Grand Bahama Grand Port Project
Benthic Habitat Mapping and Characterization Survey Report

Submitted to:

Applied Technology and Management
2047 Vista Parkway, Suite 101
West Palm Beach, Florida 33411
Telephone: 561-659-0041

Submitted by:

CSA Ocean Sciences Inc.
8502 SW Kansas Avenue
Stuart, Florida 34997
Telephone: 772-219-3000

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List of Acronyms and Abbreviations

Carnival	Carnival Grand Bahama Investments Limited
CSA	CSA Ocean Sciences Inc.
ESA	Endangered Species Act
IUCN	International Union for Conservation of Nature
PCNP	Peterson Cay National Park

Executive Summary

CSA Ocean Sciences Inc. (CSA) was subcontracted by Applied Technology & Management, Inc. to characterize and map marine benthic habitats near Port Lucaya, Grand Bahama Island, Bahamas in June and July 2019. These efforts will support an Environmental Impact Assessment and other marine environmental management aspects associated with development of the Carnival Grand Port (Project Area) proposed by Carnival Grand Bahama Investments Limited (Carnival).

The marine benthic habitat mapping and characterization survey was executed in two phases. The first phase entailed collection of aerial imagery of two marine sites, the Project Area and nearby Peterson Cay National Park (PCNP). Detailed aerial imagery of the two sites was collected via drone in June 2019 to serve as the base layer from which benthic habitat maps were created. Resultant mosaicked aerial imagery was reviewed by a marine biologist and geospatial analyst to identify broad habitat types (e.g., sand, hard bottom, reefs) and create preliminary benthic habitat maps. For the second phase of the survey, a team of marine scientists visited the Project Area and PCNP to verify (groundtruth) the preliminary habitat maps by direct observation. Groundtruth sampling stations were designated within these habitats based upon a spatially balanced, random sampling design. The number of stations were allocated in proportion to overall area and complexity of the benthic habitat types (i.e., sand plains did not receive the same sampling intensity as more complex reef habitats).

A total of 36 stations were surveyed using snorkel or SCUBA within the Project Area and 44 stations were surveyed at PCNP. At each station, a qualitative, descriptive assessment of the benthic habitat type was performed for groundtruthing purposes, and underwater photos/video were collected to document the benthos during a roving diver survey. A rapid quantitative benthic assessment was also performed at 16 of 32 stations in the Project Area via random quadrat sampling. Quadrat sampling entailed a visual assessment of percent cover of abiotic and biotic functional groups; identification of all flora and fauna to lowest taxonomic level; and enumeration, size-class designation, and health assessment of all stony corals and octocorals present in each quadrat. All Endangered Species Act (ESA) and International Union for the Conservation of Nature (IUCN)-listed species (i.e., sea turtles, selected species of stony corals, marine mammals) observed during the entire survey were identified to species and their geographic location recorded. Any areas of special ecological significance were also investigated, and geographic location recorded.

The groundtruthed, mosaicked aerial imagery was then subdivided into separate classification polygons based on similar pixel spectral signature ranges using GIS. An unsupervised classification was then performed on each classification polygon using a combination of iso cluster and maximum likelihood techniques. A manual classification technique was then applied to refine the results from the unsupervised classification. The resultant benthic habitat maps for the Project Area and PCNP contain geographically quantified polygon features of the benthic habitat types, from which areal extent of each habitat type was calculated.

Eight benthic habitat types were identified within the Project Area: Land, Exposed Limestone, Hard Pan, Macroalgal Hard Pan, Sand, Ridge and Swale, Spur and Groove, and Reef Mounds; encompassing a total area of 165.50 acres. Hard Pan habitat had the greatest areal extent within the Project Area (75.69 acres) followed by sand (60.10 acres). Together Hard Pan and Sand habitats accounted for over 80% of the Project Area. Other habitats ranged from 7.94 to 0.77 acres. Habitats falling within the proposed dredge footprint included Sand, Hard Pan, Ridge Swale, Spur Groove, and Reef Mounds, encompassing a

total area of approximately 75.60 acres. In parallel with results for the entire Project Area, Hard Pan and Sand were again the two most extensive habitats within the dredge footprint.

In the Project Area, quadrat sampling showed percent cover of macroalgae ranging from 11.1% in the Hard Pan habitat to 42.5% in the Macroalgal Hard Pan habitat. Turf algae ranged from 6.0% in the Macroalgal Hard Pan habitat to 52.6% in the Hard Pan habitat. Fauna increased with distance from shore from 4.0% in the Macroalgal Hard Pan habitat to 34.7% in the Reef Mound habitat. Abiotic substrate was highest closest to shore at 47.5% in the Macroalgal Hard Pan habitat and lowest in the Reef Mound habitat at 20.6%.

A total of 17 octocoral taxa and 27 stony coral taxa were recorded in the Project Area. The most abundant stony corals were massive starlet coral (*Siderastrea siderea*), lettuce coral (*Agaricia agaricites*), and mustard hill coral (*Porites astreoides*). The bipinnate sea plume (*Pseudopterogorgia bipinnata*) and knobby sea rods (*Eunicea* spp.) were the most frequently observed octocorals. Numerous sponge taxa (total of 25) were observed in the Project Area, especially in the reef mound habitat. The most frequently observed species were yellow tube sponge (*Aplysina fistularis*) and stinker and black-ball sponges (*Ircinia* spp). Green algae *Halimeda* spp. and *Microdictyon marinum* were the most frequently observed macroalgal taxa. ESA and IUCN-listed species observed in the Project Area included: pillar coral (*Dendrogyra cylindrus*), whitestar sheet coral (*Agaricia lamarcki*), boulder star coral (*Orbicella* spp.). Although not observed, the Project Area contains habitat potentially utilized by Nassau grouper (*Epinephelus striatus*), listed as critically endangered by the IUCN.

Fifteen distinct benthic habitat types were identified within PCNP, including the eight habitat types also present within the Project Area, accounting for a total survey area of approximately 860 acres. Additional benthic habitat types found at PCNP included Artificial Structure, Cay, Macroalgae In Sand, Low Relief Hardbottom, Patch Reef, Reef Crest, Rubble, and Seagrass. Sand had the greatest areal extent within the survey area (242.17 acres) followed by Hard Pan (213.60 acres) and then Seagrass (171.60). Together, Sand, Hard Pan, and Seagrass habitats accounted for approximately 73% of the survey area. Other habitats ranged from 0.12 to 104.37 acres.

ESA and IUCN-listed species observed in PCNP included elkhorn (*Acropora palmata)* and staghorn coral (*A. cervicornis*), both listed as Critically Endangered by the IUCN. Fused staghorn coral (*A. prolifera*), a hybrid of the other two Acroporids was also observed however data on *A. prolifera*'s stability are deficient and the IUCN does not report on this species. Other listed coral species included the *Orbicella* species complex (*O. annularis*, *O. faveolata*, *O. franksi*) and pillar coral (*D. cylindrus*). A green sea turtle (*Chelonia mydas*), listed as Endangered by both the ESA and IUCN was observed in the seagrass habitat. Additionally, mating pairs of bridled terns (*Sterna anaethetus*), a regionally endemic species protected in The Bahamas, were observed on the emergent cay.

This survey provides important baseline marine benthic habitat maps and characterizations of the Project Area and PCNP. Data of this nature previously did not exist for marine habitats on the south coast of Grand Bahama, filling data gaps and aiding mitigation planning for the Grand Port Project.

1.0 Introduction

CSA Ocean Sciences Inc. (CSA) was subcontracted by Applied Technology & Management, Inc. to conduct marine benthic habitat mapping and characterization surveys to support an Environmental Impact Assessment and other marine environmental management aspects associated with development of the Carnival Grand Port being proposed by Carnival Grand Bahama Investments Limited (Carnival) near Port Lucaya, Grand Bahama Island, The Bahamas.

Carnival is proposing a new cruise port terminal, "Carnival Grand Port", to be located along and just offshore Barbary Beach, an undeveloped stretch along the southern (leeward) coast of Grand Bahama Island, approximately 14.9 km (9.3 mi) east of Port Lucaya and approximately 6.4 km (4 mi) east of the Grand Lucayan Waterway inlet (**Photo 1**). The cruise port terminal is proposed to include land-based and marine-based facilities. The proposed marine-based facilities encompass an area of approximately 150 acres (Project Area) and include berthing docks for two cruise ships (XL Class ships) and adjoining pier to shore, day dock, small marina, and other over-water structures.

Photo 1. Portion of proposed Project Area on Barbary Beach east of Port Lucaya, Grand Bahama Island. Image courtesy of Applied Technology & Management, Inc.

The marine benthic habitat mapping and characterization survey included collection of aerial imagery combined with *in situ* field biological assessments via snorkel and SCUBA of two sites, a Project Area and also Peterson Cay National Park (PCNP)(**Photo 2**), due its proximity and protected status, located approximately 2.1 km (1.3 miles) west of the Project Area.

Photo 2. Peterson Cay National Park. Image courtesy of Bahamas National Trust.

Peterson Cay is a Bahamian National Park managed by the Bahamas National Trust and includes a small cay located approximately 1.6 km (1 mi) offshore and includes a fringing coral reef, hardbottom, lagoon and seagrass habitats. It was established as a national park in 1968. The limestone cay is the only cay on the south shore of Grand Bahama and is internationally recognized as an Important Bird Area, as it provides nesting habitat for Bridled Terns (*Onychoprion anaethetus*) (Henwood and Nolan, 2013). It is a popular tourist destination for boating, snorkeling, and SCUBA diving.

Hurricane Dorian recently struck Grand Bahama September 1 to 3, 2019 as an extremely powerful Category 5 hurricane causing catastrophic damage and flooding to the island. Wind gusts exceeded 200 miles per hour and storm surge was estimated between 18 to 23 feet (Resnick, 2019). Severe impacts to marine resources in the Project Area and PCNP are probable as a result; therefore, a post-hurricane survey is recommended at some point in the future to assess diversion from the baseline condition summarized in this report.

2.0 Methods

The aerial imagery collection survey was conducted from 21 to 22 June 2019 and the benthic survey was conducted from July 26 to August 31, 2019. Weather conditions during both surveys were ideal with calm seas, light winds, excellent vertical water visibility and generally sunny skies.

2.1 AERIAL IMAGERY SURVEY

The first step in the benthic mapping process was to obtain recent, detailed aerial imagery of the Project Area and PCNP to serve as the base layer from which benthic habitat maps of the seafloor would be created of the two sites. The imagery was collected using an unmanned aerial vehicle; specifically, a DJI Phantom 4 Pro drone equipped with a gimbal-mounted 20 mega-pixel camera (**Photo 3**).

Photo 3. DJI Phantom 4 Pro drone used in the aerial survey of the Project Area and Peterson Cay National Park, Grand Bahama June 21-22, 2019.

The aerial survey was conducted from June 21-22, 2019 and covered the proposed survey area for each site plus a buffer zone extending a minimum distance of approximately 35 m [115 ft]) to each side for both the Project Area and PCNP (**Figure 1**). Imagery was collected by a USA-licensed drone pilot with Federal Aviation Administration certification. Permission to perform the drone-based survey was obtained through the Bahamas Civil Aviation Authority and clearance from Freeport Airport. The survey of each area was conducted from land on Barbary Beach near Sharps Rock with a flight height of 200 m (656 ft) above ground level.

The total area surveyed at the Project Area was approximately 150 acres and included nearshore waters from the beach extending offshore to approximately the 15 m (49 ft) depth contour. A total of 353 images were collected and total flight duration was approximately 21 minutes using 2 batteries. Flight speed was approximately 25 mph. Weather at the time of the survey was sunny with west winds approximately 5 kns and calm seas. The area surveyed for PCNP was approximately 860 acres and included the cay itself and surrounding waters extending to the beach to the north (lagoon habitats) and extending approximately to the 15 m (49 ft) depth contour to the south (reef habitats) (**Figure 1**). A total of 2,754 images were collected and total flight duration was approximately 128 minutes using 9 batteries. Flight speed was approximately 25 mph. Weather at the time of the survey was partly cloudy with southwest winds 5 to 10 kns and calm seas. Aerial images were collected using WGS 1984 BLM Zone 17N geodesy. Aerial imagery frames were mosaicked using Drone Deploy software with 75% front overlap and 65% side overlap. Frames were initially mosaicked in the field for both sites at low resolution for quality assurance and quality control and completeness purposes, then again at higher resolution at CSA. The resultant high-resolution aerial imagery was true color with a resolution of 0.08 m (0.26 ft).

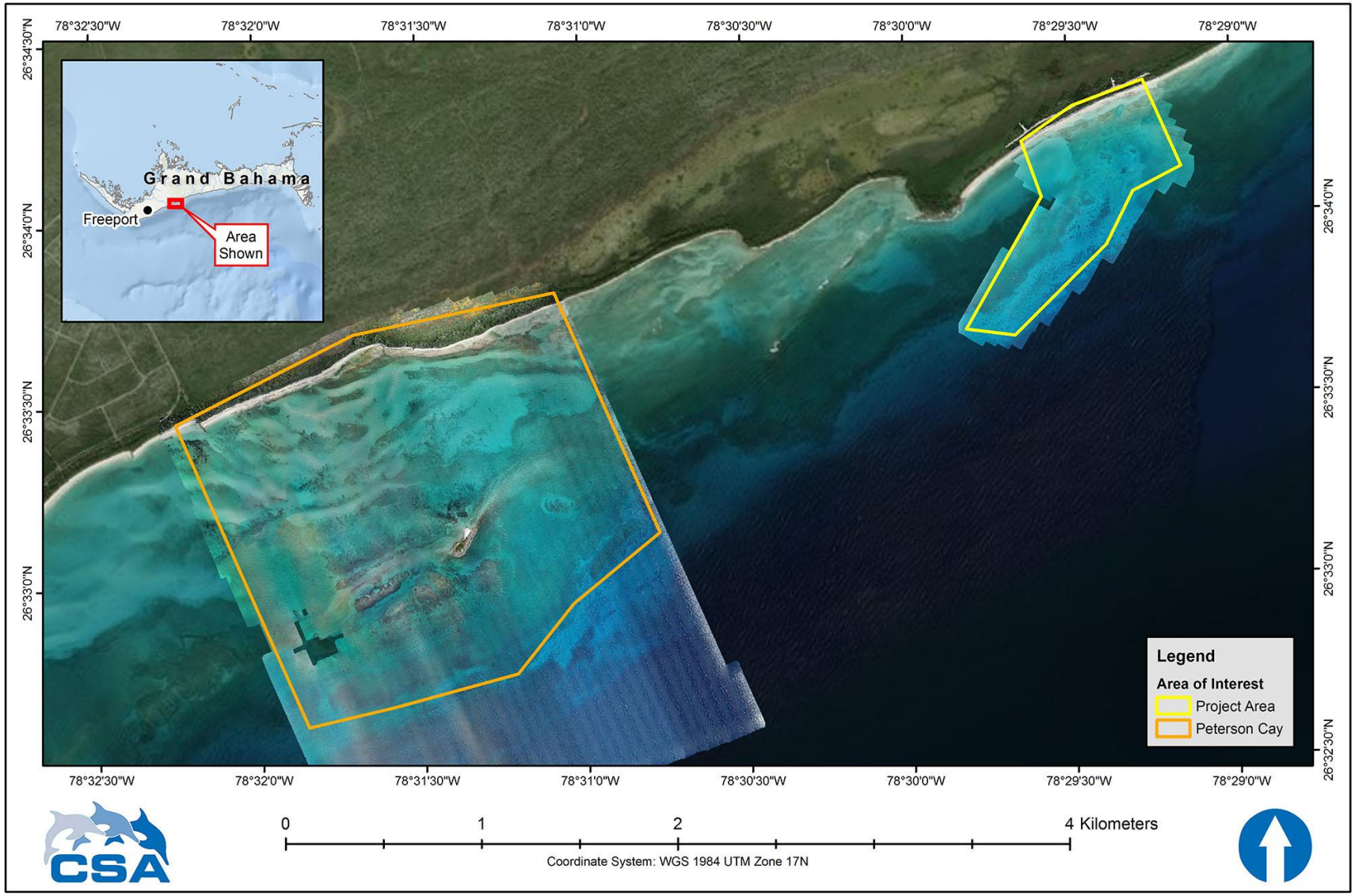


Figure 1. Overview map showing survey areas for the Project Area and Peterson Cay National Park.

2.2 BENTHIC CHARACTERIZATION AND GROUNDTRUTHING SURVEY

Imagery from the aerial survey was reviewed by a marine biologist and geospatial analyst to identify broad benthic habitats such as hard bottom, sand bottom, seagrass meadows, and patch reefs. These benthic habitats served as the foundation for the diver-based groundtruthing and characterization survey. Groundtruth sampling stations were designated based upon a spatially balanced, random sampling design. The number of stations were allocated in proportion to overall area and complexity of the benthic habitat types (i.e., sand plains did not receive the same sampling intensity as more complex reef habitats).

