U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Center for Coastal Fisheries and Habitat Research
101 Pivers Island Road
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Comparative analysis of the functioning of disturbed and undisturbed coral reef and seagrass ecosystems in the Tortugas: Phase I- Establishing a baseline

Progress Report # 3

January 1, 2001

Submitted By:

Mark S. Fonseca
Project Coordinator, CCFHR
October 1, 2000

Approved By:

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October 1, 2000

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October 1, 2000

Previous Data Collections: Data processing continues from the first season's cruise. To date, all TOV video transects have been interpreted (i.e. characterization of the benthos). Live bottom mixed reef communities dominate the area covering roughly 67% of the total area viewed in the video transects. Statistical analyses of the video data are ongoing.

Survey Development: We have completed development of the Seafloor Mapping System (SMS). This is composed of a Quester Tangent Sonar system, integrated with a georectified video system, all towed from a ship using a Minibat tow body. The SMS will be deployed in February and April 2001, aboard the Oregon II and Ferrel, respectively, to provide the mapping needed to fix the permanent sampling stations needed for the final, long-term sampling strategy that we have imposed (see attached 2001-2003 operating plan; Appendix I).

We are in ongoing negotiations with SSE to obtain sub support for our deep site characterization, particularly at Reilly's Hump and Tortugas South in general, as well as the deeper areas of Tortugas North. Dr. Steven Miller has indicated that there may be training opportunities to use Trimix and rebreathers to allow our divers direct access down to ~300'.

NURC is again supplying a small ROV at no cost, but must now charge for the use of the S2 - an item for which we had not previously budgeted; we are attempting to find support to continue use of that instrument.

New Sampling Design: In consultation with all project Principal Investigators and CCFHR biometrician, Dr. David Colby, we have instituted a new sampling design for Tortugas North that involves the creation of permanent, fixed transects (Figure 1). Five randomly selected transects will be placed at the interface between the reef and the adjacent, non-reef flats in each of six strata. The six strata are the product of the three use zones (Park, Ecological Reserve, Unprotected) and whether the interface zone is located on the upstream or downstream side of the reef structures. Please refer to Appendix I, the operating plan for 2001-2003 for detailed information.

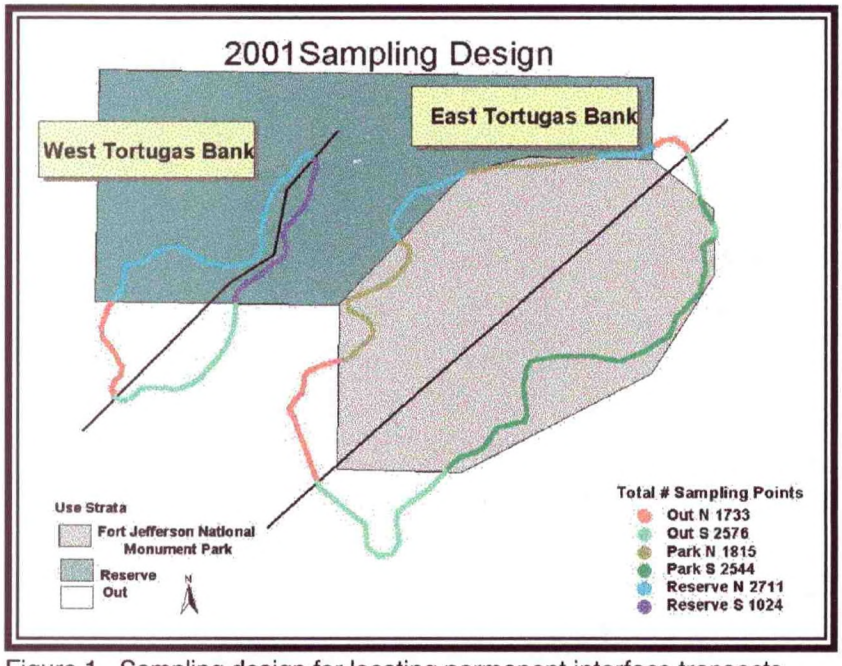

Figure 1. Sampling design for locating permanent interface transects. The numbers associated with the box include the total number of potential random locations within each strata separated by 50 m - the approximate width needed to prevent overlap from visual assessment methods that are employed in the study.

