RAPID ECOLOGICAL ASSESSMENT
WEST COAST OF ANDROS, THE BAHAMAS
JUNE 19th -29th, 2006

PRELIMINARY REPORT OF SCIENTIFIC FINDINGS
DECEMBER 2006

The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

BAHAMAS NATIONAL TRUST

National Fish and Wildlife Foundation

kerzner marine foundation

Particpant list of the west side rapid ecological assessment

June 18-29, 2006

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Josh Spring, Videographer

Acknowledgements:

The Rapid Ecological Assessment (REA) for the West Coast of Andros, The Bahamas was undertaken as a partnership between The Nature Conservancy (TNC) and the Bahamas National Trust (BNT), and it was made possible through grants from the Kerzner Marine Foundation and The National Fish and Wildlife Foundation. We greatly appreciate their support and encouragement over the course of the assessment process.

The team wishes to thank Andros fly fishing guides: Prescott Smith, Chairman of the Bahamas Sportfishing and Conservation Association (BSCA), and fly fishing guides Philip Rolle, Harrington "Skeebo" Frazier, Shawn Leadon, Danny Newbold, Andy Smith, Charlie Neymour, and Shawn Neeley, whose knowledge of the area and guidance in advance of the assessment was invaluable. Andy Smith is also thanked for providing several key supply trips which kept us going.

We were particularly fortunate to be based from the Flamingo Cay Rod and Gun Club where the owner Charles Bethell and manager Cindy Rimstad contributed significant time and resources to the effort including the use of their 9-person float plane for accessing some of the most remote areas. Also, Roger - the chef was a blessing with his willingness to cook around the hectic field schedule.

Eleanor Phillips arranged many of the complicated logistics for this assessment and Kim Thurlow undertook much of the preparatory coordination amongst scientists. Rivean Gibson- the Andros West Side Project on-site Coordinator in as our 5th guide for much of the time on the west side.

Photographer, Carlton Ward, shot over 4,000 images during the expedition including some spectacular air shots, which will be available for use in presentations. In addition, Josh Spring, the videographer, was able to collect more than 12 hours of high quality video during his short four days with the team which should form the basis for an excellent educational piece on the REA.

We would also like to express our thanks to the Bahamian students: Ashley Miller, Montara Roberts, Ketroya Oliver, and David Rees whose assistance in conducting the field work and entering the data was greatly appreciated.

Executive Summary:

The West side of Andros is an extensive carbonate mud complex virtually saturated with small islands and estuaries, including tidal creeks and wetlands. Local knowledge of the west side by bonefish guides and other Androsians who frequently spend time there (e.g., spongers, fisherman) suggest that the west side estuaries are important nursery and foraging habitat for commercially valuable species such as snapper, spiny lobster, tarpon, and bonefish. The nursery habitats are thought to significantly contribute to fisheries stocks throughout the Caribbean region, particular for highly migratory species such as bull sharks and tarpon.

Threats to the biodiversity on Andros are still relatively low due to its small population and vast uninhabitable areas. However, despite its relatively intact marine systems compared to other areas in the Caribbean, the perception of deterioration is shared by almost everyone who has known the marine environment well over the last few decades including scientists, divers, fishermen and crabbers. The most noticeable changes are declines in the numbers and size of adult fish, particularly Nassau grouper, as well as reduced numbers of conch and crawfish, all of which are exploited commercially. The main user groups of the resources found on the west side include catch-and-release fishermen, who primarily fish the bights and creeks with little negative impact and commercial fishermen, who primarily target lobster and stone crab along portions of the Great Bahama Bank. However, given the west side of the island has only limited forms of active regulation and protection, many impacts such as those associated with aquaculture, development and sand/mud mining, as well as unregulated sport fishing and tourism remain significant threats.

The Nature Conservancy, in partnership with the Bahamas National Trust and other local partners, is working on a comprehensive strategy to promote the establishment of a new marine protected area on the West side of Andros in order to protect these vital nursery habitats from future threat. One of the priority activities was to undertake a scientifically-based rapid ecological assessment of the west side to identify priority sites for conservation. The rapid ecological assessment was conducted by an interdisciplinary team of natural resource experts and local fishing guides and Bahamian students. The information collected through the REA will serve as the basis for a joint proposal to the Prime Minister requesting the formal establishment of a new marine protected area, a public education/outreach campaign and a management plan for the area.

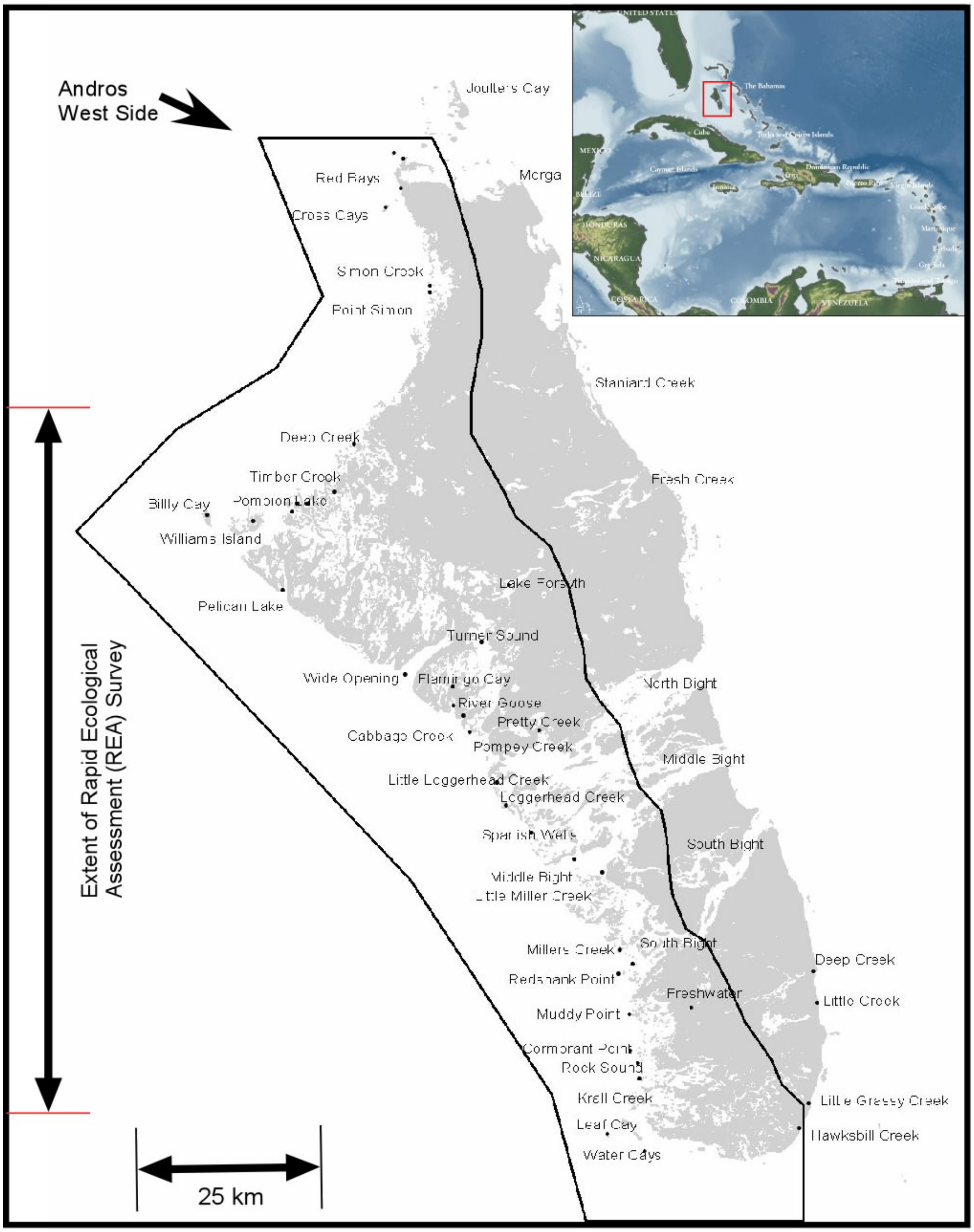

Figure 1: Map of the west side of Andros with major place names.

The goal of the rapid ecological assessment (REA) was to provide information on the spatial distribution and condition of biodiversity on the west side of Andros Island needed to fill the largest information gaps. The results consist of a series of Geographic Information Systems (GIS) maps identifying critical/unique areas using benthic habitats, fish, focal species, substrate and vegetation characteristics across the west side of Andros. This information along with data on usage and impact will help focus discussions around priority areas for conservation and compatible zoning of the chosen area.

In preparation of the REA, the team utilized satellite imagery (Landsat 7 with 30-m resolution, and IKONOS scenes with 4-m resolution) along with national topographic maps and aerial photographs. In addition, various stakeholders that use the west side (fishing guides, commercial fisherman) were asked to identify important biodiversity features they may have seen such as bonefish spawning areas, turtle feeding or nesting locations, flamingo foraging or breeding areas, blue holes, coral, unusual oceanographic conditions, and freshwater wetlands. From these information sources and the logistical constraints (10 days, 5 boats, 20 persons) a sampling scheme was designed to optimize the amount of information that could be collected by each team. Each team lead was responsible for collecting the data, analyzing the data, and developing a report with a summary of findings and recommendations. REA teams comprised of:

Biophysical Mapping Team- This team collected information on sediment type, % cover of sea grass and macro algae, other sessile invertebrates (sponges, gorgonians, stony corals) as well as basic salinity, dissolved oxygen, water depth and geological characteristics.
Fish and Estuarine Team- This team collected fish diversity, abundance, and biomass estimates, as well as information on mobile invertebrates (crabs, conch, lobster). This team also documented the size and extent of mangrove communities.
Bonefish and Tarpon Team- This team examined juvenile and adult bonefish and tarpon habitats to gain a better understanding of their resource utilization movements. Also targeted sampling to verify the genetic species identity and develop size-age growth curves.
Terrestrial Team- This team assessed species composition and vegetation structure of inland areas and also conducted iguana and other reptile surveys.
Flamingo Team- This team examined the presence and abundance of flamingos on the west side via aerial surveys on detailed on-the ground observations.
Sea Turtles Team This team assessed presence and absence information on foraging and possible nesting habitat for sea turtles.

Each team consisted of 2-3 persons per boat including a well-respected local sport fishing guide who regularly uses the west side, scientific lead/s from US Universities who have previously conducted research in other parts of the Bahamas, and a student from the Bahamas. A total of 10 days was spent conducting field work from June 18 to 29, 2006.

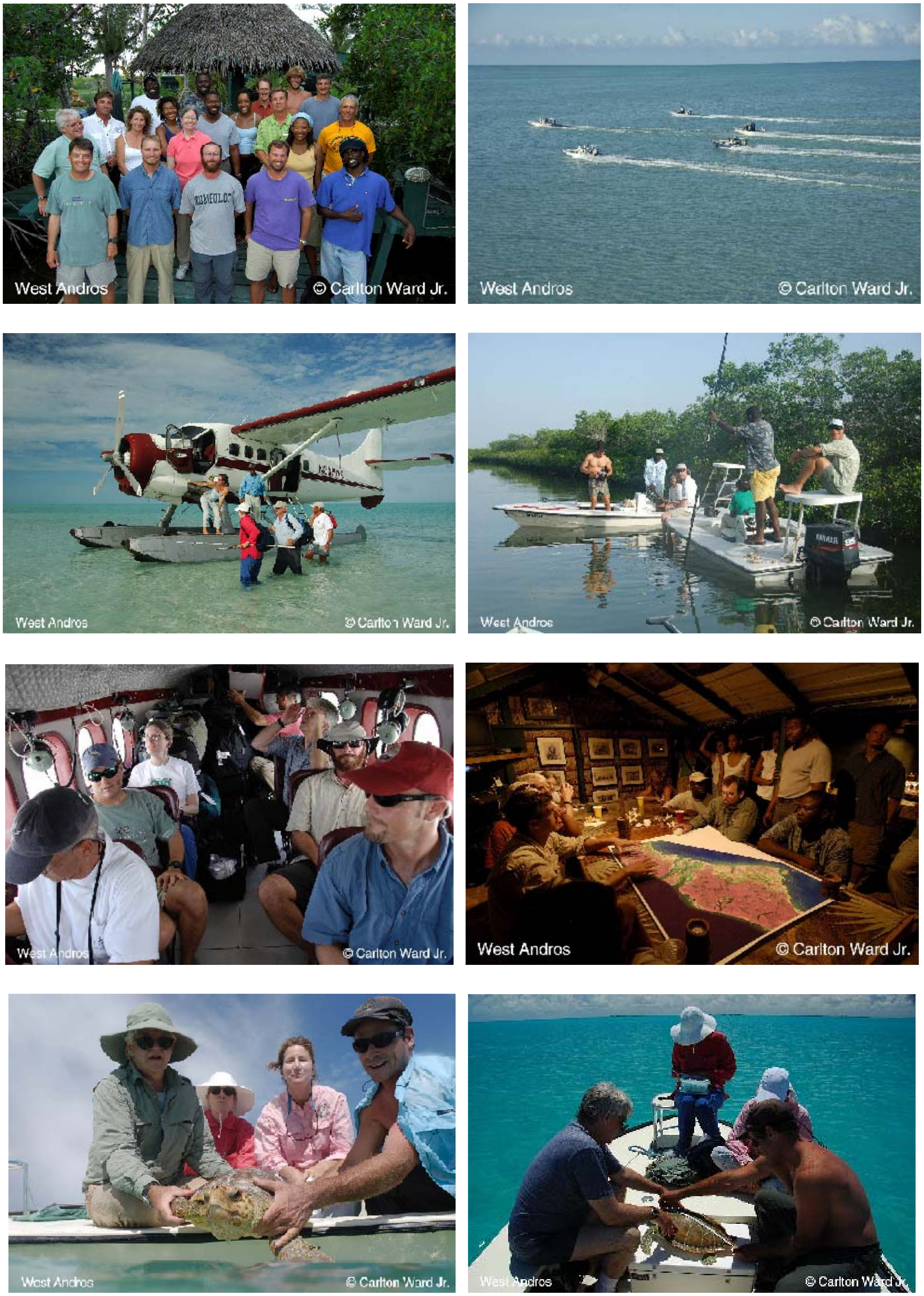

Figure 2A: Selected photographs from the West Side REA

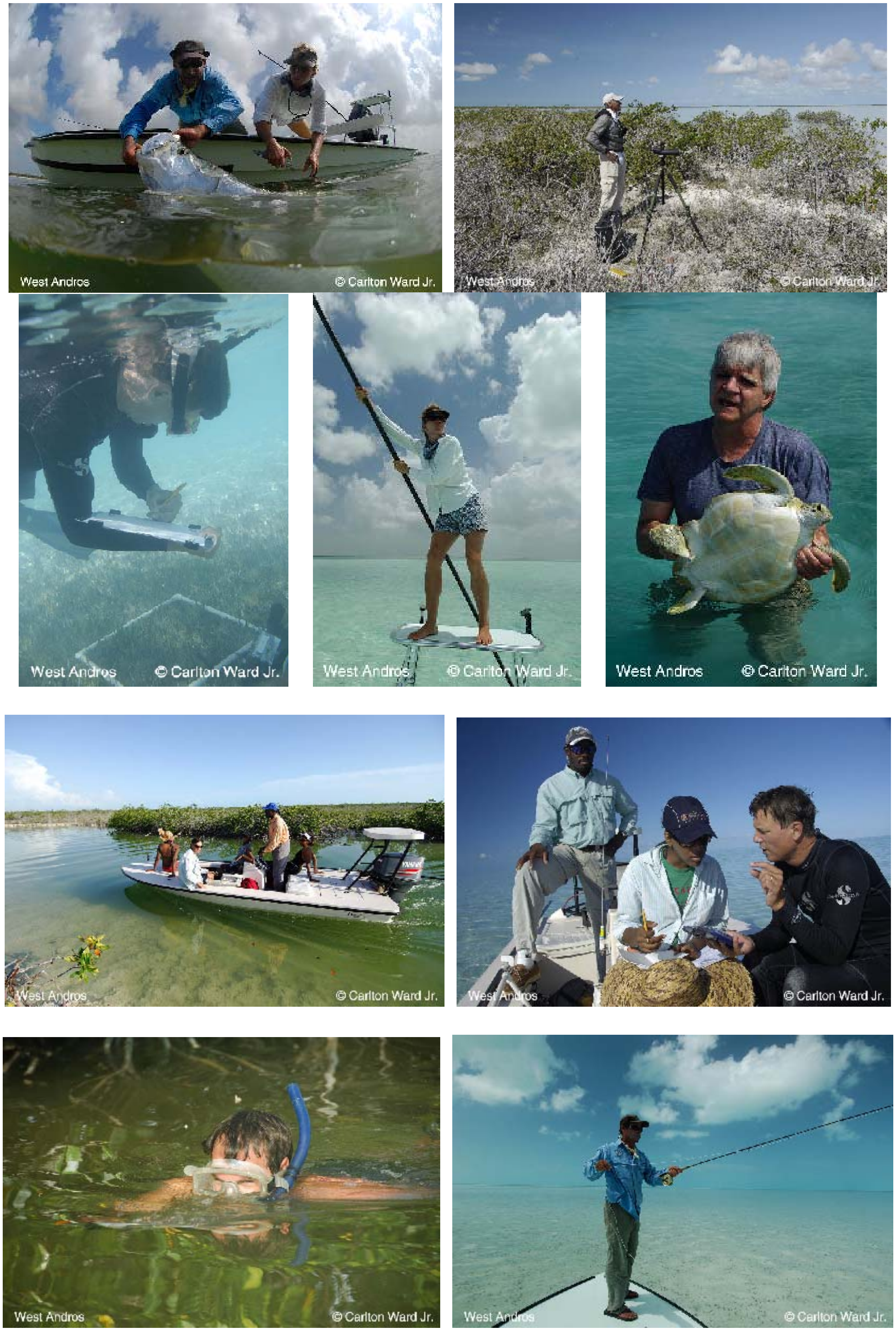

Figure 2B: Selected photographs from the West Side REA

Many of the scientific observations made during the REA validated what the fishing guides and other locals familiar with the west side have been saying for years- West Andros is as pristine a place as exists on earth today. The assessment crossed many hundreds of miles of flats, mangroves, and forests the team found very few signs of human presence. An abbreviated summary of the major findings for each of the teams is is given below but readers are encouraged to read the more detailed individual reports that follow.

Biophysical Characterization

- The highest diversity of seagrasses, macroalgae and other sessile invertebrates were associated with hardbottom areas (Billy Island area and creeks north; Water Cays areas, and several creek bottoms
- The dominant benthic habitat for offshore areas of the west side is sparsely colonized mud. No major north to south gradients occur in benthic habitats which are mostly determined by substrate type ,depth of bedrock, and proximity to tidal currents.
- The largest freshwater/esturaine system in the Bahamas occurs in the Lake Forsyth /Turner Sound/Wide Opening Area.
- Freshwater inputs supports several unique species/breeding grounds in this area and are essential for ensuring that the west Andros ecosystem will continue to function as one of the most important nursery systems in the Bahamas.

Mangrove Creek Fish Assemblages

- The West side of Andros supports highly productive mangrove fish assemblages and important areas for several species of interest including …(e.g. elasmobranches, including endangered sawfish).
- There was a significant correlation between fish abundance and water depth, water and mangrove height, and mangrove height and mangrove canopy cover.
- Tall/thick mangrove areas support orders of magnitude more biomass than dwarf mangroves, and are thus of up-most importance as conservation targets.
- Tall/thick mangroves encompass far less area (<5% of total mangrove extent) than dwarf mangroves, so these areas should be preferentially considered when developing priorities for conservation.
- Tall/thick mangrove areas are found primary at the mouths of creeks, especially ones with well-defined channels, and at various island sites in creeks interior sites.

Bonefish and Tarpon

- The complex life histories and variety of habitats used by bonefish makes management focused solely on bonefish unrealistic. Instead, an ecosystem approach, whereby the habitat mosaics that encompass the bonefish life cycle are protected, should be the center of an appropriate conservation plan.
- At present the bonefish population of West Andros appears to be in good condition, and the bonefish fishery should remain catch and release to ensure it remains strong.
- Indications are that West Andros may be important habitat for bonefish that migrate to the eastern shoreline of Andros to spawn. The possible spawning migration should be investigated so appropriate protection measures can be enacted.

Vascular Plant Diversity and Vegetation

- The terrestrial vegetation of western Andros is intact and shows excellent examples of Pine Woodlands (PW) and Dry Broadleaf Evergreen Formations - Palm Shrublands (DBEF-PS).
- Terrestrial Plant Conservation needs to be across broad areas throughout Andros to insure capturing the range of taxonomic and structural variation.

Iguanas (and Reptiles)

- The majority of the west side of Andros Island does not provide suitable habitat for iguanas. It is instead inhabited by feral hogs, which appear to inhibit iguana populations and perhaps populations of other reptile species. The hogs should be prevented from dispersing south of North Andros Island.
- The existing National Park on North Andros Island is not adequate to ensure the long-term survival of the Andros Iguana. The management of invasive species should be implemented since only a few, if any, iguanas inhabit the west side of North Andros Island.
- South Andros area in particular holds great potential for iguana conservation. The isolated small and large cays of the south/southwestern area (south of Mangrove Cay) support the largest pines remaining in the Bahamas, lack feral animals and are far from human settlements, roads, and commercial logging practices.

Flamingos

- North Andros is currently home to a resident non-breeding flock of flamingos that varies in size from approximately 100 to over 1000 individuals from year to year.
- The lake system north of Wide Opening that is more saline than other lake systems on the west side of North Andros appears to be an important resting area for flamingos although it is not entirely clear where these flamingos are foraging.
- At this time it is unclear what factors are preventing successful nesting of flamingos on Andros. One likely factor is the high density of wild hogs (a potential nest predator).

Sea Turtles

- The west coast of Andros is important habitat for 3 species of sea turtles: green turtles (*Chelonia mydas*), loggerheads (*Caretta caretta*), and hawksbills (*Eretmochelys imbricata*). The sea turtle populations observed on the west coast of Andros are significant in the Bahamas Archipelago and may well be of regional significance in the Greater Caribbean.
- The juvenile loggerhead population observed in the waters around the west coast of Andros represents the only known aggregation of juvenile loggerheads in The Bahamas and is of regional significance for the Greater Caribbean.
- The disease fibropapillomatosis (FP) was observed in green turtles in three areas surveyed for sea turtles (Billy Island, Spanish Wells, and Little Miller Creek). Prior, confirmed reports of FP from The Bahamas have been limited to Crooked Acklins and Grand Bahama.
- South Andros may have regionally significant hawksbill populations. The possibility of sea turtle nesting on the cays off South Andros needs further investigation.
- South Andros may have significant loggerhead (*Caretta caretta*) and hawksbill (*Eretomochelys imbricata*) populations. The importance of South Andros for sea turtle populations may be significant within The Bahamian Archipelago as well as for the Greater Caribbean.

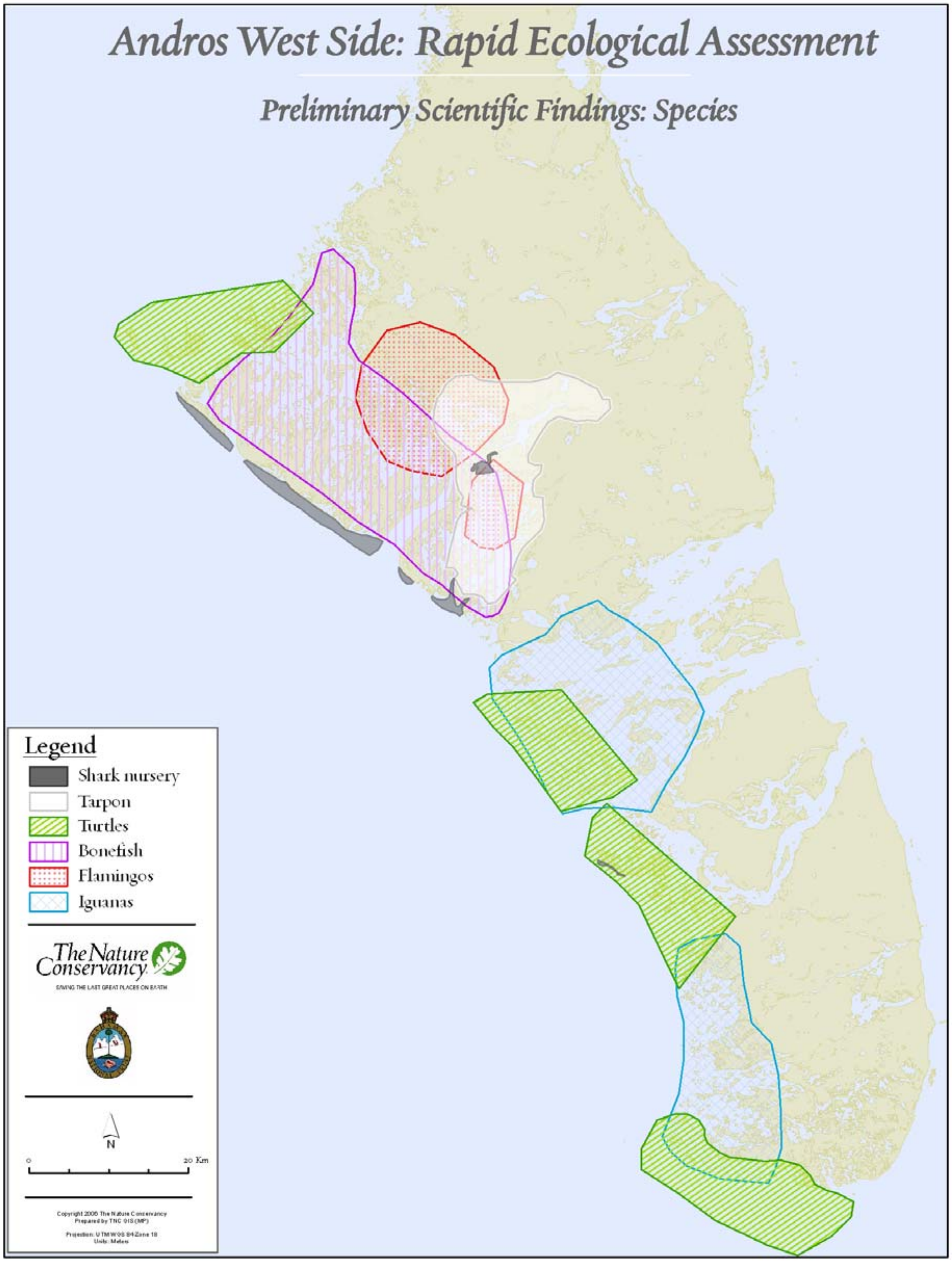

Figure 3A: Map of west Andros showing generalized critical areas for focal species investigated during the REA: Sharks, Tarpon, Bonefish, Turtles, Flamingos, and Iguanas,

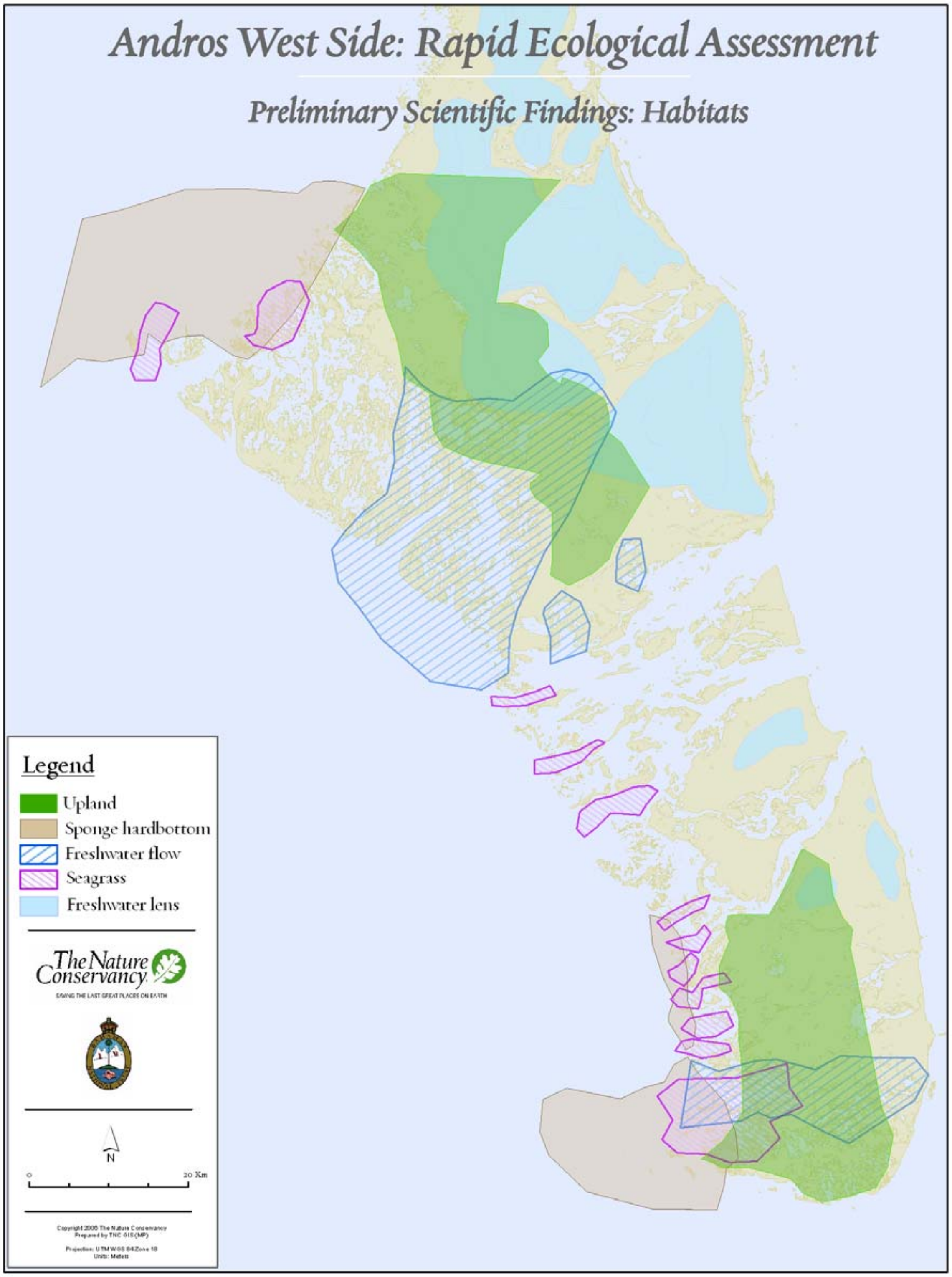

Figure 3B: Map of west Andros showing intact highly diverse habitat areas for Upland vascular plants, sponge and macroalgal dominated hardbottom areas, dense seagrass beds. Also shown are major estuarine areas of freshwater flow and the adjacent freshwater Andros aquifer.

Scientific Recommendations for Conservation

- The existing park does not adequately protect representative examples of most benthic habitat parks. The protected areas should be expanded to include representative examples of all benthic habitats (sparse, dense seagrass, bare mud, hardbottom)
- The existing park does not capture the principal freshwater sources and the associated downstream estuaries. Expanded parks on the west side should include the entire lake Forsythe source area and important freshwater sources on south Andros..
- Since the aquatic ecosystem of western Andros ranges from nearshore marine systems, to brackish tidal creeks and freshwater ponds, which are often interconnected, the protected area planning should include all of these areas and focus on species management, habitat protection and water quality protection.
- The protected area planning should take the approach of protecting representative habitat types from throughout western Andros.
- Priority should be given to the areas north of the westernmost point of Andros (including Williams Island and Billy Island), the Bights, and southern Andros since they had slightly higher fish and benthic diversity and were important for fishery species such as spiny lobster.
- Turner Sound, visited infrequently at present, appears to be an important area for bull sharks and possibly sawfish. It should be a priority site for protection from future threats to habitat, water quality and disturbance of these species due to human visitation.
- At least 50% of these creek systems that have significant areas of tall mangrove should be protected in any management plan: Big Loggerhead, Billy's Creek, Chalk's Sound, Cut-off Creek, Little Loggerhead, Spanish Wells, Timbler Creek, Whale's Creek, William's Creek, and various sites on Southern Andros.
- Inland shallow backcountry areas should be protected as important juvenile bonefish habitats
- Creeks along West Andros, from Cabbage Creek to Timber Creek should be protected as sub-adult and young adult habitats.
- Creek mouths and adjacent bottoms should be protected as adult bonefish habitats
- Protections should include prohibition of direct habitat impacts (e.g., dredging, shoreline development) as well as alterations of freshwater flow patterns
    - This may involve management of the freshwater lens
    - Protections are for bonefish as well as their prey and habitats
- West Andros protected areas designed for iguana conservation should be demarcated south of Lisbon Creek, and encompass Sandy Cay in South Bight and adjacent Alcorine Cay.
- The identified lake system is currently an important resting area for flamingos on West Andros and should be included as part of the National Park System.

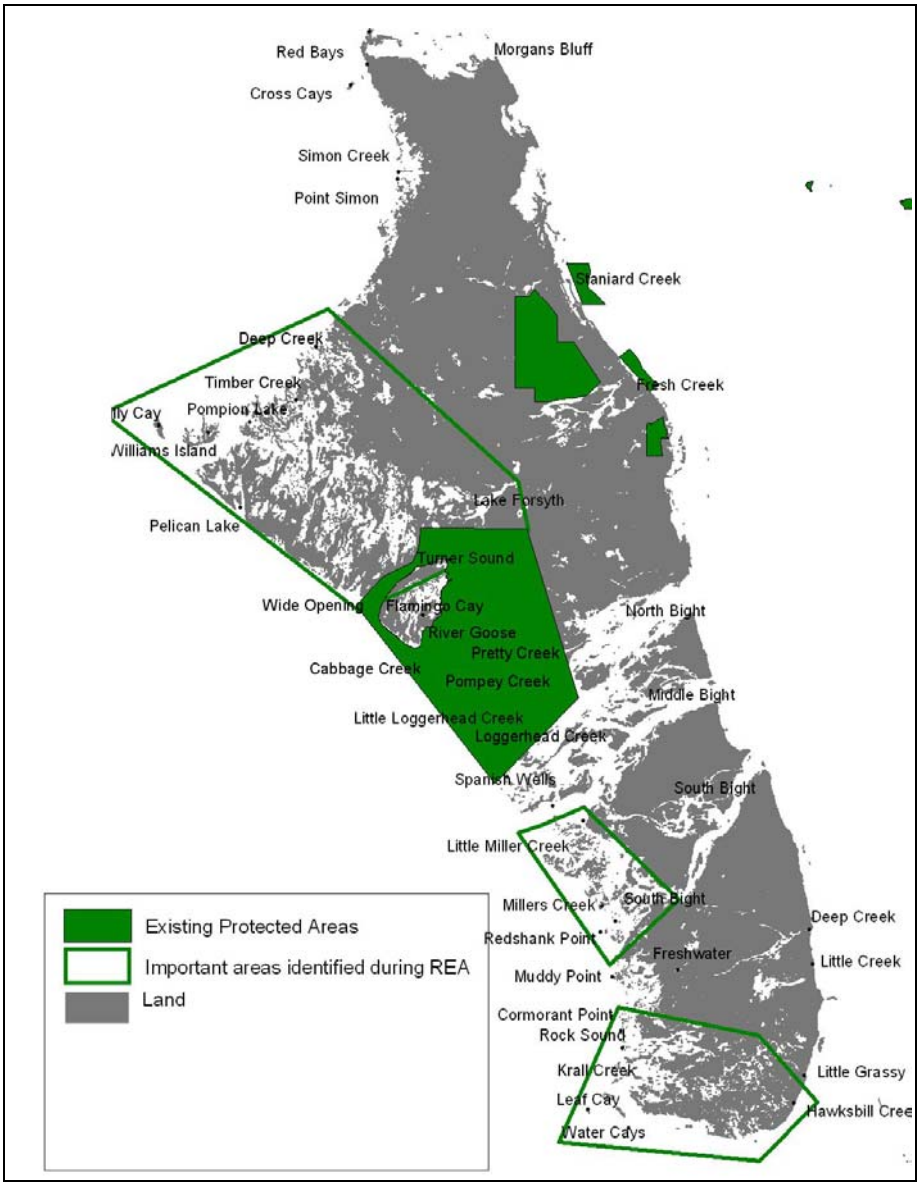

Figure 4: Map of Andros Island showing existing protected areas and areas identified during the REA as important for conserving its biodiversity for future generations..

The next steps for this project is to translate the scientific information into publicly digestible format so it can be used to create a common vision for resource use on the west side. A stakeholder engagement process will also take place over the next year to share results of the REA and better characterize historic and current resource use of the area. Opportunities for public input will also occur through evening workshops and outreach sessions. Potential conflicts with current and future Park boundaries will be identified and zoning schemes will be evaluated. All of this information along with the REA scientific recommendations will be put into a proposal for an expanded Park for the West Side of Andros Island.

RAPID ECOLOGICAL ASSESSMENT
WEST COAST OF ANDROS, THE BAHAMAS

REPORT

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1. Biophysical Characterization of the West Side

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INTRODUCTION:
Located on the leeward side of the eastern margin of the Great Bahama Bank, west Andros is a low energy settings with abundant low-lying carbonate islands, tidal flats ,tidal creeks, brackish lagoons, and seagrass beds along with sponge-dominated hard-bottoms. The large array of organisms which make up the biodiversity of the west side depend on this complex distribution of habitats along with the key hydrological processes to sustain them. Characterizing the major gradients in habitat distribution, geological nature of the sediments, and hydrological characteristics such as salinity provides an underlying framework for understanding the ecology of this vast ecosystem. The objectives of this biophysical characterization of the west side were as follows:

• Characterize the benthic cover (e.g., seagrass, macroalgae, sponges, etc..) and sediment composition (e.g., gravel, sand, mud) along the west side of Andros.

• Collect groundtruth points for validating benthic habitat and bathymetry maps for the west side of Andros.

• Determine basic water quality (e.g., salinity, temperature, turbidity, dissolved oxygen) for the major water bodies along the west side of Andros.

• Characterize tidal movement patterns and monthly and seasonal variability.

• Identify patterns and possible factors influencing water quality, geology, and benthic cover along the west side.

BACKGROUND:
The west side of Andros extends from Red Bays to the north down to the Water Cays in the south and spans a distance of some 200 km. The area has little scientific investigation since it was first described in the early 1950's (Cloud, 1961). Most of the studies have been geological in nature and focused on understanding the geologic origin of the tidal flats (Shinn et al., 1969; Ginsburg, 1971; Gebelein, 1974; Hardie & Shinn, 1986). These geological studies have shown that most of the sediments on the west side are composed of small soft 'pellets' of mud that originate from the breakdown of calcareous macroalgae located on the adjacent Bahama Bank. The mud accumulates in backwater settings and has caused portions of the western shoreline of Andros to extend westward up to 10 km over the past several thousands of years. The fairly strong tidal forces produce a migrating complex subenvironments around the tidal creeks which are distributed all along the west side.

The climate on Andros is dominated by Atlantic Southeast winds in the summer and cool dry North American high-pressure systems in winter. Rainfall for Andros Island ranges from 100 cm (40 inches) in the dryer southern part of the island to over 130 cm (50 inches) in wetter northwestern portions of the island (highest in the Bahamas). Most rainfall occurs during the warmer summer months (May to October) and during is limited between November to April to the passage of North American winter frontal systems. Hurricanes play a major role on the annual rainfall totals and have greatly influenced the west side of Andros. Between 1886 and 2004, several hurricanes have passed over

Andros including the 1929 hurricane which took many lives in the community of Red Bays, Hurricane Andrew in 1992; and most recently, hurricane Marylyne in 2001.

Freshwater resources on the west side are abundant due to fairly high rainfall and the presence of the year-round Andros freshwater aquifer which abuts much of western Andros. The freshwater aquifers on Andros (and most Bahamian carbonate Islands) are the Ghyben-Hertzberg type lenses who's thickness is primarily dependent on the width and elevation of the islands (Cant, 1986). The Andros freshwater lens is reported to reach a maximum thickness of 30 m near the widest portions of the island. Freshwater lakes and seasonal brackish ponds occur along much of the interior of western Andros. Outflows of freshwater have been reported by local guides but have never been quantitatively mapped. Seasonal variation in salinity, temperature, and dissolved oxygen on the west side can also influence the distribution of many species and their foraging base.

West Andros has received minimal ecological investigations and systematic mapping to our knowledge. Most of what is known about the area comes from the communities of Red Bays and Mangrove Cay where commercial sponging and fishing activities along the west side have been historically based. Duck hunting and pig hunting also draw people to this area during particular seasons. More recently, high end catch and release fly fishing has become the principal use for much of the area. There is only one lodge currently based on the west side (Flamingo Cay), but flats boat regularly access the area from Bearing Point, Mangrove Cay, and Red Bays.