Diving activities were conducted by a team of four CSA marine scientists/divers over a six-day period from July 26 to 31, 2019 from a 28-ft CSA dive vessel equipped with a Hypack navigation system. At each station, a weighted buoy was first deployed to mark the site. A two-person dive team then entered the water to perform groundtruthing and characterization surveys. A total of 32 groundtruthing stations (referred to hereafter as "Bounce Dive Stations") were surveyed within the Project Area (**Figure 2**) and a total of 34 Bounce Dive Stations were surveyed at PCNP (**Figure 3**). At each station, a qualitative, descriptive assessment of the benthic habitat type was performed for groundtruthing purposes, and underwater photos/video were collected to document the benthos during a roving diver survey of approximate 15-minute duration. Underwater photos and video were collected using a Canon G12 camera with Fisheye FIX housing and INON strobe and a GoPro Hero 7 Black video camera.

Sixteen Quadrat Stations within the Project Area were also surveyed to obtain quantitative habitat characterization data (**Figure 2**). The Project Area was sampled more intensely than PCNP to better inform management decisions regarding marine resources that will be directly impacted by dredging for the port development project. A rapid quantitative benthic assessment was performed at each of these stations via random quadrat sampling (5 × 1 m^2 quadrats, for a total area of 5 m^2) within a 25 m (82 ft) range from the center point of the designated station. Quadrats made of polyvinyl chloride were placed within each station using pre-determined random compass bearings and distances from the center point (**Photos 4** and **5**). In a few instances, the quadrat location landed on sand substrate adjacent to hardbottom/reef substrate, and the quadrat location was moved slightly in order to survey the hardbottom/reef substrate.

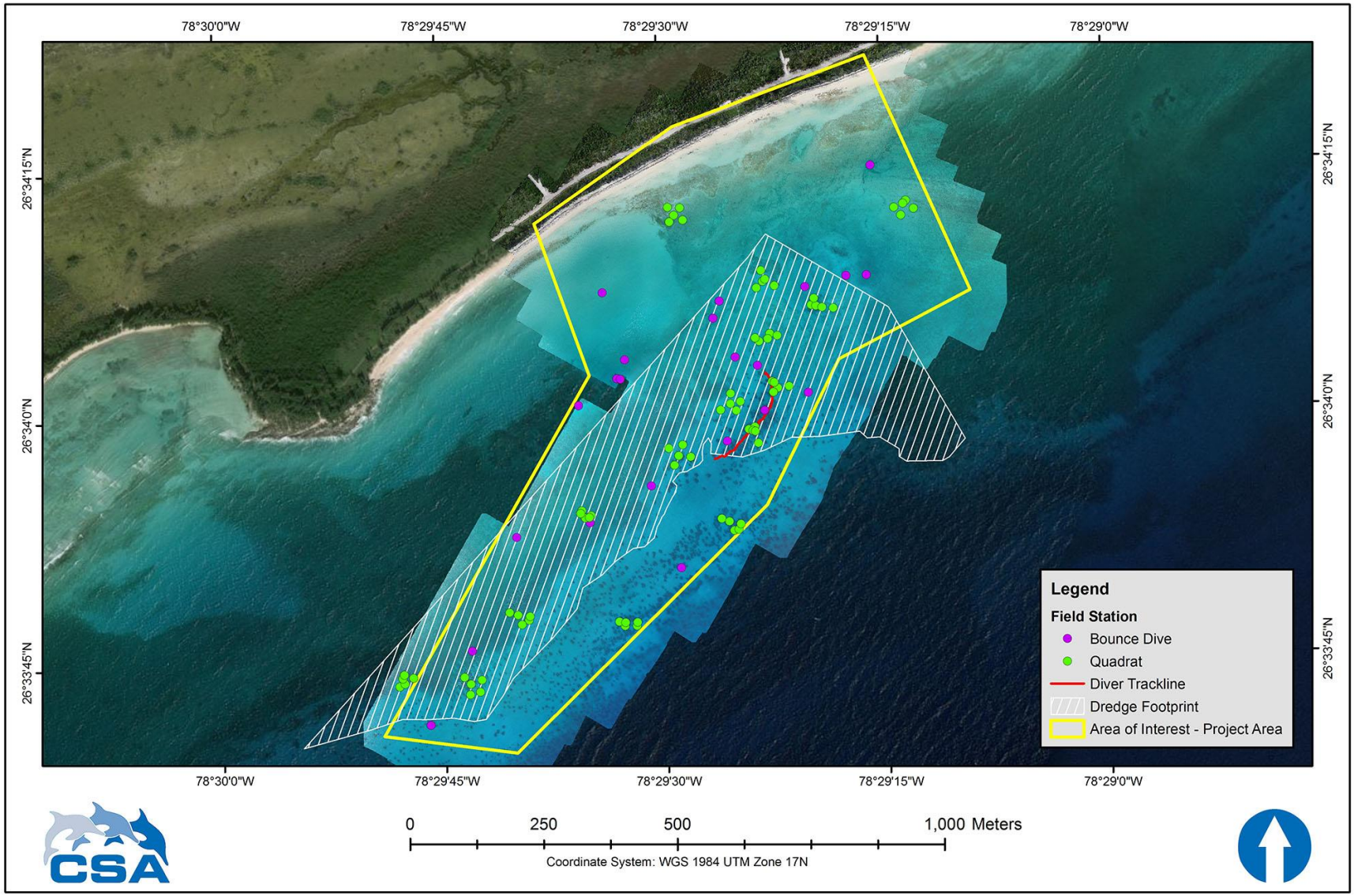


Figure 2. Field survey map showing all sampling stations within the Project Area, Grand Bahama.

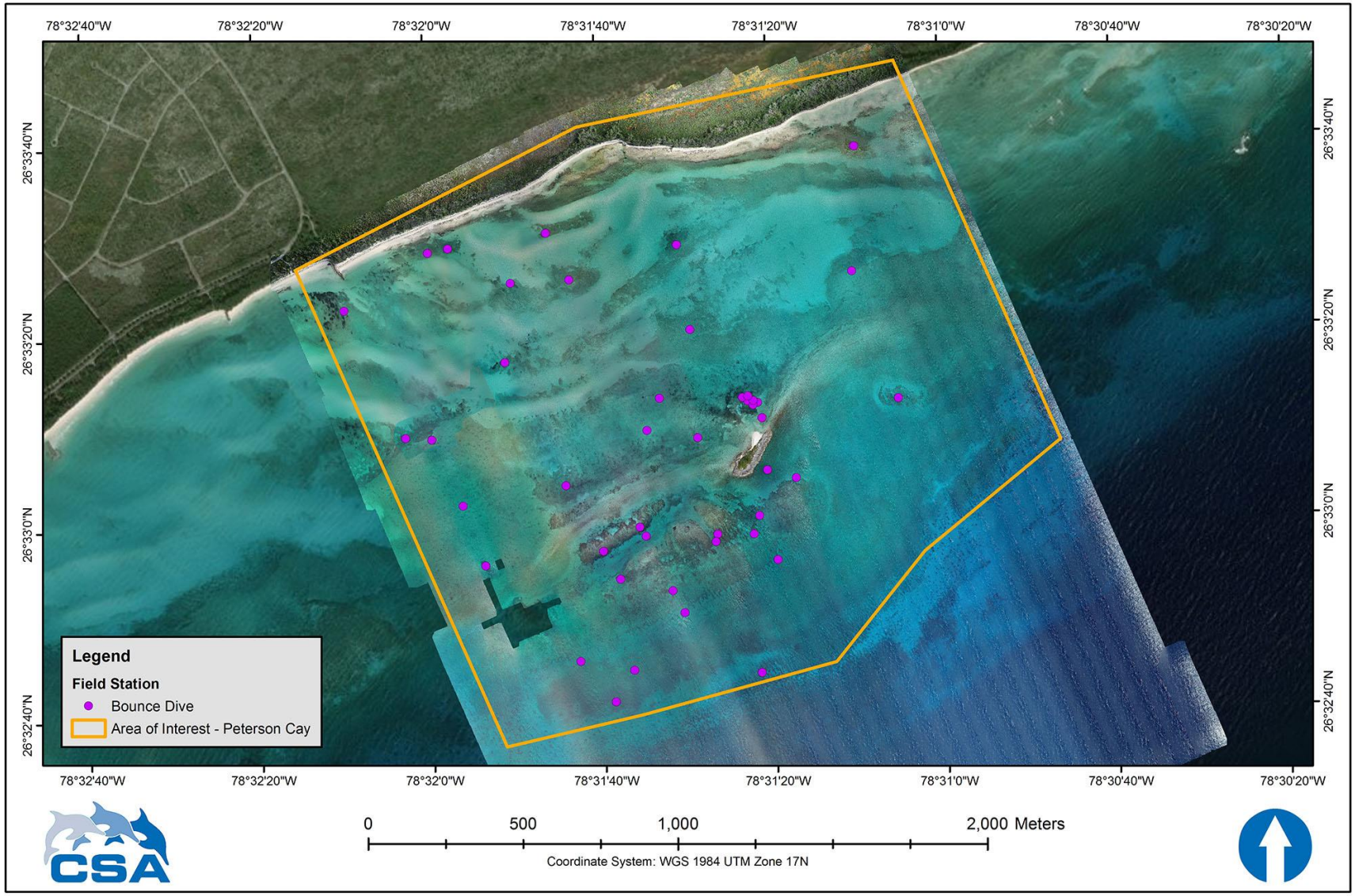


Figure 3. Field survey map showing all sampling stations within Peterson Cay National Park, Grand Bahama.

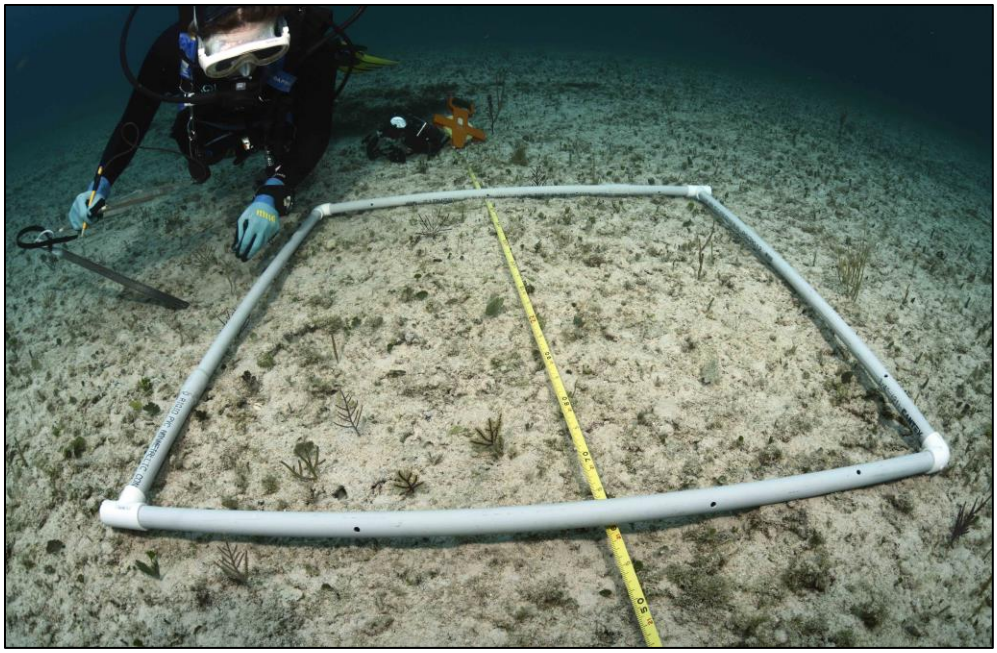


Photo 4. Marine biologist performing a quadrat assessment of benthos at Quadrat Station 36 in the Project Area off Grand Bahama on July 29, 2019.

Quadrat sampling entailed a visual assessment of percent cover of abiotic and biotic functional groups. Abiotic substrate groups included sand, hardbottom, and rubble and biotic groups included macroalgae, turf, stony corals, octocorals, sponges, and other fauna (**Photo 5**). All flora and fauna present within each quadrat were listed and identified to lowest taxonomic level. All stony corals and octocorals present in the quadrats were counted, assigned to a size class (0-5 cm, 6-10 cm etc.), and assessed for health status (e.g., bleaching, tissue loss, disease). These sample data were used to extrapolate stony coral and octocoral densities (by size class) to larger habitats within the Project Area.

All Endangered Species Act (ESA) and International Union for the Conservation of Nature (IUCN)-listed species (i.e., sea turtles, selected species of stony corals, marine mammals) observed during the entire survey were identified to species and their geographic location recorded. Any areas of special ecological significance were also investigated, and geographic location recorded.

At the completion of each field day, all navigation, video, and still photo data were downloaded and reviewed, and then copied onto multiple storage devices for security and redundancy. Biologists later reviewed the data to assist in providing a general description of benthic habitats and biological communities.

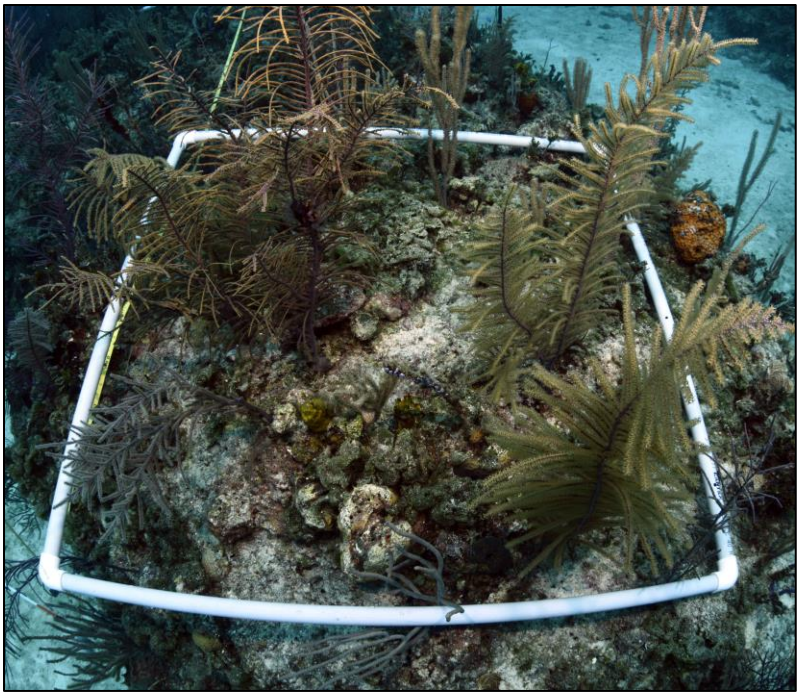


Photo 5. Quadrat containing macroalgae, stony corals, octocorals, and sponges at Quadrat Station 38 in the Project Area off Grand Bahama on July 28, 2019.

2.3 BENTHIC HABITAT MAPPING

Upon completion of the field survey, groundtruthing data collected by divers (**Appendix**) was incorporated into the aerial interpretation database.

The georeferenced, high-resolution mosaicked aerial image was then used to classify benthic habitat types. The image was subdivided into separate classification polygons based on similar pixel spectral signature ranges. An unsupervised classification was then performed on each classification polygon using a combination of iso cluster and maximum likelihood techniques using ESRI ArcGIS 10.6 software. After running the unsupervised classifications, each polygon was manually interpreted by denoting visually apparent benthic categories. Spectral noise and holes within the classification results were removed and corrected using a combination of majority filter, region group, set null (enhanced boundary edges and removed groups of small non-contiguous pixels that were smaller than a specified value), and eliminate polygon part (eliminated areas that were less than a specified value) tools in ArcGIS. Lastly, a manual classification technique was then applied to the classification with guidance from a geospatial analyst and a marine biologist.

Aerial imagery and groundtruthing data were merged in Geographic Information System to create benthic habitat maps of the seafloor for the Project Area and PCNP. The classified maps contain geographically quantified polygon features of the benthic habitat types. These quantified polygons provide estimates of the various benthic habitat types within the Project Area and PCNP. Several areas of ecological significance were also included in the maps as points or line features.

3.1 BENTHIC HABITAT MAPPING

3.1.1 Project Area

The benthic habitat map of the Project Area resulting from interpretation of aerial imagery is displayed in **Figure 4**. The following eight benthic habitat types were identified: Land, Exposed Limestone, Hard Pan, Macroalgal Hard Pan, Sand, Ridge and Swale, Spur and Groove, and Reef Mounds; encompassing a total area of 148.83 acres (**Table 1**). Hard Pan habitat had the greatest areal extent within the Project Area (75.69 acres) followed by sand (60.10 acres). Together Hard Pan and Sand habitats accounted for approximately 80% of the Project Area. Other habitats ranged from 7.94 to 0.77 acres (**Table 1**).