Cruises: We will conduct at least 3 cruises this year. Cruise 1 aboard the Oregon II from Feb 3 - Feb 13th for purposes of mapping out potential permanent transect sites. Cruise 2 aboard the Ferrel from April 6 - April 20 to conclude the mapping, deploy ARGOS drifters, conduct gear impact studies on the west Florida shelf. Cruise 3 - 4 weeks duration either side of the 4th of July week will implement the detailed benthic assessments at the permanent transects in Tortugas North, assessments of spawning aggregations at Tortugas South, herbivory studies, and detailed seafloor mapping of deeper areas of the reserves using SSE subs (their cruise dates aboard the Gordon Gunter

may correspond with ours) and/or NURC Phantom S-2.

Dispersal of fish larvae from the Dry Tortugas MPA: Data obtained from the ARGOS drifters indicate that the fate of larvae spawned over Riley's Hump is quite variable. Larvae spawned over a 1month period can supply recruits to areas ranging from the West Florida shelf to the East Florida shelf well within the 30 day larval duration times for snapper.

Stable Isotope Analysis: We are preparing to ship the first year's sampling from DT to Dr. Steve Macko (Univ. of Virginia) - Dr. Macko will travel to Beaufort in late January to discuss processing protocols and the efficacy of compound specific isotope analysis to determine the relative contribution of coral vs. algae to the reef's trophic structure.

Herbivory Study: In addition to the aforementioned Operating Plan, Drs. Penny Hall (Florida Marine Research Institute) and Susan Bell (Univ. South Florida) will conduct a herbivory study along our permanent transects to determine the spatial extent of diel foraging activities out from the reef - a direct attempt to gauge the buffer area needed around a reef structure needed to provide food resources for transport back onto the reef.

Presentations: Project Coordinator, Dr. Mark Fonseca presented a description of the project to the Science Advisory Panel at a meeting of the FKNMS in Marathon last December. He will also present this information to HQ in late February. Dr. Carolyn Currin will give the following oral presentation in the "Nutrients, Primary Production and Aquatic Ecosystems" Session at ASLO in early February, in Albequrque, NM.

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SOURCES OF PRIMARY PRODUCTION SUPPORTING THE FOOD WEB AT MODERATE DEPTHS ON THE WEST FLORIDA SHELF: The seafloor on the West Florida Shelf is a habitat mosaic composed of open sand areas, *Halophila decipiens* beds, and live bottom. In a series of cruises in 1999, we sampled primary producers, benthic invertebrates and fish at stations ranging from 12 to 30 m depth. Microalgal biomass in the top 2 cm of the sediment exceeded depth-integrated phytoplankton biomass at each station and sampling time. Seagrass and macroalgal biomass were patchily distributed, with peaks in biomass occurring at shallower stations and late summer. Benthic invertebrates, particularly shrimp, had isotopic signatures indicating utilization of *Halophila* production. Fishes also demonstrated a reliance on benthic production, including benthic species (flatfish, catfish) which had isotopic signatures indicating a benthic algal-based food web, but also pelagic planktivores (sardines) and predators (jacks and scombrids). Our results support the hypothesis that benthic primary production provides the base for the food web on this portion of the West Florida Shelf, and that high levels of fishery production associated with the live bottom habitats are in fact directly supported by the surrounding open sand, algae and *Halophila* communities.

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CURRIN, C. A.

Data Availability: Copies of our cruise and progress reports are being uploaded in .pdf format onto our web sites: http://shrimp.bea.nmfs.gov/admin/labpubs.html and, http://shrimp.bea.nmfs.gov/~mfonseca/ .