METHODS

Sampling design: For the biophysical characterization component of the REA, the west side was divided into four latitudinal areas based on presence of bights, shoreline aspect, and geology . In addition, three cross shelf "zones" were delineated (A-C in figure 1) based on buffering the shoreline by a distance of 5 km (Zone A), a zone of predominantly marine connected inland water bodies (Zone B), and a zone of predominantly disconnected inland freshwater bodies (Zone C). This yields 12 unique zones or strata that represent a first cut subdividing of the study area. Because of time limitations and difficulty of access by boat, it was decided to focus the June surveys on zones A and B only, leaving zone C for future follow-up assessment via overland access from the east side.

Random site locations for benthic and water quality sampling were generated within the sampling domain using the generalized random tessellation sampling (GRTS) method (Olson et al., 1997). Hexagons were generated with a 2 km size (~6 km^2 area) and a primary and two secondary sites (each approximately ~100 m^2 in size) were randomly generated using Arcview GIS extension tools. The total number of primary sites for the zones A and B were 155 and 130 sites respectively. The geographic locations of all the randomized sites were pre-loaded onto GPS units. Alternate sites were sampled in cases where primary sites where either not accessible or where water depths were greater than 5 m. Approximately 30 strategic (non-randomized) sites were also included in the survey based on input from local guides to capture variation that might be missed with randomized sampling.

Geology: A total of 256 sites were visited during the 10 days of field work on the west side. For each survey site, a surface sediment grab sample was also collected at each site to allow basic sediment composition analysis and stable isotopic composition ($\delta^{18}O$ and $\delta^{13}C$) of carbonate. Holocene sediment thickness measured by probing down to the underlying Pleistocene bedrock was also recorded at each site. Depth of the bedrock was also determined relative to MSL after correcting for daily tidal fluctuations.

Water quality: Standard water quality parameters were collected from 256 sites using a YSI conductivity/DO/Temp sensor from each site at two depths (0.5 m below the surface; and 0.5 m above the bottom (where depths were greater than 1 m). Sechi disk visibility was used to record water visibility at each site. GPS position, time of day and water depth were also be recorded. The measured water depth will later be reconciled to mean water level (MWL) using two stationary water pressure gauges that were deployed on the west side at an interior site (Turner Sound) and bank site (outer wide opening).

Benthic habitats: Benthic habitats were characterized at 200 point locations in water depths ranging from 0.1 m to 9 m. The percent cover of benthic organisms was quantified using 0.25 m^2 quadrats that were haphazardly placed on the bottom. Seagrass, macroalgae, and sessile invertebrates recorded using the Braun Blanquet relative abundance scoring scale (Fourquen et al., 2003). All identifications were made by the same 2 observers either to the species level or genus level. Underwater oblique digital photographs were also taken at selected sites for archival purposes.

All data was entered into excel spreadsheets and benthic community composition was tabulated into relative abundance for each benthic taxa (seagrasses, green, brown and red macroalgae, corals, and other sessile invertebrates). Maps were generated in Arcview by spatially interpolating the point data into grids showing the relative abundance distribution of the data (salinity, sediment depth, limestone bedrock depth).

RESULTS:

Geology:

Surface sediments sampled on the west side were predominately fine-grained peloidal mud. Analytical results of the isotopic analysis (^{13}C & ^{18}O) of the surface sediments were not complete as of the writing of this report. The maximum sediment thickness recorded during our survey occurred within in-filled blue holes (>9 m probe depth) and along the levees boardering tidal creeks of River Goose and Cut Off Creek (up to 4 meters above MSL). Outside of these occurrences, mud reached a maximum thickness between 4 and 5 meters immediately westward of the present day shoreline between South Bight and Pompion Cay (Figure 2). Mud thickness decreased significantly north and south of these points concomitant with a coarsening of sediment grain size, particularly north of Billy and Williams Islands and South of Cormorant Point on south Andros. Pleistocene bedrock depth varied between exposed (above MSL) to 7.8 m below MSL (excluding blue holes). A bedrock high extends in a east to west orientation from the Fresh Creek area of central Andros westward to the northern tips of Williams and Billy Island. The bedrock dips steeply to the southwest down to a depth of 8 m but much more gradually to the northwest (Figure 2). Another bedrock high occurs south of Comerant point on south Andros and extends all the way around the southern tip of Andros. Between these high, the bedrock slopes between 0.25 and 0.5 m/km away from the present shoreline of Andros down to a depth of 7-9 meters after which it flattens out.

Water quality:
Surface salinities (measured at 0.5 m) ranged from 6 to 42 psu during the 9 days of field sampling is shown in figure 2. The lowest salinities were encountered in the inland lakes and ponds near the Lake Forsythe area and far up tidal creeks on south Andros. These areas are thought to be primarily fed by groundwater discharge from freshwater aquifer that occurs along the 'backbone' of Andros island. A schematic map showing the primary outflow patterns of freshwater on Andros is shown in figure 2 The highest salinities occurred near the Williams Island/Billy Island area which is consistent with results reported by Cloud (1962) and other identifying this area as having waters with the longest residence time on the Great Bahamas Bank. Significant stratification between surface and bottom waters were noted in places where tidal flow was substantial- at the mouths of tidal creeks, around the bights. Surface temperatures were diurnally highly variable and ranged from 26 to 37°C with the highest temperatures documented in the shallow interior ponds with limited tidal circulation. Dissolved oxygen ranged from 2.6 to 9 mg/l with a mean of 5.6 mg/l. A cross plot of dissolved oxygen and temperature for surface waters shows that warm shallow interior brackish ponds often had higher oxygen concentration thought to be associated with oxygen generating cyanobacterial algal mats (Figure 3). We probed several of the blue holes encountered during the survey and found that interior blue holes (around Lake Forsythe) only had freshwater in the uppermost 5 meters below which dissolved oxygen decreased and salinity increased. Another blue hole probed near Pompion Cay displayed a hot briny layer with low dissolved oxygen about 5 meters down that is thought to be associated with density driven reflux during periods of minimal tidal exchange. Tides on the west side during the survey period were semidiurnal and averaged 0.6 m near the mouth of Wide Opening and between 0.05 and 0.2 m in the interior portions of Turner Sound and embayments north of Cut Off Creek. Wind was a more significant factor in changing water levels up to 0.5 m in the interior ponds than tides. Tidal variation on the west side was smaller than on the east side of Andros probably because the influenced of the Atlantic is dampened by the Great Bahama Bank.

Benthic habitats:
Photographs of some of the more common benthic assemblages encountered are shown in figure 4 (A-J). Maps showing the cover of seagrass, calcareous green macroalgae, red macroalgae, and brown macroalgae are showing in figure 5 (A-D) The most common biotic benthic cover found over mud substrate was sparse (<10% cover) seagrass (Shoal grass- *Haladule*) and green macro algae (most commonly *Botophora*) along with scattered calacareous green macro algae (e.g., *Halameda, Penicillus, Udotea*). In the interior bays and brackish water estuaries, the cover became even sparser (often less than 1% with primarily *Botphora* and *Haladule*) and a reddish cyanobacterial layer was often present on the surface of the mud Dense (>75% cover) seagrass beds (primarily Turtle grass-*Thallassia*) occurred in places of high tidal current flow- within tidal creeks, at the mouths of tidal creeks, and within offshore channels between Billy Island and Williams Island and those around the Water Cays in the South. Manatee grass (*Syringonium*) was rarely observed but did occur in localized dense halos around submerged sunken debris. Medium seagrass density occurred in some areas often associated with an increase in

burrowing shrimp mounds and the presence of the green macroalgae, *Caldocephalus scoparius*.

Hardbottom communities were primarily associated with exposed Pleistocene bedrock and were mapped to the areas north of Billy and Williams Island and around much of the southern portions of southwestern tip of Andros. Hardbottom communities were also mapped within many of the larger tidal channels where strong currents scoured away up to 3 meters of sediments. The inner bays and freshwater lakes such as Lake Forsythe often had freshwater grasses growing in abundance on the rocky bottom *(*Widgeon grass- *Ruppia maritime)*   Hardbottom benthic assemblages ranged from fairly barren low diversity areas (*botophora* dominated) found in interior ponds and brackish lagoons to high diversity sponge sponges (*Spheciospongia spp*) and sea rods (*Pseudoplexaura spp.*) areas which occurred offshore in locations of high tidal flow. Stony corals (*Siderastraea radians*, *porites astreoides*) were present in high tidal flow areas and major reef growth was observed on several submerged plane wrecks where tidal flow was high. Hardbottom areas also supported several types of macroalgae (e.g., *Laurencia* spp; *Calerpa* spp; *Dictyota spp*; *Cladophora spp*).

DISCUSSION

Hydrological connectivity:

The freshwater flowing from interior land areas out to the west side of Andros is a critical process that maintains the ecosystem function of many habitats which wading and migratory birds numerous aquatic species depend. Numerous small freshwater outflows occur on the west side including several small creeks which feed into North Bight and South Bight and north of Timber Creek. While seasonally important, these are smaller outflows are not thought to be connected year round to the Andros aquifer and mostly flow during the rainy season. We mapped two major freshwater outflows that are probably vital to the west Andros ecosystem because they are thought to provide nearly year-round freshwater inputs. One originates in Lake Forsythe and extends through Milk River into Turner Sound and then out through Wide Opening and River Goose. Wide Opening and Turner sound are two of the largest brackish estuaries documented during our survey. This freshwater river/estuary system represents the largest of its kind in the Bahamas and should be termed the "everglades of the Bahamas". The other occurred in south Andros around the Krall creek area and but was not as well mapped during our survey due to limited survey time in the south. The endangered saw fishes encountered during the survey and the bull shark nurseries are just two examples of species that require these freshwater inputs. In addition, the tarpon fishery is highly depending on these flows. Maintaining the freshwater hydrological connections of these two major areas should be a major objectives of conservation efforts on the west side and any expanded park system should include the upland sources of freshwater into the management plan.

Benthic habitat types and distribution.

Factors which influence the distribution and growth of seagrasses and macroalgae on the west side include light levels, nutrient concentration and salinity, sedimentation, water depth, and substrate composition. Light levels penetrating to the bottom are directly influenced by the turbidity of surface waters. Sechi disk visibility measured during the survey generally exceeded the depth of water at nearly all locations and therefore we postulate that there is probably sufficient light for seagrass growth across most of the area for most of the year. Salinity can also influence seagrass distribution within esturaries (Fourquen et. al., 2004). *Halodule* and *Halophylia* can thrive in low or highly variable salinity, whereas *Thallassia* is favored under more stable, marine salinities (~35 psu). *Thallassia* was absent from most of the brackish embayments and interior ponds on the west side. Nutrients were not sampled during our assessment but all indications are that west Andros is a nutrient poor (oligotrophic) system. The sparse seagrass cover over most of the area and the drawf sizes of mangroves attests to the harsh growing conditions. The only locations where growth and coverage was high occurred at the mouth of tidal creeks where flow was very high or around plane wrecks or submerged structures where reef fish locally enriched the waters with their waste. Substrate sediment type is another important factor that explains much of the spatial variability observed during our survey. Sediment composition on the west side of Andros is tightly related to tidal flows and bedrock depth. Areas with strong tidal movement have coarser substrates (fine sand to coarse sand) and patches of exposed hardbottom. None the less, tidal forcing is still comparatively quite large and well pronounced around the mouths of tidal creeks and within channels between offshore islands. These are the locations where *Thallassia* densities were highest and corresponded with major sea turtle foraging areas (juvenile Green and Loggerhead primarily).

Sea level rise and hurricanes

The deposition of lime mud on western Andros is a key process which shapes the myriad of tidal flats, creeks, and lagoons that dot the landscape. This process has been underway for many thousands of years (~3-4,000 ybp) when rising seas first flooded the area. During this time, rates of sedimentation have generally exceeded rates sea level rise allowing shorelines to move seaward. Evidence for this movement is most pronounced between Pompion Cay south to Loggerhead creek. Here the shoreline appears to have migrated to the southwest by at least several 10's of kilometers leaving behind relict shoreline evident in satellite imagery. Many of the openings along this section of the coast (e.g., Hawk Creek and Wide Opening) are being filled-in with sediments by the daily tidal cycles. Exposed bedrock highs around Pompion, Loggerhead, and Krall Creeks provide anchor points for the present day shoreline in these locations. Hurricanes and large tropical storms are the principal mechanisms by which sediment is transported far inland (Rankey et al., 2004). Few large hurricanes that have passed over the west side in recent history which has limited substantial sediment movement. In fact, some interior ponds appear to be sediment starved and are possibly expanding as the shorelines are re-worked by wind and waves. Rates of sea level rise have already begun to increase compared to the past several thousands of years and are being enhanced by global warming. The influence of increased rates of sealevel rise on western Andros are potentially quite high and shoreline contraction or expansion will depend on the interplay between sediment production and deposition. Sediment starved portions of the west Andros (south Andros and areas north of Timber Creek) will migrate inland and water depth and wetlands will expand in interior lakes. Major depositional areas such as around Wide Opening will probably continue to build seaward.

CONCLUSIONS

- Highest diversity of seagrasses, macroalgae and other sessile invertebrates were associated with hardbottom areas (Billy Island area and creeks north; Water Cays areas, and several creek bottoms

- The dominant benthic habitat for offshore areas of the west side is sparsely colonized mud. No major north to south gradients occur in benthic habitats which are mostly determined by substrate type ,depth of bedrock, and proximity to tidal currents.

- The largest freshwater/esturaine system in the Bahamas occurs in the Lake Forsyth /Turner Sound/Wide Opening Area.

- These freshwater inputs supports several unique species/breeding grounds in this area

- Numerous other smaller estuarine systems exists- Pretty Creek, Cut-off Creek, Timber Creek, Selected creeks of south Andros.

- West side is a dynamic area susceptible to change due to hurricanes, sea level rise- change needs to be factored in- protecting larger areas will spread risk.

RECOMMENDATIONS

- Expanded parks should include representative examples of all benthic habitats (sparse, dense seagrass, bare mud, hardbottom)

- Expanded parks on the west side need to include more hydraulically connected inland lakes in order to maintain key species and productivity associated with these estuaries.

- Maintaining critical processes such as freshwater flow and tidal movements are essential for ensuring that the west Andros ecosystem will continue to function as one of the most important nursery systems in the Bahamas.

- Continued research into the biophysical characterization of west Andros is needed. More detailed mapping in the southwest and transitional brackish areas are recommended. A monitoring station should be established for tides and documenting long-term sealevel rise.

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TABLE 1- Water quality and selected benthic abundance field data.

Wpt_site	Date	X-coord (UTM)	Y-coord (UTM)	Corr. Wat. Depth (m)	Sed. Thicknes s (m)	Bedrock depth below MSL (m)	DO (0.5 m	Temp (0.5 m)	Salinity (0.5 m)	Source	Seagrass	Calc. Green macro	Green macro	Red macro	Brown macro
1	06.06.19	159345.1	2732396	0.56	1.3	1.86	6.4	31.5	20.8	Kramer	0.00	0.00	0.80	0.00	0.00
3	06.06.19	172131.9	2725977	0.36	1.86	2.22	4.3	28.6	21	Kramer	0.10	0.00	0.00	0.00	0.00
7	06.06.19	186669.6	2713768	0.46	1.35	1.81	5.65	29.9	19.6	Kramer	0.10	0.00	0.00	0.00	0.00
8	06.06.19	187145.9	2715559	0.43	1.86	2.29	5.7	30.8	24.9	Kramer	0.08	0.00	0.00	0.00	0.00
9	06.06.19	189484.9	2705906	0.61	1.52	2.13	7.1	30.7	8.6	Kramer	0.00	0.00	0.80	0.00	0.00
10	06.06.19	172526.3	2704619	0.46	1.52	1.98	4.7	31.6	19.7	Kramer	0.65	0.00	0.00	0.00	0.00
11	06.06.19	153097.7	2715137	0.55	2.84	3.39	5.9	31	37.8	Kramer	1.50	0.10	0.10	0.10	0.00
12	06.06.19	142727	2732545	1.4	2.29	3.69	6.05	30.5	38.5	Kramer	0.67	0.10	0.00	0.17	0.00
13	06.06.19	177087.7	2708253	1.48	1.6	3.08	6.15	30.5	38.3	Kramer	0.50	0.30	0.00	0.10	0.00
14	06.06.19	179342.9	2708402	1.17	2.23	3.4	5.8	30.8	38.6	Kramer	0.60	0.10	0.00	0.50	0.00
15	06.06.19	215295.3	2644977	0.89	2.21	3.1	5.9	31.1	38.7	Kramer	0.80	0.12	0.00	0.02	0.00
16	06.06.19	214018.7	2644585	0.97	2.41	3.38	6	30.9	39	Kramer	1.50	0.10	0.00	0.10	0.00
17	06.06.19	208136.1	2702097	0.47	3.45	3.92	6.14	31.3	36.9	Kramer	1.00	0.00	0.10	0.10	0.00
19	06.06.20	205407.9	2696973	1.18	1.4	2.58	4.2	28.8	33.6	Kramer	1.10	0.10	0.10	0.00	0.00
20	06.06.20	206135.6	2694042	1.16	1.65	2.81	3.94	28.6	28.5	Kramer	0.70	0.10	0.00	0.00	0.00
21	06.06.20	198054.5	2696092	2.16	0.02	2.18	4.52	29.2	30.6	Kramer	0.10	0.10	0.10	0.50	0.00
22	06.06.20	182824.2	2697068	0.89	0.02	0.91	3.76	28.8	32.7	Kramer	0.50	0.10	2.50	0.10	0.00
23	06.06.20	179342.9	2708399	1.99	0.2	2.19	5.07	29.3	34	Kramer	2.75	0.20	0.20	0.00	0.00
24	06.06.20	215283.2	2630400	1.78	0.02	1.8	4.81	29.3	34.9	Kramer	0.00	0.20	2.50	0.30	0.00
25	06.06.20	180145	2713368	2.6	0.51	3.11	5.74	29.3	36.7	Kramer	0.83	0.83	0.00	0.17	0.00
26	06.06.20	159435.3	2734963	2.57	0.48	3.05	5.65	29.5	35.3	Kramer	1.00	0.40	0.00	0.00	0.00
27	06.06.20	166884.5	2745466	1.68	0.18	1.86	5.2	29.8	35.2	Kramer	1.40	1.20	0.00	0.20	0.00
28	06.06.20	158014	2741078	1.75	1.62	3.37	5.28	29.6	35.1	Kramer	0.40	0.20	0.00	0.00	0.00
29	06.06.20	164677.1	2740659	1.86	0.56	2.42	5.6	29.5	35.4	Kramer	1.70	0.80	0.00	0.20	0.00
30	06.06.20	207310.4	2702098	1.97	0.69	2.66	5.35	29.5	35.8	Kramer	1.70	0.80	0.00	0.20	0.00
31	06.06.20	146987.3	2733118	1.79	0.13	1.92	5.47	29.9	36.3	Kramer	0.00	0.00	4.00	0.20	0.00
32	06.06.20	168200.4	2747275	1.5	7.62	9.12	5.14	30.4	35.8	Kramer	0.25	0.00	0.00	0.00	0.00
33	06.06.20	201408.1	2693055	0.83	0.02	0.85	4.55	31.2	36.1	Kramer	0.00	0.00	5.00	1.00	0.00
34	06.06.20	198950.4	2694048	1.41	0.15	1.56	5.3	30.8	35.4	Kramer	1.00	0.40	0.00	0.00	0.00
35	06.06.20	164791.2	2744875	1.57	0.01	1.58	5.44	30.7	37	Kramer	0.00	0.00	1.00	2.00	0.00
36	06.06.20	213298.3	2637487	1.69	0.02	1.71	5.37	30.3	37.3	Kramer	0.00	0.00	1.20	0.00	0.00
37	06.06.20	210013.9	2643446	1.34	0.04	1.38	5.3	31	38	Kramer	0.60	0.60	0.20	0.00	0.00
38	06.06.20	205413.1	2696979	1.72	0.79	2.51	5.65	30.4	37.7	Kramer	1.40	0.60	0.00	0.20	0.00
39	06.06.20	169965.2	2751638	2.07	0.02	2.09	5.35	30.4	37.1	Kramer	0.20	0.40	0.00	0.20	0.00
40	06.06.20	153820.9	2732922	2.17	1.35	3.52	5.24	30.5	39.2	Kramer	1.00	0.40	0.00	0.00	0.00
41	06.06.20	146924.4	2728318	1.79	0	1.79	5.59	30.7	37.8	Kramer	0.00	0.00	0.00	0.00	0.00
42	06.06.20	216236	2629823	1.14	0.18	1.32	5.67	30.8	35.6	Kramer	0.60	0.20	0.20	2.00	0.00
43	06.06.21	161949.4	2735348	1.23	3.81	5.04	5.2	29.1	39.3	Kramer	1.50	0.40	0.00	0.00	0.00
44	06.06.21	214223	2632248	1.09	3.99	5.08	5.29	29.1	40.1	Kramer	1.20	1.00	0.00	0.20	0.00
45	06.06.21	213296.3	2642601	1.11	4.72	5.83	5.52	29.2	40.1	Kramer	1.20	1.00	0.20	0.20	0.00
47	06.06.21	198049.5	2696092	1.32	4.29	5.61	5.31	29.4	40.3	Kramer	0.60	0.00	3.00	2.00	0.00
48	06.06.21	198054.5	2696092	1.93	3.86	5.79	5.09	29.8	42.1	Kramer	1.60	1.40	0.00	0.20	0.00
49	06.06.21	141358	2729456	1.08	4.22	5.3	5.4	29.1	38	Kramer	0.20	1.00	0.20	0.00	0.00
50	06.06.21	191984.8	2710880	1.4	2.87	4.27	5.91	30.2	34	Kramer	1.40	0.80	0.00	0.20	0.00
51	06.06.21	205245.4	2702464	0.81	4.37	5.18	5.71	30	32.6	Kramer	2.10	0.00	0.60	0.20	0.00
52	06.06.21	206133.8	2694040	1.4	4.08	5.48	5.6	30.2	35.8	Kramer	1.20	0.30	0.00	0.10	0.00
54	06.06.21	169311.1	2753339	2.22	3.4	5.62	5.8	30.3	38.7	Kramer	0.70	0.30	0.30	0.10	0.00
55	06.06.21	167671.1	2752122	2.03	3.18	5.21	5.55	30.4	38.9	Kramer	1.00	0.60	0.40	0.20	0.00
57	06.06.21	191760.4	2710136	0.59	3.39	3.98	5.85	31.1	37	Kramer	0.00	0.50	4.20	0.00	0.00
58	06.06.21	168587.7	2748436	0.8	3.51	4.31	6.77	31.9	38.4	Kramer	0.00	0.10	4.50	0.50	0.00
59	06.06.21	144546.1	2732328	2.39	3.48	5.87	6.18	30.6	38.8	Kramer	1.00	0.20	0.00	0.20	0.00
60	06.06.21	210087.3	2647766	1.65	2.77	4.42	5.91	31	37.4	Kramer	1.50	0.30	0.00	0.10	0.00
61	06.06.21	151573.3	2732290	1.55	2.77	4.32	5.8	31	34.8	Kramer	2.00	0.30	0.00	0.00	0.00
62	06.06.21	210725.4	2654565	1.49	2.36	3.85	5	31.5	35.3	Kramer	1.00	0.50	0.20	0.10	0.00
63	06.06.21	209753.7	2649916	1.11	2.31	3.42	5.39	31.9	36.5	Kramer	2.40	1.00	0.40	0.00	0.00
64	06.06.21	167470	2748611	1.57	2.16	3.73	5.11	31.3	37.7	Kramer	1.20	0.20	0.40	0.00	0.00
66	06.06.21	208346.2	2700071	1.6	2.69	4.29	5.95	31.4	38.7	Kramer	0.60	0.30	0.20	0.20	0.00
67	06.06.21	144251.6	2733427	0.6	0	0.6	5.85	31.7	38	Kramer	0.00	0.00	1.00	0.00	0.50
68	06.06.21	213559	2647009	0.46	2.92	3.38	6.73	33.9	39	Kramer	0.00	0.00	0.00	0.00	0.00
70	06.06.21	191253	2703219	2.09	4.11	6.2	6	31.3	39.5	Kramer	2.50	0.10	0.00	0.00	0.00
71	06.06.22	211800.7	2634576	1.33	3.48	4.81	4.81	29.5	38	Kramer	0.35	0.80	1.10	0.10	0.00
72	06.06.22	206293.5	2702418	1.63	3.18	4.81	5.46	29.3	38	Kramer	4.00	0.10	0.00	0.00	0.00
73	06.06.22	209746.7	2703154	2.91	3.35	6.26	5.6	29.5	38	Kramer	0.30	0.20	0.30	0.10	0.00
74	06.06.22	162112.6	2741136	3.03	3.71	6.74	5.5	29.5	38	Kramer	0.40	0.20	0.30	0.00	0.00
75	06.06.22	212677.2	2650053	3.26	4.27	7.53	5.5	29.5	38	Kramer	0.40	0.00	0.00	0.00	0.00
76	06.06.22	187974.9	2714748	3.63	3.66	7.29	5.33	29.7	38	Kramer	0.40	0.30	0.20	0.00	0.00
77	06.06.22	198054.5	2696092	3.09	3.66	6.75	5.49	30	38	Kramer	0.60	1.00	0.60	0.10	0.00
78	06.06.22	188454.2	2710910	1.66	2.74	4.4	5.39	29.6	38	Kramer	4.00	0.00	0.00	0.00	0.00
79	06.06.22	190595.2	2710142	0.68	1.98	2.66	5.62	29.9	38	Kramer	0.00	0.00	3.50	0.00	0.00
80	06.06.22	208151.2	2655953	2.11	2.13	4.24	4.9	30.3	38	Kramer	0.20	0.00	0.30	0.00	0.00

Wpt_site	Date	X-coord (UTM)	Y-coord (UTM)	Corr. Wat. Depth (m)	Sed. Thicknes s (m)	Bedrock depth below MSL (m)	DO (0.5 m	Temp (0.5 m)	Salinity (0.5 m)	Source	Seagrass	Calc. Green macro	Green macro	Red macro	Brown macro
82	06.06.22	183254.1	2711243	3.25	3.66	6.91	5.79	30.1	38	Kramer	0.20	0.10	0.20	0.10	0.00
83	06.06.22	208316.2	2634681	2.45	2.74	5.19	5.78	29.9	38	Kramer	0.20	0.30	0.20	0.00	0.00
84	06.06.22	209662.9	2652229	3.18	3.66	6.84	5.59	29.7	38	Kramer	0.30	0.30	0.40	0.00	0.00
85	06.06.22	187342.3	2689331	1	2.13	3.13	5.88	30.3	38	Kramer	0.30	0.20	3.30	0.60	0.00
86	06.06.22	180954.8	2707939	0.66	2.29	2.95	5.04	30.1	38	Kramer	0.50	0.30	1.10	0.20	0.00
87	06.06.22	205130.1	2659187	2.54	2.59	5.13	5.67	30.1	38	Kramer	4.00	0.50	0.00	0.00	0.00
89	06.06.22	152946.4	2731235	2.16	3.96	6.12	5.4	29.8	38	Kramer	0.50	0.10	0.20	0.00	0.00
90	06.06.22	143287.4	2731541	2.33	5.49	7.82	5.49	30.5	38	Kramer	0.30	0.10	0.20	0.10	0.00
91	06.06.22	215954.7	2636106	1.22	3.66	4.88	4.73	30.3	38	Kramer	0.20	0.20	0.20	0.00	0.00
92	06.06.22	207138.3	2652901	1.18	2.74	3.92	5.83	30.3	38	Kramer	0.30	0.20	0.20	0.10	0.00
93	06.06.22	147772.2	2731628	0.74	3.05	3.79	5.33	30.3	38	Kramer	1.00	0.10	1.00	0.10	0.00
94	06.06.22	145795.4	2723265	-0.25	3.35	3.1	6	30.2	38	Kramer	0.00	0.00	0.00	0.00	0.00
95	06.06.22	145206	2726739	0.45	2.9	3.35	4.51	31.5	38	Kramer	0.20	0.10	0.00	0.00	0.00
98	06.06.24	208847.5	2656805	0.66	2.23	2.89	5.67	28.8	18.5	Kramer	0.00	0.10	0.10	0.00	0.00
99	06.06.24	207913.1	2657596	0.46	2.51	2.97	6.14	28.5	16.9	Kramer	0.20	0.10	0.10	0.00	0.00
100	06.06.24	179212	2717947	0.5	2.36	2.86	4.84	28.6	16.3	Kramer	0.60	0.00	0.60	0.00	0.00
101	06.06.24	188398.3	2713794	1.31	2.95	4.26	5.6	28.7	15.9	Kramer	1.50	0.00	0.60	0.00	0.00
102	06.06.24	178946	2719626	2.33	0.91	3.24	5.1	28.6	16	Kramer	3.50	0.00	0.50	0.00	0.00
103	06.06.24	187890	2715792	3.03	0	3.03	6.06	28.9	15.5	Kramer	0.00	0.00	0.50	0.00	0.00
104	06.06.24	179598.8	2715806	0.81	1.27	2.08	6.06	28.8	15.3	Kramer	0.00	0.00	0.00	0.00	0.00
105	06.06.24	155772.6	2740290	0.89	1.8	2.69	6.24	29.5	13.4	Kramer	0.00	0.00	0.00	0.00	0.00
106	06.06.24	179762	2715679	0.63	0.84	1.47	5.15	31.8	12.2	Kramer	0.00	0.00	4.50	0.00	0.00
107	06.06.24	158740.7	2732817	0.84	1.4	2.24	5.25	31.5	12.3	Kramer	0.00	0.00	0.00	0.00	0.00
108	06.06.24	188581.6	2716100	0.91	1.32	2.23	5.91	30.5	11.8	Kramer	0.00	0.00	1.00	0.00	0.00
109	06.06.24	217193.2	2646643	0.86	1.62	2.48	4.63	30.2	11.2	Kramer	0.00	0.00	1.00	0.00	0.00
110	06.06.24	177623.1	2719727	0.99	0	0.99	4.63	30.2	11.2	Kramer	0.00	0.00	1.00	0.00	0.00
111	06.06.24	179758.3	2715684	0.43	0.89	1.32	6.31	30	16.5	Kramer	0.00	0.00	1.00	0.00	0.00
112	06.06.24	190300	2705584	1.04	0.89	1.93	7.29	33.2	18	Kramer	0.00	0.00	0.50	0.00	0.00
113	06.06.24	178687.4	2695484	0.48	0	0.48	5.7	32.3	12	Kramer	0.50	0.50	0.20	0.00	0.00
114	06.06.24	170454.6	2749814	0.53	0.51	1.04	6.18	32.5	6.6	Kramer	0.00	0.00	0.00	0.00	0.00
116	06.06.24	187096.2	2713714	0.25	0.36	0.61	7.38	37.5	9.4	Kramer	0.00	0.00	0.10	0.00	0.00
117	06.06.24	178938.6	2718106	2.01	1.96	3.97	6.07	33.1	17.8	Kramer	0.08	0.00	0.08	0.00	0.00
118	06.06.24	161283	2731228	0.51	0	0.51	6.84	33.6	22	Kramer	0.00	0.00	0.10	0.00	0.00
119	06.06.24	187777.4	2699260	0.97	1.52	2.49	6.75	34.2	21.9	Kramer	0.00	0.00	0.10	0.00	0.00
120	06.06.24	143536.7	2733221	0.63	0.76	1.39	7.25	32.5	23.9	Kramer	0.00	0.00	2.00	0.00	0.00
121	06.06.24	144365	2731280	1.32	1.73	3.05	6.5	34.5	26.4	Kramer	0.00	0.00	0.00	1.00	0.00
122	06.06.24	189179	2703243	1.98	0	1.98	6.16	34.7	27	Kramer	0.00	1.50	0.10	1.00	0.00
123	06.06.24	198054.5	2696092	1.29	1.65	2.94	5.4	31.8	32.2	Kramer	2.50	1.00	0.00	0.00	0.00
124	06.06.24	189108.2	2714693	0.65	2.13	2.78	6.29	31.6	36.2	Kramer	0.58	0.00	0.10	0.00	0.00
126	06.06.25	213435.5	2655794	0.67	2.29	2.96	5.56	29.5	25	Kramer	0.50	0.10	1.00	0.00	0.00
127	06.06.25	179234.2	2713034	1.3	2.19	3.49	5.2	29.4	39.1	Kramer	1.20	2.00	0.00	2.20	0.30
129	06.06.25	172989	2716025	1.29	0	1.29	5.2	29.4	42.1	Kramer	0.30	0.01	0.70	0.00	0.00
131	06.06.25	179461.4	2715766	2.5	0	2.5	5.33	29.8	40.3	Kramer	0.70	0.20	0.20	0.10	0.00
132	06.06.25	187044.8	2705279	3.15	1.14	4.29	5.27	29.9	39.1	Kramer	0.20	0.10	0.50	0.10	0.00
133	06.06.25	195377.6	2680905	3.08	1.14	4.22	5.34	29.9	39.6	Kramer	1.20	0.40	0.40	0.00	0.00
134	06.06.25	150307.3	2729522	2.64	0.18	2.82	5.3	29.9	40.4	Kramer	0.00	0.33	0.50	0.17	0.00
136	06.06.25	177174.1	2703769	3.83	0	3.83	5.21	29.8	40.8	Kramer	0.00	0.00	2.00	0.20	0.20
137	06.06.25	150166.2	2729410	3.01	0.56	3.57	4.85	29.7	40.7	Kramer	0.40	1.40	0.20	0.00	0.00
138	06.06.25	178841	2711399	2.61	0.74	3.35	5.15	29.8	40.7	Kramer	1.20	0.00	0.00	0.20	0.00
139	06.06.25	193545.1	2682683	1.37	1.68	3.05	4.95	29.6	40.6	Kramer	0.80	0.20	0.60	0.20	0.00
140	06.06.25	190537.6	2685803	2.24	0	2.24	5.23	29.9	40.7	Kramer	0.00	0.00	0.20	0.20	0.00
141	06.06.25	183145.1	2697035	2.96	0	2.96	5.08	29.9	40.9	Kramer	0.00	0.17	0.83	0.33	0.00
142	06.06.25	156264.7	2732697	3.35	0.33	3.68	5.19	30	40.5	Kramer	2.00	0.40	2.40	0.00	0.20
143	06.06.25	177689.7	2699168	2.09	1.04	3.13	5.08	29.8	40.8	Kramer	2.00	0.20	0.20	0.20	0.00
144	06.06.25	181694.4	2696146	3.07	0.05	3.12	4.99	30	40.4	Kramer	1.00	0.00	0.20	1.00	0.00
145	06.06.25	180689.8	2695377	0.89	1.09	1.98	5.24	29.7	40.1	Kramer	2.00	0.00	2.00	0.00	0.00
146	06.06.25	180042.7	2709488	0.98	2.44	3.42	5.24	29.7	39.7	Kramer	2.20	0.00	0.00	0.00	0.00
148	06.06.25	176440.6	2697999	0.6	0	0.6	5.76	30.9	31.1	Kramer	0.00	0.00	0.00	0.00	0.00
149	06.06.25	190043	2687895	0.75	0	0.75	5.44	30.9	32.9	Kramer	2.00	0.00	0.00	0.00	0.20
150	06.06.25	176880.8	2706982	1.05	0	1.05	6.32	31	26.7	Kramer	0.00	0.20	2.00	0.00	0.00
151	06.06.25	215306.7	2647096	2.01	0.99	3	2.68	30	19.6	Kramer	0.00	0.00	0.00	0.00	0.00
152	06.06.26	156360	2730812	1.51	0.76	2.27	5.2	28.7	32.3	Kramer	2.60	0.60	0.20	0.00	0.00
153	06.06.26	155309.2	2729589	1.84	0.91	2.75	5.57	29.4	34.3	Kramer	1.40	0.40	1.40	0.00	0.00
154	06.06.26	182328.8	2710936	0.66	0.02	0.68	5.59	28.9	35.9	Kramer	1.00	0.60	1.40	1.00	0.20
155	06.06.26	177906.5	2706260	0.5	0.01	0.51	5.31	29.2	35.8	Kramer	0.00	0.40	6.80	3.00	0.00
156	06.06.26	149400.8	2731583	0.62	0.18	0.8	5.41	29.3	35.9	Kramer	1.40	0.20	4.00	0.00	0.00
157	06.06.26	180427.9	2697566	0.82	0.23	1.05	5.21	29.4	34.6	Kramer	1.00	0.20	1.80	0.20	0.00
158	06.06.26	146582.6	2730425	1.1	1.07	2.17	5.89	29.5	26.4	Kramer	0.60	0.20	4.00	0.20	0.00
159	06.06.26	181204.4	2709617	2.01	0	2.01	5.75	29.1	26.1	Kramer	0.80	0.20	0.20	0.00	0.00
160	06.06.26	210826.8	2658492	2.31	0.15	2.46	5.43	29.8	25.5	Kramer	1.00	0.20	3.00	1.00	0.00

Date	X-coord (UTM)	Y-coord (UTM)	Corr. Wat. Depth (m)	Sed. Thicknes s (m)	Bedrock depth below MSL (m)	DO (0.5 m	Temp (0.5 m)	Salinity (0.5 m)	Source	Seagrass	Calc. Green macro	Green macro	Red macro	Brown macro
06.06.26	156243.3	2724191	2.69	1.17	3.86	5.46	30.8	34.1	Kramer	0.70	0.00	0.30	0.00	0.00
06.06.26	149821.5	2723300	2.97	0.99	3.96	5.78	30.8	35.4	Kramer	0.70	0.10	0.20	0.10	0.00
06.06.26	200495.9	2672964	1.21	2.57	3.78	5.79	31.2	32.2	Kramer	4.50	0.00	0.00	0.50	0.00
06.06.27	199445.8	2671894	1	0	1	7.25	34.5	26.4	Kramer	0.00	0.00	3.00	0.00	0.00
06.06.27	188667	2692870	1.12	0.76	1.88	9.31	33.7	25.6	Kramer	0.10	0.00	0.00	0.00	0.00
06.06.27	150353.3	2723944	1.04	0.46	1.5	6.69	34.6	23.8	Kramer	0.00	0.00	0.20	0.00	0.00
06.06.27	149885.5	2723490	1.19	0.04	1.23	7.25	32.9	26.7	Kramer	0.00	0.00	2.00	0.00	0.00
06.06.27	180786.7	2699502	1.27	0	1.27	6.73	32.4	28.2	Kramer	0.00	0.00	1.00	0.00	0.00
06.06.27	148249.7	2725724	1.04	0	1.04	6.57	32.5	29.7	Kramer	0.00	0.00	2.00	2.00	0.00
06.06.27	202230.4	2673040	1.06	0.76	1.82	6.62	31.9	31.3	Kramer	0.50	0.00	0.00	0.00	0.00
06.06.27	149346.6	2725253	1.09	0.71	1.8	6	32.8	31.2	Kramer	0.40	0.00	0.00	0.00	0.00
06.06.27	191755	2675868	1.99	0	1.99	5.94	31.9	31.2	Kramer	0.00	0.00	2.00	0.50	0.00
06.06.27	196681.5	2678713	1.48	0	1.48	5.75	33.4	33.7	Kramer	0.20	0.00	0.00	0.00	0.00
06.06.27	185390.9	2687124	2.11	0.15	2.26	5.68	31.7	33.4	Kramer	1.00	0.00	0.00	0.00	0.00
06.06.27	188961.1	2686690	1.04	0	1.04	5.97	32.2	33.2	Kramer	0.00	0.00	0.00	0.00	0.00
06.06.27	183985.3	2693128	1.22	0.46	1.68	6.13	32.1	34.1	Kramer	0.70	0.00	0.00	0.00	0.00
06.06.27	198298.3	2670558	1.45	0.13	1.58	6.06	32	34.2	Kramer	0.00	0.00	0.00	0.00	0.00
06.06.27	172479.4	2704711	1.41	0.13	1.54	5.64	31	31.8	Kramer	0.00	0.00	0.00	0.00	0.00
06.06.27	160912.8	2711335	1.46	0.3	1.76	6.77	32.8	19.8	Kramer	1.00	0.00	0.00	0.00	0.00
06.06.27	184142.5	2690692	1.26	0.3	1.56	5.42	31.3	30.8	Kramer	0.00	0.00	0.00	0.00	0.00
06.06.27	168578.1	2708205	0.66	1.75	2.41	5.5	31.2	34	Kramer	0.00	0.00	0.00	0.00	0.00
06.06.27	154093.9	2718823	1.31	0.84	2.15	6.02	30.6	32.9	Kramer					
06.06.27	145538.5	2729175	1.62	0	1.62	5.79	31.5	34.4	Kramer					
06.06.27	160384.6	2714248	3.21	0	3.21	5.7	30.6	35.3	Kramer					
06.06.27	195178.3	2670264	2.65	0.97	3.62	5.66	30.6	36.3	Kramer					
06.06.27	165143.8	2709993	0.16	0	0.16	5.59	31	37.2	Kramer					
06.06.27	156336.6	2719046	0.16	0	0.16	5.5	30.1	37.9	Kramer					
06.06.27	156118.6	2719126	0.15	0	0.15	5.4	30.4	38.1	Kramer					
06.06.27	166540	2708165	1.17	2.06	3.23	5.66	31	34.9	Kramer					
06.06.27	182264.4	2692137	1.07	2.39	3.46	5.94	31.4	31.9	Kramer					
06.06.27	167211.8	2746789	0.16	0	0.16	6.62	30.7	23	Kramer					
6/19/2006	178033.8	2709297	0.23	3	3.23	5.33	29.3	24.5	Layman					
6/20/2006	159345.1	2732396	0.98	0	0.98	4.34	28.5	30.3	Layman					
6/20/2006	159792.7	2732304	0.48	0	0.48	4.35	28.9	29.9	Layman					
6/20/2006	161652.9	2735742	0.49	0	0.49	3.76	28.4	34.2	Layman					
6/20/2006	167409.7	2744016	0.24	0	0.24	5.3	28.5	30.3	Layman					
6/20/2006	172131.9	2725977	0.71	0	0.71	5.38	30.6	34.5	Layman					
6/20/2006	163402.7	2737644	0.79	0	0.79	5.93	31.5	34.4	Layman					
6/20/2006	165323.8	2739204	0.63	0	0.63	8.52	34.8	31.8	Layman					
6/19/2006	179000.5	2712789	0.49	3	3.49	4.49	28.5	20.9	Layman					
6/21/2006	156243.3	2724191	0.36	3.1	3.46				Layman					
6/21/2006	156118.6	2719126	0.49	4.5	4.99				Layman					
6/21/2006	150307.3	2729522	0.69	2	2.69				Layman					
6/21/2006	150166.2	2729410	0.56	2.1	2.66				Layman					
6/21/2006	152946.4	2731235	1.23	1	2.23				Layman					
6/21/2006	151573.3	2732290	0.54	0.6	1.14				Layman					
6/21/2006	149785.4	2731537	0.49	2.6	3.09				Layman					
6/21/2006	149400.8	2731583	0.76	2.4	3.16				Layman					
6/21/2006	144365	2731280	0.79	1.7	2.49				Layman					
6/22/2006	199286	2677484	0.44	1.86	2.3	3.56	27.6	39.9	Layman					
6/19/2006	178989.9	2712798	0.44	3	3.44	4.37	28.7	20.8	Layman					
6/22/2006	201688	2680991	0.48	1.85	2.33	5.69	29.7	32.6	Layman					
6/22/2006	206496	2684471	0.28	0.85	1.13	5.75	28.7	28.2	Layman					
6/22/2006	206497	2684469	0.72	0.03	0.75	5.41	28.9	29.5	Layman					
6/22/2006	199689	2686829	0.28	1.92	2.2	6.3	29.5	33.4	Layman					
6/22/2006	196565	2683492	0.47	1.13	1.6	7.2	29.7	34	Layman					
6/22/2006	196552	2686385	0.38	0.03	0.41	7.12	30.5	28.9	Layman					
6/22/2006	191341.1	2687214	0.34	1.64	1.98	5.9	30.4	36.3	Layman					
6/22/2006	192089.8	2687910	0.91	1.25	2.16	8.65	28.6	34.9	Layman					
6/22/2006	192657.2	2688116	0.2	1.64	1.84	8.3	32.7	35.6	Layman					
6/22/2006	188533.4	2693156	0.62	2.62	3.24	5.65	29.8	35.8	Layman					
6/19/2006	179762	2715679	1.1	1.4	2.5	5.68	30.4	20.3	Layman					
6/22/2006	188521.7	2692885	0.93	0.03	0.96	4.67	31.4	28.7	Layman					
6/22/2006	185285.4	2697661	0.48	3.38	3.86	5.39	32	34.6	Layman					
6/25/2006	214938	2638692	0.24	1.1	1.34			24	Layman					
6/19/2006	179461.4	2715766	0.21	1.9	2.11	6.2	31.2	20.2	Layman					
6/19/2006	179212	2717947	0.49	1.21	1.7	6.41	31.2	18.4	Layman					
6/25/2006	228159	2639747	0.5	0.5	1			18	Layman					
6/25/2006	229054	2640195	0.45	0.8	1.25			20	Layman					
6/25/2006	216545	2639381	0.54	0.15	0.69			22	Layman					

