were joined by the University of Miami-RSMAS/University of North Carolina Southeast Florida Coral Reef Evaluation and Monitoring Program (SCREAM) team, who also conducted their coral, sponge, and, algal monitoring protocol on the SFCN transects, allowing comparison of methods and the integration of SFCN permanent sites with SCREAM team random sites surveyed as part of RSMAS/National Oceanic and Atmospheric Administration (NOAA) fish monitoring. SFCN collected more than 250 randomly chosen accuracy assessment points throughout the park to evaluate the accuracy of a newly created benthic habitat map contracted by the Florida Fish and Wildlife Research Institute (FWRI) in partnership with SFCN.

Preliminary Results

Bird Key Reef: Monitoring during 2004-2009 indicated a significant downward trend in stony coral cover at the Bird Key site from 13.2 to 10.6% ($p<0.0001$) but the decrease in coral cover at Bird Key-North (11.0 to 9.7%) was not statistically significant (Fig. 2). This decrease is a concern as FWRI monitoring data collected using similar methods on selected transects located within the Bird Key study site show stony coral cover in 1999 of more than 20%. The octocorals (e.g., sea fans, sea whips, etc.) also showed a significant 1-year decline at both sites from an average of 20.0% in 2005 to 8.9% cover in 2006 ($p<0.0001$) followed by a slight increase through 2009 (we suspect the octocorals were damaged by four hurricanes that impacted the park in late 2005).

Random Sites: Results in 2008 from video-transect monitoring estimated stony coral cover at 3.6% (SE=1.0) outside the RNA and 7.8% (SE=3.4) inside the RNA (within areas of from 2 to 20-m in depth and estimated to be initially >5% coral cover using the rapid habitat assessment method). Two sites inside the RNA fell on an area of exceptionally high coral cover called "Loggerhead Forest" of which SFCN and park staff were largely unaware. Estimated stony coral cover at these sites was 29.9% and 20.3% respectively. Without these two sites, coral cover inside the RNA at the remaining sites was 2.8% (SE=0.5). Analysis of 2009 video data is pending.

During June and July 2008, SFCN staff observed above-normal levels of white plague disease, a coral disease syndrome that results in partial or full mortality of affected coral colonies. In response, SFCN organized a return trip in July 2008 with coral disease experts from the U.S. Coral Disease and Health Consortium and George Mason University. Affected sites were resurveyed and tissue samples collected from colonies with active disease. Initial attempts to isolate disease agents were unsuccessful, but further analysis is pending.

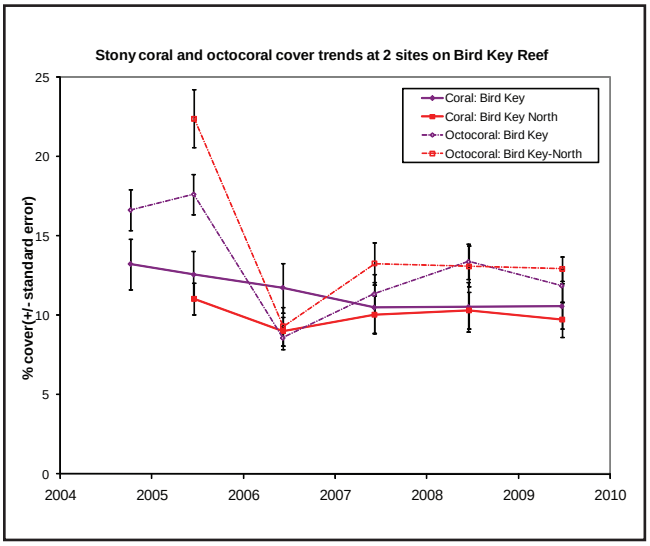

Figure 2. Trends in percent live stony coral cover and octocoral (e.g., sea fans, sea whips) cover at Bird Key and Bird Key North monitoring sites, Dry Tortugas National Park.

Two SCREAM team divers conducting coral monitoring protocol on one of the NPS-SFCN coral monitoring transects. Photo by Rob Warra, NPS.

Future Work

SFCN staff are refining the Coral Reef Monitoring Protocol and including sections on the random site monitoring design, revised coral disease monitoring procedures, Rapid Habitat Assessment procedure, and analysis and reporting procedures. A completed document is anticipated in 2010-2011.

Staff will analyze the annual coral reef community data from the random sites for trends and will examine levels of variation to determine if sufficient statistical power exists to detect changes over time and differences between RNA and non-RNA areas of the park. A method comparison will be conducted between the SFCN video-transect method and the SCREAM team in-situ method on data collected simultaneously on the random site transects in 2008.

Staff will work to improve the newly created benthic habitat map using a combination of 2009 interferometric side-scan SONAR data collected by Dr. Stan Locker of the University of South Florida in 2009, LIDAR data collected by the U.S. Geological Survey in 2004, accuracy assessment data, rapid habitat assessment data, and reef fish visual census data. The map will then be compared with the NOAA/UM-RSMAS reef fish visual census habitat map grid.

RNA Performance Topic 4

Trophic relationships on coral reefs of Dry Tortugas National Park: Inside and outside of the Research Natural Area

Investigators

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Project Description

The goal of the project is to examine trophic interactions and the important reef process of herbivory in Dry Tortugas National Park (DRTO). There is inadequate knowledge regarding the complex interactions between herbivores, the macroalgae they eat, and the stony corals that provide the carbonate structures that act as shelter for most reef organisms. The interdependency among these three main components of reef ecosystems is quite circular in nature, and the tidy recycling of resources (e.g., space, food) among them has been disrupted during the past century on a global scale. Many of the world's experts believe this is largely a result of the cascading effects of overfishing. Coral reefs in the waters of the United States are some of the most degraded; overfishing combined with the Caribbean-wide die-off of the keystone herbivore, *Diadema antillarum*, are major contributing factors. Protection of reef resources in the United States within no-take zones has begun, and there is a critical need to document the changes in trophic relationships as protective measures are implemented. Because corals are the "ecosystem engineers" responsible for producing the topographically complex habitat that defines a coral reef, the perpetuation (or recovery) of reef-building corals is of foremost concern to resource managers. Our study aims to understand better the intricate balance among herbivores, macroalgae, and corals, and to determine if that balance can be restored in protected areas.

Accomplishments

The field work for this study took place during October 15-21, 2007. We accomplished surveys at 18 sites, including 9 inside and 9 outside of the Research Natural Area (RNA) designated by the National Park Service in 2007. Sites were chosen randomly from a population of possible sites identified to fit the criteria of being in the 3- to 5-m depth stratum and contained within low-relief reef and hardbottom habitat (Fig. 1). We chose these criteria because (1) algal growth and herbivory are greatest within this shallow depth range, (2) these habitats are very abundant within the park (much more so than true coral reef habitat) in the desired depth range, and (3) other benthic monitoring efforts are focused on deeper coral reef habitat. We conducted detailed species-level surveys of macroalgae, scleractinian and gorgonian corals, herbivorous and exploited (e.g., grouper and snapper) fish species, urchins, and substratum rugosity (topographic complexity) at the chosen sites. Our work resulted in a high quality data set documenting the status of some important resources in the park and will serve as a valuable baseline for future comparisons in addressing change in and outside of the RNA within DRTO. This work was published in the conference proceedings of the 9th International Coral Reef Symposium in Ft. Lauderdale, Florida, "Reef communities in the Dry Tortugas (Florida, USA): Baseline surveys for the new no-take area," and is at available at http://www.reefbase.org/resource_center/publication/icrs.aspx.

