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 Park

Assessing the Conservation Efficacy of the Dry Tortugas National Park Research Natural Area

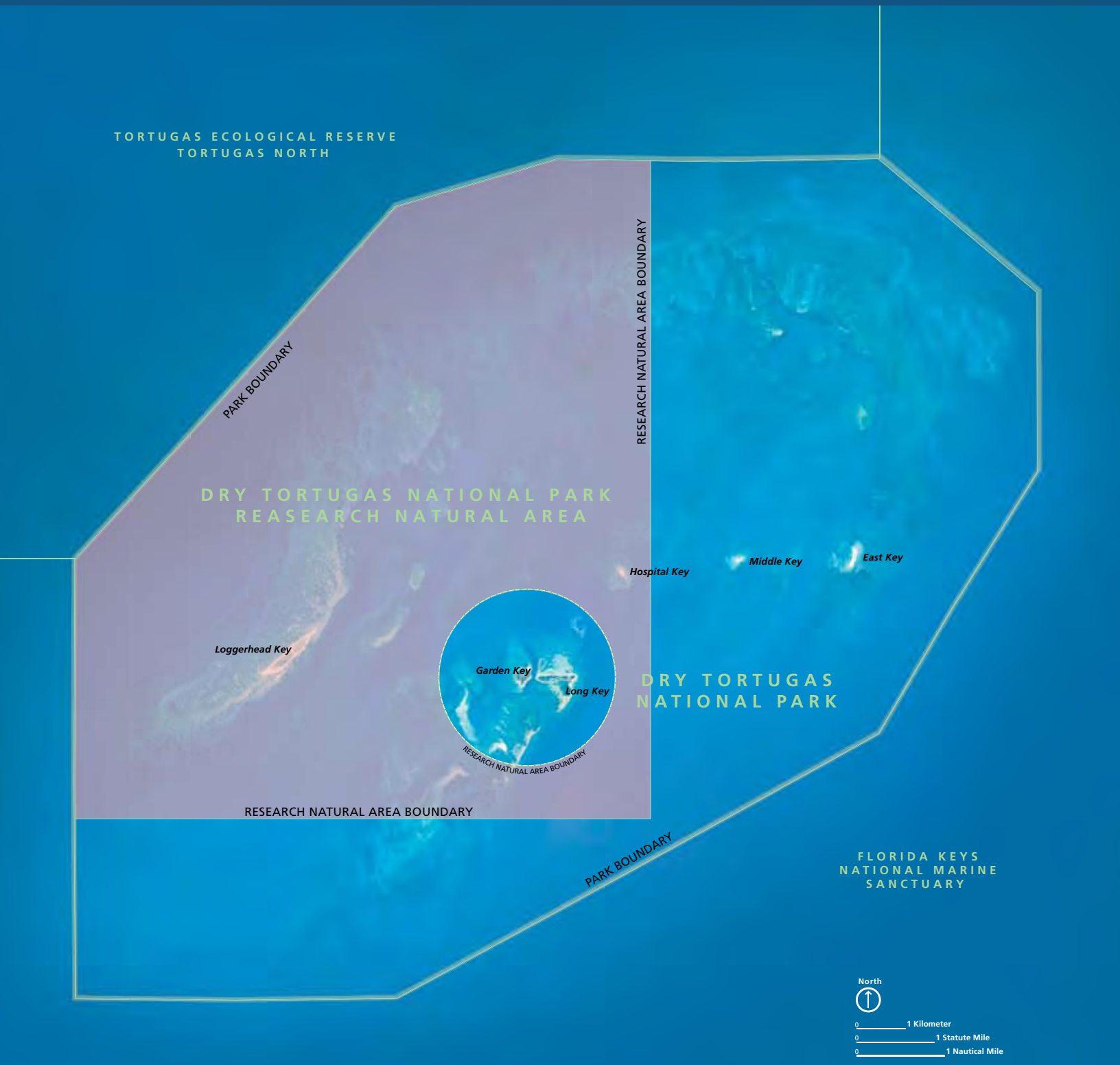
A Science Plan Prepared by the

National Park Service

and the

Florida Fish and Wildlife Conservation Commission

2007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TORTUGAS NORTH
PARK BOUNDARY
RESEARCH NATURAL AREA BOUNDARY
DRY TORTUGAS NATIONAL PARK
REASEARCH NATURAL AREA
Hospital Key
Middle Key
East Key
Loggerhead Key
Garden Key
Long Key
DRY TORTUGAS
NATIONAL PARK
RESEARCH NATURAL AREA BOUNDARY
RESEARCH NATURAL AREA BOUNDARY
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Tallahassee, Florida

Cover photograph of red grouper by Jerry Ault, Univ. of Miami/RSMAS
Cover photograph of blue striped grunt and gray snapper by Brett Seymour, NPS

Assessing the Conservation Efficacy of the Dry Tortugas National Park Research Natural Area

EXECUTIVE SUMMARY

Introduction

The newly established Research Natural Area (RNA) of Dry Tortugas National Park (DTNP) is a 46-square mile marine reserve designed to restore ecological integrity and capacity for self-renewal by minimizing the effects of human activities. Anchoring and fishing are prohibited within the RNA. This report presents a science plan developed by the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) that will be used to assess the effectiveness of the RNA.

The goal of establishing the Dry Tortugas National Park RNA is to protect shallow water marine habitat, ensure species diversity, and enhance the productivity and sustainability of fish populations throughout the region. 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.

In February 2007, the NPS and the FWC established a Memorandum of Understanding (MOU) to facilitate cooperation in the evaluation of six areas of RNA performance. A summary description of these six performance areas, together with associated performance measures and monitoring and research activities, is provided here in the Executive Summary. An in depth discussion follows in the Monitoring and Research Activities section of the main report. While the performance areas are described as separate topics, there are important interdependencies among them. These relationships are illustrated in Figure 1.

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

Research suggests that the abundance and population size-structure of exploited species in the RNA are below levels required to sustain the species. An intended conservation function of the RNA is to increase the abundance and size-structure of these exploited species. Multiple scientific studies of no-take marine reserves suggest that these areas have served to enhance fisheries.

Performance Measures

Abundances, sizes, occurrence frequency, and estimates of fisheries stock assessment parameters for groupers, snappers, and grunts inside and outside the RNA. Abundance of reference (non-fishery) reef fishes (e.g., parrotfishes).

Essential Activities

1) Implement an annual coral reef fish visual census (RVC) in DTNP using a stratified random sampling design (SRS) inside and outside the RNA.

2) Employ fish traps and hook-and-line gears to collect additional information on selected species to evaluate changes in relative abundance and size-structure. At least initially, data should be collected three times a year. These efforts will also provide individual fish for use in tagging activities (see Topics 2 and 5).

Supplemental Activities

1) Conduct visual surveys of fishes in seagrass communities inside and outside the RNA. Reef fish species, especially juveniles, found in seagrass beds may be an early indicator of RNA success.

2) Conduct seasonal coral reef visual surveys inside and outside the RNA to provide additional information on the abundance and size of reef fish.

Yellowtail snapper and staghorn coral. Photo by William Perry, NPS.

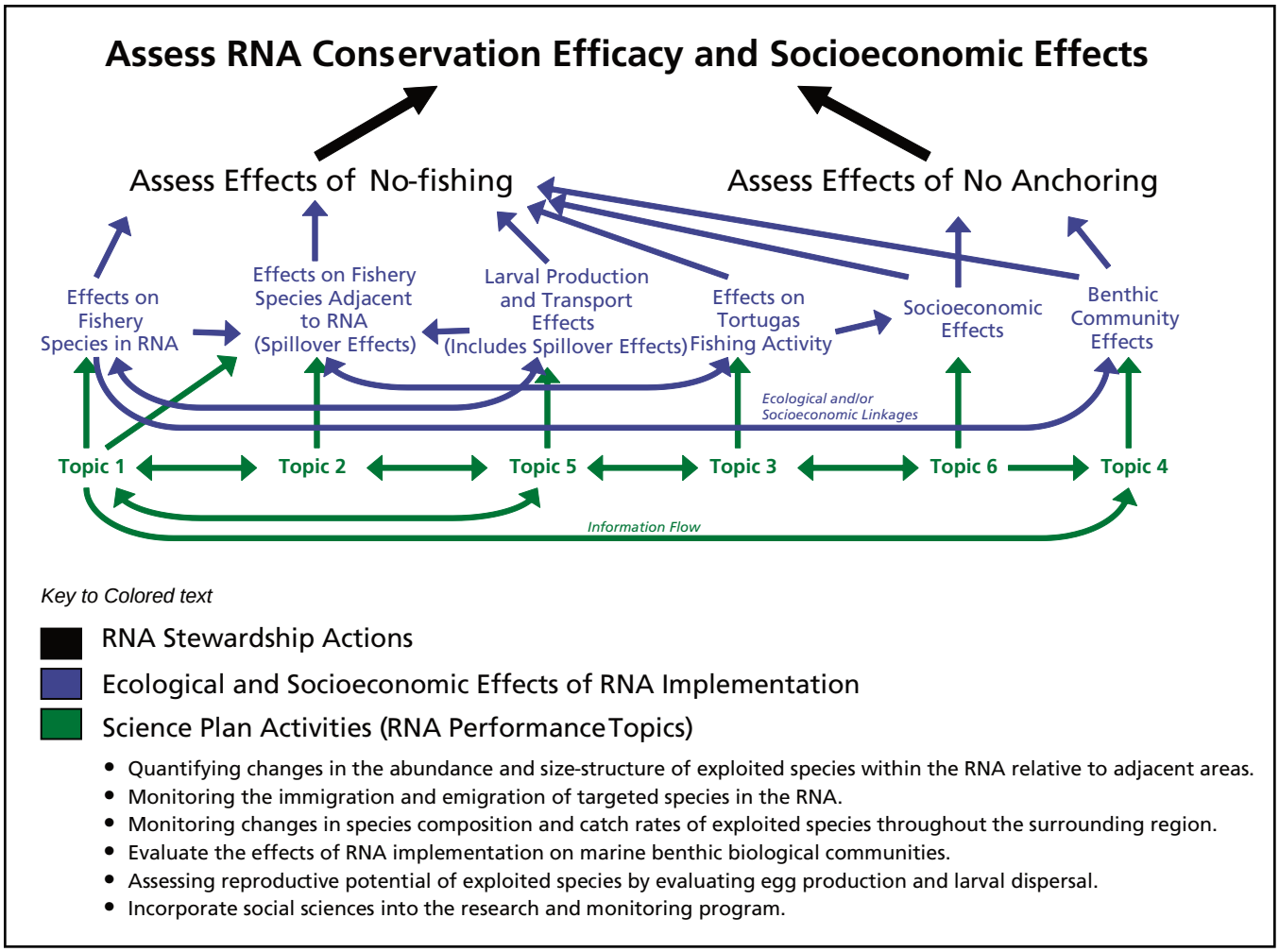

Figure 1. There are numerous ecological connections between and among the six distinct topical areas of study identified within the DTNP RNA science plan. Information (sampling data, biological specimens, etc.) will be shared across the topical areas as well in order to assess efficiently the effects of the no-fishing and no-anchoring management actions on marine resources.

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

The abundance and size-structure of target species are expected to increase in areas adjacent to no-take marine reserves due to emigration from the protected areas. Recent scientific studies of coral reef fisheries confirm that marine reserves have the ability to enhance adjacent fisheries, resulting in greater fish biomass (more and larger fish). This outcome is commonly known as a spillover effect.

Performance Measures

Net emigration of select species from the snapper-grouper complex from the RNA to adjacent fished areas inside and outside DTNP.

Essential Activities

1) Implement a sonic tagging study to monitor broad scale net emigration patterns of selected species from the RNA to fished areas in the DTNP region. The study area will encompass the Florida Shelf of the DTNP region and consist of open fished areas (Natural/Cultural Zone (NCZ), DTNP and Florida Keys National Marine Sanctuary (FKNMS) waters south of the DTNP to Rebecca Shoals (15 km east of DTNP), and regulated marine protected areas (RNA, Tortugas South Ecological Reserve (TSER) and Tortugas North Ecological Reserve (TNER)).

2) Use external tags on selected species to monitor broad scale net emigration patterns from the RNA to fished areas in the DTNP region. Recaptured individuals should then be identified from subsequent sampling events as well as from reports made by recreational anglers to the FWC Fish and Wildlife Research Institute tag return hotline.

Supplemental Activities

1) Expand sonic tagging to examine immigration and emigration from the RNA to the TSER.

2) Expand sonic tagging to examine immigration and emigration from the RNA to the TNER.

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

The benefits of establishing the RNA may include an enhancement of recreational and commercial fisheries. Recent scientific studies of coral reef fisheries have shown that other marine reserves have contributed to the enhancement of adjacent fisheries. These effects include more and larger fish, increased catch rates, and reduced fishing effort per catch.

Performance Measures

Catch per unit effort (CPUE), including released fish, harvest per unit effort, estimated total catch and harvest, and population size-structure of targeted reef fishery species, especially grouper and snapper species, throughout the Tortugas region.

Essential Activities

1) Design and implement an angler creel survey in fished areas within DTNP (survey conducted by fixed intercept at Garden Key, roving patrol, and via the visitor use permit system). This survey should record catch per unit effort and sizes of reef fish caught.

2) Collect DTNP permitted charter boat recreational fishing data via a logbook system.

3) Review and utilize data from existing Tortugas recreational and commercial fisheries dependent monitoring programs to evaluate the effects of RNA implementation on fisheries outside DTNP.

Supplemental Activities

1) Estimate overall fishing activity in DTNP using the park visitor use permit system and/or aerial surveys.

2) Conduct aerial surveys of fishing activities in the Tortugas region.

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

RNA implementation may have a variety of direct and indirect effects on coral reef benthic, and perhaps even seagrass, communities. Prohibiting anchoring in the RNA should greatly reduce or eliminate any anchor damage to coral reef, other hard bottom, and seagrass communities.

However, because the RNA is a no anchor zone, diving will be concentrated at designated dive sites associated with mooring buoys. The intensity of diving activity at these sites could cause direct damage to corals. In addition, anchor damage to corals could increase at prime fishing and diving sites adjacent to the RNA (e.g., Bird Key Reef) if fishing and diving activity is effectively displaced to these sites. Also, from an ecological perspective, the recovery of reef fishes in the RNA following the elimination of fishing could have cascading effects on coral reef benthic communities and ecological processes.

Mooring buoys provide an alternative to substrate-damaging boat anchors. Photo by FKNMS.

Performance Measures

Damage to and loss of stony and soft corals species (Essential Activities 1 and 2 below), seagrass, benthic community structure, abundance of functional groups; measures of grazing pressure, coral recruitment, spawning, and disease; and measures of primary productivity (Essential Activity 3 and Supplemental Activity 1 below).

Essential Activities

1) Assess the effects on corals of SCUBA and snorkeling use at RNA designated (mooring buoy) dive sites. At least four dive sites and four reference sites should be sampled once per year.

2) Using visual methods, evaluate the ecological effects of fishing and dive boat anchoring on coral reefs adjacent to the RNA. These activities could be conducted annually at Bird Key Reef.

3) Investigate trophic cascade effects on RNA coral reef community structure and ecological processes resulting from the removal of fishing activities.

Supplemental Activities

1) Assess the effects of creating the RNA no anchor zone on coral reef and seagrass beds.

Sailboat anchored in Dry Tortugas National Park. Photo by Brett Seymour, NPS.

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

Protecting populations of reef sportfish may result in larger, more fecund fish. Productivity of these fishes may help replenish sportfish populations regionally via larval transport. An improved understanding of reproductive and larval dispersal parameters will help inform larval transport models and assist in understanding of the regional benefits of RNA establishment.

