INTERNATIONAL CORAL REEF INITIATIVE: CREATION OF A HIGHLY DETAILED MAP OF THE CORAL REEF SYSTEM SURROUNDING PETERSON CAY GRAND BAHAMA ISLAND

EXPLORERS CLUB FLAG EXPEDITION
INTERNATIONAL CORAL REEF INITIATIVE: CREATION OF A HIGHLY ACCURATE MAP OF
THE CORAL REEF SYSTEM SURROUNDING PETERSON CAY, GRAND BAHAMA ISLAND

Explorers Club Flag Expedition Report

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EXPLORERS CLUB FLAG EXPEDITION TEAM

An international expedition from its inception, we originally hail from Canada, the United States, Germany, England and The Bahamas. Most of us are members of The Explorers Club and our expedition was carrying the Club’s Flag. We were given Flag 100. First flown in 1939, it is slightly tattered, its woolen fibers worn thin, and its colors are fading from its many expeditions to the West Indies, Galapagos Islands and off of the Australian coast, as the Club’s records would show. For almost eight decades it endured scorching sun and stiff winds, silently witnessing scientific research carried out by members of The Explorers Club.

Five of our expedition’s seven members are members of The Explorers Club, and they include Dr. Stefan Harzen, FN’ 01 and Dr. Barbara Brunnick, FN’ 01 of the Taras Oceanographic Foundation, a husband and wife team from Jupiter, Florida, who developed the intricate methodology to map critical habitats on a level of detail not seen before being used on this expedition.

Other Club members include Lt(N) Joseph Frey, FI’ 02, a Canadian naval officer, science writer and Chairman of the Club’s Canadian Chapter, who served as the expedition’s co-leader together with Stefan Harzen, Harvey Oyer, FN’ 07, an underwater archaeologist and lawyer from West Palm Beach, Florida, and Jonathan Frey, SM’ 06, a Student Member of the Club, a high school student and naval reservist in Toronto who is using this project for the Expedition portion of his Duke of Edinburgh Gold Award.

Non-Explorers Club members of the expedition include Larry Wood from Jupiter, Florida who is an expert sea turtle researcher and a conservation biologist with the Taras

Explorer Club Flag flying high on the communication antenna of our 42 ft research vessel the Bahamas Breeze.

Explorers Club Flag being flown over Explorers Reef.
Oceanographic Foundation and the Palm Beach Zoo and Paul Mockler, an award winning cinematographer and underwater production specialist who whose resume lists feature films, countless documentaries and work on 8 IMAX productions, including *Titanica*. Bahamian Philip Kemp (PK) was the skipper of our research vessel and Poncho Bain our dive master. They skillfully provided a safe base for the entire team in all weather conditions and their knowledge of the area and diving experience proved to be invaluable.
International Coral Reef Initiative: Creation of a highly accurate map of the coral reef system surrounding Peterson Cay, Grand Bahama Island

1. Introduction
The objective of this expedition was to create a map of delineated marine community types of the reef complex situated next to Peterson Cay, Grand Bahama. Both applicants have been involved in similar mapping efforts which were based on available LANDSAT 7 satellite images and other remote sensed data. The resulting maps, together with other ancillary information were published by the Taras Oceanographic Foundation in 2002.1

Over the last few years, the authors have developed the intricate methodology needed to map critical habitats, such as reefs, on a level of detail not seen before. It takes advantage of the most advanced technologies, combining aerial imagery, Global Positioning Systems (GPS), remote sensing and Geographical Information Systems (GIS) with scientific field surveys. The spatial information is then combined with the marine habitat classification framework defined by the Ecological Society of America (ESA) and the National Oceanic and Atmospheric Administration’s (NOAA) Office of Habitat Conservation. The result is a high resolution map that discerns different habitat types from bare bottom to sea grass and coral reef, highlights density variations and pinpoints the exact location of individual species of interest, such as the endangered Elkhorn coral.