Preliminary Results

To understand the current community structure of some of the benthic habitats in DRTO, we conducted species-level surveys of macroalgae, coral diversity, herbivorous and game fishes, urchins, and substratum composition (e.g., rugosity) in shallow (3- to 5-m depth) low-relief reef and hardbottom habitats in October 2007. We had particular interest in the ecological process of herbivory inside and outside of the no-take RNA and in establishing a baseline to assess future changes to trophic functioning. Abundance of *Diadema antillarum* and herbivorous fish, percent cover of macroalgae, and species richness of corals and gorgonians at the 18 randomly selected survey sites were not significantly different inside versus outside of the RNA. Coral cover was estimated to be between 1% and 5% at these sites. Mean density of *D. antillarum* ranged from 0.01 to 0.54 individuals per m^2, with 11 of the 18 sites having a density above 0.10 individuals per m^2. Both *D. antillarum* density and coral species richness were positively correlated to rugosity of the substratum (Fig. 2). *D. antillarum* density also was positively related to the percentage of the substratum composed of *Acropora cervicornis* rubble. Improved trophic functioning and increases in *D. antillarum* density can improve reef condition in the Dry Tortugas, and the RNA is an important management tool to achieve increases in reef resilience to global-scale stressors.

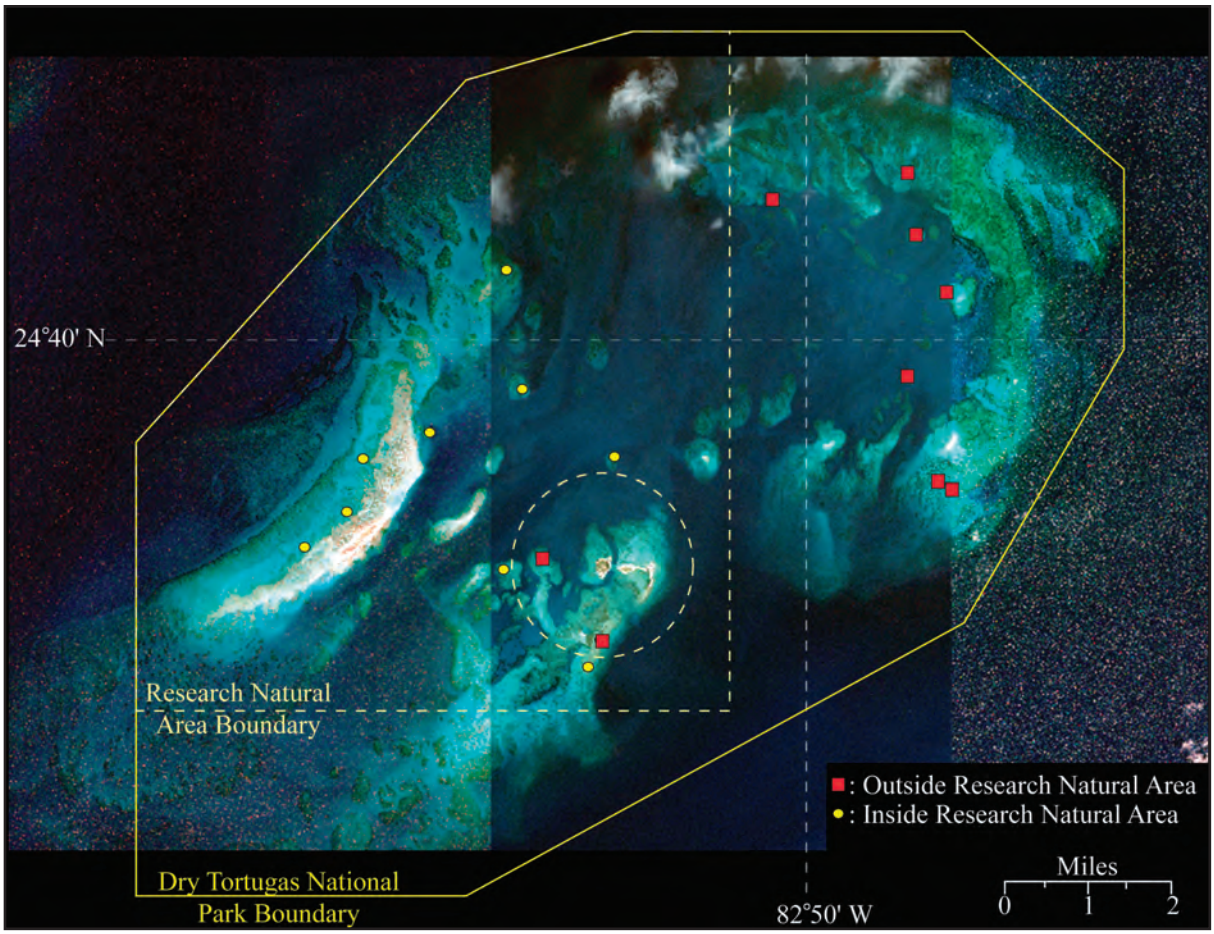

Figure 1. Satellite mosaic of Dry Tortugas National Park with the locations of 18 randomly selected sites where in-situ surveys were conducted October 16 – 20, 2007. The "no-take" Research Natural Area is within the dashed lines in the NW quadrant of the park and does not include the area within the circle.

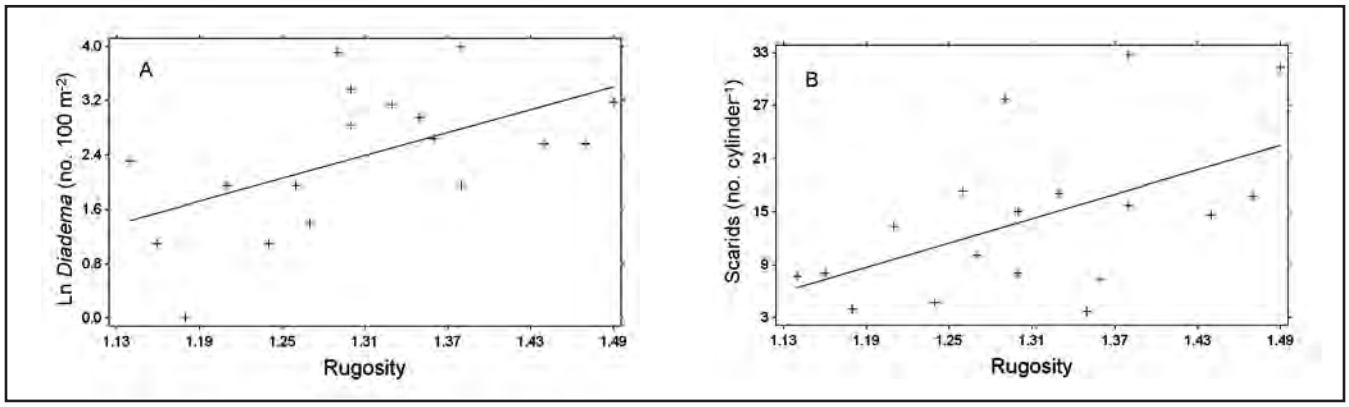

Figure 2. Linear-regression plots of A) *Diadema antillarum* density (Ln transformed data) and B) scarid (parrotfish) abundance (no. cylinder^{-1}) versus substratum rugosity at 18 sites within Dry Tortugas National Park.

