The State of Coral Reef Ecosystems of Navassa Island

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INTRODUCTION AND SETTING

Navassa Island is a small, uninhabited, oceanic island approximately 50 km off the southwest tip of Haiti (Figure 6.1). It is under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) as one component of the Caribbean Islands National Wildlife Refuge (NWR). Based on some preliminary quantitative surveys in 2000, and because of its isolated and uninhabited status, Navassa has been presumed to provide a relatively pristine end member for reef status in the Caribbean (Miller and Gerstner, 2002). Local land-based anthropogenic pollution and recreational uses are essentially absent. Thus, Navassa reefs may provide valuable insight regarding Caribbean coral reef structure and function. However, there is substantial but unquantified fishing activity at Navassa by transient Haitians and their impact has been suggested to be substantial (Collette et al., 2003) and potentially rapidly increasing (Miller and Gerstner, 2002).

Navassa is a raised dolomite plateau ringed by vertical cliffs. For most of the Island's circumference, these cliffs reach straight down to approximately 25 m depth where a submarine terrace slopes out gradually. In limited areas around the northwest point and at Lulu Bay, the island has small shoulders of shallow reef habitat (10-15 m). The primary reef habitats are: 1) reef walls (formed by the cliffs); 2) large boulders that have been dislodged from the cliffs; 3) scattered patch reefs and hardbottom areas on the 25-30 m terrace; and 4) deeper reef slopes (>30 m) farther offshore that have not been well described. Navassa's oceanic position in the Windward Passage exposes it to substantial physical energy. The East Coast bears the brunt of persistent swells and regular storms and hurricanes. The Island does not exhibit typical Caribbean patterns of reef zonation; inshore and backreef habitats including mangroves, sandy beaches, and seagrasses (important in the life history of several reef fish groups) are largely absent at Navassa.

Despite its status as a NWR, regulations are currently not enforced and fishing activity is unmanaged with no quantitative catch or effort data available. Substantial fishing activities are, however, undertaken by transient Haitian subsistence fishers and appear to have been ongoing since at least the 1970s. Qualitative observations suggest that rapid depletion of Navassa fishery resources is underway.

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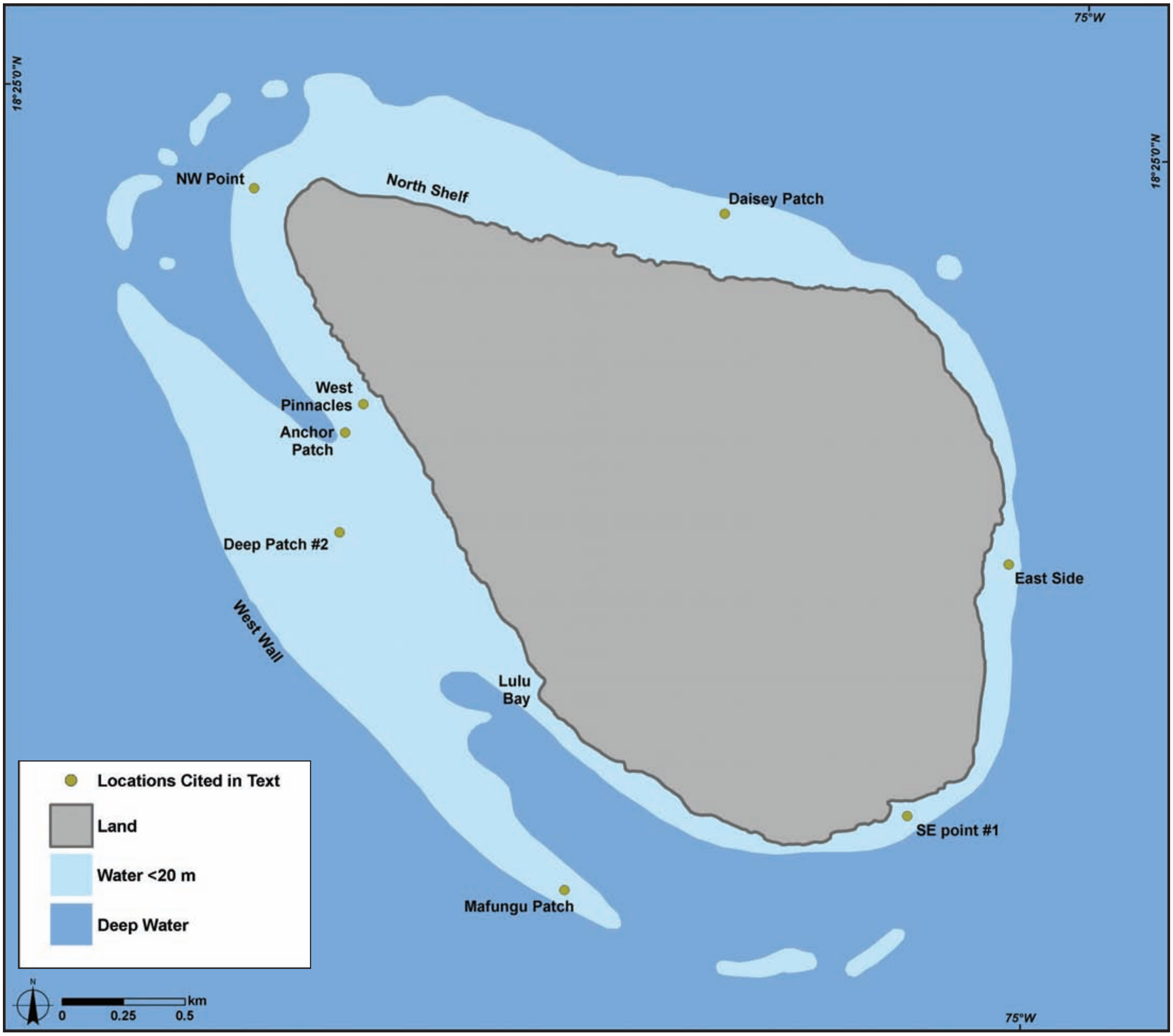

Figure 6.1. A map of Navassa Island showing locations referenced in this chapter. Map: A. Shapiro.

ENVIRONMENTAL AND ANTHROPOGENIC STRESSORS

Climate Change and Coral Bleaching

No historic observations are available that are suitable for the evaluation of effects of climate change or episodes of coral bleaching. Much of the high coral-cover habitat, however, is in deep (18-30 m) waters exposed to strong currents and surge. This may provide some protection from elevated water temperatures.

Diseases

No diseased corals were noted in quantitative surveys that observed a total of 985 colonies at six shallow-water sites (<20 m). An unknown disease with an appearance similar to white plague, however, was observed on brain corals at some deeper reef sites. The quantitative surveys found an average of over 4% of coral colonies affected by predation and over 14% affected by competitive overgrowth by algae and sponges.

Tropical Storms

Navassa's oceanic position in the Windward Passage exposes it to substantial physical energy. The East Coast, in particular, bares the brunt of persistent swells, regular storms, and occasional hurricanes (Figure 6.2). However, no quantitative studies have been done on the effects of a particular storm.

