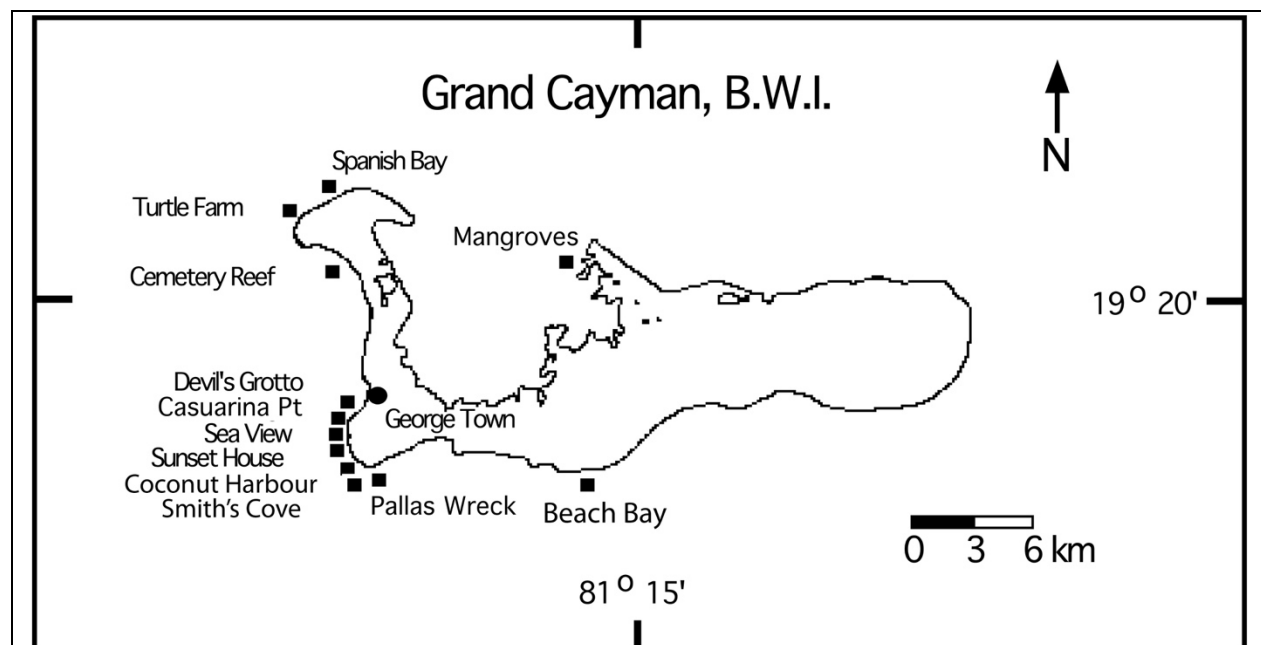


## A Survey of Grand Cayman Reefs

**Methods:**

Data was collected in the field predominately through the use of SCUBA techniques. Ten reefs were surveyed, representing a wide diversity of habitats and exposure conditions around Grand Cayman. Traveling around the island from southeast clockwise to the north east, those sites are: Bodden Bay Lagoon (BL), Beach Bay (BB), Smith's Cove (SC), Sunset House (SH), Sea View (SV), Casuarina Point (CP), Devil's Grotto (DG), Eden's Rock (ER), Cemetery Reef (CR), Turtle Farm (TF), Spanish Bay (SB), and Mangroves (MG) (Fig. 3). Coral diversity was primarily quantified using transects of coral spurs between 40 and 60 feet in depth. A buoyant, 10m-long chain was held above the reef, secured at each end by a diver. A third diver would then hold the chain close to the coral while a fourth diver used a video camera to record the chain across the length of the coral spur. The video was later analyzed to determine the percent composition of organisms beneath the chain. Only the area directly beneath the chain was analyzed (i.e. the area covered by the links), and the organism that represented the largest area covered by that link was counted. Hard corals were identified to species level, but other organisms were not. Non-hard-coral aspecific groups included sponges, gorgonians, zoanthids, macroalgae (large, blade-like in appearance), turf algae (high relief, thin, and fibrous), encrusting algae (no three-dimensional structure; individuals not distinguishable), dead coral, and sand.



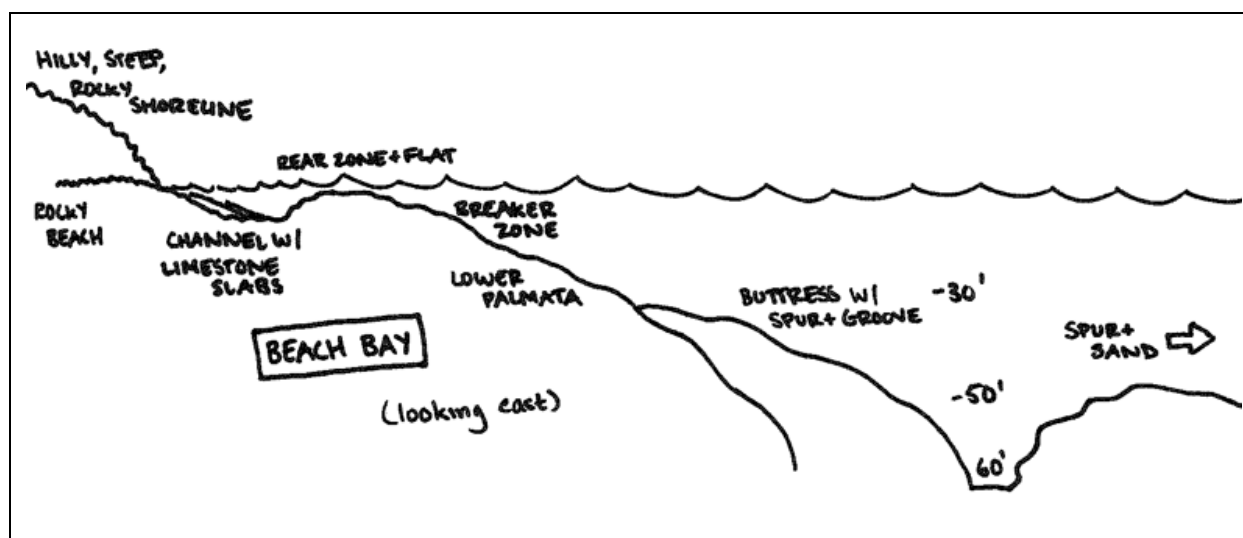
**Figure 3.** Map of Grand Cayman with many sites labeled. Coconut Harbour and Pallas Wreck were not surveyed. Eden's Rock is directly to the north of Devil's Grotto, and Bodden Bay Lagoon extends from Beach Bay to the East, until the first undulation on the south side of the island. Figure from De Stasio, 2018.

Roving diver surveys were used to quantify fish and reef invertebrate species richness and abundance, as well as to inform descriptions of each reef's structure. Fish abundance was quantified using a 0-to-4 scale, where "0" represents no individuals sighted, "1" represents a single individual, "2" indicates between 2 and 10 individuals were spotted, "3" represents between 10 and 100 individuals, and "4" means that over 100 individuals of a given species were sighted on a single dive, as described by REEF (2018). Species were identified during a surface snorkel to the reef, during waiting periods during chain transect videography, and during the return from the deeper reefs to the shallower areas nearshore. Each survey lasted between 20 and 50 minutes, depending on the diver and other factors, mostly air consumption and non-decompression limits. Divers used underwater paper and pencils to record species real-time under water. Coral species were also recorded using this, although they were not factored into the species diversity and percentage coverage calculations. Instead, that data was used to inform site descriptions. Data was transformed and collated, and most figures were generated in Microsoft Excel, while statistical tests and analyses were performed using Past3.