Future Work

Pending funding, the survey could be conducted again in 2011 (4 years after the initial survey) to see if any changes are occurring in the populations of exploited fishes, herbivores, algal communities, and corals. Changes in proportions of these ecosystem components could allow us to make inferences about trophic functioning in the reef system, and thus, assess the efficacy of the RNA in meeting the goal of restoring benthic communities through no-take protection.

RNA Performance Topic 4

Assessing the effects of creating the Research Natural Area no-anchor zone on seagrass meadows

Investigator

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Project Description

Implementation of the Research Natural Area (RNA) in Dry Tortugas National Park (DRTO) creates a no-anchoring zone covering 46% of the park. This action should greatly reduce or eliminate any anchor damage to coral reef benthic, other hard bottom, and seagrass communities in the RNA. RNA resource stewardship targets are to eliminate anchor damage to RNA coral reefs and seagrass beds and to enhance recovery of RNA marine benthic communities from any previous anchor damage. This project is designed to detect changes in the abundance (percent cover) of seagrass and is a component of the DRTO Seagrass Communities Assessment Program.

A fully replicated Before–After-Reference–Impact sampling design is used to measure and compare contemporaneous changes at RNA seagrass sites and equivalent reference sites in the Historic Adaptive Use (HAU) Zone (anchoring permitted). Three shallow (less than 3 m deep) monitoring sites around Loggerhead Key (RNA, future no anchoring) and three shallow sites near Garden and Bush Keys in the HAU were randomly selected. One HAU site (GK-2) is on the periphery of the Garden Key visitor anchorage. Percent cover of seagrass and associated key benthic ecological attributes is measured using a 0.25-m^2 quadrat subdivided into 5% sections. About 20 haphazardly located quadrats are sampled annually at each site. Annual visual surveys for potential anchor damage, such as dragging anchor scars, are also conducted at each site (survey area about 5,000 m^2).

Accomplishments

Annual seagrass, associated macroalgae, and sea urchin assessments at the three Loggerhead Key sites (RNA, future no-anchoring) and three reference sites near Garden and Bush Keys in the HAU (anchoring permitted) have been conducted from 2005 through 2009. The RNA no-anchoring regulation has yet to be implemented. Hence, five years of pre-implementation baseline data have been established.

Park ecologist surveying seagrass meadow in the Research Natural Area of Dry Tortugas National Park. Photo by Melissa Memory, NPS.

Preliminary Results

Pre-implementation seagrass (all species combined) percent cover data are presented in Figure 1. No evidence of anchor damage at any RNA monitoring site has been observed in five years of pre-implementation surveys. Only two instances of probable anchor damage have been observed at the HAU sites, both at GK-2, which is on the edge of the Garden Key visitor anchorage.

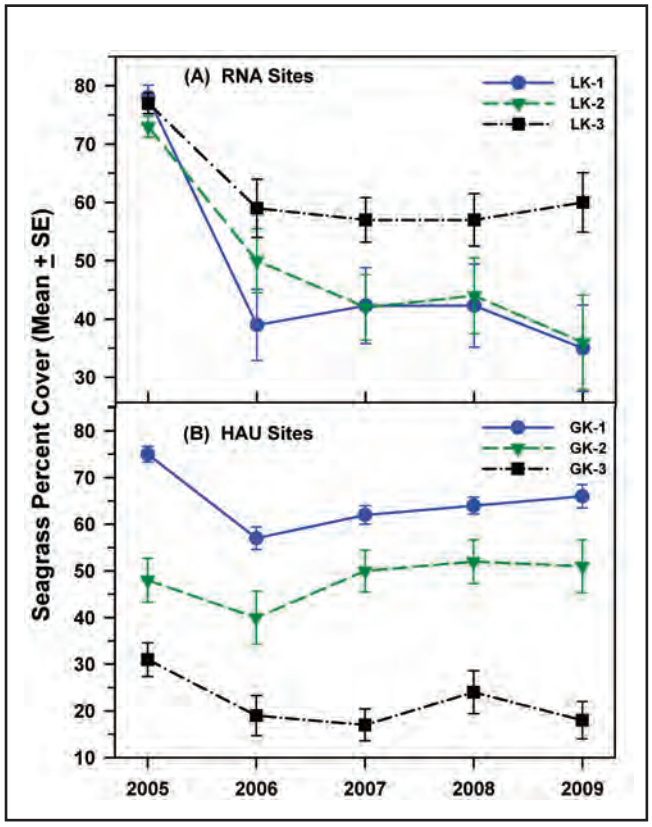
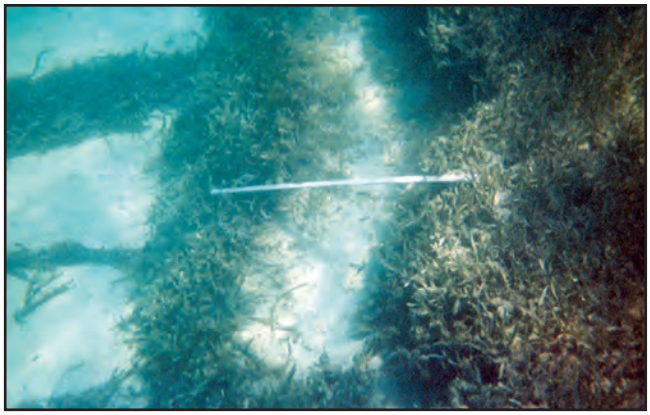


Figure 1. Seagrass percent cover, before implementing no anchoring in the RNA, at (A) shallow RNA sites around Loggerhead Key [LK], and (B) shallow sites near Garden Key [GK] where anchoring is permitted [HAU Zone].

However, all sites experienced statistically significant seagrass loss caused by four hurricanes in a 4-month period in 2005; an unprecedented occurrence in the 130 year history of Tortugas science. As of May 2007, 19.7 hectares (48.7 acres) of seagrass meadows had been destroyed around Loggerhead and Bush Keys due to the 2004-2005 hurricanes and subsequent winter and tropical storms (Table 1). This loss is equivalent to nearly one-half of the terrestrial land (island) area in Dry Tortugas National Park. Additional seagrass loss from Hurricane Ike in September 2009 occurred at two RNA sites (LK-1 and LK-2).