Table 1. Area calculations for benthic habitat types identified from aerial imagery interpretation within the Project Area, Grand Bahama.

Location	Habitat	Area (acres)	Area (ft^2)	Area (m^2)
Project Area	Land	7.94	345,786.41	32,124.74
	Sand	60.10	2,618,096.54	243,230.10
	Exposed Limestone	0.77	33,703.68	3,131.19
	Macroalgal Hard Pan	4.95	215,576.41	20,027.78
	Hard Pan	75.69	3,297,146.44	306,316.15
	Ridge and Swale	7.17	312,463.70	29,028.94
	Spur and Groove	4.41	192,145.84	17,851.00
	Reef Mounds	4.46	194,280.50	18,049.32
Total		**165.50**	**7,209,199.50**	**669,759.23**

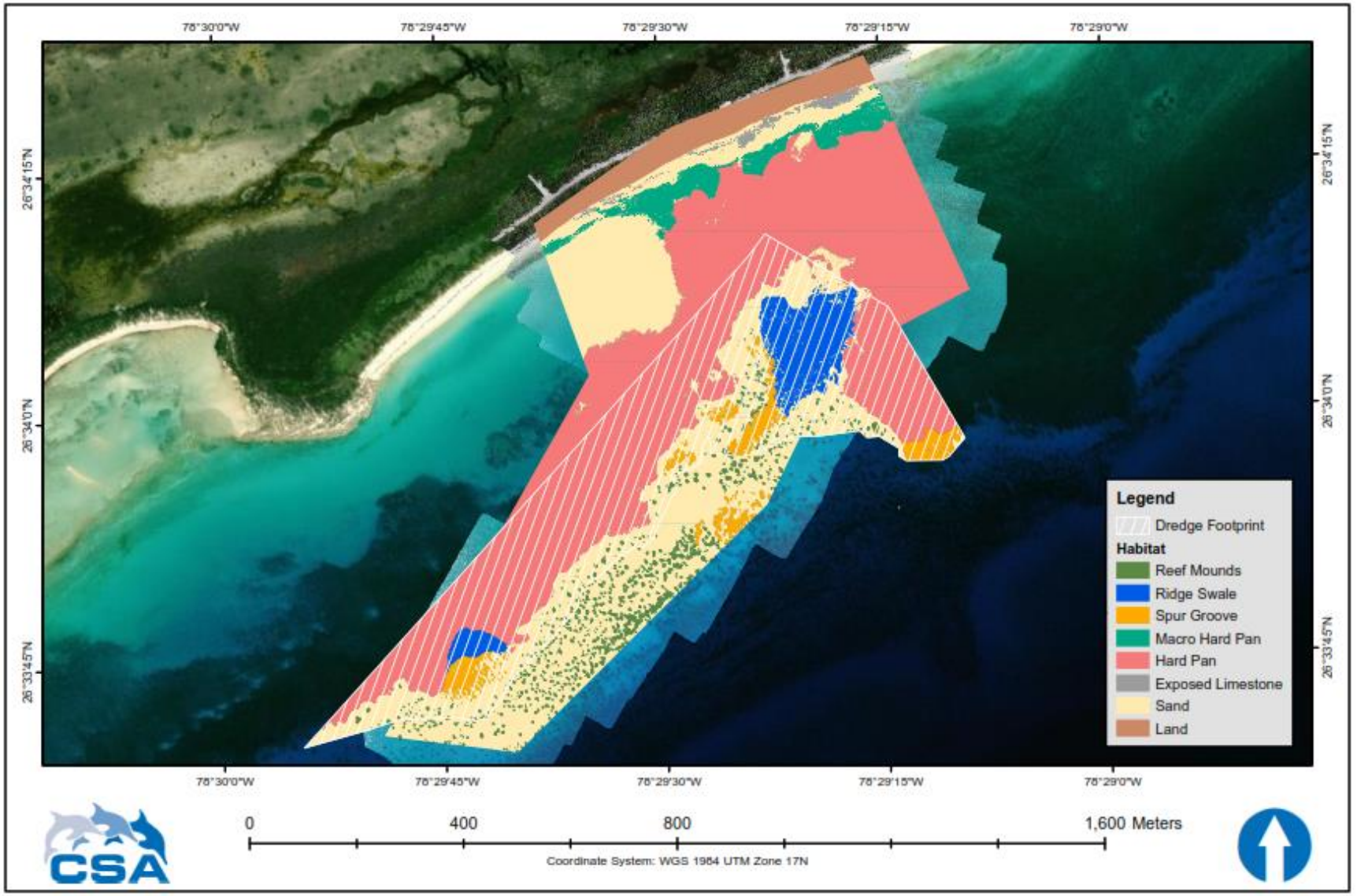


Figure 4. Benthic habitat map resulting from interpretation of aerial imagery collected in June 2019 of the Project Area, Grand Bahama.

Habitats falling within the proposed dredge footprint included Sand, Hard Pan, Ridge Swale, Spur Groove, and Reef Mounds, encompassing a total area of approximately 58.92 acres (**Table 2**). In parallel with results for the entire Project Area, Hard Pan and Sand were again the two most extensive habitats within the dredge footprint.

Table 2. Area calculations for benthic habitat types identified only within the proposed dredge footprint, Grand Bahama.

Location	Habitat	Area (acres)	Area (ft^2)	Area (m^2)
Dredge Footprint	Land	0.00	0.00	0.00
	Sand	22.85	995,343.89	92,470.84
	Exposed Limestone	0.00	0.00	0.00
	Macroalgal Hard Pan	0.00	0.00	0.00
	Hard Pan	40.77	1,775,875.44	164,984.89
	Ridge and Swale	7.17	312,463.69	29,028.94
	Spur and Groove	3.71	161,817.13	15,033.36
	Reef Mounds	1.09	47,501.45	4,413.05
	Total	**75.60**	**3,293,001.62**	**305,931.08**

Calculations were performed in projected coordinate system WGS 1984 BLM Zone 17N, Units: Feet.

Benthic habitat types found in the Project Area are defined briefly below along with example photos.

Land – Beach and dry, vegetated upland habitat (**Photo 6a**).

Sand – Soft bottom comprised of primarily calcareous sand with no biological colonization (**Photo 6b**).

Exposed Limestone – Recently exposed limestone with little to no biological colonization in the intertidal and subtidal zones, in water depths less than 1 m (3.3 ft) (**Photo 6c**).

Macroalgal Hard Pan – Hardbottom with low relief (≤0.5 m [1.6 ft]), colonized only by turf and macroalgae, in water depths approximately 1 to 3 m (3.3 to 9.8 ft) (**Photos 6d, 6e**).

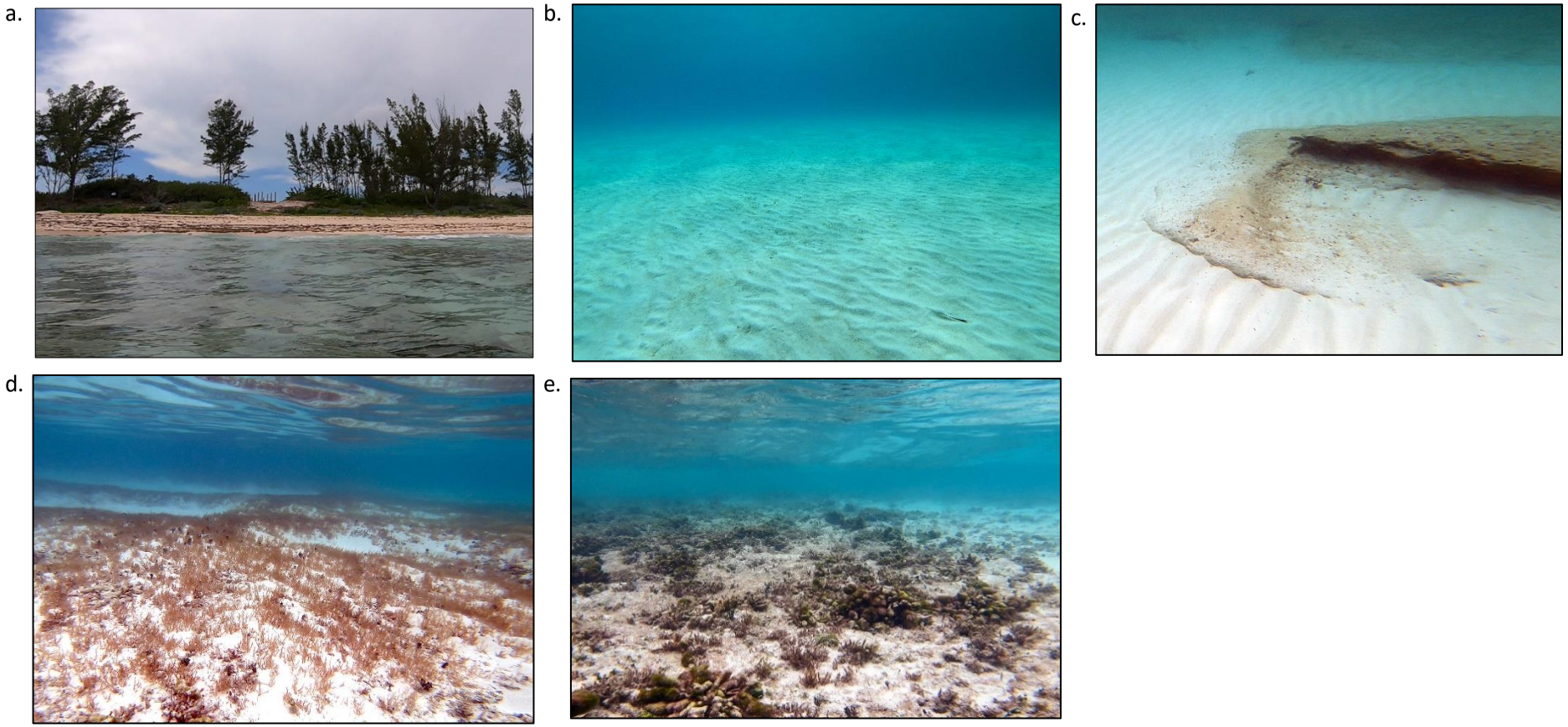


Photo 6. Representative photos of various benthic habitats identified in the Project Area, Grand Bahama. a) Land (including beach and vegetated upland), b) Sand, c) Exposed Limestone, d) Macroalgal Hard Pan – example 1, e) Macroalgal Hard Pan - example 2.

Hard Pan – Hardbottom with low relief (≤0.5 m [1.6 ft]), colonized primarily by algae and octocorals with sparse sponges and stony corals, in water depths ranging from approximately 1 to 10 m (3.3 to 33 ft) (**Photos 7a, 7b**).

Ridge and Swale – Hardbottom with undulating, alternating ridge and swale features. Ridges composed of hardbottom with up to 2 m (6.6 ft) relief colonized by algae, octocorals, sponges, and stony corals. Swales (trough-like low features between ridges) composed of hardbottom rubble and sediment veneer over hardbottom with little to no biological colonization, but often contain detritus. Occurring in water depths from approximately 5 to 15 m (16.4 to 49 ft) (**Photo 7c**).

Spur and Groove – Finger-like hardbottom features alternating with sand. Spurs with relief up to 3 m (9.8 ft) and heavily colonized by octocorals, sponges, and stony corals, with lower cover of algae relative to Ridge Swale habitat, in water depths from approximately 5 to 15 m (16.4 to 49 ft) (**Photo 7d**).

Reef Mounds – Isolated mounds of limestone hardbottom surrounded completely by sand. Range in maximum diameter from 1 to 10 m (3.3 to 33 ft) with average diameter of approximately 3 m (9.8 ft) and height of approximately 2 m (6.6 ft). Bases of mounds often eroded and undercut. Heavily colonized by algae, octocorals, larger sponges, tunicates, and stony corals. Percent cover of stony corals ≤ 10%. Occurring in water depths from approximately 5 to 15 m (16.4 to 49 ft) (**Photos 7e, 7f**).

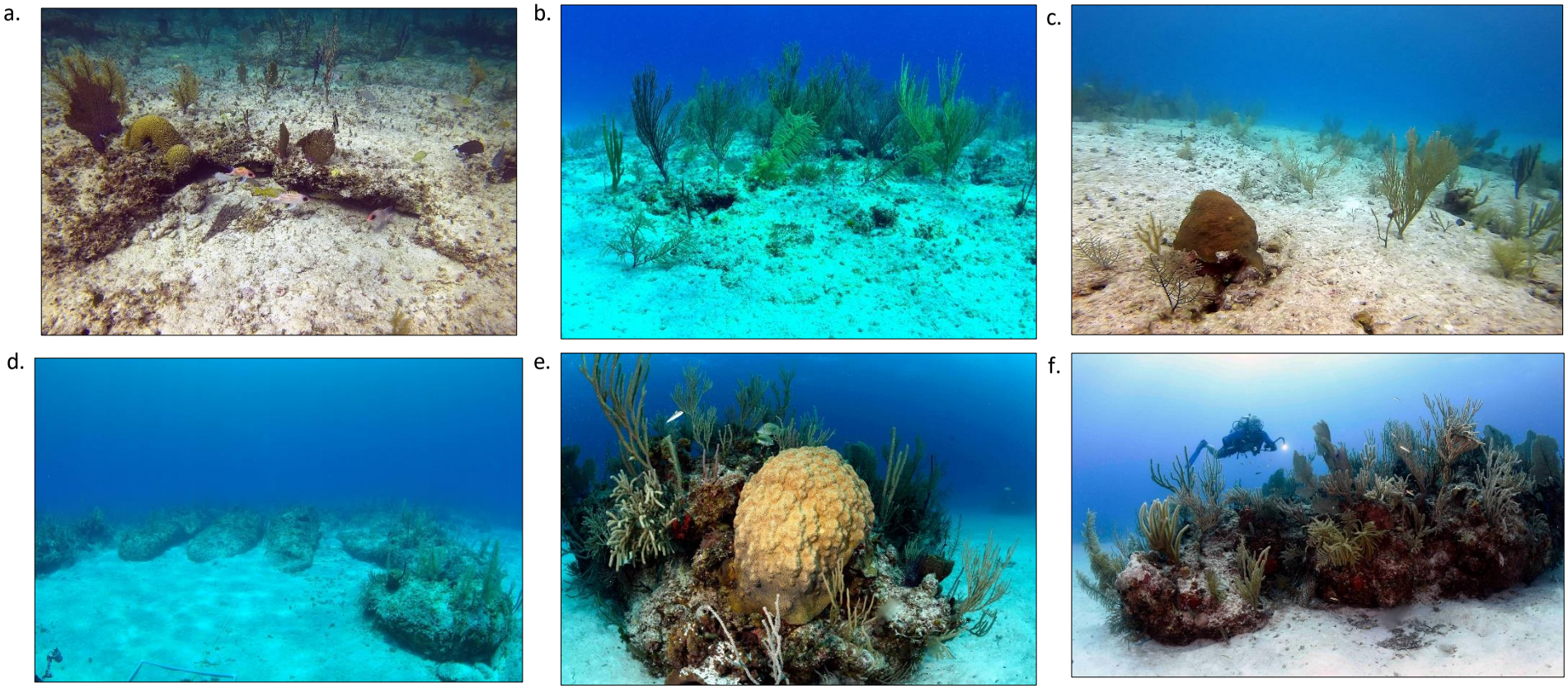


Photo 7. Representative photos of various benthic habitats identified in the Project Area, Grand Bahama. a) Hard Pan – example 1, b) Hard Pan – example 2, c) Ridge and Swale, d) Spur and Groove, e) Reef Mounds – example 1, f) Reef Mounds - example 2.

3.1.2 Peterson Cay

The resultant benthic habitat map of Peterson Cay following interpretation of aerial imagery is displayed in **Figures 5** and **6** (due to size two figures were necessary). Fifteen distinct benthic habitat types were identified within the Peterson Cay survey area, including the eight habitat types also present within the Project Area (however with some variation in water depth), accounting for a total survey area of approximately 860 acres (**Table 3**). Additional benthic habitat types found at Peterson Cay included Artificial Structure, Cay, Macroalgae In Sand, Low Relief Hardbottom, Patch Reef, Reef Crest, Rubble, and Seagrass (**Table 3**). Sand had the greatest areal extent within the survey area (242.17 acres) followed by Hard Pan (213.60 acres) and then Seagrass (171.60). Together, Sand, Hard Pan, and Seagrass habitats accounted for approximately 73% of the Peterson Cay survey area. Other habitats ranged from 0.12 to 104.37 acres.

Table 3. Area calculations for benthic habitat types identified from aerial imagery interpretation within the survey area for Peterson Cay, Grand Bahama.