FIGURES

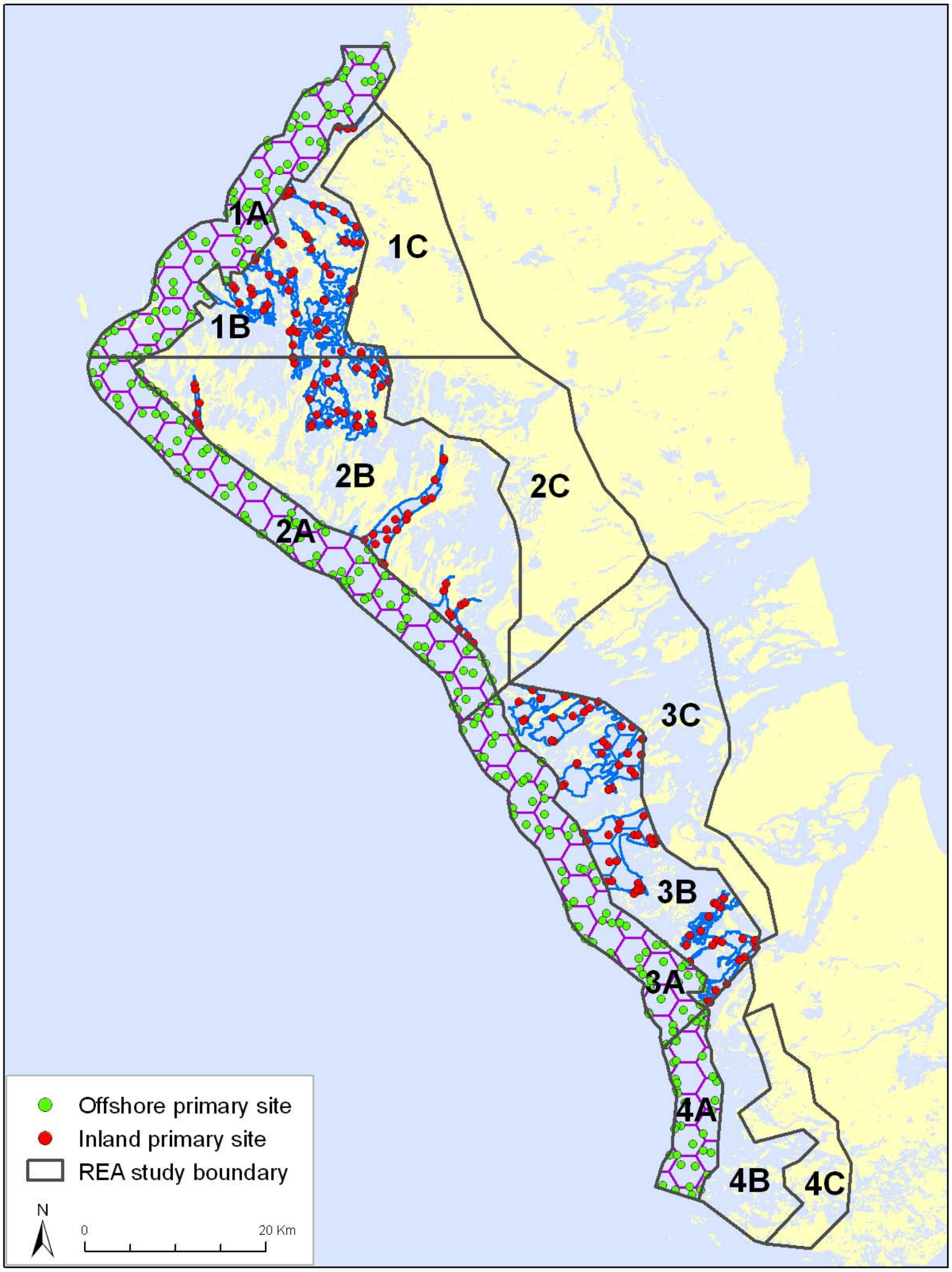

Figure 1. Map of West side sampling area showing randomly probability sites within each of the three cross shelf zones (A, B, C) divided into four latitudinal areas (1, 2, 3, 4). Only zones A and portions of zone B were surveyed during the June assessment.

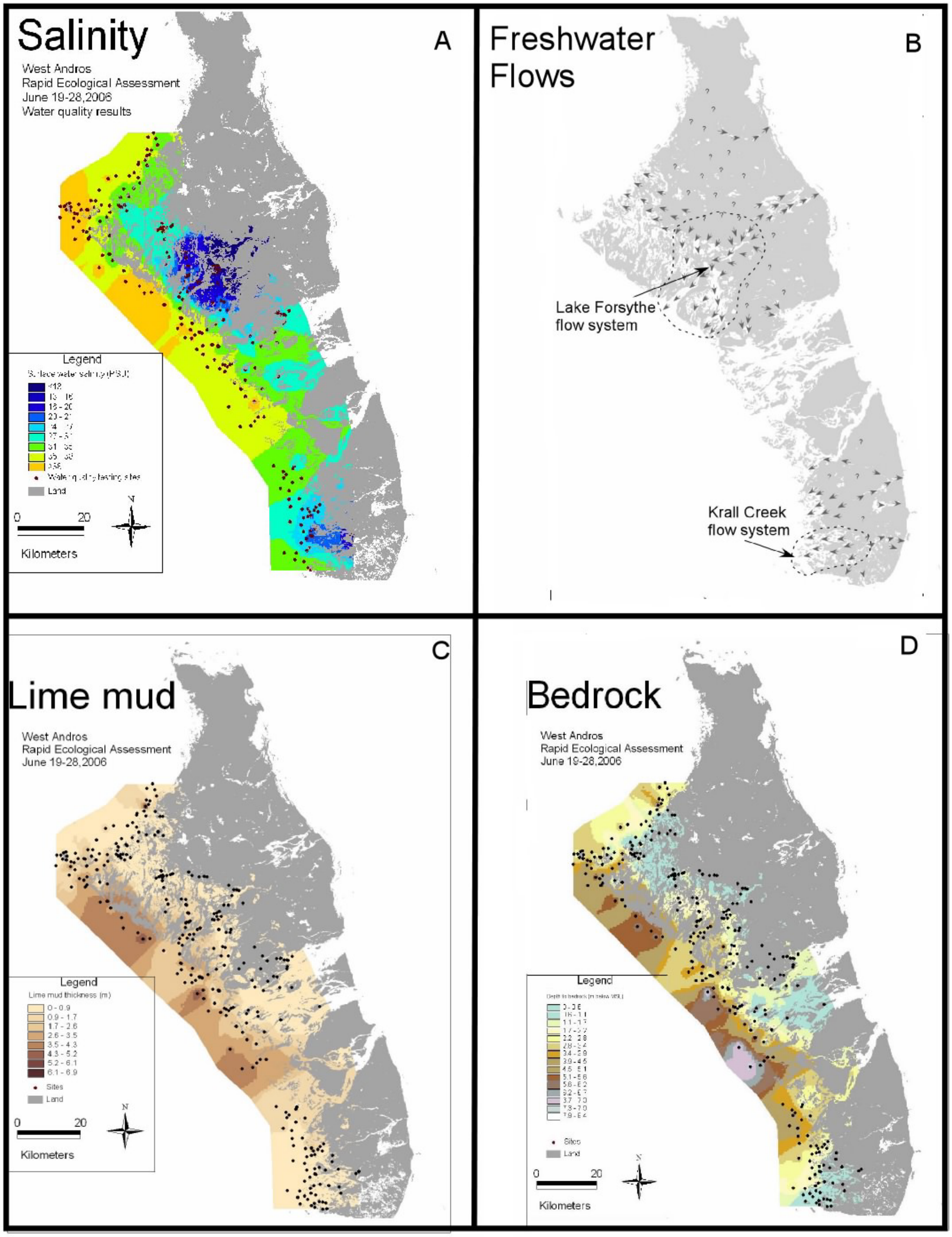

Figure 2. West Andros biophysical maps showing A) Surface (0.5 m) water salinity; B) major freshwater flows; C) Holocene mud thickness; D) Pleistocene bedrock depth below MSL. Maps generated by interpolating between point observations made June 19-28, 2006

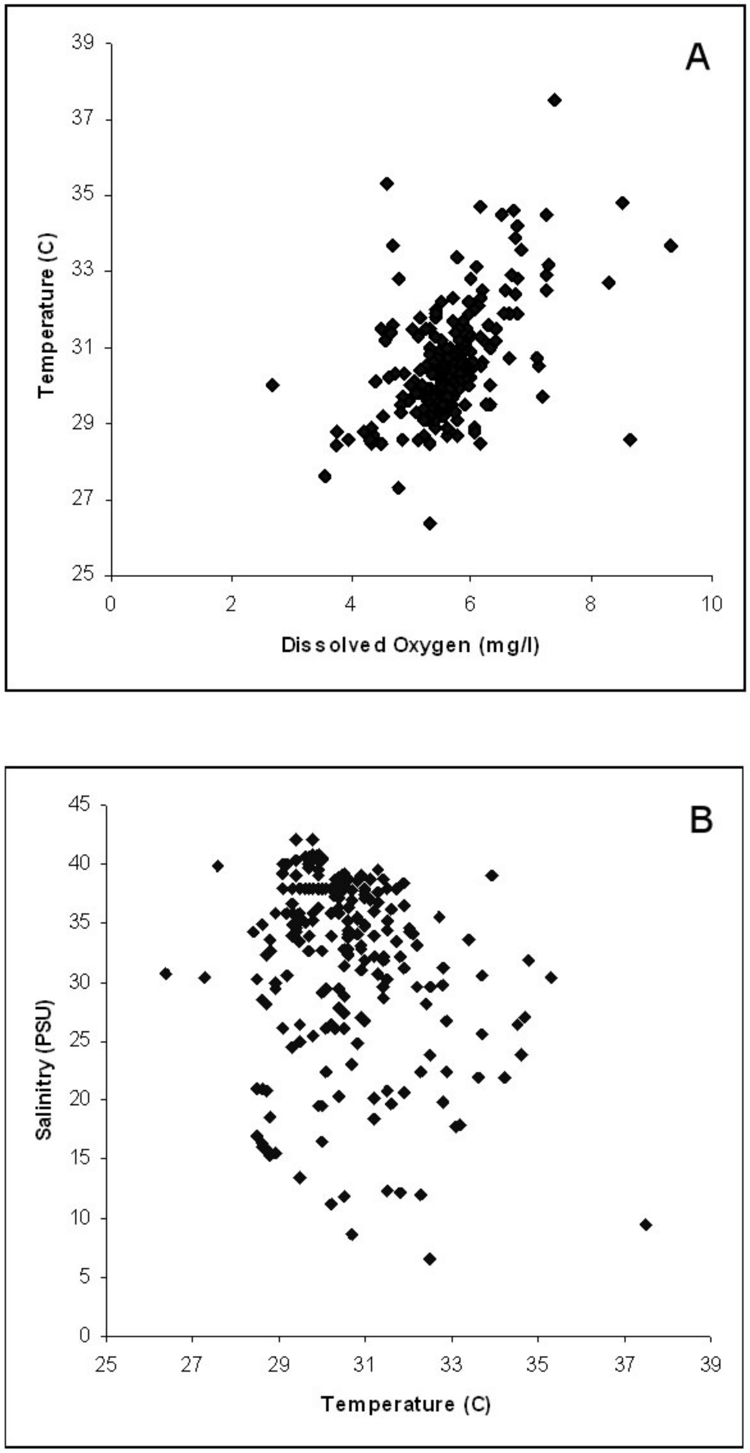

Figure 3. Water quality cross plots for of 250 sampling points taken from 0.5 m depth. A) Dissolved oxygen versus temperature; B) Salinity versus Temperature.

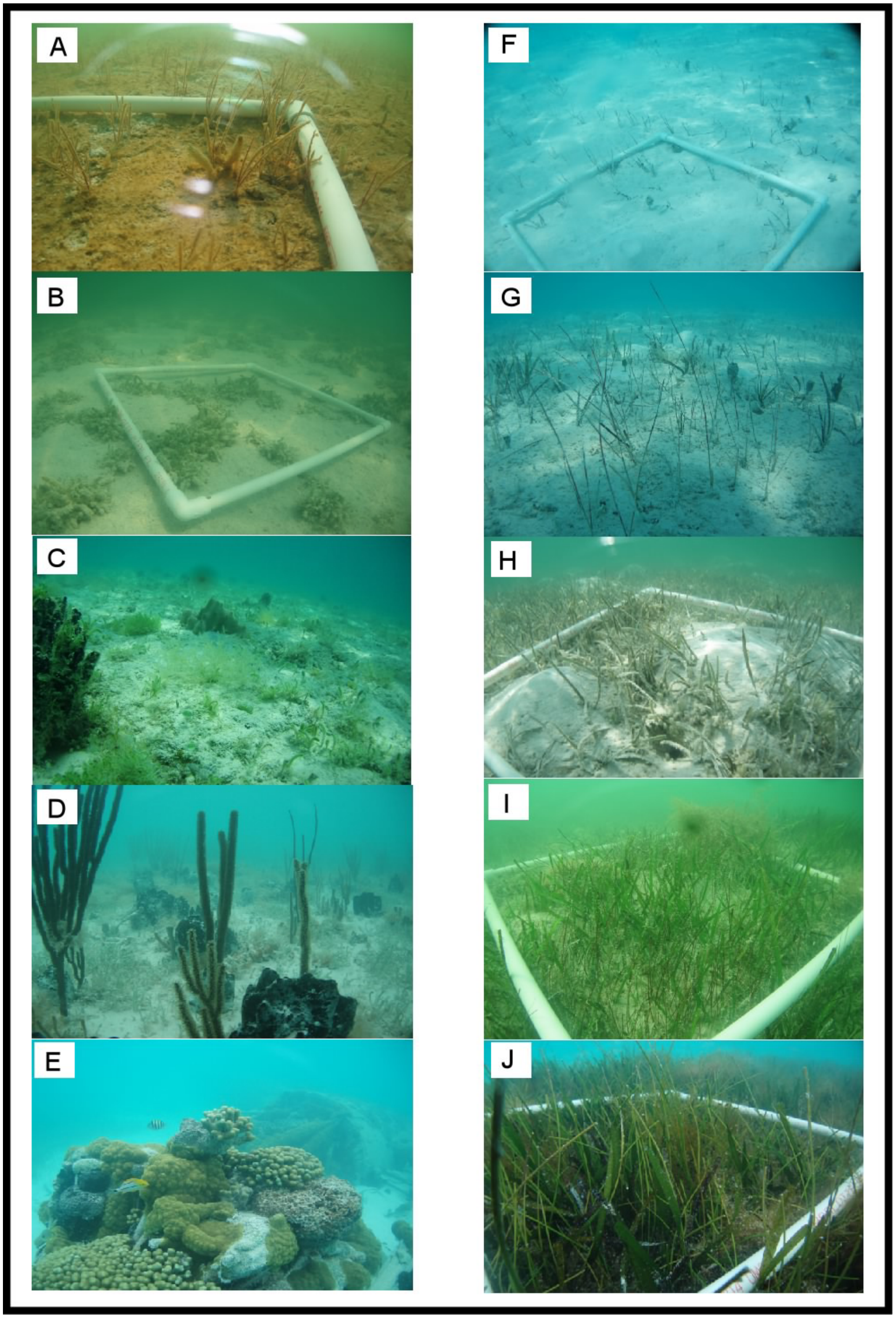

Figure 4. Range of benthic habitats observed during survey. A) Mud with *botophora* and cyanobacterial film; B) *Botphora* Hardbottom; C) *Laurencia* Hardbottom 2; D) Sponge and sea rod Hardbottom 3: E) Coral community growing on plane wreck; F) Baren mud; F) Sparsely colonized mud; H) Burrowed seagrass on mud; I) Dense *thallassia* on mud; J) Dense *Syringonium* on mud;

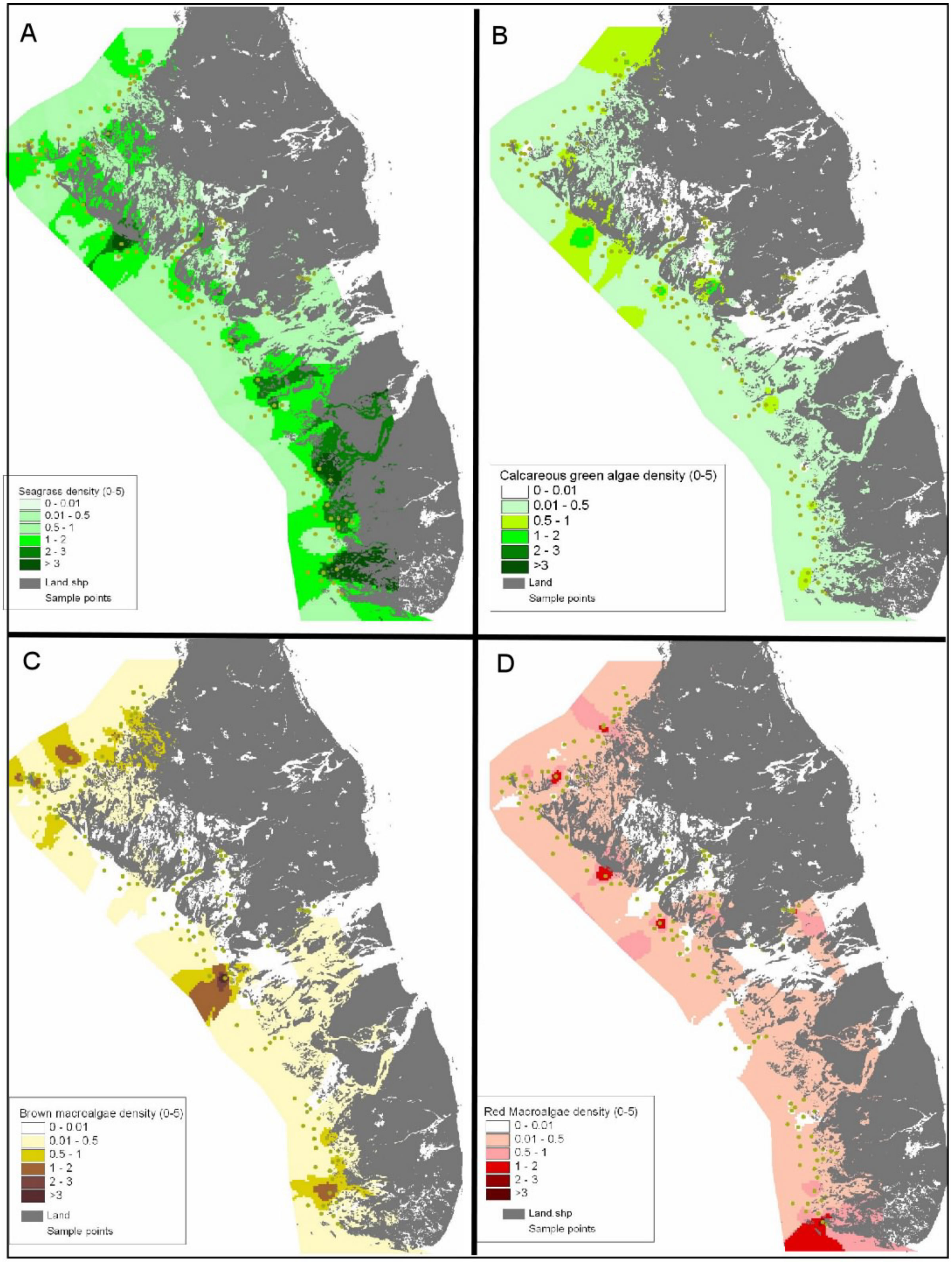

Figure 5. Maps showing distribution of major benthic biota observed during the assessment based on Braun Blanquet densities which range from 0 (0%) to 5 (100%). A) Seagrasses; B) Calcareous green algae; C) Brown macroalgae; D) Red Macroalgae.

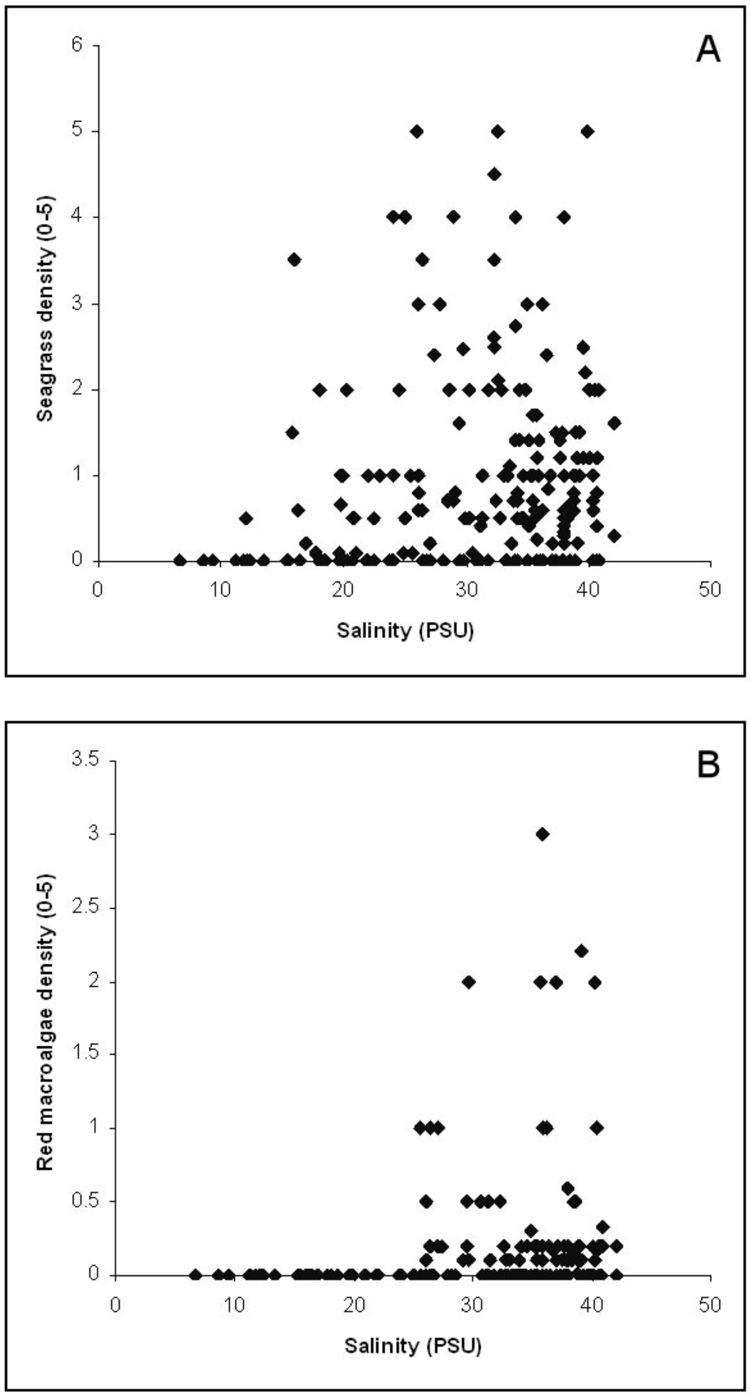

Figure 6. Cross plots for a) Seagrass density and salinity (0.5 m); B) Red macroalgal density and salinity (0.5 m).

Mangrove Creek Fish Assemblages

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Introduction

Western Andros is one of the largest remaining insular areas of the wider Caribbean region that may be called wilderness. While there are some areas of western Andros used by humans, most of the area lacks permanent human presence and is infrequently visited. There are only a handful of locations where there is even any evidence of past or current human development. While threats to western Andros are minimal at present, the area is ideally suited for creating a protected area to preserve its marine environment in its near pristine condition.

The commingling of marine, freshwater and terrestrial environments throughout western Andros has produced a patchwork of habitats that vary in environmental conditions and ecological communities. While mangrove lined creeks and sounds dominate the landscape of western Andros, variability in substrate, salinity, temperature, depth, mangrove development, and seascape properties (e.g., habitat configuration) can all contribute to the occurrence of important fish and invertebrate species, as well as the function of these habitats for key species. To gain a better understanding of the marine resources of Western Andros, the fish and benthic communities of the area were characterized as part of a Rapid Ecological Assessment (REA) of the area in June, 2006.

The purpose of this component of the REA is to characterize the fish assemblages and benthic communities of western Andros. Specifically, assessments targeted: (1) fish assemblages and nursery value of mangrove fringed creeks; (2) benthic communities of mangrove fringed creeks; (3) identification of important areas for key commercial fishery species (e.g., snapper, lobster); and (4) the occurrence of sharks and other large elasmobranches.

Methods

Study sites throughout the Western Andros area were haphazardly selected based on ecological and logistical considerations (Fig. 1). From the ecological perspective, primary study sites were mangrove fringed creeks that had direct or indirect (i.e., via a number of interconnected creeks and sounds) surface connection to open seawater. To ensure that a the range of creek habitats of western Andros were sampled, sites were selected to cover a range of depth, salinity, distance from open water and mangrove height and cover (see report by C. Layman for information on mangrove habitat characteristics). Sites were also selected to cover a broad area that ranged from The Timber creek area of North Andros, to creeks near the southern tip of South Andros, and from Williams Island, Billy Island and marine waters along the shoreline of western Andros to near freshwater areas well into the interior of the island. Within zones of western Andros (i.e., North of the westernmost point of Andros; between the westernmost point of Andros and North Bight; within the Bights; and South Andros; Fig. 1), sites surveyed were stratified by mangrove type, with representative dwarf (<2m), medium (2-3m) and tall mangroves sampled (>3m). Logistical considerations, however, limited the number of sites able to be sampled along South Andros and led to a greater number of sites being sampled near the base of operations near Wide Opening (Fig. 1).

At each study site, environmental and habitat data was recorded (see other reports from this REA for details), as were various aspects of fish and benthic communities. Since the majority of fish inhabiting creek systems live in association with the mangrove fringes of creeks, surveys primarily focused on the mangrove shoreline. At each site a single 30 m visual transect was surveyed along the mangrove fringe of creeks from the shoreline out to a distance of 2 m from the shoreline, swimming against the current to minimize siltation. Within the visual survey, all fish were identified to the species level (or family level for most gerreids, atherinids and clupeids) counted, and their size estimated to the nearest centimeter of total length (TL). During these surveys, mobile invertebrates, particularly commercially important species such as the Caribbean spiny lobster (*Panulirus argus*) were also recorded to address Objective 3 above.

The sampling design of a single survey per site was adopted to maximize the number of sites and geographic range that we were able to survey during the REA. The limitation to this sampling design is that it makes statistical comparisons between sites difficult; however, the sampling design allows for generalizations about the fish assemblages and statistical comparisons among habitat types and across a range of environmental variables (e.g. salinity, depth, mangrove height). Since previous research (e.g., Dahlgren et al. in prep) suggests that differences among sites are driven by differences among habitat types or across a range of environmental variables, this sampling design is preferred for site characterization and management planning.

Following fish surveys, the percent cover of various components of benthic communities was estimated along transects approximately 2 m from the mangrove shoreline. In estimating percent cover, all species observed along the transect were identified to the lowest taxonomic level possible and the % of the survey area that they occupied estimated. For seagrasses and corals, estimates were made for individual species. For macroalgae, identifications were generally made at the genus level. All other components of the benthic community (e.g., sponges) were made at higher taxonomic levels.

For both fish and benthic data, analysis included descriptive statistics to characterize sites. Cluster analyses using the Bray-Curtis similarity index were also performed on fish and benthic data separately to examine the variability of fish assemblages and benthic communities among sites and to group sites based on similarities among them. Additional multi-dimensional scaling (MDS) analyses were conducted to graphically display differences between sites and the taxa driving these differences.

In addition to surveys along the mangrove shoreline, a 30m x 2 m visual transect survey was conducted in the middle of the creek channel for a few sites following the methodology outlined for fish and benthic communities above. Mid-channel surveys were not conducted at sites in which depth exceeded 3 m, visibility was less than 2 m or currents were too strong to allow effective surveys while swimming upstream. Mid-channel surveys were also not conducted at sites with an entirely mud substrate (most sites); since these sites rarely have fish living along the substrate in the middle of the channel (Dahlgren personal observation).

Data were also collected from fish and benthic communities of several sites that were not part of the primary sampling design. These included assessments of several offshore hardbottom areas in the William's Island area (Fig. 1), and two inland water bodies with minimal or no connection to open water. For hardbottom areas, visual surveys followed a 10 minute roving diver visual census in which no transect was used, but all fish observed during a 10 minute period were identified, counted and their size estimated as outlined above. Benthic communities at these sites were characterized by P. Kramer and are included in his report from the REA. In the inland ponds, qualitative samples of fish were conducted using seine and gill nets to document the occurrence of fish in these areas.

No standardized survey methodology was used to assess large elasmobranches inhabiting Western Andros; however, all sightings of large elasmobranches (*in situ* or from boats while running between survey sites) were recorded and the species observed identified. This provided a qualitative assessment of which species were observed and where they occurred. When possible, size of elasmobranches was also estimated to determine whether the individual observed was a juvenile or adult.

Results and Discussion

Quantitative visual transect surveys were conducted at a total of 62 sites (Table 1; note that some sites include both mangrove and hardbottom habitat surveys). Most surveys were conducted in mangrove habitats (n=53), but several were conducted in hardbottom habitats within creek channels (n=7) and two surveys were conducted on artificial hardbottom habitats, airplane wrecks near Wide Opening and Billy Island. Additional qualitative fish surveys were also conducted at several hardbottom sites near William's and Billy Island (roving diver surveys) and at two inland ponds (seine and gill nets).

Fish Assemblages

A total of 32 fish taxa were observed in our surveys. Only 19 taxa, however, were observed in mangrove habitats, with the remaining 13 taxa only observed only in hardbottom habitats, primarily artificial reef habitats. Compared to mangrove creeks on the eastern side of Andros and elsewhere in the Bahamas, the mangrove sites surveyed on the west side of Andros were species-poor. For example, the number of taxa observed per transect on the west side of Andros ranged from 1-8 with a mean of 4.2 species per transect, as opposed to up to 19 taxa with a mean of 7.9 taxa on the eastern side of Andros (Dahlgren et al. in prep). This may be due to a number of factors that may make mangrove habitats on the western side of Andros unsuitable for a number for species. For example, environmental factors such as salinity in creeks on the western side of Andros may fluctuate outside of the preferred range for some species. Alternatively, the western side of Andros may simply be recruitment limited for these species (i.e., insufficient numbers of larvae reach mangroves on the western side of Andros) Western Andros may also lack seagrass, hardbottom or coral reef habitats used by fish during various life stages, or these habitats may not occur in a spatial configuration that supports various species throughout their life cycle.

Despite the low number of species found in mangroves of western Andros, the total biomass of fish was high with total fish biomass exceeding 100kg per transect at several sites and an average of nearly 40 kg per transect across all sites. This average biomass is nearly four times that of mangrove creeks on the eastern side of Andros, which have a mean of 10.3 kg (Dahlgren et al. in prep). These differences are likely due to the mangrove creeks on western Andros having naturally high rates of productivity coupled with the absence of human impacts, such as creek fragmentation, fishing and coastal development, which can reduce the amount of fish biomass in mangrove systems (Dahlgren et al. in prep).

Snappers, primarily gray snapper (*Lutjanus griseus*) and mojarras (Gerreidae, known locally as shad) were each observed in 42 of the 53 mangrove sites, with silversides (Atherinidae), schoolmaster snapper (*Lutjanus apodus*) and barracuda (*Sphyraena barracuda*) observed at more than 20 mangrove sites (Table 1). Mojarras were the dominant fish in shallow water and/or dwarf mangroves and gray snapper were dominant in deeper water and taller mangroves. In addition to variability based on differences in habitat, sites between the westernmost point of Andros and North Bight generally had fewer species than those in the area of the Bights, north of the westernmost point of Andros (including Williams and Billy Island), and South Andros (Fig. 2). Such patterns in species richness are consistent with both the recruitment limitation hypothesis mentioned above (i.e., sites with greater access to water input from the Andros barrier reef had higher species richness) and greater seascape heterogeneity (i.e., sites with greater number of species are also ones in which there was greater benthic habitat diversity, including hardbottom areas and seagrass beds). This latitudinal trend was not statistically significant, however, probably due to the complexity of the interactions between larval supply, environmental variability, and habitat suitability throughout western Andros.

Fish assemblages varied among sites; however groupings of similar fish assemblages among sites did not correspond to geographic variability. Cluster analysis of the Bray-Curtis Similarity index among sites revealed six major groupings of fish assemblages with similarities greater than 25% within each grouping (Fig. 3). Several sites, however, were outliers and did not fit within any of the groupings. Sites belonging to group 1 were dominated by herring (Clupeidae) and gray snapper (*Lutjanus griseus*). Sites belonging to group 2 were also dominated by baitfish and gray snapper, but the baitfishes were silversides and/or anchovies. Groups 3 and 4 were dominated by gray snapper, but the relative density tended to be higher in group four, and there were also differences in abundance of other fish species. Groups 5 and 6 were dominated by mojarras (Gerreidae), but densities were higher in group five than group six.

Although these groupings do not form along latitudinal gradients, some groups are dominated by sites from a particular region of Western Andros (e.g., a large number of sites in group 2 were from the Bights region). It is more likely that groups are more closely related to environmental variables (e.g., depth and salinity), and other features of the habitat (benthic habitat cover, mangrove cover). For example, coarse scale classification of mangrove habitats indicate that groups 1 - 4 were dominated by sites with tall mangroves, with groups 5 and 6 consisting of a variety of mangrove sizes and most of the outlying sites that did not fall into groups were dwarf mangrove sites (Table 1, Figure 3).

For the few sites in which fish surveys were conducted within creek channels, the fish species composition closely resembled those of the mangrove fringes of the channel, but fish densities were generally lower (Table 1). At the two airplane wrecks surveyed, however, greater fish diversity was observed than at any mangrove site (11 taxa observed at each airplane site). Fish at these sites, included several species that were not observed within transects in mangrove creek systems, including snapper (*Lutjanus analis* and *Lutjanus mahagoni*), southern stingray, (*Dasyatis americana*), grunts (*Haemulon plumieri* and *Anisotremus virginicus*), butterflyfish (*Chaetodon capistratus*), and Atlantic spadefish (*Chaetodipterus faber*, although this species was observed outside of transects in the channel at the southernmost site surveyed). All of these species except for the two snapper species were only observed at the airplane wreck near Billy Island. The fish assemblage at the airplane wreck near Wide Opening had similar species to those found within mangrove creek systems, but at greater species richness than at mangrove sites; and also included two snapper species not observed in mangroves (and a black grouper, *Mycteroperca bonaci*, which was observed off the transect). While quantitative data on benthic communities for these wrecks is not included in this report (but see REA report by P. Kramer), they were both surrounded by a halo consisting of an inner ring of bare sand and an outer ring of seagrass, primarily *Thalassia*. The wreck near wide opening also had an abundance of macroalgae growing on or around the plane (primarily *Laurencia* sp.), while the wreck near Billy Island had corals (primarily *Porites astreoides*) colonizing its surface. These observed fish and benthic patterns suggest that both benthic habitats (i.e., the proximity of relatively high rugosity hardbottom with seagrass) and proximity to sources of reef fish larvae (i.e., Andros barrier reef) influence the fish community of western Andros.

One fish species of note observed in mangrove surveys of western Andros near the Bights and southern end of South Andros is the pinfish (*Lagodon rhomboides*; note that some identification of pinfish may have actually been Western Atlantic seabream, *Archosargus rhomboidalis*, which is nearly indistinguishable for small individuals in visual transects). While the pinfish and seabream both occur in abundance in seagrass beds near mangroves in Florida, they are rarely if ever observed in the Bahamas (see references on www.fishbase.org). These fish were observed from several sites from western Andros in which seagrass cover was high, similar to habitats where they are found in Florida, particularly in the Bights and south Andros.

Benthic Communities

The benthic communities of Western Andros creeks were generally soft-substrate communities with varying amounts of vegetation. Of the 55 sites for which benthic data is available (Table 3), 48 sites were mud dominated, with other sites being mostly hardbottom or sand bottom areas. In several cases, creeks had a muddy bank and exposed hardbottom in the middle of the channel. When mid-channel hardbottom habitats and muddy banks were separated (i.e., the channel was wide enough such that hardbottom habitats were not included in initial benthic surveys), and depth, visibility, and currents allowed, separate surveys were conducted close to the mangrove shoreline and in the mid-channel hardbottom habitats (e.g., sites 8 and 18).

Some sites lacked any vegetation or other epibenthic structure, but most sites had at least 40% cover by seagrass, macroalgae, sponges and/or corals, with seagrass (*Thalassia* and *Halodule*) having the greatest average coverage. Seagrass coverage was greatest, however, at sites from the Bights and south, as well as several sites at Williams Island and north of the westernmost point of Andros Island.

The distribution of seagrass and macroalgae in the system are likely to be influenced by primarily substrate type and variability in environmental factors, including temperature and salinity. While mud substrates dominated the creek systems of western Andros, areas in which hardbottom was exposed were often sites in which macroalgal diversity was relatively high. Since our surveys show conditions during a single time period, we are unable to assess variability in environmental factors at sites over time, but sites in which environmental factors are likely to be more stable and dominated by marine waters (i.e., sites near the Bights, Williams Island, and the south end of South Andros) also tended to have a higher benthic diversity, primarily due to a greater occurrence of sponges, corals and some macroalgae. Inland sites and those in the central part of North Andros from Whale Creek to Hawk Creek had the greatest amount of bare mud substrate and the lowest amount of vegetation or other structure that may provide habitat for fish.