Example of hurricane (Charley, August 2004) damage to a seagrass meadow off Loggerhead Key in the RNA. There is a white one meter stick in the photo for size reference. Photo by Douglas Morrison, NPS.

Future Work

It is anticipated that the RNA no-anchor regulation will be implemented in 2010. Thus, post-implementation monitoring will be conducted at the three RNA and three HAU seagrass sites in 2010 and 2011. Annual monitoring is planned to continue after 2011 because all sites are part of the Dry Tortugas National Park Seagrass Communities Assessment Project. Pre- and post- no-anchor implementation seagrass abundance data will be compared at each site.

Table 1. Seagrass loss from 2004-2005 hurricanes around selected islands in Dry Tortugas National Park (ha=hectares, ac=acres). Seagrass loss is calculated using satellite imagery.

Island	Seagrass Area		Seagrass Loss
	April 2003	May 2007	2003-2007
Loggerhead Key	33.5 ha	26.5 ha	7.0 ha [17.3 ac] (20.9%)
Bush Key (north side)	31.9 ha	19.2 ha	12.7 ha [31.4 ac] (38.9%)
East Key (1 km radius)	105.6 ha	75.8 ha	29.8 ha [73.6 ac] (28.2%)

RNA Performance Topic 5

Reproductive potential of exploited reef fishes within the newly established Dry Tortugas Research Natural Area and adjacent open-use areas

Investigators

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Project Description

In association with a trapping and hook-and-line study titled "Examining the efficacy of the newly established Research Natural Area (RNA) for protecting coral reef fishes within Dry Tortugas National Park (DRTO)," an opportunistic examination of reproductive potential of exploited reef fishes was conducted. In association with spring and fall trap and hook-and-line surveys, a small number of individuals (n = 10 per family per season) were sacrificed for life-history studies. As part of these studies, a macroscopic examination of gonad tissues was conducted to assess whether gonads were in an advanced stage of development. If so, a sample of gonad tissue was preserved for further reproductive analysis.

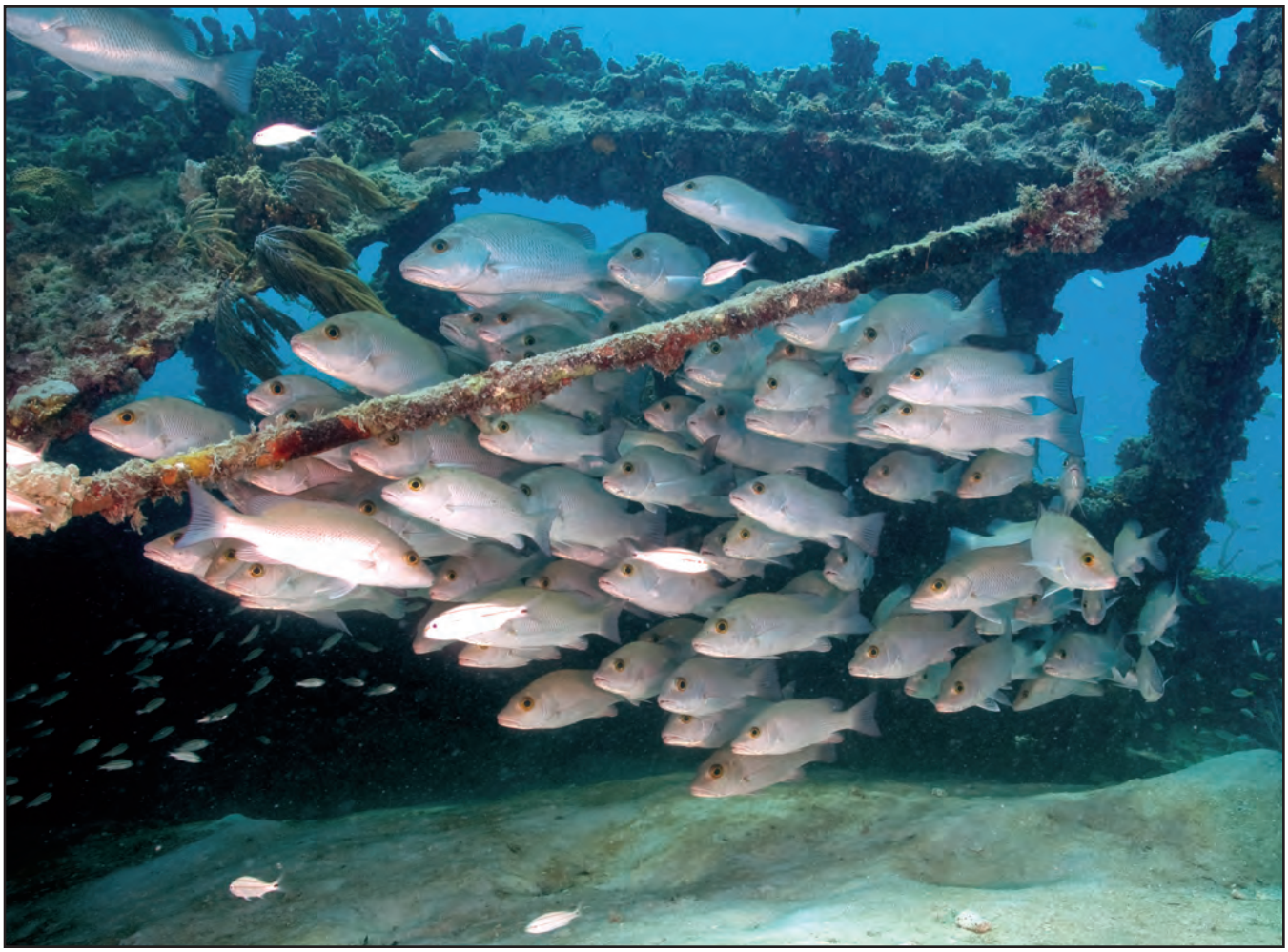
Accomplishments

Biological specimens have been collected for snappers and groupers during spring and fall surveys for 2008 and 2009.

Preliminary Results

Specific catch data are unavailable at present because data entry and processing are currently ongoing. Biological

Mutton snapper *(Lutjanus analis)* on *Acropora prolifera* reef in Dry Tortugas National Park. Photo by Douglas Morrison, NPS.



Gray snapper (*Lutjanus griseus*). Photo by Brett Seymour, NPS.

specimens have been retained from a variety of snappers (primarily yellowtail snapper, gray snapper, and mutton snapper) and groupers (primarily red grouper, black grouper, and graysby) collected during spring and fall surveys conducted in 2008 and 2009. To date, we have yet to find evidence of individuals in either an advanced stage of development or post-reproduction, and so we do not have any estimate of reproductive potential or fecundity.