Location	Habitat	Area (acres)	Area (ft^2)	Area (m^2)
Peterson Cay	Land	48.82	2,126,510.43	197,560.07
	Artificial Structure	0.12	5,202.71	483.35
	Cay	2.32	101,028.64	9,385.91
	Macroalgae In Sand	1.07	46,746.26	4,342.89
	Exposed Limestone	8.97	390,644.54	36,292.21
	Macroalgal Hard Pan	14.56	634,174.09	58,916.94
	Hard Pan	213.60	9,304,509.07	864,420.64
	Low Relief Hardbottom	2.89	125,685.11	11,676.58
	Patch Reef	1.46	63,546.19	5,903.66
	Reef Crest	13.46	586,425.76	54,480.95
	Ridge and Swale	104.37	4,546,391.43	422,375.27
	Rubble	3.67	159,899.46	14,855.21
	Sand	242.17	10,548,670.26	980,007.46
	Seagrass	171.60	7,474,653.00	694,420.76
	Spur Groove	30.76	1,339,796.77	124,471.69
Total		**859.83**	**37,454,194.8**	**3,479,608.56**

Calculations were performed in projected coordinate system WGS 1984 BLM Zone 17N, Units: Feet

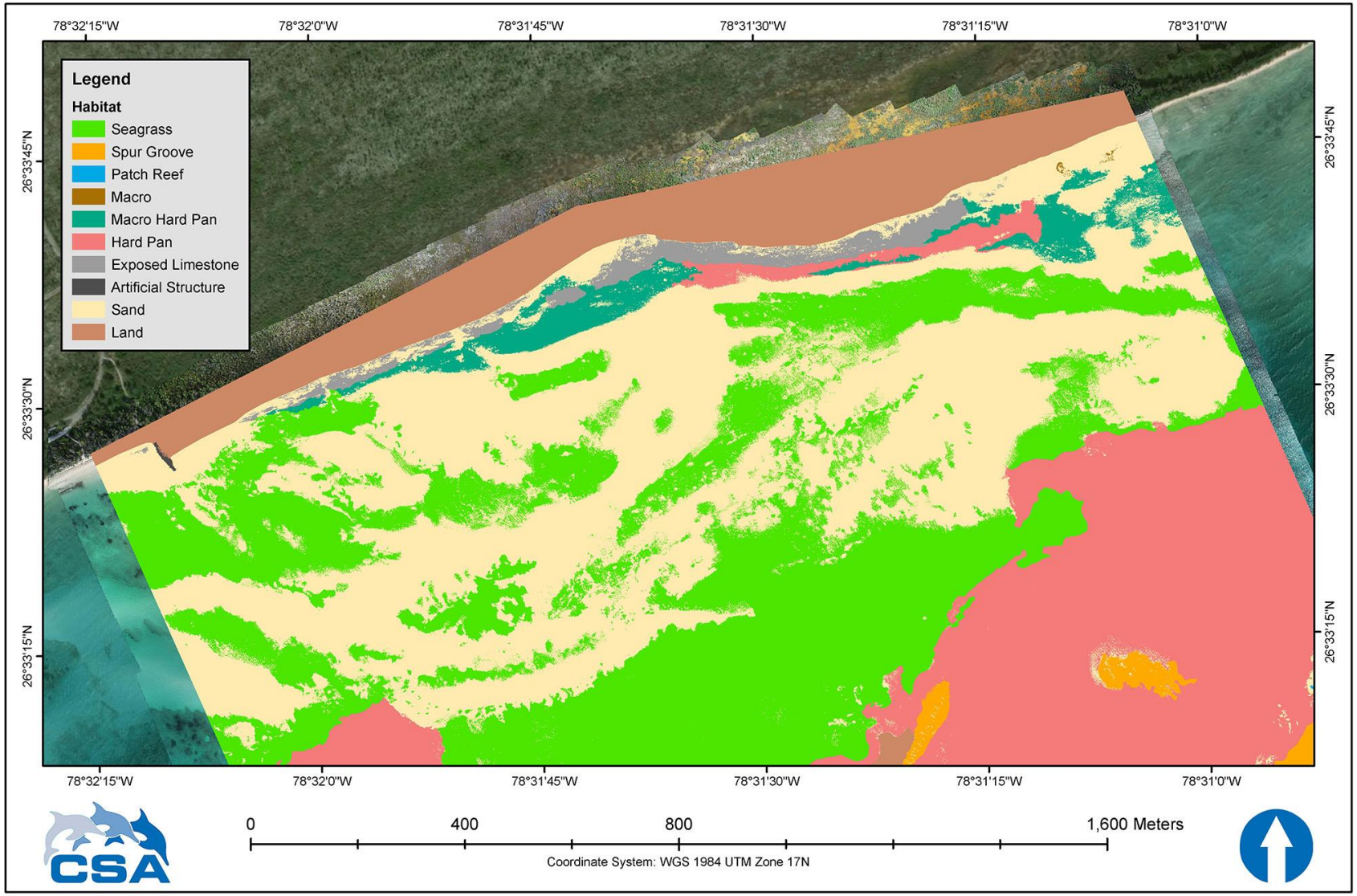


Figure 5. Benthic habitat map resulting from interpretation of aerial imagery collected in June 2019 of the northern half of the survey area for Peterson Cay, Grand Bahama.

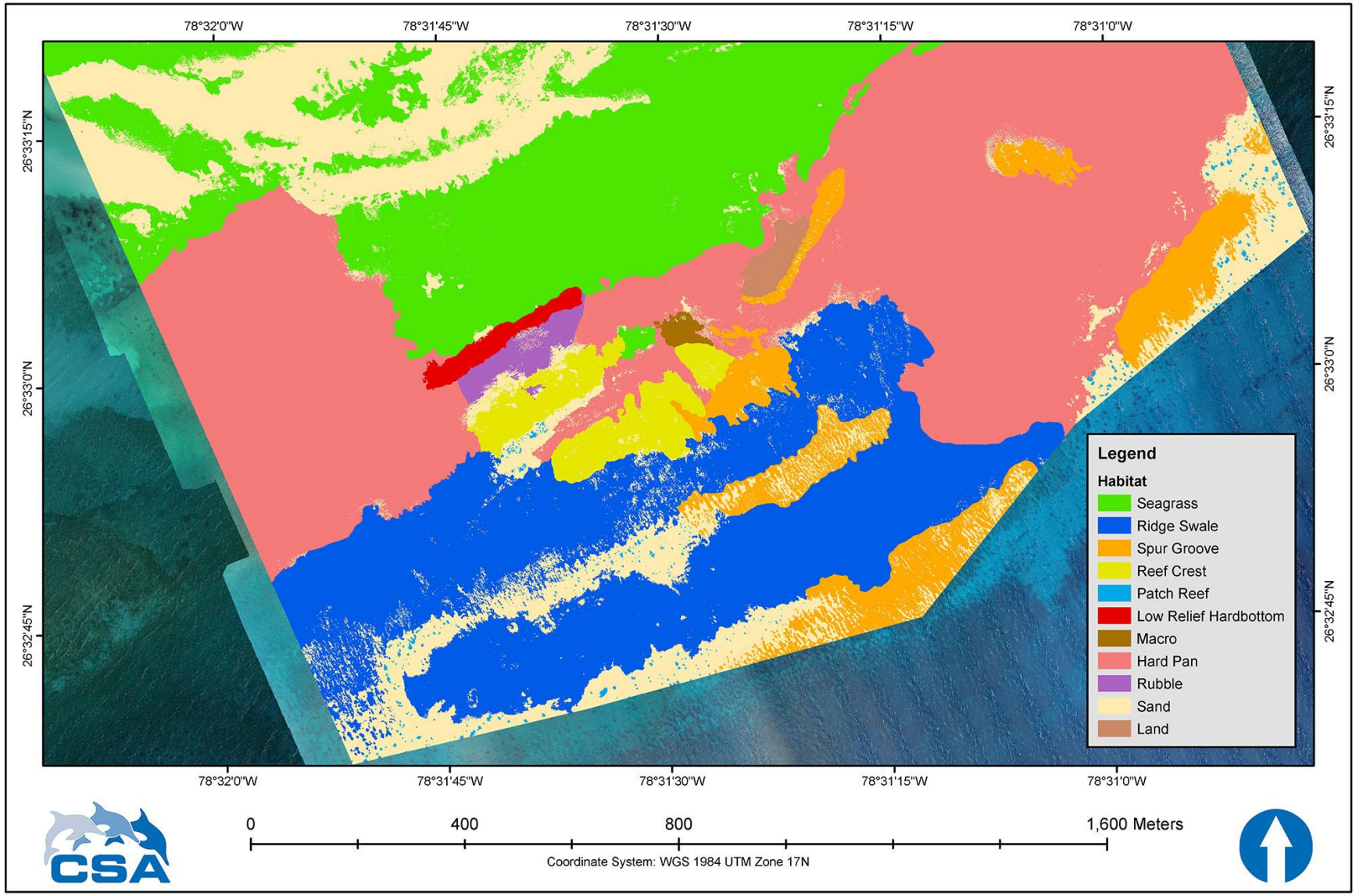


Figure 6. Benthic habitat map resulting from interpretation of aerial imagery collected in June 2019 of the southern half of the survey area for Peterson Cay, Grand Bahama.

Additional benthic habitat types found in the survey area for Peterson Cay (and not present within the Project Area) are defined briefly below along with example photos.

Artificial Structure – Man-made jetty containing rock boulders (**no photo**).

Cay – Small, carbonate-based island with low elevation, surrounded by sand or coral reef habitats (**Photo 8a**).

Macroalgae in Sand - Marcroalgae occurring in sand, occurring in water depths of approximately 1 m (3.3 ft) (**no photo**).

Low Relief Hardbottom – Hardbottom with relief up to 1 m (3.3 ft) colonized by primarily by fire coral (*Millepora* spp.), followed by octocorals, sponges, and stony corals, occurring at a water depth of approximately 2 m (6.6 ft) (**Photo 8b**).

Patch Reef – Isolated carbonate features, surrounded by sand or hardbottom, heavily colonized by algae, octocorals, sponges, and stony corals. Similar to reef mounds but smaller in diameter (up to 2 m [6.6 ft]), occurring in water depths from approximately to 3 to 15 m (9.8 to 49 ft) (**Photo 8c**).

Reef Crest – Shallowest portion of the fringing reef occurring in water depths from 0 to 3 m (0 to 9.8 ft), exposed to sustained wave action. Composed of Acroporid coral framework and other stony coral skeleton rubble supporting primarily live Acroporid corals (*Acropora cervicornis*, *A. palmata*, and *A. prolifera*), followed by large colonies of boulder and brain corals (*Diploria*, *Montastraea*, *Orbicella*, and *Porites* spp.), with occasional octocorals. Substrate is also heavily colonized by crustose coralline algae and fire coral (*Millepora* spp.) (**Photos 8d, 8e**).

Rubble – Eroded *Acropora* spp. (primilary *A. palmata*) skeletons and other loose carbonate pieces, colonized by crustose coralline algae, fire coral, and octocorals (**Photo 8f**).

Seagrass – Seagrass meadows composed primarily of turtle grass (*Thalassia testudinum*) followed by manatee grass (*Syringodium filiforme*), occurring within the shallow lagoon (0 to 3 m [0 to 9.8 ft] water depth) in the lee of Peterson Cay and the fringing reef (**Photos 9a, 9b**).

a.

b.

c.

d.

e.

f.

Photo 8. Representative photos of various benthic habitats identified in survey area for Peterson Cay, Grand Bahama. a) Cay, b) Low Relief Hardbottom, c) Patch Reef, d) Reef Crest – Staghorn coral (*A. cervicornis*), e) Reef Crest – boulder and brain corals, (f) Rubble.

a.

b.

Photo 9. Representative photos of seagrass habitat identified in survey area for Peterson Cay, Grand Bahama. a) Dense bed of turtle grass, b) bed comprised primarily by manatee grass also containing turtle grass.

3.2 BENTHIC CHARACTERIZATION

Benthic habitats in the Project Area and Peterson Cay are defined by various forms, exposure, and relief of hardbottom substrate, originating from underlying calcium carbonate bedrock and coral reef formation. Hardbottom substrates are colonized by a variety of tropical reef biota, typical of The

Bahamas and tropical western Atlantic, differing in diversity and cover based on persistence of hardbottom exposure and water depth. Carbonate and aragonitic-based sand plains and channels intertwine hardbottom features, and sediment veneers over hardbottom are common on hardbottom platforms with low relief, particularly in the intertidal and shallow subtidal zones close to shore.

A total of 36 Bounce Dive Stations were surveyed in the Project Area, and 44 Bounce Dive Stations were surveyed at Peterson Cay, to document and characterize the marine biological communities present, and help differentiate and groundtruth the various benthic habitats. Within the Project Area, a total of 70 quadrats (each 1 m^2) were also sampled from 16 Quadrat Stations to provide quantitative data. Results from quadrat surveys provided estimates of percent cover of flora and fauna, densities and size classes of octocorals and stony corals, and an assessment of stony coral health. Lists of all taxa of sponges, octocorals, stony corals, and fishes observed within the Project Area and within Peterson Cay are displayed in **Tables 4** through **7**, respectively. More taxa were recorded in the Project Area versus Peterson Cay likely due to greater sampling intensity.

Table 4. Fish species and families observed during field surveys of the Project Area and Peterson Cay listed in phylogenetic order.

Common Name (Family)	Family	Common Name (Species)	Scientific Name	Project Area	Peterson Cay
Nurse sharks	Ginglymostomatidae	Nurse shark	*Ginglymostoma cirratum*	+	--
Whiptail rays	Dasyatidae	Southern stingray	*Hypanus americanus*	+	--
Manta rays	Mobulidae	Giant manta	*Mobula birostris*	+	--
Moray eels	Muraenidae	Spotted moray	*Gymnothorax moringa*	+	--
Lizardfishes	Synodontidae	Redbarred lizardfish	*Synodus synodus*	+	--
Squirrelfishes	Holocentridae	Longspine squirrelfish	*Holocentrus rufus*	+	+
		Reef squirrelfish	*Neoniphon coruscum*	+	--
		Dusky squirrelfish	*Neoniphon vexillarium*	+	--
Trumpetfishes	Aulostomidae	Atlantic trumpetfish	*Aulostomus maculatus*	--	+
Scorpionfishes	Scorpaenidae	Red lionfish	*Pterois volitans*	+	--
Cardinalfishes	Apogonidae	Barred cardinalfish	*Apogon binotatus*	+	--
		Sawcheek cardinalfish	*Apogon quadrisquamatus*	+	--
Groupers and hinds	Epinephelidae	Graysby	*Cephalopholis cruentata*	+	+
		Coney	*Cephalopholis fulva*	+	--
		Red hind	*Epinephelus guttatus*	+	--
		Black Grouper	*Mycteroperca bonaci*	+	--
		Tiger grouper	*Mycteroperca tigris*	+	--
Seabasses	Serranidae	Butter hamlet	*Hypoplectrus unicolor*	+	--
		Lantern bass	*Serranus baldwini*	+	--
		Tobaccofish	*Serranus tabacarius*	+	--
		Harlequin bass	*Serranus tigrinus*	+	+
Fairy basslets	Grammatidae	Royal gramma or Fairy basslet	*Gramma loreto*	+	--
Tilefishes	Malacantidae	Sand tilefish	*Malacanthus plumieri*	+	+

Table 4. (Continued).

Common Name (Family)	Family	Common Name (Species)	Scientific Name	Project Area	Peterson Cay
Jacks	Carangidae	Yellow jack	*Carangoides bartholomaei*	+	+
		Bar jack	*Carangoides ruber*	+	+
		Blue runner	*Caranx crysos*	+	+
		Horse-eye jack	*Caranx latus*	+	+
Snappers	Lutjanidae	Mutton snapper	*Lutjanus analis*	+	--
		Schoolmaster snapper	*Lutjanus apodus*	+	+
		Blackfin snapper	*Lutjanus buccanella*	+	--
		Cubera snapper	*Lutjanus cyanopterus*	+	--
		Grey snapper	*Lutjanus griseus*	+	+
		Mahogany snapper	*Lutjanus mahogoni*	+	--
		Lane snapper	*Lutjanus synagris*	+	--
		Yellowtail snapper	*Ocyurus chrysurus*	+	+
Mojarras	Gerreidae	Spotfin mojarra	*Eucinostomus argenteus*	--	+
		Yellowfin mojarra	*Gerres cinereus*	--	+
Grunts	Haemulidae	Porkfish	*Anisotremus virginicus*	+	--
		Bonnetmouth	*Emmelichthyops atlanticus*	+	--
		Margate grunt	*Haemulon album*	+	+
		Tomtate grunt	*Haemulon aurolineatum*	+	+
		Smallmouth grunt	*Haemulon chrysargyreum*	+	+
		French grunt	*Haemulon flavolineatum*	+	+
		Cottonwick grunt	*Haemulon melanurum*	+	+
		Sailor's-choice grunt	*Haemulon parra*	+	--
		White grunt	*Haemulon plumierii*	+	+
		Bluestriped grunt	*Haemulon sciurus*	+	+
		Boga	*Haemulon vittata*	+	+
		Striped grunt	*Haemulon striatum*	+	--
Porgies	Sparidae	Saucereye porgy	*Calamus calamus*	+	--
		Sheepshead porgy	*Calamus penna*	+	--
		Pluma porgy	*Calamus pennatula*	--	+
Goatfishes	Mullidae	Yellow goatfish	*Mulloidichthys martinicus*	+	+
Seachubs	Kyphosidae	Yellow seachub	*Kyphosus vaigiensis*	+	+
Spadefishes	Ephippidae	Atlantic spadefish	*Chaetodipterus faber*	+	--
Butterflyfishes	Chaetodontidae	Foureye butterflyfish	*Chaetodon capistratus*	+	+
		Reef butterflyfish	*Chaetodon sedentarius*	+	--
		Banded butterflyfish	*Chaetodon striatus*	+	+

Table 4. (Continued).