Cluster analysis of benthic communities reflects the patterns mentioned above. There were five distinct groupings of sites with more than 50% similarity using a Bray-Curtis similarity index (Fig. 4). Group 1 consisted primarily of sites in southern Andros and around the Bights, but also includes one site from William's Island. Group 2 consists of three sites, two from Little Loggerhead creek and one from the interior of South Andros. Group 3 consists of only two sites, both from the northern part of the study area. Group 4 consists of sites from Williams Island and one site from South Andros. The last group contained the most sites and is primarily composed of sites in the area between Hawk Creek and Whale Creek. Multidimensional scaling analysis (MDS) shows that these groupings are dictated to a great extent by the percent cover of *Thalassia*, *Halodule*, *Laurencia* sp. and bare substrate (Fig. 5).

<u>Mobile Invertebrates</u>

Caribbean spiny lobsters (*Panulirus argus*, locally called crawfish) are the most valuable commercial fishery species in the Bahamas. One of the most important spiny lobster fishing grounds in the Bahamas are the extensive bank areas to the west and southwest of Andros Island, where fishers use artificial habitats (i.e., condos) to attract lobsters. According to fishers, estimates of the number of active condos being used on the Bahama Banks near Andros may be in the tens or hundreds of thousands.

Caribbean spiny lobsters have a complex life cycle in which they use several different habitats as they grow. After they hatch from eggs and go through numerous larval stages (>3 mos.) in the plankton, they settle to nearshore nursery areas where they develop as juveniles before moving onto rock and coral reef habitats as sub-adults and adults. A primary settlement and early juvenile nursery habitat for Caribbean spiny lobster is the macroalgae, *Laurencia* sp. (particularly *Laurencia intricata*). Since spiny lobster go through juvenile stages in nearshore macroalgal habitats that are commonly associated with mangrove lined creeks and sounds, similar to those of Andros Island, identifying key nursery areas for this species was a high priority during the REA.

Most of the sites surveyed contained little suitable macroalgal habitats for juvenile spiny lobsters (<14 mm CL). During surveys, creek systems with hardbottom macroalgal communities containing the macroalgae *Laurencia* sp. were generally limited to creek systems to the north of the westernmost point of Andros, a few areas around Williams and Billy Island, a few creeks near the southern end of South Andros and the plane wreck near Wide Opening. Of the areas surveyed, concentrations of spiny lobster were observed within a creek leading to the interior of Williams Island from the north side of the island (and surrounding hardbottom area outside of the creek mouth), and areas of hardbottom and undercut seagrass "blow-outs" near Billy Island (Table 1). Occasional lobsters were also observed in hardbottom areas between and to the south of Williams and Billy Island. Lobster molts (hard shell parts shed as the lobster grows) were also observed in several creeks in the northern part of the study area. Other areas where *Laurencia* sp. was observed, such as the airplane near Wide Opening, had no lobsters.

In nearly all cases where lobsters were observed, their small size indicated that they were juveniles and suggests that these creek and hardbottom areas serve a nursery function. The relatively small size of areas in which juvenile lobsters were found and the relatively low densities of lobsters observed in these areas, however, suggests that these areas may not be the effective juvenile habitat (Dahlgren et al. 2006) responsible for providing the majority of lobsters to the lobster fishery to the west of Andros Island. While it is acknowledged that surveys during the REA may have missed several critical areas for juvenile lobsters, particularly to the north and south, western Andros alone does not appear to be capable of supporting large-scale lobster fisheries and lobsters from the east side or Andros or other areas may in fact be supporting the fishery in this area. Alternatively, lobster recruitment may have been extremely low prior to our surveys, making these otherwise productive areas appear less productive. Nevertheless, the scarcity of appropriate settlement and nursery habitat types between the westernmost point of Andros and North Bight (if not all the way to South Andros), coupled with the extensive distance over shallow areas that larvae would have to travel to reach much of the western side of Andros, indicates that productive areas for lobsters are likely to be limited to only a few locations to the north and south. These areas should be targeted for management in support of the lobster fishery.

Few other mobile invertebrates of significance were observed on the western side of Andros. Queen conch, *Strombus gigas* were not observed, and suitable conch settlement or nursery habitats were not present (Stoner 2003). Blue crabs (*Calinectes* sp.) were commonly observed in muddy substrates with and without vegetation throughout the survey region. Surveys primarily targeted fish, however, and were not designed to accurately quantify population characteristics (e.g., distribution, density, sizes) of the crab population in the area. Because these crabs support a small fishery and are also an important prey item for fish in the area, particularly valuable bonefish, snappers, and permit, further investigation into the status of the blue crab resource is warranted.

Elasmobranches

During surveys and in transit between sites, all elasmobranches observed were recorded. Within several kilometers of the western Andros shoreline, particularly along the sandy bottom area near the shoreline between Williams Island and Wide Opening, adult nurse sharks (*Ginglymostoma cirratum*) were frequently observed. Up to 25 adult nurse sharks, occurring as individuals or in pairs, were observed between the westernmost point of Andros island and Wide opening during transit between sites. Based on the high abundance, adult size (>1.5 m), and anecdotal reports from fishing guides, it is likely that these sharks were in the area for mating. Observations of nurse shark mating in habitats similar to those of western Andros at the same time of year in other locations (e.g., Carrier et al. 1994, Dahlgren 1998) provides further evidence in support of this hypothesis. Based on the relatively high number of nurse sharks observed, the western Andros area is likely to be an important mating area for nurse sharks throughout that part of the Bahamas. Smaller sub-adult nurse sharks were occasionally seen within creek systems, particularly those near the North and Middle Bight. Further quantitative investigations of the nurse shark population of western Andros, including spatial and temporal studies of shark movement and habitat use should be conducted to provide further information on the importance of western Andros in supporting nurse shark populations.

Within nearshore, creek and sound systems, an abundance of lemon sharks (*Negaprion brevirostris*) were also observed. Based on the size of sharks sighted (predominantly <1.5 m), most of the lemon sharks observed were juveniles. Similar mangrove fringed, shallow creek and sound systems (e.g., Bimini's lagoon: Marquesas Keys, FL) have been identified as important nursery areas for lemon sharks (e.g. Gruber et al. 1988). The vast expanse of this type of habitat suggests that western Andros provides an important nursery area for this species. The abundance of bonefish, mojarra, and other food resources in these areas further supports the value of these areas as a nursery for lemon sharks.

While nurse sharks were observed over large areas within a few kilometers of the western Andros shoreline, and lemon sharks were observed throughout western Andros' nearshore areas and creek and sound systems, several other elasmobranch species were only observed in specific locations. Juvenile bull sharks (*Carcharhinus leucas*), for example, were only observed within the inner reaches of Turner Sound, particularly near two creek systems feeding into Turner Sound from inland areas. While visiting these areas at least 5 juvenile bull sharks were observed in sizes that ranged from 1 to nearly 2 meters in length, suggesting that they were all juvenile sharks. These areas had relatively low salinities at the time these sharks were observed. Sightings of juvenile and/or adult bull sharks throughout the creek and sound systems of western Andros is not surprising, given their ability to tolerate low salinity conditions and the abundance of fish prey resources, including snapper and tarpon throughout these areas. No published records of other potential bull shark nursery areas have been reported in the Bahamas. During the

REA, there was one observation of an adult bull shark in Big Loggerhead creek, an area where fishing guides report frequent shark sightings. Fishing guides also report sightings of adult bull sharks in other creek systems throughout western Andros. While it is unclear whether these adults are residents of the area or are transient (e.g., *en route* to give birth in nursery areas), the frequency of bull shark sightings in this area compared with the rest of the Bahamas suggests that western Andros is an important area for maintaining populations of the species.

During the REA, two sawfish (most likely smalltooth sawfish, *Pristis pectinata*) were observed, one in Timber creek in the north, and the other in a marine blue hole at the southern end of South Andros. This species, like bull sharks, can tolerate a wide range of salinities and environmental conditions, making it capable of living throughout the western Andros area. Observations of the fish at the northern and southern extremes of the survey area, and anecdotal reports from fishing guides of sawfish observed in Turner Sound and Wide Opening, suggest that sawfish may be found throughout the entire western Andros system. While sawfish have been reported in the Bimini lagoon system and other parts of the Bahamas (Bohlke and Chaplin 1993), their sightings are extremely infrequent due to their camouflage, cryptic behavior (often remaining still, partially buried in a mud bottom matching their own color) and scarcity. The smalltooth sawfish is currently classified as Critically Endangered on the IUCN Red List of endangered species (IUCN 2006; www.iucn.org/themes/ssc/redlist2006/redlist2006.htm). Factors such as habitat loss, their occurrence in bycatch, and targeted recreational and commercial fisheries have all contributed to population declines throughout their range. Our observations, anecdotal reports of seeing more than 10 sawfish together in Turner Sound (Shawn Leadon, Andros fishing guide, personal communication), and reported observations of fish in excess of 4 m (Charles Bethel, Flamingo Cay, personal observation) suggest that western Andros may be an important area for the species and may harbor a significant portion of the Bahamian sawfish population.

Other Sites of Note

Qualitative fish and benthic surveys were also conducted in several additional sites worth noting. Inland from Turner sound, a brackish water lagoon was surveyed for fish using gill nets, seine nets and visually. Fish observed in these qualitative surveys included mojarras (*Eucinostomus* spp.), jacks (Carangidae), herring (Clupeidae), and checkered pufferfish (*Sphoeroides testudineus*). Within an inland blue hole adjacent to this site gray snappers (Lutjanus griseus), mojarras, blennies and gobies were observed. Mosquitofish (Gambusia sp.) were also observed along the shoreline.

At a nearby freshwater pond, fish were surveyed in aquatic vegetation near a mangrove island (and large bird rookery), using both seine nets and gill nets. Fish observed included freshwater herrings and anchovies as well as grey snapper (*Lutjanus griseus*). The occurrence of grey snapper within this freshwater system suggests that there may be some periodic connection to marine waters (e.g., during hurricane events). While these areas are unlikely to serve much of a nursery function for marine species, they are likely to be important areas for freshwater species since the occurrence of large freshwater areas is relatively rare in the Bahamas.

Hardbottom sites near Williams and Billy Island were also surveyed qualitatively. These sites typically had relatively high fish diversity, with several groupers (Serranidae), grunts (Haemulidae) and snappers (Lutjanidae) observed, typically at low densities. At one hardbottom site between Williams and Billy Island two remoras (*Remora remora*) were observed and a sea bass (*Centropristis* sp.) was observed at another. The sighting of a sea bass is rare in the Bahamas since the species typically occurs along the Gulf of Mexico and Southeastern coast of the United States.

Recommendations

Quantitative and qualitative surveys indicate that western Andros supports highly productive mangrove fish assemblages and important areas for several species of interest (e.g. elasmobranches, including endangered sawfish). Based on survey results, several recommendations can be made for the management of western Andros' fish and benthic communities:

- The aquatic ecosystem of western Andros ranges from nearshore marine systems, to brackish tidal creeks and sounds all the way to freshwater ponds. Because many of these areas are interconnected, protected area planning should include all of these areas and should include species management, habitat protection and water quality protection throughout the area.
- Because few biodiversity "hotspots" were found, protected area planning should take the approach of protecting representative habitat types from throughout western Andros.
- Areas North of the westernmost point of Andros (including Williams Island and Billy Island), the Bights, and southern Andros had slightly higher fish and benthic diversity and were important for fishery species such as spiny lobster and should be given priority in protected area planning.
- Turner sound appears to be an important area for bull sharks and possibly sawfish. While it is visited infrequently at present, it should be a priority site for protection from future threats to habitat, water quality and disturbance of these species due to human visitation.
- Further quantitative survey work is warranted to assess populations of several species (e.g., sawfish, sharks, blue crabs, sponges, spiny lobster, tarpon, and bonefish).
- Any protected area established should include an monitoring and evaluation program to assess the impact that protection has on the environment, habitats, living resources, and human use of the area.

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Tables

Table 1. Sites in which quantitative surveys were conducted in mangrove creek habitats.

Site #	UTM Coordinates		Date	Time	Site Name	Mangrove Max Height (cm)	Mean Depth (cm)
1	0787092	2712052	6/19/2006	10:06	Cut-off Creek	450	49
2	0787081	2712061	6/19/2006	10:45	Cut-off Creek	115	44
3	0787727	2714972	6/19/2006	11:22	Cut-off Creek	660	110
4	0787423	2715046	6/19/2006	11:55	Cut-off Creek	112	21
5	0787079	2717213	6/19/2006	12:30	Cut-off Creek	550	49
6	0786799	2717360	6/19/2006	12:42	Cut-off Creek	150	22
7	0788210	2712680	6/19/2006	1:54	Cut-off Creek	620	119
8	0787827	2712245	6/19/2006	2:00	Cut-off Creek	220	38
9	0786993	2710657	6/19/2006	2:54	Cut-off Creek	210	93
10	0786383	2708604	6/19/2006	3:29	Cut-off Creek	620	113
11	0786278	2708522	6/19/2006	3:40	Cut-off Creek	240	23
12	0766609	2730776	6/20/2006	8:30	Shortcut Creek	340	98
13	0767060	2730704	6/20/2006	9:00	Shortcut Creek	150	48
14	0768767	2734218	6/20/2006	9:48	North Timbler Creek	390	49
15	0774153	2742733	6/20/2006	10:29	Timbler Creek	260	24
17	0779658	2724925	6/20/2006	12:33	Timbler Creek	670	71
18	0770431	2736194	6/20/2006	1:36	Timbler Creek	530	79
19	0772281	2737836	6/20/2006	2:13	Timbler Creek	510	63
20	0763870	2722449	6/21/2006	9:00	Hawk's Creek	370	36
21	0763966	2717386	6/21/2006	9:45	Hawk's Creek	420	49
22	0757711	2727512	6/21/2006	9:56	William's Creek	490	69
23	0757575	2727394	6/21/2006	10:18	William's Creek	210	56
24	0760271	2729338	6/21/2006	10:34	William's Creek	310	123
25	0758854	2730331	6/21/2006	11:10	William's Creek	290	54
26	0757102	2729501	6/21/2006	11:41	William's Creek	540	49
27	0756716	2729530	6/21/2006	12:13	William's Creek	150	76
28	0751702	2729008	6/21/2006	1:16	Billy's Creek	560	79
29	0199286	2677484	6/22/2006	8:31	Spanish Wells	460	44
30	0201688	2680991	6/22/2006	9:03	Spanish Wells	420	48
31	0206496	2684471	6/22/2006	9:43	Chalks Sound	480	28
32	0206497	2684469	6/22/2006	10:12	Chalks Sound	340	72
33	0199689	2686829	6/22/2006	11:38	Big Loggerhead Creek	104	28
34	0196565	2683492	6/22/2006	12:06	Big Loggerhead Creek	320	47
35	0196552	2686385	6/22/2006	12:40	Big Loggerhead Creek	350	38
36	0800525	2687039	6/22/2006	1:32	Big Loggerhead Creek	520	34
37	0801243	2687766	6/22/2006	2:00	Little Loggerhead Creek	530	91
38	0801801	2687997	6/22/2006	2:23	Little Loggerhead Creek	90	20
39	0797464	2692854	6/22/2006	2:54	Whale's Creek	470	62
40	0797464	2692583	6/22/2006	3:35	Whale's Creek	290	93
41	0794025	2697214	6/22/2006	3:59	Whale's Creek	410	48
63	0228159	2639747	6/25/2006	10:40	SOUTHERN ANDROS	430	50
64	0229054	2640195	6/25/2006	11:08	SOUTHERN ANDROS	570	45
65	0216545	2639381	6/25/2006	12:17	SOUTHERN ANDROS	160	54
66	0216213	2639547	6/25/2006	12:34	SOUTHERN ANDROS	470	101
68	0216163	2640978	6/25/2006	1:04	SOUTHERN ANDROS	680	96
70	0217530	2641429	6/25/2006	1:28	SOUTHERN ANDROS	524	52
73	0216166	2645215	6/25/2006	2:20	SOUTHERN ANDROS	440	99
74	0215862	2646247	6/25/2006	2:37	SOUTHERN ANDROS	330	101
75	0217740	2647535	6/25/2006	3:00	SOUTHERN ANDROS	440	123
76	0218886	2648314	6/25/2006	3:25	SOUTHERN ANDROS	140	62
78	0221567	2662152	6/25/2006	4:18	SOUTHERN ANDROS	-	-
79	0211076	2659102	6/25/2006	4:49	SOUTHERN ANDROS	590	50
X			6/26/2006	8:00	Flamingo Cay Creek	380	78

Table 2. Summary of quantitative fish surveys from mangrove creek habitats. All surveys are from mangrove shorelines.

Site	Abudefduf saxatilis	Atherinidae	Belonidae	Clupeidae	Gambusia sp_	Gerreidiae	Gerres cinereus	Haemulon flavolineatum	Haemulon parra	Haemulon sciurus	Lagodon rhomboides	Lutjanus apodus	Lutjanus cyanopterus	Lutjanus griseus	Lutjanus jocu	Palinuridae	Scarus iserti	Sparisoma aurofrenatum	Sphoeroides testudineus	Sphyraena barracuda
1	0	10	0	0	0	28	0	0	0	0	0	0	0	15	0	0	0	0	0	0
2	0	0	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	186	0	0	0	0	0	0
4	0	0	0	0	0	155	0	0	0	0	0	0	0	0	0	0	0	0	12	0
5	0	200	0	0	0	19	0	0	0	0	0	0	0	66	0	0	0	0	1	0
6	0	0	0	0	0	66	0	0	0	0	0	0	0	0	0	0	0	0	15	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0
8	0	0	0	0	0	8	0	0	0	0	0	0	0	20	0	0	0	0	2	1
9	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	2	1
10	0	15	0	800	0	0	0	0	0	0	0	2	0	255	0	0	0	0	0	2
11	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	2	0
12	0	0	0	300	0	30	0	0	1	0	0	2	1	47	0	0	0	0	0	0
13	0	20	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1
14	0	0	0	0	0	52	0	0	0	0	0	1	0	3	0	0	0	0	0	1
15	0	0	1	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	100	0	0	0	0	0	0	0	0	0	0	0	72	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	8	0	13	1	0	0	0	0	3
19	0	0	0	0	0	43	0	0	3	50	0	19	1	72	2	0	0	0	5	0
20	0	0	0	0	0	41	0	0	0	0	0	0	0	1	0	0	0	0	0	4
21	0	0	12	0	0	100	0	0	0	0	0	1	0	7	0	0	0	0	0	1
22	0	0	0	0	0	33	0	0	0	0	0	0	0	98	0	0	0	0	0	0
23	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	46	0	0	0	0	0	0
25	0	0	0	0	0	38	0	0	0	6	0	8	0	57	0	0	0	0	0	1
26	0	150	0	0	0	37	0	0	0	0	0	0	0	32	0	0	0	0	0	0
27	0	8	0	0	0	6	0	0	0	1	0	8	0	23	0	2	0	0	0	0
28	0	0	0	0	0	15	10	0	5	1	0	6	0	99	0	0	0	0	0	1
29	0	0	0	0	0	4	0	0	0	1	6	1	0	13	0	0	0	0	0	1
30	1	0	5	200	0	75	0	1	5	116	60	17	0	182	0	0	1	0	0	0
31	0	160	0	0	3	39	0	0	0	6	16	1	0	9	0	0	0	0	0	0
32	1	200	0	0	0	10	0	0	0	56	0	7	0	189	0	0	0	0	0	1
33	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	0	500	0	0	0	38	0	2	0	1	14	1	0	105	0	0	1	0	0	1
35	0	5	0	0	0	10	4	0	2	6	3	1	0	50	0	0	0	0	0	3
36	0	100	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	2	0	0	0	0	15	7	1	132	0	0	0	0	0	0
38	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	1
39	0	80	0	0	0	8	0	0	0	0	0	0	0	134	0	0	0	0	0	0
40	0	0	0	0	0	54	0	0	0	2	4	2	0	117	0	0	0	0	0	1
41	0	0	0	0	0	80	13	0	0	2	3	1	2	55	0	0	0	0	0	2
63	2	8	0	0	0	6	12	0	2	5	0	1	0	30	0	0	0	0	0	0
64	0	0	0	0	0	24	15	0	0	0	1	0	0	75	0	0	0	0	0	0
65	0	0	0	0	0	55	1	0	0	0	0	0	0	2	0	0	0	0	0	0
66	0	0	0	0	0	2	0	0	0	14	0	1	0	62	2	0	0	0	0	0
68	0	60	0	0	0	0	0	0	0	2	0	2	0	225	1	0	0	0	0	0
70	0	0	2	0	0	1	1	0	0	0	0	0	0	2	0	0	0	0	0	0
73	0	5	0	0	0	0	2	0	0	0	0	3	0	120	0	0	0	0	0	0
74	1	100	0	0	0	0	0	0	0	6	0	7	0	55	0	0	0	0	0	0
75	0	0	0	100	0	21	0	0	2	3	7	3	0	86	0	0	0	0	0	1
76	0	0	0	0	0	8	7	0	0	0	0	0	0	0	0	0	0	0	0	0
78	0	100	0	0	0	31	1	0	0	0	3	0	0	2	0	0	0	0	0	2
79	1	80	0	0	0	3	0	0	0	7	0	3	0	9	0	0	0	2	0	1
X	0	0	0	0	0	2	2	0	0	0	0	2	0	36	2	0	0	0	0	7

Table 3. Summary of quantitative benthic surveys from all mangrove creek sites.

Site #	Substrate	Thalassia	Halodule	Penicillus, Halimeda, Udotea	Batophora	Laurencia	Acetabularia	Caulerpa	Hypnea	Cladophora	Ulva	Dictyota	Cladophora	Other macroalgae	Cyanobacteria	Sponges	Porites porites	Siderastrea	Manicina	Other	Bare Substrate	Comments
1	mud	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
2	mud	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	
3	mud	0	25	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	
4	mud	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
5	mud	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	
6	mud/rock	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
7	mud	0	10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89	
8	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	
8b	hardbottom	0	10	0	20	5	0	0	0	0	0	0	0	10	0	5	0	0	0	0	50	mid-channel
9	mud/rock	0	15	0	15	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	60	
10	mud	5	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	
11	mud	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	
13	mud	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	
14	mud	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
15	mud	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
17	mud	0	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	
18	mud	10	20	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	
18b	hardbottom	30	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	mid-channel
19	mud	30	10	0	0	30	0	3	0	0	0	0	0	3	0	0	0	0	0	0	24	
20	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	90	
21	mud	10	10	0	10	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	
22	mud	60	37	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
23	mud	20	30	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	
24	mud	0	50	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	50	
25	hardbottom	0	20	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	74	
26	mud	20	30	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	40	
27	mud	0	0	0	10	0	0	5	0	0	2	0	0	0	0	3	0	0	0	0	80	
28	sand/mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	
29	sand/mud	90	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
30	sand/mud	90	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
31	hardbottom	0	0	0	0	10	0	0	0	0	<1	0	0	5	0	20	5	0	0	0	60	
32		n/a - poor visibility/deep																				
33	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	
34	mud	90	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	
35	sand	50	40	0	0	1	0	0	0	0	0	1	1	0	0	0	1	1	0	0	5	
36	sand/hardbottom	50	5	0	10	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	15	
37	sand/hardbottom	50	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	20	
38	mud	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
39	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	
40	mud	0	30	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	
41	mud	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	
61	mud	60	20	0	10	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	no fish data
62	mud/hardbottom	0	30	0	10	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	45	no fish data
63	mud	50	0	0	0	10	0	0	0	0	0	0	0	0	1	0	0	0	0	30	9	other = detritus
64	mud	0	20	0	10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	69	
65	mud	5	20	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	
66	mud/hardbottom	20	0	0	0	1	0	1	0	0	0	0	0	0	0	10	2	2	2	0	62	
68	sand/mud	90	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	
70	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	
73	mud	20	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	77	
74	mud	80	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	
75	mud	80	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
76	mud	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95	
78	mud/hardbottom	70	5	0	0	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9	
79	mud	15	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	75	
X	mud	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	

Figures

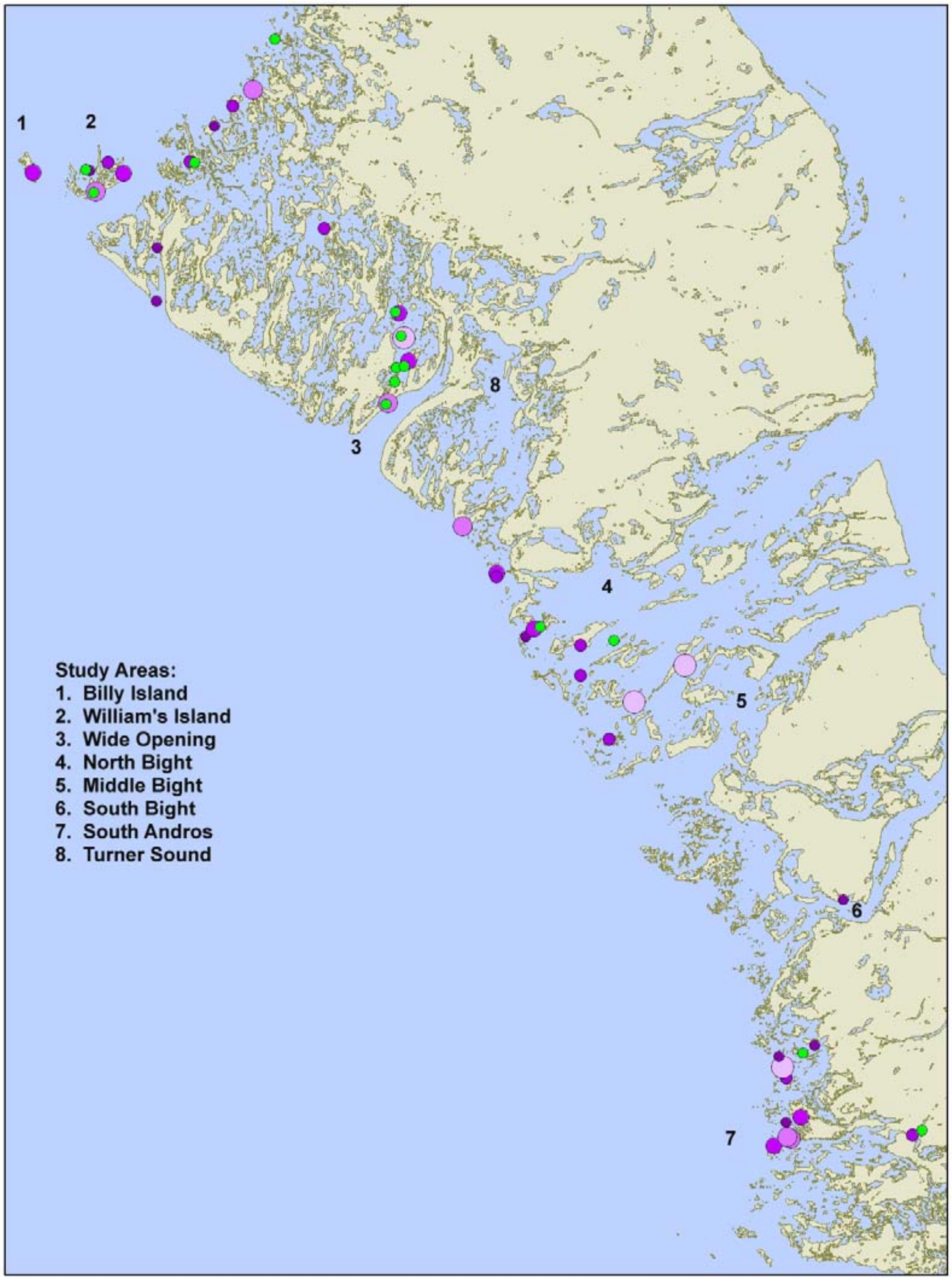


Figure 1. Map of study sites where quantitative fish and benthic surveys were conducted in mangrove creeks. Green circles represent sites with dwarf mangroves. Purple circles represent tall mangrove sites with the size and shading of the circle representing relative fish biomass at the site (lighter and larger circles = higher biomass).

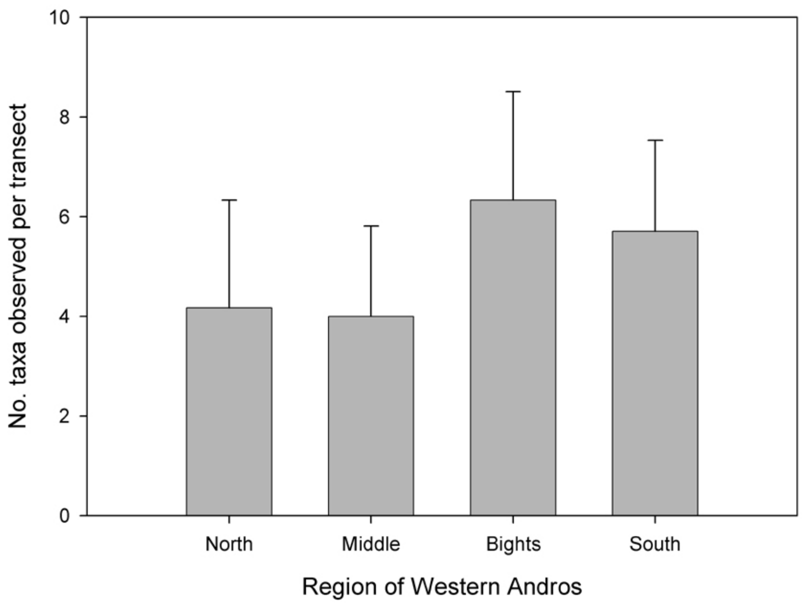


Figure 2. Mean species richness for tall mangrove sites on western Andros, grouped by region. North sites include all tall mangrove sites north of the westernmost point of Andros. Middle sites include all sites between the westernmost point of Andros and North Bight. The Bights include sites in North, Middle and South Bight. South Andros includes all sites south of South Bight. Dwarf mangrove sites are not included since their species richness was low throughout western Andros.

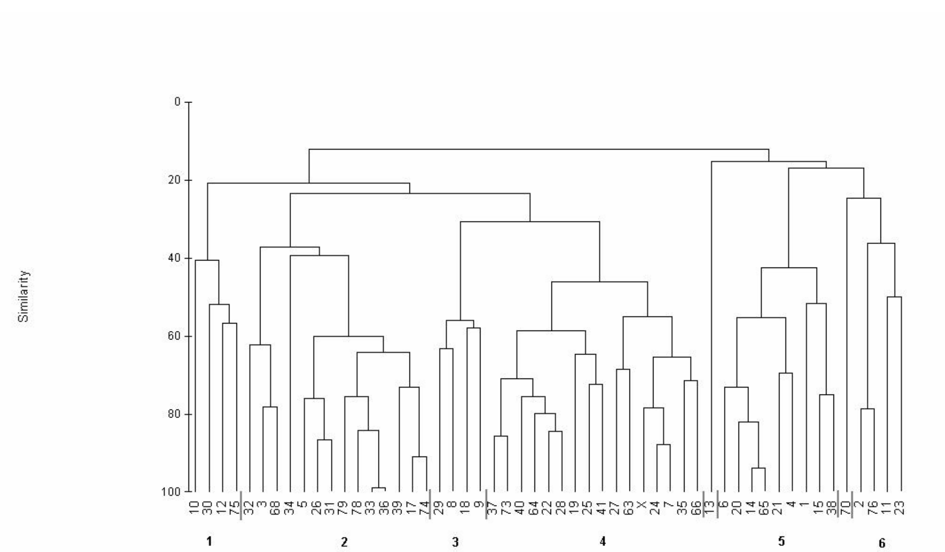


Figure 3. Cluster diagram using Bray-Curtis Similarity index to determine similarity in fish assemblages among sites. Site numbers are listed in the top row of the horizontal axis and groupings are marked by a line separating site numbers. Groupings (1-6) based on similarity >25% are listed under site numbers.

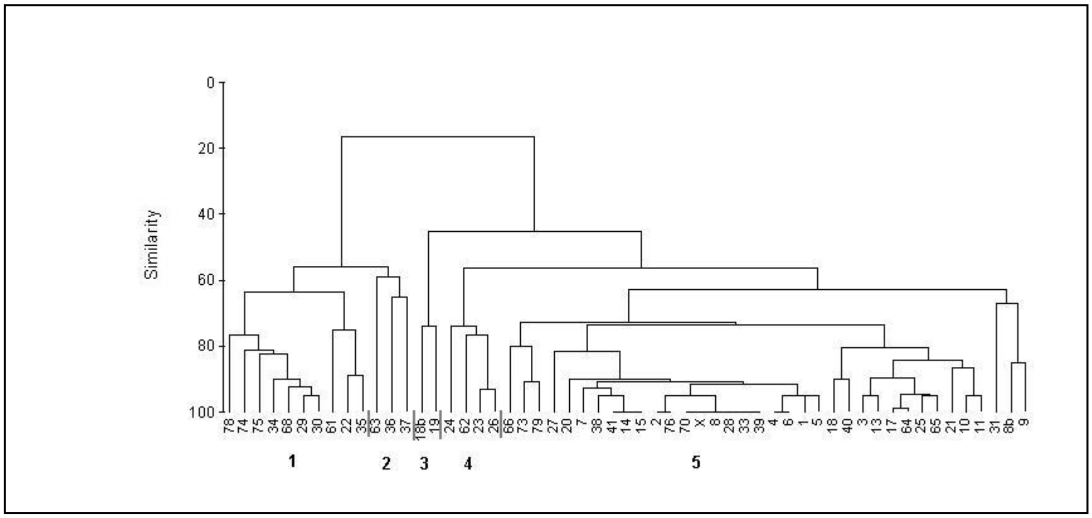
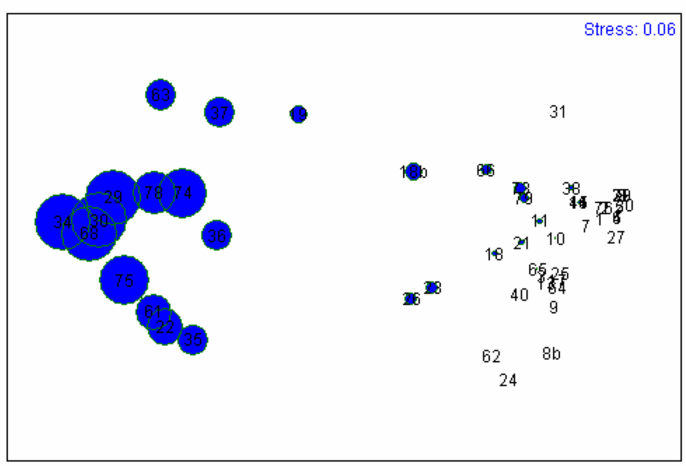
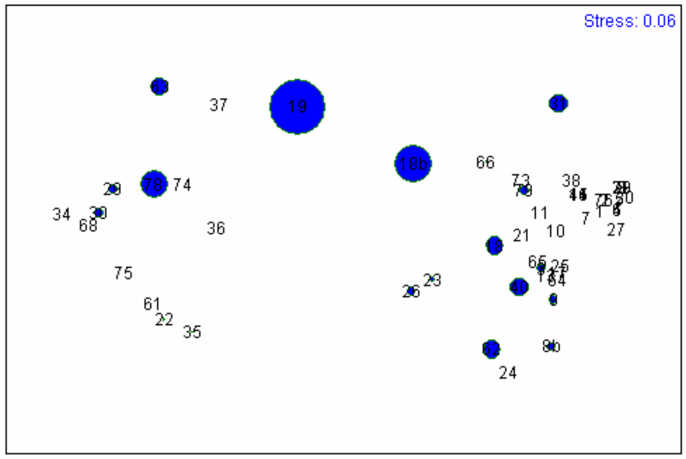


Figure 4. Cluster diagram using Bray-Curtis Similarity index to determine similarity in benthic assemblages among sites. Site numbers are listed in the top row of the horizontal axis and groupings are marked by a line separating site numbers. Groupings (1-5) based on similarity >50% are listed under site numbers.



A.



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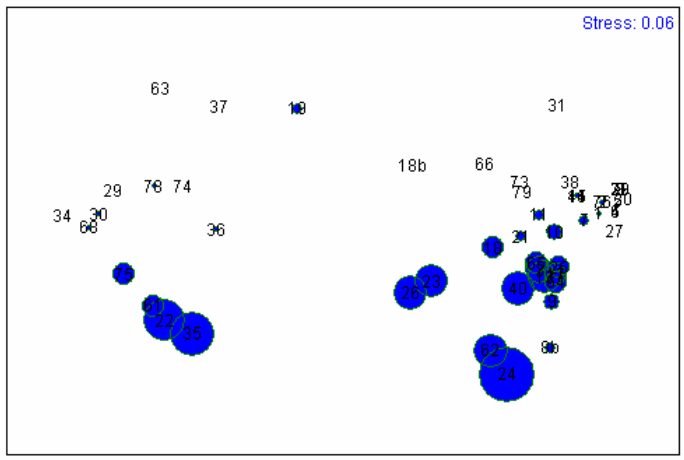

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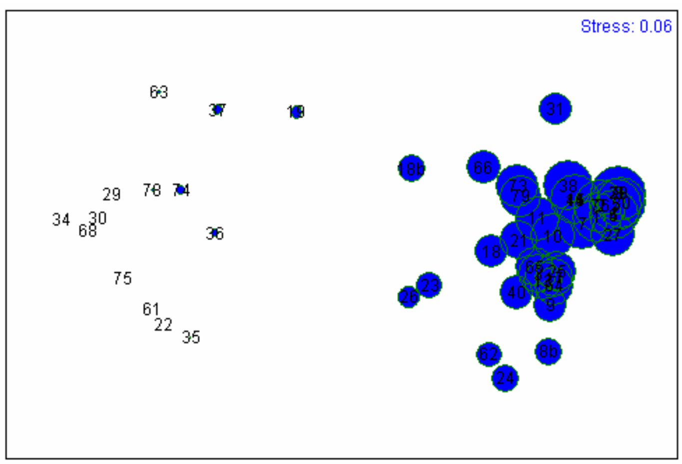

D.

Figure 5. Multidimensional scaling plot of benthic assemblages among sites. All plots show the same sites (site numbers shown) with sites that are more similar spaced close together having greater similarity in benthic assemblages than those spaced farther apart. To help interpret how benthic assemblages differ among sites (and clusters of sites as determined in Figure 4) circles in each plot show the relative percent cover of (A) Thalassia; (B) Halodule; (C) Laurencia; and (D) Bare substrate at each site.

Relating Fish Abundance and Diversity to Mangrove Characteristics

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Introduction

Available conservation resources, at both global and regional scales, are insufficient to completely protect every threatened landscape/seascape or species. As such, a thorough understanding of trade-offs inherent in conservation programs is always essential. For example, when designing conservation strategies for extremely large areas, logistical constraints render it impossible to completely survey the entire area of the landscape/seascape of interest. Developing approaches that can simplify identification of critical areas within a larger landscape/seascape is very useful to guide effective conservation and management strategies.

For example, the West Side of Andros is a vast area in which a complete survey of every fish, turtle, sponge, or seagrass bed is impossible. To this end, identifying landscape/seascape features that can help guide conservation priorities can be extremely useful in developing a conservation strategy. The central objective of this phase of the Rapid Ecological Assessment was to:

Attempt to link one aspect of local fauna (abundance of fishes) to readily observable characteristics (e.g., height, coverage) of the dominant vegetation (red mangrove), and to assess whether patterns at a relatively small-scale can be linked to landscape-scale patterns recognizable from satellite imagery.

If this relationship can be demonstrated, conservation targets at a local scale may be identified using landscape-scale approaches. As such, conservation resources can be allocated to other activities (e.g., developing monitoring strategies, building public support for initiatives, political lobbying) and not exhausted on surveys of faunal and floral resources.

In Figure 1, we outline the steps necessary to make the link from local assemblage composition (e.g., abundance of fishes) to the landscape-scale characteristics. This served as the framework for the actions carried out in this component of the REA. This series of steps implies a set of hypotheses that provided the framework for this study. We tested each linkage separately, and then analyzed whether fish abundance could be linked directly to the percent cover of mangroves – a feature that can be analyzed at a landscape scale. Then, using these findings, we suggest the "hotspots" of fish abundance that should be an important part of protected marine areas of West Andros.

Methods

Fish surveys were conducted as described in the previous chapter, i.e. based on 30m transects conducted along the mangrove fringes of creek banks. In this analysis, we focused mainly on biomass data, as we observed little variation in species richness across the survey sites (see previous chapter). Along each 30m transect, the "water depth" variable was calculated as the mean depth of water at 0, 15, and 30m. Maximum height of mangroves along the 30m transect was determined using a telescopic measuring pole.

Height was measured either to the ground or creek bottom, dependent over which area the highest mangrove branch was located. Percent cover of mangroves was determined by taking a digital photo of the canopy from 1m height above the ground/creek bottom (2m in from the outer edge of the mangrove fringe). The camera was oriented parallel to the ground/creek bottom so that the photo was taken directly vertical through the mangrove canopy. Percent cover was estimated by dividing the digital image into 100 equally sized squares and estimating the mangrove coverage within each square as 0%, 50%, or 100% covered. The hundred squares were summed for the total percent cover. Pictures were taken at 0, 15, and 30m along the transect, and the mean value of the three were used in analyses.