Future Work

Stratified-random trapping and hook-and-line surveys will be conducted in the RNA and open-use areas in spring and fall during both 2010 and 2011, and we will continue to examine gonad tissue for signs of reproductive development. Given the current level of biological sampling (n = 10 individuals per family per season), as well as the timing of current sampling efforts (late spring and early fall), it is unlikely that we will obtain sufficient data to determine the fecundity of reef fishes within DRTO. To do so will require either sampling during different seasons (i.e., late winter to early spring for groupers) or enhanced levels of biological sampling (i.e., for snappers).

Red grouper (*Epinephelus morio*). Photo by Brett Seymour, NPS.

RNA Performance Topic 5

Immigration and emigration of selected reef fish species from the Research Natural Area to the Tortugas South Ecological Reserve

Investigators

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Project Description

Snappers and groupers migrate long distances to specific sites to form spawning aggregations of hundreds to thousands of individuals at specific times of the year. Unfortunately, traditional fishery management strategies have not always accounted for the vulnerable nature of spawning events and these prime fishery targets are frequently overfished. Recent changes in fishery regulations have placed greater emphasis on marine protected areas (MPAs) to preserve reef habitat, enhance reef fish production, conserve functional ecosystem processes, and protect a certain proportion of the population. After years of over-exploitation, the Tortugas South Ecological Reserve (TSER) was established in 2001 to protect the mutton snapper spawning aggregation on Riley's Hump and the surrounding deep-water habitat. Re-formation of the mutton snapper spawning aggregation has been documented since closure of the TSER to fishing, but little is known about adult reef fish movements in the region or the characterization of transient reef fish spawning aggregations at Riley's Hump. Spatial and temporal rates of movement of acoustically tagged snappers and groupers are being measured in the Tortugas region, including annual spawning migratory movements between Riley's Hump, the Tortugas Ecological Reserves, and Dry Tortugas National Park (DRTO), including the Research Natural Area (RNA). A multi-agency managed array of approximately 80 Vemco VR2 receivers will be used to assess habitat utilization patterns, residence times, migration patterns, and timing of multispecies aggregations. Results will assess the importance of habitat linkages between adjacent MPAs and provide information for an ecosystem-based approach to reef fisheries management.

Mutton snapper spawning event in the late afternoon on Riley's Hump. Photo by Chris Parsons.

Accomplishments

An array of 64 Vemco VR2 acoustic receivers was deployed in three phases between May and July 2008 in the Tortugas region. The array covers approximately 800 km^2 and is designed to capture small-scale movement and long-range migrations of fishes in water 5 – 50 m deep. In the first phase, 32 VR2 receivers were placed within DRTO, including within and outside the borders of the RNA. The second phase was completed in June 2008, with 23 acoustic receivers placed throughout DRTO, the Tortugas North Ecological Reserve (TNER), and adjacent open-fished areas of the Florida Keys National Marine Sanctuary (FKNMS). The final nine receivers were set up in July 2008 on Riley's Hump. All of our VR2 receivers were successfully deployed and are operational on or near our proposed locations. This array is complemented by two collaborative acoustic telemetry projects in the region (approximately 20 VR2s); the Mote Marine Laboratory nurse shark project (Principal Investigator (PI): Dr. W. Pratt) and the U.S. Geological Survey sea turtle project (PI: Dr. K. Hart) (Fig. 1). Extensive nurse shark and sea turtle data have been collected by the array in addition to valuable long-range movement information on lemon sharks tagged on the east coast of Florida near Jupiter. In addition, the presence of a solitary white shark near a snapper spawning aggregation was confirmed by a benthic video/acoustic recorder on Riley's Hump in June 2009. During 2008 and 2009, selected reef fish species were tagged inside the TSER from the M/V Spree. All fish were surgically implanted with Vemco V16 coded transmitters in-situ to avoid barotrauma induced mortality associated with bringing fish to the surface after hook-and-line capture from relatively deep water (30 – 45 m).

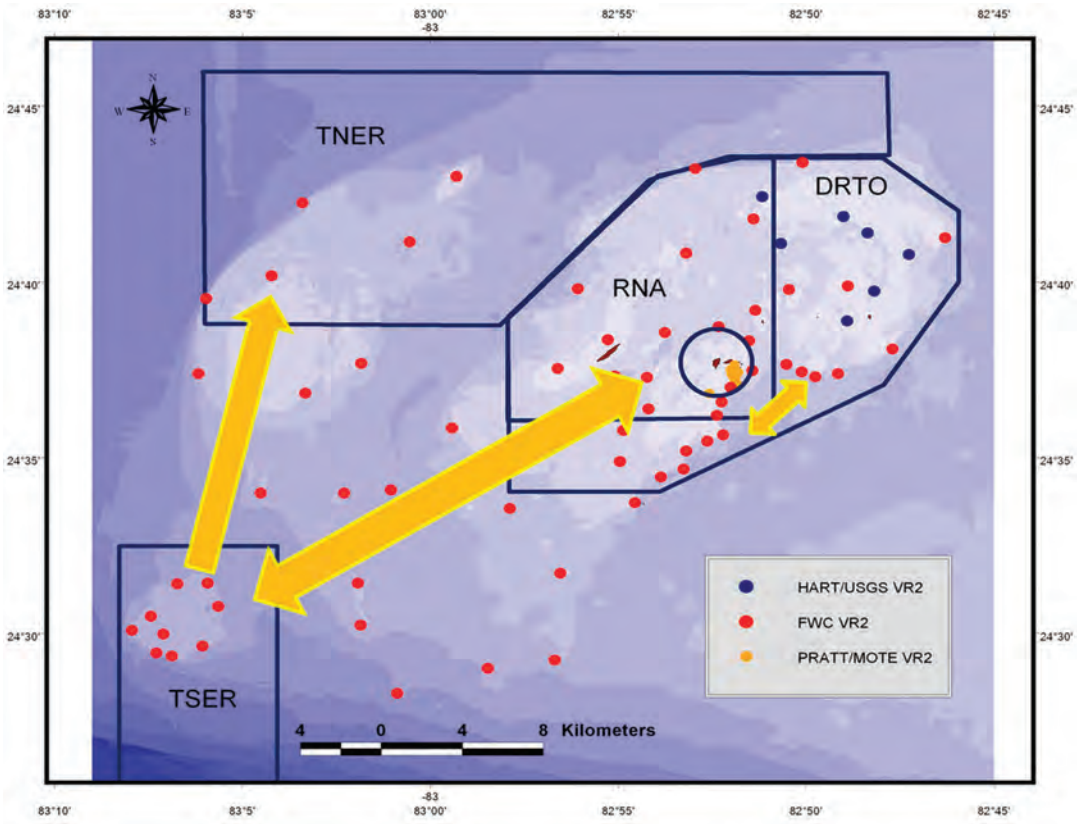

Figure 1. Map of the Dry Tortugas region indicating locations of acoustic receivers and offshore migration patterns of tagged mutton snapper (arrows).