Common Name (Family)	Family	Common Name (Species)	Scientific Name	Project Area	Peterson Cay
Angelfishes	Pomacanthidae	Queen angelfish	*Holacanthus ciliaris*	+	--
		Rock beauty	*Holacanthus tricolor*	+	--
		Grey angelfish	*Pomacanthus arcuatus*	+	+
		French angelfish	*Pomacanthus paru*	+	+
Damselfishes	Pomacentridae	Sergeant-major	*Abudefduf saxatilis*	+	+
		Night sergeant	*Abudefduf taurus*	--	+
		Blue chromis	*Chromis cyanea*	+	+
		Brown chromis	*Chromis multilineata*	+	+
		Yellowtail damselfish	*Microspathodon chrysurus*	--	+
		Dusky damselfish	*Stegastes adustus*	+	+
		Longfin damselfish	*Stegastes diencaeus*	--	+
		Beaugregory	*Stegastes leucostictus*	+	+
		Bicolor damselfish	*Stegastes partitus*	+	--
		Threespot damselfish	*Stegastes planifrons*	+	+
Hawkfishes	Cirrhitidae	Redspotted hawkfish	*Amblycirrhitus pinos*	--	+
Jawfishes	Opistognathidae	Yellowhead jawfish	*Opistognathus aurifrons*	+	--
		Mottled jawfish	*Opistognathus maxillosus*	+	--
Wrasses and parrotfishes	Labridae	Spanish hogfish	*Bodianus rufus*	--	+
		Creole wrasse	*Clepticus parrae*	+	+
		Slippery dick	*Halichoeres bivittatus*	+	+
		Yellowhead wrasse	*Halichoeres garnoti*	+	+
		Clown wrasse	*Halichoeres maculipinna*	+	+
		Rainbow wrasse	*Halichoeres pictus*	+	+
		Blackear wrasse	*Halichoeres poeyi*	+	+
		Puddingwife	*Halichoeres radiatus*	+	+
		Hogfish	*Lachnolaimus maximus*	+	--
		Redband parrotfish	*Sparisoma aurofrenatum*	+	+
		Redtail parrotfish	*Sparisoma chrysopterum*	+	+
		Bucktooth parrotfish	*Sparisoma radians*	+	+
		Yellowtail parrotfish	*Sparisoma rubripinne*	+	+
		Stoplight parrotfish	*Sparisoma viride*	+	+
		Bluehead wrasse	*Thalassoma bifasciatum*	+	+
		Blue parrotfish	*Scarus coeruleus*	+	--
		Striped parrotfish	*Scarus iseri*	+	+
		Princess parrotfish	*Scarus taeniopterus*	--	+
		Queen parrotfish	*Scarus vetula*	+	+
Labrisomids	Labrisomidae	Hairy blenny	*Labrisomus nuchipinnis*	+	--
		Goldline blenny	*Malacoctenus aurolineatus*	--	+
		Diamond blenny	*Malacoctenus boehlkei*	+	+

Table 4. (Continued).

Common Name (Family)	Family	Common Name (Species)	Scientific Name	Project Area	Peterson Cay
Tube blennies	Chaenopsidae	Roughhead blenny	*Acanthemblemaria aspera*	+	+
		Spinyhead blenny	*Acanthemblemaria spinosa*	--	+
Blennies	Blenniidae	Redlip blenny	*Ophioblennius macclurei*	--	+
Gobies	Gobiidae	Frillfin goby	*Bathygobius soporator*	+	+
		Colon goby	*Coryphopterus dicrus*	+	+
		Pallid goby	*Coryphopterus eidolon*	+	--
		Bridled goby	*Coryphopterus glaucofraenum*	+	--
		Peppermint goby	*Coryphopterus lipernes*	+	--
		Masked goby	*Coryphopterus personatus*	+	--
		Bluelip parrotfish	*Cryptotomus roseus*	+	--
		Cleaner goby	*Elacatinus genie*	+	+
		Goldspot goby	*Gnatholepis thompsoni*	--	+
Surgeonfishes	Acanthuridae	Doctorfish	*Acanthurus chirurgus*	+	+
		Blue tang surgeonfish	*Acanthurus coeruleus*	+	+
		Ocean surgeon	*Acanthurus tractus*	+	+
Barracudas	Sphyraenidae	Great barracuda	*Sphyraena barracuda*	+	--
Mackerels	Scombridae	Cero mackerel	*Scomberomorus regalis*	+	--
Trunkfishes	Ostraciidae	Scrawled cowfish	*Acanthostracion quadricornis*	+	+
		Smooth trunkfish	*Lactophrys triqueter*	+	+
Triggerfishes	Balistidae	Queen triggerfish	*Balistes vetula*	+	--
		Ocean triggerfish	*Canthidermis sufflamen*	+	+
		Black durgon	*Melichthys niger*	+	--
Filefishes	Monacanthidae	Orange filefish	*Aluterus schoepfii*	+	--
		Scrawled filefish	*Aluterus scriptus*	+	--
		Orange-spotted filefish	*Cantherhines pullus*	--	+
		Slender filefish	*Monacanthus tuckeri*	--	+
		Sharpnose-puffer	*Canthigaster rostrata*	+	+
			Total Species Observed	**108**	**74**

+ = present; -- = absent

Table 5. Sponge taxa and families observed during field surveys of the Project Area and Peterson Cay listed in alphabetic order.

Family	Common Name	Scientific Name	Project Area	Peterson Cay
Agelasidae	Brain sponge	*Agelas cerebrum*	+	+
	Elephant ear sponge	*Agelas clathrodes*	+	+
Aplysinidae	Branching tube sponge	*Aiolochroia crassa*	+	+
	Row pore rope sponge	*Aplysina cauliformis*	+	--
	Yellow tube sponge	*Aplysina fistularis*	+	+
	Netted barrel sponge	*Verongula gigantea*	+	--
	Pitted sponge	*Verongula rigida*	+	--
Axinellidae	Orange tree sponge	*Ptilocaulis sp.*	+	--
Callyspongidae	Azure vase sponge	*Callyspongia plicifera*	+	--
	Branching vase sponge	*Callyspongia vaginalis*	+	+
Clionaidae	Green boring sponge	*Cliona viridis*	+	--
Clionaidae	Loggerhead sponge	*Spheciospongia vesparium*	+	+
Geodiidae	Leathery barrel sponge	*Geodia neptuni*	+	--
Hadromerida	Orange wall sponge	*Spirastrella sp.*	+	--
Iotrochotidae	Green finger sponge	*Iotrochota birotulata*	+	+
Irciniidae	Stinker sponge	*Ircinia felix*	+	+
	Black-ball sponge	*Ircinia strobilina*	+	+
Mycalidae	Orange icing sponge	*Mycale laevis*	+	--
	Strawberry vase sponge	*Mycale laxissima*	+	--
Niphatidae	Erect rope sponge	*Amphimedon compressa*	+	+
	Brown bowl sponge	*Cribrochalina vasculum*	+	+
	Pink vase sponge	*Niphates digitalis*	+	+
Petrosiidae	Giant barrel sponge	*Xestospongia muta*	+	+
Raspailiidae	Brown encrusting octopus sponge	*Ectyoplasia ferox*	+	--
Spongiidae	Grass sponge	*Spongia tubulifera*	+	--
		Total Species Observed	**25**	**13**

+ = present; -- = absent

Table 6. Octocoral taxa and families observed during field surveys of the Project Area and Peterson Cay listed in alphabetic order.

Family	Common Name	Scientific Name	Project Area	Peterson Cay
Briareidae	Corky sea finger	*Briareum absestinum*	+	+
Anthothelidae	Encrusting gorgonian	*Erythropodium caribaeorum*	+	--
Plexauridae	Sea rods	*Plexaura spp.*	+	+
Plexauridae	Bent sea rod	*Plexaura flexuosa*	+	+
Plexauridae	Porous sea rods	*Pseudoplexaura spp.*	+	+
Plexauridae	Knobby sea rods	*Eunicea spp.*	+	+
Plexauridae	Slit-pore sea rods	*Plexaurella spp.*	+	+
Plexauridae	Spiny sea rods	*Muricea spp.*	+	+
Gorgoniidae	Slimy sea plume	*Pseudopterogorgia americana*	+	+
Gorgoniidae	Bipinnate sea plume	*Pseudopterogorgia bipinnata*	+	+
Gorgoniidae	Caribbean sea plume	*Pseudopterogorgia elisabethae*	+	+
Gorgoniidae	Sea whip	*Pterogorgia spp.*	+	+
Gorgoniidae	Common sea fan	*Gorgonia ventalina*	+	+
Gorgoniidae	Venus or Bahamian sea fan	*Gorgonia flabellum*	+	+
Gorgoniidae	Wide-mesh sea fan	*Gorgonia mariae*	+	--
Gorgoniidae	Colorful sea whip	*Leptogorgia spp.*	+	+
Telestinae	White telesto	*Carijoa riisei*	+	--
		Total Taxa Observed	**17**	**14**

+ = present; -- = absent

Table 7. Stony coral taxa and families observed during field surveys of the Project Area and Peterson Cay listed in alphabetic order.

Family	Common Name	Scientific Name	Project Area	Peterson Cay
Acroporidae	Staghorn coral	*Acropora cervicornis*	--	+
Acroporidae	Elkhorn coral	*Acropora palmata*	--	+
Acroporidae	Fused staghorn coral	*Acropora prolifera*	--	+
Agariciidae	Lettuce coral	*Agaricia agaricites*	+	+
Agariciidae	Fragile saucer coral	*Agaricia fragilis*	+	--
Agariciidae	Dimpled sheet coral	*Agaricia grahamae*	+	--
Agariciidae	Whitestar sheet coral	*Agaricia lamarcki*	+	--
Astrocoeniidae	Blushing star coral	*Stephanocoenia intersepts*	+	--
Caryophylliidae	Smooth flower coral	*Eusmilia fastigiata*	+	--
Faviidae	Boulder brain coral	*Colpophyllia natans*	+	+
Faviidae	Symmetrical brain coral	*Diploria strigosa*	+	+
Faviidae	Knobby brain coral	*Diploria clivosa*	+	+
Faviidae	Grooved brain coral	*Diploria labyrinthiformis*	+	+
Faviidae	Golf ball coral	*Favia fragum*	+	--
Faviidae	Rose coral	*Manicina areolata*	+	--
Faviidae	Great start coral	*Montastraea cavernosa*	+	+
Faviidae	Boulder star coral	*Orbicella annularis*	+	+
Faviidae	Mountainous star coral	*Orbicella favelota*	+	+
Faviidae	Boulder star coral	*Orbicella franksi*	+	+
Faviidae	Smooth star coral	*Solenastrea bournoni*	+	+
Meandrinidae	Pillar coral	*Dendrogyra cylindrus*	+	+
Meandrinidae	Elliptical star coral	*Dichocoenia stokesi*	+	+
Meandrinidae	Maze coral	*Meandrina meandrites*	+	+
Mussidae	Cactus coral	*Mycetophyllia sp.*	+	--
Mussidae	Artichoke coral	*Scolymia sp.*	+	--
Pocilloporidae	Ten-ray star coral	*Madracis decactis*	+	+
Poritidae	Mustard hill coral	*Porites astreoides*	+	+
Poritidae	Finger coral	*Porites porites*	+	+
Siderastreidae	Lesser starlet coral	*Siderastrea radians*	+	--
Siderastreidae	Massive starlet coral	*Siderastrea siderea*	+	+
		Total Species Observed	**27**	**20**

+ = present; -- = absent

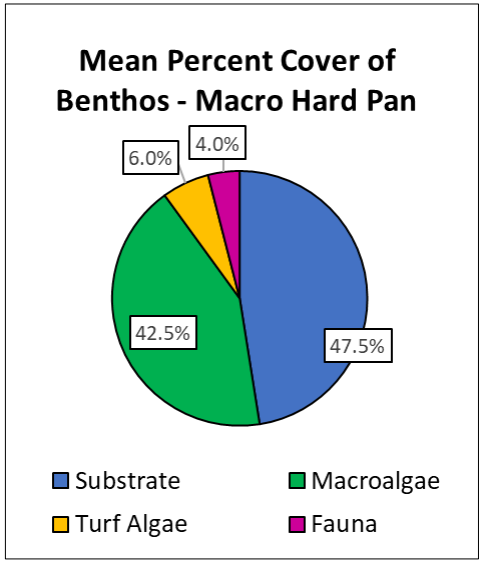
3.2.1 Project Area

The Project Area contained several predominant hardbottom habitat types, each with increased epibiotic cover and species richness in a gradient from shore to increasing water depth. Areas of bare exposed limestone in the intertidal and shallow subtidal zones graded to hard pan substrate (pavement-like hardbottom with less than or equal to 0.5 m [1.6 ft] relief) heavily colonized by macroalgae. Slightly further offshore, hard pan substrate was colonized by a mix of turf algae, macroalgae, and octocorals, with occasional stony corals. Stony corals were typically found on areas of the hard pan habitat with slightly higher relief. The hard pan habitat merged into undulating hardbottom with higher relief typified by ridges and swales that generally ran north to south. Ridge features supported heavier colonization by reef biota. At deeper water depths, relief of hardbottom features continued to increase forming "spur" finger-like features alternating with narrow sand channels ("grooves"), also running generally north-south. Finally, isolated mound-like hardbottom features surrounded completely by sand, supporting the highest cover and species richness of epibiota, were observed in the deepest waters surveyed (maximum of 14 m [46 ft]).

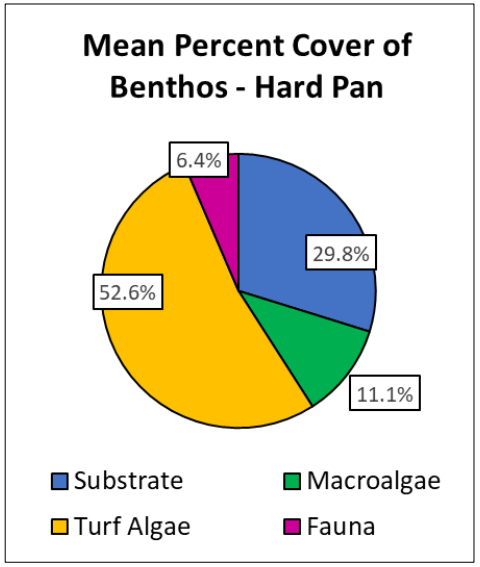
3.2.1.1 Epibiota

Mean percent cover estimates of epibiota and non-living substrate for each habitat from quadrat surveys are displayed in **Figure 7**. The Macroalgal Hard Pan habitat was the most distinct among habitat types, having high cover of each macroalgae and substrate relative to other habitat types (**Figure 7a**). Hard Pan habitat was differentiated from the other more "reef-like" habitats (Ridge and Swale, Spur and Groove, and Reef Mounds) by a higher percent cover of turf algae (over 50%) and lower cover of fauna (6.4%) (**Figure 7b**). Ridge and Swale, Spur and Groove, and Reef Mound habitats were more similar, with smaller variations in the contributions by turf algae, macroalgae, fauna, and substrate (**Figures 7c**, **7d**, **7e**). Percent cover of fauna increased with distance from shore and was highest on reef mounds at 34.7% (**Figure 7e**).