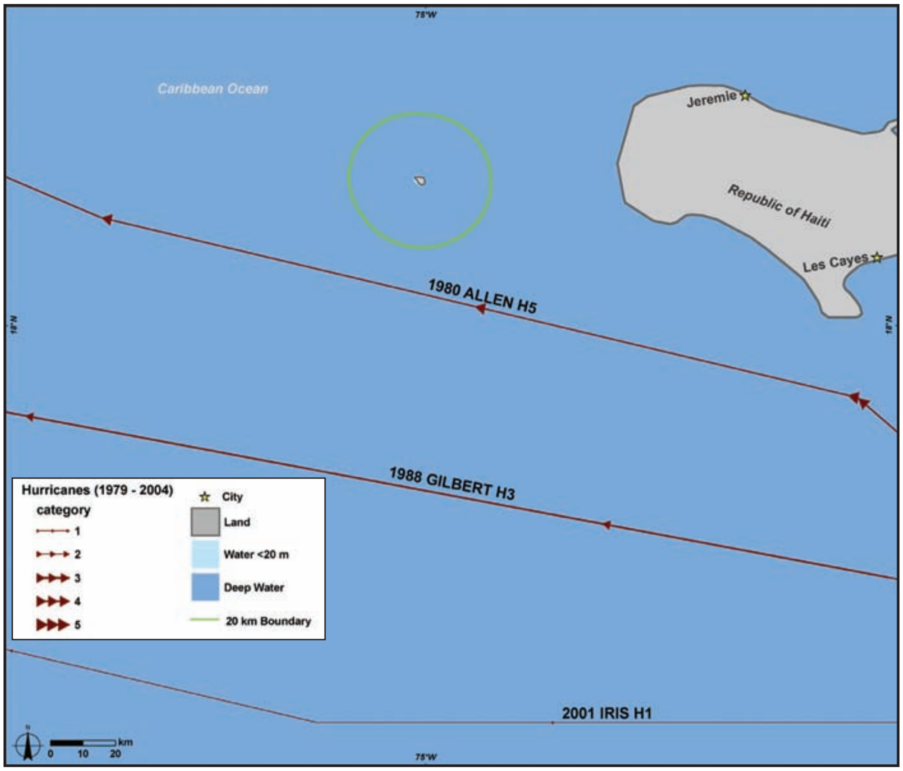

Figure 6.2. The path and intensity of hurricanes passing near Navassa Island. Year of storm, Hurricane name and storm strength on the Saffir-Simpson scale (H1-5) are indicated for each. Map: A. Shapiro. Source: NOAA Coastal Services Center.

Coastal Development and Runoff

Navassa is uninhabited, although Haitian squatters frequent the Island. With the exception of an old abandoned lighthouse building and cistern, there is no development on Navassa. Approximately 200 acres were burned in 2000 by transient Haitians and 5-7 acres were planted in corn, squash, and watermelon. Native vegetation is not fire adapted, so recovery rates are very slow.

Though there is no activity presently, there was an active terrestrial mining operation (guano and/or other phosphorus-rich deposits) on Navassa from the late 1800s through the turn of the century. The Navassa Phosphate Company acquired the Island in 1864 and invested $50,000 to establish a small town which had grown to include two dozen small buildings by 1889, although none remain today. It was estimated that one million tons of phosphate-bearing materials were removed from the Island by the mining operations subsequent to burning and vegetation removal to facilitate access to the mined material.

Coastal Pollution

Navassa is uninhabited.

Tourism and Recreation

There is no tourism or recreational use at Navassa. A Special Use Permit from the USFWS is required for entry.

Fishing

Despite its status as a NWR, fisheries at Navassa are effectively unmanaged as regulations are not well publicized and enforcement is nonexistent. Fishing activities are undertaken by migrant Haitian artisanal fishers, and these activities have been ongoing since at least the 1970s. Anecdotal evidence suggests that some technological escalation in Navassa fisheries occurred between 1997 and 2000. While no motors were observed in 1997, all of the vessels observed during the 2000 expedition had 10-15 h.p. motors. Quantification of catch or effort has not been undertaken for the Navassa fisheries, although deliberate qualitative observations were made during scientific expeditions in April 2000 (Miller and Gerstner, 2002) and November 2002 (Miller et al., 2003).

Fishing boats observed were wooden, 6-9 m in length, and manned by three to six fishers (Figure 6.3). In 2000, hook-and-line and Antillean Z-traps were observed whereas in 2002, the additional use of nets was observed. The adoption of net fishing corresponded with exploitation of new species, particularly queen conch (*Strombus gigas)* and Hawksbill sea turtles (*Eretmchelys imbricata).* Finfish catch appeared unselective and included predominantly small (<30 cm, most <20 cm) fishes including trunkfish, ocean triggerfish, surgeonfish, and bar jack (Miller et al., 2003). Ancillary effects of this artisanal fishing include a system of makeshift moorings and rock anchors which are deployed at Lulu Bay, one of three sites around the island with an extensive stand of elkhorn coral (*Acropora palmata;* Figure 6.4).

Figure 6.3. Typical Haitian boat and fishers, fishing with hook-and-line at Navassa in 2002. Photo: M. Miller.

The extent to which larger commercial fishing vessels operate in Navassa waters is not known. Observations of larger Cayman- and Dominican-flagged fishing vessels as well as a recreational vessel from Florida have been made at Navassa (J. Schwagerl, pers. obs.).

Trade in Coral and Live Reef Species

No such trade is known to occur on Navassa.

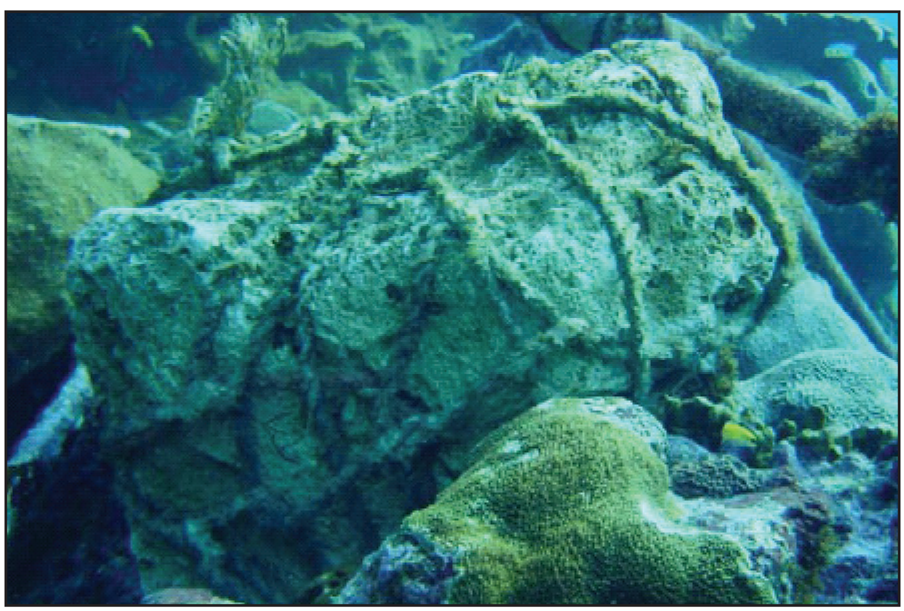

Figure 6.4. An example of a rock ‘anchor’ used by Haitian fishers. Photo: M. Miller.

Ships, Boats, and Groundings

No vessel groundings are known or suspected around Navassa. However, it does lie in an exposed position in the Windward Passage, so future threat from shipping is not implausible.