Results and Discussion

As was reported in the previous chapter, there was no obvious longitudinal pattern of fish biomass from the northern to southern extent of West Andros (Fig. 2). This suggested that local factors may be driving the abundance of fish at the particular survey sites, and our data support this hypothesis. There was a significant correlation between fish abundance and water depth, water and mangrove height, and mangrove height and mangrove canopy cover (Figure 3, all at a level of $P < 0.001$). Most importantly, there was significant correlation between the fish biomass at a survey site and the percent cover of the mangrove canopy. Since there are at least two levels at which mangrove vegetation can be distinguished from satellite imagery (i.e., "dwarf" vs. "tall mangrove" areas), our data strongly suggest that the "hotspots" of fish biomass are found adjacent to the "tall" mangrove stands. The Nature Conservancy is currently conducting a detailed analysis of Andros Island satellite imagery, and eventually will be able to identify all tall mangrove areas on West Andros. But even with a preliminary visual inspection of satellite imagery, tall (and thick) mangrove stands can be identified readily from satellite images. These are typically found in one of two places: at the mouths of creeks alongside deep channels and mangrove islands in the interior of creeks. As an example, the highest biomass (~1.5lbs of fish/m^2) was observed at an island area of tall mangroves readily identifiable from satellite imagery near the mouth of Chalk's Sound. This site had a percent cover estimate of 74%, one of the higher percent covers calculated.

It is important to note that these data are relevant to those demersal fish species that utilize mangroves as fish habitat, mainly snappers, grunts, and barracuda on West Andros. Additional information is necessary to identify critical habitat areas for more motile fish (e.g., bonefish, tarpon) and/or those that may have very specific habitat requirements (e.g., sawfish, bull sharks). But because many of the areas identified below are consistent with conservation priorities for other reasons (sea turtles, benthic habitat quality), these data provide an important complement to other sections of this REA.

Recommendations

These data suggest that satellite imagery, in conjunction with our supporting data, can be used to identify "hotspots" of demersal fish abundance.

- Tall/thick mangrove areas support orders of magnitude more biomass than dwarf mangroves, and are thus of up most importance as conservation targets.

- Tall/thick mangroves encompass far less area (<5% of total mangrove extent) than dwarf mangroves, so these areas should be preferentially considered when developing priorities for conservation.
- Tall/think mangrove areas are found primary at the mouths of creeks, especially ones with well-defined channels, and at various island sites in creeks interior sites.
- These sites, readily identifiable from satellite imagery, should be identified and given preferential consideration for protection.
- More specifically, these creek systems have significant areas of tall mangrove. At least 50% of these should be protected in any management plan:

Big Loggerhead	Spanish Wells
Billy's Creek	Timbler Creek
Chalk's Sound	Whale's Creek
Cut-off Creek	William's Creek
Little Loggerhead	Various sites on Southern Andros

Figures

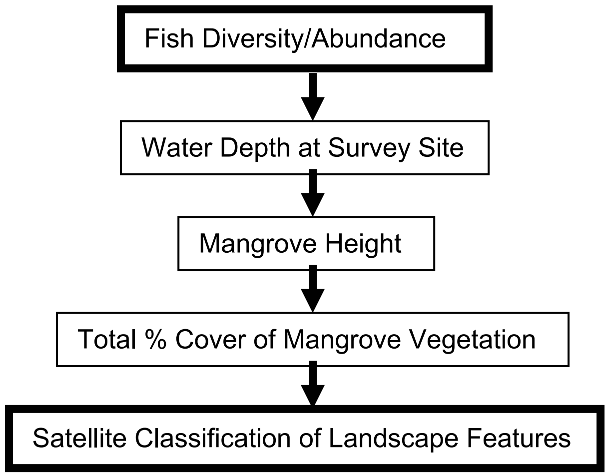

Figure 1. Steps involved in this phase of the West Side REA, linking local faunal characteristics to landscape-scale features.

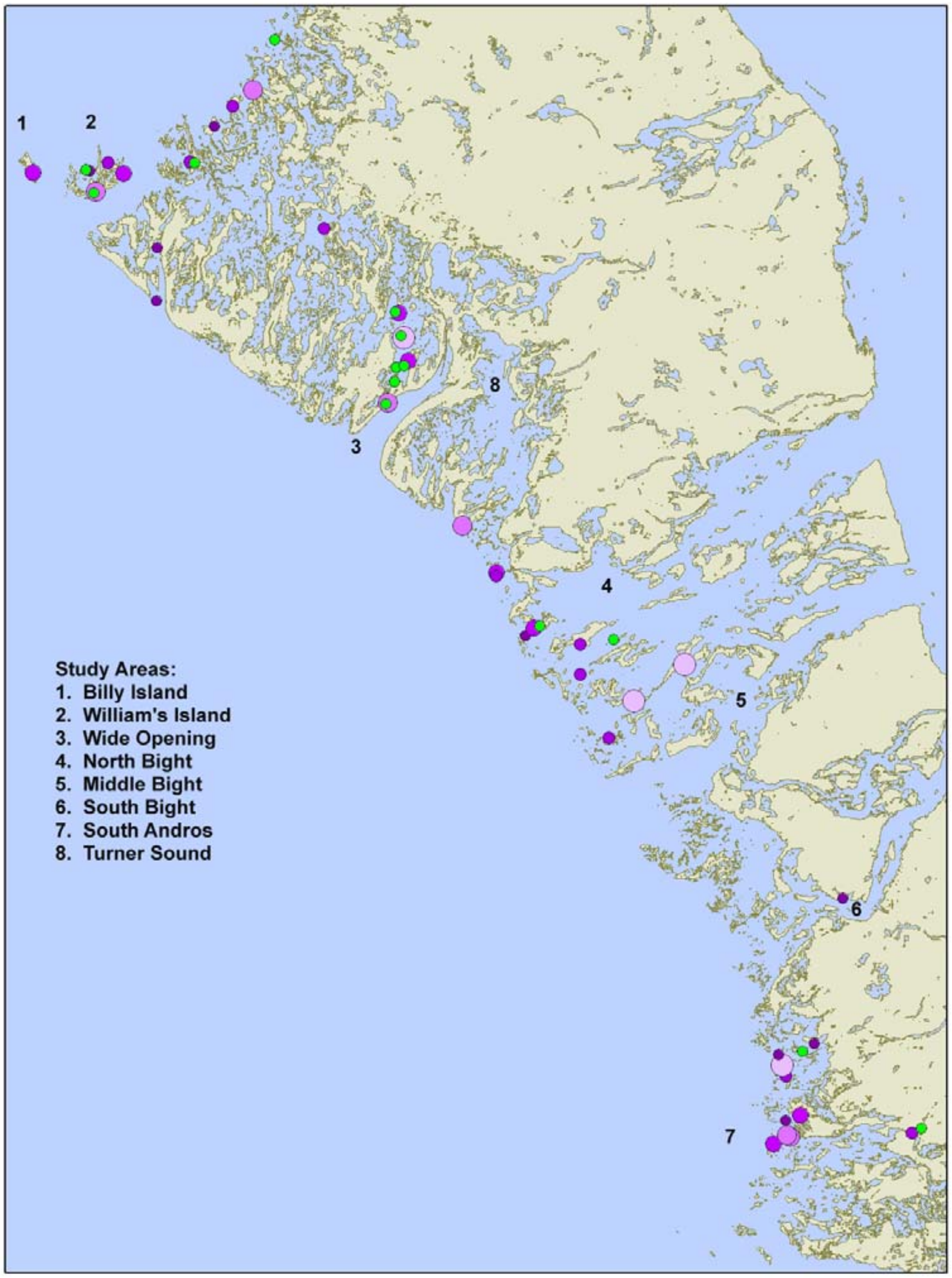

Figure 2. Map of study sites where quantitative fish surveys were conducted in mangrove creeks. Green circles represent sites with dwarf mangroves. Purple circles represent tall mangrove sites with the size and shading of the circle representing relative fish biomass at the site (lighter and larger circles = higher biomass).

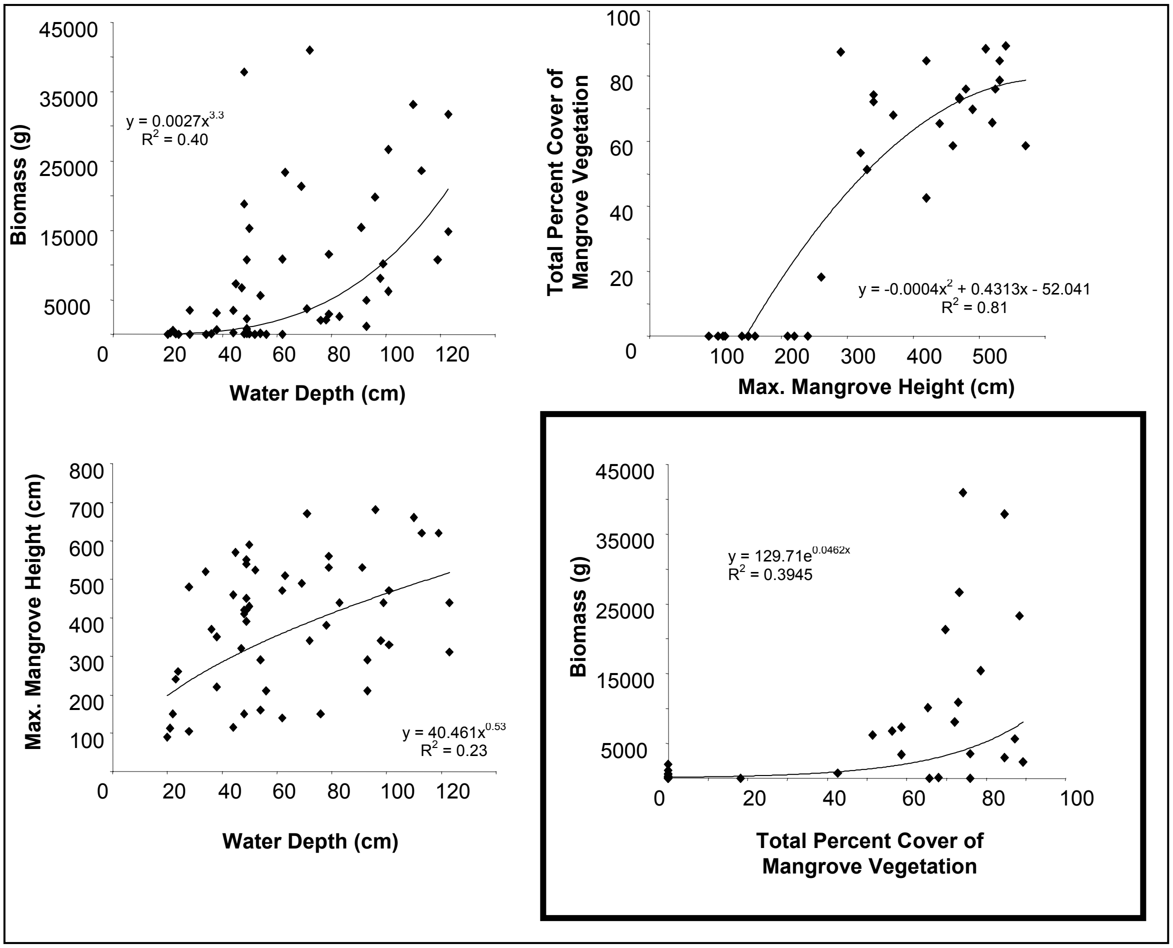

Figure 3. Regressions of the primary variables measured in this study. The lower right hand figure represents the link from a local scale variable of ecological importance (fish biomass) to vegetation characteristic that be detected at a landscape scale. As such, identifying areas of dense mangrove coverage will facilitate identification specific "hotspots" of fish abundance.

Bonefish and Tarpon

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Introduction

The overall goal of this project was to conduct a Rapid Ecological Assessment (REA) of bonefish populations on the west side of Andros. Despite the bonefish fishery being primarily catch-and-release, numerous anthropogenic activities in the future may threaten bonefish populations, so basic ecological information is needed to formulate responsible management plans. This report summarizes the need for this information, the methods used during the REA, and recommendations for conservation and management of bonefish on West Andros to ensure a sustainable fishery.

Despite their economic importance, little is known about bonefish ecology. A further challenge to effective conservation and management is that there are two species of bonefish that may be found in shallow waters of the Caribbean and Western Atlantic. Until 2001, there was thought to be only one species of shallow water bonefish in the Caribbean and Western Atlantic – *Albula vulpes*. Genetic analysis, however, revealed a second, morphologically nearly identical species, presently identified as *Albula* species B (commonly referred to as *Albula garcia*). Effective management requires knowledge of which species comprise the fishery. Therefore, one goal of this REA was to determine which species of bonefish occurs on West Andros.

A second item of concern is lack of knowledge of the bonefish life cycle. (Since all bonefish on West Andros were genetically identified as *Albula vulpes*, all remaining references to bonefish will be for *Albula vulpes*.) Although we have enough information to paint a general picture of bonefish life history, we lack the specifics needed for effective conservation and management. Histological data indicate spawning occurs November through May. Spawning dates estimated from larval ages suggest that bonefish spawn around the full moon, and capture of young larvae offshore suggests spawning occurs in deeper water outside the typical recreational fishing grounds. However, there are no published observations of spawning bonefish.

After hatching, bonefish leptocephalus larvae remain in the plankton between 41 and 71 days before migrating into shallow coastal habitats during nights near the new moon. Bonefish larvae are able to tolerate a wide range of salinity and dissolved oxygen conditions, but may be susceptible to hypoxia during metamorphosis (an 8 - 12 day process). These environmental requirements are important to consider when identifying possible post-settlement and juvenile habitats.

Habitat use by juvenile bonefish remains unknown. Sampling in the Florida Keys in the 1990s and from 2004 – 2006, and in Belize in 2003 and 2005, captured numerous juvenile bonefish along shallow sandy beaches, but genetic analysis revealed that 97% of these juveniles were Albula species B. Therefore, juvenile Albula vulpes habitats remain unknown. This is especially disconcerting because loss or degradation of juvenile habitats can lead to population declines. Identification of juvenile habitats is necessary for proactive management and conservation.

Information on growth rates of bonefish and of the age structure of the population allows estimation of the overall health of the population. Most published research on adult bonefish has been conducted in the Florida Keys, but recent research in non-Florida Caribbean locations suggests that the Florida Keys results may not be applicable to non-Florida bonefish. For example, growth rates of Florida Keys bonefish appear to be two to three times faster than bonefish in Caribbean locations, so the length-age equations used to estimate the age structure of the Florida Keys fishery may not be applicable in other locations. Therefore, it is necessary to validate the growth rates of bonefish on West Andros prior to estimating the ages of fish captured in the fishery.

Little information on bonefish diet exists. In Grand Bahama and Puerto Rico, bivalves dominated the diet, followed by crustaceans, whereas the diet in the Florida Keys was dominated by crustaceans and a teleost. In Grand Bahama, species composition of bonefish diet differed between seagrass and open sand habitats, with bivalves most common in open sand habitats. The Florida Keys study also found a difference in diet with bonefish size, indicating an ontogenetic diet shift, but these size-specific data were not available from the Grand Bahama study. Given that bonefish require multiple habitats during their life cycle, prey availability is likely an important component of habitat quality. Since anthropogenic changes to habitats (e.g., changes in salinity resulting from water withdraws) can greatly influence the number of prey eaten by bonefish, knowledge of prey eaten by bonefish of different ages is important information for management.

Objectives

I: Provide an estimate of the general spatial distribution of bonefish on West Andros
II: Provide estimates of adult bonefish habitat use patterns by habitat type
III: Determine habitat types used by juvenile bonefish
IV: Describe characteristics of bonefish populations, including age structure, and age length and length-weight relationships
V: Genetics: confirm, through genetic testing, that bonefish on West Andros are *Albula vulpes*.
VI: Provide rough estimates of adult bonefish diet via stomach content analysis
VII: Estimate adult bonefish prey availability via sampling of infauna of selected adult bonefish habitats

Methods

The estimate of general spatial distribution of bonefish on West Andros (Objective I) was generated from interviews and discussions with guides during pre-REA meetings, during the REA, and by observations and sampling during the REA. This information showed where guides fish with clients, as well as allowed estimation of general patterns of bonefish habitat use. This approach follows procedures used at Turneffe Atoll, Belize. The pre-REA discussions also helped to pinpoint locations for the most efficient targeted sampling of adults during the REA.

Because bonefish are most often encountered in groups, and their distribution is patchy, temporally variable, and tidally influenced, catches of bonefish of all life stages can be highly variable. Therefore, sampling effort was targeted at locations most likely to contain bonefish.

The viscous muddy sediments of West Andros prevented using a seine for sampling shoreline and backwater habitats for small juvenile bonefish (as originally proposed). This sediment type clogs the small mesh (3 mm) of the seine, quickly filling the net with mud and making it impossible to pull the seine. Instead, visual surveys of backwater habitats were conducted by poling or idling a flats boat through the shallows.

Large juvenile, sub-adult and adult bonefish were captured with hook and line and with a gill net. For large juveniles and sub-adults, areas of mudding fish were targeted. Sub-adults and adults were targeted in locations frequented by guides. Hook and line was used to sample sub-adult and adult bonefish from exposed and protected flats, creeks, creek mouths, and deep sandy bottoms. All captured bonefish were measured (fork length) and weighed, and a fin clip taken for later genetic analysis. A sub-sample of fish was permanently retained for otolith extraction (for aging) and stomach content analysis. Individuals representative of all size groups captured were retained to ensure all age classes were sampled. Date, time, latitude, and longitude were recorded for each sample.

All fin clips were placed in vials containing Puregene Lysis solution, and were shipped to the Molecular Genetics Laboratory at the Florida Fish and Wildlife Institute in St. Petersburg, FL, for analysis. Otoliths were cleaned in seawater while on Andros, placed in individual plastic bags, and returned to Mote Marine Laboratory for analysis. Otoliths were sectioned, mounted, and read (annuli counted) with a compound microscope at Mote Marine Laboratory to estimate fish age. Length and age data were used to estimate a von Bertallanfy growth equation, and to compare growth rates with findings from the Florida Keys, other Caribbean islands, and other islands in the Bahamas (Exuma, Eleuthera). Length and weight data were used to generate a length-weight curve so that anglers can estimate the weight of their fish based on length measurements.

Stomach contents of collected adult bonefish were processed the day of collection. Prey items in the stomach were identified to the lowest possible taxon. Diet was calculated based on number of items and percent abundance, and examined by bonefish size to test for ontogenetic changes in diet.

Benthic infauna were sampled at three locations (upper, middle, lower) along the northern and southern shorelines of Wide Opening from the upper end to the mouth, and one location each approximately 1km north and south of the mouth. Bonefish were observed at all sample locations. A shovel was used to dig approximately 5cm depth x ¼ m^2 amount of sediment (area marked by a pvc quadrat), which was sorted through a 3mm mesh sieve. Individual sample locations were haphazardly located by throwing the quadrats from a drifting boat. Ten samples per site were taken. Soft-bodied organisms were counted on site. Bivalve and gastropod shells were identified, sorted and counted at Mote Marine Laboratory.

Results

The findings of the REA provide information on the West Andros bonefish population that is essential to formulation of a comprehensive management plan. The findings point to the need for habitat protections to ensure the long-term sustainability of bonefish and the economically important fishery they support.

<u>Species Identification</u>

Fin clip samples were taken from 71 bonefish during the REA. All were genetically identified as *Albula vulpes*. Thus, based on the REA, *Albula* species B does not occur in West Andros so does not need to be considered in management plans.

<u>Spatial Distribution</u>

Perhaps resulting from the combination of the bonefish life cycle and the unique geography of West Andros, bonefish exhibited a distinct pattern of spatial distribution that indicated ontogenetic habitat shifts. Within the sample area from Cabbage Creek to XX creek (Figure 1), the general pattern was that smaller fish were limited to upper reaches of the creeks and associated shallow backcountry, and larger fish were most common at creek mouths and adjacent areas.

Juvenile bonefish (< 200mm Fork Length (FL)) were observed only in the upper reaches of tidal creeks and shallow backcountry areas. No fish of this size were captured with hook and line. Most of these habitats were estuarine, with salinities 25ppt and lower. Juveniles were present in these habitats at all tide stages sampled, and appeared to school in submerged depressions during low tide rather than exit the shallow backcountry habitats. Nonetheless, foraging seemed related to tidal stage, with most feeding observed at higher water when the fish were not restricted to the depressions. The smallest juveniles observed (≤ 100mm) were in a closely packed school of approximately 50 individuals moving along a mangrove shoreline. Otherwise, large juveniles and sub-adults in backcountry areas were generally in small, loosely associated groups. The lack of schooling behavior was probably in response to an overall lack of predators in these habitats. The few juvenile sharks that were observed in these shallow habitats were only present in the few hours before and after high tide, and did not exhibit any behavior indicating stalking or pursuit of juvenile bonefish.

Sub-adult bonefish (200 – 350 mm FL) in this region were generally limited to creek habitats, but with a considerably larger range than juveniles. Sub-adults were present from upper reaches of tidal creeks through middle portions of the creeks, their movements up and down the creeks apparently related to tidal stage – they were in greatest abundance in upper creek habitats near high tide, and slowly moved out of the creeks with the ebbing tide. In upper creek habitats sub-adults were present equally as loosely associated aggregations of up to 15 fish and as lone individuals. In contrast, when in middle creek areas, they were mostly in groups.

Adult bonefish were present in the middle sections of the creeks near high tide, but were most abundant in the lower portions of the creeks and in habitats (flooded mangroves, mud flats) near the creek mouths. They were not observed in shallow backcountry habitats. Adult bonefish were observed traveling as lone individuals or in small loosely associated groups of < 10 fish.

In contrast to the creeks, different patterns were observed in North Bight. No juveniles were observed – the smallest fish observed or sampled was 250mm FL. The shallow backcountry embayments that might have held small juveniles were not accessible. Sub-adults were observed in large schools over soft bottom in water 1 – 2m depth. The locations of these schools were indicated by the presence of large plumes of suspended sediment (commonly referred to as 'muds'), purportedly caused by the bonefish stirring up sediment as they searched for food in the soft bottom. All fish captured from muds were between 250mm and 300mm FL. Adults were observed as lone fish or in small groups (≤ 5 fish) in shallow bays with sparse seagrass and along mangrove shorelines within North Bight.

Size, Age and Growth

Seventy bonefish captured ranged from 250mm to 580mm FL, of which a representative sample of 37 fish was retained for age analysis (Figure 2). In addition to those captured, fish smaller (100mm FL) and larger (> 650mm FL) were observed during sampling. Nonetheless, the size range captured and sampled for age analysis accurately reflects the dominant portion of the population of West Andros. Based upon captures and observations, the average length of West Andros bonefish was 400mm, and the population was dominated by fish between 350mm and 450mm ((0.7 – 1.8Kg). Although larger fish are relatively abundant compared to other locations, the size of the typical bonefish in the fishery is similar to many other islands in the Bahamas. The relationship between fish length and weight was not significantly different from estimates for Florida Keys bonefish (Figure 3).

Growth rates as determined by otolith analysis were highly variable, but lengths by age were most similar to findings from Caribbean islands (Figure 4). Slower growth rates may be, in part, associated with earlier maturity. Estimates of size at maturity suggest that slower growth rates may be the norm in the West Andros population – estimated size at maturity for West Andros fish was 350mm FL. This is in contrast to 50% maturity at 418mm (males) and 488mm (females) in the Florida Keys, but in agreement with smaller size at maturity for Caribbean bonefish (a gravid female 342mm FL was collected at Little Cayman, Cayman Islands).

Diet

Stomach contents of 37 bonefish were examined. Twenty-eight stomachs contained identifiable food items, and 9 stomachs were empty. Size of fish analyzed for stomach contents ranged from 250 – 580mm FL (mean = 395mm), thus encompassing the size range of bonefish captured and the majority of the size range of bonefish observed. When examined by bonefish size, an ontogenetic shift in diet was evident (Table 1). This diet shift partly reflected the abovementioned ontogenetic shift in habitat use. Bonefish < 400mm FL (n = 17) ate primarily polychaetes and bivalves. The high frequency of stomachs with sediment reflects the foraging behavior for these prey – large amounts of sediment are incidentally ingested when infaunal organisms such as polychaetes and bivalves are eaten. In contrast, the diet of fish ≥ 400 mm FL (n = 20) was dominated by crustaceans, and polychaetes and bivalves were in relatively low abundance. Portunid crabs were by far the most abundant and frequent prey item of bonefish ≥ 400mm, followed by frequently occurring walking crabs and peneaid shrimp. A similar shift in diet was observed by researchers in the Florida Keys, but in that study the primary shift was for larger fish to rely more upon teleost prey (toadfish, *Opsanus beta*). During the REA, no teleosts were found in bonefish stomachs, but the aggressive response of large bonefish to live mojarra (genus *Eucinostomus*) used as bait indicates that fish are likely important prey to large bonefish.

Benthic Infauna Sampling

The extent to which bonefish diet reflected prey availability vs. ontogenetic differences for small fish is unclear. The most abundant items in small bonefish stomachs were polychaetes and small bivalves, and these were the most abundant items in infaunal surveys. Although not as abundant, crustaceans were also present in upper creek and backcountry areas, but were relatively rare in small bonefish stomachs. This may be an artifact of small sample size, but also might indicate an integration of habitat and prey in ontogenetic requirements of small bonefishes. In contrast, although they also had ample opportunity to feed on polychaetes and bivalves, larger fish clearly preferred crustaceans. The mobile crustaceans preferred by large bonefish were not sampled by the infauna sampling procedures used in this study.

Eighty samples were collected over six locations along Wide Opening – one site on the east side and one on the west side of the creek at an upper, middle, and lower station. Bivalves dominated in the upper sites, and bivalves and gastropods were both common in the middle sites. Despite being an important component of small bonefish diet, polychaetes were present only in lower sites, and were dominant in these sites. Far more polychaete holes were observed than polychaetes were found at the upper and middle sites, probably because the burrows extended below the area sampled by the shovel. That most polychaetes were collected as partial animals (i.e., cut by the shovel blade) supports this assumption. The outer sites were dominated by gastropods. Overall, few live bivalves and gastropods were found, so whole shells were used as a proxy for bivalve abundance. Despite the abundance of gastropod shells, gastropods did not appear in bonefish stomachs.

Recommendations

The complex life histories and variety of habitats used by bonefish makes management focused solely on bonefish unrealistic. Instead, an ecosystem approach, whereby the habitat mosaics that encompass the bonefish life cycle are protected, should be the center of an appropriate conservation plan. The following recommendations follow this approach, and suggest that a large-scale habitat conservation strategy is required to ensure the long-term sustainability of West Andros bonefish.

The shallow, protected, soft-bottom embayments (i.e., backcountry) at the upper portions of creeks from Cabbage Creek northward to Timber Creek should be provided protection as important juvenile bonefish habitats. It appears that this backcountry provides juvenile bonefish protection from predation: few predators were observed in these habitats; the predators that were observed were present only near high tide (thus limiting their impact); and the behavior of juvenile and sub-adult bonefish in these habitats (from single fish to small, loosely associated schools) indicated a lack of predators. These habitats also provide the prey that is needed by juvenile and sub-adult bonefish – primarily polychaetes, bivalves, and other infauna.

Although overfishing is often blamed for declines in fish populations and for the inability of many of these populations to recover, it is becoming increasingly apparent that anthropogenic changes to habitats may be equally to blame. This is especially true for species whose juvenile habitats are impacted by anthropogenic habitat alterations. While no obvious immediate threats to juvenile bonefish habitats on West Andros are apparent, a precautionary approach (i.e., proactive habitat protection) is recommended. Such a proactive approach is especially prudent for bonefish, a long-lived species with a long adult stage. If juvenile habitats are lost or degraded, and the number of juveniles that survive to adulthood declines, it may be years before these losses are detected. This is because of a phenomenon called the storage effect, whereby adult populations of long-lived species can remain stable, or decline slowly, over time, even when few young fish are entering the adult population. Thus, even as the population size remains relatively stable, the population is aging. In a worst case scenario, population size remains relatively stable until older fish begin to die off, and the population declines rapidly because there are so few younger fish. By the time the problem is identified, the damage has already been done, and recovery is difficult. This is one of the possible causes of the apparent decline in bonefish populations in the Florida Keys.

The creeks also appear to provide transition habitat for sub-adult fish shifting from juvenile habitat (backcountry, upper creeks) to adult habitat (lower creeks and adjacent areas) and diet requirements. This size class of fish is likely able to avoid many of the predators they encounter in the creeks, so they can take advantage of a larger area to forage. Adult bonefish continue to use creek habitats, but appear to be mostly limited to the lower portions of the creeks. Adults were also the only age class of bonefish observed in habitats outside creeks (primarily mud flats along the western shoreline). Given the importance of the entire creek systems to multiple bonefish life stages, the entire creek habitats should be protected.

Protective measures should not address only direct habitat alteration (e.g., dredging, filling of wetlands, shoreline development), but should also include protections against alteration of the hydrodynamic patterns that characterize this area. Anthropogenic alterations of freshwater flows into estuaries impact estuarine ecology. Freshwater flow is a major ecological structuring factor in estuaries, influencing abundance and distributions of vegetation, and of invertebrates and vertebrates that use estuaries for some or all of their life cycles. This includes bonefish and their prey. Any changes in the source, timing, and velocity of freshwater flows influences salinity patterns, which in turn alters habitat use patterns by marine organisms. This is especially true for sedentary organisms such as bivalves. Given the apparent dependence of juvenile and sub-adult bonefish on these creek systems (low predation, plenty of food), any change in their habitat use patterns may cause declines in survival.

Although West Andros has low diversity of marine organisms, it is a highly productive system. This high productivity, even with low habitat diversity, probably results from the estuarine character of the creek habitats – higher system productivity is possible even without the high primary production from seagrass beds. The high productivity is essential for bonefish. For example, the juvenile life stages of portunid crabs and penaeid shrimp, both important prey for adult bonefish, require estuarine habitats. Thus, any alterations of the freshwater flows that impact these estuarine characteristics of the creeks will impact the entire system.

That the West Andros marine ecosystem is low diversity is also cause for a proactive approach. It can be argued that a more diverse system is more resistant to stress such as habitat loss, degradation, or overfishing. Since there are numerous species that fulfill similar ecological roles (e.g., detritivores) in diverse systems, loss of one species can be compensated by numerous other species. In a low diversity system such as West Andros, loss of one species might have large-scale impacts. For example, given the preponderance of bivalves in the diet of small bonefish, would small bonefish find sufficient prey if changes in salinity characteristics of the upper creeks caused severe declines in bivalve abundance?

The size and age structure of the bonefish population on West Andros, and growth rates and length-weight relationship, all indicate that the West Andros bonefish population is strong. Growth rates similar to those observed in Caribbean islands (i.e., slower than the Florida Keys), indicates the dominant size classes are sub-adults and young mature adults, and that sufficient larger fish are present to indicate consistent recruitment from juvenile habitats. Although there appear to be no problems with the current bonefish population, the proactive approach is to maintain the fishery as catch and release until complete population-level data have been collected.

During the REA, numerous guides described seasonal movements of schools of large bonefish that suggested spawning migrations might take place along West Andros. The popular thought is that adult bonefish migrate southward from West Andros, eastward through North Bight, and then to a location outside the reef on the east side of Andros. Although no immediate threats to migrating and spawning bonefish on Andros are evident, information on spawning is essential to proactive management. Given the large number of bonefish in West Andros, and the apparent migration of large numbers of adults for West Andros to possible spawning locations off the eastern shoreline, it is possible that West Andros supports adult bonefish that are essential to the bonefish population throughout Andros. If this is the case, then any negative impacts to West Andros could have implications throughout Andros.

Spawning aggregations are especially susceptible to overfishing because there are so many large fish gathered in one place. For some tropical species, such as Nassau Grouper (*Epinephelus striatus*), fishing of the spawning aggregations has caused complete collapse of the fishery in most locations in the Caribbean. For example, in the U.S. Virgin Islands, spawning aggregations were fished to such an extreme that the species is now considered 'fisheries extinct' (i.e., too few fish remain to warrant fishing effort), and the fishery has been closed indefinitely. Over a decade after the fishery closure, the abundance of Nassau Grouper has not increased. Similar problems are occurring for bonefish species on some Pacific islands where spawning aggregations are targeted by the local fisheries. Since spawning aggregations often attract adult fish from a large geographic area, fishing pressure on these aggregations and the associated migrations can have wide-reaching impacts. In addition, habitat degradation and declines in water quality can negatively impact spawning locations. Thus, identifying bonefish spawning sites is important for proactive management and conservation.

Summary of Recommendations:

- Shallow backcountry areas should be protected as important juvenile bonefish habitats

- Creeks along West Andros, from Cabbage Creek to Timber Creek should be protected as sub-adult and young adult habitats.

- Creek mouths and adjacent bottoms should be protected as adult bonefish habitats

- Protections should include prohibition of direct habitat impacts (e.g., dredging, shoreline development) as well as alterations of freshwater flow patterns
    - This may involve management of the freshwater lens
    - Protections are for bonefish as well as their prey and habitats

- At present the bonefish population of West Andros appears to be in good condition, and the bonefish fishery should remain catch and release to ensure it remains strong.

- Indications are that West Andros may be important habitat for bonefish that migrate to the eastern shoreline of Andros to spawn. The possible spawning migration should be investigated so appropriate protection measures can be enacted.

Tables

Table 1. Results of stomach analysis of 37 bonefish captured at West Andros in June 2006.

Prey	Bonefish Size Class	Total Abundance <400mm FL	Total Abundance ≥400mm FL	Percent Total Abundance <400mm FL	Percent Total Abundance ≥400mm FL	Frequency of Occurrence (% of Stomachs) <400mm FL	Frequency of Occurrence (% of Stomachs) ≥400mm FL
Portunidae							
Callinectes sp		2	47	11.8	63.5	5.3	44.8
Xanthidae/Majidae		0	6	0	8.1	0	10.3
Penaeidae		1	3	5.9	4.1	5.3	10.3
Polychaeta		5	8	29.4	10.8	10.5	6.9
Isopods		2	0	11.8	0	5.3	0
Bivalvia*		-	-	-	-	36.8	20.7
Sediment[a]		-	-	-	-	58.8	20
Empty[a]		-	-	-	-	36.8	10

* Bivalves were not individually counted - it was generally not possible to identify whether the bivalves had been live when ingested (i.e., whether live bivalves were eaten as prey or empty shells were incidentally ingested). Therefore, bivalves were recorded as presence/absence, so only Frequency of Occurrence was a valid calculation.

[a] Sediment and empty stomach were recorded as presence/absence only, so only Frequency of Occurrence was a valid calculation.

Table 2. Results of benthic infauna samples in Wide Opening, West Andros. Sample locations were at upper, middle, and lower stations along the North and South shorelines of Wide Opening, and 1km north and south of the mouth of Wide Opening. Values are percent of abundance within each sample location. N = 10 for all locations.

Location	Tellina sp	Bivalvia Codakia sp	Unknown	Gastropoda	Polychaeta
Upper North	34.04	48.94	8.51	8.51	0.00
Upper South	25.00	60.47	0.58	13.95	0.00
Middle North	17.13	35.20	0.93	46.73	0.00
Middle South	11.56	12.04	5.30	71.11	0.00
Lower North	11.39	7.43	0.00	31.19	50.00
Lower South	7.34	8.57	4.60	35.31	44.18
Outside North	2.54	2.75	1.23	93.48	0.00
Outside South	3.16	12.25	3.56	81.03	0.00

Figures

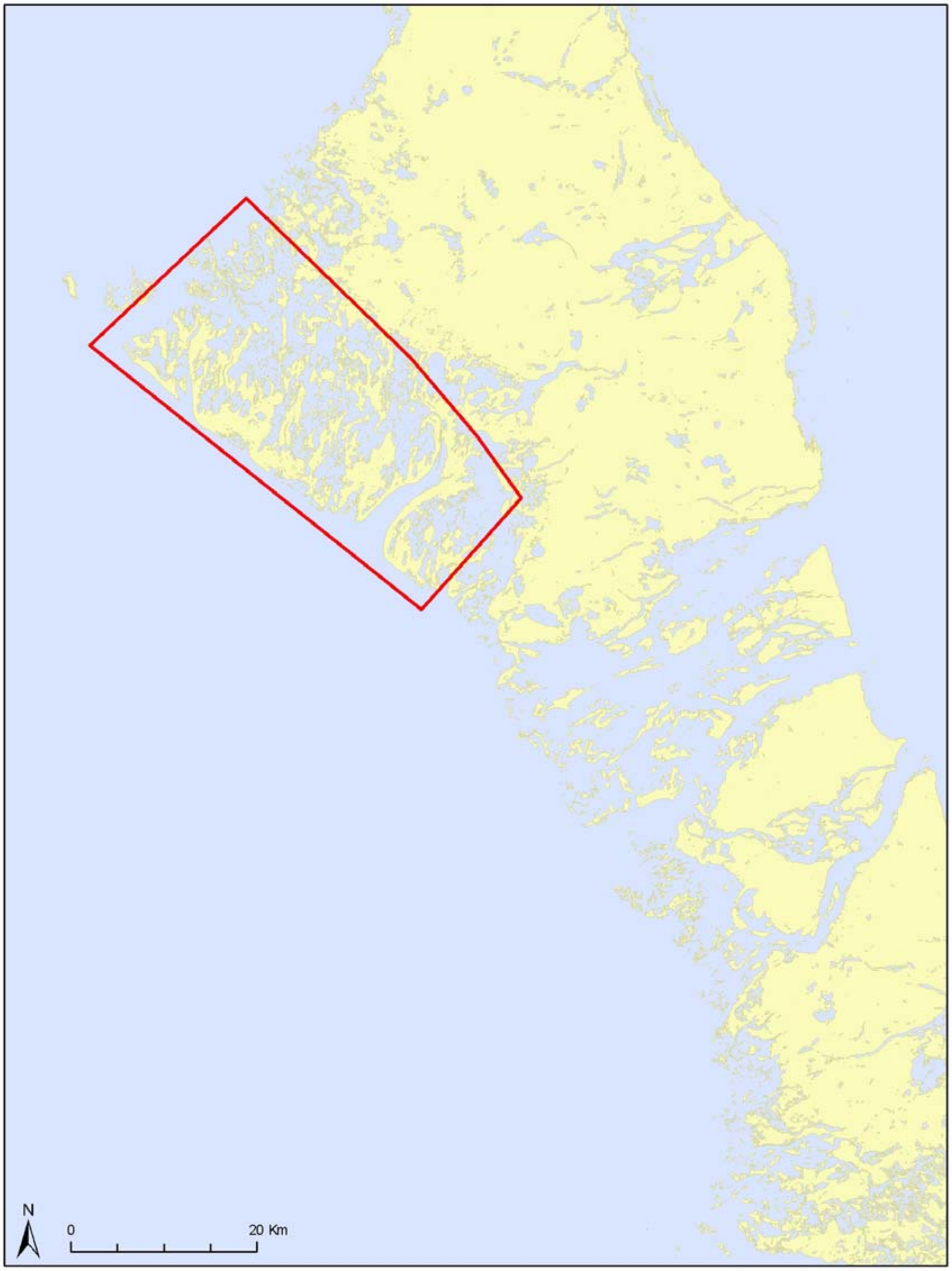

Figure 1. Map showing the area sampled during this Rapid Ecological Assessment of bonefish on West Andros, from Cabbage Creek in the south to Timber Creek in the north.

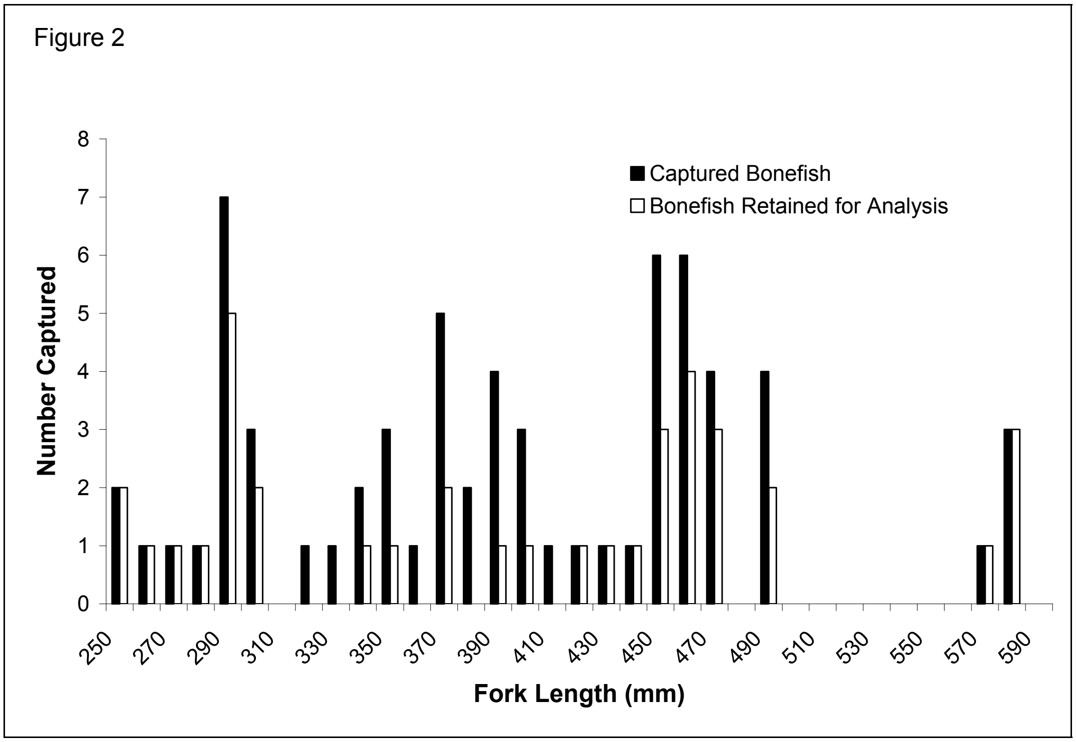

Figure 2. Length Frequencies of bonefish captured and retained at West Andros.