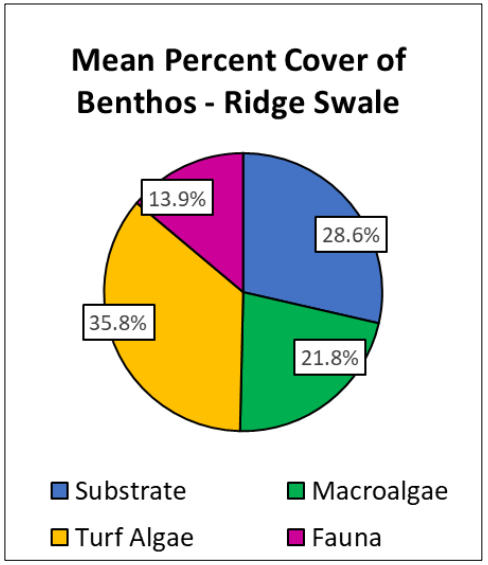
a.



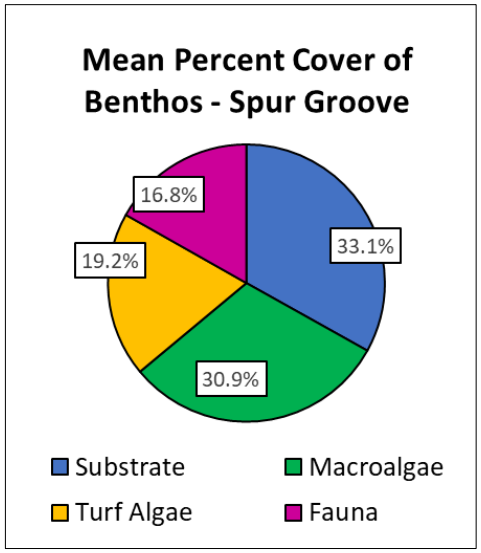
b.



c.



d.



e.

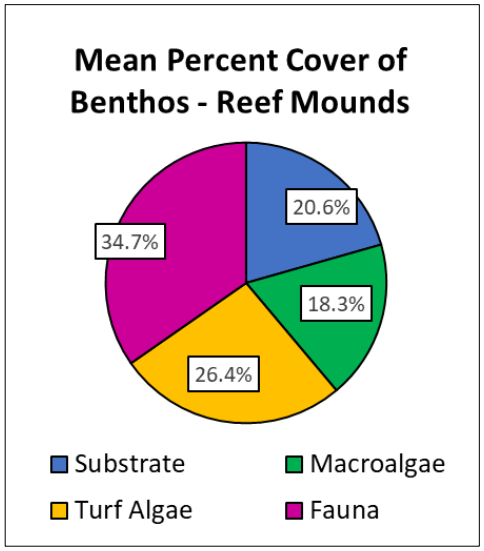


Figure 7. Mean percent cover results of epibiota and non-living substrate based on quadrat surveys for a) Macroalgal Hard Pan, b) Hard Pan, c) Ridge Swale, d) Spur Groove, and e) Reef Mound benthic habitats in the Project Area, Grand Bahama.

All octocoral and stony coral colonies occurring within each quadrat were enumerated. Densities of colonies with a maximum height or diameter greater than or equal to 10 cm (3.9 in) were calculated for the Hard Pan and "Reef" habitat (Reef = combined Ridge Swale, Spur Groove, and Reef Mound habitats) (**Figure 8**). Mean density of stony corals in the Hard Pan habitat was 0.13 (±0.07 SE) colonies/m^2 and in "Reef" habitat was 1.07 (±0.21 SE) colonies/m^2.

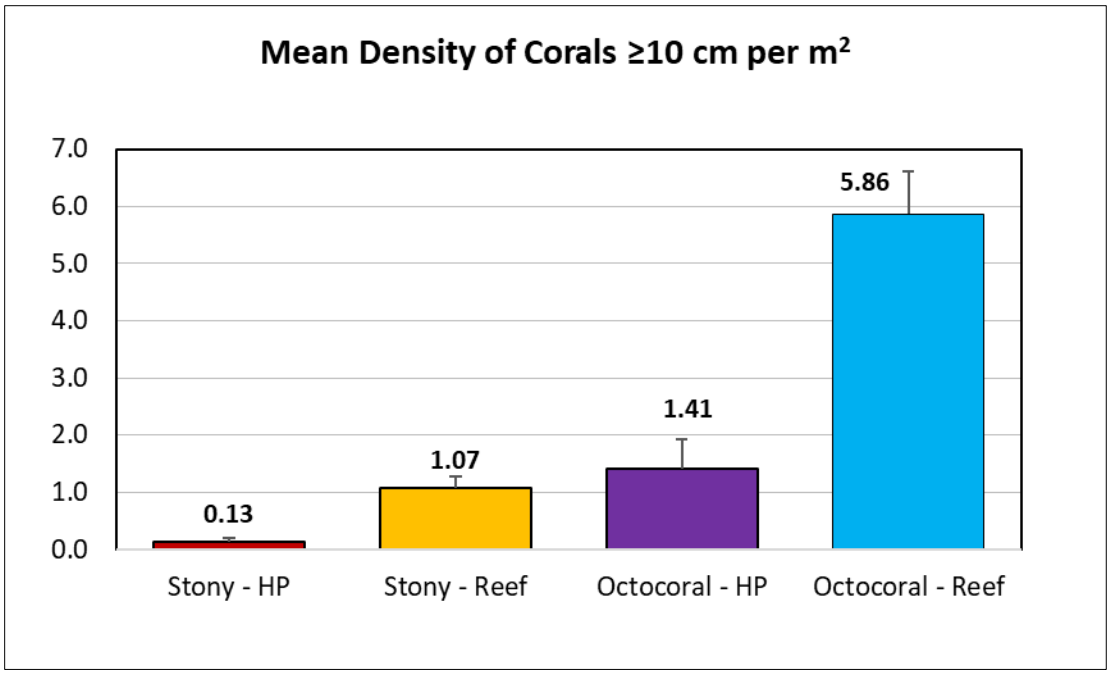


Figure 8. Mean density of stony corals and octocorals in Hard Pan and "Reef" (combined Ridge Swale, Spur Groove, and Reef Mound) habitats for the Project Area, Grand Bahama.

For potential mitigation planning purposes, the estimated number of stony coral colonies greater than 10 cm (3.9 in) occurring either in Hard Pan or "Reef" benthic habitats, falling within the proposed dredge footprint, were calculated as follows:

Hard Pan- 0.13 colonies/m^2 x 121,592.03 m^2 = **15,806 colonies**

"Reef" - 1.07 colonies/m^2 x 42,755.98 m^2 = **45, 749 colonies**

A total of 17 octocoral taxa and 27 stony coral taxa were recorded in the Project Area (**Tables 6** and **7**). The bipinnate sea plume (*Pseudopterogorgia bipinnata*) and knobby sea rods (*Eunicea* spp.) were the most frequently observed octocorals (**Photo 10**). The most abundant stony corals were massive starlet coral (*Siderastrea siderea*), lettuce coral (*Agaricia agaricites*), and mustard hill coral (*Porites astreoides*). Numerous sponge taxa (total of 25) were observed in the Project Area, especially in the reef mound habitat. The most frequently observed species were yellow tube sponge (*Aplysina fistularis*) (**Photo 11**) and stinker and black-ball sponges (*Ircinia* spp).

Photo 10. Various octocorals including the bipinnate sea plume (*Pseudopterogorgia bipinnata*) (lower right) and knobby sea rods (*Eunicea* spp.) (top middle of photo) on a reef mound in the Project Area, Grand Bahama.

Photo 11. Yellow tube sponge (*Aplysina fistularis*) on a reef mound in the Project Area, Grand Bahama.

Green algae *Halimeda* spp. and *Microdictyon marinum* were the most frequently observed macroalgal taxa in the Project Area. At the time of the survey, a dense algal mat, several centimeters thick covered many portions of reef substrates in the Ridge Swale, Spur Groove, and Reef Mound habitats (**Photo 12**). The algal mat was primarily comprised by *M. marinum* and *Boodlea struveoides* (also a green alga). Monospecific fields of each the red alga *Chrondria littoralis* (**Photo 6d**) and the green alga *Cymopolia barbata* were observed in the Macroalgal Hard Pan habitat. A mix of several calcareous green algal species were commonly observed in the Hard Pan habitat, consisting of *Avrainvillea* spp., *Halimeda* spp., *Penicillus* spp., and *Rhipocephalus* spp.

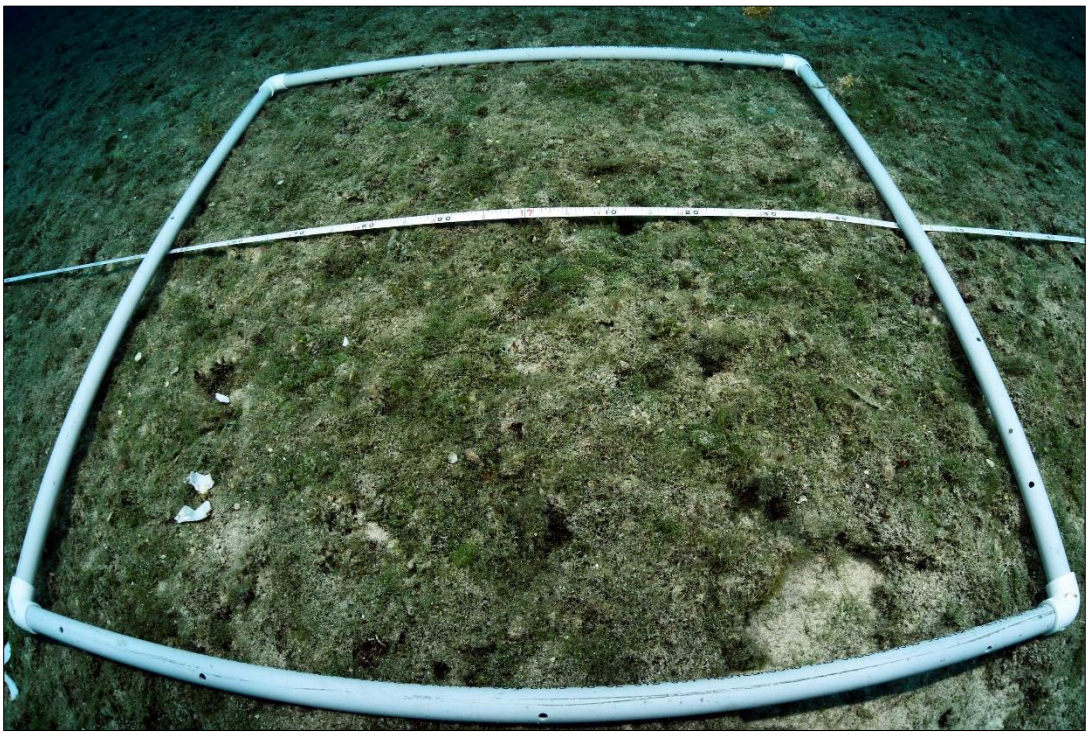


Photo 12. Algal mat comprised primarily by green algae *Microdictyon marinum* and *Boodlea struveoides* in the Project Area, Grand Bahama.

3.2.1.2 Areas and Features of Ecological Significance

Several unique areas of ecological significance were surveyed within the Project Area and are described herein.

Reef Mounds

This benthic habitat type had the highest percent cover and species richness of epibiota, as well as the highest species richness of fishes. Commercially valuable taxa such as snappers and groupers were most frequently observed in this habitat type. The unique spatial arrangement of the mounds, with maze-like channels between mounds, and structure of the mounds themselves with high relief and undercut bases providing over-hang features, provides excellent shelter and foraging areas for fishes (**Photo 13**). Higher species richness of stony corals was observed in this habitat compared to all other habitat types, in part due to the availability of vertical substrates on the sides of the mounds, which are preferred by some species, especially *Agaricia* spp. Large, healthy colonies of whitestar sheet coral (*Agaricia lamarcki*),

currently listed as Threatened by the United States ESA and Vulnerable by the IUCN (Aronson et al., 2008) were frequently observed on the vertical surfaces of mounds (**Photo 14**). At the time of the survey several colonies of *Agaricia* spp. exhibited paling or partial bleaching of tissues. Sponges were also observed in higher frequency and species richness on the reef mounds (**Photo 15**). Approximately 160 reef mound features varying in size and also varying in abundance and health of epibiotic cover were enumerated *in situ* within the dredge footprint (**Photo 16**).

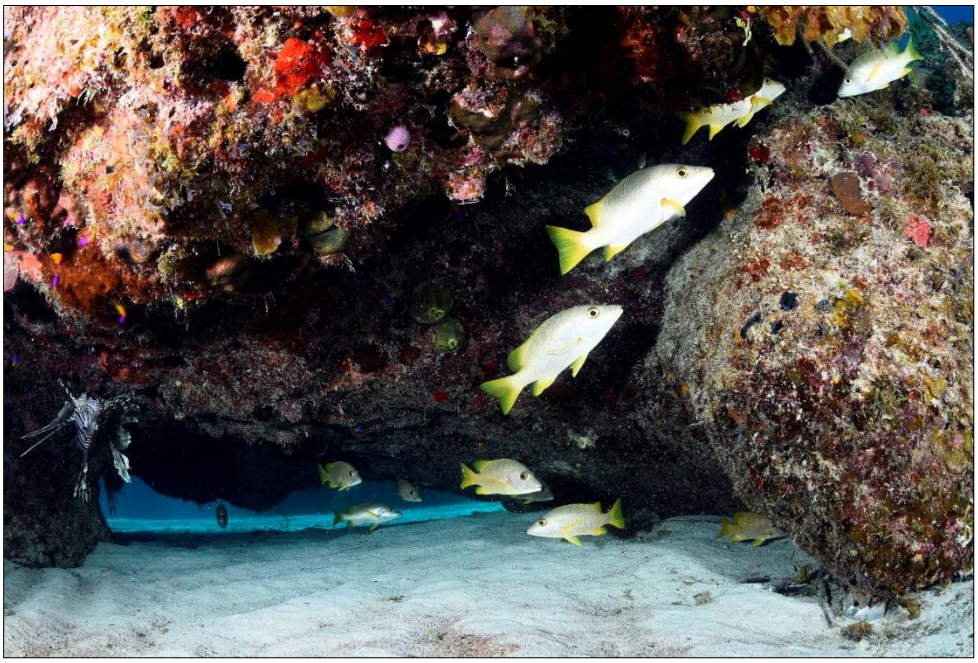


Photo 13. Undercut area at the base of a reef mound with schoolmaster snappers (*Lutjanus apodus*), a red lionfish (*Pterois volitans*), and royal grammas (*Gramma loreto*) in the Project Area, Grand Bahama.

Photo 14. A colony of whitestar sheet coral (*Agarcia lamarcki*) on the vertical face of a reef mound in the Project Area, Grand Bahama. Note the colony is exhibiting slight paling of tissues.

Photo 15. A variety of sponge taxa including the barrel sponge (*Xestospongia muta*), yellow tube sponge (*Aplysina fistularis*), green finger sponge (*Iotrochota birotulata*), and branching vase sponge (*Callyspongia vaginalis*) on a reef mound in the Project Area, Grand Bahama.

Photo 16. Several reef mounds in the Project Area, Grand Bahama.

Pillar Corals

Three large (≥ 1 m [3.3 ft]) colonies of pillar coral (*Dendrogyra cylindrus*) were observed in the Project Area and their geographic locations were recorded (**Appendix**). Pillar corals are currently listed as Threatened under the United States ESA and have drastically declined throughout the Caribbean in recent years due to coral white diseases (Kabay, 2016). Colonies observed had healthy tissue but evidence of recent tissue mortality at the base was observed on some colonies (**Photo 17**).

Photo 17. Large colony of pillar coral (*Dendrogyra cylindrus*) exhibiting an area of recent tissue mortality as evidenced by the detailed calices still evident on the bare skeleton (lower middle of photo).

Sharps Rock

A wave-cut, jagged limestone platform extending out over the sea runs along the shoreline at the west end of the Project Area. This feature, locally known as "Sharps Rock" exhibits honeycomb weathering giving the rock a jagged and sharp morphology (Sealy, 1994). This limestone platform extends into the water and connects to expanses of Exposed Limestone and Hard Pan habitats along the shoreline. Healthy colonies of predominantly brain (*Diploria* spp.) and starlet (*Siderastrea* spp.) stony corals were occasionally observed colonizing the hardbottom substrate along with various octocorals (**Photo 18**). A giant manta ray (*Mobula birostris*) was observed near this area in the Macroalgal Hard Pan habitat (**Photo 19**).

Photo 18. Brain (*Diploria* spp.) and starlet (*Siderastrea* spp.) stony corals, sea fans (*Gorgonia* spp.), fire coral (*Millepora* sp.), and turf algae within the Hard Pan habitat near Sharps Rock in the Project Area, Grand Bahama.

Photo 19. Giant manta ray (*Mobula birostris*) observed in the Macroalgal Hard Pan habitat close to shore in the Project Area, Grand Bahama.