Performance Measures

Fecundity and larval production of reef sportfish and movement of reef sportfish from the RNA to spawning aggregation sites. RNA export of targeted reef fishery species, primarily larval groupers and snappers, throughout the Tortugas and Florida Keys.

Essential Activities

1) Collect and develop population data on reef sportfish fecundity. Use a variety of methods inside and outside the RNA to develop a robust fecundity dataset for one or two species, representative of the snapper-grouper complex.

2) Incorporate tagging studies to evaluate movement to and from spawning aggregations outside of the RNA.

3) Implement drifter studies using spawning aggregations to assess regional larval export.

4) Review and provide recommendations for expanding ongoing efforts to study and model larval transport.

Supplemental Activities

1) Expand ongoing efforts to model larval transport throughout the region.

2) Implement a demonstration of connectivity between the RNA and surrounding regions by inducing females to produce larvae with a unique genetic marker, possibly by chemical- or radiation-induced chromosome damage or insertion of a particular gene sequence into lab-reared females.

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

Given that a key component of the National Park Service mission is to provide for public enjoyment of the natural and cultural resources held within national parks and to provide educational opportunities, the NPS seeks to understand the effect of the RNA on the visitor experience. Visitors understand, appreciate, and are inspired by NPS resources; and, given appropriate information and education, they also tend to support resource protection efforts. It is expected that the quality of the visitor experience will be enhanced by RNA implementation.

Performance Measures

Fishing activity, SCUBA and snorkeling activity (total number of SCUBA divers and snorkelers and duration in water for each designated dive site and reference site), number of boats anchoring by location, visitor satisfaction, and law enforcement activity and regulatory compliance rates (number and percentage of violations by user permit type). Creel survey performance measures and required fishing activity data are discussed under Topic 3.

Essential Activities

1) Collect and analyze fishing, diving, and boat use data needed to assess the effects of RNA implementation on visitor use.

2) Implement an appraisal system to characterize visitor use experience and views regarding RNA implementation.

3) Monitor RNA law enforcement activity and regulation compliance rates by visitors, commercial operators, and scientific researchers on an annual basis.

Supplemental Activities

1) Assess the economic effects of RNA implementation using standard socioeconomic methods.

Schedule of Deliverables

As established in the MOU between the FWC and the NPS, a jointly prepared report evaluating the performance of the RNA will be provided to FWC Commissioners, NPS managers, and the public at three and five year intervals.

Ranger and visitor snorkel at Fort Jefferson, Dry Tortugas National Park. Photo by Brett Seymour, NPS.

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Opposite page: NPS scientists evaluating benthic communities. Photo by Brett Seymour, NPS.

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LIST OF ABBREVIATIONS

BACI	Before-After-Control-Impact
CPUE	Catch per unit effort
DTNP	Dry Tortugas National Park
ENP	Everglades National Park
ESA	Endangered Species Act
FKNMS	Florida Keys National Marine Sanctuary
FWC	Florida Fish and Wildlife Conservation Commission
GMP	General Management Plan
MOU	Memorandum of Understanding
NCZ	Natural/Cultural Zone
NEPA	National Environmental Policy Act
NMFS	National Marine Fishery Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
REEF	Reef Environmental Education Foundation
RNA	Research Natural Area
RSMAS	Rosenstiel School of Marine and Atmospheric Science
RVC	Reef Visual Census
SDCP	Stationery Diver Circular Plot
SEFSC	Southeast Fisheries Science Center
SFCN	South Florida Caribbean Network
SOW	Scope of Work
SRS	Stratified Random Sampling
TER	Tortugas Ecological Reserve
TNER	Tortugas Northern Ecological Reserve
TSER	Tortugas Southern Ecological Reserve
USGS	United States Geological Survey

Please reference this report as follows:
SFNRC and FWC. 2007. Assessing the Conservation Efficacy of the Dry Tortugas National Park Research Natural Area. South Florida Natural Resources Center, Everglades and Dry Tortugas National Parks, Homestead, FL, and the Florida Fish and Wildlife Conservation Commission, Tallahassee, FL. 47 pp.

INTRODUCTION

Renowned for its cultural and natural resources, Dry Tortugas National Park (DTNP) lies at the western end of the Florida Keys along the Straits of Florida. First established as Fort Jefferson National Monument in 1935, the site was reauthorized in 1992 as Dry Tortugas National Park. Congress established the park 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 must be managed so as to protect, among other values, "a pristine subtropical marine ecosystem, including an intact coral reef community." The seven islands of the Dry Tortugas are composed of sand, limestone, and coral reef fragments and are surrounded by shoals and water to depths of 25 m (82 ft). A significant characteristic of the park is its ratio of land to water; 99.8% of the park consists of marine ecosystems.

This report presents a science plan developed by the National Park Service (NPS) and the Florida Fish and Wildlife Conservation Commission (FWC) that will be used to assess the effectiveness of the Research Natural Area (RNA) of Dry Tortugas National Park, established in January 2007. The RNA is a 46-square mile marine reserve designed to restore ecological integrity and capacity for self-renewal by minimizing the effects of human activities (see map of RNA on inside cover). The RNA complements protection afforded by the adjacent Tortugas Ecological Reserve (TER) of the Florida Keys National Marine Sanctuary (FKNMS) established by the National Oceanic and Atmospheric Administration (NOAA) and the state of Florida, and thereby contributes to a region-wide effort to strengthen resource protection. Together, the RNA and the larger TER will help to ensure the success of both marine and terrestrial ecosystems while offering outstanding opportunities for scientific research and public education (see map of the regional reserve network on the inside back cover).

The goal of establishing the DTNP RNA is to protect shallow water marine habitat, ensure species diversity, and enhance the productivity and sustainability of fish populations throughout the region. Appropriate activities within the reserve include boating, swimming, snorkeling, scuba diving, hiking, research, and education. Anchoring and fishing are prohibited; however, mooring buoys will be provided for day use by snorkelers and scuba divers. No manipulation of resources is allowed, except as needed to accomplish restoration. 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 NPS and the FWC are committed to working together to conduct research, education, enforcement, and adaptive management of the Dry Tortugas ecosystem. In February 2007, the NPS and the FWC established a Memorandum of Understanding (MOU) to facilitate cooperation in the evaluation of the performance of the RNA. The MOU identifies six areas of RNA performance to be evaluated:

1. Quantification of changes in abundance and size-structure of exploited species within the RNA relative to adjacent areas;
2. Monitoring of the immigration and emigration of targeted species in the RNA;
3. Monitoring of changes in species composition and catch rates of exploited species throughout the surrounding region;
4. Monitoring of species composition and abundance of the benthic community;
5. Assessment of reproductive potential of exploited species by evaluating egg production and larval dispersal; and
6. Incorporation of social sciences into the research and monitoring program.

Grunts and yellowtail snappers in soft coral. Photo by Jerry Ault, Univ. of Miami/RSMAS.

The MOU stipulates that a monitoring and research plan be developed that incorporates the RNA performance areas described above. The MOU requires that a review and summary of past and existing work in DTNP relevant to the RNA be undertaken and that a schedule of deliverables for reporting be provided.

In response to the direction provided by the MOU, this report identifies monitoring and research activities for each of the performance areas. Appropriate performance measures are listed for each performance area, along with both essential and supplemental categories of monitoring and research activities. Each performance area described in the Monitoring and Research Activities section of this report includes a summary of relevant past and existing work in DTNP. A schedule for delivery of evaluation reports is provided. For reference, the MOU is included as Appendix I of this report.

In order to ensure that science plan activities chosen would be those best suited to address the marine conservation objectives of the RNA, the NPS and FWC facilitated two science coordination meetings. The first meeting was held to obtain recommendations from state and federal agency scientists on February 12 and 13, 2007, in Homestead, Florida. Participating agencies included: Florida Fish and Wildlife Conservation Commission, National Park Service (DTNP, South Florida Caribbean Network, and Water Resources Division), NOAA (Fisheries, National Marine Sanctuary Program, and National Ocean Service), and U.S. Geological Survey (USGS). Using the recommendations gathered, the NPS and FWC developed a draft science plan and distributed it to agency scientists and members of the public for a 30-day review period. To provide additional opportunities for comment and input on the science plan, a public meeting was held in Key Largo, Florida on May 3, 2007. The meeting was well-attended by agency scientists, representatives of nongovernmental organizations, and concerned citizens. Review comments were addressed in the writing of this document. Both the comments and FWC/NPS responses are provided in Appendix II.

The implementing agencies believe that the RNA will provide substantial benefits to the Tortugas region; however, the authors of this report also recognize that ecosystems take time to respond to management actions. The developers of the assessment plan have recommended 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 this document and thereby have the potential to complicate RNA assessment. We anticipate that work summarized in the first three- and five-year assessment reports will document only the initial ecosystem response resulting from the implementation of the RNA. The full benefit of the RNA to the Tortugas region will likely only be measurable in the long-term.

The science plan presented in this report is specifically designed to address issues related to the RNA and identified in the associated MOU. However, because there remain important resource issues that are not directly addressed by the establishment of the RNA, additional resource stewardship strategies are being developed to help accomplish effective conservation of DTNP resources. For instance, while reef fish and coral declines are important DTNP natural resource stewardship issues, RNA establishment does not directly address the root causes of coral decline. A substantial decrease in stony corals has occurred over the last 30 years, especially among the major reef forming *Acropora* species, now formally listed under the Endangered Species Act (ESA). The loss of stony corals has been due mostly to disease, bleaching, hypothermic events (strong cold fronts), and hurricanes. Other resource protection strategies will be considered to address coral loss.

Diver in Dry Tortugas National Park conducting survey of fish and coral. Photo by Brett Seymour, NPS.

Resource managers will also need to assess the conservation efficacy of the newly created Special Protection Zones in DTNP. Special Protection Zones have been established in areas requiring protection from human impact, including areas of shallow and sensitive corals. The purpose of these zones is to protect and restore ESA listed species and other rare, at-risk species, assemblages, and habitats by providing maximum protection within the park. Science needs and activities for these and other natural resource stewardship issues not covered by the RNA MOU will be discussed in a more comprehensive DTNP science plan developed by the NPS.

MONITORING AND RESEARCH ACTIVITIES

This section of the science plan provides a detailed description of the monitoring and research activities associated with the six RNA performance areas identified in the MOU. For each topic, relevant performance measures are stipulated, a summary of past and existing work in DTNP and the region is provided, and anticipated essential and supplemental activities are identified. Though it may be valuable to develop quantitative targets for each performance measure, at this point, performance measure targets are directional and qualitative. Principle investigators that develop more detailed sampling designs should consider use of statistical techniques, such as power analysis, to develop sound quantitative targets. The first few years of study will help establish baseline variability in performance measures, vital to the development of quantitative targets.

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

MOU Scope of Work (SOW) A.2.a: "Expansion of ongoing research and monitoring program that assesses important reef fish populations, including the Dry Tortugas region and DTNP RNA. Expansion of this program shall be designed to provide a more robust database for examination of the performance of the RNA regarding its stated goals. The expanded research and monitoring program could incorporate a broad, multi-gear sampling approach to monitor changes in abundance and size of targeted species inside and outside RNA boundaries. Increases in the abundance and size-structure of these species in the absence of fishing mortality serve as an indicator that the RNA is protecting spawning biomass, age-structure, and genetic diversity that potentially enhance the productivity and sustainability of these species in the region."

The primary goal of no-fishing marine reserves is to produce long-lasting increases in the abundance, size-structure, and productivity of target fishery species within the reserve. Numerous scientific studies have demonstrated that marine reserves can and do achieve this goal (National Academy of Sciences 2001, Halpern 2003, Lubchenco et al. 2003). The activities described below are designed to test the hypothesis that implementation of the RNA will enhance reef fish populations within the protected area.

Performance Measures

Abundances, sizes, occurrence frequency, and estimates of fisheries stock assessment parameters for groupers, snappers, and grunts inside and outside the RNA.

Abundance of reference (non-fishery) reef fishes (e.g., parrotfishes).

Essential Activities

1) Implement an annual coral reef fish visual census (RVC) in DTNP using a stratified random sampling design (SRS) inside and outside the RNA.

Previous and Existing Studies. DTNP coral reef fish monitoring, using the same visual survey methods as described below, was conducted in 1999, 2000, 2002, 2004, 2006, and will be performed in 2008 (Ault et al. 2002, Ault et al. 2006, Ault et al. 2007). Habitat based stratified random sampling was done inside and outside the RNA. Abundance, individual size (length), and occurrence frequency data for reef fishes, primarily groupers and snappers, and non-gamefish reference species (e.g., parrotfish) were collected. Ault et al. (2006, 2007) have combined the 1999-2000 data and designated these the "baseline years." Ault et al. compared park wide abundance data statistically for each reef fish species that could be analyzed. The abundance of red grouper, gray snapper, hogfish, white grunt, and blue striped grunt in DTNP did not change significantly between 1999-2000 and 2004. Black grouper, mutton snapper, and yellowtail snapper increased in abundance between 1999-2000 and 2004 (Ault et al. 2006). However, comparing 1999-2000 and 2006 data, only mutton snapper increased significantly in abundance (Ault et al. 2007). There was no significant change between 1999-2000 and 2006 in the abundances of all other DTNP reef fishes that could be analyzed (Ault et al. 2007). Ault et al. (2006) presented "inside RNA" and "outside RNA" abundance data (mean + standard error) for key reef fish and reference species for each year (1999-2000, 2002, and 2004); however, statistical analyses were not performed.

Yellowtail snapper school. Photo by Jerry Ault, Univ. of Miami/ Rosenstiel School of Marine and Atmospheric Science (RSMAS).

DTNP reef fisheries assessments, using the reef fish monitoring data described above, were performed in 2002 and 2006 (Ault et al. 2002, Ault et al. 2006). The 2002 assessment, based on data gathered in 1999 and 2000, concluded that 45% (13 of 29) of reef fish species that could be analyzed are over-fished; 62% (18 of 29) of fish species analyzed exceeded the federal fishing mortality target by two to six times (Ault et al. 2002). This study also concluded that the DTNP fishery for reef fishes is in worse condition than the rest of the Tortugas region, and that increased regional fishing pressure over the previous 30 years is likely an important factor in these declines. The 2006 assessment, based on data collected from 1999 to 2004, concluded that over 80% of reef fish species, and over 90% of grouper and snapper species, that could be analyzed are over-fished (Ault et al. 2006).

NOAA has conducted annual fish visual census surveys since 2001 at 10 sites in DTNP, four in the RNA and six in the natural/cultural use zone (fishing permitted), and three sites adjacent to DTNP where fishing is permitted (Fonseca et al. 2006). This monitoring is part of the NOAA Tortugas Ecological Reserve Biogeographic Assessment Project. These surveys could provide additional information for assessing changes in reef fishes within the RNA relative to adjacent fished areas.

Proposed Studies. Implementation of an annual coral reef fish visual census using a stratified random sampling design could be accomplished by adding two strata (RNA and non-RNA zone) to the ongoing monitoring effort, and increasing sampling frequency to once a year for those two strata. Previous NOAA Southeast Fisheries Science Center (SEFSC) sampling of reef fishes in the Tortugas region used a Stationary Diver Circular Plot (SDCP) technique (Bohnsack and Bannerot 1986) with goals of distinguishing spatial differences between DTNP, Fished Tortugas Bank and the Tortugas North Ecological Reserve (TNER), detecting biannual temporal changes within each area, and detecting reef fish changes for the total Tortugas sample domain.