Maps have played an important part in human history. In the past, maps have been made by different people at different scales and different levels of accuracy. Everyone has seen maps and many have experienced how difficult it is to compare different versions of a map showing the same area. Now we have the technology to create geo-rectified maps of great accuracy and detail. In 3, 5 or 10 years we can return to layer new data over the original ones. As result, we are able to discern different habitat types on the smallest scale, analyze their spatial and temporal relationships, and identify minute changes.

Figure 1. Peterson Cay off Grand Bahama Island

2. Material and Methods

2.1. Mapping
In preparation of the field expedition, a set of ortho- and geo-rectified aerial raster images (see Figure 1) of the study area were analyzed to create a first draft of the map by applying

ArcGIS at various scales. Discernable community types were outlined to create numbered polygons in the vector layer of the map. Each polygon was assigned a particular code to organize similar habitats by appearance. The first draft of the map was then uploaded to ArcPad and transferred to a Trimble Unit, a highly accurate GPS tool (accuracy ≤1m), which will be used in the field.

From this classification framework that contains a total of 13 levels, the Grand Bahama marine area is consistent through the first six levels (water, marine, non-continental, benthic, shallow<200m). The lower levels include specific modifiers and address the particular environmental conditions found. These next five levels include regional wave/wind energy, bank energy, hydrodynamic features: subtidal, photic/aphotic, photic and geomorphic types. Geomorphic types include four distinct marine types including A) soft sediments, B) non-reefal hardbottom, C) reefal hardbottom and D) deep reef resources. At this level (11), the framework was further defined and customized for Grand Bahama and includes the following subcategories (Level 12: Ecotype) for habitat classification:

A) Soft Sediment
   1. Bare Sand : 0-10% cover
   2. Low Density Sea grass: 10-30% cover
   3. Medium Density Sea grass: 30-60% cover
   4. High Density Sea grass: 60%+ cover
   5. Anthropogenic

B) Non-Reefal Hardbottom
   1. Nearshore
   2. Channel, Algae dominated
   3. Channel, Octocoral / Sponge dominated
   4. Platform Margin, Algae dominated

2.2. Grand Bahama Marine Environment
Grand Bahama is the northern most island of the Bahamian archipelago, a unique carbonate bank system, with shallow banks and deep-water basins providing a variety of marine benthic and open water habitats. The marine habitat mapping assessment utilizes the overall classification framework defined by the Ecological Society of America (ESA) and the National Oceanography and Atmospheric Administration (NOAA) Office of Habitat Conservation.

Figure 2. Example of raster aerial image of Peterson Cay
C) Reefal Hardbottom
  1. Reefal Hardbottom
  2. Platform Margin
  3. Nearshore Patch Reef

D) Deep Reef Resources
  1. Deep Water: 20m+

The main ecotype for non-reefal hardbottom is *Near-shore*. These areas can be algae dominant and/or can contain corals and sponge. There is a distinction as to when Hardbottom is considered reefal or non-reefal and changes between these habitats are often gradual with exception of where near-shore coral heads or patch reefs are found. Based on information available to us we expanded on the classification system to include the following:

B) Non-Reefal Hardbottom Algae Dominant
   1) Hardbottom: 0-10% cover
   2) Hardbottom: 10-30% cover
   3) Hardbottom: 30-60% cover
   4) Hardbottom: 60%+ cover

C) Reefal Hardbottom Coral/Sponge Dominant
   5) Hardbottom: 0-10% cover
   6) Hardbottom: 10-30% cover
   7) Hardbottom: 30-60% cover
   8) Hardbottom: 60%+ cover

2.3. Ground-truthing
We conducted a series of ground-truthing or field surveys from August 15 through August 29. The *Bahama Breeze*, a 42’ vessel served as our working platform in the field together with a 26 ft fishing boat and a kayak which we used to access very shallow area.