Marine Debris

There is a small amount of marine debris (large tanks, metal debris) leftover from earlier mining activities on the Island (Figure 6.5) as well as from more recent fishing activities at Lulu Bay, the only landing site on the island. It is not known to what extent fish traps are lost and continue "ghost fishing" or are broken up, as no comprehensive survey of the mid-depth shelf (25-35 m) has been made. Whatever debris is present is likely to impose relatively large impacts given Navassa's high-energy environment and frequent exposure to storms.

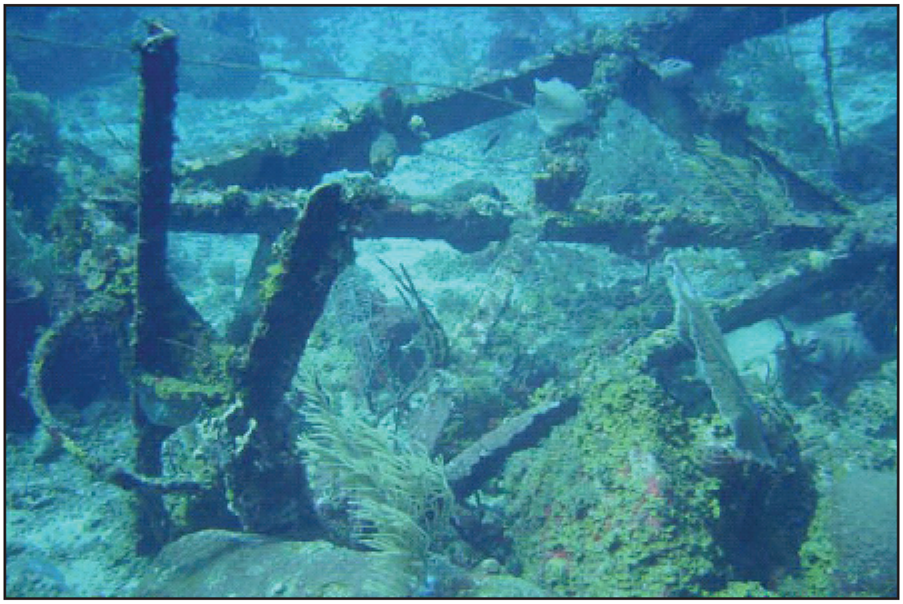

Figure 6.5. Debris remains of a former mining operation, circa 1900. Photo: D. McClellan.

Aquatic Invasive Species

No aquatic invasive species are known to occur at Navassa.

Security Training Activities

No military activities are undertaken at Navassa.

Offshore Oil and Gas Exploration

No oil and gas exploration activities occur at Navassa.

CORAL REEF ECOSYSTEM MONITORING EFFORTS AND RESOURCE CONDITION

Description of Local Coral Reef Monitoring Programs

There is no formal reef monitoring program for Navassa. The only quantitative reef status information available for Navassa has been obtained on individual cruises. Specifically, a cruise in April 2000 funded by the Center for Marine Conservation (now the Ocean Conservancy) in partnership with the John G. Shedd Aquarium, National Oceanic and Atmospheric Administration (NOAA) Fisheries, USFWS, and academic researchers focused on building a taxonomic inventory and conducting some limited reef assessments. More extensive assessments (as reported here) were performed in October and November 2002 during a cruise funded by NOAA Fisheries Southeast Fisheries Science Center, in partnership with U.S. Fish and Wildlife Service and academic researchers (Miller, 2003). The extent of data obtained in the 2002 cruise was greatly enhanced by the availability of nitrox diving (i.e., using a gas mixture different from compressed air) which allows extended bottom times for work in the mid- and deep-shelf habitats around Navassa (Figure 6.6).

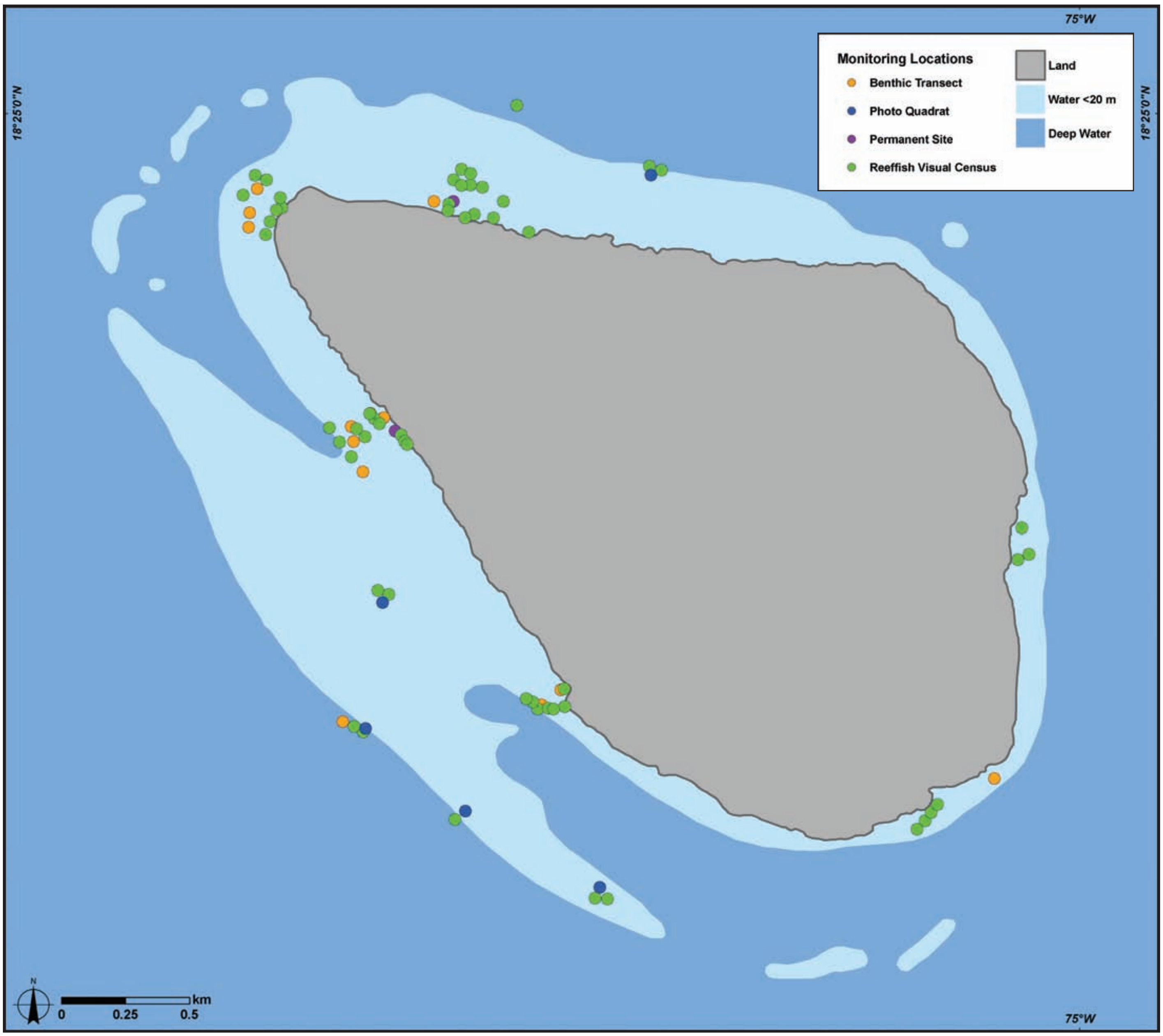

Figure 6.6. A map of the monitoring locations visited during recent scientific expeditions to Navassa. Map: A. Shapiro.