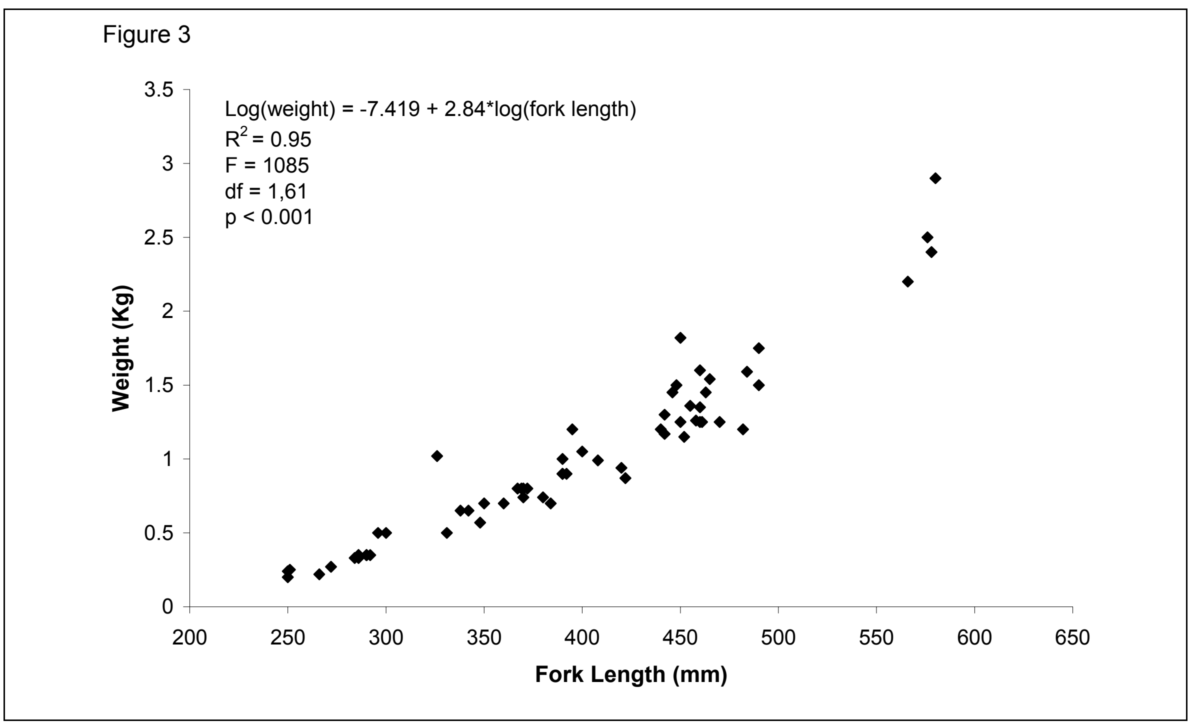

Figure 3. Weight as a function of Fork Length of bonefish captured at West Andros.

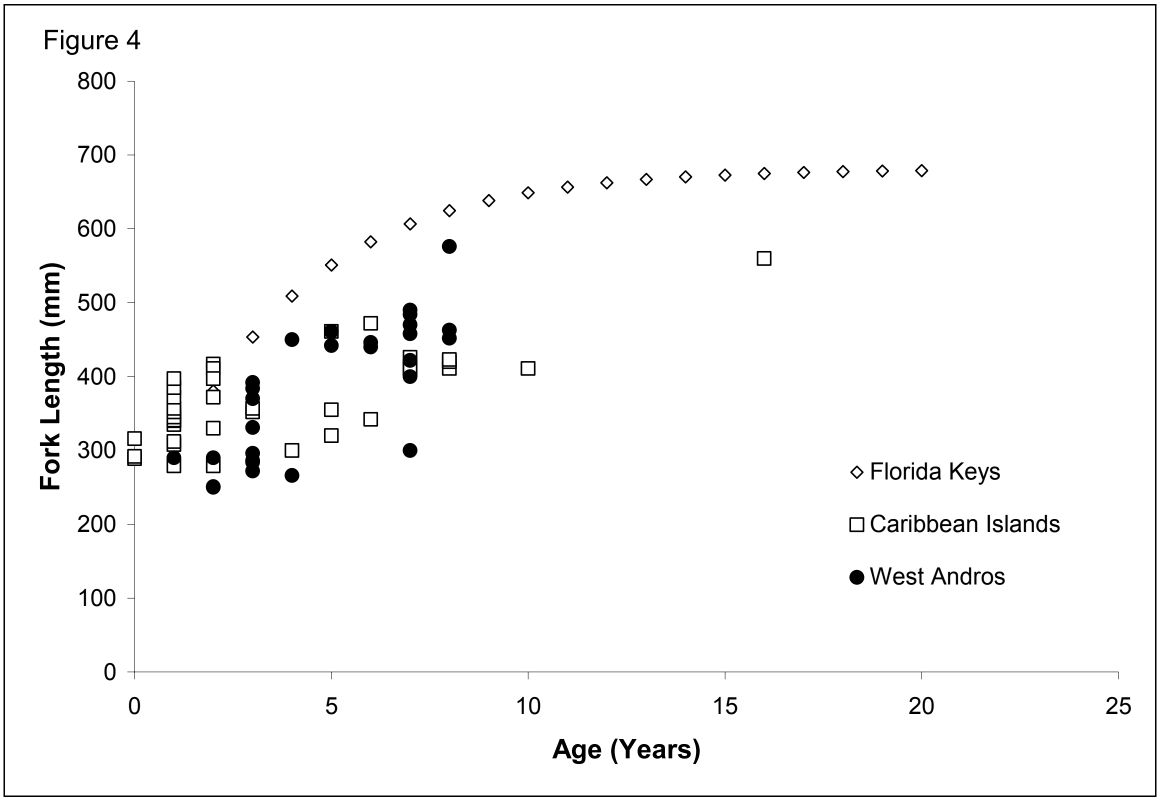

Figure 4. Relationship between otolith-based estimation of age and fork length for bonefish captured at West Andros compared to bonefish captured on other Caribbean islands and predicted ages for Florida Keys bonefish (Florida Keys data from Crabtree et al., 1996).

Vascular Plant Diversity and Vegetation

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Introduction

Not since Alice Northrop published a study the west side of Andros in 1902 (Northrop 1902) has there been a large-scale survey of the flora and vegetation of the West side of Andros Island. The goals of the terrestrial botanical survey were to document three levels of variation through out the west side of Andros Island, Bahamas: Taxonomic, Vegetation Type, Vegetation Structure. Areas that are inundated by sea-water (i.e. mangrove systems) were not surveyed. Survey time was primarily focused was on three areas of the Westside: North, Central and the Bights. A half-day was dedicated to surveying a small portion of the west side of south Andros.

Four questions were asked during the surveys including:

- What is the range of variation of vegetation types of western Andros (North, Middle, and South)?
- What is the taxonomic diversity within each vegetation type?
- What vegetation types have the highest levels of vascular plant diversity?
- What is the range and structural variation of each vegetation type?

Methods

As the taxonomic and vegetation diversity for the western side of Andros had not been studied in-depth, the locations of surveys changed as new information was obtained and interpreted. The surveys were all descriptive in nature. Taxonomic determination and nomenclature was determined by Correll and Correll (1982). Vegetation types' terminology was based on Areces *et al* (1998). Voucher specimens of species encountered *were not* collected as part of this project. Quantitative information for comparative purposes *was not* collected.

<u>Aerial Surveys</u>*:* Low altitude grid pattern aerial surveys was conducted over an approximate half (1/2) day period over north, central, and south Andros. The aerial surveys provided a general understanding of the range of variation in community types. Additionally, information on prospective areas for further investigation and determining issues of access was obtained.

<u>Ground Surveys</u>*:* Once the general variation in habitat types was surveyed via aerial reconnaissance, specific locations were targeted to understand the vascular plant diversity and habitat structure. Landings by boat and floatplane were made at Thirty-Six (36) different locations (See Knapp 2006). Walking transects were conducted through the habitat types recording variation in community structure, what species were encountered, and the substrate. Digital images of vegetation types were recorded.

Results

The west side of Andros contains five basic vegetation types include the following:

1. Coppice (Dry Broadleaf Evergreen Formations-Forest Mixed)
2. Palm Shrublands (Dry Broadleaf Evergreen Formations - Palm Shrublands)
3. Pine (*Pinus caribaea* var. *bahamensis* Woodlands)

4. Saw grass (*Cladium jamaicense* Shrublands)
5. Rocky shore (Dwarf *Rhachicallis americana* Shrublands)

Eighty –Two (82) waypoints were recorded in the community types (See table 1). Cumulative species list were constructed showing the range of plant diversity throughout each community type (See tables 2-6).

Discussion

<u>Habitat Type Descriptions</u>

Coppice (Dry Broadleaf Evergreen Formations-Forest Mixed (DBEF-FM)): The Coppice vegetation type was uncommon on the west side of Andros. It occurred on upland areas (elevations greater than 1 meter) that had exposed limestone. The vegetation was tall (greater than 5 meters) with poorly developed shrub, herb and vine layers (Figure 1). No one species dominated the Coppice vegetation type. As there are few locations on the West Side of Andros with sufficient exposed limestone at appropriate elevations this vegetation type was uncommon and observed at only two landings.

Sixty species were observed throughout all areas surveyed (Table 2). While as a community type (DBEF-FM) was lower in overall diversity than the Pine Woodlands (PW) that were surveyed on the West Side, the Coppice community was higher taxonomically than the other vegetation types. Additionally it should be noted that the higher taxonomic variation of DBEF-FM was observed across a significantly smaller area surveyed indicating a high taxonomic diversity per unit area.

Palm Shrublands (Dry Broadleaf Evergreen Formations - Palm Shrublands (DBEF-PS)): The Palm Shrublands occur as narrow bands along the edges of the western shoreline, bights and tidal creeks (Figure 2) as well as patches within Red Mangrove (*Rhizophora mangle*) Shrublands. The vegetation units varied from 50 to 150 meters wide and extended from small pockets less than 500 meters long to large sections along tidal creeks encompassing several kilometers. The substrate is typically solidified marl on low ridges 0.5 to 1 meters above high tide.

Palm Shrublands are 2-3 meters in height dominated by the presence of Thatch (*Thrinax morrisii*) and Silver top (*Coccothrinax argentata*) Palms (Figure 3). Throughout this vegetation type the under-story is dominated by Saw Grass (*Cladium jamaicense*). The Palm Shrubland vegetation type grades into Saw Grass Shrublands. Palm Shrubland vegetation is considered to be intact and without disturbance other than by hogs. Forty-seven species were observed throughout all areas surveyed (Table 3). This community had a high abundance of orchids (*Encyclia* sp, *Cattleyopsis lindenii*)

Pine Woodlands (Pinus caribaea var. bahamensis Woodlands (PW)): Pine Woodlands occurred as isolated patches of varying sizes from small pockets less than 2 hectares to extensive sections covering square kilometers. On Northern Andros The further west the less likely encounters Pine Woodlands occur where as on Southern Andros the Pine Woodlands extended closer to the western shoreline and extensively on the northern shore of South Andros in the South Bight. The substrate is exposed limestone with pockets of soil development 1-2 meters above sea level.

There are vegetation layers that can be distinguished within the Pine Woodlands vegetation type that was not observed in the Coppice or Saw Grass communities. In Pine Woodlands there is an emergent tree layer, small tree layer, a shrub, and an herb/vine layer (Figure 4). The pine woodlands harbor the highest level of diversity of the vegetation types encountered. One hundred and fourteen species were observed throughout all areas surveyed (Table 4).

Contributing to the high level of diversity was the broad range of structural variation within the PW community. Variation within the community included the area of each unit within the vegetation type, distance to closest neighboring area of Pine Woodlands, the length of time since the last burn (changes vegetation structure), and elevation.

Pine Woodlands are dependent on fire to expose seeds to light and release nutrients. With fire being a naturally occurring phenomenon of this vegetation type, the shrub, herb and vine layers can be in different levels of succession depending on when the last time the system had burned. The larger and more connected the Pine Woodland locations are the greater the likelihood an area has burned (fire can more easily move between areas). Conversely the smaller and more isolated a pocket is the less likely is has burned. Areas that can harbor PW, further to the west, tend to be smaller in size, less likely to burn and have a taller and more taxonomically diverse under-story. Areas that have not burned recently (greater than 10 years ago) (Figure 5) will have an under-story layer that has changed from shrubs to trees.

Saw Grass Shrubland (Cladium jamaicense Shrublands (CJS)): The Saw Grass community occurs across large areas (square hectares to square kilometers) that are low lying (less than 0.5 meters above high tide) The substrate is typically a solidified marl that has poor drainage and the areas have a tendency to be inundated with fresh or saline water for extended periods (days to weeks).

The vegetation is low (less than 0.5 meters in height) and ranged in taxonomic structure from being almost completed dominated by Saw Grass (Figure 6) to areas that have low shrubs and small trees and grades into Palm Shrublands in many areas (Figure 7). A notable variant occurs in the northern sections of western Andros where the dominant shrub/tree was *Bucida spinosa* (Table 1 waypoints 6, 28 and 29). Forty-one species were observed throughout all areas surveyed (Table 5).

Rocky shore (Dwarf Rhachicallis americana Shrublands (DRAS)): The Rocky Shore occurred in limited areas along the shores of the Bights. It is a narrow band (1-5 meters) between the Bights and Palm Shrublands (Figure 8). It is dominated by shrubby *Rhachicallis americana* (Wild Thyme) that is less than 1 meter in height. The areas where Rocky Shore occurs tend to be high energy and are over washed at high tides and during storm periods. The substrate is exposed eroded limestone. Three (3) species were observed throughout all areas surveyed (Table 6).

General Discussion

Each community varied structurally in terms of plant height, openness of the sub-canopy layers and floristic/taxonomic diversity across the entire landscape. Throughout the West Side the vegetation types grade into each other in some locations when there are very gradual changes in substrate and elevation. In other areas there can be distinct and sharp boundaries with distinct and abrupt changes in substrate and elevation. There were no true beaches except in the extreme southern West Andros.

The Pine Woodlands harbored the highest diversity (Table 4). Within the Bahamian Archipelago the Coppice (Dry Broadleaf Evergreen Formation – Forest Mixed) is thought to be higher in diversity than Pine Woodlands. On the West Side of Andros Island the situation is different in that there is a relative dearth of high relief (greater than 1 meter), exposed limestone that can develop a tall canopy coppice. All interior areas of the west side (essentially middle Andros) that did have exposed limestone are low in relief (less than 1 meter) and occupied by Pine Woodlands. Additionally the interior "upland" areas are larger and have been known to catch on fire by lightening strikes thus maintaining a fire driven system favored by *Pines caribaea* var. *bahamensis* rather than Coppice As there was a relatively smaller amount of acreage occupied by Coppice there were relatively fewer species observed within it.

The Palm Shrublands (Dry Broadleaf Evergreen Formations - Palm Shrublands (Table 2) and Saw Grass (*Cladium jamaicense* Shrublands) (Table 5) showed less diversity than the Coppice (Table 2) and Pine Woodlands (Table 4). Both vegetation types (DBEF-PS and CJS) occurred solidified marl and at elevations less than 0.5 meters above sea level. These areas routinely flooded at seasonal high tides and the rainy season and fewer species are adapted to live within an environment that shifts between these extremes.

In decreasing order the relative area of each community type is as follows Palm Shrublands, Saw Grass Shrublands, Pine Woodlands, Coppice and Rocky Shore.

Diversity of a vegetation type at any location was lower than diversity across the vegetation type. The range of variation in the size, shape, and elevation of the locations of each vegetation type maintains that any one area does not have all taxonomic and structural variation that does occur in the vegetation types. Thusly conservation of the taxonomic and structural variation of each community type requires that large areas be included in the formation of additional park areas.

Results

- The terrestrial vegetation of western Andros is intact and shows excellent examples of Pine Woodlands (PW) and Dry Broadleaf Evergreen Formations - Palm Shrublands (DBEF-PS).

- There is a high degree of structural and taxonomic variation within terrestrial vascular plant habitat types between North, East, South and West Andros.

- Terrestrial Plant Conservation needs to be across broad areas throughout Andros to insure capturing the range of taxonomic and structural variation.

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Tables

Table 1: Terrestrial Vegetation Way points on the Westside of Andros Island, Bahamas taken during June 2006.

1.	17R 0793354	UTM 2698731	Palm Shrubland
2.	17R 0793446	UTM 2698646	Dwarf Rhachicallis americana Shrubland
3.	17R 0793187	UTM 2698160	Cladium Shrubland
4.	17R 0793515	UTM 2700181	Cladium Shrubland
5.	17R 0795748	UTM 2698647	Cladium Shrubland
6.	17R 0795622	UTM 2698656	Ecotone Between Palm Saw Grassland and Bucida spinosa Shrubland
7.	17R 0795452	UTM 2698588	Palm Shrubland
8.	17R 0795766	UTM 2699175	DBEF-FM
9.	17R 0795698	UTM 2699217	DBEF-FM
10.	17R 0794940	UTM 2698753	DBEF-FM
11.	18R 0196585	UTM 2687291	DBEF-FM
12.	18R 0196674	UTM 2687223	Palm Shrubland
13.	18R 0196449	UTM 2687070	Palm Shrubland
14.	18R 0196203	UTM 2687030	Palm Shrubland
15.	18R 0204101	UTM 2697888	Pine Woodland
16.	18R 0204000	UTM 2697864	Pine Woodland
17.	18R 0202184	UTM 2694376	DBEF-F/S
18.	18R 0204099	UTM 2694343	Rocky Shore
19.	18R 0204021	UTM 2694337	Palm Shrubland
20.	18R 0203851	UTM 2694694	Palm Shrubland
21.	18R 0203722	UTM 2694816	Cladium Shrubland
22.	18R 0208496	UTM 2692504	Pine Woodland
23.	18R 0208651	UTM 2692616	Pine Woodland
24.	18R 0208316	UTM 2692428	Palm Shrubland
25.	17R 0779740	UTM 2739877	DBEF-FM
26.	17R 0779550	UTM 2739626	DBEF-FM
27.	17R 0780183	UTM 2739874	Sparse Avicennia Shrubland
28.	17R 0773323	UTM 2736000	Bucida spinosa /Cladium Shrubland
29.	17R 0773246	UTM 2735773	Bucida spinosa /Cladium Shrubland
30.	17R 0755311	UTM 2729609	Palm Shrubland
31.	17R 0755329	UTM 2729500	Palm Shrubland
32.	17R 0804378	UTM 2683732	Palm Shrubland
33.	17R 0804350	UTM 2683820	Palm Shrubland

34.	18R 0203194	UTM 2690046	Sparse Avicennia Shrubland
35.	18R 0207786	UTM 2686958	DBEF-FM
36.	18R 0209663	UTM 2674301	Cladium Shrubland
37.	18R 0209475	UTM 2673662	Palm Shrubland
38.	18R 0209580	UTM 2673876	Palm Shrubland
39.	18R 0208522	UTM 2676800	Palm Shrubland
40.	17R 0800582	UTM 2722331	Pine Woodland
41.	17R 0800348	UTM 2722341	Pine Woodland
42.	17R 0800102	UTM 2722500	Pine Woodland
43.	17R 0802260	UTM 2688272	Palm Shrubland
44.	17R 0802520	UTM 2688495	Palm Shrubland
45.	17R 0803327	UTM 2686666	Cladium Shrubland
46.	17R 0803281	UTM 2686464	Palm Shrubland
47.	18R 0200057	UTM 2688693	Palm Shrubland
48.	18R 0199499	UTM 2688294	Palm Shrubland
49.	18R 0201233	UTM 2689245	Palm Shrubland
50.	18R 0201302	UTM 2689242	Palm Shrubland
51.	18R 0206308	UTM 2693930	Red Mangrove Shrubland
52.	18R 0206139	UTM 2693754	Dwarf Rhachicallis Shrubland
53.	18R 0206204	UTM 2693535	Dwarf Shrubland/Sedgeland
54.	18R 0206391	UTM 2693479	Palm Shrubland
55.	18R 0217763	UTM 2708080	Sparse Pine Woodland
56.	18R 0199195	UTM 2673698	Mangrove Over Wash Area
57.	18R 0199476	UTM 2673810	Cladium Shrubland
58.	18R 0199450	UTM 2673847	Palm Shrubland
59.	18R 0199579	UTM 2673874	Shrubland Mixed Palm Coppice
60.	18R 0199645	UTM 2673748	Red Mangrove Shrubland
61.	18R 0218727	UTM 2685799	Pine Woodland
62.	18R 0218725	UTM 2685693	Pine Woodland
63.	18R 0218873	UTM 2685808	Pine Woodland Sparse
64.	18R 0216892	UTM 2687412	Pine Woodland
65.	18R 0216943	UTM 2687400	Pine Woodland Sparse
66.	18R 0210359	UTM 2681401	Black Mangrove
67.	18R 0210188	UTM 2681269	Palm Shrubland
68.	18R 0210050	UTM 2681336	Palm Shrubland
69.	18R 0209981	UTM 2681505	Palm Shrubland
70.	18R 0209480	UTM 2672632	Pine Woodland
71.	18R 0209492	UTM 2672544	Pine Woodland
72.	18R 0209670	UTM 2672671	Pine Woodland
73.	18R 0209816	UTM 2672748	Pine Woodland
74.	18R 0209900	UTM 2672785	Pine Woodland
75.	18R 0209503	UTM 2673258	Palm Shrubland
76.	18R 0216121	UTM 2673603	Pine Woodland
77.	18R 0216090	UTM 2673707	Pine Woodland
78.	18R 0215940	UTM 2673783	Pine Woodland With Palm Understory
79.	18R 0221018	UTM 2686689	Pine Woodland Sparse
80.	18R 0220937	UTM 2686733	Pine Woodland With Palm Understory
81.	18Q 0226914	UTM 2637972	Pine Woodland With Palm Understory
82.	18Q 0226860	UTM 2638021	Pine Woodland With Palm Understory

Table 2: Vascular plants observed within Dry Broadleaf Evergreen Formations- Forests Mixed (DBEF-FM) on the Western side of Andros

	GENUS	SPECIFIC EPITHET
1.	Acacia	choriophylla
2.	Angalinis	maritima
3.	Antirhea	myrtifolia
4.	Bourreria	succulenta
5.	Bumelia	americana
6.	Bumelia	salicifolia
7.	Buxus	bahamensis
8.	Bucida	spinosa
9.	Bursera	simaruba
10.	Bysonima	lucidus
11.	Cassytha	filiformis
12.	Cassia	lineata
13.	Chiococca	alba
14.	Chiococca	parviflora
15.	Chrysophyllum	oliviforme
16.	Cladium	jamaicense
17.	Coccothrinax	argentata
18.	Cordia	bahamense
19.	Coccoloba	diversifolia
20.	Coccoloba	northropiae
21.	Coccoloba	tenuifolia
22.	Crossopetalum	rhacoma
23.	Cynanchum	angustifolium
24.	Dichromena	floridensis
25.	Diospryus	crassinervis
26.	Encyclia	sp.
27.	Erithalis	fruticosa
28.	Ernodea	littoralis
29.	Erythroxylum	areolatum
30.	Erythroxylum	rotundifoium
31.	Exothea	paniculata
32.	Eugenia	axillaris
33.	Eugenia	foetida
34.	Flaveria	linearis
35.	Guapira	discolor
36.	Guettarda	elliptica
37.	Guettarda	scabra
38.	Gundlachia	corymbosa
39.	Jacquemontia	havanensis
40.	Lasiacis	divaricata
41.	Leptochlopsis	virgata
42.	Manilkara	bahamensis
43.	Maytenus	buxifolium
44.	Metopium	toxiferum
45.	Morinda	royoc
46.	Nectandra	coriacea
47.	Oeceoclades	maculata
48.	Oncidium	floridanum
49.	Passiflora	bahamensis
50.	Passiflora	cupraea
51.	Pisonia	aculeata
52.	Pithecellobium	keyense
53.	Psidium	longipes
54.	Pteris	longifolia
55.	Randia	aculeata
56.	Reynosia	septentrionalis
57.	Smilax	havanensis
58.	Sophora	tomentosa
59.	Strumpfia	maritima
60.	Stigmaphyllon	sagraeanum
61.	Sweitenia	mahagonii
62.	Tabebuia	bahamensis
63.	Thrinax	morrisii
64.	Tournefortia	volubilis
65.	Triopteris	jamaicensis
66.	Vernonia	arbuscula
67.	Zanthoxylum	coriaceum

Table 3: Vascular plants observed within Palm Shrublands (Dry Broadleaf Evergreen Formations - Palm Shrublands (DBEF-PS))

	GENUS	SPECIFIC EPITHET
1.	Acacia	choriophylla
2.	Angalinis	maritima
3.	Bourreria	succulenta
4.	Bumelia	americana
5.	Buxus	bahamensis
6.	Bucida	spinosa
7.	Bysonima	lucidus
8.	Cassytha	filiformis
9.	Cassia	lineata
10.	Cattleyopsis	lindenii
11.	Chiococca	parviflora
12.	Cladium	jamaicense
13.	Coccothrinax	argentata
14.	Cordia	bahamense
15.	Coccoloba	diversifolia
16.	Coccoloba	northropiae
17.	Coccoloba	tenuifolia
18.	Cynanchum	angustifolium
19.	Dichromena	floridensis
20.	Encyclia	sp.
21.	Erithalis	fruticosa
22.	Ernodea	littoralis
23.	Guapira	discolor
24.	Guettarda	elliptica
25.	Guettarda	scabra
26.	Jacquemontia	havanensis
27.	Jacquinia	keyensis
28.	Leptochlopsis	virgata
29.	Linum	bahamense
30.	Manilkara	bahamensis
31.	Metopium	toxiferum
32.	Passiflora	bahamensis
33.	Passiflora	cupraea
34.	Pisonia	aculeata
35.	Pithecellobium	keyense
36.	Psidium	longipes
37.	Pteris	longifolia
38.	Randia	aculeata
39.	Reynosia	septentrionalis
40.	Smilax	havanensis
41.	Sophora	tomentosa
42.	Strumpfia	maritima
43.	Stigmaphyllon	sagraeanum
44.	Tabebuia	bahamensis
45.	Tabebuia	lepidota
46.	Thrinax	morrisii
47.	Vernonia	arbuscula

Table 4: Vascular plants observed within Pine Woodlands (PW)

	GENUS	SPECIFIC EPITHET
1.	Acacia	choriophylla
2.	Alvaradoa	amoirphoides
3.	Anemia	adinatifolia
4.	Angalinis	maritima
5.	Antirhea	myrtifolia
6.	Angadenia	sagraei
7.	Atelia	gummifera
8.	Ateramnus	lucidus
9.	Bletia	purpurea
10.	Bourreria	succulenta
11.	Bumelia	americana
12.	Buxus	bahamensis
13.	Bumelua	celestrina
14.	Buchnera	floridana
15.	Bumelia	salicifolia
16.	Bursera	simaruba
17.	Bucida	spinosa
18.	Bysonima	lucidus
19.	Caesalpinia	bahamensis
20.	Cassytha	filiformis
21.	Cassia	Lineata
22.	Catesbaea	parviflora
23.	Catopsis	Berteroniana
24.	Cattleyopsis	lindenii
25.	Chrysobalanus	icaco
26.	Chrysophyllum	olivivorme
27.	Chiococca	parviflora
28.	Cladium	jamaicense
29.	Coccothrinax	argentata
30.	Cordia	bahamense
31.	Coccoloba	diversifolia
32.	Coccoloba	northropiae
33.	Coccoloba	tenuifolia

34.	Crossopetalum	aquifolia
35.	Crossopetalum	rharcoma
36.	Dichromena	colorata
37.	Diospyrus	crassinervis
38.	Dichromena	floridensis
39.	Echites	umbellata
40.	Encyclia	sp.
41.	Erythroxylum	areolatum
42.	Erithalis	fruticosa
43.	Ernodea	littoralis
44.	Erythroxylum	rotundifolium
45.	Eugenia	axillaris
46.	Eugenia	foetida
47.	Eupatorium	villosum
48.	Exothea	paniculata
49.	Galactia	rupdolphoides
50.	Guapira	discolor
51.	Guettarda	elliptica
52.	Guettarda	scabra
53.	Helicteres	jamaicensis
54.	Ilex	krugiana
55.	Jacquemontia	havanensis
56.	Jacquinia	keyensis
57.	Juniperus	barbadensis
58.	Lasiacis	divaricata
59.	Lantata	involucrata
60.	Leptochlopsis	virgata
61.	Linum	bahamense
62.	Manilkara	bahamensis
63.	Maytenus	buxifolium
64.	Mastichodendron	foetidissimum
65.	Malipighia	polytricha
66.	Manilkara	zapota
67.	Metopium	toxiferum
68.	Myrica	cerifera
69.	Myrsine	floridana
70.	Neobracea	bahamensis
71.	Neolaugeria	densiflora
72.	oncidium	floridanum
73.	Oplonia	spinosa
74.	Passiflora	bahamensis
75.	Paspulum	blodgettii
76.	Passiflora	cupraea
77.	Pera	bumeliifolia
78.	Phyllanthus	epiphyllanthus
79.	Phoradendron	sp.
80.	Pisonia	aculeata
81.	Pinus	caribaea
82.	Pithecellobium	hysterix
83.	Pithecellobium	keyense
84.	Psychotria	ligustrifolia
85.	Psidium	longipes
86.	Pteridium	aquilinum
87.	Randia	aculeata
88.	Rajania	hastata
89.	Reynosia	septentrionalis
90.	Savia	bahamense
91.	Sabal	palmetto
92.	Sabatia	stellaris
93.	Schizachyrium	gracile
94.	Scleria	lithosperma
95.	Scolosanthus	bahamensis
96.	Smilax	havanensis
97.	Solannum	bahamense
98.	Sophora	tomentosa
99.	Spigelia	americana
100.	Strumpfia	maritima
101.	Stigmaphyllon	sagraeanum
102.	Sweitenia	mahagonii
103.	Tababuia	bahamensis
104.	Tetrazygia	bicolor
105.	Thrinax	morrisii
106.	Tillandsia	balbisiana
107.	Tillandsia	flexuosa
108.	Tillandsia	valenzuela
109.	Tournefortia	volubilis
110.	Triopteris	jamaicensis
111.	Vanilla	barbellata
112.	Vernonia	arbuscula
113.	Waltheria	indica
114.	Xylosma	bahamensis

Table 5: Saw Grass Shrublands (*Cladium jamaicense* Shrublands (CJS)).

	GENUS	SPECIFIC EPITHET
1.	Acacia	choriophylla
2.	Angalinis	maritima
3.	Bourreria	succulenta
4.	Bumelia	celestrina
5.	Buxus	bahamensis
6.	Bucida	spinosa
7.	Bysonima	lucidus
8.	Cassytha	filiformis
9.	Cassia	lineeata
10.	Chiococca	parviflora
11.	Cladium	jamaicense
12.	Coccothrinax	argentata
13.	Cordia	bahamense
14.	Coccoloba	diversifolia
15.	Coccoloba	northropiae
16.	Coccoloba	tenuifolia
17.	Cynanchum	angustifolium
18.	Dichromena	floridensis
19.	Encyclia	sp.
20.	Erithalis	fruticosa
21.	Eugenia	foetida
22.	Guapira	discolor
23.	Guettarda	elliptica
24.	Jacquemontia	havanensis
25.	Jacquinia	keyensis
26.	Leptochlopsis	virgata
27.	Manilkara	bahamensis
28.	Metopium	toxiferum
29.	Passiflora	bahamensis
30.	Passiflora	cupraea
31.	Pithecellobium	keyense
32.	Psidium	longipes
33.	Randia	aculeata
34.	Reynosia	septentrionalis
35.	Sabal	palmetto
36.	Smilax	havanensis
37.	Sophora	tomentosa
38.	Strumpfia	maritima
39.	Stigmaphyllon	sagraeanum
40.	Tabebuia	lepidota
41.	Thrinax	morrisii

Table 6: Vascular plants observed within Rocky Shore (Dwarf *Rachicallis americana* Shrublands (DRAS))

	GENUS	SPECIFIC EPITHET
1.	Borrichia	arborescens
2.	Conocarpus	erectus
3.	Rachicallis	americana

Figures

Figure 1: Coppice (Dry Broadleaf Evergreen Formation - Forest Mixed.

Figure 2: Aerial image of a band of Palm Shrubland (Dry Broadleaf Evergreen Formation – Palm Shrubland (DBEF-PS) along a tidal creek.

Figure 3: Palm Shrubland (Dry Broadleaf Evergreen Formation – Palm Shrubland (DBEF-PS).

Figure 4: Pine Woodlands (PW) with a palm under-story.

Figure 5: Pine Woodlands (PW) that have not had recently (greater than 10 years ago) burned showing tall under-story.

Figure 6: Saw Grass Shrubland (*Cladium jamaicense* Shrubland (CJS)).

Figure 7: Ecotone between Saw Grass Shrublands (*Cladium jamaicense* Shrublands (CJS) and Palm Shrublands (Dry Broadleaf Evergreen Formation - Palm Shrublands (DBEF-PS).

Figure 8: Rocky Shore (Dwarf *Rhachicallis americana* Shrubland (DRAS) along the northern shore of the South Bight.

Iguanas (and Reptiles)

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Introduction

The Bahamian Andros iguana (*Cyclura cychlura cychlura*) is the largest native terrestrial vertebrate, and the only iguana (of 3 species, 7 subspecies) in the Bahamas that is presently not confined to small cays (Alberts, 2000). The lizards face unique anthropocentric pressures relative to other islands in the archipelago such as habitat loss, illegal hunting, and impacts from historic large-scale logging practices for Caribbean pine (*Pinus caribaea* var. *bahamensis*), which destroyed large tracts of iguana habitat in the 1960s and 70s for saw lumber and pulpwood (Little et al., 1976; Knapp et al., 1999). These deleterious effects are compounded further with predation by feral animals (e.g. cats, dogs, and hogs). Consequently, the Andros iguana is formally listed as Endangered under 2004 IUCN Red List criteria (Knapp and Buckner, 2004) and classified under Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In 2002, the Bahamas National Trust (BNT), the non-government organization mandated with managing national parks in the country, established the Central Andros National Parks (total area 115,770 ha). These areas were established to protect inland forest, coral reef, and wetland nursery areas on North Andros Island. At the time, no detailed ecological data were available for the endemic iguana. Therefore, little input concerning habitat requirements or current distribution patterns were incorporated into delineating protected area boundaries. Consequently, these protected areas are not ideal for iguana conservation because they are located in areas that are severely degraded habitat for iguanas because of feral animals, loss of habitat, logging roads that allow access to the island interior, and illegal hunting pressure.

In 2006, the Nature Conservancy, in partnership with the Bahamas National Trust (BNT) and the Bahamas Sportfishing Conservation Association (BSCA), and with grant support from the Kerzner Marine Foundation, organized a rapid ecological assessment of the marine and terrestrial ecosystems on the west side of Andros Island. The west side is free from human settlements, logging roads, and is generally considered near-pristine habitat. This science-based assessment, performed by an interdisciplinary team of natural resource experts and local fishing guides, was conducted to identifying critical conservation areas in order to maintain ecosystem function. The assessment also was conducted to fill information gaps on the distribution of high-profile endangered species such as flamingos, sea turtles, and iguanas.

My participation in the rapid assessment included conducting iguana surveys on the west side of North Andros Island on the western cays of North and Middle Bights. Objectives for the rapid assessment were to 1) locate areas of relatively high iguana density and attempt to correlate density with environmental variables including vegetation, elevation, and substrate composition, 2) survey within the existing Central Andros National Park boundary on North Andros to identify if iguanas inhabit the region, and 3) conduct general herpetofauna surveys to produce species distribution lists.

Methods

Visual encounter surveys were conducted between 19 and 27 of June 2006 primarily on the West Side of North Andros Island and the North and Middle Bight areas. Base camp was Charles Bethel's fishing camp on Flamingo Cay on the west side of North Andros Island. This central location allowed surveys as far north as Timber Creek and Williams Island to the north and, with transport provided by a float plane, Water Cay to the south. Mr. Bethel's float plane also enabled access to Lake Forsythe in the interior of North Andros Island and one site in south-central South Andros Island. These locations would normally be extremely difficult to access and thus this survey is significant in possibly being the first time terrestrial animal ecologists have reached these interior regions (see Fig. 1).

Other locations were dependent on balancing fuel restrictions and boat requirements for the assessment team and therefore the majority of sites were concentrated on North Andros and the cays in North and Middle Bights. The research team consisted of Ethan Freid, botanist and assistant professor and the University of Tampa, an alternating local guide, and an alternating Bahamian student. We visited between 1 to 7 sites per day (total = 39, mean = 4.3, SD = 0.6 sites) for 15 to 210 minutes (mean = 53, SD = 5.0 min.). Man hours at each site ranged from 0.8 to 7.0 hrs. (mean = 2.8, SD = 0.2 hrs.). At each site, the location was recorded by GPS and then individually surveyed the areas for vegetation richness, habitat complexity, and the presence of iguanas (visual, feces, or tracks), termite mounds, feral animals, and overall conspicuous herpetofauna richness.

General herpetofauna surveys were rapid, and only conspicuous species were documented. Detection probabilities for iguanas were not calculated because of the rapid nature of these surveys. For example, nocturnal boas (*Epicrates striatus fowleri*), which typically reside underground in limestone crevices (Knapp and Owens, 2004) were not noted in these surveys although their presence is know from at least one site from past surveys. Bahamian brown racers (*Alshophis vudii*) and also fossorial snakes (*Typhlops* spp.) are also difficult to detect in short time periods and were thus excluded. Therefore, this assessment adequately augments distribution data for the iguana but provides only a course-scale outlook of general herpetofauna diversity.

Results and Discussion

The primary habitat types encountered during this survey included pine woodland, and palm schrubland with fringing beach scrub and mangrove habitats. Coppice was encountered sporadically interspersed at three sites. Substrate was typically compressed mud often punctuated with crab (*Cardisoma guanhumi* and *Gecarcinus lateralis*) burrows. Exposed limestone was observed at eight sites.

Iguanas were observed at six sites (15% of 39 sites), while recent tracks were observed at another site (Fig. 1). A total of 43 iguanas was observed during the surveys (mean = 7.2, SD = 2.5 iguanas, range 2-16). The highest concentrations were identified from two locations on North Alcorine Cay adjacent to Middle Bight. Iguanas were observed in both pine woodland and palm schrubland habitats and in areas with both hard-mud and exposed limestone substrates. Feral pigs (*Sus scrofa*), or their sign, were observed from eight of 11(73%) sites on mainland North Andros Island. Hog tracks also were observed under 0.8 meters of water crossing creeks between cays on the west side of North Andros Island. No hogs were observed south of mainland North Andros. It appears that the deeper water of the bights is an effective barrier to date keeping hogs from dispersing south.

Fifteen surveys sites were located in the existing protected area on North Andros Island. Iguanas were observed at two of the sites located on small cays in North Bight (Fig. 2). No mainland North Andros sights including Williams and Billy Islands, whether in or out of the park boundaries yielded iguana observations. Although various people still observe iguanas on North Andros, these and past surveys suggest that few iguanas remain above North Bight. On the east coast of North Andros Island, juvenile iguanas are seen after hatching season but soon disappear, presumably eaten by cats. Additionally, iguana poachers on North Andros now venture south to catch iguanas because of the scarcity in their area.

Seven species of amphibians and reptiles were observed during the surveys including Blue-tail Lizard *(Ameiva auberi)*, Cuban Twig Anole (*Anolis angusticeps*), Cuban Brown Anole (*Anolis sagrei*), Bahamian Green Anole (*Anolis smaragdinus*), Andros Island Iguana (*Cyclura cychlura*), Curly-tailed Lizard (*Leiocephalus carinatus*), and Cuban Tree Frog (*Osteopilus septentrionalis*). Additionally, Greenhouse Frog (*Eleutherodactylus planirostris*), was observed at our base camp and the introduced pig frog, *Rana grylio*, was heard at the interior Lake Forsythe pine woodland site. At least one species was observed from all sites (mean = 2.3, SD = 0.2 species, range = 1-5). *Anolis sagrei* was observed at all but one site while *Leiocephalus* and *Ameiva* were observed at 20 and 12 sites, respectively. Although preliminary, the data suggest a latitudinal gradient in conspicuous species richness ($r^2 = 0.38$, $P < 0.001$; Fig. 3) within the western study area. These surveys were restricted to the west side of Andros with a relatively homogenous palm schrubland community and with a general lack of exposed limestone. Also, because of the rapid survey scheme and notable lack of snake species, caution should be used when interpreting these data. However, this assessment provides basic richness and distribution data, which can be used to develop additional detailed survey assessments.