## Results

### *Roving Diver surveys and Site Descriptions*

#### Beach Bay



**Figure 4.** Schematic drawing of Beach Bay, Grand Cayman

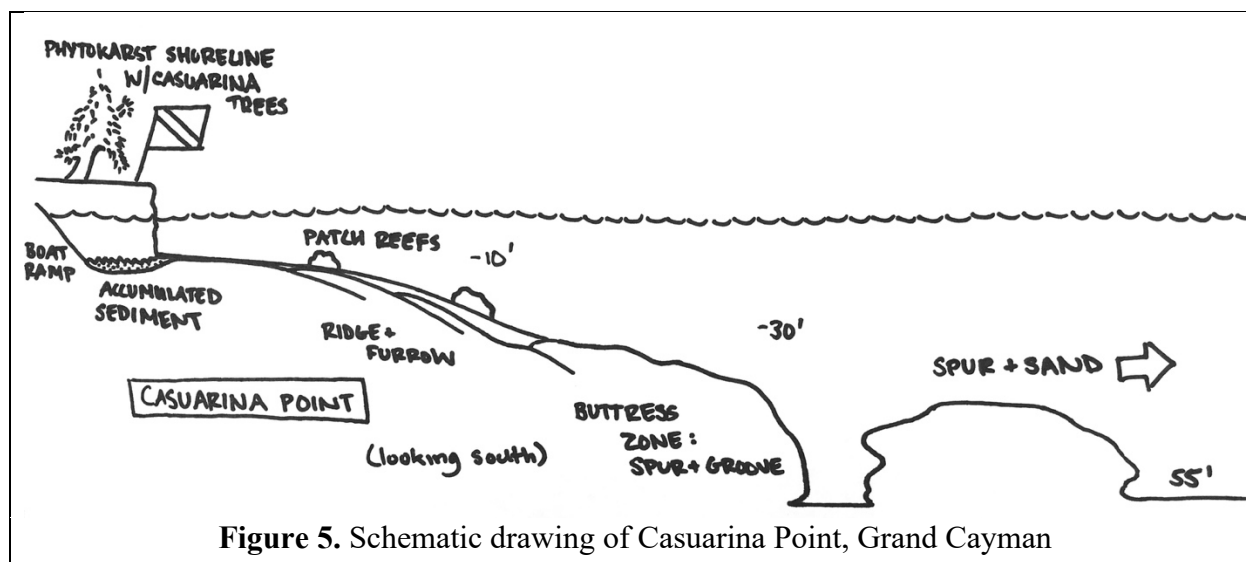
Beach bay is an exposed site on the southern, windward margin on Grand Cayman (Fig. 4). The shoreline is predominately steep phytokarst hills with some vegetative cover, although the water entrance is a rocky beach covered with large coral fragments and thick, platy slabs of limestone that extend at a shallow angle from the sediment. Further West along the beach was extensive shoreline development, including the construction of an artificial breakwater and protected area to service a large hotel planned for that plot of land. This site closely follows the structure outlined by Goreau (1959) for a windward fringing reef. Directly at the shoreline there is an immediate two-to-three-foot drop where the bottom half of waves scour away any loose material. Larger pieces and deceased coral of limestone remain and are covered with slippery, green encrusting algae.

A 5-foot-deep channel extends for a couple tens of meters until the reef flat and rear zone, at which point depth decreases to less than three feet. *A. palmata* is found here, although the colonies observed appeared to either be dead or dying. Rock-Boring Urchins were common in this zone, and occupied many small holes in the exposed, unvegetated limestone and coral substrate. Wave action was intense in this shallow area, which made access to the outer reef challenging. Past the breaker zone, the lower *palmata* zone sloped quickly away from shore. Brown Coral Encrusting Sponges and Yellow Tube Sponges were common in this area and complimented abundant *G. ventalina*, *M. alcicornis*, *M. complanata*, *S. radians*, *P. astreoides*, and Star Horseshoe Worms. Large tufts of blue, iridescent *P. sanctae-crucis* and dark green *S. zonale* were also common. By 30 feet, *P. strigosa*, *A. agaricites*, *P. porites*, and *P. clivosa* formed small patches with Yellow Fanworms hiding in recesses. The lower *palmata* zone transitioned into the buttress zone with spurs and grooves between 50 and 60 feet. Each spur was around 10 feet tall and, in addition to those species found at 30 feet, had colonies of *O. annularis* (both platy and massive forms), *M. cavernosa*, *S. siderea*, and *C. natans*. Macroalgae such as *L. variegata* and *Halimeda spp.* and other organisms such as white Hydroids covered areas without active coral growth.

A total of 29 species of fish were observed at this site during one roving diver survey. This site had relatively turbid water and was noticeably barren of many common species of fish. Damselfish, although present, were several times less abundant than every other site. Neither Blue Chromis nor Four-Eyed Butterflyfish were observed. Parrotfish diversity was moderate,

although the abundance of each species was low. Black Durgon were by far the most abundant fish and usually swam in loose groups a few feet above each spur. Tarpon, which are usually active at night, as well as Lionfish, which usually hide in crevices in the reef, were observed swimming out in the open between spurs. Longjaw and Longspine Squirrelfish were present, but the more common Squirrelfish was not.

### Casuarina Point



Casuarina Point is a protected, fringing reef on the southern leeward side of Grand Cayman (Fig. 5). The shoreline is Phytokarst and has many Casuarina trees growing nearby. There is a boat ramp carved into the sharp shoreline for access to the reef. Although there is sediment buildup in the boat ramp area, there is little sand offshore in the ridge and furrow formation. The exposed substrate that exists immediately beyond the wall of phytokarst has many *G. ventalina*, and small patches of coral composed predominately of *P. strigosa*, *P. astreoides*, and *D. stokesi*. Deceased *A. palmata* provide a *M. alcicornis*, *M. complanata* as well as other invertebrates such as Long-Spined Sea Urchins and Hermit Crabs a growth platform. *S. radians*, *F. fragum*, and Sea Whips grow independently along the tops and sides of each ridge. By 30 feet, the ridge and furrow structures develop into a buttress zones with independent spurs and grooves, and coral species such as *O. annularis* and *A. agaricites* as well as macroalgae such as *Halimeda*, *spp.* become common. Filter feeders such as Christmas Tree Worms and Yellow

Tube Sponges are also common. Oersled's Brittle Stars were observed intertwined in the structure of *O. annularis* as well as were found residing in the hollows of sponges.

A spur and sand formation develops by 55 feet. Although many of the coral species on those spurs are similar to the ones in shallower water, other species such as *M. cavernosa*, *P. divaricata*, and *A. cervicornis* also become important parts of the reef structure. Green Finger Sponges, Sea Whips, Encrusting Sponges, Iridescent Tube Sponges, Elephant Ear Sponges, Barrel Sponges, Zoanthids, and Anemones cling to the tops and sides of the deeper spurs or hang underneath overhangs above the sand beside Fairy Basslet, Harlequin Bass, Schoolmaster, Sharpnose Puffer, and Trumpetfish. A Green Sea Turtle was observed feeding on large pieces of macroalgae, sponges, and coral.

A total of 51 species of fish were observed at this site during two roving diver surveys; one during the day and one at night. During the day, large Queen Angelfish, Cowfish, Smooth and Spotted Trunkfish, Butterflyfish, Chromis, French Grunts, Stoplight Parrotfish, and Bar Jack were among the most visible fish foraging in the open above both the shallow and deep spurs in addition to the ridge and furrow formations. Mutton Snapper patrolled the edges of the deeper spurs and sand flats covered with Brown Garden Eels and Sand Tilefish. At night, the biota changed drastically. Sea Wasps replaced Sea Walnuts as the most common jellyfish in the surface waters, and vibrantly-colored Caribbean Reef Squid and octopus came out of hiding and interacted with divers and their dive lights. Cardinalfish, absent during the day, became one of the only species actively foraging. Squirrelfish and Caribbean Spiny Lobster were also present but stayed within protected areas of the reef. Diurnal species such as Balloonfish and Stoplight Parrotfish were found sleeping, wedged between pieces of coral or in indentations in the ridge and furrow structure. Tarpon occasionally were spotted rocketing above near the surface in small groups. Plankton bioluminesced when disturbed in the vortices formed by fin kicks or hand movement.