Sampling in DTNP used a two stage survey design that in 2004 included 194 primary 200 x 200 m sample units and 355 15 m diameter circular plots as second-stage units (Ault et al. 2006). Each primary sample unit included four fish census dives of circular plots. In 2006, 154 primary units and 298 second-stage units were sampled.

Detecting temporal changes and spatial differences of reef fish populations within the RNA and between the RNA and the non-RNA areas in DTNP will require appropriately stratified sampling within these zones. To ensure the same level of statistical power within the RNA and non-RNA zones, approximately twice the previous total number of samples will need to be collected annually. However, if it is determined that it is necessary to detect small parameter changes, then the increased statistical power required will necessitate larger sample sizes. In either case, an analysis of the actual occurrence by habitat type and spatial distribution of reef habitat strata within the RNA and non-RNA will be necessary to determine the optimal allocation of samples.

Previous SEFSC sampling in DTNP used a habitat strata classification based on the degree of patchiness and vertical relief. Sample allocation among strata was based on coverage area and variability in fish data. For comparison purposes, in 2006 primary sampling units in DTNP were allocated among eight strata as follows: low relief hard bottom - 81, low relief spur and groove - 14, patch hard bottom in sand - 24, medium-profile reef - 23, rocky outcrops - 24, reef terrace - 17, high-relief spur and groove - 4, and pinnacle reef - 7. If management desires to increase the number of habitat strata analyzed, then additional samples will be required. Actual sample size allocation in a monitoring plan will require a determination of the distribution of total habitat by type in the RNA and non-RNA. The final sample size allocation decision will be a compromise between total cost versus the desired precision of parameter estimates by habitat for total RNA and non-RNA zones.

Historical reef fish monitoring in DTNP focused on fixed sites such as “Little Africa” and “Texas Rock.” If managers decide that it is important to continue to monitor these sites, additional sampling should be considered for these locations in addition to the randomized stratified by habitat approach described above. The problem of pseudo replication should be considered. Multiple samples for fixed sites (especially small sites) may give a misleading sense of precision because the samples are not independent - the same fish are repeatedly sampled. In this regard collecting multiple samples on the same day is less desirable from a statistical perspective than having the same number of samples collected over a longer time period. In addition, since these historical sites were not randomly selected, the results from monitoring the sites may not reflect broader RNA and non-RNA trends.

2) Employ fish traps and hook-and-line gears to collect additional information on selected species to evaluate changes in relative abundance and size-structure. At least initially, data should be collected three times a year. These efforts will also provide individual fish for use in tagging activities (see Topics 2 and 5).

Previous and Existing Studies. DTNP partially initiated this activity in 2006 in conjunction with a sonic tagging project to assess reef fish movement (Ault et al. 2007). Eighty-four groupers were captured in 2006; length and weight data were recorded (Ault et al. 2007). FWC recently (2007) received USGS funding to continue this activity for three years beginning in 2008.

Proposed Studies. It is recommended that current research and monitoring efforts be expanded to incorporate passive sampling techniques such as baited fish traps and baited hook and line. Such a multi-gear approach would complement existing RVC monitoring by providing additional data from which abundance, frequency of occurrence, and size-structure of selected species can be compared among three regions (previously-established TER no-fishing zone, newly-established RNA, and areas open to fishing within DTNP). Because the actual length of each individual will be measured

and not estimated, this approach will allow for a more accurate comparison of size-structure of selected species. In addition, implementation of these gear types would provide individuals of selected species for use in tagging and telemetry studies of movement within and across RNA boundaries (see Topic 2 below) and biological material for life history studies (see Topic 5 below).

Collection of fisheries-independent data using fish traps and hook and line would be based upon the existing stratified random sampling design developed for the RVC monitoring program to maximize comparability of results. Sampling would occur within each of the three regions; within each region effort would be partitioned among habitat strata based on the degree of vertical relief and patchiness of hard bottom substrate. At each randomly-chosen sampling site, a series of fish traps will be deployed for a short duration (approximately 1 hour) to reduce the likelihood of trap feeding. While traps are soaking, the field crew will conduct a one-hour hook and line survey within the same sampling grid. All individuals collected during both fish trap and hook and line surveys will be identified to the lowest practical taxon, measured and enumerated, while individuals of selected species will undergo additional processing (see Topics 2 and 5 below). During fish trap and hook and line surveys, physiochemical and habitat data will be collected at each sampling site. Additionally, for hook and line surveys, detailed effort data as well as specific catch information (e.g., bait type, hook type, hook placement, condition of fish upon release) will be recorded.

SRS surveys incorporating fish traps and hook and line would preferably be conducted during three research cruises annually to examine seasonal dynamics of the reef fish community within DTNP as well as address the potential impacts of hurricanes and other stressors. Due to the difficult logistics of sampling during winter months, sampling would likely be restricted to a spring, summer, and fall research cruise.

Supplemental Activities

1) Conduct visual surveys of fishes in seagrass communities inside and outside the RNA. Reef fish species, especially juveniles, found in seagrass beds may be an early indicator of RNA success.

Previous and Existing Studies. No previous monitoring of reef fish species in DTNP seagrass beds has been conducted.

Proposed Studies. Reef fish species abundance and size-structure, especially of juveniles, would be measured at depth stratified randomly selected seagrass sites within the RNA and fished areas outside the RNA — similar to the sampling design recommended for coral reefs (see Essential Activity 1 above). The visual fish survey would be the SDCP technique (Bohnsack and Bannerot 1986) used on coral reefs (see Essential Activity 1 above). Seagrass plant community rapid assessments should be done at the fish survey sites (e.g., percent cover using the Braun-Blanquet or similar method). These seagrass plant community assessments would also contribute to Topic 4, Supplemental Activity 1. We suggest completing at least two surveys, one as soon as possible (because the RNA no-fishing zone has already been implemented), and one near the conclusion of the first five year assessment period.

2) Conduct seasonal coral reef visual surveys inside and outside the RNA to provide additional information on the abundance and size of reef fish.

Previous and Existing Studies. There has been no seasonal coral reef fish monitoring conducted in DTNP.

Proposed Studies. This activity would add seasonal monitoring (i.e., summer and winter) to Essential Activity 1 above. Previous visual sampling in the Florida Keys region has been based on annual sampling conducted in the summer to provide a consistent time frame when the weather is most predictable and conducive for conducting diving surveys. This approach was based on the assumption that annual sampling was sufficient to characterize reef fish communities since most reef species are long-lived (life spans on the order of years to decades) and exhibit high site fidelity. Previous NOAA SEFSC sampling in the Tortugas region was conducted biannually in June/July because of logistical constraints and the high expense of chartering a live-aboard diving vessel sufficient to carry numerous divers. Conducting sampling in the June/July time period ensured consistent weather for sampling and eliminated season as a confounding variable.

Southeastern Fisheries Science Center (NOAA) divers beginning a survey. Photo by Jerry Ault, Univ. of Miami/RSMAS.

Adding seasonal monitoring, in theory, requires obtaining the same number of samples for each season included. Thus, if two seasons (summer and winter) are considered, the total number of visual stations will be twice that of an annual sample, with half collected in the summer and half in winter. If four seasons are desired (summer, fall, winter, and spring), the

total number of samples will need to be four times as many as a single annual sample. However, the total cost for obtaining additional samples is likely to be much higher than a simple multiple of the summer sampling cost. Weather becomes more uncertain during other seasons (especially in the winter and spring) and fewer days are suitable for diving, extending the time required in the field. Options to be considered:

1. Continue to conduct sampling once a year in late spring or summer as representative of annual trends.
2. Expand directed sampling to include two seasons: winter and summer.
3. Expand directed sampling to include four seasons: winter, spring, summer, and autumn.

Options 2 and 3 are predicted to be disproportionately more expensive than summer sampling due to increased and unpredictable frequency of unsuitable conditions due to wind and turbidity. Locally chartered smaller vessels with fewer divers than used in the summer sampling could be used to take advantage of short periods of suitable weather in the other seasons. Nonetheless, a longer sampling period with more transit days would be still be required, as well as a readily available supply of trained divers.

Little evidence exists to support the possibility that southern Florida reef fish communities change radically during a year, although seasonal patterns in recruitment, movements, or spawning may occur for some species. For example, a preliminary analysis of data collected by Jones, Thompson, and Schmidt from Biscayne National Park in the 2006 Reef Revisited Project did not detect significant seasonal changes in reef fish populations (Dr. Todd Kellison, personal communication). Another experiment comparing summer and winter reef fish communities in Biscayne National Park by the University of Miami using SDCP methodology, is in the process of being analyzed (Dr. S. Smith, personal communication).

School of grunts in Dry Tortugas National Park. Photo by Douglas Morrison, NPS.

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

MOU SOW A.2.b: "Implementation of a variety of tagging studies (e.g., using acoustic tags as well as conventional dart-tags) to examine broad- and fine-scale movement patterns of targeted species in and out of the RNA. This would be accomplished by expanding ongoing collaborative acoustic tracking research projects as well as by conducting new studies. Such studies will help evaluate if adjacent fishing areas are enhanced through emigration of target species from the RNA."

An intended conservation benefit and ecological effect of no-fishing marine reserves is that the abundance and size-structure of targeted fishery species should increase in areas adjacent to the reserve due to net emigration from the reserve. This ecological process is commonly called the spillover effect. Scientific studies on coral reef fishery species have demonstrated spillover effects from no-fishing reserves (McClanahan and Mangi 2000, Roberts et al. 2001, Galal et al. 2002, Russ et al. 2003, Russ et al. 2004). Multiple tagging studies will be implemented to assess net movement of targeted reef fishes (groupers and snappers) from the RNA to adjacent fishing areas, and thus test the spillover effect hypothesis with this protected area.

Performance Measures

Net emigration of select species from the snapper-grouper complex from the RNA to adjacent fished areas inside and outside DTNP.

Essential Activities

Previous and Existing Studies. DTNP implemented a pilot sonic and external tagging project to monitor movement of selected grouper and snapper species out of and into the RNA in 2006 (Ault et al. 2007). This study initially focused on movement between the RNA and NOAA TER. In 2006, only three of the 33 sonic tagged fished were detected moving between the RNA and TER. The low percentage of individuals moving between the areas may reflect the lack of contiguous reef habitat transversing the RNA-TER boundary where the study was conducted. A deep (>40 m) and wide (2-6 km) sand trench separates most of the RNA and TER reef habitat in this area. This project is being expanded in 2007 to assess net movement of grouper and snapper species from the RNA to adjacent fishing areas.

FWC recently (2007) received USGS funding to implement a spatially extensive sonic and external tagging project to assess net emigration of groupers and snappers from the RNA to adjacent fishing areas. This three year project will begin in 2008.

1) Implement a sonic tagging study to monitor broad scale net emigration patterns of selected species from the RNA to fished areas in the DTNP region. The study area will encompass the Florida Shelf of the DTNP region and consist of open fished areas (Natural/Cultural Zone (NCZ), DTNP and Florida Keys National Marine Sanctuary (FKNMS) waters south of the DTNP to Rebecca Shoals (15 km east of DTNP), and regulated marine protected areas (RNA, Tortugas South Ecological Reserve (TSER) and Tortugas North Ecological Reserve (TNER)).

Proposed Studies. Sonic tags will be used to monitor broad scale immigration/emigration or flux of selected species from the RNA to fished areas throughout the DTNP region, with a focus on evaluating diel patterns of habitat use and identifying core utilization areas (home range). Samples will be collected using a SRS design. Broad scale movement studies will complement and be combined with fine scale acoustic studies currently being conducted along the northwest border of the RNA. The study area will encompass the Florida Shelf of the DTNP region and consist of open fished areas (NCZ, DTNP, and FKNMS waters south of the DTNP to Rebecca Shoals [15 km east of DTNP]) and regulated marine protected areas (RNA, TSER, and TNER).

Fifty acoustic Vemco VR2 receivers will be placed around and within the designated zones of the DTNP region. Zones will be classified into three categories: no-fishing zones (RNA, TSER, and TNER), DTNP, and FKNMS. Within these zones habitat will be classified by depth (0-10, 10 – 30, 30 – 60 m) and substrate (patchy hard bottom in sand, low relief hard bottom in sand, medium profile reef, low relief spur and groove, high relief spur and groove, reef terrace and pinnacle). Receivers will be anchored to the bottom with a 75 lb down weight attached to subsurface buoys and mounted on 2" x 3' PVC pipe. The receivers will be placed within the designated zones near capture and release sites and along bathymetric strata that approximate the sanctuary and park boundaries. Data will be downloaded tri-annually (early spring, summer, and late fall) with Vemco software requiring three boat trips per year.

Goliath grouper in Dry Tortugas National Park. Photo by Douglas Morrison, NPS.

Downloading efforts will require four working days with a team of four personnel.

Individuals of targeted species will be surgically implanted with Vemco acoustic pinger tags (V13 and V16) and external anchor tags. Samples will be collected by directed fishing efforts for targeted species with the assistance of a commercial fisher. In addition, fish will be captured and tagged in conjunction with the fishery independent SRS efforts using fish traps (Topic 1, Essential Activity 2). A total of 120 fish will be acoustically tagged (60 each year). Fishing trips will be coordinated with the acoustic data retrieval trips and SRS trips. Fishing efforts will require 5 working days with a team of four personnel. Each combined tri-annual trip to the DTNP will encompass a total of 9 working days plus 2 travel days.

2) Use external tags on selected species to monitor broad-scale net emigration patterns from the RNA to fished areas in the DTNP region. Recaptured individuals should then be identified from subsequent sampling events as well as from reports made by recreational anglers to the FWC Fish and Wildlife Research Institute tag return hotline.

Proposed Studies. Fish tagging will be conducted in conjunction with SRS surveys. Three research cruises are planned every year to examine the seasonal dynamics of reef fish communities within DTNP. The tagging projects are designed to track broader scale fish movements throughout the region and over time. In addition to movement information, the tagging program will also monitor fish survival within DTNP. The key to determining habitat range and monitoring survival is to maintain a consistent flow of tags going out into the fish population; this means continued tagging for a number of years with ongoing updates on survival estimates. It takes at least three tagging sessions to derive the first estimate of survival. With each subsequent tagging session, the survival estimate is extended an additional year. The premise underlying this monitoring tool is the probability of recapturing tagged fish. This approaches provides, and relies on, outreach to the recreational fishing community.

Methods: Conventional tagging techniques will be used during the SRS monitoring component to record fish movements and fish survival, within the three sampling regions (previously-established Marine Protected Area in TNER, newly-established RNA, and open-use areas within DTNP). All individuals of exploited species that are to be released alive will be tagged using conventional external tags prior to release. Recaptured individuals will then be identified from subsequent sampling events as well as reports from recreational anglers made to the FWC Fish and Wildlife Research Institute tag return hotline (1-800-367-4461). Information advertising the tagging program will be distributed throughout the Florida Keys and DTNP and will be published in local newspapers. Double and triple color-coded tags are now available to support a large number of individual identification codes. These tags will allow divers and snorkelers to report sightings without having to catch the fish.

The possibility of tag loss must be addressed in any monitoring program involving fish tagging. Survival estimates can appear artificially low if tag loss is not taken into account. Double tagging of individual fish allows for assessment of tag loss. This approach can be achieved through the application of two numbered tags or one numbered tag combined with a dorsal fin clip. In either case, the loss of numbered tags can be estimated. There are other approaches available, such as Passively Integrated Transponder tags, but they are more expensive.

Public Outreach: It is important to develop a high quality tagging program utilizing recreational anglers to enhance data collection efforts. Information advertising the tagging program and educating fishers and anglers about how to respond if they catch a tagged fish will be distributed throughout the Florida Keys, the DTNP, and other parks in south Florida. This information will also be published in local newspapers. Cooperation and participation from a wide range of fishers and divers is the key to the success of our tagging effort.