Preliminary Results

Twenty-three mutton snapper, *Lutjanus analis*, and 8 groupers, including 3 black grouper, *Mycteroperca bonac*i, 2 Nassau grouper, *Epinephelus striatus*, and 3 red grouper, *Epinephelus morio*, were acoustically tagged within the TSER in 2008 and 2009. The first complete year of acoustically collected movement data were downloaded in October 2009. Preliminary results indicate a possible corridor exists for the seasonal movements of mutton snapper between the DRTO/RNA and the TSER, providing a link between marine protected areas (Fig. 1). Individual mutton snapper have been documented making repeated migratory round trips (three or fewer trips per fish) of as far as 50 km to spawning grounds during the spawning season (May to August). Individual fish stay on the spawning grounds for as long as 10 days surrounding the full moon phase before returning to home forage territory within DRTO/RNA. Limited movement has been detected to the east or directly north to the TNER; however, one mutton snapper tagged at Riley's Hump was detected in the TNER and later at Pulaski Shoals, a movement of 40 km in 2 days. Mutton snapper appear to emigrate from Riley's Hump by the end of August, although possible residential mutton snapper have been observed there as late as October. A mutton snapper aggregation of thousands (about 4,000) was documented on Riley's Hump in June 2009, along with small subgroups (60 or fewer) of fish spawning in the late afternoon (about 4:30 PM EST), 2 days after the full moon.

Future Work

Our current work primarily focuses on mutton snapper utilizing one known spawning site. There are potentially other ecologically and economically important species that may use Riley's Hump as an aggregation site (i.e., black grouper) and potentially other regionally important spawning sites to be discovered. We are funded to acoustically tag fish within the TSER in 2010, and future efforts will emphasize tagging black grouper. Since multi-year transmitters were implanted in fish, we will continue to collect data on receivers through 2011. Data analyses will establish the degree of connectivity between habitats and the network of management areas in the Dry Tortugas and determine the efficacy of current management zones. Information will help determine the migratory ability of fishes and determine the buffer space required to protect fish while in migration to and from a spawning site. Preliminary results from this study will be analyzed and a scientific presentation and peer-reviewed publication will be produced.

RNA Performance Topic 5

Larval transport modeling from the Dry Tortugas

Investigators

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Project Description

The goal of this study is to evaluate the expected physical transport and fate of reef fish eggs and larvae spawned in the Dry Tortugas region to the adjacent waters of the south Florida coral reef ecosystem. The study utilizes the Hybrid Miami Isopycnal Coordinate Ocean Model (HYCOM) physical oceanographic model along with information on spawning and larval life history characteristics of snapper-grouper reef fish species.

Accomplishments

Work commenced on this project in fall 2009. We developed a computer interface to link the HYCOM model with a particle flux model to simulate larval transport. The model domain is the northern Caribbean Sea, Gulf of Mexico, and south-

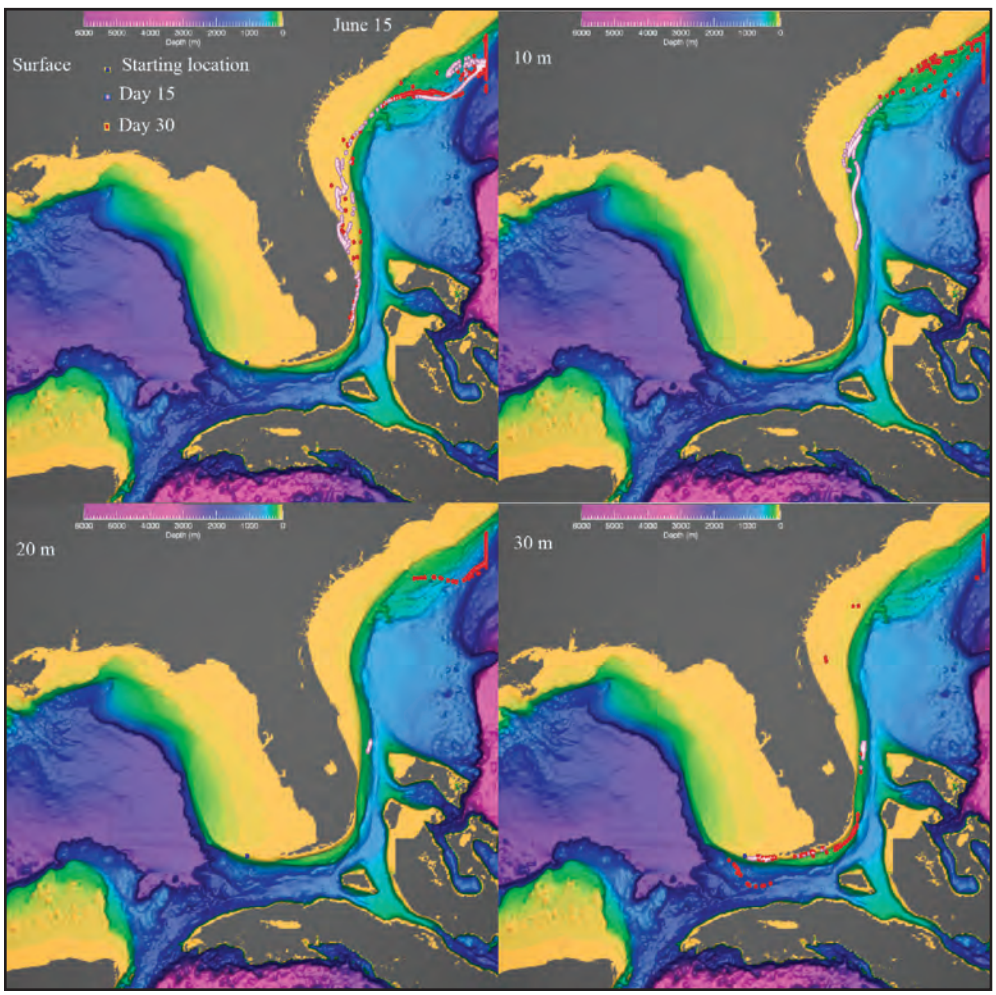

Figure 1. Distribution of "larval particles" at 15 days (light purple) and 30 days (red) simulated with HYCOM model current vectors starting from Riley's Hump on June 15, 2008 at four depth layers: (a) surface; (b) 10 m; (c) 20 m; and (d) 30 m.

eastern United States with a grid spacing of 4 km. The model utilizes meteorological and oceanographic data that allow "real time" simulations of transport. Biological information including spawning timing and duration and larval phase durations was compiled for principal snapper and grouper species. Preliminary experimental design includes the release of thousands of passive larval particles at designated spawning locations, depths (0 to 30 m), and times (winter and spring-summer). The particles are continuously tracked for a period equal to the larval duration, and the outcome spatial distribution is evaluated.