APPENDIX I - OPERATING PLAN

A) TITLE: ***Comparative analysis of the functioning of disturbed and undisturbed coral reef and seagrass ecosystems in the Tortugas: Phase I- Establishing a baseline*: *YEAR TWO (FY 01) PROJECT DESCRIPTION***

B) OBJECTIVES:
1) A preliminary characterization and inventory of the benthic habitat and fish communities in the extreme depths of the Tortugas South reserve component.
2) Characterize spawning aggregations and initiate development of a probabilistic model of the fate of snapper larvae, focusing on Riley's Hump.
3) Begin comparative characterization of shallow and deepwater seagrass communities and their contribution to fishery resources in disturbed (outside the reserve) and undisturbed sites (inside the reserve).
4) Determine the accuracy of existing habitat delineations within the proposed ecological reserve as a function of depth disturbed and undisturbed sites.
5) Examine how high resolution ecological data of a given habitat type can be scaled to the larger spatial context of the proposed ecological reserve.

C) BACKGROUND/ WORK UNDERWAY: The Tortugas Ecological Reserve will be implemented in the year 2000. It will include two components: Tortugas North and South. Tortugas North will be approx. 151 nm^2 and cover the northern half of Tortugas Bank, Sherwood Forest, and the pinnacle reefs north of the bank. Tortugas South will be approx. 60 nm^2 and encompass Riley's Hump as well as deep water habitats to the south which are home to several snapper species, snowy grouper, tilefish, and golden crab. The implementation of this reserve provides an excellent opportunity for NOAA to investigate the effects of human disturbance on the functioning of coral reef and seagrass ecosystems and to monitor the long-term effects of this reserve on the local and regional areas in terms of larval export, changes in adult biomass, and changes in ecosystem processes.

The CCFHR is uniquely poised to provide critical mission support to habitat characterization and marine reserve questions that are facing the proposed Tortugas Ecological Reserve (TER) within the Florida Keys National Marine Sanctuary (FKNMS). CCFHR has researched fishery-habitat interactions in south Florida and the Keys since the early 1980's and brings a wide range of scientific expertise to bear on fisheries and habitat issues.

The need for detailed habitat characterization is inextricably linked with the reserve issue. Many reef fishes leave the structure of the reef at night to forage in the adjacent sand and seagrass flats, thereby importing significant amounts of nutrients onto the reef environment, contributing to its high productivity. This mass transfer also ultimately contributes to energy requirements of small grazers that cannot themselves access the flat resources. The adjacent seagrass and algal beds are also significant settlement areas for post-larval reef fishes. Over-fishing of the diurnally migrating fishes and/or physical damage to the foraging/settlement environment could prove disastrous to the reserve's productivity and biological diversity. Therefore, habitat characterization is critical to determine the distribution of sessile resources that are susceptible to injury. Characterization is also crucial to ultimately determine an ecologically optimal size of the reserve complex (i.e., the reef and the adjacent areas upon which reef fauna are dependent) to yield optimum fishery production and maintain the ecological health of the reef ecosystem. Finally, conducting work in the proposed TER provides a unique opportunity to compare the structure and function of a relatively undisturbed system with those elsewhere in the FKNMS and adjacent waters.

D) STATEMENT OF WORK: The project consists of 5 tasks designed to meet information gaps in the assessment of the effectiveness of the ecological reserve:

Task 1. CCFHR shall conduct a preliminary investigation into the technical and logistic difficulties in preparing a numerically accurate and spatially precise characterization and inventory of the fish and benthic communities of the Tortugas South reserve component, focusing on the Riley's Hump area. While

the area boundaries have been delineated, the structure of the benthos has not been tightly linked with its function as fishery habitat. Therefore, bathymetric delineation alone is not sufficient - a direct examination is required to determine the amount of living sessile and motile resources, their kind (taxonomy) and spatial organization and distribution. However, the depth ranges involved in this examination exceed NOAA diving safety standards and remote means or piloted submersibles are needed to conduct the study correctly. CCFHR will utilize its videographic technology within the depth ranges of its equipment, to continue the assessment of the benthic resources. We will also utilize NURC ROV technology to expand this search on an as-available basis. From the interpretation of these videographic images, correlated with their geographic position, we will build GIS data layers of species distributions and conduct statistical analyses to project and conduct comparative analysis of the local ecology as the Reserve is instituted. We will also attempt to utilize historical videography of this site from other programs and recruit other programs utilizing technology with greater deep ranges into the delineation process. Finally, we will attempt to secure sub support from the Sustainable Seas effort to support this characterization effort.