3.2.2 Peterson Cay

The surveyed area within PCNP included a fringing reef, which surrounds emergent land of a cay. The reef has a well-developed reef buttress zone at 10 m (33 ft) water depth, which progresses shallower to a reef crest which is nearly emergent at low tide. The buttress zone is populated by massive varieties of boulder and brain stony corals including *Montastraea cavernosa*, *Orbicella* spp., *Porites astreoides*, and *Diploria spp.* These species give way to elkhorn coral (*Acropora palmata*), staghorn coral (*A. cervicornis*), blade fire coral (*Millepora complanata*) and coralline algae at the shallowest portions of the reef crest. Landward from the reef crest, in the reef flat, lies a rubble zone consisting of primarily staghorn and elkhorn coral which fragment over time during rough weather and form a substrate of coral skeleton rubble behind the wave-impacted reef crest. Within and landward of the rubble zone lie patch reefs which support brain corals (*Diploria* spp.), staghorn coral, and sea fans (*Gorgonia* spp.). Immediately landward of the reef flat lies a shallow lagoon in the lee of the cay and fringing reef. The substrate in the lagoon is primarily carbonate sand, with dense seagrass cover by turtle (*Thalassia testudinum*) (**Photo 9a**) and manatee (*Syringodium filiforme*) (**Photo 9b**) grass. Shoreward in < 2 m (6.6 ft) water depth, macroalgae were prevalent and intermixed with seagrasses. At approximately 0.5 m (1.6 ft) water depth, exposed bare limestone (occasionally colonized by turf algae or cyanobacteria) was found close to shore among sand plains extending to the beach.

To the east and west of the cay and surrounding fringing reef lies hard pan substrate (pavement-like hardbottom with less than 0.5 m [1.6 ft] relief) which is colonized by macroalgae, sponges, and octocorals with sparse stony corals. Moving further offshore, the hard pan substrate was colonized by a mix of turf algae, macroalgae, and octocorals, with occasional stony corals. Stony corals were typically found on areas of the Hard Pan habitat with slightly higher relief. Small patch reefs were also observed within the Hard Pan habitat, rising 1 to 1.5 m (3.3 to 4.9 ft) from the hard pan substrate. These were

often colonized heavily by stony corals including the vulnerable species *Dendrogyra cylindrus* and many genera of octocorals.

Offshore, the hard pan substrate merged into ridge and swale features (undulating hardbottom with ≥2 m [6.6 ft] relief ridges) that generally ran north to south. The ridges supported heavier colonization by reef biota with larger stony corals, sponges, and octocorals. Macroalgae and sponges were more abundant on the deeper ridges.

3.2.2.1 Areas and Features of Ecological Significance

Acropora Corals

All three species of Caribbean *Acropora* corals were observed on the fringing reef at Peterson Cay. *A. palmata* was dominant within the reef crest community, where large stands extended from the shallowest portion of the reef crest to the fore reef slope (**Photo 20**). *A. palmata* was the major contributor of skeletal material for substrate in the rubble zone; hundreds of coralline encrusted relic *A. palmata* branches comprised the majority of the habitat. *A. cervicornis* was a major component of the back-reef community, forming stands up to 4 m (13 ft) in diameter (**Photo 8d**). The substantial lee provided by the reef crest and fore reef communities provides a relatively quiescent habitat ideal for growth of *A. cervicornis*. Both species, *A. palmata* and *A. cervicornis* are listed by the IUCN as Critically Endangered (Aronson et al., 2008). Behind the reef crest within the rubble zone, *A. prolifera* was occasionally observed, one of the only live coral species observed in the Rubble habitat (**Photo 21**). This species is a hybrid of the other two Acroporids and was located in between stands of the other two species. Data on *A. prolifera*'s stability are deficient and the IUCN does not report on this species.

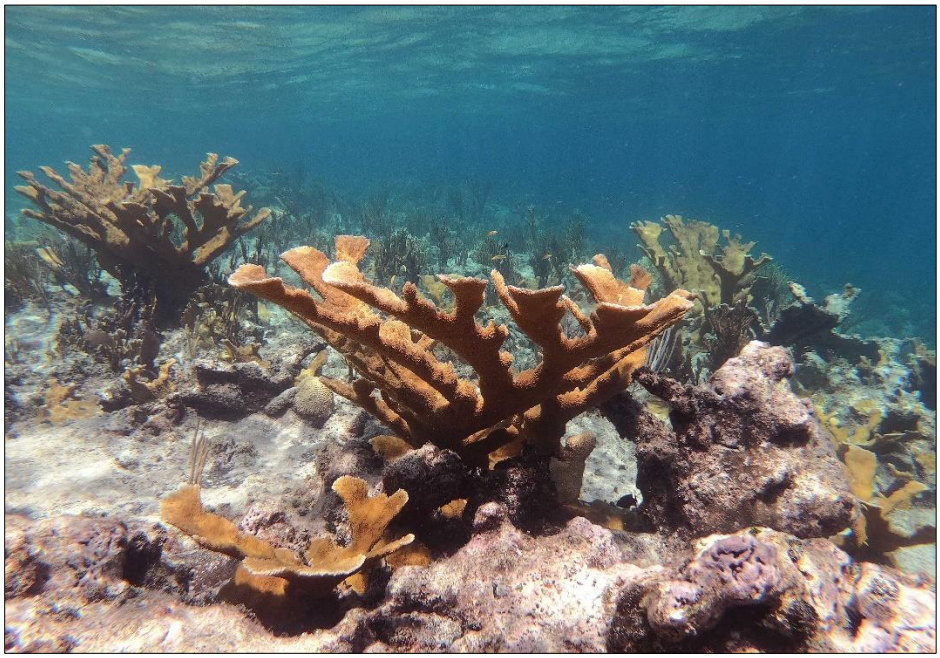


Photo 20. Stands of live elkhorn coral (*Acropora palmata*) in the Reef Crest habitat within the survey area for Peterson Cay, Grand Bahama.

Photo 21. Several colonies of fused staghorn coral (*Acropora prolifera*) observed in the Rubble habitat within the survey area for Peterson Cay, Grand Bahama.

Other Vulnerable Coral Species

The *Orbicella* species complex (*O. annularis*, *O. faveolata*, *O. franksi*) was observed on the fore reef slope portion of the fringing reef and all species are listed as Endangered or Vulnerable by the IUCN (Aronson et al., 2008). These species are also listed as Threatened under the United States ESA.

Three colonies of pillar coral (*Dendrogyra cylindrus*), listed as Vulnerable by the IUCN, were found within the survey area, within Hard Pan habitats south of the cay and within the lagoon (Aronson et al., 2008). The largest colony (approximately 2 m [6.6 ft] in diameter) was located in a sparsely colonized seagrass meadow in the lagoon of Peterson Cay (**Photo 22**).

Seagrass Meadows

The seagrass habitat in the lagoon of Peterson Cay was extensive in area of cover and supported meso-grazers including queen conch (*Strombus gigas*), king helmet (*Cassis tuberosa*), west Indian chank (*Turbinella angulata*), various sea urchins, and cushion sea star (*Oreaster reticulatus*), as well as macro-grazers such as green sea turtles (*Chelonia mydas*). Green sea turtles are listed as Endangered under the U.S. ESA and are listed as Endangered by the IUCN (Seminoff, 2004). Significant grazing by turtles was evident in seagrass beds immediately adjacent to Peterson Cay. Upon close examination, many seagrass blades in this area were clipped bluntly at the tips. During the survey, scientists had close encounters with one resident green sea turtle (**Photo 23**).

Photo 22. Large colony of pillar coral (*Dendrogyra cylindrus*) observed within Seagrass habitat in the lagoon of Peterson Cay, Grand Bahama.

Photo 23. A juvenile green sea turtle (*Chelonia mydas*) observed in the Seagrass habitat in the lagoon of Peterson Cay, Grand Bahama.

Bridled Tern Nesting Habitat

The emergent Cay at Peterson provides habitat for nesting Bridled Terns, (*Sterna anaethetus*) a regionally endemic species noted by the Conservation Unit, Bahamas Department of Agriculture (Cary et al., 2001) as warranting protection due to population declines. Mating pairs were observed on the cay at the time of the survey (July 2019) (**Photo 8a**).

4.0 Conclusions

This survey provides important baseline marine benthic habitat maps and characterizations of the Project Area and PCNP. Eight benthic habitat types occurring within the Project Area, and 15 benthic habitat types occurring within PCNP were classified, described, and mapped. The areal extent of each habitat type was also calculated. Areas of ecological significance and vulnerable marine species within the Project Area and PCNP were also identified, described, and mapped geographically. Data of this nature previously did not exist for marine habitats on the south coast of Grand Bahama, filling data gaps and aiding mitigation planning for the Grand Port Project.

5.0 Literature Cited

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil 2008. *Acropora cervicornis*. *The IUCN Red List of Threatened Species* 2008: e.T133381A3716457. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133381A3716457.en. Downloaded on 15 October 2019.

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil 2008. *Acropora palmata*. *The IUCN Red List of Threatened Species* 2008: e.T133006A3536699. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133006A3536699.en. Downloaded on 15 October 2019.

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil 2008. *Agaricia lamarcki*. *The IUCN Red List of Threatened Species* 2008: e.T132970A3515504. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T132970A3515504.en. Downloaded on 15 October 2019.

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil 2008. *Dendrogyra cylindrus*. *The IUCN Red List of Threatened Species* 2008: e.T133124A3582471. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133124A3582471.en. Downloaded on 08 October 2019.

Aronson, R., Bruckner, A., Moore, J., Precht, B. & E. Weil 2008. *Montastraea annularis*. *The IUCN Red List of Threatened Species* 2008: e.T133134A3592972. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T133134A3592972.en. Downloaded on 15 October 2019.

Cary, E., S. Buckner, A. Alberts, R. Hudson and D. Lee, Eds. 2001. Protected Areas Management Strategy for Bahamian Terrestrial Vertebrates: Iguanas and Seabirds. San Salvador, The Bahamas. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA. 71 pp.

Henwood, W.D. and D. Nolan. 2013. A Proposal for the Expansion of Lucayan National Park, Grand Bahama Island, The Bahamas. 38 pp.

Kabay, L. 2016. Population Demographics and Sexual Reproduction Potential of the Pillar Coral, *Dendrogyra cylindrus*, on the Florida Reef Tract. Master's Thesis, Nova Southeastern University.

Resnick, B. 2019, September 6. "We are in the midst of a historic tragedy": Hurricane Dorian in photos. Retrieved from https://www.vox.com/energy-and-environment/2019/9/4/20847941/hurricane-dorian-photos-bahamas-grand-bahama-abaco.

Sealy, N.E. 1994. Bahamian landscapes: An introduction to the geography of the Bahamas. Media Publishing, Nassau, Bahamas. 128 pp.

Seminoff, J.A. (Southwest Fisheries Science Center, U.S.) 2004. *Chelonia mydas*. *The IUCN Red List of Threatened Species* 2004: e.T4615A11037468. http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en. Downloaded on 15 October 2019.

Appendix

Table A-1. GIS metadata associated with all survey station locations, including benthic habitat designation and geographic coordinates.

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Bounce Dive	36	0	2461419.505766	9650088.742389	26.570792	-78.487739	Hard Pan	Hardbottom	Algae/Octo/Coral	hardpan with macroalgae, octo, and sparse stony corals
Project Area	Bounce Dive	37	0	2461396.838665	9649415.482117	26.568942	-78.487849	Hard Pan	Hardbottom	Algal Mat/Octo/Coral	hardpan with algal mat, sparse octo and stony corals
Project Area	Bounce Dive	38	0	2461271.241867	9649411.543403	26.568938	-78.488233	Hard Pan	Hardbottom	Algae/Octo/Coral	low relief hardpan with rubble
Project Area	Bounce Dive	39	0	2461018.908978	9649342.565450	26.568762	-78.489009	Sand	Sand	Algae	sparse macroalgae
Project Area	Bounce Dive	40	0	2459775.983630	9649304.125057	26.568723	-78.492812	Sand	Sand	None	sand only
Project Area	Bounce Dive	41	0	2460493.737537	9649253.792302	26.568546	-78.490620	Hard Pan	Hardbottom	Algae/Octo/Coral	low relief hardpan
Project Area	Bounce Dive	42	0	2460454.675037	9649148.518865	26.568258	-78.490746	Hard Pan	Hardbottom	Algae	sparse macroalgae
Project Area	Bounce Dive	43	0	2460591.087797	9648909.593807	26.567594	-78.490343	Sand	Sand	Algae	sparse macroalgae
Project Area	Bounce Dive	44	0	2459912.919394	9648893.968807	26.567588	-78.492418	Hard Pan	Sand	Algae	sparse macroalgae
Project Area	Bounce Dive	45	0	2459866.261408	9648777.866376	26.567271	-78.492567	Hard Pan	Hardbottom	Coral	Dendro present
Project Area	Bounce Dive	46	0	2461040.916356	9648694.091782	26.566977	-78.488981	Ridge Swale	Hardbottom	Algae	sparse macroalgae
Project Area	Bounce Dive	47	0	2459629.712652	9648612.022916	26.566828	-78.493300	Hard Pan	Hardbottom	N/A	N/A
Project Area	Bounce Dive	48	0	2460078.184875	9648120.719386	26.565453	-78.491959	Sand	Hardbottom	Algae/Octo	12m from HRSG, near hardbottom-sand transition
Project Area	Bounce Dive	49	0	2459250.806402	9647803.494270	26.564625	-78.494507	Hard Pan	Hardbottom	Algal Mat	Millepora present
Project Area	Bounce Dive	50	0	2458978.670986	9647106.834114	26.562724	-78.495381	Ridge Swale	Hardbottom	Algal Mat/Octo	octocorals on ridges
Project Area	Bounce Dive	51	0	2458726.023416	9646652.354947	26.561488	-78.496181	Sand	Hardbottom	Octo/Coral	3 m relief, high quality hardbottom, near hardbottom-sand transition

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Added Target Point	#35, Dendrogrya	0	2459701.609458	9647894.155617	26.564850	-78.493124	Hard Pan	Hardbottom		
Project Area	Added Target Point	Dendro	0	2460729.363308	9648859.868908	26.567450	-78.489923	Sand	Hardbottom	Coral	Dendrogyra colony, near hardbottom-sand transition
Project Area	Added Target Point	dendro_colony	0	2459887.435858	9648774.567242	26.567261	-78.492503	Hard Pan	Hardbottom		
Project Area	Added Target Point	Extra,3	0	2460773.523325	9648585.164733	26.566692	-78.489805	Spur Groove	Hardbottom	Algae/Octo	some corals, large undercut features
Project Area	Added Target Point	Extra,4	0	2460543.405675	9648394.876400	26.566182	-78.490520	Sand	Hardbottom	Octo/Sponge	isolated mounds, 12m in diameter x 3m relief, near hardbottom-sand transition
Project Area	Added Target Point	Extra,5	0	2460262.828808	9647618.992125	26.564063	-78.491424	Sand	Hardbottom	Octo/Sponge	stony corals, mounds 60'x30'x5' on sand, near hardbottom-sand transition
Project Area	Quadrat Centerpoint	26	26	2461619.999765	9649854.790127	26.570137	-78.487140	Hard Pan	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	101	26	2461636.372448	9649873.096954	26.570187	-78.487089	Hard Pan	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	102	26	2461607.075573	9649783.036190	26.569941	-78.487184	Hard Pan	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	103	26	2461564.013507	9649830.547764	26.570074	-78.487313	Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Subpoint	104	26	2461685.367673	9649823.473111	26.570048	-78.486942	Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Centerpoint	27	27	2460213.808909	9649779.192622	26.570005	-78.491445	Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Subpoint	105	27	2460250.944207	9649824.966167	26.570129	-78.491328	Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Subpoint	106	27	2460176.291429	9649827.917556	26.570141	-78.491556	Macro Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Subpoint	107	27	2460186.360873	9649738.334223	26.569895	-78.491531	Macro Hard Pan	Hardbottom	Algae	