Preliminary Results

Preliminary Lagrangian simulations of larval drift patterns from a potential spawning site at Riley's Hump using HYCOM model daily outputs are shown in Figures 1 and 2. Neutral passive particles were released at two different times, June 15, 2008 (Fig. 1) and July 15, 2008 (Fig. 2), and at 4 different depths. Outputs are shown 15 and 30 days after spawning simulations. For a summer-spawning animal with a larval duration of about 30 days, both the timing and depth appear to be critical factors in the outcome distribution of particles. For example, particles "spawned" at different times and depths had the potential of ending up on the West Florida Shelf, the Florida Keys, or on the Eastern Seaboard as far north as the South Atlantic Bight.

Future Work

Future research will involve running simulations for a more complete range of conditions including timing and depth of spawning, larval behavior, and tidal influence.

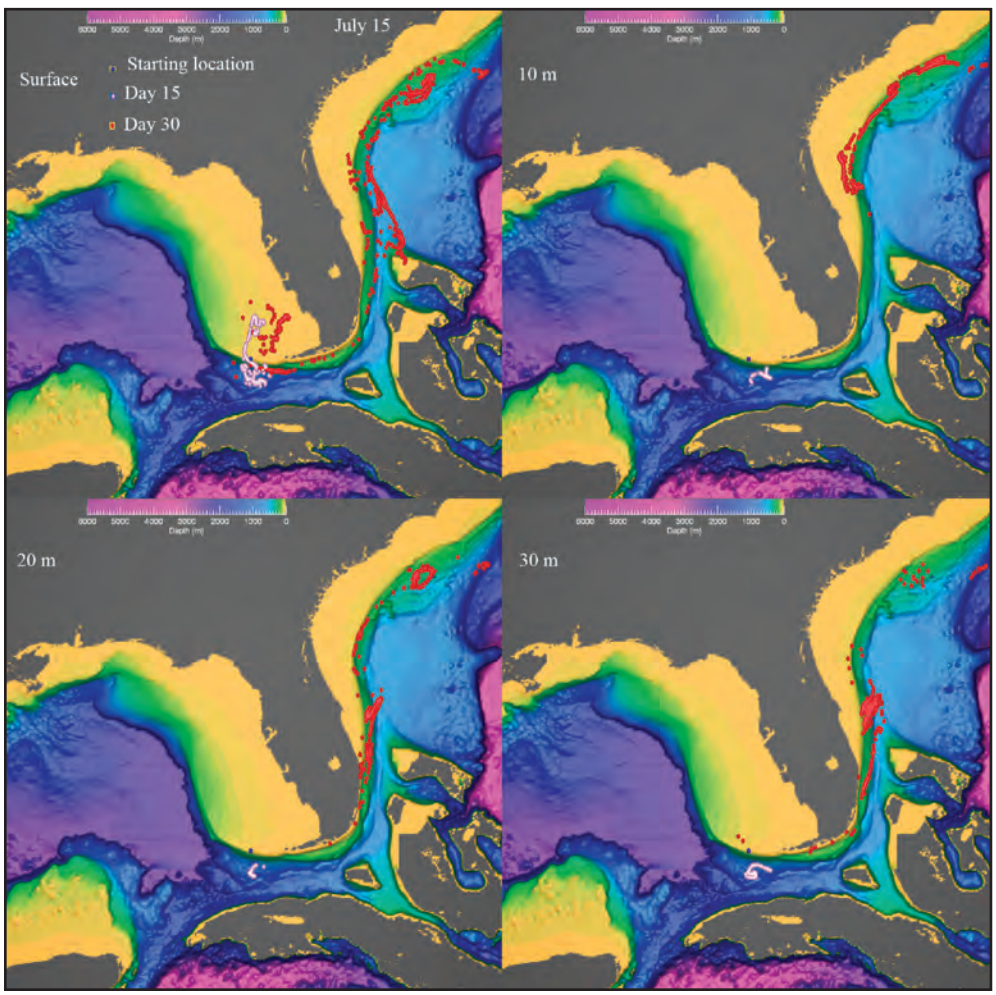

Figure 2. Distribution of "larval particles" at 15 days (light purple) and 30 days (red) simulated with HYCOM model current vectors starting from Riley's Hump on July 15, 2008 at four depth layers: (a) surface; (b) 10 m; (c) 20 m; and (d) 30 m.

RNA Performance Topic 6

A survey of visitor demographics, attitudes, perceptions, and experiences in Dry Tortugas National Park

Investigator

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Project Description

This project surveys visitor demographics, attitudes, perceptions, and experiences of park resources among visitors who enjoy recreational boating, fishing, SCUBA diving, snorkeling, and other activities. In addition, the report will provide a geospatial assessment of geographic locations of these uses. The science plan calls for the identification of human factors contributing to behaviors and actions of park visitors that have significant impacts on resources and the success of the Research Natural Area (RNA). A better understanding of the human dimension will greatly inform adaptive management efforts by National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) in evaluation of the RNA and other park management zones. By characterizing visitors' ecological knowledge and perceptions, NPS and FWC will improve education and outreach messages, encourage compliance with fishing and anchoring regulations, and enable visitors to protect the resources they enjoy. The geospatial assessment and survey questions will help elucidate heavily utilized areas within the park, as well as highlight possible areas of user-group conflicts. Another component included in the survey instruments will address a travel-cost analysis to estimate the value of recreational benefits generated by marine ecosystems. Finally, NPS also seeks to measure visitor satisfaction and enjoyment after RNA implementation. The project is funded by the NPS service-wide recreational fee program and coordinated by the NPS Ocean and Coastal Resources Branch of the Natural Resource Program Center and Dry Tortugas National Park.

Survey data will be collected through visitor contact and mail and internet surveys. Separate surveys will be administered to visitors arriving either by commercial ferry or by private boats. Visitors will be contacted on-site and those agreeing to participate will complete a brief on-site contact sheet. The main survey questionnaire will be sent to these identified individuals within one month of being contacted and will be completed either by mail or internet.

Tourist ferries docked at Garden Key in front of Fort Jefferson. Photo by Mike Ryan, NPS.

An NPS ranger and visitor snorkel outside the moat wall at Fort Jefferson, Dry Tortugas National Park. Photo by Brett Seymour, NPS.

Accomplishments

Design of the survey questionnaires was completed. University of Massachusetts and NPS collaborated to develop the survey questionnaires and methodology. These efforts have improved understanding of the human dimension information needed for the project, as well as the survey methods needed for the unique conditions and visitor use patterns at this remote marine park. Separate survey questionnaires for ferry passengers and private boats were designed and completed in September 2008. These quantitative survey instruments were informed by similar research activities completed by the University of Massachusetts for the Florida Reef Resilience Program in 2007. In addition, prior research drawn from a wide array of social science literature and discussions with park management informed the design and format of specific questions.