Supplemental Activities

1) Expand sonic tagging to examine immigration and emigration from the RNA to the TSER.

Proposed Studies. Test the hypothesis that fish move from foraging grounds (RNA, DTNP, and TNER) to spawning areas. Understanding population connectivity, spawning migratory movements, reproductive potential, and spillover in the DTNP region is critical to the assessment of the effectiveness of existing Tortugas no-fishing zone boundaries.

2) Expand sonic tagging to examine immigration and emigration from the RNA to the TNER.

Proposed Studies. Understanding population connectivity, spawning migratory movements, reproductive potential, and spillover in the DTNP region is critical to the assessment of the effectiveness of existing Tortugas no-fishing zone boundaries.

Nassau grouper, federal species of concern. Photo by Douglas Morrison, NPS.

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

MOU SOW A.2.c: "Development of a fisheries-dependent monitoring program to evaluate potential changes in catch rates, species composition, and size composition of commercial and recreational fisheries in areas surrounding the RNA. This program could use a variety of data collection methods including on-board observers, logbooks, aerial surveys, and recreational fisheries interviews."

One purpose of establishing no-fishing marine reserves, such as the RNA, is to enhance fisheries in areas proximate to the no-fishing zone. Recent scientific studies of coral reef fisheries have shown that marine reserves have enhanced adjacent fisheries, as measured by greater fish biomass (more and/or larger fish), greater catch, increased catch rate, and reduced fishing effort (McClanahan and Mangi 2000, Roberts et al. 2001, Galal et al. 2002, Russ et al. 2003, Russ et al. 2004). NPS and FWC will develop and implement a fisheries-dependent monitoring program to assess the effects of RNA implementation on recreational and commercial fisheries in fishing areas surrounding the RNA. Recreational fishing activity in DTNP will be monitored using private angler creel and charter fishing boat logbook surveys. Note: Commercial fishing has been prohibited in DTNP since 1935. This information will also contribute to targeted fishery species stock assessments. Existing Tortugas recreational and commercial fisheries dependent monitoring programs will be used to evaluate the effects of RNA implementation on fisheries outside DTNP.

Performance Measures

Catch per unit effort (CPUE), including released fish, harvest per unit effort, estimated total catch and harvest, and population size-structure of targeted reef fishery species, especially grouper and snapper species, throughout the Tortugas region.

Essential Activities

1) Design and implement an angler creel survey in fished areas within DTNP (survey conducted by fixed intercept at Garden Key, roving patrol, and via the visitor use permit system). This survey should record catch per unit effort and sizes of reef fish caught.

Previous and Existing Studies. DTNP private boat recreational fishing activity (creel survey) data were collected from 1981-1984 and 2000-2004. Ault et al. (2006) analyzed these data for historical trends. Grunt and gray snapper CPUE

declined between the two time periods; whereas, yellowtail snapper and grouper CPUE increased substantially. Creel results suggest that DTNP gray snapper abundance might be undergoing a long term decline. The decrease in grunt CPUE coupled with a decline in trips that caught grunts might indicate that grunt fishing intensity has been increasing in the park over the last 20 years.

Proposed Studies. A traditional creel census project will collect DTNP recreational fishing activity data from private boat anglers using access point intercept interviews conducted at the Garden Key and roving on-water interviews. Data recorded include fished species composition (emphasizing grouper, snapper, and grunt species), area fished (three fished zones: the Adaptive Use Zone, one nautical mile radius around Garden Key; the Natural Cultural Zone east of the RNA; and the Natural Cultural Zone west of the RNA), fish kept and released by species and zone, fish length by species, fishing effort (number of anglers multiplied by hours fishing), species preference, and angler residence.

The proposed DTNP visitor use permit system will require all private boat anglers to obtain a permit. Anglers could be required to provide fishing activity data as a component of this permit system. Anglers would be provided with survey forms when obtaining their permits. Anglers would be required to return completed surveys either at Garden and Loggerhead Keys, by US mail, or via the internet. This data collection technique could be as, or more, effective than the interview methods described above. This survey method should be developed, initiated, and evaluated when the new permit system is implemented.

2) Collect DTNP permitted charter boat recreational fishing data via a logbook system.

Previous and Existing Studies. DTNP charter boat recreational fishing activity surveys using a logbook system began in 2005. No catches were reported in 2005. Thirty-four trips were reported in 2006 and five trips thus far in 2007. The most common reef fishes caught were yellowtail snapper and red grouper.

Proposed Studies. All professional charter and guide boats operating in DTNP are required to obtain annual permits. These operators are required to provide monthly reports of the catch and effort for each fishing trip using logbooks supplied with their permits.

3) Review and utilize data from existing Tortugas recreational and commercial fisheries dependent monitoring programs to evaluate the effects of RNA implementation on fisheries outside DTNP.

Previous and Existing Studies. There are several existing Tortugas recreational and commercial fisheries dependent monitoring programs. Fishing activity by "head boats" has been collected by the National Marine Fisheries Service (NMFS) since 1981 using a logbook system. FWC initiated an on-board observer head boat survey program in 2005. A cooperative federal-state Fisheries Information Network (Gulf States Marine Fisheries Commission/FWC/NMFS) head boat survey is underway which will compare results from the NMFS and FWC programs. Tortugas charter boats report their fishing data via logbooks to the NMFS Charter boat Survey Program.

Tortugas commercial fisheries data are collected through the NMFS Florida commercial fisheries trip ticket program. Catches for most Tortugas commercial fisheries have declined over the past decade.

Proposed Studies. There are several recreational and commercial fisheries dependent monitoring programs that collect data from the Tortugas region. Recreational charter boat data in the Florida Keys/Gulf Coast are gathered through the Cooperative Gulf Charter Boat Survey Research Program administered in the SE Gulf Region by the state of Florida and Gulf States Marine Fishery Commission in cooperation with the NMFS. There is also a pilot logbook/telephone survey underway to determine which is the best method to estimate total effort (number of trips/anglers/hours fished) and angler catches. These are side-by-side survey comparisons with the current method used by the NMFS Marine Recreational Fishery Statistics Survey. The method deemed the best of the above alternatives will be implemented to assess charter boat fishing activity in the Tortugas. Tortugas commercial fisheries data will be compiled from federal and state commercial landings and logbook data collection programs that include the Tortugas Region.

Yellowtail snapper. Photo by Jerry Ault, Univ. of Miami/RSMAS.

Supplemental Activities

1) Estimate overall fishing activity in DTNP using the park visitor use permit system and/or aerial surveys.

Previous and Existing Studies. No studies have estimated overall fishing activity in DTNP.

Proposed Studies. The proposed DTNP visitor use permit system will require all private boat anglers to obtain a permit. Anglers could be required to provide fishing activity data through this permit system. Anglers would be provided with survey forms when obtaining their permits and would be required to return completed surveys either at Garden and Loggerhead Keys, by US mail, or via the internet. This method should be developed, initiated, and evaluated when the new permit system is implemented.

If the proposed permit system data collection technique is not feasible, then an aerial survey method should be designed and implemented. Aerial survey design should be similar to those conducted elsewhere (e.g., the current Everglades National Park (ENP) marine fishing boat surveys). The aerial survey technique provides less comprehensive data and is more costly than fishing activity surveys via the permit system. Visual surveys from Fort Jefferson could be conducted but these would likely be effective only for the Adaptive Use Zone, the one nautical mile radius around the fort.

2) Conduct aerial surveys of fishing activities in the Tortugas region.

Previous and Existing Studies. We have no knowledge of previous aerial surveys of fishing activities in the Tortugas region.

Proposed Studies. Aerial survey design should be similar to those conducted elsewhere (e.g., the current ENP marine fishing boat surveys).

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

MOU SOW A.2.d: "Increasing the number of benthic monitoring stations to include specific sites to evaluate the impacts of RNA mooring buoy visitor activities and fishing and boating effects in the Dry Tortugas. Measures of benthic community change and condition will be used to assess the impacts of diving and snorkeling activities in the RNA."

RNA implementation potentially could have a variety of effects on coral reef benthic, and perhaps even seagrass, communities. Because the RNA is a no anchor zone, diving will be concentrated at designated dive sites with mooring buoys. Frequent diving activity at these sites could cause damage to corals, as has been documented elsewhere. Anchor damage to corals could increase at prime fishing and diving sites adjacent to the RNA (e.g., Bird Key Reef) as a result of increased fishing and diving activity at these sites.

The recovery of reef fishes in the RNA after eliminating fishing could have cascading effects on coral reef benthic communities and ecological processes. Prohibiting anchoring in the RNA should greatly reduce or eliminate anchor damage to coral reef, other hard bottom, and seagrass communities. Science activities to assess these potential ecological effects are discussed below.

Performance Measures

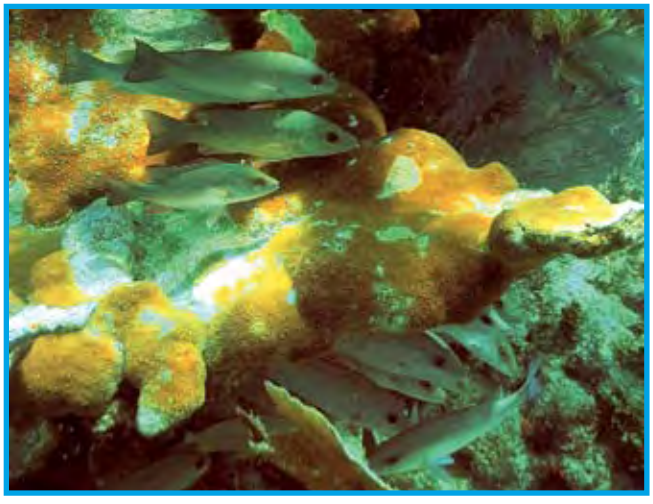
The resource stewardship target or objective is to have no long term effects on corals from diving or boat anchoring

Aerial photo of Bush Key and Fort Jefferson on Garden Key. Photo by Brett Seymour, NPS.

activities. The primary performance measures are damage and loss of branching, foliose, and plating stony coral species, especially ESA listed ***Acropora*** *species. Secondary performance measures are damage and loss of sponges, branching soft corals and head type stony coral species. Stony coral species with branching morphology (e.g.,* ***Acropora*** *and* ***Porites*** *species) are most susceptible to damage by diving activities (Hawkins and Roberts 1992, Harriott et al. 1997, Rouphael and Inglis 2002).* ***Acropora*** *species are now rare in DTNP and thus are at highest risk. Foliose and plating stony corals (e.g.,* ***Agaricia*** *species) are more susceptible than branching soft corals and head type stony corals (e.g.,* ***Montastrea*** *species). Damage can be measured as the percentage and/or number/area of coral branches and/or colonies broken and abraded. Loss can be assessed by measuring changes in live coral percent cover.*

Changes in the following key ecological attributes: Comprehensive coral reef benthic community structure; abundances of key species and functional groups, including stony and soft corals, sea urchins, especially Diadema, algal functional groups, and sponges. Herbivore grazing intensity; direct measures of fish grazing (e.g., bites/area/time); indirect measures of sea urchin grazing, especially Diadema (abundance/density). Coral recruitment and mass spawning. Coral disease and bleaching incidence; needed to differentiate effects of no-fishing from these important coral stressors. Benthic primary productivity. Target and non-target fish species and assemblage performance measures from Topic 1 (abundances and individual size of key fish species and functional groups).

The resource stewardship target or objective is ecological recovery of RNA coral reefs and seagrass beds from any previous anchor damage. Changes in the abundances (percent cover) of stony and soft corals, sponges, and seagrass.



White grunts and gray snapper around diseased elkhorn coral. Photo by William Perry, NPS.

Essential Activities

1) Assess the effects on corals of SCUBA and snorkeling use at RNA designated (mooring buoy) dive sites. At least four dive sites and four reference sites should be sampled once per year.

Previous and Existing Studies. There are no previous assessments of the ecological effects of diving on DTNP coral reefs. Preliminary baseline data are being collected at DTNP coral reef monitoring sites that will likely serve as reference sites for the RNA designated dive sites. The National Environmental Policy Act (NEPA) process for selecting RNA coral reef dive sites is ongoing; no mooring buoys have been installed yet.

Proposed Studies. Because boat anchoring is not permitted in the RNA, SCUBA diving and snorkeling activities in the RNA will be concentrated at designated dive sites with mooring buoys, and the designated Loggerhead Key swim areas. Multiple assessments from around the world have found that heavy diving activity, in most cases greater than 5,000-6,000 divers per year per site, on coral reefs have damaged corals (Harriott et al. 1997, Hawkins and Roberts 1997, Hawkins et al. 1999, Rouphael and Inglis 2002, Zakai and Chadwick-Furman 2002). Generally, at sites with less than 5,000 divers per year diver impacts are minimal or undetectable compared to undived control sites. Most studies recommend a diver carrying capacity of 5,000-6,000 divers per year per site.

Monitoring potential effects on corals of diving activity at DTNP designated dive sites is needed. However, initially a focused assessment project, described below, is recommended for the following reasons:

- Near term diving activity at almost all DTNP dive sites will probably be less than 5,000 divers/year; hence, diver damage is likely to be minimal at most sites, especially relative to other stressors. Furthermore, the carrying capacity for DTNP reefs might be higher than 5,000-6,000 because DTNP reefs are dominated by head and soft corals. Most impact assessments have been done on reefs dominated by branching stony corals which are more susceptible to diver damage than head type stony corals and soft corals (see below). An assessment conducted on soft coral dominated reefs recommended an annual limit of 7,000 dives per site (Schleyer and Tomalin 2000).
- Anticipate the need to continue comprehensively assessing coral reef "health" and the effects of known major stressors, such as disease and bleaching, on coral communities.

Scientific Approach/Methods: Damage and loss within the entire stony and soft coral assemblage at the three or four coral reef dive sites projected to have the most dive activity will be assessed annually for at least five years. Such a comprehensive assessment at all sites is cost prohibitive. Damage and loss of *Acropora* species will be surveyed annually at all dive sites. A fully replicated Before–After-Control–Impact (BACI)

sampling design (Green 1979, Underwood 1992) should be used to measure and compare contemporaneous changes at dive sites and equivalent reference reef sites with no or little diving activity. Baseline conditions need to be defined before dive sites are implemented. Statistically significantly greater damage at a dive site than its corresponding reference site will indicate diver damage. Coral damage and loss will be measured using a combination of scientifically accepted direct visual and photographic methods. Ideally surveys should be conducted in May and October to best differentiate diver damage from natural disturbance. Diving activity is greatest and the frequency of wave induced disturbance is usually lowest during this period. However, surveys will more likely be conducted once a year because of funding limitations. Diver use data will be obtained through the DTNP permit system (Topic 6, Essential Activity 1).

NPS divers conducting coral surveys. Photo by Brett Seymour, NPS.

2) Using visual methods, evaluate the ecological effects of fishing and dive boat anchoring on coral reefs adjacent to the RNA. These activities could be conducted annually at Bird Key Reef.

Previous and Existing Studies. There are no previous DTNP ecological assessments directly related to this activity. Preliminary baseline data are being collected at the DTNP coral reef monitoring site that will serve as the reference site for this activity.