WATER QUALITY

There is neither data nor targeted monitoring regarding water quality at Navassa. Qualitatively, Navassa's oceanic position appears to afford it extremely high water clarity as well as strong currents and swells. Zooplankton density sampled in November 2002 was substantially lower than that measured in other Caribbean reef areas (Sandin, 2003). Also, a few targeted water samples taken in and around a small underwater cave during the April 2000 cruise suggested that at least some natural high nutrient input, perhaps a groundwater seep, was occurring on Navassa reefs (Figure 6.7).

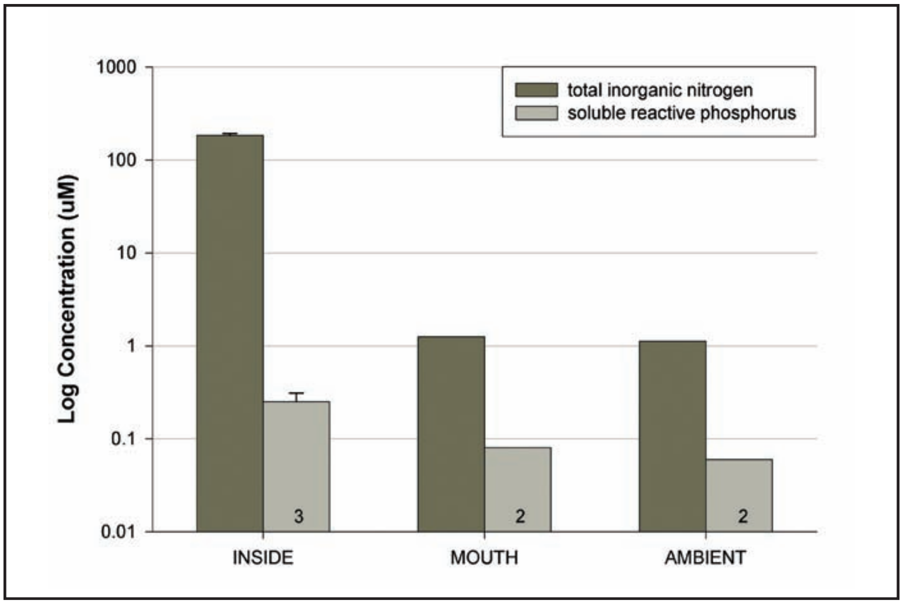

Figure 6.7. Dissolved inorganic nutrient concentrations (note log scale) in and adjacent to a cave along the western cliff of Navassa measured in 2000. Number of replicate analyses given in bars. Source: M. Miller, unpublished data.

BENTHIC HABITATS

Methods

Standard line intercept transects (15 m x one point sampled each 15 cm) were primarily used to estimate cover of primary community components (scleractinian corals, macroalgae, octocorals, sponges). In addition, a 1 m swath around this transect was used to estimate size and condition of coral colonies (diameter, height, presence of predators, disease, competitive damage) (Miller et al., 2003). Special attention was paid to crustose coralline algae and voucher specimens were collected for species level identification (Begin and Steneck, 2003). In deeper habitats (>20 m) where *in situ* transect sampling was not feasible due to bottom time constraints, ten haphazard 1 m^2 photo quadrats were taken and percent cover was later analyzed by superimposing dots on the image.

During the 2002 cruise, permanent monitoring quadrats were established to quantify scleractinian recruitment and survivorship. At each of two sites (15 m and 20 m depth), 15 1 m^2 permanent quadrats were marked with stakes and numbered tags. Photographs and *in situ* maps were made to indicate location of juvenile corals within quadrats. The *in situ* maps were used to annotate the photographs that will be used in subsequent surveys to assess persistence and growth of individual colonies.

Lastly, settlement plates (15 x 15 cm) were deployed (as part of a Caribbean-wide study by R. Steneck) to examine coral settlement in relation to colonization by crustose coralline algae.

Results and Discussion

The 2002 assessment included extensive survey of deeper shelf reef habitats (20-30 m). The percent cover by the dominant benthic groups for all sites is given in Figure 6.8.

Macroalgae (predominantly *Lobophora variegata* and *Dictyota* spp.) comprise the dominant benthic group overall, and a breakdown by genus is provided in Table 6.1. At several sites, however, (e.g., shallow shelf at Lulu Bay and several deep patch reefs), live coral cover was equal to or exceeded the cover of macroalgae. Live coral cover was highest (up to 46%) at the deep sites (25-30 m) including patch reefs and one site on the deep southwest dropoff. In shallower habitats (10-20 m), live coral cover was in the range of 10-20%. Live coral less than 10% (coinciding with extremely high macroalgal cover) was observed in sites with apparently intense disturbance regimes, including the East Coast; apparently scoured deep hardbottom habitats; and the "avalanche zone" observed at the North Shelf.