To test and verify aerial projection, accuracy and the tentatively identified habitats of the first draft of the map, we followed high contrast edges between discernable habitats, coupled with stratified, linear transects across the study site. This process ensured that individual habitat/community types were correctly assigned and verified. Each such transect followed a pre-determined route. The spatial and biological information was collected using the Trimble unit referenced above (see 2.1.). In addition, the exact locations of stands of Elkhorn coral specimens (one of the target species listed in the Eco-regional Plan for the Bahamian Archipelago) were recorded.

Finally, we photographed and filmed individual sites located throughout the study area.

2.4. Post-Expedition Completion of the Map
Upon return to our lab, each polygon was checked and verified for habitat and received its final attribution and color coding. The map will then be complete, providing a highly accurate representation of the reef complex as of August 2008. In addition to the map itself, our analysis will provide a quantitative analysis of the area covered by the discernable habitat types. Repeating the ground-truthing and mapping procedure in the future will then allow for the determination of possible changes in size, area, distribution and composition of each habitat type, thus providing an invaluable management tool to all stakeholders long into the future.
Results
The study area around Peterson Cay comprised a total of 278 hectares (688 acres), extending from the beach to about 1,600m offshore and 600m to the east, and 940m to the west of the Cay. The area represents a combination of three main benthic substrates:

1. White sand (composed of oolite in the Bahamas), a substrate that promotes the growth of turtle grass meadows (*Thalassia* sp.);
2. Non-reefal hardbottom (also known as hard pan), a flat, very hard substrate, much like a road or parking lot. Various red and brown algae dominate as they outcompete other organisms; and
3. Reefal hardbottom, a rocky substrate. As reefal communities (coral and sponges) grow and expand they raise the substrate from the hardpan, creating reefs.

Overall, we were able to discern and map a total of 17 benthic community types which are illustrated below (Figure 3 through 14).

![Figure 3. Bare Sand](image)

![Figure 4. Sea grass 10-30%](image)

![Figure 5. Sea grass 30-60%](image)
Figure 6. Sea grass >60%

Figure 7. Hard bottom Algae <10%

Figure 8. Hard bottom Algae 10-30%

Figure 9. Hard bottom Algae 30-60%
Figure 10. Hard bottom Algae >60%

Figure 11. Hard bottom Reefal <10%

Figure 12. Hard bottom Reefal 10-30%

Figure 13. Hard bottom Reefal 30-60%
The delineation of the discernable benthic community types resulted in a highly precise map of the marine area surrounding Peterson Cay all the way across to the beach of Grand Bahama Island (see Figure 15). Figure 15 shows the area all the way across to the beach of Grand Bahama while Figure 16 zooms in the area immediately adjacent to the Cay.

Further analysis revealed that of the entire area of 278 hectares (688 acres), coral reef, in its various expressions of density covers 84 hectares (208 acres), sandy bottom with various degrees of sea grass spread out over 106 hectares (263 acres), and areas of hard pad, with algae (generally red and brown algae) of one degree or another covered 84 hectares (209 acres). It is worth emphasizing though that the density of algae coverage in two-third of these areas is less than 10% (see Figure 17 for details).
Figure 16. Map of marine area immediately adjacent to Peterson Cay, Grand Bahama Island, The Bahamas
Figure 17. Frequency distribution of discernable community types
Elkhorn Corals

Elkhorn coral (*Acropora palmata*) is a member of the Family *Acroporidae*. Its blades are flattened and palm-shaped, with branches emerging at acute angles, generally in the same plane of growth as the parent blade. The species has very fast growth rates (up to 10 cm per year), which are measured as rates of linear extension of particular branches. It primarily depends on asexual reproduction, especially fragmentation, to form new colonies.