Task 2. CCFHR shall characterize the mutton snapper spawning aggregations on Riley's Hump by documenting the approx. size of the aggregation, its timing and duration, and other species involved. Aggregations of four other species of snappers also occur on Riley's Hump. Management strategies have not sufficiently limited fishing pressure at this site, nor decreased the potential damage to coral reefs through fishing activities. There remains real concern about the viability of the population of mutton snapper that uses this site for spawning, and more generally, about the viability of large spawning aggregations of groupers and snappers once spawning aggregations are found. To better protect spawning aggregations, research into the special characteristics of the specific spawning sites is needed. In addition, knowledge of the fate of larvae spawned from these sites in crucial to evaluate a site's larger importance to populations throughout the southeastern United States. We will attempt to identify specific spawning sites of mutton snapper via SCUBA surveys during the spawning months. Characteristics of specific spawning sites (e.g. benthic cover, bathymetry) will be recorded. During spawning site characterization, satellite tracks drifters will be released to estimate the potential fate of larvae spawned at the site. These drifter tracks will be used in the development of a probabalistic model to assess the regional importance of mutton snapper spawning at Riley's Hump.

Task 3. CCFHR shall begin to characterize the deepwater seagrass and other non-reef benthic communities and its contribution to sustaining the fishery resources in the proposed ecological reserve and compare this contribution to a disturbed site (e.g., nearby site not within the reserve designation). This work is an examination of the geographic extent and offshore depth limit of the various seagrasses and other primary producers within the reserve, including the deeper *H. decipiens* bed and a study of how these seagrasses and other habitats (benthic and macro-algae, live bottom) sustain the fishery resources of the TER, particularly at Tortugas North. We would attempt to locate the offshore limit of forage areas of hard bottom/coral reef resident fishes of the TER proper within the ranges of our divers and remote technology. We will measure the flux of fishes between hard bottom and seagrass habitats in both disturbed and undisturbed representative habitats by documenting their movement, particularly during crepuscular hours. The offshore limit of the distribution of resident reef fishes, together with their isotopic signatures, would delineate the areal extent of their habitat utilization in both areas. This area would also define that required to support the current reef fish population - the functional area of the reef ecosystem which is critical in order to evaluate effectiveness of the reserve, both in a disturbed and undisturbed state. This delineation is the *de facto* definition of Essential Fish Habitat. Having located the habitat extent in year 1, we will capitalize on those year 1, random point-grid surveys (stratified by depth of portions of the reserve where NOAA ships can maneuver), and place transects that will allow detailed, direct comparative analysis of ecological characteristics of the Proposed Reserve vs. Unprotected areas vs. the National Monument (long-term protection) (Figure 1). We will also concentrate on areas that have been heavily trawled by monitoring (e.g. Pinnacle Reefs on the northern edge of Tortugas North) them for their recovery after imposition of the Reserve. As in our ongoing work, stable isotope analyses (C, N, S) and most likely, compound-specific isotope analyses will be taken of plants and animals comprising these communities to more precisely define food webs and linkage among habitats.

Task 4. The CCFHR will initiate a comparative analysis of the delineation of habitats based on depth will

be performed by conducting a georectified towed video transects the seafloor within and outside of the reserve at various depths and within previously delineated habitat boundaries. Statistical analyses will be performed after interpretation of the video as to the probability of habitat type occurrence by depth using the existing delineations vs. those of the towed video. Data will be compiled in [ArcVIEW] GIS. Upon availability of imagery from NCCOS cooperators, we will attempt to update coral and seagrass maps of Tortugas North, verified with the georectified towed video transects and sonar seafloor classification systems. Specific attention will be paid to characterizing the transects for the comparative analyses across the interface of the various levels of protection.

Task 5. We will examine how well ecological data collected at high resolution can be scaled to the larger spatial extent of a given habitat type within the proposed ecological reserve. Georectified videographic records of habitat distribution and bathymetric data will be examined using geostatistical methods to determine the scale dependency of the benthic structure.