### Cemetery Reef

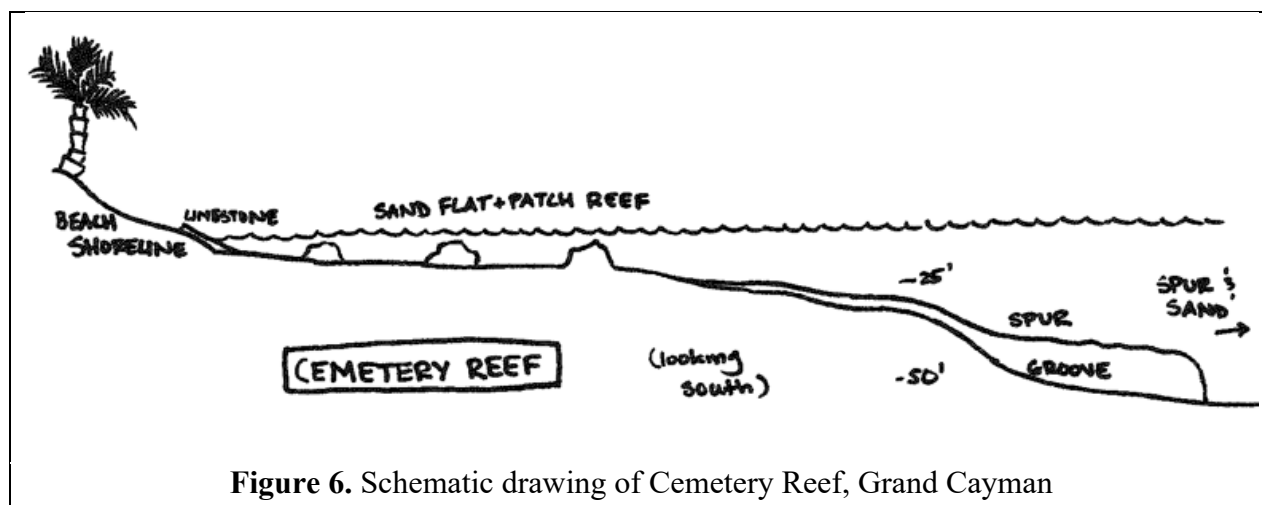


Figure 6. Schematic drawing of Cemetery Reef, Grand Cayman

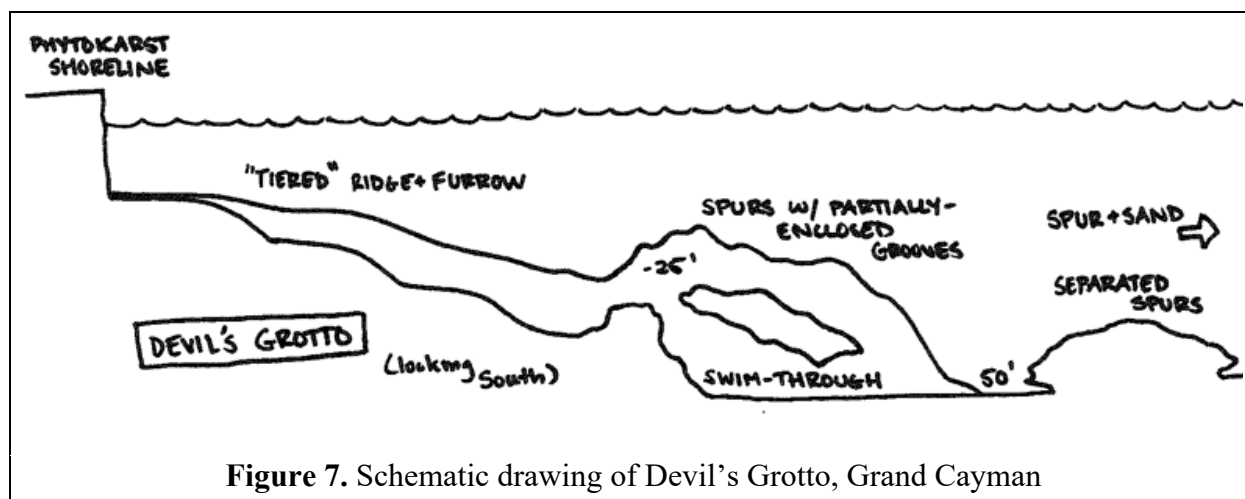
Located near the northern extent of Seven Mile Beach, cemetery reef lies a hundred meters offshore from Georgetown Cemetery. The site is very protected from wind and wave action and the shoreline is an extensive sand beach with occasional partially buried patches of heavily eroded, smooth, algae-covered limestone (Fig. 6). Juvenile Sergeant Major less than 1cm in length were found hiding in the irregular pockets of water around these structures, oftentimes in less than 10cm of water and are subjected to relentless wave action. There are several tens of meters of skeletal sand flats with occasional small patch reefs that gently slopes outwards away from the island before spurs form. No microbenthic organisms directly inhabit the sand, although *G. ventalina*, *M. alcicornis*, *M. complanata*, *A. agaricites*, *P. astreoides*, *F. fragum*, *S. radians*, *E. fastigiata*, *D. Stokesi*, *P. porites*, and *P. strigosa* are present on the shallow, stable substrate that the patch reefs provide. Accompanying the corals are Christmas Tree Worms, Hermit Crabs, Long-Spined Sea Urchins, Star Horseshoe Worms, Wideband Tube Dwelling Anemones, and Yellow Fanworms. Many filter feeders including Sea Walnuts, Winged Comb Jellies, Warty Comb Jellies, and a Ctenophore were observed floating within several feet of the surface.

At approximately 15 to 25 feet depth, the sand and patch reefs transition into spur and groove formations with less sediment. The sand forms thick layers in the grooves is home to Queen Conch, Sea Cucumbers and Goldspot Gobies, and the elevated structure provides a lower-loading, lower light, lower-energy environment which supports the growth of *M. cavernosa*, *D. labyrinthiformis*, *M. meandrites*, *O. annularis*, *A. cervicornis*, and *S. siderea*. The invertebrate community on the spurs changes as well, and sponges (including the Barrel Sponge, Green Finger Sponge, Pore Rope Sponge, Iridescent Tube Sponge and Yellow Tube Sponge) are more

dominant than on the shallow patch reefs. Oersled's Brittle Stars and mysid shrimp inhabit many of the sponges, and zoanthids and hydroids encrust many lower-light parts of the vertical structure.

A total of 54 species of fish were observed at this site during two roving diver surveys. Sandy areas had different dominant fish species compared to the rocky, coralline areas. Brown Garden Eels, Barracuda, Smooth and Spotted Trunkfish, Hogfish, Bar and Horse-eye Jack, Yellowfin Mojarra (unique to CR), Southern Stingray, and Sand Tilefish were all common in the sand flats and in larger grooves but absent above or integrated into the 3-dimensional reef structure. Large schools of yellow and striped goatfish were accumulated at the reef-sand interface usually at the bottom of a spur where it meets the sand underneath an overhand, large species such as midnight parrotfish, grouper, mutton snapper, and green sea turtles grazed on the coral and would occasionally switch from spur to spur in search of the best food.

#### Devil's Grotto



**Figure 7.** Schematic drawing of Devil's Grotto, Grand Cayman

Devil's Grotto is just south of Georgetown Harbor between Eden's Rock to the north and Casuarina Point to the South (Fig. 7). The shoreline is phytokarst, and there are several residences and a dive shop nearby. Where the phytokarst meets the ocean, there is a shear drop off about 10 feet in depth with the bottom 5 feet under water. The wall has many nooks and crannies that house Long-Spined Sea Urchins, Hermit Crabs and juvenile damselfish. Ridges and furrows extend from the shoreline out to sea and are covered with *G. ventalina* and a pseudo-palmata zone with some live *A. palmata* (rare elsewhere on the island), and shallow patch reefs

composed of *P. clivosa*, *P. astreoides*, *P. divaricata*, *M. complanata*, *S. radians*, *P. strigosa*, and *M. alcicornis*. The furrows descend in a distinct, tiered formation reminiscent of a series of underwater rapids and pools that characterize some terrestrial fluvial systems. There is little sediment accumulation except at the seaward lip of each “tier.” Several cryptically-colored Caribbean Reef Squid were observed hiding in these structures.

Below the ridge and furrows below 20-25 feet is a buttress zone with spurs and grooves. Near shore, the spurs were dominated almost exclusively by *O. annularis*, which forms undulating, club-like crowns in the shallower water. Once the surface of the spurs becomes lower than 30 feet, other corals such as *M. lamarckiana*, *M. cavernosa*, *D. labyrinthiformis* and *A. cervicornis*, as well as Erect Rope Sponges, Yellow Tube Sponges, Feather Duster, Star Horseshoe and Christmas Tree Worms are present. Giant Caribbean anemone were observed in some places, their tentacles extending from cracks in the structure. Extensive areas of spurs are connected at the top by coral, making enclosed areas coated in purple Hydroids, Crinoids and Encrusting Sponges and provide refuge for Lionfish and Tarpon. Areas between spurs that are not covered are sandy flats that become more expansive at increasing depth. By 50 feet, these flat, exposed areas with separated spurs are home to Queen Conch and *Callianassa* shrimp.

A total of 23 species of fish and eels were observed at Eden’s Rock after one roving diver survey. Blue Chromis and Sergeant major were the most abundant fish observed on the reef, although Bluehead Wrasse, Blue Tang, Stoplight Parrotfish, French Grunt, Cleaning Gobies, Four-eyed Butterflyfish, and Fairy Basslet were also abundant. Squirrelfish were common in hiding places higher in the reef structure. Devil’s Grotto was the only site at which a Sand Diver was reported, although upon further consideration, it is likely that it was a misidentified Sand Tilefish. The only other parrotfish identified in addition to the Stoplight Parrotfish was the Princess Parrotfish.