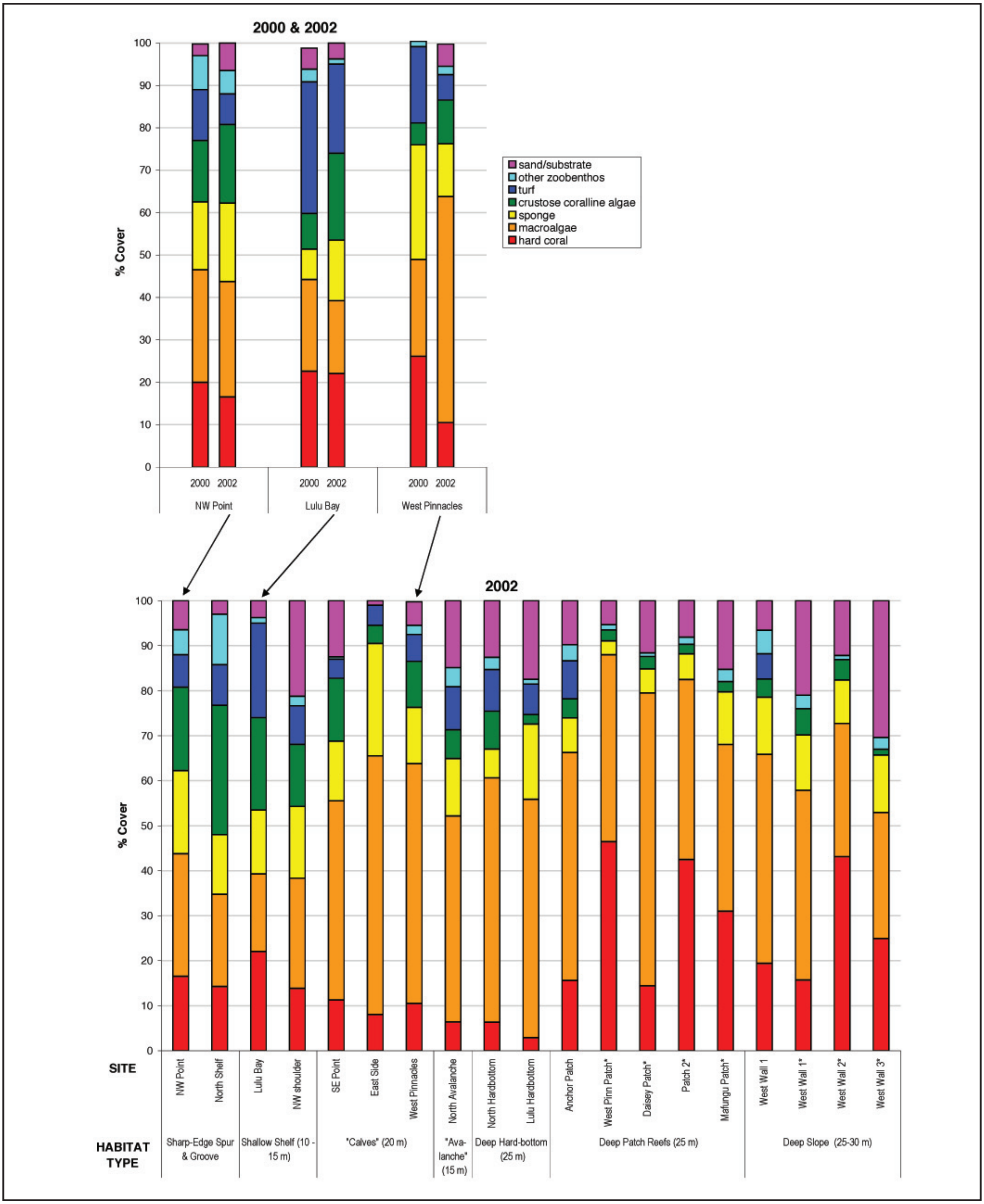

Figure 6.8. Lower panel: Community composition for all sites surveyed at Navassa in November 2002. Sites along the bottom axis with asterisk were surveyed by haphazard photo quadrats (n=8-15); others were surveyed *in situ* via point intercept transects (n=2-4 per site). Algal turfs were not resolvable from photographs. The "avalanche zone" is located on the north shelf, but is treated as a different habitat due to the level of disturbance. "Calves" are blocks of fallen rock from sea cliffs. Categories along the bottom axis indicate a priori habitat type classified according to depth and topography. Upper panel: Comparison with sites that were surveyed in April 2000. Source: Miller et al., 2003.

Table 6.1. Mean ± one standard deviation (SD) percent cover by genus for macroalgae at the six sites sampled by *in situ* line intercept transects. The first three sites are deeper sites (~20 m) while the last three sites are shallow reefs (<10 m) on the 'shoulders' of Navassa. All are n=4 transects except for the East Side, where n=2 transects. Source: M. Miller, unpublished data.

GENUS	EAST SIDE	SOUTHEAST PT.	WEST PINNACLES	LULU BAY	NORTHWEST PT.	NORTH SHELF
Halimeda	4	4.3(1.3)	15.5(6.8)	8.5(3.9)	9.8(4.5)	5.5(1.9)
Dictyota	35	15.8(6.2)	14.5(7.0)	5.8(1.7)	11.0(1.2)	12.0(4.1)
Lobophora	8.5	13.3(3.9)	22.3(8.0)	1.5(1.7)	6.0(3.5)	1.3(2.5)
Sargassum	6.5	8.5(10.4)	0.3(0.5)	0	0	0.3(0.5)
Stypopodium	3	1.3(1.0)	0	1.5(2.4)	0.5(1.0)	0.8(1.0)
TOTAL	**57**	**43**	**52.8**	**17.3**	**27.3**	**19.8**

Sponges covered 10-20% of the reef area at most sites. *Agelas spp.* was the dominant sponge taxa across habitats. Gorgonian density was relatively low (averaging <2 colonies per m^2 for the four shallow sites sampled) and a total of 21 spp. were observed.

At one site, algal cover had increased by 100% from 2000 to 2002 (25-50% cover), but was similar at two other re-sampled sites (Figure 6.8). It is not clear if this increase is attributable to seasonal effects (fall vs. spring). Little other change in benthic community structure was observed.

The relative composition of the coral community at deeper (>25 m) sites is given in Figure 6.9. The dominant coral taxa at these sites were *Montastraea* spp., *Agaricia* spp. and *Porites porites*. Overall, *Agaricia* spp. was the dominant component of the coral community in shallower sites.

The relative incidence of various coral conditions for a subset of shallow and mid-depth sites (10-25 m) is given in Table 6.2. A total of 985 colonies were examined for conditions including disease, impact of predators, and impact by competition with adjacent organisms. The most common condition was algal overgrowth where coral tissue was clearly affected was algal overgrowth, which was strongly correlated with overall macroalgal abundance among sites (r^2=0.55, n=6). A weaker relationship was found between sponge cover and incidence of sponge overgrowth damage on corals (r^2=0.27, n=6). Just over 4% of colonies on average showed signs of predation by snails, fire worms, or fish (Table 6.2). No colonies in this sample were observed with active disease although substantial impact of disease on brain corals (*Diploria* spp. and *Colpophyllia natans*) was observed in deeper sites.

Elkhorn coral (*Acropora palmata)* appears to be increasing in abundance. Substantial populations were observed at all three shallow reef sites (Lulu Bay, Northwest Point, and North Shelf) compared to the April 2000 observations when substantial *A. palmata* development was confined to Lulu Bay. Interestingly, genotyping of *A. palmata* colonies from all three sites indicates that asexual reproduction is absent at Navassa while sexual recruitment is effective (Baums, 2004). Also, the range of sampled colony sizes indicates that successful sexual recruitment is occurring repeatedly. In contrast, staghorn coral, *A. cervicornis*, remains rare and in poor condition.

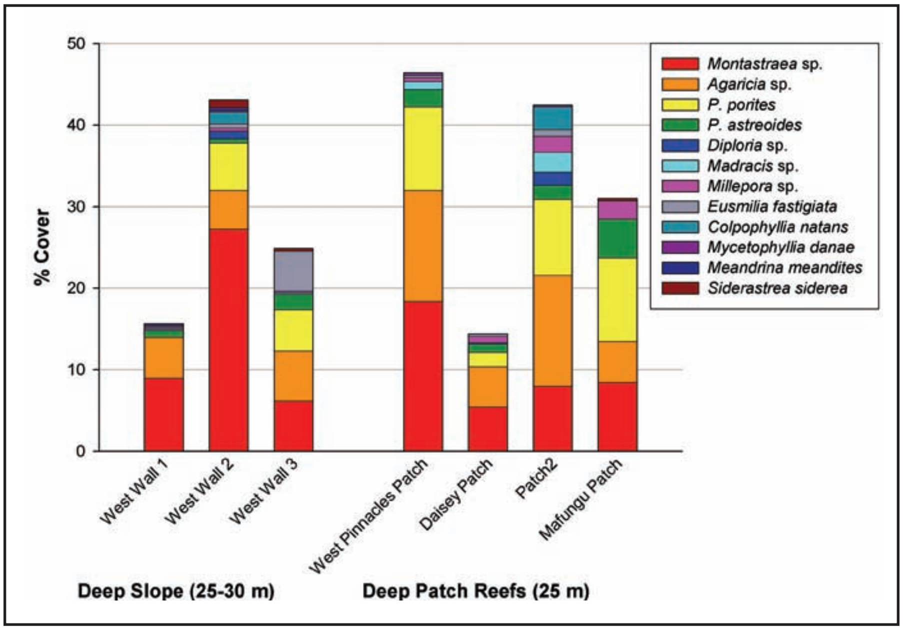

Figure 6.9. Coral species composition for deeper sites (>25 m) sampled via photo quadrats. Source: Miller et al., 2003.