E) SCHEDULE:

1. October 2001- continuing

   - analyze and interpret field data from July cruise to Tortugas on NOAA ship Ferrel
   - develop and refine equipment for visually and remotely characterizing benthic habitats of the Dry Tortugas
   - Attend Sanctuaries workshop and present summary of results

2. February 2001 - Execute 5 day Cruise to Dry Tortugas on NOAA ship Oregon II - submit cruise report.

3. April 2001 - Execute 14 day Cruise to Dry Tortugas on NOAA ship Ferrel - submit cruise report.

   - continue benthic habitat characterization by towed video camera, QTSea-View bottom characterization and ROXANN
   - continue benthic habitat characterization by divers and ground truth QTSea-View and ROXANN
   - begin site specific experimental analysis of before and after closure effects on fishery habitat

4. July 2001 - Execute 30 day Cruise to Dry Tortugas on NOAA ship Ferrel - submit cruise report

   - continue benthic habitat characterization by towed video camera, QTSea-View bottom characterization and ROXANN
   - continue benthic habitat characterization by divers and ground truth QTSea-View and ROXANN
   - monitor site specific experimental analysis of before and after closure effects on fishery habitat

5. September 2001 - Prepare progress report

F) PRODUCTS:

General: Cruise reports and quarterly reports on an ongoing basis. At the end of FY 2001 CCFHR will provide a summary document describing what goals have been met over the course of the cruises in the form of these combined progress and cruise reports to OCRM/SRD and NOAA ship operations. Data will be easily accessible as all reports will be posted on our web site:
(http://shrimp.bea.nmfs.gov/admin/labpubs.html)

Task 1 Product: At the end of year 1, CCFHR will provide a characterization report describing challenges in performing an accurate benthic and fish communities characterization with taxonomic lists for fish, stony corals, soft corals, sponges, and algae. CCFHR will also provide a preliminary assessment of these communities in the form of GIS data layers within the depth ranges addressable with current technology.

Task 2 Product: A spawning characterization chapter shall be produced as part of the overall site

characterization document for Tortugas South. (Interim report in each of years 1-2; final in 3-5 years). Task 3 Product: Preliminary comparative analysis of the structure of faunal-habitat linkages among disturbed and undisturbed portions of the reserve as an indicator of reserve effectiveness. (Interim report in each of years 1-2; final in 3-5 years).

Task 4 Product: Preliminary report on comparative analysis of error in habitat delineation within and outside of the reserve as a function of water depth. This report would also lay the baseline data for the comparative analyses of resource status both before and after the implementation of the Reserve (Interim report in each of years 1-2; final in 3-5 years).

Task 5 Product: A statistical analysis of the minimum spatial scales that should be utilized to conduct unbiased parametric assessments of habitat-linked resources in and out of the reserve. (Interim report in years 1; final in 2 years)

G) RESOURCES:

1) CCFHR Personnel:

a). Dr. Mark S. Fonseca - Research Ecologist and Project Coordinator: Will serve as project coordinator, acting as liaison between CCFHR researchers and other parties as needed. Supervises data sharing among project participants, organizes cruises and acts as chief scientist and field party chief. Research duties include all aspects of planning, preparation, field research, data analysis and report writing. Target area = habitat mapping and spatial analysis. NOAA working diver.

b). Dr. W. J. Kenworthy - Research Fishery Biologist - Will serve as alternate project coordinator. Acts as chief scientist and field party chief. Research duties include all aspects of planning, preparation, field research, data analysis and report writing. Target area = plant and animal ecology. NOAA working diver.

c) Dr. John S. Burke - Research Fishery Biologist - Acts as chief scientist and field party chief. Research duties include all aspects of planning, preparation, field research, data analysis and report writing. Target area = fish utilization of habitats. NOAA scientific diver.

d) Dr. Carolyn A. Currin - Research Microbiologist -Acts as chief scientist and field party chief. Research duties include all aspects of planning, preparation, field research, data analysis and report writing. Target area = food web and benthic flux. Retired NOAA working diver.

e) Dr. Jon Hare - Research Fishery Biologist - Acts as chief scientist and field party chief. Research duties include all aspects of planning, preparation, field research, data analysis and report writing . Target area = Riley's Hump.