Progress was made toward Office of Management and Budget (OMB) approval and public commenting. Regulations under the Paperwork Reduction Act require review by OMB on social science surveys as well as two opportunities for public notice and comment. The initial public notice was published in the Federal Register on May 6, 2009. (Only one comment was received during the 60-day comment period.) The Investigator working with NPS staff submitted justifications and copies of the survey questionnaires required by OMB. Department of the Interior and OMB must review these materials before publication notice in the Federal Register of the second and final 30-day opportunity for public comment and before final approval.

Preliminary Results

Each survey instrument is unique because of differences in opportunities for visitors arriving by ferry at Garden Key and from private boats with greater access to marine resources. Each has an identical set of core questions followed by questions specific to primary recreational activity and location. The survey questionnaires will provide basic demographic information on the respondents, the frequency and extent to which they engage in different types of recreational activities, their experience levels as anglers, divers, or in other activities, their perceptions of the RNA, their views on the ecological health of resources and the relative impacts of environmental stressors and recreational activities, their preferred sources of information, and factors such as ecological health and visitor crowding that diminish their enjoyment.

Future Work

Data collection will continue from February 2010 through December 2010. We will then enter the data and perform quality control checks during the period of December 2010 and February 2011. A draft report will be prepared by May 2011. The final report for the project will be completed by October 2011.

RNA Performance Topic 6

Law enforcement in Dry Tortugas National Park

Investigator

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Project Description

The primary law enforcement goals at Dry Tortugas National Park (DRTO) are to educate the public and enforce zones that do not permit anchoring and fishing. This includes an emphasis on enforcing fishing limits in areas where fishing is permitted, as well as enforcing laws that protect sensitive turtle, coral, and seagrass habitat. At DRTO, it also includes the protection of submerged cultural resources.

Law enforcement also strives to minimize hazards that pose a threat to human health and safety. One of the most significant aspects of the DRTO law enforcement program is to provide education to the user group to build a greater understanding and appreciation of the values the park is working to perpetuate. Building the user group constituency will translate into a greater protection of the resource and more support for the programs.

Law enforcement must partner with neighboring agencies to be effective and maximize enforcement potential. DRTO currently partners with a wide range of state and federal law enforcement agencies and the military.

Law enforcement is able to account, several times a day, for visitor use in the Research Natural Area (RNA). Vessels are contacted on the water or, more frequently, when they return to Garden Key. Area closures are enforced as are prohibited activities in the Research Natural Area, such as fishing. Law enforcement personnel also make frequent contact with researchers to identify at-risk areas.

Accomplishments

DRTO was fortunate to be able to capitalize on information supplied by a confidential informant concerning illegal fishing activities in the park. DRTO used the information to collaborate with law enforcement personnel from the U.S. Fish and Wildlife Service. The goal for this case was to publicize that fishing illegally in the park has significant consequences. The case yielded jail time and forfeiture. The case also led to the largest lobster poaching case in Florida history, called "Operation Freezer Burn," which was widely publicized. The case targeted one of the biggest threats to DRTO, which is overfishing.

There is also commercial pressure from fishing along the park and RNA boundary. A case was successfully made when a commercial trap line was placed along the boundary that was partially in the RNA. As a result of this case, trapping and commercial fishing are no longer occurring as close to the boundary.

The majority of commercial fishermen and private boaters are contacted and briefed about the values of the resource and the rules and regulations that govern their use. This is often accomplished with pamphlets written in English and Spanish. Partnerships with state and federal law enforcement agencies have been made. Deputization with the Florida Fish and Wildlife Conservation Commission is being pursued.

Preliminary Results

DRTO has a frequent turnover of law enforcement staff. Replacing a law enforcement ranger presently takes longer than 6 months. Once replaced, the training time required for the position to conduct effective enforcement is about a year. The park is frequently staffed below effective levels to execute its mission. As a result, the law enforcement actions described above are intermittent and dependent on staffing levels. Presently DRTO is relying on seasonal rangers that are limited to 26 weeks of employment.

Future Work

Continue to develop collaborative relationships with state and federal law enforcement agencies and the military. Establish a Memorandum of Understanding with Florida Fish and Wildlife Conservation Commission to establish cross-deputization. Maintain the fiduciary agreement with the U.S. Department of Homeland Security for reimbursement of expenses related to illegal immigration that would otherwise detract from the NPS mission. Fund the hiring of enough rangers so that the loss of a position does not severely impact the entire program and will allow continuity of the protection function. Overcome housing limitations to provide adequate housing for needed staff.

Law enforcement ranger spots a boat from the lighthouse on Fort Jefferson, Garden Key, Dry Tortugas National Park. Top photos by David Walton, NPS. Garden Key Harbor Light on top of Fort Jefferson overlooking a fishing boat anchored in the harbor. Bottom photo by Joy Brunk, NPS.

RNA Performance Topic 6
Submerged cultural resource condition assessment project

Investigators

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Project Description

This project was designed to conduct current condition assessments of known submerged cultural resources in the park. Most sites had not been monitored since their discovery in the 1970s and 1980s, and implementation of the Research Natural Area (RNA) Submerged Cultural Resource Strategy called for baseline documentation and monitoring. The goals of the project were to gather baseline data on all sites and implement a subsequent monitoring program. The NPS Submerged Resource Center (SRC) led the condition assessments and provided training to park divers to develop internal capacity to continue site monitoring. In addition to the primary project goals, additional funding allowed follow-up investigation of magnetic anomalies discovered during magnetometer surveys by the SRC in the 1990s.

NPS divers assess cultural resource at Dry Tortugas National Park. Photo by Brett Seymour, NPS.

Accomplishments

- The project achieved its primary goals by either completing condition assessments or determining that submerged resources could not be located at 43 sites listed in the NPS Archeological Sites Management Information System (ASMIS), including verifying or correcting location data
- Added 10 sites to the ASMIS database
- Captured numerous high quality digital and video images of RNA cultural and natural resources and park operations; these will be available for publications and outreach efforts
- Trained the DRTO/EVER dive team on dive operations, conducting condition assessments, and underwater mapping techniques that can be used for cultural resource documentation, groundings, etc.
- Developed a database of all corrected DRTO site data for development of the park's cultural resource management/compliance database
- Provided training to maritime archaeologists from South Africa researching the history of the international slave trade, and set the groundwork for future collaborations on this topic of international importance.

Preliminary Results

All but one of the submerged cultural resources inspected in DRTO were in good condition. This relatively consistent baseline data should provide an opportunity to observe the long-term trends of RNA implementation on submerged cultural resources.

Future Work

The SRC plans to return in 2010 to try and relocate sites not relocated in 2009 (per ASMIS guidelines). Further investigation of known magnetic anomalies, as well as survey of deeper waters, is also planned. Maritime archaeologists from South Africa are planning to return to learn documentation techniques relevant to their research on the historical international slave trade. Continuation of site monitoring is planned for 2011.

National Park Service diver records information about a cultural resource near Garden Key, Dry Tortugas National Park. Photo by Brett Seymour, NPS.

Area of Detail

North

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www.nps.gov/ever/naturescience/sfnrc.htm
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