Recommendations

The west side of Andros Island is low in elevation and dominated by palm schrubland with compressed mud substrate. Tidal fluctuations often raise water table levels to just below or above the surface. Iguanas can inhabit these areas but only if there are areas of exposed limestone or if the habitat is adjacent to pine woodland areas. The majority of the west side of North Andros Island lacks these criteria and is instead inhabited by feral hogs, which appear to inhibit iguana populations and perhaps populations of other reptile species. It was discouraging to find extensive evidence of hog activity and it is apparent from this survey and aerial observations that feral hogs can venture freely to any portion of the North Island (see Figure 5). Extreme care should be made to insure that hogs to not disperse south of North Andros Island.

The primary goal of this survey was to fill information gap concerning the distribution of the Andros iguana. Based on our survey results we conclude that few, if any, iguanas inhabit the west side of North Andros Island. Additionally, the existing National Park on North Andros Island is not adequate to ensure the long-term survival of the Andros Iguana until the management of invasive species can be implemented.

Andros Island harbors a vast amount of terrestrial biological diversity in general, and the south Andros area in particular holds great potential for iguana conservation. The isolated small and large cays of the south/southwestern area (south of Mangrove Cay) lack feral animals and are far from human settlements. These areas are relatively pristine in comparison to North Andros (Eshbaugh and Wilson, 1996). No roads exist in these areas and feral pigs are non-existent because of the North Bight water separation. Additionally, commercial logging practices were not initiated in the area because much of the pineland is on hummocks of high ground surrounded by lower elevated mangrove and marsh. These isolated "pine islands" support the largest pines remaining in the Bahamas (Campbell, 1978) and are areas of high conservation priority for iguanas (Knapp and Owens, 2005).

Protected areas designed for iguana conservation should therefore be demarcated south of Lisbon Creek. Based on this survey and past research, I suggest strongly that large protected areas encompass Sandy Cay in South Bight and adjacent Alcorine Cay (Fig. 4).

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Table 1. Raw herpetological visual encounter data from The Nature Conservancy rapid ecological assessment.

Site	Area	Location	Date	Eastings	Northings	Iguana	No. species	Hog	Start time	Man hours	Time (m)	Species
1	1	River Goose Creek	6/19/2006	793192	2698815	0	2	1	1015	5.3	60	ANSAG, AMAUB
2	1	River Goose Creek	6/19/2006	793798	2700132	0	1	1	1225	1.5	30	ANSAG
3	1	Cabbage Creek (south side)	6/19/2006	796255	2698886	0	1	0	1355	3.3	65	ANSAG
4	1	Cabbage Creek north	6/19/2006	795851	2699120	0	1	1	1510	2.0	40	ANSAG
5	1	Cabbage Creek north	6/19/2006	794952	2698659	0	1	1	1605	1.3	25	ANSAG
6	2	Little Wood Cay	6/20/2006	195841	2687347	1	4	0	810	6.5	90	ANSAG, AMAUB, LECAR. CYCYC
7	1	Desmond Creek	6/20/2006	204263	2697974	0	2	1	1120	2.3	45	ANSAG, AMAUB
8	2	Black Creek Is.	6/20/2006	202367	2694495	1	4	0	1320	3.0	60	ANSAG, AMAUB, LECAR, CYCYC, ANSMA
9	1	Fish Cut, Gaza Strip	6/20/2006	204095	2694334	0	2	0	1440	2.5	50	ANSAG, ANSMA, OSSEP
10	2	Pine Cay	6/20/2006	208347	2692312	0	2	0	1550	1.2	35	ANSAG, LECAR
11	1	Deep Creek	6/21/2006	780267	2739907	0	1	1	840	3.5	70	ANSAG
12	1	Timber Creek	6/21/2006	773535	2735724	0	1	1	1200	1.5	30	ANSAG
13	1	Williams Is	6/21/2006	756273	2729671	0	1	0	1335	1.0	20	ANSAG
14	1	Williams Is	6/21/2006	756273	2729671	0	1	0	1405	1.0	20	ANSAG
15	1	Billy Is	6/21/2006	751682	2729712	0	1	0	1450	1.8	35	ANSAG
16	1	Big Loggerhead 1	6/22/2006	204401	2683992	0	3	0	820	2.0	30	ANSAG, LECAR, AMAUB
17	1	Big Loggerhead 2 (east)	6/22/2006	197842	2684752	0	2	0	900	3.3	50	ANSAG, LECAR
18	2	Jump over cay?	6/22/2006	203086	2689833	0	3	0	1010	4.7	70	ANSAG, AMAUB, LECAR
19	2	Chicken Cay	6/22/2006	207673	2687038	0	3	0	1150	3.3	50	ANSAG, AMAUB, LECAR
20	2	Alcorine Cay	6/22/2006	209663	2674329	1	4	0	1420	4.0	60	ANSAG, AMAUB, LECAR, CYCYC
21	2	Across Alcorine	6/22/2006	208517	2676591	1	4	0	1535	2.0	30	ANSAG, AMAUB, LECAR, CYCYC
22	1	Lake Forsythe	6/23/2006	800680	2722289	0	2	1	830	7.0	210	ANSAG, ANANG, OSSEP
23	1	No Andros/ Little Loggerhead	6/24/2006	802387	2687738	0	1	0	855	2.3	45	ANSAG

24	2	Cay just south of previous	6/24/2006	803384	2686965	0	4	0	1010	3.0	30	ANSAG, ANSMA, AMAUB, LECAR
25	2	Small Sponge Cay	6/24/2006	200000	2688750	0	1	0	1105	0.8	15	LECAR
26	2	West of Sponge Cay	6/24/2006	199835	2688558	0	3	0	1125	1.3	25	ANSAG, LECAR, AMAUB
27	2	Island	6/24/2006	201275	2689099	0	2	0	1245	2.8	55	ANSAG, LECAR
28	2		6/24/2006	206310	2694091	0	2	0	1405	2.5	50	ANSAG, LECAR
29	2	Pine Cay	6/24/2006	208821	2692260	0	3	0	1515	3.0	60	ANSAG, LECAR, AMAUB
30	2	West Side Middle	6/25/2006	199075	2673616	1	4	0	1010	3.0	60	ANSAG, AMAUB, LECAR. CYCYC
31	2	North Mangrove Cay	6/25/2006	218913	2686046	0	3	0	1230	4.0	80	ANSAG, LECAR, AMAUB
32	2	Cay in middle bight	6/25/2006	216800	2687318	0	4	0	1405	2.3	45	ANSAG, ANSMA, AMAUB, LECAR
33	2	Cay across Honeycutt	6/25/2006	210411	2681262	0	3	0	1515	2.0	40	ANSAG, LECAR, AMAUB
34	2	Alcorine (NW)	6/26/2006	209060	2673577	1	4	0	900	5.3	105	ANSAG, AMAUB, LECAR. CYCYC
35	2	Mangrove Cay (across camp)	6/26/2006	216111	2673506	0	2	0	1130	2.3	45.0	ANSAG, ANSMA
36	2	North Mangrove Cay	6/26/2006	220972	2686834	0	2	0	1345	1.8	35	ANSMA, LECAR
37	3	Leaf Cay, South Andros	6/27/2006	208864	2628428	0	0	0	845	3.0	60	
38	3	Water Cay	6/27/2006	218423	2621613	0	3	0	1010	3.0	60	ANSAG, ANSMA, LECAR
39	3	Charlie's Landing, south-central Andros	6/27/2006	226930	2637753	1	3	0	1315	3.8	75	AMAUB, ANSMA, CYCYC

Species Key
ANSAG = *Anolis sagrei*; ANSMA = *Anolis smaragdinus*; AMAUB = *Ameiva auberi*; LECAR = *Leiocephalus carinatus*; CYCYC = *Cyclura cychlura*; ANANG = *Anolis angusticeps*; OSSEP = *Osteopilus septentrionalis*

Figures

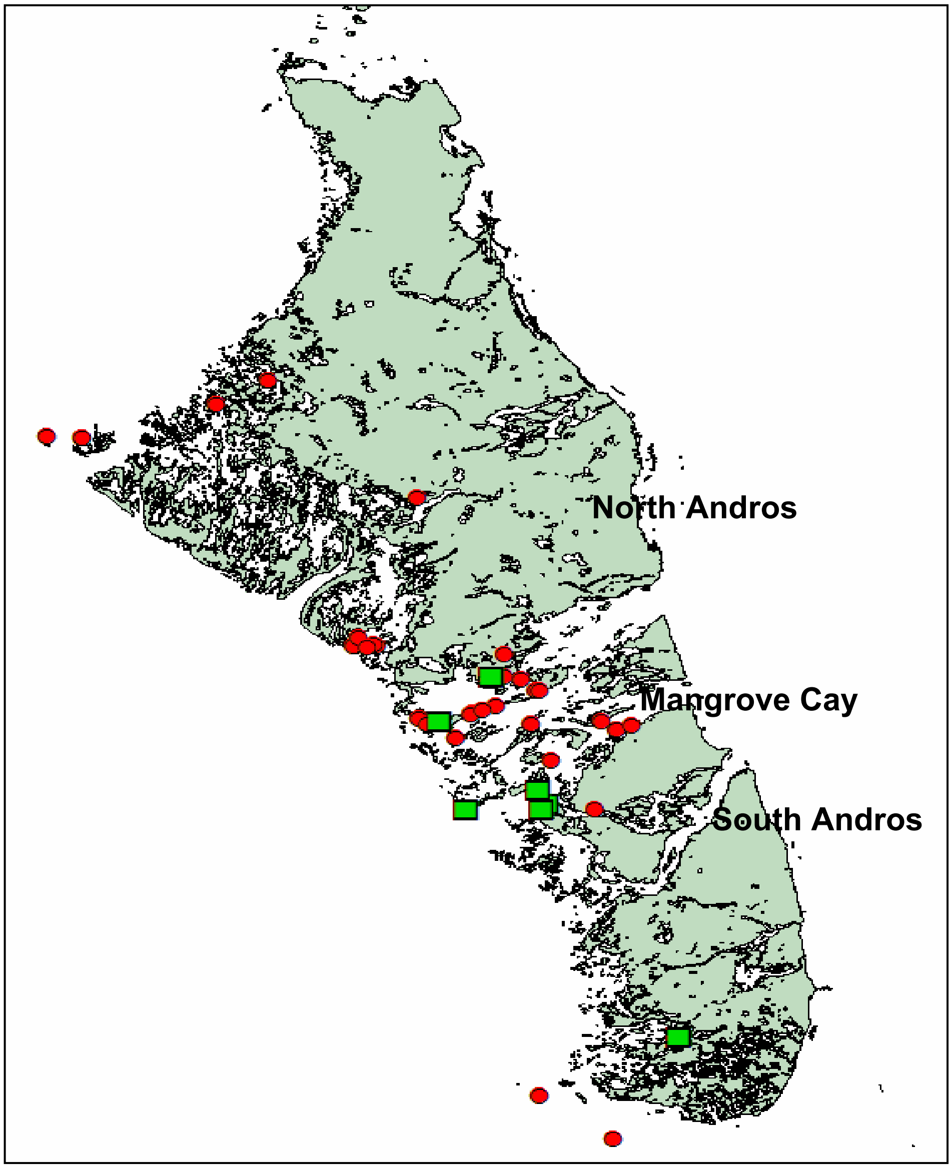

Figure 1. Map depicting sites visited during this rapid ecological assessment. Squares represent sites where iguanas were recorded.

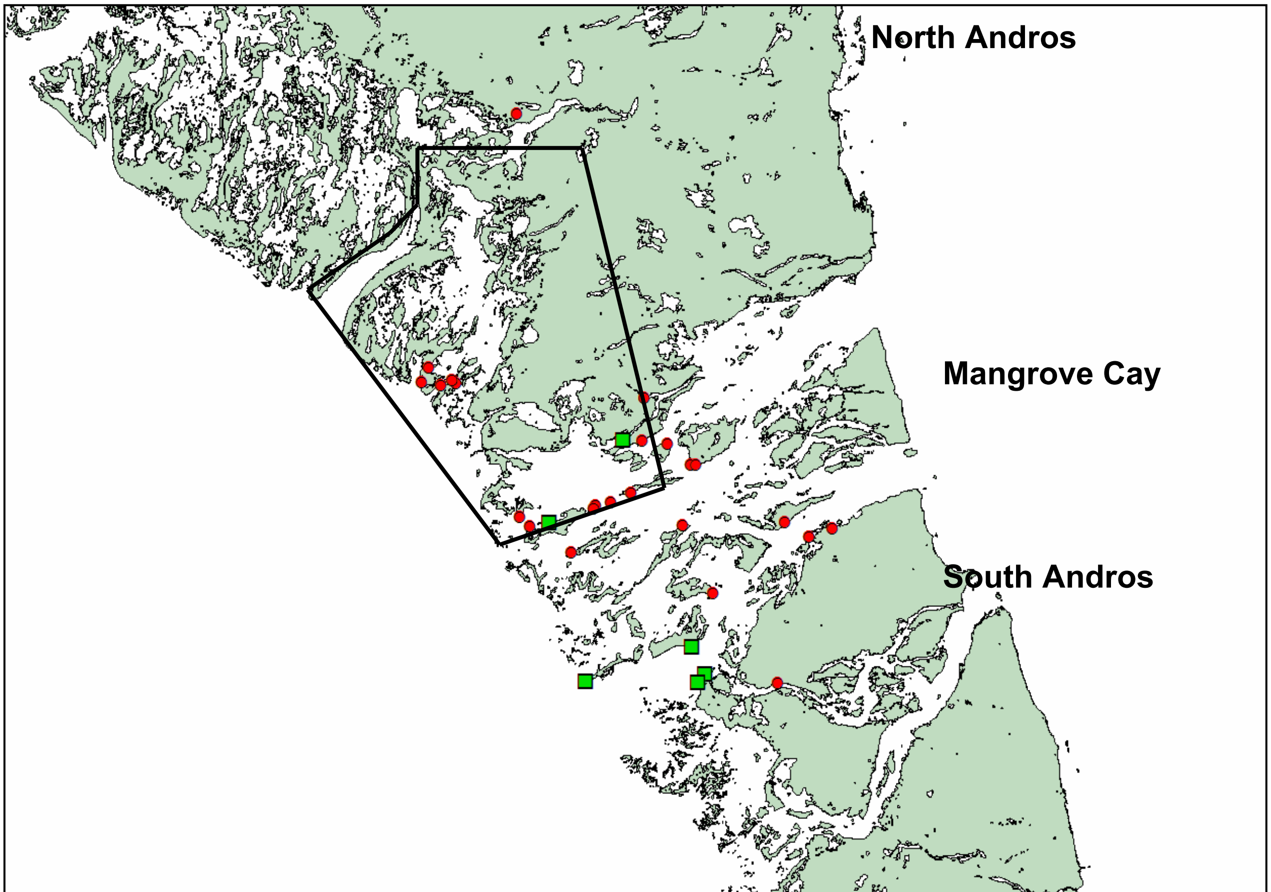

Figure 2. Map depicting sites within the largest existing National Park on North Andros Island. The two squares represent sites where iguanas were recorded. They were both on small cays in North Bight.

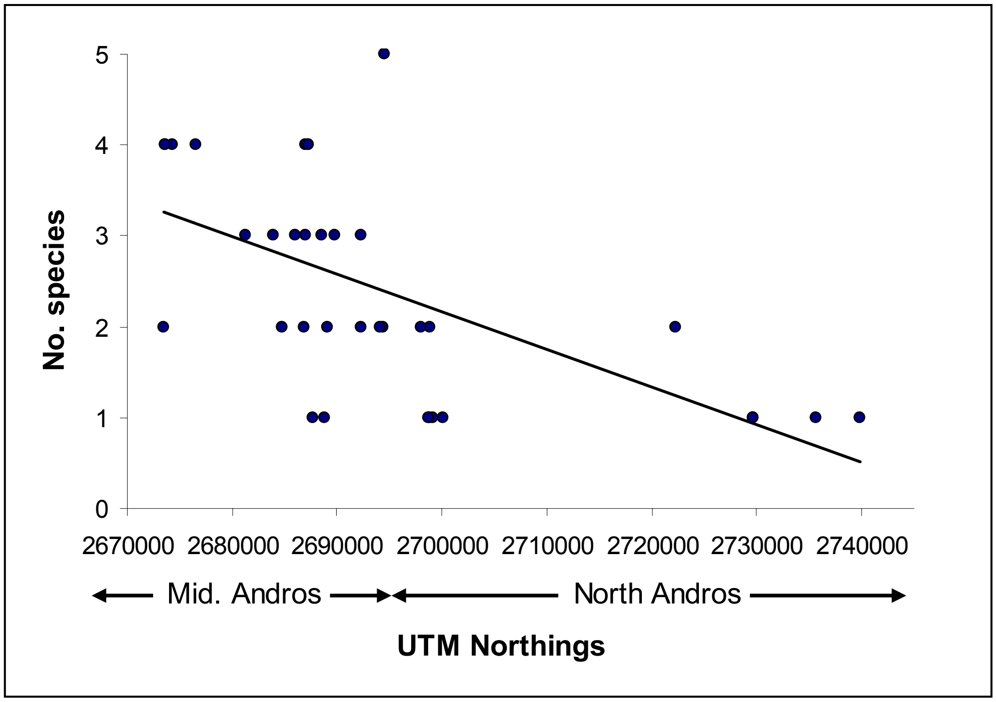

Figure 3. Species richness plotted against Northings on the Universal Transverse Mercator System. North Andros represents North Andros Island. Mid. Andros represents the area south of North Andros Island and north of Lisbon Creek.

Figure 4. Adult Andros iguana (*Cyclura cychlura cychlura*) from the north shore of Alcorine Cay adjacent to Middle Bight.

A B

C D

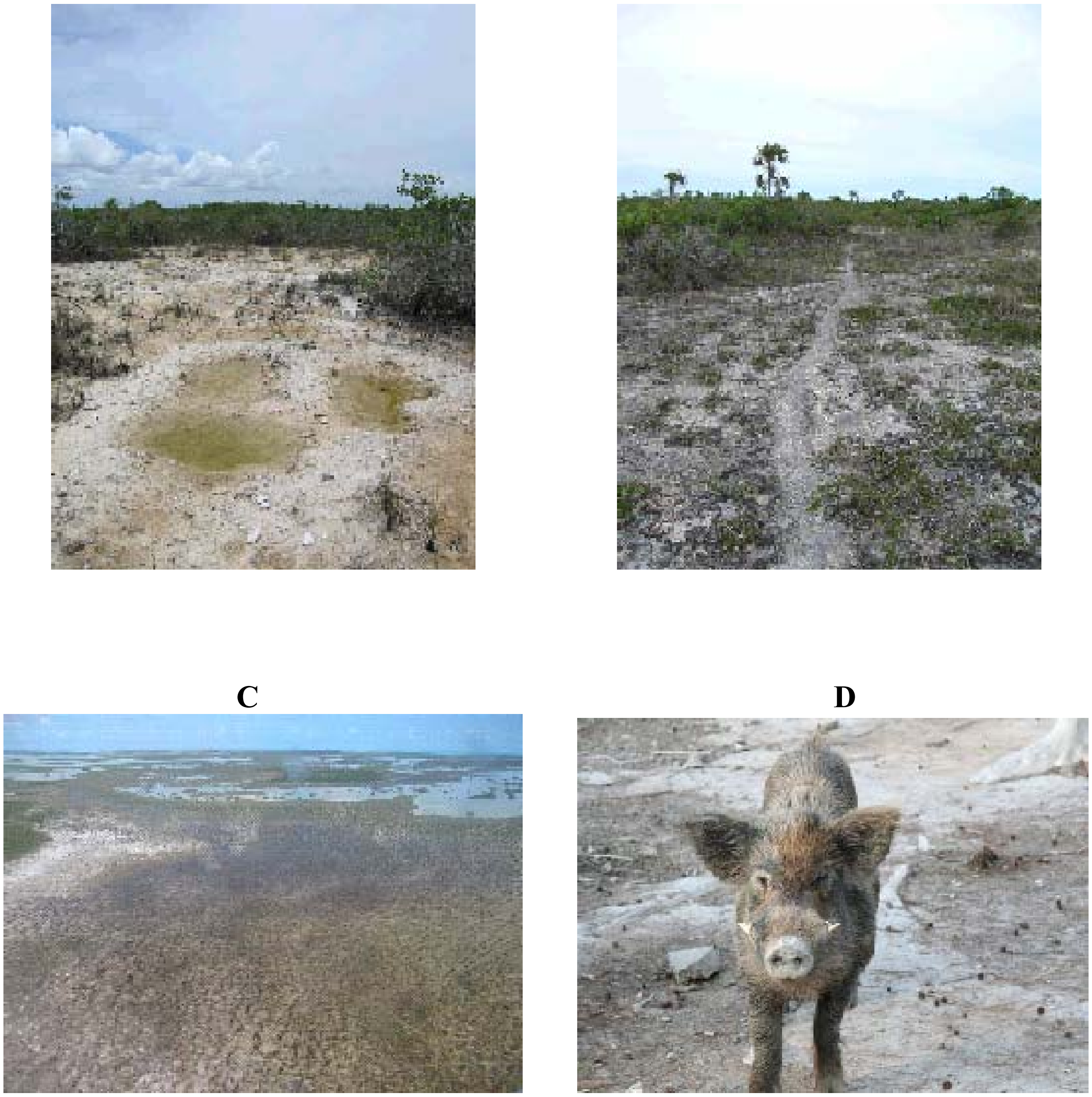

Figure 5. Evidence of feral pig activity on North Andros Island. A) Wallow holes dug by feral pigs, and B) trails used by feral pigs at Goose Creek, North Andros. C) flooded terrain of the West Side of North Andros Island. Pig tracks can be viewed from the air. D) Feral pig on North Andros Island.

Figure 6. Map Showing the Generalized Critical Iguanas Areas

Flamingos (and Observations of West Side Birds)

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Introduction

The Caribbean Flamingo (*Phoenicopterus ruber ruber*), the national bird of The Bahamas, occurred historically throughout the archipelago, with records of breeding colonies from Abaco, Andros, Rum Cay, Exuma, Long Island, Ragged Island, Acklins, Mayaguana, and Great Inagua (Allen 1956). Breeding colonies on Andros were estimated to be 30,000 in the early 1900s (Zahl 1947) but had reportedly disappeared by 1950 (Zahl 1951). Currently, Great Inagua has the only known breeding colony of flamingos in The Bahamas.

During the last decade however, there have been numerous reports of flamingos from the west side of North Andros suggesting the possibility that flamingos might once again be breeding on Andros. Aerial surveys of Andros during the summers of 2004 and 2005 revealed flocks of flamingos totaling more than 1,000 individuals both years (Baltz 2004, 2005), but did not establish the breeding status of the birds on the island.

In June 2006, as part of a team of scientists engaged in a Rapid Ecological Assessment of West Andros, the third annual aerial survey was conducted. The undertaken short-term study addressed the following objectives:

- The 3rd annual breeding-season population estimate,
- Identification of the lake system where flamingos are seen most frequently,
- The physical and chemical characteristics of the frequently used lake system, and
- The probable current breeding status.

Methods

<u>Aerial survey:</u> An aerial surveys of West Andros was undertaken on 17 June, 2006, to assess the exact number and location of flamingos on the island. A small, 6 passenger aircraft was used to fly a roughly north-to-south grid over the western half of North and South Andros at an altitude that allowed for identification of birds without disturbing them (no lower than 800 feet) following approximately the same routes flown in 2004 and 2005. When flamingos were encountered the coordinates of their location was recorded using a hand-held GPS receiver.

<u>Site visits and flamingo observations:</u> Follow-up ground surveys were undertaken from June 18th to June 27th to investigate the lake system where flamingos were seen during the 2006 survey. This was the same lake system where flamingos were recorded during the 2004 and 2005 aerial surveys and, where bonefish guides have recently seen flocks of flamingos. Observations of flamingos were made between dawn and dusk on 19 June (2 hours), 22 June (4 hours), 23 June (6 hours), 25 June (4 hours), 26 June (4 hours). Birds were observed from the shore using binoculars and/or a spotting scope from distances ranging from <100 meters to >500 meters.

<u>Habitat sampling:</u> Physical characteristics (water depth and salinity) of the primary flamingo ponds were quantified along a north-south transect on June 21st. Measurements were taken approximately 30 m off-shore (based on observations and descriptions of where flamingos had been seen), in the primary high-use areas.

Results and Discussion

Third annual aerial survey of West Andros: A single flock of approximately 75 birds was observed on North Andros on 17 June 2006. The flock was within a few hundred meters of where flamingos were seen in both 2004 and 2005. (Observations of the flock from the ground on 19 June yielded a high count of 107 birds.) As in other survey years, no flamingos were seen on South Andros.

Seventy-five flamingos are significantly fewer than the numbers estimated in previous surveys (at least 1,000 in 2004 and 2005). However, the reduced number of birds is consistent with observations of flamingos in other parts of the Bahamas Archipelago in June 2006. Namely, birds were absent from some islands where they had been observed in 2005 (Nancy Clum, Wildlife Conservation Society, pers.com.).

Banding studies on Great Inagua by Sandy Sprunt in the 1960's and 70's established that flamingos disperse to other islands from Great Inagua after breeding and return to Great Inagua during breeding years. Flamingos do not breed every year in The Bahamas and 2004 and 2005 were non-breeding years for flamingos on Great Inagua (Lynn Gape, Bahamas National Trust, pers. com), whereas birds did breed on the island in 2006 (Nancy Clum, pers. com.). One explanation for the reduced number of flamingos on Andros in June 2006 (and other islands) is that a majority of the island's flock had returned to Great Inagua to breed (whereas flamingos remained on Andros in 2004 and 2005). It should be noted that the Andros flamingos could have left to breed somewhere other than Great Inagua. There is a large breeding colony on flamingos on the north coast of Cuba and this would be closer to Andros then Great Inagua. The recent breeding history of the Cuba population is not known to the author, however.

That the whole Andros flock did not leave the island in June 2006 may be explained by the fact that flamingos take several years to reach sexual maturity. So, if flamingos did leave Andros to breed somewhere else, the birds that remained on Andros might have done so because they were not sexually mature.

Flamingos' habitat use on Andros: For the third year in a row, flamingos were seen in the southern portion of a large, unnamed lake system north of Wide Opening during the aerial survey. Recent records/photos of flocks of flamingos by Prescott Smith and Harrington Frazier, both bonefishing guides, and their guests were also taken from the same lake system. According to bonefish guides participating in the REA, there have been few observations of flocks of flamingos north of this lake system and in the Bights of Andros (although exact dates of these observations were not obtainable). Charles Bethel, owner of the Flamingo Cay Rod and Gun Club, also reported that flamingos occur in Turner Sound on Flamingo Cay although there were no flamingos seen in that area during the REA. However, Mr. Bethel presented pictures of a small flock of flamingos in Turner Sound taken in March or April of 2006.

It is interesting to note that the lake system north of Wide Opening that the flamingos are using is one of the most difficult of the West Andros lake systems to access by boat. The south end of the lake system is especially difficult to access because it is shallow (< 46cm) regardless of the tide (pers. obs.) This may be one reason why flamingos are seen there so consistently.

Field observations of flamingo behavior on the lake system during this REA were limited to watching the flock in a bay at the south end of the lake system. During the approximately 20 hours of observation it was notable that the birds almost exclusively rested and/or preened. Very little feeding was observed. In addition, the small flock appeared to leave the bay around dusk and then return to the bay around dawn. This observation begs the questions of where the birds were feeding and where they were spending the night.

<u>Physical and chemical characteristics of the most frequently used lake system</u>: The lake system in which the flamingos were found was notable in that it had a higher salinity than any other lake system on West Andros (avg. 32.1 ppt, range = 27.3-35.3 ppt, n=6). This is notable because flamingos in the Caribbean tend to be associated with high or hypersaline habitats. During the dry season, the salinity of the lake is expected to be much higher.

<u>Current breeding status of flamingos on West Andros:</u> There was no evidence of current or recent breeding activity discernable during the aerial survey or while observing flamingos from the ground. Evidence visible from the air would have included flamingos attending nests, old nest mounds (potentially visible from the air), or flightless young. Observations on the ground confirmed that the birds were not in breeding plumage nor did they display any behavior associated with breeding or raising young. Observations several hundred meters of shoreline along a bay in the lake system where flamingos were always seen also showed no evidence of nesting. Therefore, it appears that flamingos are not currently breeding on the west side of Andros.

Hogs or hog trails were observed on North Andros including along the shore of the lake system that was being used by the flamingos. Because flamingos lay their eggs atop relatively short mud mounds, their eggs and/or young would present the omnivorous hogs with a meal within easy reach. Certainly, wild hogs are known to depredate flamingo nests on Great Inagua (Lynn Gape, pers. com.).

Summary of Results

North Andros is currently home to a resident non-breeding flock of flamingos that varies in size from approximately 100 to over 1000 individuals from year to year. In May-June, this flock occurs consistently in a lake system north of Wide Opening that is more saline than other lake systems on the west side of North Andros. This lake system appears to be an important resting area for flamingos although it is not entirely clear where these flamingos are foraging. At this time it is unclear what factors are preventing successful nesting of flamingos on Andros. One likely factor is the high density of wild hogs (a potential nest predator).

Recommendations

My recommendation is that the lake system identified in this report be included as part of the National Park System on West Andros for several reasons.

- This lake system is currently an important resting area for flamingos on West Andros.
- Flamingo breeding occurred historically in this area and the area apparently continues to represent potential nesting habitat.
- The only other area on West Andros where flocks of flamingos have been documented (Turner Sound on Flamingo Cay) is privately owned and not protected.

Additional Outcomes and Potential Next Steps

- Non-breeding season aerial survey: An aerial survey of West Andros during the non-breeding season would be useful to establish the importance of the island to flamingos during the non-breeding season. Because flamingos begin congregating on Inagua as early as February during breeding years, October-November would be the best time to conduct a non-breeding season aerial of West Andros.

- Involving bonefish guides in data collection: Bonefish guides could provide invaluable information about when and where they see flamingos on West Andros that would help establish the spatial and temporal extent of flamingo occurrence on West Andros. An easy-to-use form has been developed that guides could use to record their observations.

- Publication of observations: A paper will be prepared by Nancy Clum, Michael Baltz, and Tony White (Bahamas National Trust) summarizing the aerial survey results, a history of recent flamingo sightings in The Bahamas, and a recent history of flamingo breeding on Inagua.

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Figure 1. Map of Generalized Flamingo Critical Areas.

Table 1: Bird list from West Andros REA June 19-28, 2006, Prepared by: Michael E. Baltz, The Nature Conservancy of Illinois

Species	**Abundance**	**Comments**
Brown Pelican (*Pelecanus occidentalis*)	Common	Reported that birds may nest on west side in some years
Double-crested Cormorant (*Phalacrocorax auritus*)	Common	Several dozen seen on Flamingo Cay
Yellow-crowned Night Heron (*Nyctanassa violacea*)	Rare	1 seen on Leaf Cay
Black-crowned Night Heron (*Nycticorax nycticorax*)	Rare	At least 2 seen during boat rides
Green Heron (*Butorides virescens*)	Uncommon	
Tricolored Heron (*Egretta tricolor*)	Abundant	12-18 nests in a mangrove clump on North Andros
Little Blue Heron (*Egretta caerulea*)	Uncommon	Likely nesting, 3 individuals seen in heron rookery on North Andros
Reddish Egret (*Egretta rufescens*)	Common	Notes indicate 5 white morphs to every 1 dark morph
Cattle Egret (*Bubulcus ibis*)	Rare	1 seen in heron rookery on North Andros
Great Blue Heron (*Ardea herodias*)	Uncommon	
Caribbean Flamingo (*Phoenicopterus ruber*)	Rare	Flock seen repeatedly in one location on North Andros(high count 107)
White Ibis (*Eudocimus albus*)	Common	Saw individuals in both mature and immature plumage
Roseate Spoonbill (*Ajaia ajaja*)	Rare	One group of 7 seen on Flamingo Cay
White-cheeked Pintail (*Anas bahamensis*)	Rare	Nest reported on a cay in the Bights
Turkey Vulture (*Cathartes aura*)	Uncommon	
Osprey (*Pandion haliaetus*)	Uncommon	
Black-bellied Plover (*Pluvialis squatarola*)	Uncommon	Seen on two cays at southern tip of South Andros
Wilson's Plover (*Charadrius wilsonia*)	Uncommon	
Black-necked Stilt (*Himantopus mexicanus*)	Common	Reported that birds were nesting in Turner Sound
Willet (*Catoptrophorus semipalmatus*)	Common	Nest found on Leaf Cay
Yellowlegs sp. (*Tringa sp.*)	Rare	Heard on Flamingo Cay

Laughing Gull (*Larus atricilla*)	Common	
Royal Tern (*Sterna maxima*)	Uncommon	
Gull-billed Tern (*Sterna nilotica*)	Uncommon	
Least Tern (*Sterna antillarum*)	Uncommon	Nesting on Leaf Cay and on unnamed cay off west coast
White-crowned Pigeon (*Columba leucocephala*)	Common	
Zenaida Dove (*Zenaida aurita*)	Rare	2 seen on Leaf Cay
Common Ground Dove (*Columbina passerina*)	Rare	1 seen on unnamed Cay on South Andros
Mangrove Cuckoo (*Coccyzus minor*)	Rare	1 heard on North Andros
Smooth-billed Ani (*Crotophaga ani*)	Rare	Seen around Flamingo Cay Rod and Gun Club
Greater Antillean Nighthawk (*Chordeiles gundlachii*)	Uncommon	Found nesting on West Andros and Leaf Cay
Bahama Woodstar (*Calliphlox evelynae*)	Uncommon	
Cuban Emerald	Rare	1 male seen on west coast of North Andros
Gray Kingbird (*Tyrannus dominicensis*)	Common	
Thick-billed Vireo (*Vireo crassirostris*)	Uncommon	
Northern Mockingbird (*Mimus polyglottos*)	Common	
Bahama Mockingbird (*Mimus gundlachii*)	Common	
Yellow Warbler (*Dendroica petechia*)	Uncommon	
Bahama Yellowthroat (*Geothlypis bahamensis*)	Rare	Two heard on North Andros
Bananaquit (*Coereba flaveola*)	Rare	Nesting at Flamingo Cay Rod and Gun Club
Black-faced Grassquit (*Tiaris bicolor*)	Rare	Seen around Flamingo Cay Rod and Gun Club
Greater Antillean Bullfinch	Rare	Seen around Flamingo Cay Rod and Gun Club
Red-winged Blackbird (*Agelaius phoeniceus*)	Common	
Bahamas Oriole (*Icterus northropii*)	Rare	Nesting at Flamingo Cay Rod and Gun Club

Total Species (44)

Abundant = Several seen everyday
Common = At least one seen everyday
Uncommon = Seen several times, but not everyday
Rare = Seen only once or only in one location

Sea Turtles

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Introduction

The west coast of Andros is important habitat for 3 species of sea turtles: green turtles (*Chelonia mydas*), loggerheads (*Caretta caretta*), and hawksbills (*Eretmochelys imbricata*). The sea turtle populations observed on the west coast of Andros are significant in the Bahamas Archipelago and may well be of regional significance in the Greater Caribbean.

Methods

Surveys on the west coast of Andros, Bahamas were conducted from 19 – 27 June 2006 (Figure 1). Tracks for each survey day were recorded using a handheld GPS (Garmin model GPS map 76CSx), and uploaded into PC based software (MapSource version 6.5, Garmin, Inc.). Survey tracks for each day are presented in Figures 2-9. They were conducted along the shore up to 3 nautical miles offshore and within the networks of creeks. At each survey site (Table 1) line transects were systematically established to allow for robust statistical estimates of relative abundance. Transect lines were developed and uploaded to handheld GPS units to conduct the surveys. The sites surveyed along the shoreline to 3nm offshore used "W" configuration line transects (sighting were measured per distance traveled and per unit time). The sites surveyed within the network of creeks used time transect (sightings per unit time).

Project Objectives

1. Survey the west coast of Andros for sea turtles:
   - Determine species present and their relative abundance (sightings per unit time).
   - Determine size class / life stage of sea turtles present.
   - Determine evidence of sea turtle nesting and any evidence of nest predation and/or poaching.
   - Determine evidence for sea turtle diseases.

2. Identify areas that need to be protected to ensure sea turtle conservation for The Bahamas.

3. Determine if any sites are suitable for establishing long-term demographic studies (e.g., mark-recapture data for somatic growth rates and estimates of survivorship) to complement our demographic studies in other regions of The Bahamas.

Results

Numbers of turtles observed per survey hour are presented for locations surveyed in Table 1. Summary of data collected for turtles caught, measured, and tagged is presented in Table 2.

The disease fibropapillomatosis (FP) was observed in green turtles in three areas surveyed for sea turtles (Billy Island, Spanish Wells, and Little Miller Creek). Prior confirmed reports of FP from The Bahamas have been limited to Crooked Acklins and Grand Bahama.

Summary of Results

- The waters around the west coast of Andros are important habitat for 3 species of sea turtles: green turtles (*Chelonia mydas*), loggerheads (*Caretta caretta*), and hawksbills (*Eretmochelys imbricata*). The sea turtle populations observed along the west coast of

Andros are significant for The Bahamas Archipelago and may well be of regional significance in the Greater Caribbean.

- The juvenile loggerhead population observed in the waters around the west coast of Andros represents the only known aggregation of juvenile loggerheads in The Bahamas and is of regional significance for the Greater Caribbean.

- The disease fibropapillomatosis (FP) was observed in green turtles in three areas surveyed for sea turtles (Billy Island, Spanish Wells, and Little Miller Creek). Prior, confirmed reports of FP from The Bahamas have been limited to Crooked Acklins and Grand Bahama.

- Based on discussions with bonefishing guides and our abbreviated survey on 27 June, South Andros may have regionally significant hawksbill populations. The possibility of sea turtle nesting on the cays off South Andros needs further investigation.

Recommendations

Loggerhead demography:

The populations of juvenile loggerheads (*Caretta caretta*) on the west coast of Andros (e.g., Miller Creek) are of regional significance in the Greater Caribbean. Information from this warm water habitat will have significant implications for models of population dynamics. Therefore, we propose to develop a mark-recapture study of loggerhead sea turtles in the waters of the west coast of Andros. These data will allow for analyses of somatic growth rates, residence times in the creek habitats, movement patterns out of the creeks, annual survival probabilities, and population abundance and trends.

South Andros sea turtle surveys:

Based on a survey conducted 27 June 2006 and discussions with bonefishing guides, South Andros may have significant loggerhead (*Caretta caretta*) and hawksbill (*Eretomochelys imbricata*) populations. The importance of South Andros for sea turtle populations may be significant within The Bahamian Archipelago as well as for the Greater Caribbean.

The area to survey is from Muddy Point (N23.89) on the west coast of Andros south to Water Cays, Curly Cut Cays and up the east coast to Little Creek (N23.95) including offshore cays and coral heads. Surveys should also include the network of creeks (e.g., Rock Sound, Kraal Creek, Hawksbill Creek, and Grassy Creek). Both foraging and nesting habitats should be evaluated.

Distribution, frequency of occurrence, and severity of fibropapillomatosis disease (FP):

FP is a serious disease for both green turtles (*Chelonia mydas*) and loggerheads (*Caretta caretta*). Prior to our June 2006 survey of coastal waters of west Andros, there have been only a few confirmed reports of FP from The Bahamas (Crooked Acklins, Grand Bahama). During our June 2006 assessment, we observed FP in green turtles in the 3 main sea turtle areas surveyed (Billy Island, Spanish Wells, and Little Miller Creek).

We propose to catch turtles in foraging areas throughout coastal waters of west Andros to determine the distribution and frequency of occurrence of FP. We will use an established ranking system (visual assessment of number and size of tumors) to quantify the severity of the disease in individual turtles. Small samples of the tumors will be collected for pathological evaluation.

Training modules (PowerPoint):
A series of training modules on birds, sharks, turtles, etc., should be developed for bonefishing guides and other individuals involved in ecotourism. The objective of these modules would be to increase awareness of the importance of these ecosystem components and to allow the guides to provide a richer environmental experience for ecotourists. We propose to develop the module for sea turtles which will include the following topics: sea turtle species in The Bahamas and how to identify them; basic sea turtle biology and life cycles; distribution of sea turtles in The Bahamas; importance of sea turtles in their ecosystems; importance of sea turtles for ecotourism; and sea turtle regulations in The Bahamas.

Observation forms / booklets:
An observation booklet should be developed for bonefishing guides and other interested individuals to record sea turtle observations. The following data fields should be included: date, location, species, size class, presence of fibropapillomas. These booklets should have an introductory section on species identification and sections defining the variables.

Table 1. Numbers of sea turtles observed per observation hour. CC = *Caretta caretta*; CM = *Chelonia mydas*; EI = *Eretmochelys imbricata*; unk = unidentified species.