### Eden’s Rock



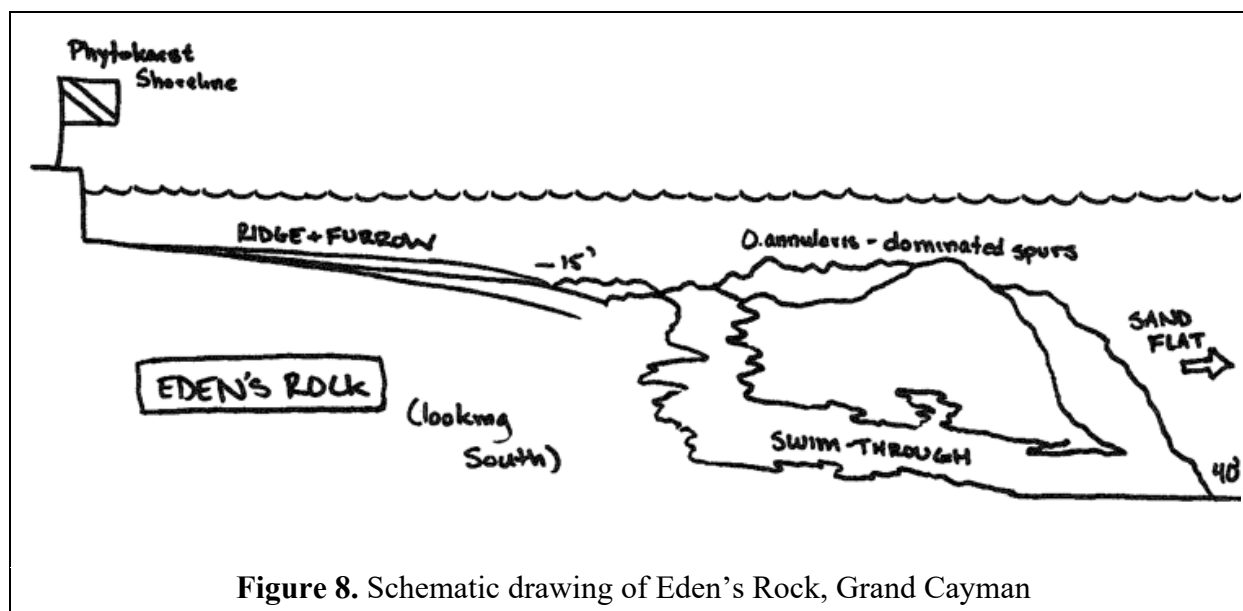


Figure 8. Schematic drawing of Eden's Rock, Grand Cayman

Eden's Rock is the closest dive site that we surveyed to the cruise ship dock and the cruise ship anchoring zones (Fig. 8). Access to Eden's Rock is from the same entry point from the phytokarst shoreline as the Devil's Grotto site, which is located approximately 100m to the south. Directly offshore, ridges and furrows that gently undulate perpendicular to shore. Each ridge top is coated with abundant *G. ventalina*, *P. strigosa*, *S. radians*, *P. astreoides*, *F. fragum*, and various frondose macroalgae. There are occasional patch reefs in which deceased colonies of *A. palmata* are encrusted with and support the growth of corals such as *M. alcicornis*, *M. complanata*, *P. divaricata*, *P. porites*, *D. stokesi*, and *A. agaricites*. Accompanying those species are Christmas Tree and Star Horseshoe Worms, Long-Spined, Variegated, and Rock-Boring Urchins, and Social Feather Dusters. At about 15 feet, the reef structure transitions into the spur and groove formations of the buttress zone. The tops of the spurs remain around 15 feet and are predominately covered with *O. annularis*. Corkscrew anemones, Oersled's Brittle Stars, Mysid Shrimp, the silver, metallic "sea pearl" *Valonia ventricosa* covered in a blotchy crust of lavender encrusting algae, and Spotted Moray Eels reside in-between the lobe-like growth form of that coral.

Although the majority of the shallow, vertical structure of the buttresses is dominated by *O. annularis*, in some places the buttress top is lower – between 20 and 30 feet in depth. In those locations, corals including *M. cavernosa*, *D. labyrinthiformis*, *E. fastigiata*, *Madricis*, spp. *M. lamarckiana* and sponges (Black Ball, Erect Rope, Iridescent Tube, Tubulate, and Yellow Tube)

are also present. Hard substrate not covered in coral or sponges is home to organisms such as zoanthids or *L. variegata*. At the end of buttresses, or in places near the bottom that are partially exposed to sunlight, there are large colonies of *S. siderea* or the occasional single colony of *Scolymia*, spp. Queen Conch, *Callianassa* shrimp and Tiger Tail Sea Cucumbers are also found in those areas. One of Eden Rock's Defining characteristics is that in many places, the top of adjacent spurs have grown together, forming tunnels with extensive dark, protected areas. The inside of these formations is covered with bryozoans, boring and encrusting sponges, as well as hydroids and coralline algae, and provide refuge for nocturnal or deeper-dwelling creatures such as Blackbar Soldierfish (one of which was hosting a single Cymothoid Isopod), large Green Moray Eels, Tarpon, Nurse Sharks and Lionfish.

A total of 64 species of fish and eels were observed at Eden's Rock after 2 roving diver surveys. Several large predators were found here, including a Great Barracuda, Tiger Grouper, Yellowfin Grouper, Black Grouper and Nassau Grouper (unique to ER). Other unique fish were a Bandtail Puffer, Gray Snapper, Slippery Dick, and a Sailor's Choice. Blackbar soldierfish, Queen Triggerfish and Tobacconfish were only found at one other site in addition to Eden's Rock. The sandy regions in between spurs and between the end of the spurs and the drop off at the end of the annularis zone were inhabited by several large hogfish, schools of yellow and striped goatfish, snapper, and jack, while the tops of the reef swarmed with parrotfish, eight species of Damselfish, Brown and Blue Chromis, large feeding schools of Blue Tang, Ocean Triggerfish, and pairs of Four-eyed Butterflyfish. Large schools of blue, intermediate-phase Creole Wrasse and heterospecific agglomerations including Mahogany Snapper, French, and Bluestripe Grunts made use of small overhangs and swim-throughs formed from overgrowth of *O. annularis*.

### Sea View

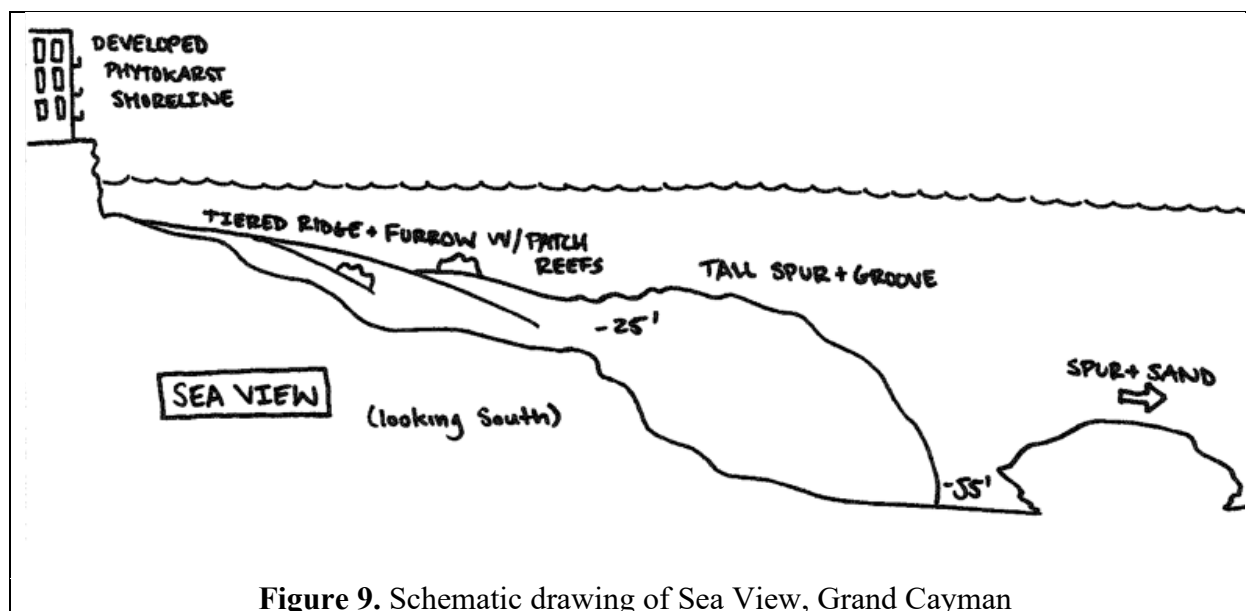


Figure 9. Schematic drawing of Sea View, Grand Cayman

Sea View is a protected fringing reef on the southern part of the leeward margin on Grand Cayman (Fig. 9). The site is a couple hundred meters south of Casuarina Point and uses the same boat ramp as an access point. The shoreline is phytokarst, and the lots directly in front of the reef have condominiums built on them. Offshore, there is a ridge and furrow zone that has a tiered structure similar to Devil's Grotto, although less pronounced. There is little sediment accumulation in these tiers, although there is an abundance of *S. zonale* fragments. *Galaxura spp.* and *S. radians* grow on the sides and along the bottom of the furrows. The ridges, have abundant *G. ventalina*, and large patches of Coral Encrusting Sponges, as well as small patch reefs composed of *P. strigosa*, *P. clivosa*, *P. astreoides*, *D. stokesi*, *F. fragum*, *M. areolata*, *M. alvicornis*, and *M. complanata*. Other invertebrate creatures observed in the shallow ridges, furrows, and patch reefs are Christmas Tree Worms, Flamingo Tongues, Long-Spined Sea Urchins, Rock-Boring Urchins, Caribbean Reef Squid, Star Horseshoe Worms, Club Hydromedusae, and Winged Comb Jellies.