Table 6.2. Percent of scleractinian coral colonies (>4 cm diameter) surveyed at subset of shallow sites (<20 m) that displayed various conditions. Overgrowth was designated only in cases where visible tissue damage was evident on the colony margins. "% w/snails" indicates the presence of corallivorous snail *Coralliophila abbreviata*; "% w/other predation" includes the presence of fishes and the fireworm, *Hermodice carunculata*. The only bleaching observed was mild (pale or splotchy appearance). Source: Miller et al., 2003.

SITE	# COLONIES	% W/ SNAILS	% W/ OTHER PREDATION	% W/ ALGAL OVER-GROWTH	% W/ SPONGE OVER-GROWTH	% W/ CORAL OVER-GROWTH	% W/ DISEASE	% W/ BLEACHING/ DISCOLORATION
NW Pt	185	0.5	1.6	5.4	1.6	0	0	2.2
North shelf	201	2.5	0	10.4	5	2	0	1.5
Lulu Bay	177	5.6	0	6.8	4.5	2.8	0	1.7
East Side	69	4.3	2.9	27.5	8.7	1.4	0	1.4
SE	179	2.8	0.6	7.8	4.5	2.2	0	1.7
West side	174	4	0	14.9	4.6	0	0	4
TOT/MEAN	**985**	**3.28**	**0.85**	**12.1**	**4.82**	**1.4**	**0**	**2.08**

Current threats to live coral include predation by the snail, *Coralliophila abbreviata*; invasion by the eroding sponge, *Cliona* sp.; and the presence of an unidentified disease affecting mainly brain corals (*Diploria* spp. and *Colpophyllia natans*). Densities of coral juveniles are similar to other areas in the northern Caribbean (e.g., United States Virgin Islands, Florida Keys, Jamaica). The crustose coralline algal flora is characteristic of one that is highly grazed (Begin and Steneck, 2003). Extended depth distributions were observed across diverse groups including elkhorn coral, benthic foraminifera (Williams, 2003), and crustose coralline algae (Begin and Steneck, 2003), with shallow water species being observed at much greater depths than typically observed for the Caribbean. This pattern is seemingly attributable to consistently clear waters surrounding Navassa.

ASSOCIATED BIOLOGICAL COMMUNITIES

Methods

Data on reef fish assemblages were collected using two complimentary methods (McClellan and Miller, 2003; Sandin, 2003). First, a stationary point sampling technique was used (Bohnsack and Bannerot, 1986). This fishery independent sampling and habitat characterization method, referred to here as the Reeffish Visual Census (RVC) approach, has been used extensively in the Florida Keys National Marine Sanctuary, Dry Tortugas National Park, and Biscayne National Park to provide baseline information and multispecies stock assessments of reef fishes (Ault et al., 1998, 2001, 2002). At each point, divers recorded fishes observed in five minutes within an imaginary cylinder extending from the surface to the bottom with a radius of 7.5 meters from the observer. Fish fork lengths (average, maximum, and minimum for each species) were estimated in centimeters by comparing fishes to a ruler attached perpendicular to the end of a scaled PVC rod. The observer also recorded new species to the sample, including rare or cryptic species, that were observed after the initial five minutes, along with estimates of length for selected species. Water temperature and visibility, presence or absence of fishing gear and artifacts, habitat characteristics, and numbers of marine turtles, spiny lobster (*Panulirus argus*), queen conch (*Strombus gigas*), and long-spined urchin (*Diadema antillarum*) were recorded if present in the sample area. For details, see McClellan and Miller (2003).

A second census technique was designed to accurately estimate the size distributions and standing crop biomass of the fish community, and to provide information on the reproductive and harvest potential from the location (Sandin, 2003). Thirty-seven 5 x 2 m quadrats were sampled between 10-30 m depths across Navassa. During a 12-minute sampling interval, one diver recorded the species and length of all site-attached fish present in a quadrat. Length was estimated to the nearest centimeter by sight and corroboration with direct measurement of nearby landmarks.

Mobile species were counted three times throughout the sampling interval, with counts taken each six minutes. The diver left the quadrat for one minute prior to the count, then recorded a scan sample of all fish in the column of water above the quadrat. Fast-moving fish were counted individually, noting species identity and length estimate. Lengths of fish were converted into biomass estimates based on published length-mass relations (available online at http://www.fishbase.org). The simple allometric function $M = \alpha L^{\beta}$ was used, where M is the mass of the fish, L represents fish standard length, and β and α are species-specific constants. Although this functional form is not ideal for estimating all size classes of a fish species, it provides an efficient size-specific mass scaling for this analysis. For species lacking specific allometric constants, parameters from a closely related, similarly shaped species were used. Final quadrat biomass estimates were calculated as the sum of all site-attached fish plus one third of the biomass of each fish counted in each of the three transient fish counts. The transient fish mass estimates thus were averaged across the three replicate scan samples. Fish densities and size-frequency distributions were equivalently computed as this weighted sum of resident and transient fish. This technique minimizes the overrepresentation of mobile species in long duration counts, yet still allows a reasonably efficient means to account for all types of fish on the reef.

Density of the long-spined sea urchin, *Diadema antillarum*, was quantitatively sampled in benthic transects described above. Lastly, population structure (size structure and sex ratio) of the corallivorous snail, *Coralliophila abbreviata*, was described based on animals collected haphazardly from a range of host coral species.

Results and Discussion

Navassa reef fish assemblages were numerically dominated by planktivores, which comprised 71% of all individual fishes in both census methods, and large size fish were virtually absent from the population structure of all species. This expedition added an additional 35 fish species to the 237 Navassa Island fish species reported by Collette et al. (2003).

One hundred and ten RVC samples were collected from around the Island (McClellan and Miller, 2003), and because of depth and bottom time constraints, only two samples could be taken per site. A total of 20,901 fishes representing 110 (and one unidentified) species (45 families) were recorded from these 110 stationary samples. The most abundant fish species, comprising 59.1% of the total number, were the blue chromis *Chromis cyanea* (n=4,912), creole wrasse *Clepticus parrae* (n=3,050), bluehead wrasse *Thalassoma bifasciatum* (n=2,950), and bicolor damselfish *Stegastes partitus* (n=1,449). Species with the highest frequency of occurrence from all of the samples were the blue tang *Acanthurus coeruleus* (88.2%), followed by the princess parrotfish *Scarus taeniopterus* (86.4%), redband parrotfish *Sparisoma aurofrenatum* (86.4%), bluehead wrasse (86.4%), bicolor damselfish (86.4%), and black durgon *Melichthys niger* (80.9%).