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Quadrat Subpoint	108	27	2460268.218512	9649750.834223	26.569925	-78.491280	Hard Pan	Hardbottom	Algae	
Project Area	Quadrat Centerpoint	28	28	2460772.628353	9649387.716928	26.568899	-78.489759	Hard Pan	Hardbottom	Algae/Octo	
Project Area	Quadrat Subpoint	109	28	2460748.909340	9649442.295449	26.569050	-78.489829	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	110	28	2460830.506562	9649349.196491	26.568790	-78.489585	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	111	28	2460720.697534	9649335.524616	26.568758	-78.489921	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	112	28	2460759.543020	9649375.455172	26.568866	-78.489800	Hard Pan	Hardbottom	Algae/Coral	
Project Area	Quadrat Centerpoint	29	29	2461124.476761	9649217.331360	26.568412	-78.488694	Ridge Swale	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	113	29	2461058.013977	9649230.779246	26.568452	-78.488896	Ridge Swale	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	114	29	2461087.093838	9649227.090010	26.568440	-78.488808	Ridge Swale	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	115	29	2461193.647657	9649212.767093	26.568395	-78.488483	Ridge Swale	Hardbottom	Algae	
Project Area	Quadrat Subpoint	116	29	2461074.415886	9649272.990617	26.568567	-78.488844	Ridge Swale	Sand	None	
Project Area	Quadrat Centerpoint	30	30	2460792.158330	9649023.904710	26.567898	-78.489721	Sand	Hardbottom	Algae/Coral	near hardbottom-sand transition
Project Area	Quadrat Subpoint	117	30	2460738.128271	9649007.724413	26.567856	-78.489888	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	118	30	2460713.605701	9649027.689691	26.567912	-78.489961	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	119	30	2460803.666465	9649055.033441	26.567983	-78.489684	Ridge Swale	Hardbottom	Algae	
Project Area	Quadrat Subpoint	120	30	2460849.239382	9649043.314691	26.567948	-78.489546	Ridge Swale	Hardbottom	Algae	
Project Area	Quadrat Centerpoint	31	31	2460854.192473	9648722.975891	26.567067	-78.489550	Ridge Swale	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	121	31	2460819.385505	9648761.876613	26.567176	-78.489654	Spur Groove	Hardbottom	Algae/Coral	

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Quadrat Subpoint	122	31	2460831.104255	9648756.668279	26.567161	-78.489618	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	123	31	2460827.198005	9648695.687376	26.566993	-78.489634	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	124	31	2460922.901130	9648732.579738	26.567090	-78.489339	Ridge Swale	Hardbottom	Algae/Coral	
Project Area	Quadrat Centerpoint	32	32	2460561.733706	9648624.093512	26.566811	-78.490450	Spur Groove	Sand	Sand	
Project Area	Quadrat Subpoint	125	32	2460563.753994	9648687.006821	26.566984	-78.490440	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	126	32	2460598.649827	9648583.360988	26.566697	-78.490340	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	127	32	2460623.649827	9648637.527654	26.566844	-78.490260	Reef Mounds	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	128	32	2460502.035244	9648586.485988	26.566711	-78.490635	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Centerpoint	33	33	2460717.343515	9648456.526238	26.566342	-78.489984	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	129	33	2460676.541537	9648468.725209	26.566377	-78.490108	Sand	Hardbottom	Octo/Coral	near hardbottom-sand transition
Project Area	Quadrat Subpoint	130	33	2460714.041537	9648484.350209	26.566418	-78.489993	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	131	33	2460702.062371	9648461.693959	26.566357	-78.490031	Spur Groove	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	132	33	2460734.874871	9648384.610626	26.566143	-78.489935	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Centerpoint	34	34	2460246.013220	9648304.636047	26.565949	-78.491434	Sand	Hardbottom	Algae/Coral	near hardbottom-sand transition
Project Area	Quadrat Subpoint	133	34	2460319.189107	9648298.360626	26.565928	-78.491211	Spur Groove	Hardbottom	Octo	
Project Area	Quadrat Subpoint	134	34	2460270.360982	9648372.796390	26.566136	-78.491356	Spur Groove	Hardbottom	Algae	
Project Area	Quadrat Subpoint	135	34	2460184.712834	9648350.769480	26.566080	-78.491619	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	136	34	2460219.319315	9648246.874081	26.565792	-78.491520	Spur Groove	Hardbottom	Algae/Coral	

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Quadrat Centerpoint	35	35	2459643.984140	9647950.154710	26.565007	-78.493296	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	137	35	2459708.938818	9647938.526280	26.564972	-78.493098	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	138	35	2459672.480484	9647922.684266	26.564930	-78.493211	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	139	35	2459651.213123	9647968.040169	26.565056	-78.493273	Hard Pan	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	140	35	2459697.871109	9647927.024544	26.564941	-78.493133	Hard Pan	Hardbottom	Algal Mat/Coral	
Project Area	Quadrat Centerpoint	36	36	2460557.996003	9647902.854363	26.564828	-78.490505	Spur Groove	Hardbottom	Algal Mat/Coral	
Project Area	Quadrat Subpoint	141	36	2460588.416537	9647848.335307	26.564676	-78.490415	Spur Groove	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	142	36	2460510.508551	9647919.949891	26.564878	-78.490649	Spur Groove	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	143	36	2460615.326260	9647854.845724	26.564693	-78.490332	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	144	36	2460628.130079	9647888.482877	26.564785	-78.490291	Spur Groove	Hardbottom	Algae/Coral	
Project Area	Quadrat Centerpoint	37	37	2459260.283330	9647326.751932	26.563314	-78.494507	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	145	37	2459327.684477	9647296.785828	26.563228	-78.494303	Hard Pan	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	146	37	2459285.713991	9647269.876106	26.563156	-78.494432	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	147	37	2459333.891074	9647319.138259	26.563289	-78.494282	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	148	37	2459207.806005	9647343.226801	26.563362	-78.494666	Hard Pan	Hardbottom	Algal Mat	
Project Area	Quadrat Centerpoint	38	38	2459921.092791	9647282.425399	26.563156	-78.492489	Sand	Hardbottom	Octo	near hardbottom-sand transition
Project Area	Quadrat Subpoint	149	38	2459990.540380	9647262.775412	26.563099	-78.492278	Reef Mounds	Hardbottom	Algae/Coral	
Project Area	Quadrat Subpoint	150	38	2459993.404963	9647284.910828	26.563159	-78.492268	Reef Mounds	Hardbottom	Algal Mat	

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Project Area	Quadrat Subpoint	151	38	2459917.884130	9647262.254578	26.563101	-78.492500	Reef Mounds	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	152	38	2459882.467463	9647287.254578	26.563172	-78.492607	Sand	Hardbottom	Octo/Coral	near hardbottom-sand transition
Project Area	Quadrat Centerpoint	39	39	2458562.754394	9646959.453755	26.562342	-78.496661	Fell outside aerial survey area	Hardbottom	Algal Mat	Classified as hardpan by divers
Project Area	Quadrat Subpoint	153	39	2458618.472238	9646941.106575	26.562288	-78.496492	Fell outside aerial survey area	Hardbottom	Algal Mat	Classified as hardpan by divers
Project Area	Quadrat Subpoint	154	39	2458535.312515	9646886.939908	26.562144	-78.496750	Fell outside aerial survey area	Hardbottom	Algal Mat	Classified as hardpan by divers
Project Area	Quadrat Subpoint	155	39	2458566.388904	9646903.432964	26.562187	-78.496654	Fell outside aerial survey area	Hardbottom	Algal Mat	Classified as hardpan by divers
Project Area	Quadrat Subpoint	156	39	2458552.847238	9646936.071853	26.562278	-78.496693	Fell outside aerial survey area	Hardbottom	Algal Mat	Classified as hardpan by divers
Project Area	Quadrat Centerpoint	40	40	2458972.303005	9646904.216487	26.562168	-78.495413	Spur Groove	Hardbottom	Octo	
Project Area	Quadrat Subpoint	157	40	2459029.485692	9646856.811870	26.562034	-78.495241	Spur Groove	Hardbottom	Octo/Coral	
Project Area	Quadrat Subpoint	158	40	2458968.678401	9646839.207703	26.561989	-78.495428	Spur Groove	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	159	40	2458931.699234	9646945.457703	26.562283	-78.495534	Spur Groove	Hardbottom	Algal Mat	
Project Area	Quadrat Subpoint	160	40	2459038.470067	9646930.093120	26.562235	-78.495209	Spur Groove	Hardbottom	Octo/Coral	
Peterson Cay	Bounce Dive	4	0	2447855.497519	9645352.411371	26.558495	-78.529493	Seagrass	Hardbottom	Algae/Seagrass	sparse Halodule
Peterson Cay	Bounce Dive	5	0	2446818.805534	9645185.907464	26.558092	-78.532673	Seagrass	Seagrass	Seagrass/Algae	moderately sparse 25% cover Thalassia, algae
Peterson Cay	Bounce Dive	6	0	2446605.263868	9645139.032464	26.557974	-78.533328	Seagrass	Hardbottom	Algae/Octo/Seagrass	patchy octos, algae and seagrass
Peterson Cay	Bounce Dive	8	0	2448102.804377	9644860.386631	26.557129	-78.528766	Seagrass	Hardbottom	Algae/Octo/Seagrass	sparse seagrass and macroalgae
Peterson Cay	Bounce Dive	9	0	2447484.820436	9644822.706510	26.557058	-78.530658	Seagrass	Seagrass	Seagrass	sparse seagrass; 5 m from dense bed
Peterson Cay	Bounce Dive	13	0	2449385.320291	9644332.985011	26.555611	-78.524876	Seagrass	Hardbottom	Octo	5-10 per m2

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Peterson Cay	Bounce Dive	14	0	2449063.307849	9643606.017418	26.553629	-78.525904	Seagrass	Seagrass	Seagrass	50% cover Thalassia and Syringodium
Peterson Cay	Bounce Dive	16	0	2450150.898272	9643400.534200	26.553006	-78.522591	Hard Pan	Hardbottom	Algae/Octo/Coral	Millepora, corals
Peterson Cay	Bounce Dive	17	0	2448933.099516	9643265.305613	26.552699	-78.526322	Seagrass	Seagrass	Seagrass	50% cover, clypeaster, Thalassia and Syringodium
Peterson Cay	Bounce Dive	18	0	2449471.738839	9643187.643575	26.552457	-78.524680	Seagrass	Seagrass	Seagrass	occasional octos,Thalassia
Peterson Cay	Bounce Dive	25	0	2448925.265314	9642145.275231	26.549620	-78.526412	Hard Pan	Sand	Algae	8 m from HRSG reef with corals
Peterson Cay	Bounce Dive	27	0	2449210.982184	9641568.039988	26.548018	-78.525573	Ridge Swale	Hardbottom	Octo/Coral	sparse corals, very little algae
Peterson Cay	Bounce Dive	33	0	2448803.375847	9640726.727777	26.545726	-78.526868	Ridge Swale	Hardbottom	Algal Mat/Octo/Seagrass	1cm sed veneer, sparse octos, seagrass,algae
Peterson Cay	Bounce Dive	35	0	2448606.761263	9640391.658332	26.544815	-78.527489	Ridge Swale	Hardbottom	Algal Mat	octo skeletons w/millepora, ridges run NE-SW
Peterson Cay	Added Target Point	Dendro	0	2450069.017175	9642169.626383	26.549626	-78.522914	Ridge Swale	Hardbottom	Coral	
Peterson Cay	Added Target Point	Dendrogyro	0	2450210.191433	9642848.529225	26.551485	-78.522442	Hard Pan	Hardbottom	Coral	
Peterson Cay	Added Target Point	Extra,1,Dead, Elkhorn	0	2448858.881800	9642240.886083	26.549886	-78.526609	Reef Crest	Hardbottom	Octo/Coral	A. cervicornis & A. palmata
Peterson Cay	Added Target Point	Extra,2	0	2450154.253225	9640703.848475	26.545591	-78.522740	Sand	Hardbottom	Algae/Octo/Coral	thin veneer in troughs, reef biota on ridges with 1.5m relief
Peterson Cay	Added Target Point	Palmata,Stand	0	2449684.667550	9642167.526650	26.549641	-78.524089	Spur Groove	Hardbottom	Coral	
Peterson Cay	Added Target Point	Pillar,Coral	0	2450103.859625	9643564.505483	26.553459	-78.522725	Hard Pan	Hardbottom	Coral	
Peterson Cay	Quadrat Centerpoint	1	1	2451122.128136	9646278.813572	26.560868	-78.519451	Seagrass	Hardbottom	Algae	Chondria sp. red algae and sand patches, bare pavement 15m NNW

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Peterson Cay	Quadrat Centerpoint	2	2	2449244.234618	9645230.491812	26.558086	-78.525255	Seagrass	Seagrass	seagrass	drop on transition from dense seagrass to north, hardpan to south
Peterson Cay	Quadrat Centerpoint	3	3	2451102.408807	9644956.657900	26.557234	-78.519590	Macro Hard Pan	Hardbottom	Algal Mat/Seagrass	occasional sparse seagrass
Peterson Cay	Quadrat Centerpoint	4	4	2445720.155118	9644527.771905	26.556340	-78.536070	Seagrass	Seagrass	Seagrass	sparse at north edge, to sand 15m North, Thalassia and Syringodium
Peterson Cay	Quadrat Centerpoint	5	5	2447424.862511	9643982.285794	26.554750	-78.530891	Seagrass	Seagrass	Seagrass	transitions to sand 8m north Thalassia and Syringodium
Peterson Cay	Quadrat Centerpoint	6	6	2451598.560428	9643614.772773	26.553518	-78.518152	Hard Pan	Hardbottom	Algae/Octo/Coral	grades to RS to east, sand to W
Peterson Cay	Quadrat Centerpoint	7	7	2449998.227673	9643578.314440	26.553503	-78.523047	Seagrass	Seagrass	Seagrass	dense seagrass bed, becomes sparse 21m out, turtle grazing, Thalassia and Syringodium
Peterson Cay	Quadrat Subpoint	25	7	2449942.444496	9643615.681589	26.553609	-78.523215	Seagrass	Seagrass	Seagrass/Algae	
Peterson Cay	Quadrat Subpoint	26	7	2450057.027829	9643537.556589	26.553388	-78.522870	Seagrass	Seagrass	Seagrass/Algae	
Peterson Cay	Quadrat Subpoint	27	7	2450055.725746	9643585.473256	26.553520	-78.522871	Seagrass	Seagrass	Seagrass/Algae	
Peterson Cay	Quadrat Subpoint	28	7	2450000.777829	9643633.389922	26.553654	-78.523036	Seagrass	Seagrass	Seagrass/Algae	
Peterson Cay	Quadrat Centerpoint	9	9	2446374.486354	9643179.247599	26.552598	-78.534149	Spur Groove	Seagrass	Seagrass	Thalassia, sparse Syringodium, calcareous algae & octos
Peterson Cay	Quadrat Centerpoint	10	10	2446651.830104	9643161.452460	26.552534	-78.533302	Ridge Swale	Hardbottom	Algae/Octo	sparse seagrass, rubble 8m north
Peterson Cay	Quadrat Centerpoint	12	12	2450516.447798	9642767.638803	26.551247	-78.521511	Spur Groove	Hardbottom	Coral	Dendro 15 m W, octos, macroalgae

Table A-1. (Continued).

Site	Dive Type	Station No. / Name	Quadrat Station No.	X ft	Y ft	Latitude DD	Longitude DD	GIS Mapped Habitat	General Habitat Diver	Biota Present	Notes
Peterson Cay	Quadrat Centerpoint	13	13	2448073.951053	9642680.160504	26.551136	-78.528983	Ridge Swale	Seagrass	Seagrass	macroalgae and sand sediments, Thalassia and Syringodium
Peterson Cay	Quadrat Centerpoint	14	14	2446986.089363	9642462.517275	26.550595	-78.532322	Reef Crest	Hardbottom	Algae/Octo	sparse macroalgae
Peterson Cay	Quadrat Centerpoint	16	16	2450126.786701	9642366.089324	26.550163	-78.522726	Sand	Hardbottom	Octo/Coral	reef to NW, dense stony/octos
Peterson Cay	Quadrat Centerpoint	17	17	2449665.415173	9642088.094532	26.549423	-78.524153	Seagrass	Hardbottom	Octo/Coral	A. palmata SW of point
Peterson Cay	Quadrat Centerpoint	18	18	2448473.676169	9641986.077750	26.549206	-78.527802	Hard Pan	Hardbottom	Coral	reef crest, slopes south to HR fore reef, A. palmata
Peterson Cay	Quadrat Centerpoint	19	19	2450322.316215	9641897.196095	26.548864	-78.522156	Spur Groove	Hardbottom	Algae/Octo	organic debris in swales
Peterson Cay	Quadrat Centerpoint	20	20	2447223.806377	9641829.379254	26.548842	-78.531632	Sand	Hardbottom	Octo/Coral	raised platform, hardpan habitat
Peterson Cay	Quadrat Centerpoint	21	21	2448655.533807	9641688.667449	26.548379	-78.527264	Hard Pan	Hardbottom	Coral	ridges with Orbicella/Diploria stony corals
Peterson Cay	Quadrat Centerpoint	22	22	2449335.988090	9641334.913109	26.547370	-78.525204	Seagrass	Hardbottom	Algal Mat/Octo	finger-like ridges, up to 3m relief
Peterson Cay	Quadrat Centerpoint	25	25	2448232.110775	9640818.760041	26.546009	-78.528609	Hard Pan	Hardbottom	Octo/Coral	2 m relief, octos dominant