Proposed Studies. Fishing boats commonly anchor along the boundary of many no-fishing zones (e.g., FKNMS Special Protected Areas). The intensity of fishing and dive boat anchoring adjacent to the RNA might become great enough at some locations to impact coral reef benthic communities. The most likely location for this to occur is on the part of Bird Key Reef in the Adaptive Use Zone (anchoring permitted). Fishing and diving activities, and thus anchoring, will likely increase here because this reef is prime reef fish habitat adjacent to the RNA, is a prime dive site that will not be limited by mooring buoy availability, and is the reef closest to Garden Key. The potential for recreational use-caused coral damage here could be greater than that at any dive site within the RNA. Therefore, we propose assessing the effects of boat anchoring on the coral reef benthic community on Bird Key Reef adjacent to the RNA. This project will be integrated with the diver effects on corals assessment project described above.

Scientific Approach/Methods: Damage and loss to all stony coral, soft coral, and sponge species will be assessed annually for at least five years on the section of Bird Key Reef adjacent to the RNA (anchoring and diving allowed) and two types of reference sites on Bird Key Reef in the RNA. One reference site will be at a mooring buoy dive site (no anchoring, but diving occurring). The other reference site will be sufficient distance from a mooring buoy so that there will likely be no diving (and, no anchoring). This design should help differentiate anchor effects from diving effects. Baseline conditions need to be defined before anchoring in the RNA is prohibited. Coral and sponge damage and loss will be measured using a combination of scientifically accepted direct visual and photographic methods. Recreational boat anchoring and diver use data will be obtained through the DTNP permit system (Topic 6, Essential Activity 1).

3) Investigate trophic cascade effects on RNA coral reef community structure and ecological processes resulting from the removal of fishing activities.

Previous and Existing Studies. The USGS recently (2007) funded a research project, "Coral-Algal-Herbivore Interactions in Protected versus Unprotected Reef Ecosystems," to investigate trophic cascade effects on coral reef ecosystems in no-fishing marine reserves, including the DTNP. This project has a conceptual approach very similar to that presented under Proposed Studies below.

The NPS South Florida Caribbean Network (SFCN) has recently (2007) established coral reef and other hard bottom benthic monitoring sites inside and outside the RNA which may contribute to this activity.

Proposed Studies. Over-fishing of large carnivorous fishes can have indirect effects on the abundances of non-target species, benthic community structure, and food web dynamics; a process called trophic cascade (Pauly et al. 1998, Russ and Alcala 1998, Dulvy et al. 2004, Sala et al. 2004, Mumby et al. 2006). Fishing first focuses on large carnivores, resulting in

a disproportionate loss of top predators from the ecosystem (Pauly et al. 1998). More intense fishing and fishing of wider-scope, especially using small mesh fish traps, has depleted smaller carnivorous and larger herbivorous and omnivorous reef fishes in multiple locations in the tropical western Atlantic (e.g., Garrison et al. 1998, Wolff et al. 1999). The consequences of these trophic shifts can cause fundamental changes in marine ecosystem structure and function. Establishing no-fishing marine reserves should help restore more natural benthic community structure and ecological processes (Mumby et al. 2006).

DTNP has not experienced the intensity and breadth of fishing pressure (e.g., fish trap use and spear fishing) as other places in the tropical western Atlantic. Thus, we would not expect as rapid or perhaps extensive trophic cascade response to RNA implementation as in these other locales. It is unlikely that trophic cascade effects in the RNA could be detected in the first five years after establishment. However, monitoring and research are needed in the next three years to establish baseline conditions to ascertain any future trophic cascade effects on DTNP coral reefs. DTNP could serve as an important information source for assessing the effects of no take marine reserves on reef food webs and community structure over a broader fishing pressure gradient and geographic scale.

Scientific Approach/Methods: Establish baseline conditions by collecting data on the above key ecological attributes at sites representative of the major reef benthic community types within the RNA and corresponding reference sites outside the RNA as soon as possible. Monitoring should be conducted annually to establish baseline conditions and assess trophic cascade effects. This project would require key fish species and functional group data from, and thus be coordinated with, Topic 1 projects.

An additional, complementary approach is focused research through a competitive proposal request process, similar to the current USGS State Partnership Program "Role of Marine Reserves in Florida and the U.S. Virgin Islands" research initiative. In fact, this USGS program recently funded a research project, "Coral-Algal-Herbivore Interactions in Protected versus Unprotected Reef Ecosystems," to investigate trophic cascade effects on coral reef ecosystems in no-fishing marine reserves, including DTNP.

Supplemental Activities

1) Assess the effects of creating the RNA no anchor zone on coral reef and seagrass beds.

Previous and Existing Studies. The existing DTNP seagrass community monitoring and assessment project can be used to assess the effects on seagrass beds of creating the RNA no anchor zone. This project, which began in 2005, has shallow seagrass monitoring sites inside and outside the RNA.

The SFCN recently established coral reef benthic monitoring sites inside and outside the RNA that can be used to assess the effects on coral reefs of creating the RNA no anchor zone.

Proposed Studies. RNA implementation 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.

Scientific Approach/Methods: Annual benthic monitoring at randomly (perhaps stratified) selected coral reef and seagrass sites inside and outside (reference sites) the RNA. A fully replicated BACI assessment design should be employed. Baseline conditions need to be defined before anchoring is prohibited. Percent cover of key benthic ecological attributes will be measured using a combination of scientifically accepted direct visual and photographic methods. Currently, there is no means to effectively collect pre-implementation boat anchoring data. Post-implementation boat anchoring data at reference sites outside the RNA will be obtained through the proposed park permit system (Topic 6, Essential Activity 1).

NPS scientists evaluating benthic communities. Photo by Brett Seymour, NPS.

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

MOU SOW A.2.e: "Expansion of ongoing efforts to track and model larval movement patterns within the Tortugas and Florida Keys region from important reef fish and other aquatic species to evaluate larval recruitment of several finfish species in the south Florida region."

A hypothesized spillover effect of no-fishing marine reserves refers to a broad-scale, regional replenishment of target fishery species via larval transport from the reserve. There is scientific evidence that reserves enhance populations regionally through greater larval production and export due to increased fecundity of organisms within reserves (Lubchenco et al. 2003). Drifter studies simulating larval transport have found that reef fish larvae spawned in the Tortugas could be viably dispersed as far as Cape Canaveral on the Atlantic coast and Tampa Bay on the Gulf coast (Burke et al. 2003). The activities proposed below will test this broad-scale spillover effect hypothesis with the RNA.

Performance Measures

Fecundity and larval production of reef sportfish and movement of reef sportfish from the RNA to spawning aggregation sites. RNA export of targeted reef fishery species, primarily larval groupers and snappers, throughout the Tortugas and Florida Keys.

Essential Activities

1) Collect and develop population data on reef sportfish fecundity. Use a variety of methods inside and outside the RNA to develop a robust fecundity dataset for one or two species, representative of the snapper-grouper complex.

Previous and Existing Studies. We have no knowledge of studies currently collecting population data on reef fishery species fecundity in the Tortugas region.

Proposed Studies. Collect biological material to compare the effects of fishing pressure and/or protection on the age-structure, size at age, sex ratio, and reproductive condition of selected species. This information could be collected in association with SRS monitoring using fish traps and hook and line (Topic 1) and creel surveys (Topic 3); and thus, would likely not require additional field sampling. Biological sampling will employ non-lethal methodologies (e.g., collection of spines/rays, gonad biopsies) to the greatest extent possible to determine age and sex of selected species. Traditional methodologies (e.g., ageing using otoliths, full reproductive workup) will be conducted on all individuals sampled during creel surveys to validate age data as determined via non-lethal methodologies and to conduct a detailed study of reproductive condition and fecundity. Since creel data will not be available from within TNER and the RNA, a limited number of individuals collected within these regions will be sacrificed to provide fecundity estimates, although this sampling will likely be restricted to known spawning seasons only.

2) Incorporate tagging studies to evaluate movement to and from spawning aggregation sites outside the RNA.

Previous and Existing Studies. The Tortugas region is an important spawning area for groupers and snappers (Lindeman et al. 2000, Lindeman et al. 2001, Ault et al. 2002, Burton et al. 2005). Numerous Tortugas spawning aggregation sites have been identified. Mutton snapper spawning aggregations increased in the no-fishing TSER after its establishment (Burton et al. 2005). However, there have been no studies investigating movement between no-fishing Tortugas foraging grounds (the RNA and TNER) and spawning aggregation sites.

Proposed Studies. Use sonic tags to evaluate movements of selected species from the RNA and the TSER to spawning aggregation sites. Use sonic tags to evaluate movements of selected species from the RNA and the TNER. Testing the hypothesis that fish move from foraging grounds (RNA, DTNP and TNER) to spawning areas is essential to this study. Understanding population connectivity, spawning migratory movements, reproductive potential and spillover in the DTNP region is critical to the assessment of the effectiveness of existing no-fishing zone boundaries.

A total of 20 fish per year will be caught (hook and line) and tagged at Riley's Hump, a reef promontory within the TSER and a documented spawning area for numerous reef fish species. An array of 10 receivers will be placed around the reef, with coverage emphasized on the south edge of the reef. Fish will be surgically implanted with Vemco acoustic tags (V16P & V13P) and subsequently released at the study site. These tags have an expected battery life of 1,150 days and include a pressure sensor to determine depth. In addition, each fish will be measured, sexed, and anchor tagged. A biopsy sample of the ovary (surgical tubing cannulation) will be preserved in 90% ethanol to determine mean oocyte diameter. It is anticipated that fish will have to be vented rapidly upon capture with a 10 gauge hypodermic needle to deflate the swim bladder. Two five-day trips per year will be required near the full moon phase with a team of four people (May/June). Data on broad-scale movements to and from the aggregation site, residence time in the aggregation, and depth will be determined. This work will complement and be integrated with the acoustic tagging project described in Topic 2 above and NOAA research on spawning aggregations of *Lutjanus analis* at Riley's Hump (Burton et al. 2005).

3) Implement drifter studies using spawning aggregations to assess regional larval export.

Previous and Existing Studies. Drifter studies simulating larval transport have found that reef fishery species larvae spawned in the Tortugas could be viably dispersed as far as Cape Canaveral on the Atlantic coast and Tampa Bay on the Gulf coast (Lee et al. 1994, Lee et al. 1999, Burke et al. 2003, Domeier 2004). Drifter studies conducted in 1999 and 2000 indicated that a snapper spawning aggregation site on Riley's Hump in TSER is a recruitment source for a broad expanse of southeast Florida, including the entire Florida Keys (Domeier 2004).

Proposed Studies. The deployment of drifters within the RNA can help to determine the fate of larvae from commercially, recreationally, and ecologically important species of finfish and invertebrates. In this regard, drifter studies can be used to evaluate larval dispersal and establish if the RNA is acting as a source of recruits to the Florida Keys and/or the rest of Florida. Drifter studies do have certain limitations: they serve as "snapshots" of conditions at the time of the study, trajectories and time spent in the water before recovery are only estimates, and it is assumed that the larvae they mimic behave as passive particles (an assumption not true for many marine larvae). Therefore, drift vial recovery information should be coupled with existing hydrodynamic and larval dispersal models. Additionally, if retention and self-recruitment are important parameters to consider, we recommend that drogue studies be incorporated into the plan.

Release sites should be based on the existence or identification of spawning aggregations. Releases should occur during peak spawning times. For example, gag grouper in the Gulf of Mexico have a peak spawning period during March (South East Data Assessment and Review 2006), whereas red grouper spawn during both April-May and September-October (Collins et al. 2002). Therefore, releases should be tailored to the species of interest.

Red grouper sheltering in gorgorian soft corals in the Tortugas. Photo by Jerry Ault, Univ. of Miami/RSMAS.

We recommend that 1,000 scintillation vials (clear glass with polyethylene caps) be deployed per release. The drift vials should be neutrally buoyant and sit just below the water surface to reduce the influence of wind. A note on waterproof paper, printed in English and Spanish, should be placed inside the vial with instructions for the finder to e-mail or call a toll-free telephone number to report the date, location, and the unique alphanumeric code identifying the vial's place of release. Prior to deployment, press releases should be provided to local news sources to promote public awareness of the experiment. To encourage people to report recoveries, rewards can be offered.

The design of the drifters should minimize incidental impacts to sea life (e.g., turtles), but should also enhance the chances of being recovered. To this end, we recommend the drifters be made of clear glass with the bottom of the vials painted blue to camouflage them to sea life.

4) Review and provide recommendations for expanding ongoing efforts to study and model larval transport.

Previous and Existing Studies. There have been multiple interdisciplinary studies on Tortugas reef fishery species larval production and transport (Lee et al. 1994, Limouzy-Paris et al. 1997, Lee et al. 1999, Lee and Williams 1999, Lindeman et al. 2000, Lindeman et al. 2001, Burke et al. 2003, Domeier 2004, Yueng et al. 2004, Burton et al. 2005). There have been several efforts to model Tortugas reef fishery species larval transport (Lee et al. 1994, Lee et al. 1999, Lee and Williams 1999, Lindeman et al. 2001, Yueng et al. 2004). The Tortugas area is a principal reef fishery species recruitment source for the larger Florida subtropical seascape. Currents flowing through the Tortugas can disperse reef fishery species larvae spawned in the Tortugas as far as Cape Canaveral on the Atlantic coast and Tampa Bay on the Gulf coast.

Supplemental Activities

1) Expand ongoing efforts to model larval transport throughout the region.

Previous and Existing Studies. There have been several efforts to model Tortugas reef fishery species larval transport (Lee et al. 1994, Lee et al. 1999, Lee and Williams 1999, Lindeman et al. 2001, Yueng et al. 2004).

2) Implement a demonstration of connectivity between the RNA and surrounding regions by inducing females to produce larvae with a unique genetic marker, possibly by chemical- or radiation-induced chromosome damage or insertion of a particular gene sequence into lab-reared females.

Previous and Existing Studies. A genetic marker to identify genetic differences between individual nurse sharks and perhaps nurse sharks spawned in DTNP has been developed (Saville et al. 2002).

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

MOU SOW A.2.d: "Incorporate social sciences into the research and monitoring program for evaluating the RNA performance measures. The social science component shall include collection of compliance rates and enforcement activity in the RNA and surveys of visitor experiences related to the RNA."

Performance Measures

Fishing activity, SCUBA and snorkeling activity (total number of SCUBA divers and snorkelers and duration in water for each designated dive site and reference site), number of boats anchoring by location, visitor satisfaction, and law enforcement activity and regulatory compliance rates (number and percentage of violations by user permit type). Creel survey performance measures and required fishing activity data are discussed under Topic 3.

Essential Activities

1) Collect and analyze fishing, diving, and boat use data needed to assess the effects of RNA implementation on visitor use.

Previous and Existing Studies. DTNP private boat recreational fishing activity (creel survey) data were collected from 1981-1984 and 2000-2004. DTNP charter boat recreational fishing activity surveys using a logbook system began in 2005. Information from these surveys is summarized under Topic 3. The only SCUBA diving use data that exist were obtained from park-permitted live-aboard vessel operators. These operators were required only to report dive locations. There are no recent, adequate DTNP boat use surveys.

Proposed Studies. Park visitor use data, inside and outside the RNA, are needed for several science activities discussed previously in this plan. Visitor fishing activity (creel) surveys are described in Topic 3. SCUBA diving and snorkeling use data are required to assess ecological effects at designated dive sites and elsewhere (Topic 4). Boat use data are needed to evaluate the ecological effects of boat anchoring on coral reefs adjacent to the RNA and of creating the RNA no anchor zone (Topic 4).