At 25 feet; the bottom of the ridge and furrow zone where it transitions into a spur and groove formation, club-like *O. annularis* is the dominant reef builder. *Halimeda*, *V. ventricosa*, and Mysid shrimp live between heads of coral. In slightly deeper areas (around 35 feet) not covered with *annularis*, other species of coral including *P. divaricata*, *P. porites*, *E. fastigiata*, *M. lamarckiana*, *A. agaricites*, macroalgae such as *L. variegata*, Giant Caribbean Anemone, and *Porifera* such as Black Ball Sponges, Erect Rope Sponges, Iridescent and Yellow Tube Sponges,

Stinker Sponges, and Tubulate Sponges were also observed. Sand flats home to Queen Conch, *Callianassa* shrimp are consistently at or beyond 55 feet in depth, and the spurs associated with them contain additional species of coral including *M. cavernosa*, *D. labyrinthiformis*, *A. cervicornis*, *S. siderea*, *Madracis*, spp., *O. frankesi*, and *O. faveolata*, as well as large Barrel Sponges were observed. Brown Encrusting Octopus Sponges, Red Boring Sponges, Variable Boring Sponges, and Sponge Zoanthids were found underneath overhangs and ledges in both the shallow and deep buttresses.

A total of 63 species of fish were observed at this site during two roving diver surveys. Common reef fish such as Butterflyfish, Chromis, Tang, Chub, Surgeonfish, Black Durgon, as well as seven species of Damsel fish were found at Sea View. Larger herbivores such as Cowfish, Trunkfish, and Filefish, as well as seven species of Parrotfish (only smaller species; specifically, no Rainbow or Midnight Parrotfish) were also observed. A large heterospecific school of French Grunt, Bluestripe Grunt, and Mahogany Snapper was found at around 25 feet in depth. A Shy Hamlet; observed nowhere else on Cayman, was found at this site. Porgies, Jack, Mutton Snapper, and Sand Tilefish were occasionally present on the sand flats, while Harlequin Bass, Lionfish, Schoolmaster, Fairy Basslet, Goldspot Gobies, and White Grunt hid underneath overhangs and amongst rubble directly next to the open sand. SV had especially tall spurs in some areas with large overhangs that were common places to find large predators such as Coney and Black Grouper. The three-dimensional structure was also popular for four squirrelfish species. Dusky Squirrelfish, which were only otherwise seen at Sunset House, were not uncommon, and were frequently found alongside Longjaw and Longspine Squirrelfish.

### Smith's Cove

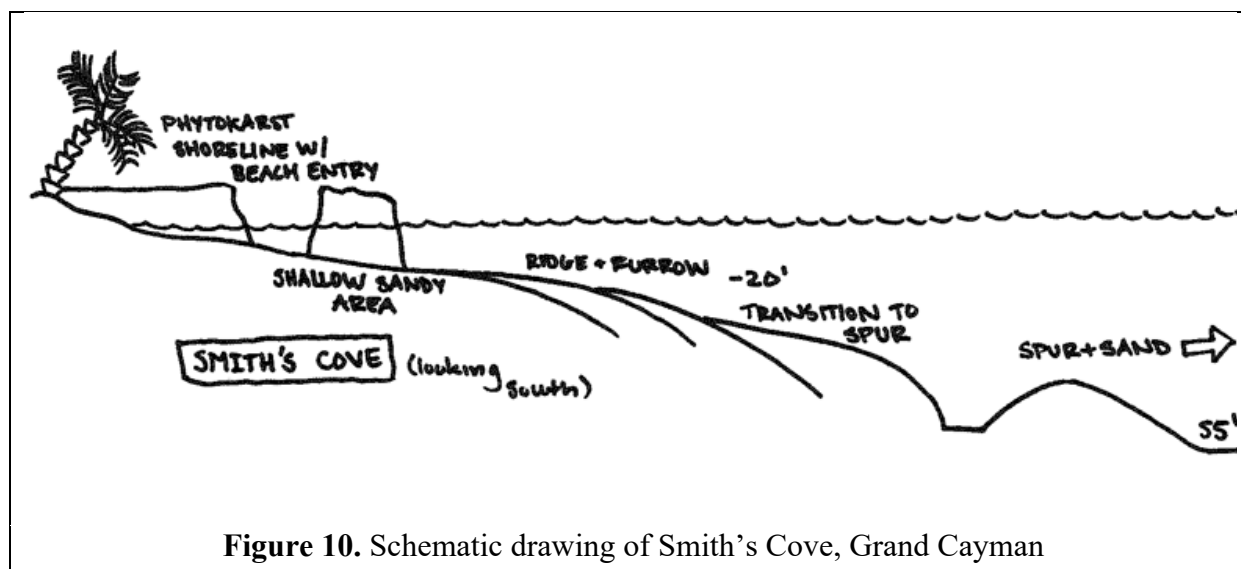


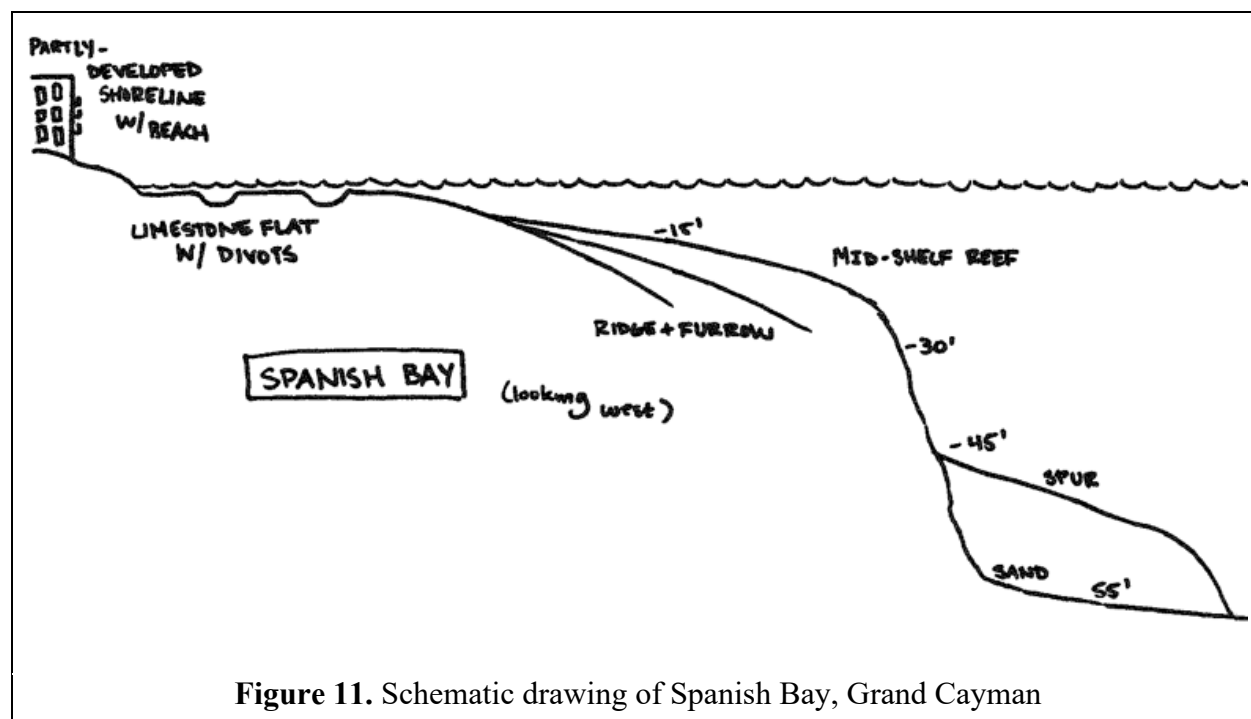
Figure 10. Schematic drawing of Smith's Cove, Grand Cayman

Smith's Cove is the southernmost site surveyed along the protected, leeward margin on the southwest extent of Grand Cayman (Fig. 10). The shoreline is mostly phytokarst, although the water entry in Smith's Cove is a beach entry that has a sandy area. Pieces of dead coral and rubble provide refuge for juvenile Damselfish, Peacock Founder, and Long-Spined Sea Urchins. Sand extends from shore about 50m from shore when a shallow ridge and furrow zone develops concentrating the unstable sediment into depressions, allowing for *G. ventalina* to find holdfasts. Corals such as *M. alcicornis*, *M. complanata*, *S. radians*, and *P. strigosa* are occasionally found in this area, although they do not become abundant until about 20 feet depth, at which point a more distinct spur and sand zone forms. Spurs are widely spaced and resemble drumlins in morphology. By 55 feet, additional species of coral including *P. porites*, *P. divaricata*, *A. agaricites*, *M. cavernosa*, *D. labyrinthiformis*, *M. meandrites*, and *E. fastigiata* are found. Erect Rope Sponges, Iridescent and Yellow Tube Sponges, as well Christmas Tree Worms are also present from the transition zone between the furrows and the spurs down to the expansive sand flats that slope gently out towards sea that was suitable habitat for several Queen Conch. There was a strong surface current from south to north that dissipated with increasing depth.