Only 12 individuals of larger grouper species (Graysby, red hind, yellowmouth, yellowedge, and tiger; no Nassau) were observed and 109 individuals of commercially important snappers were counted (8.6% of total biomass). Average size and density of grouper, snapper, and parrotfishes were substantially less in the more extensive 2002 survey than observed in 2000 at a subset of shallower habitats (Miller and Gerstner, 2002). Average length in the exploitable phase (>12 cm) of several fish families is given in Figure 6.10. Based on the second fish survey technique (weighted surveys of 37 5 x 2 m plots, Sandin, 2003), it was estimated that overall reef fish density was 5.6 ± 0.4 m^2 and overall fish biomass was 49.3 ± 4.6

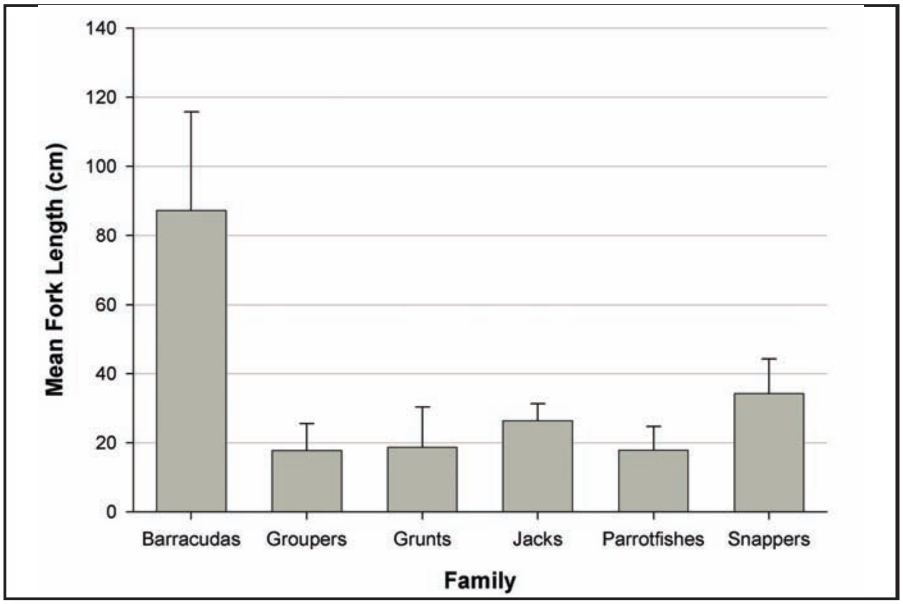

Figure 6.10. Mean lengths of selected families (in exploitable phase) observed in RVC samples. Family groups do not include individuals <12 cm that are too small to be captured with the fishing gear used (i.e., hook-and-line, traps, and nets). Source: McClellan and Miller, 2003.

g/m². For comparison, sampling via the same method in the Netherlands Antilles yielded biomass estimates ranging from 114-185 g/m² on heavily fished reefs.

Within the censused quadrats, most fish were planktivores (70.8%), followed distantly by herbivores (17.8%). The remaining trophic groups each accounted for less than 5% of the community density. In units of biomass, planktivores were the dominant contributors to reef community (36.3%). Piscivores and herbivores were the next most massive guilds (28.9% and 24.7%, respectively). Browsers composed 7.8% of community mass, and the two groups of invertebrate feeders each composed less than 2% of the total biomass (Figure 6.11). Guild-specific length-frequency distributions help to reconcile the disparity between guild contributions to density and biomass (Figure 6.12). Across all sampled fish, the average total length (TL) was 4.6 cm and only 11 individual fish (of the 1,227 counted in this approach) were larger than 24 cm standard length. Microinvertivores, planktivores, and macroinvertivores were each smaller than the community mean, averaging 3.5, 4.1, and 4.1 cm TL, respectively. Herbivores, browsers, and piscivores were each larger than the overall mean length (5.1, 8.6, and 17.7 cm TL respectively).

Quantitative transect surveys of *Diadema antillarum* at three shallow sites (7-10 m) and three mid-depth sites (17-25 m) showed they were present at mid-depth (0.16 ± 0.24 m²) and much rarer in the shallow reefs (0.02 ± 0.02 m²; Begin and Steneck 2003). A total of 18 *D. antillarum* were observed in the 110 five-minute RVC surveys across all habitat types (McClellan and Miller, 2003).

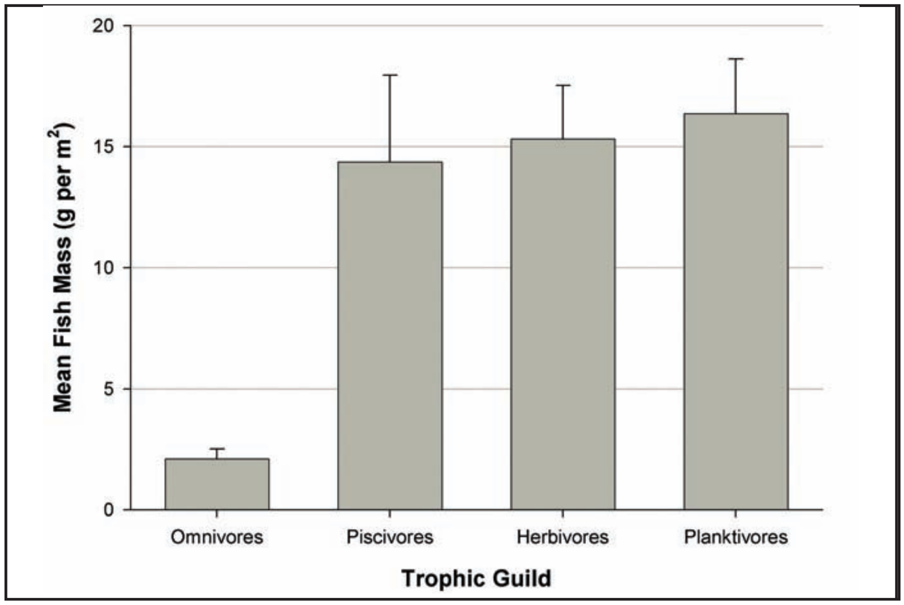

Figure 6.11. Diurnal fish biomass across trophic guilds. Averages and standard error (SE) were calculated from 37 10 m² quadrats. Fish were partitioned into trophic guilds based on the dominant food items consumed by adults. Source: Sandin, 2003.

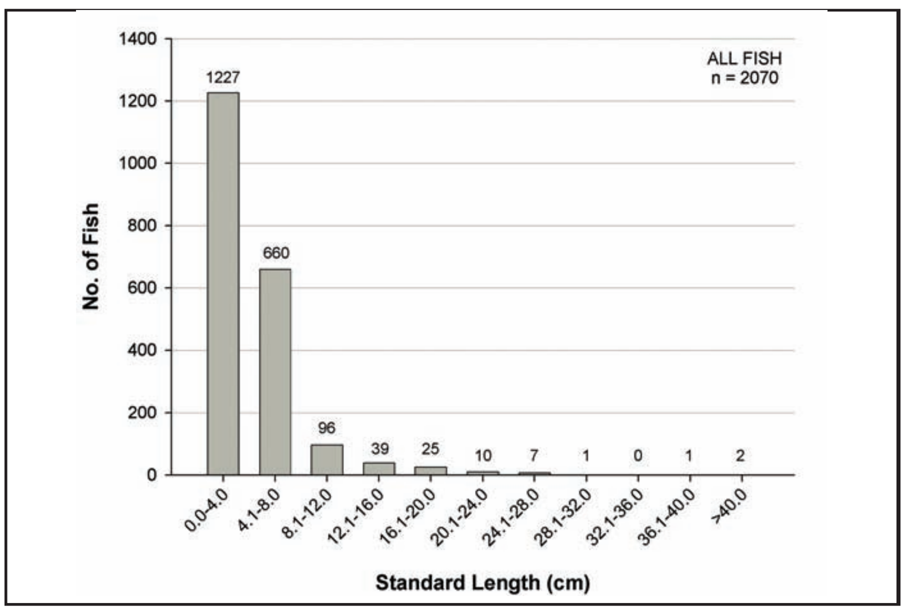

Figure 6.12. Fish community size frequency distribution observed via the weighted biomass surveys. Source: Sandin, 2003.