Date	Location	Species	Number of Turtles	Number of hours of observation	Rate (turtles observed/hr)	Visibility
19-6-2006	See Figure 2		0	4	0	Good
20-6-2006	See Figure 3: within red circle (Pumpkin Cay Lake)	CC, CM, EI, unk	13	0.9	14.4	Good
20-6-2006	See Figure 3: within red circle (Timbler Creek)	CM, unk	2	0.6	3.3	Good
20-6-2006	See Figure 3: outside circle		0	6.4	0	Good
21-6-2006	See Figure 4; blue circle (Williams Island; East, South, West Coasts)	CM, unk	7	1.5	4.7	Excellent
21-6-2006	See Figure 4; blue circle (Williams Island; North Coast)	CM, unk	7	0.5	14.0	Excellent
21-6-2006	See Figure 4; red circle (Billy Island)	CM, unk	51	1.6	31.9	Excellent
21-6-2006	See Figure 4; black circle	CM	1	0.3	3.3	Excellent

Table 1 continued.

Date	Location	Species	Number of Turtles	Number of hours of observation	Rate (turtles observed/hr)	Visibility
21-6-2006	See Figure 4; green circle (Pumpkin Cay area)	CC, CM, EI, unk	21	1.3	16.2	Excellent
22-6-2006	See Figure 5; black circle (Little Loggerhead Creek)	CM	3	0.9	3.3	Excellent
22-6-2006	See Figure 5; red circle (Little Miller Creek area)	CM, unk	10	2.5	4.0	Good to poor
22-6-2006	See Figure 5; blue circle (Spanish Wells)	EI	1	1.3	0.8	Poor
22-6-2006	See Figure 5; green circle (Big Loggerhead Creek)	CM	1	0.7	1.4	Poor
23-6-2006	See Figure 6; red circle (Cabbage Creek & River Goose)	CM, unk	3	3.25	0.9	Poor
23-6-2006	See Figure 6; black circle (Wills Creek)	CM	3	1.2	2.5	Poor
23-6-2006	See Figure 6; blue circle	CM	1	0.5	2.0	Poor

Table 1 continued.

Date	Location	Species	Number of Turtles	Number of hours of observation	Rate (turtles observed/hr)	Visibility
26-6-2006	See Figure 8; red circle (Miller Creek); 1st survey	CC, CM	18	1.3	13.8	Bright sun, dark water
26-6-2006	See Figure 8; red circle (Miller Creek); 2nd survey	CC	13	0.23	56.5	Bright sun, dark water
26-6-2006	See Figure 8; black circle		0	1.2	0	Bright sun, dark water
26-6-2006	See Figure 8; green circle (Tuckaway Creek)	CM. unk	8	0.8	10.0	Bright sun, dark water
26-6-2006	See Figure 8; blue circle (Honeycut Creek & The Landing)	unk	1	0.8	1.25	Bright sun, dark water
26-6-2006	See Figure 8; pink circle (Big Loggerhead Creek)	CC, CM, unk	15	0.8	18.75	Bright sun, dark water

Table 2. Turtles captured, tagged, and measured: CM = *Chelonia mydas*; CC = *Caretta caretta*; RF = right front flipper; LF = left front flipper; CCL = curved carapace length (cm); FP = fibropapillomatosis. Note, this does not include turtles sighted but not captured.

Date	Location	Species	RF Tag	LF Tag	CCL (cm)	FP	Skin biopsy
22-6-2006	Little Miller Creek	CM	--	--	~ 40	Yes	No
24-6-2006	Billy Island	CM	--	--	~ 40	Yes	No
24-6-2006	Billy Island	CM	W9502	W9503	46.9	No	Yes
24-6-2006	Billy Island	CM	W9504	W9505	42.6	No	Yes
24-6-2006	Billy Island	CM	W9507	W9506	35.2	No	Yes
24-6-2006	Wide Opening	CC	W9509	W9508	50.1	No	Yes

Table 3. Site data for trip to South Andros (27 June 2006), see Figure 9 for site locations.

Location	Description
Leaf Cay	Surveyed for sea turtle nesting; no signs of nesting observed. Sand depth ranged from 36-102cm. Three sand samples were collected for analyses. Sand beaches on N and NW coasts may be able to support a few sea turtle nests but this beach is not a great nesting habitat.
Water Cay	Surveyed for sea turtle nesting; no signs of nesting observed. Abandoned buildings with associated stone sea wall present. Sand depth ranged from 47-57cm. One sand sample was collected for analyses. Sea turtle nesting is possible but this is not a good nesting habitat.
Blue Hole	At least 20 turtles, both loggerheads and green turtles were observed based on head sightings. Cindy Rimstad and Charles Bethell saw 4 large hawksbills (confirmed by pictures) while swimming around Blue Hole. Saw 3 big green turtles from plane.
Iguana site	No turtles observed.

Figures

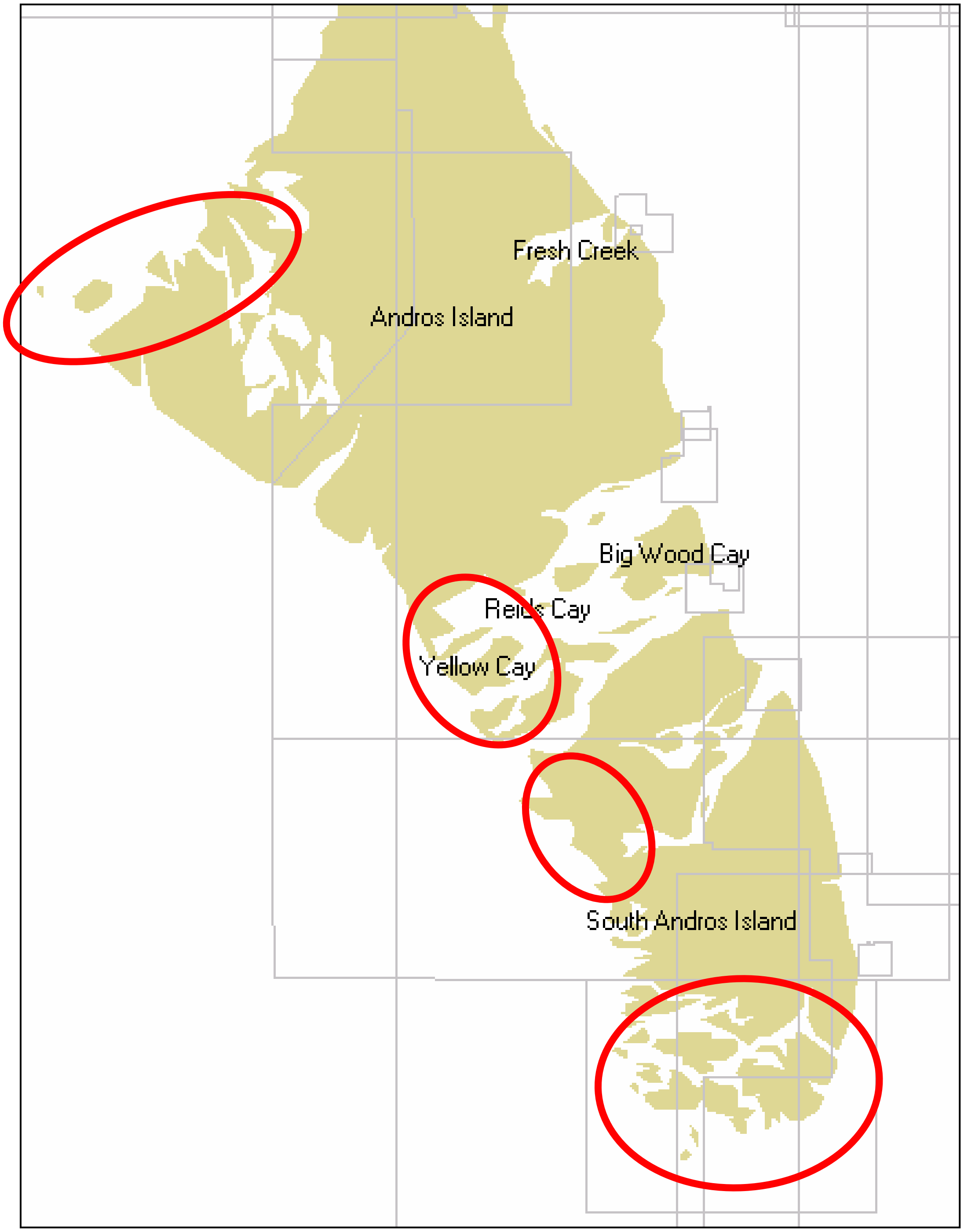

Figure 1. The west coast of Andros is important habitat for 3 species of sea turtles: green turtles (*Chelonia mydas*), loggerheads (*Caretta caretta*), and hawksbills (*Eretmochelys imbricata*). The sea turtle populations observed on the west coast of Andros are significant in the Bahamas Archipelago and may well be of regional significance in the Greater Caribbean. The circled areas are of particular importance (see Table 1). The possibility of sea turtle nesting on the cays off South Andros needs further investigation.

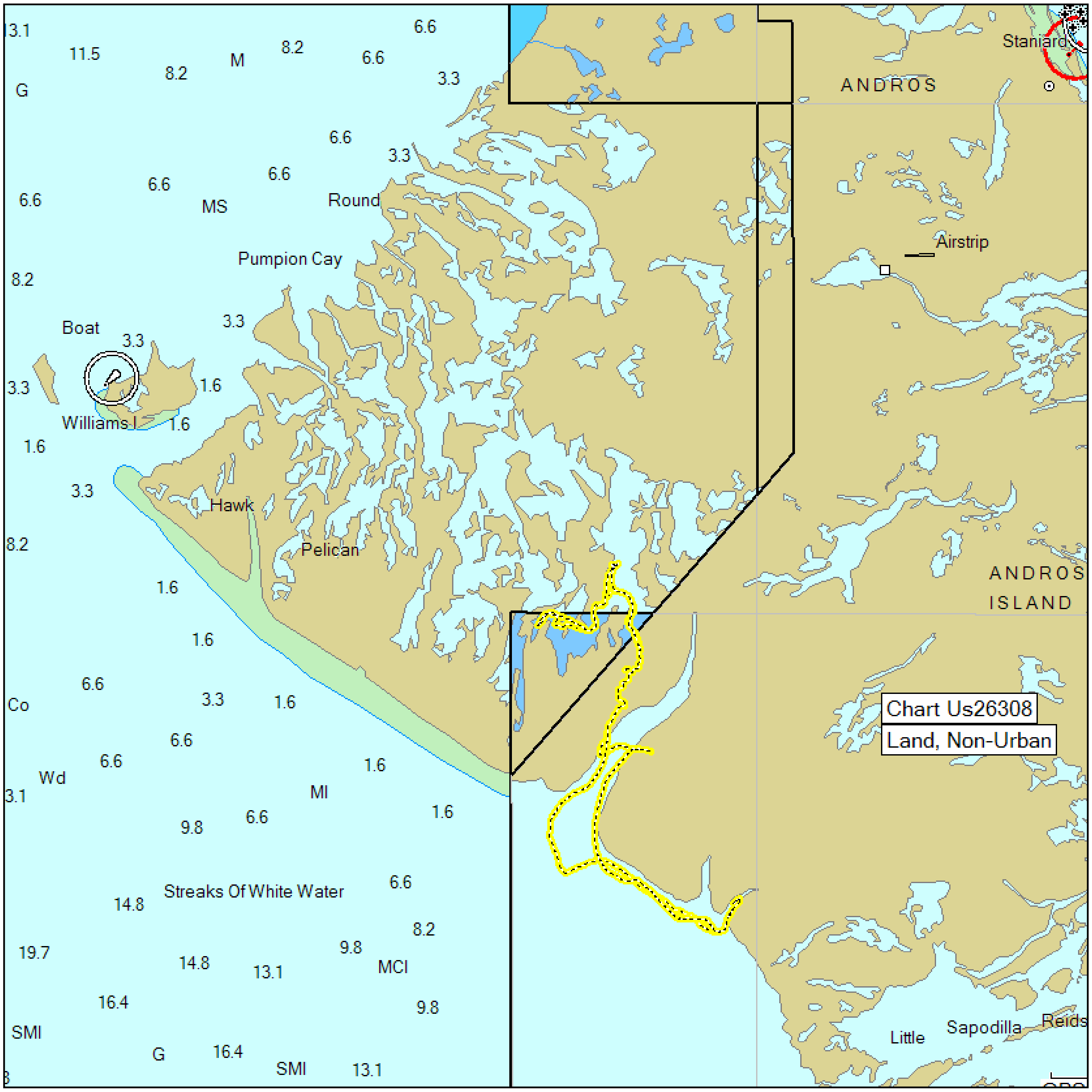

Figure 2. Survey track (yellow) for 19 June 2006; guide was Phillip Rolle. No sea turtles were observed.

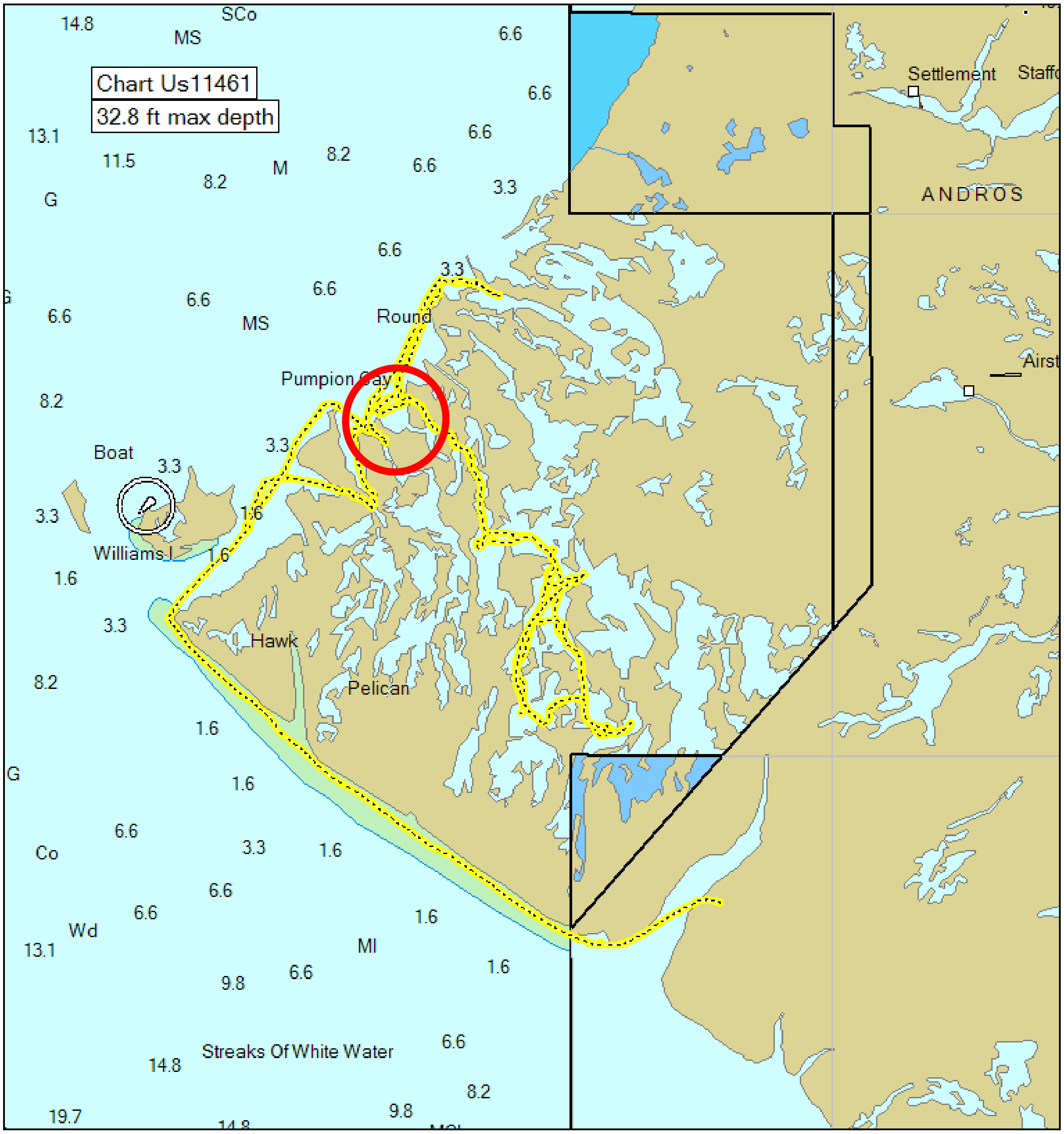

Figure 3. Survey track (yellow) for 20 June 2006; guide was Phillip Rolle. Turtles were only observed within the red circle; see Table 1 for rate of turtle observations (number of turtles observed/hour observation).

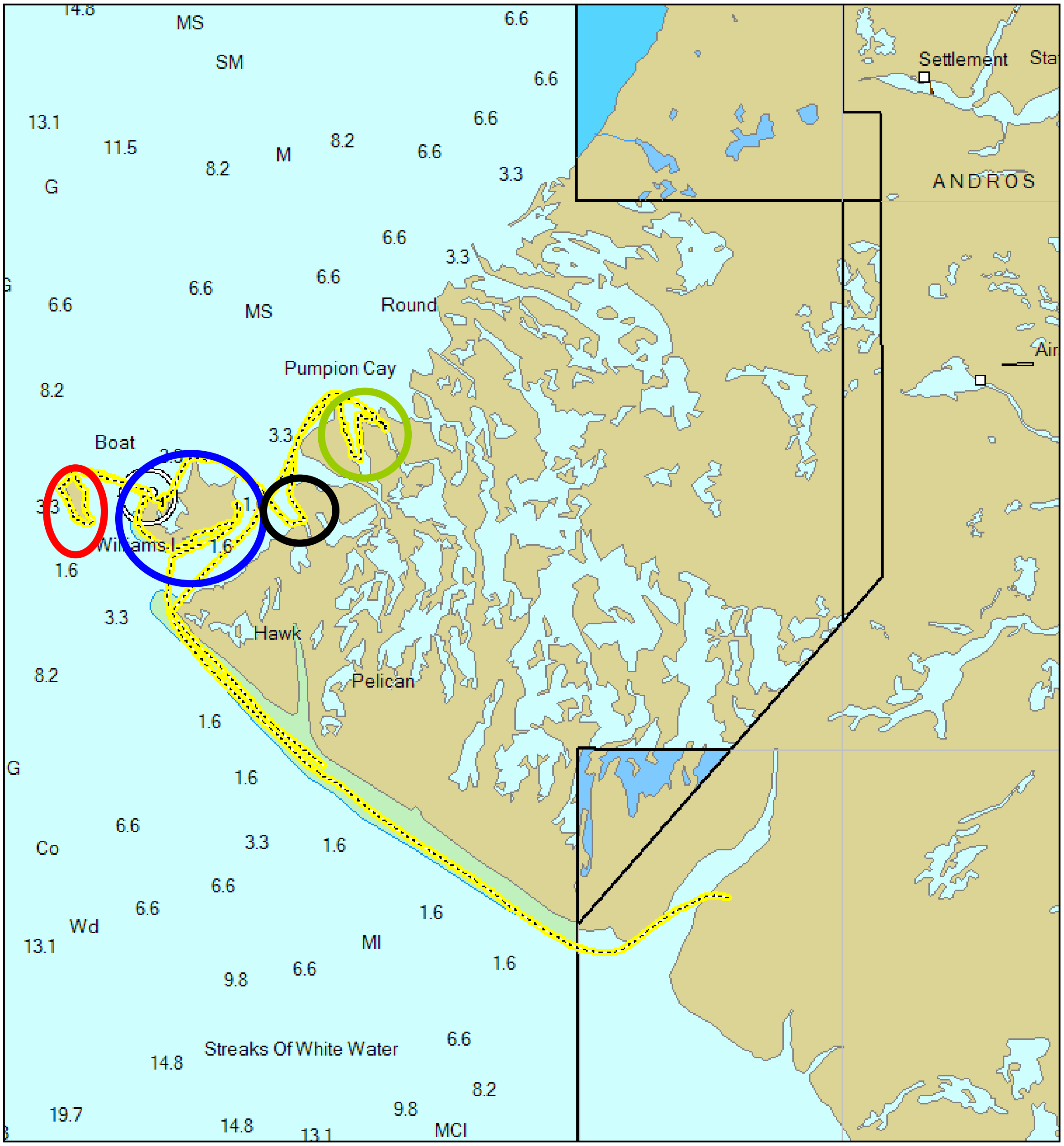

Figure 4. Survey track (yellow) for 21 June 2006; guides were Charles Bethell and Cindy Rimstad. Red circle = Billy Island; blue circle = Williams Island; green circle = Pumpkin Cay area. See Table 1 for rate of turtle observations (number of turtles observed/hour observation). No turtles observed outside of circles.

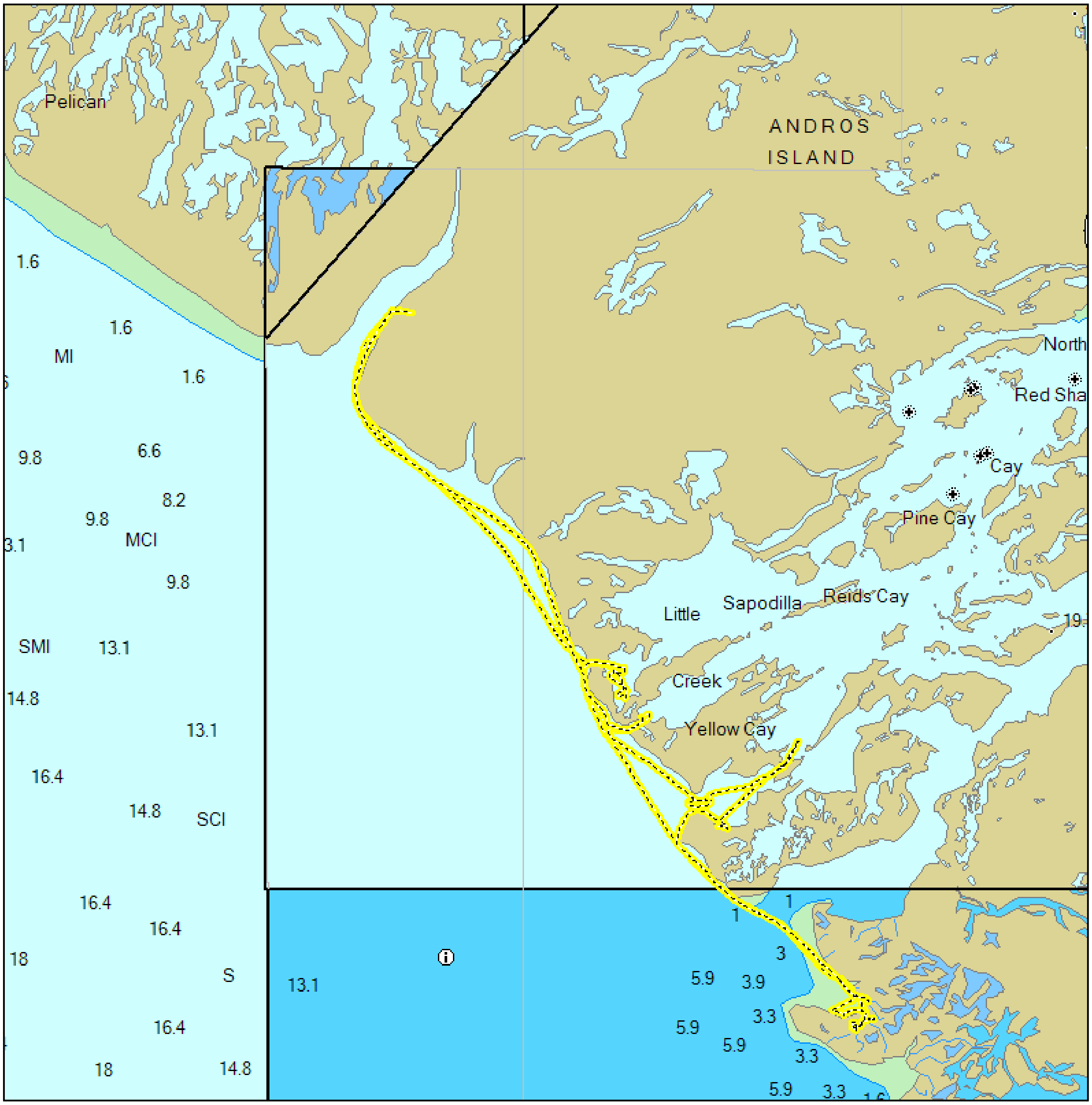

Figure 5. Survey track (yellow) for 22 June 2006; guide was Danny Newbold. Black circle = Little Loggerhead Creek; red circle = Little Miller Creek and surrounding area; blue circle = Spanish Wells; green circle = Big Loggerhead Creek. See Table 1 for rate of turtle observations (number of turtles observed/hour observation). No turtles were observed outside of circles.

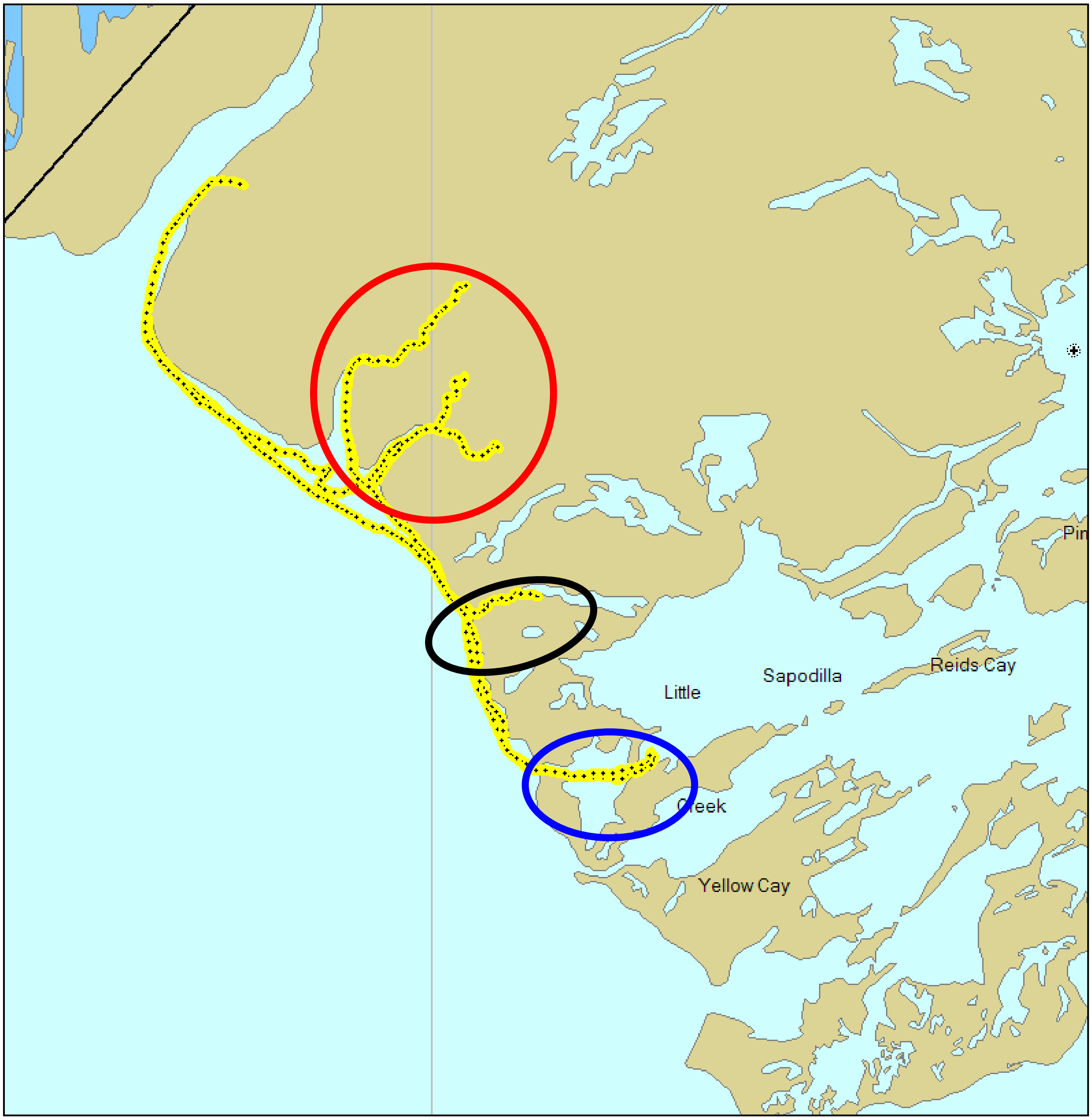

Figure 6. Survey track (yellow) for 23 June 2006; guide was Rivean Gibson. Red circle = Cabbage Creek and River Goose; black circle = Wills Creek. See Table 1 for rate of turtle observations (number of turtles observed/hour observation). No turtles were observed outside of the circles.

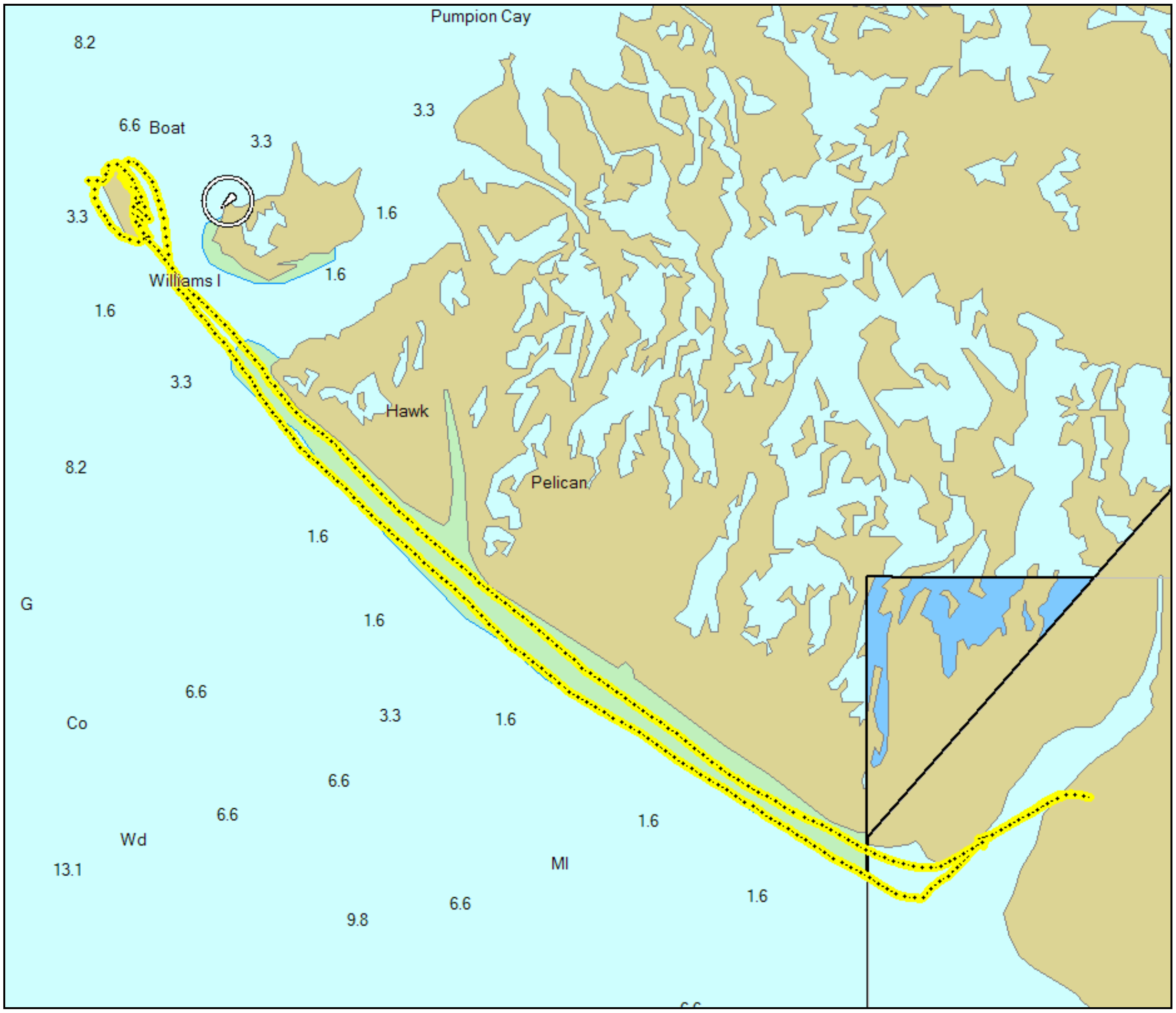

Figure 7. Track (yellow) for 24 June 2006. Survey was not conducted on this day. This day was devoted to catching, measuring, and tagging turtles around Billy Island (see Table 2) with Charles Bethell and Cindy Rimstad.

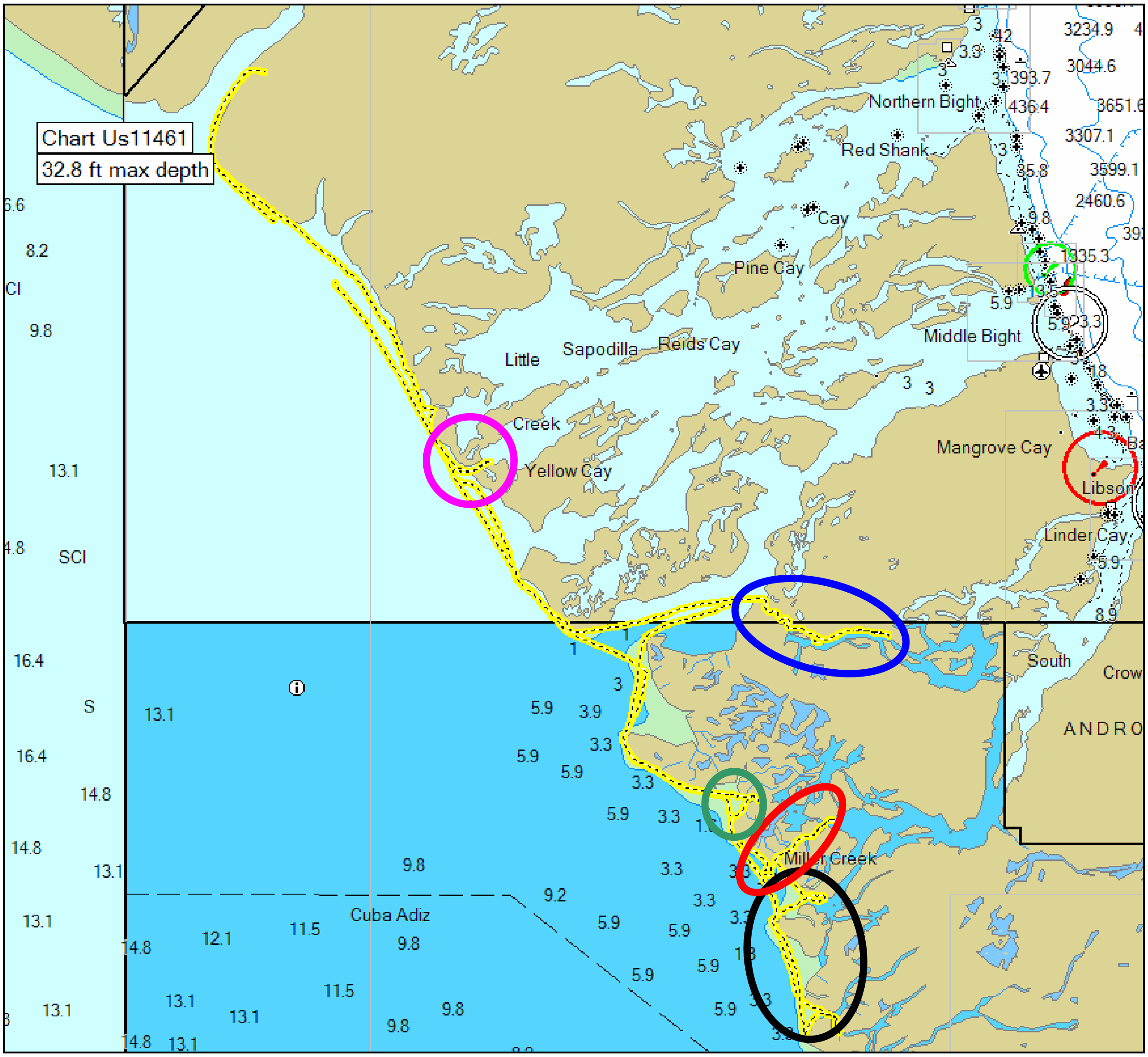

Figure 8. Survey track (yellow) for 26 June 2006; guide was Shawn Leadon. Red circle = Miller Creek; green circle = Tuckaway Creek; blue circle = Honeycut Creek and the Landing; pink circle = Big Loggerhead Creek. See Table 1 for rate of turtle observations (number of turtles observed/hour observation). No turtles were observed in the black circle or outside of the circles.

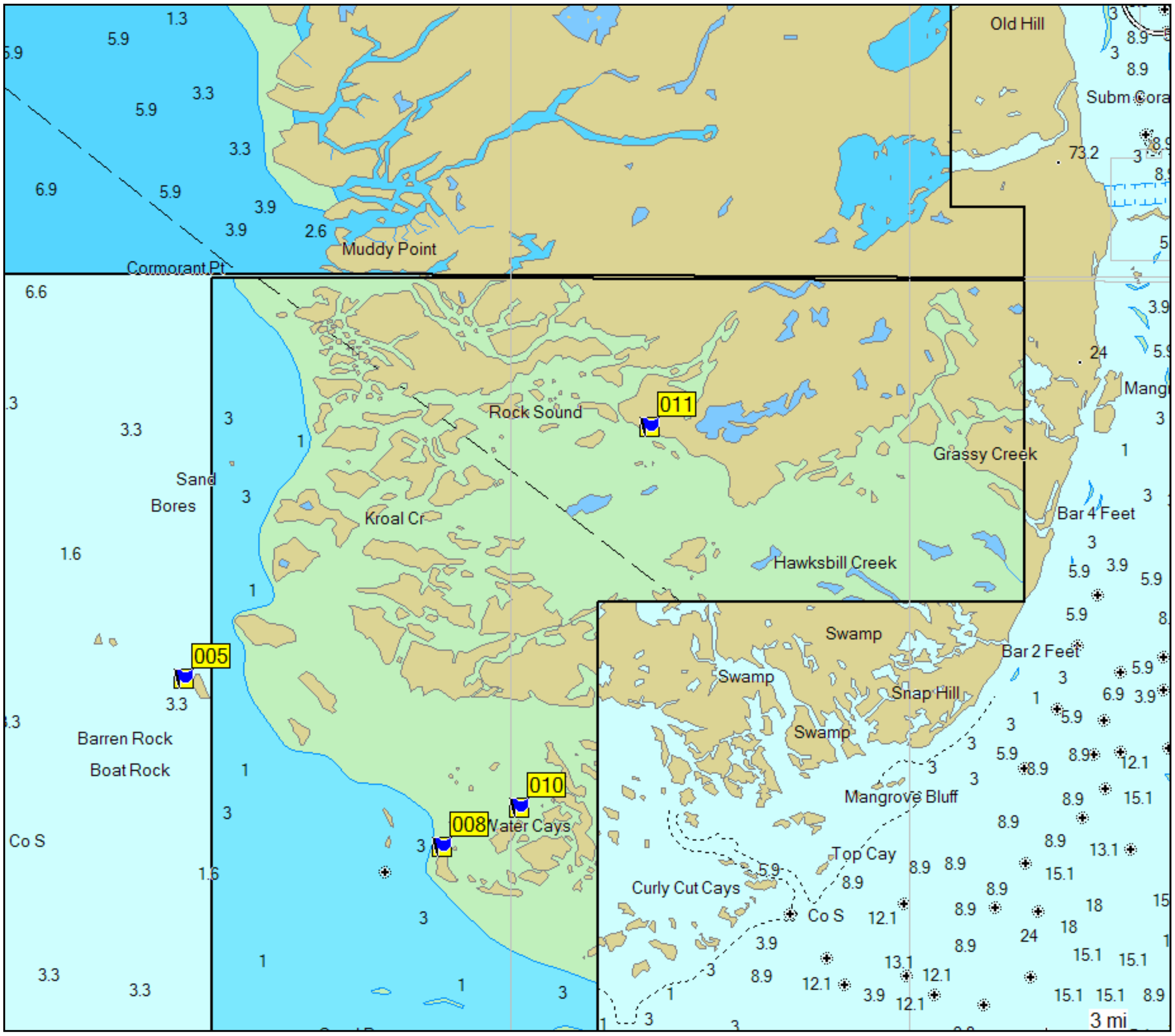

Figure 9. Site assessments (yellow waypoints) for 27 June 2006. Waypoint 005 = Leaf Cay; 008 = Water Cay; 010 = Blue Hole; 011 = "Iguana site." See Table 3 for descriptions of each site.

Figure 10. Fibropapillomatosis observed on a green turtle (~40 cm CCL) caught in Little Miller Creek (22 June 2006). Photo: Karen Bjorndal.