A total of 22 species of fish were observed at this site during one roving diver survey. In addition to juvenile Damselfish and Peacock Founder, Houndfish and Great Barracuda trawled the shallow surface waters above the sandy area close to shore. Four-eyed Butterflyfish and French Grunt were common in the ridge and furrow zone. Stoplight Parrotfish, Blue and Brown Chromis, as well as Bicolor and Dusky Damselfish were important fish species on the spurs

themselves. A rare Seahorse (probably *Hippocampus erectus*) was observed at Smith's Cove, its tail wrapped delicately around the base of a Gorgonian at approximately 50 feet. It was dark brown to black, with a complicated skin texture that resembled branching macroalgae.

### Spanish Bay



**Figure 11.** Schematic drawing of Spanish Bay, Grand Cayman

Spanish Bay is a protected, windward site on the northern tip of the western peninsula of Grand Cayman (Fig. 11). The Shoreline is a partially-developed beach that has some vegetated sand dune habitat and mangrove forests interspersed between condominiums and other developed properties. Directly offshore is an expanse of pockmarked limestone that lies between one and two feet underneath the surface. Its surface is slick, covered with green encrusting algae that can survive constant perturbation by swells. Rock-Boring urchins are common, nestled in tiny holes in the carbonate substrate such that none of their spines are sticking above the lip of their refuge and exposed to wave energy. The surface water is very warm with a sharp and several-degree thermocline 1-2 feet below the surface. Floating mats of *Sargassum* are common. There are occasional larger holes in the limestone up to three feet deep and three-to-six feet across that have a large variety of species below the hot surface water, including Hermit Crabs, Octopus (probably *Octopus briareous*), Inflated Sea Biscuits, Long-Spined Sea Urchins, Christmas Tree and Star Horseshoe worms, *M. alvicornis*, several species of Damselfish,

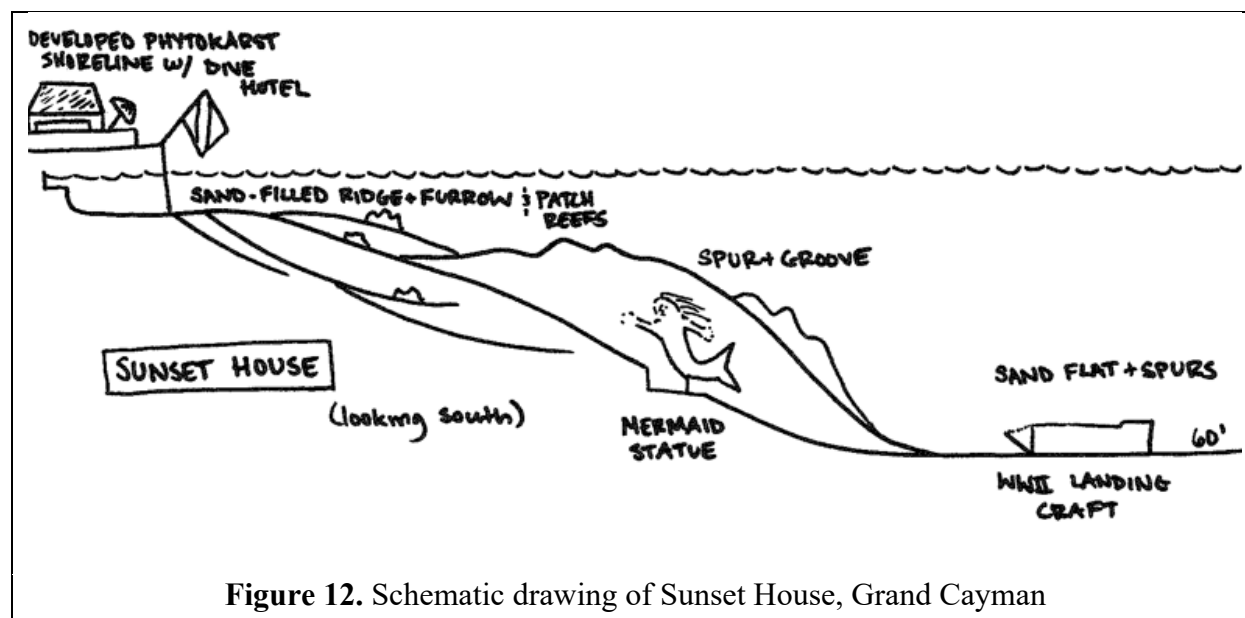
Sergeant Majors and Saddled Blennies, as well as predators including Green and Goldentail Morays that aggressively snapped at passing fish. Unlike the surface of the exposed limestone which is heavily scoured and sediment-free, the bottoms of the larger hollowed-out areas have enough sediment, coral fragments and urchin exoskeletons to allow for the growth of macrophytes including *T. testudinum*, *P. capitatus*, and *Turbinaria*, spp.

Around 100m from shore, the water becomes deep enough (~15 feet) to support the growth of large tufts of *P. boergeresii* and *P. Sanctae-crucis*, *F. fragum*, and abundant of *G. ventalina* and other branched *Gorgonia* and Sea Plumes, some of which have Flamingo Tongues or *Millepora* growing on them. Coral Encrusting Sponges also appear, revealing the three-dimensional polyp structure of the ancient coral exoskeletons that are now covered with a may of encrusting and tuft algae. Near 200m from shore, the seafloor evolves into a ridge and furrow zone whose high and low sections gradually become more and more separated until it develops into a mid-shelf reef by 30 feet. The mid-shelf reef is the beginning of significant coral growth, and has species including *S. siderea*, *P. clivosa*, *P. strigosa*, *P. astreoides*, *M. meandrites*, *P. porites*, *P. divaricata*, *M. lamarckiana*, and *S. radians*. Sponges also become more common, and larger Rope Sponges, Brown Encrusting Octopus Sponges, Iridescent, Globular, and Yellow Tube Sponges begin to appear. A small wall plummets to 45 feet in depth at the end of the mid-shelf reef with a spur and sand zone developed at the bottom with the bottom of sand channels reaching 55 feet. Large Elephant Ear Sponges and intertwining complexes of Green Finger Sponges, red and white Hydroids, *S.luetkeni*, and boring sponges cascade from the vertical structure of the small wall above the spurs. The sand channels and crevices near them are home to Queen Conch, Spiny Lobster and Green Moray Eels. In the deeper, lower-visibility water, *M. cavernosa*, *M. jacksoni*, *D. labyrinthiformis*, *A. agaricites*, *E. fastigiata*, *A. cervicornis*, *D. stokesi*, and *C. natans* become important corals. However, much of the hard substrate is covered with macroalgae such as *L. variegata* instead of hard of soft coral.

A total of 56 species of fish were observed at this site during two roving diver surveys. Although the species richness was relatively low compared to some other sites, the species present in Spanish Bay, especially at the edge of the mid-shelf reef and in the spur and sand zones were unique to SB or rare in every other site. Longsnout Butterflyfish (only sighted gain at Turtle Farm) Spotfin butterflyfish, Coney (including a bright golden phase), Tan Hamlet, and Porcupine fish (again, only sighted again at Turtle Farm), Queen triggerfish (only sighted

otherwise at ER) were present in Spanish Bay. The only Black Snapper and Yellow Stingray were seen at this site. Deeper-water, red-colored fish including Blackbar Soldierfish and Longjaw Squirrelfish were orders of magnitude more abundant in SB than any other site, and Black Durgon were most abundant at this site by a factor of 2 or 3, whereas the vibrantly-colored Spotlight Parrotfish was noticeably less abundant. In some places the reef has natural archways that form protected areas that are popular with lionfish and clouds of mysid shrimp.