Table 6.3. Survey of the corallivorous snail, *Coralliophila abbreviata,* and its host corals: *Agaricia* spp., *Montastraea annularis* complex, and *Diploria* spp. from six sites around Navassa. Group size indicates the mean number of snails per colony. Source: Williams and Miller, 2003.

	SITE	TOTAL # HOST COLONIES (A)	TOTAL # INFESTED COLONIES (B)	OVERALL INFESTATION (=B/A)	AVERAGE GROUP SIZE
Agaricia spp.	North Shelf	98	4	4%	1.3
	NW Pt.	89	0	0%	–
	East Side	27	2	7%	5.7
	SE Pt.	78	5	6%	1.8
	W. Pinnacles	90	5	6%	1.8
	Lulu Bay	65	2	3%	1
	All Sites	**447**	**18**	**4%**	**2.2**
Montastraea annularis	North Shelf	5	1	20%	7
	NW Pt.	4	1	25%	4
	East Side	1	0	0%	–
	SE Pt.	13	0	0%	–
	W. Pinnacles	4	1	25%	5
	Lulu Bay	9	3	33%	2.3
	All Sites	**36**	**6**	**17%**	**3.8**
Diploria spp.	North Shelf	8	0	0%	–
	NW Pt.	3	0	0%	–
	East Side	1	1	100%	1
	SE Pt.	2	0	0%	–
	W. Pinnacles	0	0	0%	–
	Lulu Bay	27	5	19%	2
	All Sites	**41**	**6**	**15%**	**2**

Corallivorous snails, *Coralliophila abbreviata*, were found on *Agaricia* spp., *Montastraea* spp., and *Diploria* spp. to different degrees (Table 6.3) along transects in the shallower sites (<20 m). Relatively high infestation of the rarer host taxa (i.e., *Diploria* spp. and *Montastraea* spp.) compared to lower infestation of the numerically dominant *Agaricia* spp. (Table 6.3) suggests that some level of host preference is being expressed by these predators. Snails haphazardly collected from a range of host taxa showed substantial variation in mean size (Figure 6.13) and sex ratio consistent with reports from other areas of the Caribbean (Baums et al., 2003; Bruckner et al.,1997).

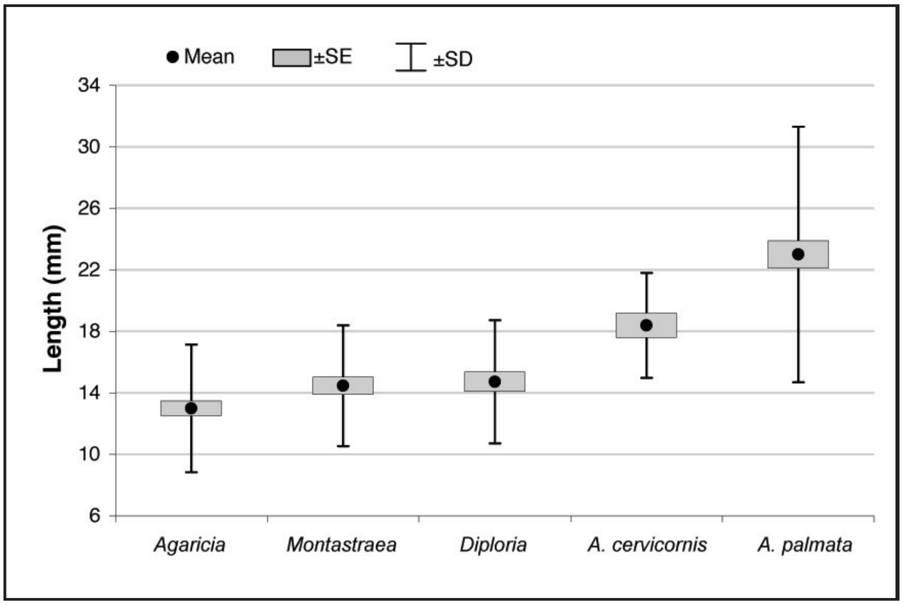

Figure 6.13. Box-whisker plot showing the mean, SE, and SD for snails collected from various coral hosts. Source: Williams and Miller, 2003.

Although no quantitative data on queen conch, *Strombus gigas*, have been collected, intense harvest of mature conch populations was observed (Miller et al., 2003). Conch population structure should be a high priority for future data collection.

CURRENT CONSERVATION MANAGEMENT ACTIVITIES

Navassa Island and a 12-mile radius of marine habitat became the 517th NWR on April 22, 1999. Navassa is one of nine NWRs administered by the USFWS as part of the Caribbean Islands NWR complex and the only refuge encompassing marine habitat. The Refuge complex will begin comprehensive conservation planning in 2004 to produce a 15-year management plan for each refuge including Navassa. The planning process will be open to public participation and comment. Thus, while Navassa does not yet have an official management plan, annual expeditions to the Refuge have produced a substantial amount of biological information which will serve as the framework for the management plan.

Six expeditions have been made to the Island to date including two land-based trips. These trips concentrated on inventory and documentation of the flora and fauna of the Island and the establishment of vegetation monitoring plots. Hunting and camping on the Island by transient Haitian fishermen have led to frequent wildfires which have been detrimental to the maintenance of forest habitat necessary for migratory songbirds and nesting seabirds.

The four marine expeditions to date have involved partners including NOAA Fisheries, U.S. Geological Survey, Ocean Conservancy, Shedd Aquarium, American Museum of Natural History, Smithsonian Institution's National Museum of Natural History, and various universities. Permanent transects have now been established around the Island to monitor changes in invertebrate and coral abundance and diversity.

Fishing pressure involving hand lines and traps by transient Haitians has been a concern since 1998. General observations have led to additional questions and further assessment and quantification is needed. The logistical difficulties involved in visiting the Island, language barriers, and international politics are all management handicaps. The USFWS has been fortunate to have so many dedicated partners who have facilitated trips to the Refuge and have contributed much of the research effort. It is hoped that annual expeditions to the Refuge will continue and that additional partners, including Haitian nationals, will be recruited.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

Navassa Island NWR encompasses approximately 290,000 acres of marine habitat in the heart of the Caribbean. Declining coral reef habitat conditions throughout the Caribbean underscores the conservation importance of this Refuge's marine ecosystem. Multinational fishing pressure within this largely marine refuge remains unquantified, but certain. Continuous heavy fishing pressure in the immediate vicinity of the Island appears to be having deleterious effects on coral reef ecosystems. Immediate implementation of systematic monitoring is needed to document ongoing changes. Of particular importance is the collection of quantitative fishery data including catch and effort information. This effort needs to include catch of the critically endangered Hawksbill sea turtles. Regular funding for the Navassa Island NWR is necessary for the accomplishment of this critical conservation effort.

While fishing is clearing having a strong impact on Navassa reef ecosystems, Navassa's small size and high physical disturbance regime imply that its communities will show strong temporal variation. The interpretation of "snapshot" surveys of reef condition is problematic and therefore subsequent periodic surveys must be undertaken at Navassa in order to draw meaningful conclusions regarding possible trends in reef condition.

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