f) Kamille Hammerstrom - Research Biologist - Acts as field party chief. Research duties include participating in all aspects of planning, preparation, field research, data analysis and report writing. Target area = ecosystem structure and function. NOAA scientific diver.

g) Donald Field - Geographer - Collaborates on habitat characterization and specializes in our attempts to utilize remote-sensed imagery to update resource maps of the area.

h) Paula Whitfield - Biological Technician - Acts as field party chief. Research duties include participating in all aspects of planning, preparation, field research, data analysis and report writing. Target area = GIS coordination. NOAA working diver.

i) Amy Uhrin - Biological Technician - Acts as field party chief. Research duties include participating in all aspects of planning, preparation, field research, data analysis and report writing. Target area = ecosystem structure and function. NOAA scientific diver.

j) Craig Bonn - Biological Technician - Acts as field party chief. Research duties include participating in

all aspects of planning, preparation, field research, data analysis and report writing. Target area = fish identification. NOAA scientific diver.

k) Mike Burton - Research Fishery Biologist - Research duties include spawning site characterization and satellite drifter work. Target area = fish identification and oceanographic sampling. NOAA Working Diver.

l) Other staff as scheduling needs require.

2) Other participants:

A) Bill Goodwin and Harold Hudson - FKNMS - Collaborate on assessment of gear impacts.

B) David Score - FKNMS - Collaborates on fish use assessments.

C) Dr. Susan Bell - Faculty - University of South Florida - Collaborates on assessment of macroepibenthic fauna and meiofauna

D) Dr. Penny Hall - Marine Researcher - Florida Marine Research Institute (FMRI) collaborates on faunal, seagrass and algae assessments.

E) Mark Finkbeiner - NOAA Coastal Services Center - Collaborates on seafloor classification using both ROXANN and QTC sonar systems.

F) Dr. Mark Monaco - CCMA - Collaborates on fishery census work and habitat characterization.

G) John Christensen - CCMA - Collaborates on fishery census work and habitat characterization.

H) Kay Lynn Plummer - FDEP - Collaborates on assessment of gear impacts.

3) Equipment:

a) Field Supplies required/used: Underwater Towed Vehicle, TVs, stationary and towed camera systems, video and control cables, satellite track drifters, nets, plastic bags, marking tapes, flagging tape and flags, pvc and pvc quadrats, film and processing, station anchors and buoys, fiberglass measuring tapes, waterproof paper, underwater pencils, SCUBA equipment and maintenance, SCUBA air and NITROX, metal and fabrication of experimental equipment, seines, beam trawls, storage chemicals, containers, CTD calibration and maintenance, incurred shipping costs, and replacement tools for an extensive array of tools.

b) Data Acquisition used: Color film and mailers, digital tapes, digital underwater cameras and housings and maintenance thereof, high 8 video cameras, ARGOS data acquisition, rechargeable batteries, alkaline batteries, digital frame-grabbing support, computer monitors, VCR, Horita signal splitter, backup tapes, multiple laptops and support thereof.

c). Data processing used: ARCView, ARCInfo, ERDAS Imagine, Pathfinder Office, ASPEN, SAS, Powerpoint, Sigmaplot, zip discs, printing paper and color printing supplies, format variable software for uploading.

H. BUDGET

FY 01

Salary + benefits	$125K
Travel	$17K
Supplies/equipment	$38K
Shipping	$2K
Field Support	$6K

Contracts (stable and compound specific isotopic analyses with Univ. Virginia - Dr. Steve Macko)	$62K
Total	**$250K**

FY02 - $220,000 - proportional distribution as per FY01

I. SUMMARY OF POTENTIAL OUT-YEAR ACTIVITIES

Having selected permanent transects for comparative analysis among the various levels of protection, we will continue detailed surveys of the biological and physical structure across the interface zones of those protected areas. The process of recovery may occur rapidly for some resources and quite slowly for others, and this must be described. We will integrate our sampling effort with ongoing gear impact studies to make specific determinations regarding the effect of closure on habitat recovery and trophic structure. We will continue our assessment of the benthic resources of Tortugas South and examine the potential for downstream benefits of the spawning sites at Riley's Hump. Findings will continue to be posted on our web site and reports filed as requested by Sanctuaries. The ultimate goal of this work is presentation at National Meetings, peer-reviewed publication, and direct interpretation and utilization of the information as ongoing cooperation between Sanctuaries and NCCOS. We are actively seeking other sources of funds to continue the comparative work regarding the relaxation of gear impacts in the proposed Reserve area.