### Sunset House



**Figure 12.** Schematic drawing of Sunset House, Grand Cayman

Sunset House is a protected fringing reef on the leeward side of Grand Cayman to the south of Sea View (Fig. 12). The shoreline is Phytokarst, but a dive hotel directly offshore has created stepped water entries into the ocean into a partly-enclosed, protected lagoon. Rock-Boring Urchins and Hermit Crabs were commonly found in holes in the phytokarst walls. Directly outside the enclosed area are pronounced ridge and furrows filled with skeletal sand and macrophyte detritus. *G. ventalina* are abundant on ridge crests, and below 15 feet, small boulder-like patch reefs containing *P. strigosa*, *S. radians*, *P. astreoides*, *F. fragum*, *M. lamarckiana*, and *M. alvicornis* and invertebrates such as Yellow Fanworms and Yellow and Brown Tube Sponges. Large spurs and grooves occur between 30 and 60 feet, and are dominated by *O. annularis*, as well as less abundant species such as *P. divaricata*, *A. agaricites*, *M. cavernosa*, *D. labyrinthiformis*, *P. porites*, *E. Fastigiata*, *M. meandrites*, *A. cervicornis*, *D. stokesi*, *S. siderea*,

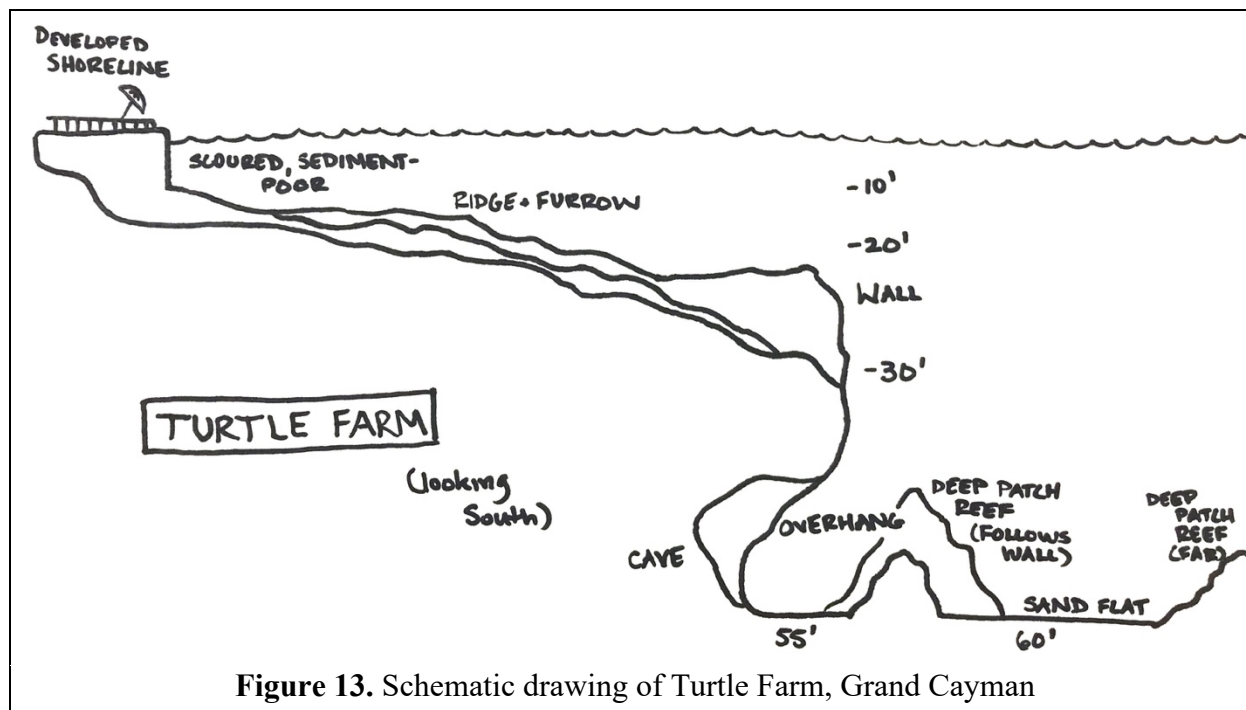


*C. natans*. The macroalgae *L. variegata* as well as Rope Sponges, Green Finger Sponges, and Tubulate Sponges are ubiquitous at all depths in the spur and groove formations.

SH is unique to the sites we surveyed in that there are several artificial reef structures specifically designed for tourists, but that also attract fish and provide a solid surface for organisms such as Hydroids, Barrel and Iridescent Tube Sponges, some corals, and Zoanthids. A 12' statue of a mermaid is nestled at the fork between two spurs, and a WWII-era landing craft lies on the bottom in a sand flat at 60 feet surrounded by *Callianassa* shrimp mounds, Brown Garden Eels, and Conch trails. The latter feature has been in place longer, and therefore has developed a more diverse assemblage of benthic biota.

A total of 48 species of fish were observed at this site during one roving diver survey. The ridge and furrow zone as well as the spur and groove areas had an unsurprising assemblage of fish composed predominately of Chromis, Damselfish, Grunts, Bar Jack, Spanish Hogfish, and Parrotfish. Surgeonfish, Tang, Basslet, and Chub. This site was, however, had a high Squirrelfish diversity with four species (Squirrelfish, Longspine Squirrelfish, Longjaw Squirrelfish, and Dusky Squirrelfish) present in near equal abundances. A vibrantly-colored Orangespotted Filefish, a juvenile Trumpetfish, and a tobaccofish; only found in two sites each during our surveys, were all found here. Porgies, Barracuda, Yellow Goatfish, Mutton Snapper, and Goldspot gobies were observed in the sand flats or directly adjacent to spurs. Although the fish assemblage around the mermaid did not qualitatively differ, the three-dimensional structure and placement of the landing craft in an otherwise cover-free area in the middle of a sand flat made it an oasis to a variety of many fish, many of which were quite large or not seen elsewhere around Sunset House. A pair of large Gray Angelfish (around 1 foot in diameter) nibbled at algae growing on the metal substrate. A large yellowfin grouper resided within part of the enclosed structure, and a large tiger grouper displaying cryptic coloring hovered above the sand near the craft's stern.

## Turtle Farm



**Figure 13.** Schematic drawing of Turtle Farm, Grand Cayman

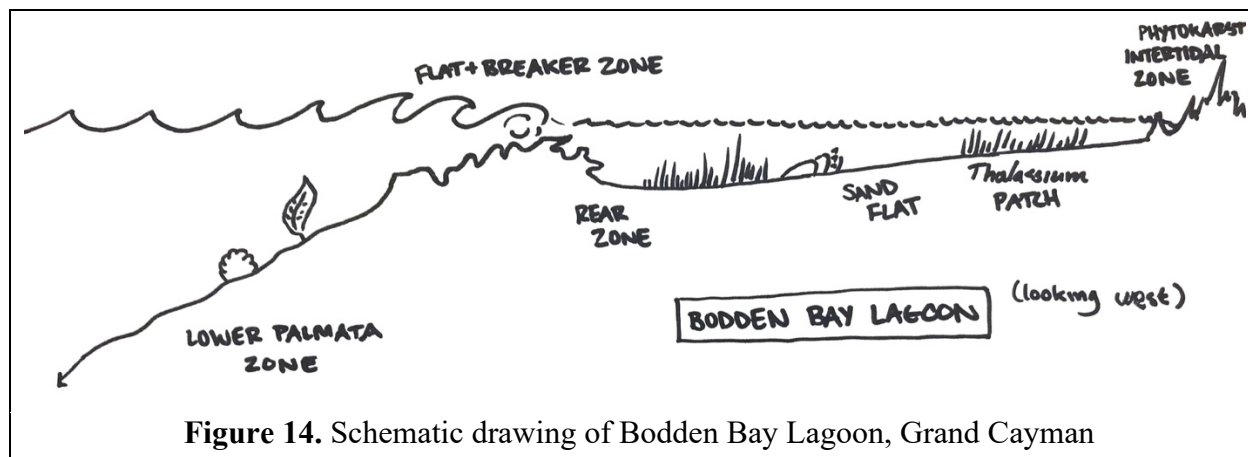
Turtle Farm reef lies north of Seven Mile Beach on the leeward margin of the western tip of Grand Cayman's northwestern peninsula, directly neighboring the Cayman Turtle Centre (Fig. 13). The shoreline is phytokarst and is heavily developed with many businesses, houses, restaurants directly at the water's edge. The intertidal area is populated with Chitons and Rock-Boring Urchins, and *Sargassum spp.* floats in large mats matching windrows on windy days or is otherwise in bands parallel to the dominant wave direction towards shore. Directly offshore, the bottom slopes gently away from the island, and gradually transitions from a scoured, sediment-poor zone covered predominately with *G. ventalina*, *S. radians*, *M. alcicornis*, and *P. astreoides*, into a ridge and furrow zone between 15 and 30 feet depth. At 30', there is a wall that descends to sixty feet and bottoms out into an expansive sand flat. The edge of the wall has a greater diversity of gorgonians and sponges including the Black Ball Sponge, and Erect Rope Sponge as well as coral species such as *P. strigosa*, *D. stokesi*, *S. siderea*, *A. agaricites*, *P. divaricata*, and *P. porites*. Representing an ancient shoreline during a period of ocean regression, the miniature wall has a near continuous overhang that provides cover for many deeper-water species such as sea whips, bryozoans, and crinoids (Orange Sea Lily), as well as obligate asymbiont heterotrophs such as the Green Finger Sponge, Tubulate Sponge, Iridescent Tube Sponge (many of which

contain Oersled's Brittle Stars, or black corals such as the occasional *S. luetkeni* colony. To the south along the wall, there is a large cave whose walls are crusted in encrusting and boring sponges, zoanthids, and a large Elephant Ear Sponge, is the regular daytime hideout of 20-30 1-1.5m-long tarpon

Sedimentation rates from shore are high or were at one point, as evidenced by occasional cones of sand extends from the top of the wall to the sand flat beneath it, forming a 20 to 30-foot-tall pile of sediment. Sand and fragments of coral and shells cover the seabed underneath the overhang, transitioning into patch reefs containing common reef building species such as *M. cavernosa*, *D. labyrinthiformis*, *O. annularis*, *E. fastigiata* and *M. meandrites*, as well as the common algae *Halimeda spp.* and *L. variegata* once there is no physical structure blocking incident light. These patch reefs also have a variety of rarer species such as *Madracis spp.*, *M. ferox*, and, of particular note, a nearly meter-wide colony of the large-polyp coral *M. angulosa*. These reefs follow the longitudinal structure of the wall and are approximately 5 to 20 feet in height and a few meters in width and are home to a variety of invertebrates including Giant Caribbean Anemones, Arrow and Channel Clinging crabs, as well as filter feeders such as Barrel and Netted Barrel Sponges, as well as Feather Duster and Christmas Tree Worms. Clouds of Mysid Shrimp are common. Past the line of patch reef, the sand flat continues with a nearly imperceptible little downward slope and is dotted with isolated mounds of coral on which *A. cervicornis* is more common, that punctuate an otherwise heterogeneous bed of Brown Garden Eels and sea cucumbers (Three-rowed and Furry), and *Callianassa* mounds.