![Figure 18. Healthy Elkhorn coral near Peterson Cay](image)

Information on the status of Elkhorn coral populations in the Bahamian Archipelago is limited. This coral is generally found in very shallow waters, especially shallow back reef, reef flat, and reef crest environments. In the Bahamas, this species is primarily restricted to the leeward and marginal sides of islands where, like off Grand Bahama Island, forms a reef framework in waters depth of 1 to 3 meters. The species is considered environmentally sensitive, requiring relatively clear, well-circulated water and is only moderately resistant to storm damage and other physical disturbances.

Since the 1970s, Elkhorn coral has experienced large-scale declines all over the Caribbean. This has become increasingly disconcerting since they create the topographic complexity a great many other species depend on. In fact, large, upright colonies provide critical habitat for a diversity of reef fishes and benthic invertebrates. The loss of Elkhorn corals has resulted in a shift from coral to algae dominance in many areas throughout the wider Caribbean.

Among the causes of decline are white-band disease, increased predation (major predators include damselfishes, the polyachaete bristle worm, and the coral-shell gastropod), and a number of anthropogenic threats, such as pollution or water quality changes, and physical impacts such as anchoring and vessel groundings. Elkhorn coral is also very susceptible to environmental changes such as hypothermic events, manifested in relatively high rates of tissue bleaching or loss of zooxanthellae.

During our ground-truthing surveys we encountered significant numbers of dead Elkhorn corals some of which however, had become the substrate for thriving species, such as sea fans and soft corals (see Figure 19). On the other hand, we also found healthy Elkhorn coral stands whose geographic locations were recorded and can be layered over the base map (see Figure 20). The fact that we also observed very young, healthy specimens suggests that Elkhorn corals in the study area are, at least in part, still thriving.
Explorers Reef
There is a fairly small reef situated to the east of Peterson Cay that is teeming with life and that we chose to name Explorers Reef. Approximately 1.6 hectares (4 acres) in size, it is home to soft corals, sponges, hard corals and numerous fish species although grunts make up the largest numbers (see Figures 21 and 22).

Unfortunately, it is also a place where we encountered four lionfish (Pterois). A native of the sub–tropical and tropical Indo–Pacific region, this species has become a significant threat to reef systems in the Atlantic Ocean and especially in the Bahamas. Lionfish have no natural enemies and can deplete large portions of a reef in just a few weeks. To project Jack’s Reef and the entire reef system along the southern shore of Grand Bahama will require a concerted and well-coordinated effort to eradicate as many of these fish as quickly as possible.
Conclusions

In the past, maps have been made by different people at different scales and different levels of accuracy. With this project we have demonstrated that our methodology is perfectly suited to create geo-rectified maps of superb detail and accuracy (error is less than 1m), and can be employed at any site or location.

With the detailed geographical and ecological information being presented together, the map also serves as a great educational tool that will help provide all stakeholders with a better understanding of the ecology of coral reefs. Coral reefs are among the most complex and diverse ecosystems in the world and their health and survival is crucial for the coastal environment, local fisheries and tourism. Knowing about coral reefs, their locations and composition is important. Generally, understanding begets caring.

The map provides direct and tangible benefits to all stakeholders, but especially to those responsible to manage Peterson Cay National Park and the surrounding marine resources. The detailed information on the distribution of main substrates and benthic community types can be used to identify sites best suited to conduct additional research, set up monitoring stations, or establish new sites for scuba enthusiasts. Knowing the locations of sensitive habitats or species, such as Elkhorn coral, should help decision makers to establish no-boating and no-anchor zones and areas in which fishing may be limited or excluded.

It is with great pleasure that we present this report and the first highly accurate and detailed map of a coral reef to the Government of The Bahamas and the stakeholders who share the benefits and responsibilities for the marine environment. We expect this map to serve as a significant tool for the long-term monitoring and management of the Peterson Cay National Park and its surrounding marine area. The map and the baseline data contained therein represent a snapshot in time that serves as a baseline for future surveys. We would hope that the technique and methodology used for this project will serve as the new standard for similar mapping efforts elsewhere throughout the Bahamas and beyond.
ACKNOWLEDGEMENTS

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