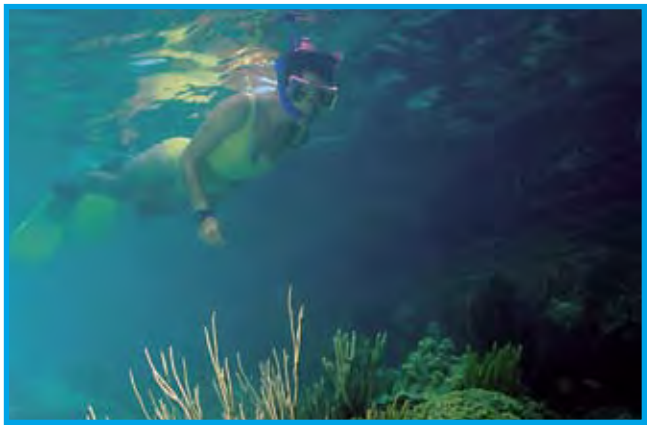
Recreational boat and diver use data will be collected through the currently proposed park permit system. All recreational diving and fishing activity in the park will require a permit which will include total number of SCUBA divers and snorkelers and duration in water by location. All permitted diving and fishing business operators will be required to submit trip information, including total number of SCUBA divers and snorkelers and duration in water by location. If the proposed permit system proves infeasible to implement, less comprehensive (and more costly) aerial surveys, visual surveys from Garden and Loggerhead Keys, and law enforcement patrol surveys of visitor use, will be necessary. Aerial surveys should be designed to meet as many of the use information needs for Topics 3 and 4 as possible. Aerial survey design should be similar to those conducted elsewhere (e.g., the current ENP marine boat surveys).

2) Implement an appraisal system to characterize visitor use experience and views regarding RNA implementation.

Previous and Existing Studies. The primary information on public views of RNA implementation is derived from the public comments on the DTNP General Management Plan (GMP) alternatives through the NEPA process (DTNP 2002). The most recent study on park visitor use was in 2002 (Le and Littlejohn 2003). This study asked visitors about the importance of protecting natural resources; however, there were no specific questions about RNA implementation.

Proposed Studies. Understanding visitor use experiences and perceptions regarding the RNA, and similar new stewardship regulations such as the Special Protection Zones, are critical to effective park adaptive management. Since the behaviors and actions of recreational users can have significant impact on resources, a study designed to identify attitudinal and cognitive factors contributing to these behaviors could assist park managers in developing education, outreach and interpretation programs, promoting compliance with regulations, and helping visitors to protect the resources they enjoy. NPS and FWC seek to understand attitudes and perceptions toward park resources and new regulations and how these factors affect visitor use patterns and visitor satisfaction over time.

The following activities are recommended; however this list may need to be prioritized and scaled back to fit available resources.



Visitor snorkeling in Dry Tortugas National Park. Photo by Brett Seymour, NPS.

- Measure visitor and broader public knowledge and perceptions about the RNA and other marine ecosystem stewardship issues, including marine ecological resource conditions, coral decline, over-fishing, anchoring, and regulations designed to protect and restore coral reefs, seagrass, and fishery resources. How do these views and experiences change over time?
- Evaluate visitor RNA use experience and satisfaction. How has RNA implementation affected visitor use throughout the park? How do these views and experiences change over time?
- Obtain a general socio-demographic profile of boaters, anglers, divers, and snorkelers
- Measure visitor contact with environmental education or interpretation programs via brochures, site bulletins, public service announcements, marine radio, visitor contact, and visitor centers.
- Coordinate socio-economic studies and human dimension assessments with NOAA Biogeographic Assessment already completed or underway.
- Integrate information obtained from social science surveys, visitor use patterns, and recreational fishing activity surveys (creel and charter boat).

3) Monitor RNA law enforcement activity and regulation compliance rates by visitors, commercial operators, and scientific researchers on an annual basis.

Previous and Existing Studies. We have no knowledge of studies that have monitored law enforcement activity and regulation compliance rates by visitors and businesses.

Supplemental Activities

1) Assess the economic effects of RNA implementation using standard socioeconomic methods.

Previous and Existing Studies. NOAA has conducted socioeconomic research on the TER before establishment (Leeworthy and Wiley 2000, Leeworthy et al. 2004) and is currently assessing the socioeconomic effects of TER implementation (NOAA 2006).

Proposed Studies. What are the economic effects of RNA implementation on private businesses operating in the park? This activity should be integrated into a more comprehensive assessment of the economic effects of DTNP GMP implementation. For example, the GMP limits the number and type of private businesses operating in the park. Conduct an analysis of the economic benefits of DTNP visitation using the NPS Money Generation Model II. Discerning the economic effects on fishing businesses should be coordinated with similar NOAA efforts in the Tortugas region.

SCHEDULE OF DELIVERABLES

The MOU established between FWC and the NPS stipulates that a jointly prepared report on the evaluation of the performance of the RNA will be provided to FWC Commissioners, NPS managers, and the public at three and five year intervals as described below.

Three-year Interim Report

The three-year interim report will be completed in February 2010 and will summarize the progress of implementation of the essential activities whether funded or not. It will also include an update on the supplemental activities.

Five-year Interim Report

The five-year interim report will be completed in February 2012 and will provide a detailed description of results of all the ongoing studies and discuss the results in relation to the stated goals of the RNA.

NPS diver evaluating benthic communities in Dry Tortugas National Park. Photo by Brett Seymour, NPS.

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APPENDIX I: MEMORANDUM OF UNDERSTANDING

Memorandum of Understanding

between

The State of Florida, Fish and Wildlife Conservation Commission

and

The National Park Service, Dry Tortugas National Park

WHEREAS, The State of Florida and the National Park Service (the Service) have entered into a Management Agreement with respect to the submerged lands within Dry Tortugas National Park (DTNP); and

WHEREAS, Consistent with the provisions of the Management Agreement, the Service has promulgated special regulations pertaining to DTNP and which have been concurred in by the Florida Fish and Wildlife Conservation Commission (the FWC) and the Board of Trustees of the Internal Improvement Trust Fund for the State of Florida; and

WHEREAS, In furtherance of the objectives of the Management Agreement, this Memorandum of Understanding is intended to facilitate the management, protection, and scientific study of fish and aquatic resources of DTNP by developing a cooperative research and monitoring plan between the FWC and the Service to evaluate the effect and efficacy of the 46-square-mile Research Natural Area (hereinafter referred to as the RNA) encompassing a portion of DTNP; and

WHEREAS, The FWC is an agency created by Article IV, Section 9, of the Florida Constitution and is vested with the state's executive and regulatory authority with respect to freshwater aquatic life, wild animal life, and marine life. This authority, directly derived from the Constitution, provides the FWC with authority to regulate and manage wild animal life, freshwater aquatic life, and marine life within the State of Florida, including the areas encompassed by DTNP; and

WHEREAS, The Management Agreement specifically provides that nothing in its terms shall be construed to affect, expand, or diminish the authority of the FWC in the exercising of its jurisdiction under the Florida Constitution with respect to marine fish; and

WHEREAS, Congress in the Organic Act of 1916, 16 U.S.C. Section 1, created the Service to promote and regulate the National Park System for "the purpose of conserving the scenery and the natural and historic objects and wildlife therein and to

provide for the enjoyment of the same in such manner and by such means as would leave them unimpaired for the enjoyment of future generations"; and

WHEREAS, In 1992, Congress enacted Public Law 102-525 (16 U.S.C. Section 410xx et seq.) abolishing Fort Jefferson National Monument and establishing DTNP in its place. Congress established DTNP "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"; and

WHEREAS, the regulations provide for the RNA which encompasses a 46-square-mile area protecting a representative range of terrestrial and marine resources in DTNP. The RNA is closed to fishing and is otherwise designed to protect near-pristine habitats and ecological processes that will afford high quality research opportunities; and

WHEREAS, both FWC and the Service (the Parties or, as appropriate, a Party) have responsibilities under Federal and State laws and regulations that affect fish and other aquatic resources within the RNA; and

WHEREAS, the Service is to provide a report to the State at least every five years concerning the status, activities, and condition of the sovereignty submerged lands that are subject to the Management Agreement; and

WHEREAS, both parties wish this Memorandum of Understanding to reflect common goals and intended cooperation and coordination to achieve these goals; and

WHEREAS, both parties recognize there may be times when the missions of the FWC and the Service may differ, and that while every effort will be made to cooperate fully and jointly manage fish stocks within the RNA, there may be occasions when the two agencies choose to disagree. Such occasions will not be construed as impasses and every attempt will be made to avoid communication barriers and not jeopardize future working relationships; and

WHEREAS, nothing in this Memorandum of Understanding shall be construed as a contract or obligating any Party hereto to the expenditure of funds or the future payment of money; and

WHEREAS, nothing contained herein shall be construed as limiting in any way the responsibility and authority, as defined by law, of the Director, National Park Service, or the Executive Director and Commissioners, Florida Fish and Wildlife Conservation Commission, in connection with the administration and protection of lands and resources under their respective administrations.

ARTICLE II – AUTHORITY

As a unit of the National Park System, DTNP is authorized to enter into agreements with governmental bodies and other appropriate organizations to further the objectives and purposes of DTNP and to promote research and protection of park resources.

The FWC is authorized under Chapter 370.103 Florida Statute, to enter into cooperative agreements with the Federal Government or agencies thereof for the purpose of preserving saltwater fisheries within and without state waters and for the purpose of protecting against overfishing, waste, depletion, or any abuse whatsoever.

NOW, THEREFORE, both parties agree as follows:

ARTICLE III – STATEMENT OF WORK

A. The parties generally agree as follows:

1. To jointly develop a program for natural resources research, inventory and monitoring within the RNA with the goal of identifying and establishing performance measures that will be used to evaluate the effectiveness of the RNA in achieving its stated goals. The goals of the RNA are to protect near pristine shallow water marine habitat, ensure species diversity, enhance the productivity and sustainability of exploited fish populations throughout the region, and provide a unique unexploited area that will be used to help assess the effects of fishing on exploited areas. To evaluate these goals, the performance of the RNA will be evaluated by, but not limited to: 1) quantifying changes in abundance and size-structure of exploited species within the RNA relative to adjacent areas; 2) monitoring the immigration and emigration of targeted species in the RNA; 3) monitoring changes in species composition and catch rates of exploited species throughout the surrounding region; 4) monitoring species composition and abundance of the benthic community; and 5) assessing reproductive potential of exploited species by evaluating egg production and larval dispersal. This program will include: 1) a review and summary of past and existing work in DTNP (including the work by FWC, National Oceanic and Atmospheric Administration (NOAA), the Service, University of Miami, Florida International University and other cooperating agencies and universities) to coordinate activities among agencies and minimize duplication of effort; 2) draft proposals to develop new research or expand upon ongoing research as deemed necessary, including social science research; 3) identification of funding sources for expanded and additional research deemed necessary; and 4) a schedule of deliverables, including performance measures designed to evaluate the effectiveness of the RNA in achieving its stated goals.

2. Subject to adequate funding, proposed research and monitoring activities will include, but not necessarily be limited to:

a) Expansion of ongoing research and monitoring program that assess important reef fish populations, including the Dry Tortugas region and DTNP RNA. Expansion of this program shall be designed to provide a more robust database for examination of the performance of the RNA regarding its stated goals. The expanded research and monitoring program could incorporate a broad, multi-gear sampling approach to monitor changes in abundance and size of targeted species inside and outside RNA boundaries. Increases in the abundance and size-structure of these species in the absence of fishing mortality serve as an indicator that the RNA is protecting spawning biomass, age-structure, and genetic diversity that potentially enhance the productivity and sustainability of these species in the region.

b) Implementation of a variety of tagging studies (*e.g.*, using acoustic tags as well as conventional dart-tags) to examine broad- and fine-scale movement patterns of targeted species in and out of the RNA. This would be accomplished by expanding ongoing collaborative acoustic tracking research projects as well as by conducting new studies. Such studies will help evaluate if adjacent fishing areas are enhanced through emigration of target species from the RNA.

c) Development of a fisheries-dependent monitoring program to evaluate potential changes in catch rates, species composition, and size composition of commercial and recreational fisheries in areas surrounding the RNA. This program could use a variety of data collection methods including on-board observers, logbooks, aerial surveys, and recreational fisheries interviews.

d) Increasing the number of benthic monitoring stations to include specific sites to evaluate the impacts of RNA mooring buoy visitor activities and fishing and boating effects in the Dry Tortugas. Measures of benthic community change and condition will be used to assess the impacts of diving and snorkeling activities in the RNA.

e) Expansion of ongoing efforts to track and model larval movement patterns within the Tortugas and Florida Keys region from important reef fish and other aquatic species to evaluate larval recruitment of several finfish species in the south Florida region.

f) Incorporate the social sciences into the research and monitoring program for evaluating the RNA performance measures. The social science component shall include collection of compliance rates and enforcement activity in the RNA and surveys of visitor experiences related to the RNA.

3. To seek concurrence in meeting the management goals of both agencies and strive to identify means, measures, and other interagency actions for the mutual benefit of the natural resources within the RNA, including the above referenced activities of research, inventory and monitoring within the RNA, and any future agreements for shared law enforcement or other responsibilities. This will include an interagency

workshop no later than 90 days following the execution of this MOU to define performance measures that will be used to assess effectiveness of the RNA regarding its stated goals and to reach agreement on the methods for data collection, and integration for the above referenced activities.

4. Based on the outcomes of the workshop referenced above and the level of available funding, develop a joint FWC/DTNP research and monitoring plan no later than 90 days following the workshop. This plan will include specific sampling methodologies and methods of data analysis and modeling to examine the defined performance measures that will be used to assess the effectiveness of RNA performance regarding its stated goals.

5. To manage fisheries within the RNA in accordance with applicable laws, and in a manner that promotes healthy, self-sustaining fish populations and recognizes the biological characteristics and reproductive potential of individual species.

6. To share scientific information, field data, and observations pertaining to the aquatic resources of DTNP and activities affecting those resources, consistent with the requirements of applicable laws for non-disclosure of certain specific information, such as law enforcement matters and confidential landings statistics. The parties will also investigate approaches for the development of a data integration system (similar to what is in place for the Florida Keys National Marine Sanctuary [FKNMS]), and will provide each other with copies of reports that include results of work conducted within the RNA and surrounding areas.

7. To meet at least once annually and additionally as needed to coordinate research activities and exchange information on fish and aquatic resources within the RNA, and to develop a three-year and five-year review schedule for examining relevant research information and assessing the effectiveness of the RNA in terms of the agreed upon performance measures. This examination and assessment shall include jointly prepared interim (3-year) and comprehensive (5-year) reports. These reports shall provide conclusions and recommendations addressing whether the RNA is achieving stated goals, through the application of the agreed upon performance measures. The parties agree to make every effort to integrate the five-year RNA review with the planned external peer review process that is in development for the science program in the FKNMS.

8. Nothing in this Memorandum of Understanding shall be construed as obligating either Party to expend funds in any one fiscal year in excess of the monies appropriated by Congress and allocated by DTNP for the performance of this agreement.

Specifically, with respect to developing a research and monitoring program and performance measures to assess the effectiveness of the RNA in achieving its stated goals, the two agencies agree as follows:

B. The FWC agrees to:

1. Assign staff, as deemed appropriate, to collaborate with the DTNP and its cooperators in preparing a research and monitoring program and performance measures from which to examine the effectiveness of the RNA during the first three-year and five-year implementation periods, and to coordinate this work with similar efforts by the FKNMS. This program will expand ongoing collaborative research efforts in DTNP among the FWC and the Service, U.S. Geological Survey, NOAA, University of Miami, and Florida International University.

2. Seek funding to support Service-sponsored RNA monitoring and research which is in furtherance of the purposes of this Memorandum of Understanding.

3. Provide three- and five-year reports to FWC Commissioners and Service managers that summarize RNA-related research and evaluate the performance of the RNA regarding its stated goals, and otherwise provide briefings to Commissioners and Service managers as appropriate.