J. CONTACT

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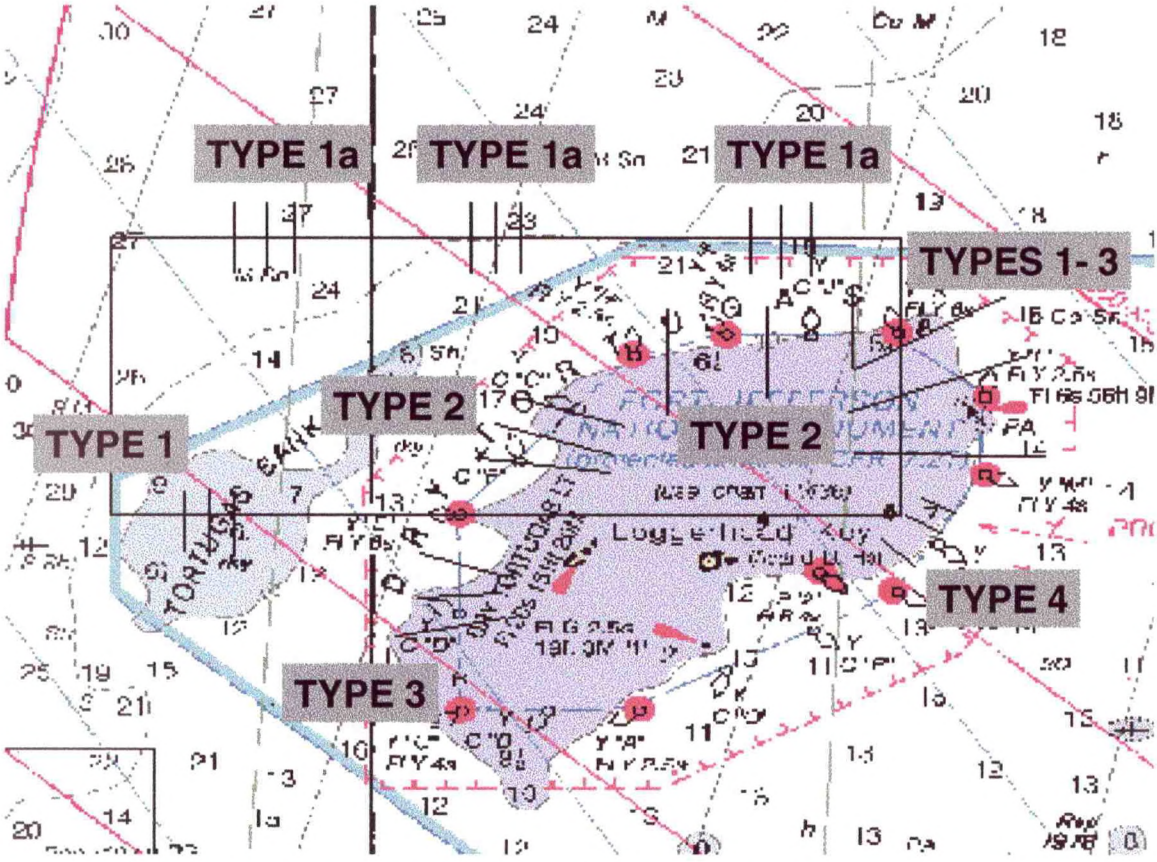

Figure 1. Location of transects for comparative analyses in Tortugas North: Type 1 = Reserve vs. Protect (predominantly hard bottom); Type 1a = Reserve vs. Protected (predominantly soft bottom); Type 2 = Reserve vs. Park (potential mature end point); Type 3 = Park vs. Unprotected; Type 4 = Interface zone (full protected endpoint).