A total of 66 species of fish were observed at this site during two roving diver surveys. Turtle Farm was the only site at which several species of fish. Ocean Triggerfish and Almaco Jack were present above the wall, a Chain Moray was observed near the wall's edge, a Greater Soapfish, Rock Hind, and Goliath Grouper were sighted underneath the overhang in the protection of its shadow, and a juvenile Spotted Drum was observed inhabiting one of the patch reefs further away from the wall. Turtle Farm was also home to a large (nearly 1m-long) midnight parrotfish, a large porcupinefish, a nearly 5-foot-wide southern stingray, and several vibrantly-colored Queen Angelfish. This was also one of the two sites at which the longsnout butterflyfish, beaugregory (juvenile phase), and spotted moray were observed.

### Bodden Bay Lagoon



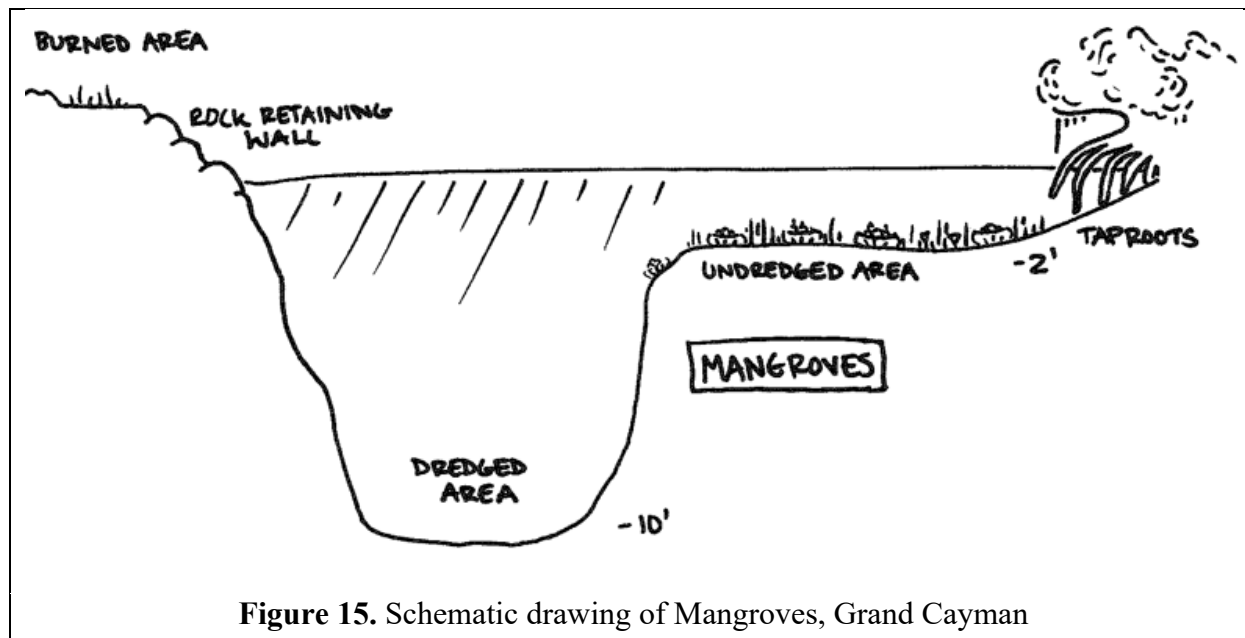
**Figure 14.** Schematic drawing of Bodden Bay Lagoon, Grand Cayman

Bodden Bay Lagoon is a protected, shallow area approximately 4km long and up to 500m wide, along the southern, exposed, windward side of Grand Cayman (Fig. 14). The shoreline was a mix of beach, phytokarst, and mangroves, depending on the level of development of seaside properties. Our residence while we were staying on Grand Cayman was located at the eastern extent of the protected area. The vast majority of the lagoon was less than 6 feet deep and was a patchwork of *T. testudinum* “fields” or sand flats. Shells of deceased Queen Conch and larger fragments of coral were popular hiding places for juvenile fish (especially Damselfish, Butterflyfish, Lionfish, and a variety of other reef-dwelling, herbivorous species), invertebrates such as Rock-Boring and Long-Spined Sea Urchins, Giant Caribbean Anemones, Hermit Crabs, and several species of Tube Worms. Live coral, although not absent in the lagoon, was rare and typically restricted to species such as *F. fragum*, *Siderastrea*, *spp.*, and *Porites*, *spp.* Vibrantly-colored purple and pink *P. divaricata* was present near the Rear Zone and the Breaker Zone, which had exposed, deceased colonies of *A. palmata* visible except at high tide. The Reef Flat was also composed primarily of dead *A. palmata* but had a large contingent of Long-Spined Sea Urchins and small, cherry-red Rock-Boring Urchins seeking refuge in the extant physical structure. *Millepora*, *spp.* was also abundant, often encrusting the *palmata* fronds. Past the Flat and Breaker Zone, the seafloor descended relatively rapidly, and below 10-15 feet, solitary mounds of *P. astreoides*, *P. strigosa*, as well as *G. ventalina* were common.

The intertidal zone next to our residence had a wide variety of organisms. There were many different varieties of snail, many of which were banded with vibrant pink, red, and blue

colors. Several species of crab were also observed, as well as a pair of small Spotted or Goldentail Morays which habitually hunted in the phytokarst tide pools. Juvenile Sergeant Major were also common in the intertidal area. After mild storms, dead *G. ventalina* would appear, washed up on shore during the period of increased wave action.

### Mangroves



**Figure 15.** Schematic drawing of Mangroves, Grand Cayman

The mangrove site that we surveyed was near the northern tip of the peninsula in the middle of Grand Cayman that defines the north-eastern extent of North Sound (Fig. 15). The mangroves grew adjacent to a main channel, half of which had been dredged to allow for the passage of boat traffic in the otherwise shallow, stagnant, brackish water. One side was burned to clear space for development, although nothing was actually constructed, and the mangroves have not returned. There was a high amount of particulate matter in the water, and the water itself was colored brown, presumably with tannic or humic compounds leached from terrestrial vegetation. While the dredged portion of the mangrove channel was relatively uninhabited by benthic macroinvertebrates and macrophytes, the un-dredged portion was thoroughly covered with Mangrove Upside-down Jellyfish; vibrant blue, green, or yellow-colored, and reaching the size of dinner plates. *F. fragum* and *S. radians* were present in small quantities, while macrophytes such as *T. testudinum*, *Penicillus*, spp., *Halimeda*, spp., *Turbinaria*, spp., as well as *P. sanctae-crucis* and possibly *Halophila Baillonis* covered the rest of the bottom. Spaghetti worms and

Hermit Crabs were abundant. The tap roots of the mangroves themselves were a productive habitat for many organisms including several varieties of stinging Hydroids, Flat Tree Oysters, Tunicates, and colonial Bryozoans.

Fish diversity was difficult to assess due to the turbid water and low visibility. However, many species of reef-dwelling fish such as French Angelfish (including several very large adults), Grunts, Squirrelfish, Mutton Snapper, Sergeant major, Ocean Surgeonfish, Butterflyfish, Filefish, and honeycomb cowfish were seen mingling in and around the taproots. Juvenile Great Barracuda less than one foot in length as well as Houndfish and a large school of silversides were observed in the exposed area outside of the mangroves in the exposed waterways. When startled, the Barracuda would move some distance, drop to the bottom, and assume a banded, olive-colored phase to help avoid detection. If disturbed again, or after sufficient time such that it believed that it was no longer in danger, it would rise from the sediment, re-adopt the silver phase, and continue swimming. The large school of baitfish would initially avoid a diver, but, after an acclimation period of a few minutes where the diver was being still, they would use them as cover and accumulate in their shadow and underneath their extremities. Many small wrasses and gobies were also present, eating small crustaceans in the muddy sediment as well as detritus as it drifted past.