4. Provide access to and support for requests by the Service to existing data and information as may be applicable to DTNP fisheries and aquatic resources.

C. Dry Tortugas National Park agrees to:

1. Assign staff, as deemed appropriate, to collaborate with the FWC and its cooperators in preparing a research and monitoring program and performance measures from which to examine the effectiveness of the RNA during the first three-year and five-year implementation periods, and to coordinate this work with similar efforts by the FKNMS. This program will expand ongoing collaborative research efforts in DTNP among the Service and the FWC, U.S. Geological Survey, NOAA, University of Miami, and Florida International University.

2. At least every five years, submit to the Board of Trustees of the Internal Improvement Trust Fund of the State of Florida (Board of Trustees) a report on the status, activities, and conditions of the sovereignty submerged lands within the park, in accordance with the terms of the established management agreement between the National Park Service and the Board of Trustees approved on August 9, 2005. Further, the National Park Service acknowledges that on November 14, 2006 the Board of Trustees concurred with the implementing regulations for the Dry Tortugas National Park for a period of five years at which time the National Park Service will bring the regulations back for review and approval under the terms of the Management Agreement.

3 Provide continuing project funding through appropriate financial assistance agreements to support ongoing Service-sponsored RNA monitoring and research which is in furtherance of the purposes of this Memorandum of Understanding.

4. Provide three- and five-year reports to FWC Commissioners and Service managers that summarize RNA-related research and evaluate the performance of the RNA regarding its stated goals, and otherwise provide briefings to Commissioners and Service managers as appropriate.

5. Provide access to and support for requests by the FWC to existing data and information as may be applicable to DTNP fisheries and aquatic resources.

6. Secure contractors and cooperators with appropriate subject matter expertise in order to develop research and monitoring projects designed to evaluate the performance of the RNA during the first three-year and five-year post-implementation periods. Such cooperators may include, but are not limited to research fishery biologists, aquatic ecologists, and fisheries program managers from the FWC, and the Service, U.S. Geological Survey, NOAA, University of Miami, and Florida International University.

7. Participate as appropriate in briefings, presentations, or other forums for which the FWC may request assistance in conducting, or otherwise attending, concerning fisheries/wildlife management within the RNA.

8. Facilitate and encourage the joint publication of press releases and the interchange between the Parties of all pertinent agency policies and objectives, statutes, rules and regulations, and other information required for the wise use and perpetuation of the fisheries resources of DTNP.

9. Facilitate research permitting to state entities for activities needed to accomplish goals identified in the research and monitoring plan.

10. Provide logistical support to the maximum extent practicable in the form of living space at DTNP and vessel support for visiting researchers conducting research consistent with this Memorandum of Understanding.

ARTICLE IV – TERM OF AGREEMENT

This Memorandum of Understanding is effective as of the date the last Party signs this agreement, and it shall remain in effect for a term of five (5) years. It may be extended for such additional terms as the parties determine to be appropriate.

This Memorandum of Understanding in no way restricts the FWC or the Park from participating in similar activities with other public or private agencies, organizations, and individuals.

This Memorandum of Understanding is neither a fiscal nor a funds obligation document. Any endeavor involving reimbursement or contribution of funds between the Park and the FWC will be handled under separate written agreements in accordance with applicable laws, regulations, and procedures.

ARTICLE V – KEY OFFICIALS

A. For Dry Tortugas National Park:

Superintendent
Dry Tortugas National Park
40001 SR 9336
Homestead, FL 33034

B. For the Florida Fish and Wildlife Conservation Commission:

Executive Director
Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, FL 323399

ARTICLE VI – PRIOR APPROVAL

Not applicable

ARTICLE VII – REPORTS AND/OR OTHER DELIVERABLES

Upon request and to the full extent permitted by applicable law, the parties shall share with each other final reports of incidents involving both parties.

ARTICLE VII – PROPERTY UTILIZATION

Unless otherwise agreed to in writing by the parties, any property furnished by one party to the other shall remain the property of the furnishing party. Any property furnished by the Park to the FWC during the performance of this agreement shall be used and disposed of as set forth in the federal property management regulations.

ARTICLE VIII – MODIFICATION AND TERMINATION

Either Party may terminate this Memorandum of Understanding by providing 60 days advance written notice to the other Party. If one Party provides the other with

written notice of its intentions to terminate this Memorandum of Understanding, the Parties will first meet and attempt to address and resolve their differences.

This Memorandum of Understanding may be modified at any time upon written agreement of the FWC and the Service.

ARTICLE IX – STANDARD CLAUSES

A. **Civil Rights**

During the performance of this Memorandum of Understanding, the participants agree to abide by the terms of the U.S. Department of the Interior (hereinafter referred to as the Department) – Civil Rights Assurance Certification, non-discrimination and will not discriminate against any person because of race, color, religion, sex, or national origin. The participants will take affirmative action to ensure that applicants are employed without regard to their race, color, sexual orientation, national origin disabilities, religion, age or sex.

B. **Public Information Release**

The FWC will obtain prior approval from the Superintendent for any public information releases, which refers to the Department of the Interior, any bureau, park unit, or employee (by name or title), or to this agreement. The specific text, layout, photographs, etc. of the proposed release must be submitted with the request for approval.

C. **Liability Provision**

To the extent allowed by applicable state and federal law, each Party will be responsible for the actions of its employees, representatives and agents in carrying out this Memorandum of Understanding.

ARTICLE X – SIGNATURES

IN WITNESS HEREOF, the parties hereto have executed this agreement on the dates set forth below.

FOR DRY TORTUGAS NATIONAL PARK:

Signature: Dan B. Kimball

Dan B. Kimball
Superintendent
Dry Tortugas National Park

Date: 2-14-2007

FOR THE FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION:

Signature: Kenneth D. Haddad

Kenneth D. Haddad
Executive Director
Florida Fish and Wildlife Conservation Commission

Date: 2/9/07

APPROVED AS TO FORM
AND LEGAL SUFFICIENCY
James V. Antista
Commission Attorney

APPENDIX II: PUBLIC COMMENT AND AGENCY RESPONSE

Dry Tortugas Research Natural Area Science Plan
Public Workshop, Key Largo, FL, May 3, 2007
Public Comments and NPS/FWC Responses

Overview/Introduction Session Comments

Comment	*Response*
Link science activities to fishery related impacts.	The science activities presented in this plan are directly linked to fishery related effects.
A funding performance measure (PM) is necessary to complement the plan – if the funding is not available, the scientific studies cannot be completed. Need a performance standard to measure how successful in getting funding, since entire science plan depends on funding. I.e., how much did not get done because did not get funded (agency folks can't lobby for funding, but NGOs can and can assist).	We appreciate these comments; however, it will be difficult to come up with very specific funding performance measures that have direct corresponding benefits related to scientific information. As opposed to eliminating completely many essential activities, we intend to scale-up or scale-down activities based on funding. Our aim is to have some substantial activity for each science topic.
Use 'funding scorecard' as leverage as what has/has not got funding.	See above.
PMs need to be refocused to specify thresholds, amounts, or ability to estimate differences. More detailed PM description is needed to drive the data collection.	Performance measures are not targets or quantified objectives; they are measures used to assess progress toward a target. We will review the performance measures to ensure that are sufficiently described. Long term resource stewardship objectives are stated for Topic 4. The long term resource stewardship objective for reef fishery species is to restore and maintain reef gamefish species populations (stocks) at levels that will sustain recreational fishing in DTNP. We agree that it may be valuable to develop quantitative targets for each performance measure. At this point, performance measure targets are directional and qualitative. The principle investigators that develop more detailed sampling designs should consider use of statistical analysis, such as power analysis, and other techniques to develop statistically sound quantitative targets. Much of the first few years of study will help establish baseline variability in performance measures. This information will be considered for development of quantitative targets.
The need for aging structures (otoliths, etc.) was mentioned earlier. All the programs need to work together and collect data in an efficient design.	We have now incorporated an aging component of our study using otoliths into the monitoring plan.

Complete habitat mapping for all areas of DTNP (particularly deeper water areas). Lidar mapping approaches along western boundary. Passage-ways of hard bottom areas. Extract to whole population level estimates, and improve sampling design.	There is an interagency benthic habitat mapping project/ program underway that includes DTNP.
Should not be rushing to get quick science answers.	We agree.
What is the science funding to support this? Work into ongoing agency funding initiatives over the next few years.	Funding is expected to come from the National Park Service, the U.S. Geological Survey, and the Florida Fish and Wildlife Conservation Commission.
Measuring accountability of performance measures, and essential activities, will take substantial resources.	We agree.
How to track funding accountability when internal funding gets shifted to take on different priorities.	The National Park Service and Florida Fish and Wildlife Conservation Commission are committed to maintaining a sustainable science program in the Research Natural Area.
Need to know how much this is going to cost. State demanding all this research, state should be held accountable if not fully funded, state acknowledges partnership by funding priorities.	The National Park Service and Florida Fish and Wildlife Conservation Commission are working as partners to maintain a sustainable science program in the Research Natural Area. For example, FWC and NPS scientists recently submitted a joint proposal to fund portions of Topic 1 essential activities. The proposal has been accepted for funding by the USGS State Partnership Program.
Difficult to show how dollars are spent if conflated with other uses simultaneously (e.g., immigration, drug enforcement, fishing).	Funding received for RNA science activities will be spent on science.
Need to capture other sources of money, competitive programs, (e.g., grants).	We agree, and are pursuing other funding sources. For example, two of the essential activities in this plan are being funded through the USGS State Partnership Program.

Performance Topic 1 Comments

Performance Measure Comments:	
Comment	*Response*
Add frequency of occurrence for all fish observed in visual surveys.	This measure is included in the current visual surveys and has been explicitly stated in the performance measure.
Essential Activity #1 Comments:	
Comment	*Response*
Co-sampling of macro-invertebrates and benthic communities, etc. Requires greater logistical support and strong project coordination (use of smaller boats, on-site housing, etc.) to reduce costs/permitting requirements. Details on sampling size, precision and cost of detection, etc. to be worked out.	This activity is being done to some extent by NPS cooperator conducting reef fish surveys (or by cooperator's associates). Fish habitat characterization is an integral part of the current and planned reef fish surveys. We will consider incorporating more extensive benthic communities monitoring. Furthermore, NPS is currently conducting multiple benthic communities monitoring and assessment projects; plus additional projects are proposed under Topic 4 of this plan. NPS and FWC plan to hold a research coordination meeting in winter of 2008 and regularly thereafter.
Link RNA/DRTO specific surveys to broader regional perspective, with comparisons to biannual Keys-wide survey. Must conduct annual RNA-specific surveys to provide adequate information for 3-5 year reviews.	DRTO studies are currently linked to, and part of, the current biannual Tortugas wide survey, and DRTO reef fisheries assessments are compared to the Keys-wide reef fisheries assessments. These are conducted by the same scientists. We agree that there needs to be more linkage and comparison between the RNA and FKNMS SPAs, particularly regarding the conservation efficacy of no fishing marine reserves. Annual RNA-specific surveys are part of the plan.
Develop more qualitative measures to show early benefits of RNA closure (more and larger observed fish).	The measures suggested, abundance ("more fish") and size ("larger fish"), are integral components of the existing and planned surveys. Qualitative measures are more coarse and thus perhaps less likely to show early benefits.
Essential Activity #2 Comments:	
Comment	*Response*
Develop a table/matrix of how this activity (collection of fishery information using traps and hook-and-line) links with multiple RNA science topics	Great suggestion. We will consider this.

For fish traps. . .include RNA, natural/cultural, historic use zones (all in southern half of DRTO initially). Focus on exploited species first, since this provides more detailed information.	This activity is proposed to be conducted in the RNA no fishing zone and fishing areas adjacent to the RNA. This activity does focus on gamefish ("exploited") species; we concur with this comment.
Supplemental Activity #1 Comments:	
Comment	*Response*
Link fish movement studies with visual census surveys, particularly for juvenile fish. Link visual surveys with recruitment.	We will attempt to provide these linkages.
Proposal to use fish nets to sample juvenile fish, by working up against inshore/beaches.	If additional resources become available, we will consider adding these sampling efforts.
Monthly fish counts by on-site resource management staff.	This is not practical because resource management staffs are limited. Furthermore, the marine fisheries scientists conducting the current surveys have suggested that monthly sampling is not necessary.
Incorporate the Reef Environmental Education Foundation (REEF) roving volunteer diver surveys, adding cryptic fish species to taxonomic inventory (abundance/occurrence scores). Investigate incorporation of quantitative Reef Visual Census (RVC) methodology to add precision. Involves public/constituents into DTNP science program.	We have considered the incorporation of REEF surveys into this plan. We are awaiting input from REEF and will incorporate it in future versions of the plan.
Use of fish monitoring cameras?	This methodology will be considered and evaluated.
Supplemental Activity #2 Comments:	
Comment	*Response*
R&D project to examine seasonal components of RVC sampling (one-time twice a year, summer-winter survey).	We will consider including this activity. However, there likely will be funding and logistical limitations. Such seasonal studies done elsewhere in the Keys suggest that seasonal sampling is no more effective than once a year sampling.

Performance Topic 2 Comments

Performance Measure Comments:	
Comment	*Response*
Natural mortality rates should be quantified as an essential activity and key parameter for all assessments, tagging data are key for obtaining these data.	This recommendation will be considered.
General concern that science plan priorities are DTNP-centric and RNA-centric. Flux from the RNA is critical, other areas (TER) are secondary.	Topic 2 science activities do include areas outside DTNP. However, the purpose of the FWC-NPS MOU, and thus the science plan, is to assess the conservation efficacy of the RNA.
Essential Activity #1 Comments:	
Comment	*Response*
Item 1 is possibly supplemental, only external tags are necessary.	We believe that sonic tagging and tracking is a more effective measure of net emigration from the RNA. Both methods are valuable.
Disagrees, recommends that the sonic array is essential, less reliance on recreational reports, higher level of scientific rigor – the two methods are complementary.	We agree.
We have been using sonic tagging for several years now – a potential complement is to ring the RNA with receivers (~80), put animals inside and out, and look at flux.	"Ring the RNA with receivers" is the ideal approach. However, funding and logistical constraints will likely require us to focus on likely key fish movement pathways.
Recommends a two-phased tagging study – to document habitat specific movements, and a broader encompassing array for movements into/out of the RNA and TERs (spillover effects).	We will consider and evaluate including this approach.
Recommends changing emigration/immigration to "flux," since understanding fish movements is the essential activity.	We will incorporate the term "flux."
Connectivity is an important topic and may be a better description of this effort. May need to include a larger concept, beyond emigration.	We agree that connectivity is an important topic. Topic 5 also addresses connectivity (on a broader scale). We will include text relating appropriate science activities to the larger connectivity concept.

An acoustic study is necessary and will include external tagging.	We agree.
Population dynamics should not be confined to the Tortugas studies. Focus on removal of fish pressure here may not be necessary – data could be obtained from other areas in the region.	We realize that fisheries management is a regional issue. Thus, we planned to coordinate work in this science plan with similar scientific studies in the Keys and other relevant areas.
Should be communication between investigators involved in all sonic studies.	We agree and will incorporate that topic into our 2008 research coordination meeting.
Mote Marine Lab is establishing a large acoustic study (Dalhousie Univ.) that we should look into, consider working together.	We will.
Important to look at flux in a broad fashion, including species that are important to the system. Okay to prioritize snapper-grouper complex, but others are also important. Consider functional groups.	We will consider and evaluate including other functional groups.
Why is there no performance measure for non-target species, they have great value to divers and snorkelers.	Non-target (i.e., non-fishery) species are addressed in Topics 1 and 4.
Nurse shark reproduction occurs at DTNP, all species should be considered.	DTNP has created a no public access nurse shark reproduction special protection zone. We have been and will continue to coordinate with Wes Pratt (Mote Marine Laboratory) on nurse shark research.
Comment: from a policy perspective, FWC may not readily embrace Marine Protected Areas (MPAs). These (tagging) studies and the funding are essential. Whatever we need, whatever we can look at, is important.	We agree that evaluating as many possible parameters relative to this essential activity is important. We will provide that information to the FWC in our future reports and presentations.
Try to obtain larger fishes that could carry a satellite tag. Independent of sonic array and specific geopositioning. Tarpon – goliath grouper, etc. Expensive, but could be done on a limited basis.	We will consider including this approach.

Essential Activity #2 Comments:	
Comment	*Response*
The most substantial value for the use of external tags is to promote public involvement and education (benefits of MPAs).	We agree that this is a substantial value.
External tagging study could be enhanced with "high reward tags" to estimate a relative reporting rate. This is a critical factor for analyzing data quality.	We will consider including this approach.
To determine net emigration, fish will need to be tagged (conventionally) outside of the RNA.	This activity is planned to be conducted inside and outside the RNA to determine net emigration.
Supplemental Activity #1 Comments: No Comments	
Supplemental Activity #2 Comments:	
Comment	*Response*
Agrees with original classification suggesting that RNA-TER tagging activities are complementary.	No response needed.

Performance Topic 3 Comments

Performance Measure Comments:	
Comment	*Response*
Critical information should include discards, species composition, lengths/weights.	This information is and will continue to be collected by multiple federal and state Tortugas fisheries assessment programs, including DTNP.
By-catch (discards) is important to include in surveys.	This information is and will continue to be collected by multiple federal and state Tortugas fisheries assessment programs, including DTNP.
Essential Activity #1 Comments:	
Comment	*Response*
Concentrate creel surveys at major boat ramp in Key West, etc.	We believe that it is more effective to concentrate DTNP creel surveys in the park. The current federally-funded MRFSS provides limited intercept contacts for private boaters returning from Tortugas fishing trips.
Difficulty in getting consistent intercept-point for private boats.	We are aware of this difficulty and are addressing it as best as possible in the recreational fishing survey design.
Partition out recreational fishing activity on Garden Key versus private boats.	We have been and will continue to do this.
Essential Activity #2 Comments:	
Comment	*Response*
Pilot survey in Florida in last two years, observers on board, multi-day trips directly to Tortugas, could increase level of sampling.	DTNP permitted charter fishing boats are allowed to carry only a maximum of six anglers. These boats may be too small to include observers. It may not be cost effective to use observers on these small charter boats. However, we will consider this idea.
Concentrate on charter boats as best representative of recreational fishery.	Collecting charter boat fishing data is an essential activity.
Need consistent units of measure (e.g., 12 charter boats).	We agree.

Use of logbooks and law enforcement data collection, need coordination.	We do and will collect charter boat fishing data via a log-book system
Logbook data need to be validated.	We agree. Compliance checks have and will continue to be made.
Does not get precise fishing location.	Collecting fishing data using locations by zones/areas has been effective and is adequate for future data collection. We would have to lump precise location data into zones to perform statistical analyses. We must consider guides desire/need not to reveal specific sites.
Essential Activity #3 Comments:	
Comment	*Response*
MRFSS regional program, but may not be at a sufficient level to detect changes in fishing activity level in Tortugas region.	This problem has been noted as a major inconsistency within MRFSS by the 2006 National Research Council review. It is being further reviewed by interagency study groups, for the "new" MRFSS data collection program.
Not enough observations from recreational fishing from Tortugas area based on MRFSS data.	We will consider this factor in conducting this activity. This problem has been noted as an inconsistency within MRFSS by the 2006 National Research Council review. It is being further reviewed by interagency study groups, for the "new" MRFSS data collection program.
Flexibility in MRFSS program to get regional-specific information.	We agree. It is planned that the 2007 revision of MRFSS will address regional specificity and provide greater fishing location detail.
Incorporate surveys into MRFSS review, and leverage that for data collection.	We agree. We are pursuing this.
Supplemental Activity #1 Comments:	
Comment	*Response*
How much activity is generated by private versus for-hire boats?	The purpose of this supplemental activity is to provide estimates of private and commercial activity in DTNP.

Supplemental Activity #2 Comments:	
Comment	*Response*
Fly-over (aerial survey) gives data point and need activity levels from creel survey.	We agree.
Aerial surveys capture edge effect, get info on other trips, GPS endpoint program?	We agree.
Aerial survey could partition out private/for-hire usages.	It might not be easy to differentiate private and DTNP charter boats from the air. However, this is a goal of this topic.
Monitoring areas through satellite to detect levels of use, may be able to determine boat size, etc. (equipment to be placed within next year or so) – Vessel Monitoring System – will show population of vessels. May help with edging effects, fishing area shifts, activity levels, radar.	This activity could be evaluated for its usefulness through Gulf of Mexico/South Atlantic regional work groups of the "new" MRFSS program.
General Comments	
Comment	*Response*
Need to account for potential decrease in effort due to economics (e.g., fuel costs), i.e., may show artificial decrease in effort/low use related to other issues.	We agree. We will consider this factor in our analyses.
Competing laws between managing agencies causes angst.	Hopefully, greater cooperation among the various fisheries management agencies in the Tortugas region as planned and the planned MRFSS revision will ameliorate this situation.
Contract to fisheries scientists to detect effort levels pre- and post-closure.	We will use the most effective methods to collect and analyze fishing activity data. We have contracted external fishery scientists to analyze DTNP recreational fishing data. Similarly, fishery scientists from fisheries management agencies and universities have collected and analyzed pre- and post-closure TER fishing activity data (these projects will continue).
Need to stratify effort related to species groups (e.g., bottom fishing).	We agree. Fishing activity data by species and functional groups has been and will continue to be collected.
Biological collection of hard parts for stock assessments.	We agree. Otoliths are being collected and analyzed by multiple federal and state fisheries management programs.

Get biological data (e.g., hard parts, lengths/weights).	This information is and will continue to be collected by multiple federal and state Tortugas fisheries assessment programs, including DTNP.
Also get gut content, gonads, get everything while have dead fish.	We will consider this option.
Information from fishing tournaments, e.g., hook/line, spearfishing.	There are few fishing tournaments in the Tortugas. Spearfishing has not been permitted in DTNP for over 25 years. MRFSS is a likely source for these data.

Performance Topic 4 Comments

Performance Measure Comments: Provided under Related Activities.	
Essential Activity #1 Comments:	
Comment	*Response*
Notes it is difficult to pull out signal of diver damage, etc.	We agree.
Notes Steve Miller's work in the area. Notes merit to adding a stratum, but the diver impacts are not presently being examined.	We are aware of Steven Miller's work. We will consider Miller's and other existing projects/work in developing and implementing the most effective approach.
Notes no signal from Keys monitoring.	We are aware of this; and that diving pressure is much less in DTNP than the main Keys. This why we propose an initially focused assessment on the three or four sites likely to receive the most diving pressure.
Heavily targeted toward physical damage.	This is because three of the four activities deal with diver and anchor effects which are primarily physical damage.
Essential Activity #2 Comments:	
Comment	*Response*
Boat damage not limited to anchoring.	We agree. RNA implementation will not prevent, or directly reduce, vessel groundings and propeller scarring.
Enforcement needs to be incorporated in evaluation. Work will assume perfect compliance.	We agree that enforcement is an important factor. This is why monitoring RNA law enforcement activity and regulation compliance rates is an essential plan activity under Topic 6.
Essential Activity #3 Comments: No Comments	

Supplemental Activity #1 Comments:	
Comment	*Response*
Size abundance of stony coral changes inside/out RNA. Would like to see more extensive randomized stratified information.	Since the draft report was produced and after this workshop, the NPS South Florida/ Caribbean Monitoring Network has initiated such a stratified random sampling approach. We will include this approach into the plan.

Performance Topic 5 Comments

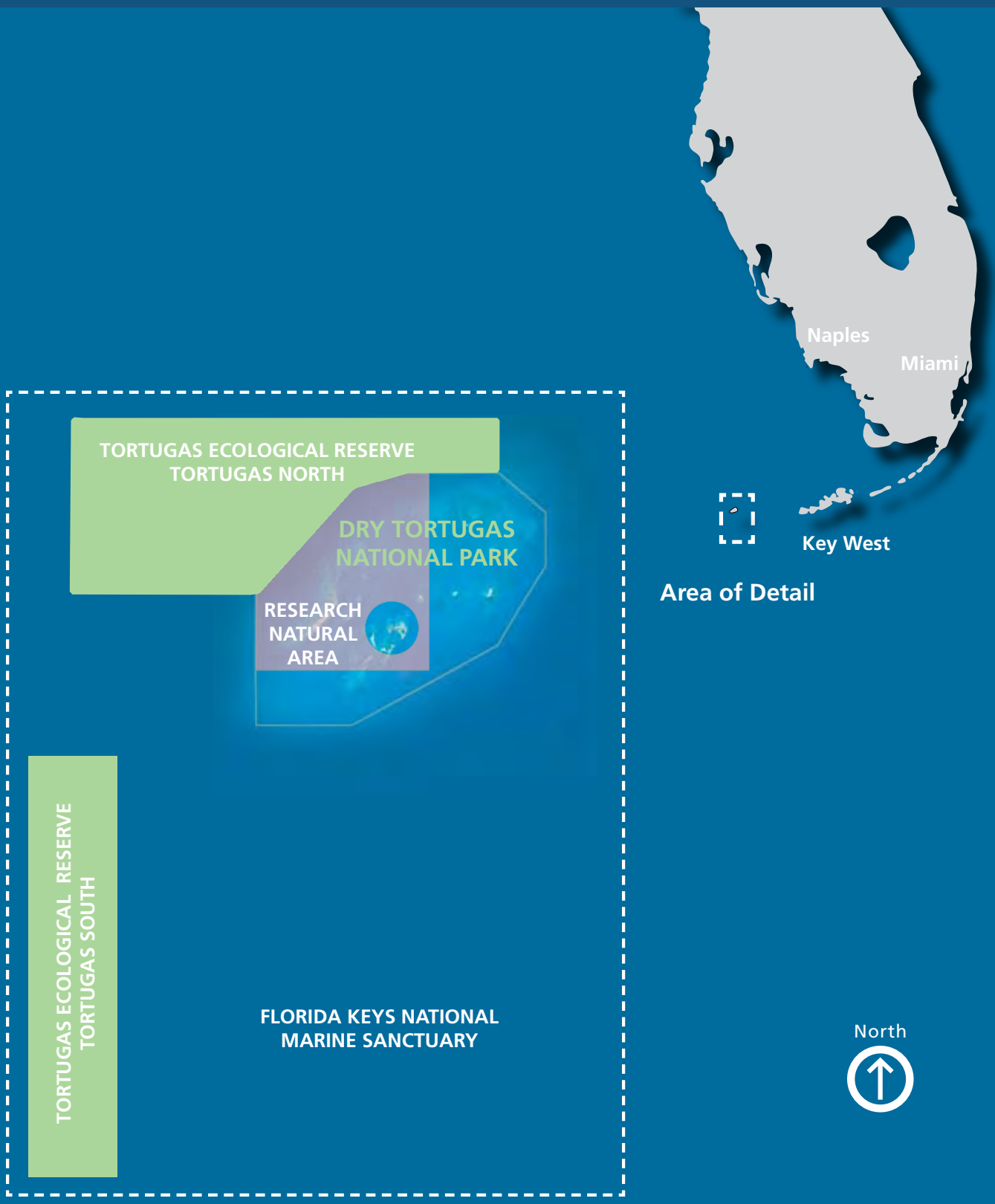
Performance Measure Comments: No Comments	
Essential Activity #1 Comments:	
Comment	*Response*
Representative subset versus all species to develop a baseline for the RNA (small numbers of samples during spawning season). Develop size/fecundity relationship.	We agree. Fecundity is a performance measure; we plan to develop size-fecundity relationships.
Analyze stomach contents of sampled fish.	In addition to evaluating reproductive potential, when analyzing fish, gut content data may be useful. If adequate funding is available, this could be added to the sampling protocols.
Essential Activity #2 Comments:	
Comment	*Response*
Comprehensive sonic array (multiple projects) to show large-scale connectivity. Identify corridors between foraging and spawning areas. Flexible arrays that are adaptive to what we learn from tagging studies.	We are actively exploring this work with NOAA.
Essential Activity #3 Comments:	
Comment	*Response*
First identify spawning aggregation sites (from tagging studies). Linkages with other ongoing larval studies to collect drift vials.	We agree and will employ this approach.
Socioeconomic benefits of larger fecund fish generated by the RNA. Observations of more large fish.	We agree.
Add coral mass spawning events to determine if RNA is a protected source.	We agree. This is a very good idea because it also addresses the other top priority DTNP natural resource stewardship issue; coral decline and lack of recovery. We will add this activity, probably under Topic 4.

Essential Activity #4 Comments: No Comments	
Supplemental Activity #1 Comments:	
Comment	*Response*
Seeding studies to understand local and long-distance transport modeling (regional scale modeling).	Some of this work has been done by NOAA. We will consider and evaluate including this activity.
Supplemental Activity #2 Comments:	
Comment	*Response*
Determine if there is a natural DTNP genetic marker? Microchemistry, real-world larval demonstration of connectivity.	We will consider and evaluate including this approach.

Performance Topic 6 Comments

Performance Measure Comments: No Comments	
Essential Activity #1 Comments:	
Comment	*Response*
Permit system does not capture activities outside RNA.	Our proposed permit system does include activities outside the RNA.
Essential Activity #2 Comments:	
Comment	*Response*
Use importance satisfaction models, measure perception by experience.	We agree and will consider this in our study design.
Need to survey general public in addition to park user groups. Many members are non-users, supports surveying general public. Collect information from general public, general stakeholders, residents of Florida (from those that do not necessarily use the area) – public involvement, NPS Planning, Environment and Public Comment (PEPC) program, opinion polls.	We agree. This activity recommends surveying the general public, in addition to park user groups. However, if funding is limited the focus will be on park visitors and user groups.
User experience surveys coupled with education, which first educate then survey, or survey then educate, or do simultaneously.	We agree.
NOAA survey will start January 2008 for broader Keys/ Tortugas, capture park users but won't be able to tease out park or RNA, would have to up sample size to obtain that, don't have complete flexibility for approval. Will need to modify current questionnaires to make Tortugas specific.	We will work with NOAA to expand and modify survey so better able to provide park- and RNA-specific information.

Essential Activity #3 Comments:	
Comment	*Response*
Science plan greatly dependent on funding for law enforcement.	We agree.
Assumes enforcement to be in place for other topic areas as well.	NPS will implement law enforcement support to the extent practicable.
"Waterways" (cable show focuses on keys) re-format for direct outreach, safe harbor issues, educate on RNA, local fishing shows, tweak for different markets, etc., evaluate opportunities.	Using the Waterways show and local fishing shows for RNA outreach is a very good idea. In fact, the RNA has already been a focal topic of the Waterways show. We will further pursue this with NPS Interpretation (education and outreach division).
Supplemental Activity #1 Comments:	
Comment	*Response*
Focus effort (research/funding) on users who could potentially be impacted negatively, but include others that may not be directly effected, may see economic values are greater for non-consumptive users than impacted fishermen, etc.	We agree with the need for an objective, comprehensive economic assessment of RNA implementation covering all user groups.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