Rapid assessment and monitoring of coral reef habitats in the Florida Keys National Marine Sanctuary

Quick Look Report: Summer 2000 Zone Monitoring

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Project Summary:

As part of a continuing study of no-fishing zones and reference areas in the Florida Keys National Marine Sanctuary, scientists from NURC/UNCW conducted large-scale surveys of coral reef and hard-bottom habitats in the lower Keys region during 2000. Forty-five sites representing seven habitat types from the shoreline to the deeper fore reef (2-12 m depth range) were surveyed from southwest of Key West to Big Pine Key. Aggregate patch reefs (4 sites near Looe Key RO), shallow fore reef (5 sites), and deeper fore reef (15) sites were re-surveyed as part of a three-year data set on offshore zones and reference areas. An additional 21 sites were surveyed inside and outside of Western Sambo Ecological Reserve and included surveys of nearshore hard-bottom, mid-channel patch reef, offshore patch reef, and back reef rubble habitats. The sampling effort was allocated with respect to habitat type, no-fishing zones, and adjacent reference areas. At each site, four random points were selected for transect deployment, and variables measured included coverage, species richness, density, size, and condition of reef benthos. In addition, a pilot study of fishing gear and other debris was undertaken, as well as *in situ* measurements of topographic complexity. Summary statistics and future plans for monitoring no-fishing zones in the FKNMS are presented.

Goals and Objectives:

The two main objectives for 2000 sampling in the lower Keys region were: 1) to continue annual surveys since 1998 of offshore no-fishing zones and reference sites; and 2) to explore cross-shelf patterns in community structure and condition of coral reefs within and near the Western Sambo Ecological

Reserve. Table 1 lists the survey sites sampled during June-September 2000. Forty-five sites were selected using a stratified random sampling approach from southwest of Key West to Big Pine Key (Figure 1). Five of the eight no-fishing zones in the lower Keys region of the FKNMS were included (Sand Key SPA, Western Sambo ER, Eastern Sambo RO, Looe Key RO, and Looe Key SPA). Seven habitat types were surveyed from the shoreline to the deeper fore reef (12 m depth) across the continental shelf: nearshore hard-bottom, mid-channel patch reef, offshore patch reef, aggregate offshore patch reef, back reef, shallow fore reef (4-7 m), and deeper fore reef (8-12 m). Two main questions were addressed from the 2000 surveys:

- How does the structure and condition of coral reef and hard-bottom habitats differ from nearshore to offshore in the lower Keys?
- What differences exist in the structure and condition of reefs in no-fishing zones and reference areas?

A suite of variables was measured at each survey site (Table 2). In addition to variables measured during 1999, we conducted pilot studies to address the extent and impacts of fishing gear and other marine debris, as well as method development for quantifying topographic complexity of the reef substratum. Reef fish surveyors from RSMAS-University of Miami and NOAA/National Marine Fisheries Service conducted concurrent surveys of abundance and size structure at most of the same locations. All surveys were conducted using SCUBA. Fieldwork was supported using The Nature Conservancy's R/V *Oak Leaf* and NURC/UNCW's vessels. Figures 2-9 and Table 3 summarize many of the significant findings from the 2000 sampling effort in the lower Keys.

Summary of Significant Results:

Benthic cover (Figures 2-3)

Benthic cover was measured by surveying 100 points per transect on four replicates in each site. Figures 2 and 3 illustrate patterns in the coverage of stony corals, sponges, total algae, and algal functional groups by habitat type and between no-take zones and reference areas by habitat type. Mean percent coral cover, except for very low values on nearshore hard-bottom, decreased with distance from shore. Mean coral cover was greatest on the three types of patch reefs surveyed in Hawk Channel (10-15%), and was lower in back reef and fore reef habitats (< 10%). Greater coral cover on patch reefs reflected the relatively high densities and large colony sizes of many reef framework species, most notably *Montastraea cavernosa*, *Siderastrea siderea*, *M. faveolata*, *M. annularis*, *Diploria* spp., and *Colpophyllia natans*. Comparisons of mean coral cover between no-take zones and reference areas illustrated different patterns with respect to distance from shore. Mean coral cover on mid-channel patch reefs, offshore patch reefs, and back reef areas was lower in reference areas compared to patch reefs within no-take zones, while mean coverage was greater in no-take zones for aggregate offshore patch reefs, the shallow fore reef, and the deeper fore reef.

Mean percent sponge cover exhibited a similar cross-shelf pattern to corals, with the greatest mean coverage (12-15%) on patch reefs, and the lowest values (< 5%) on nearshore hard-bottom, back reef, and fore reef habitats. This pattern probably reflects a combination of low physical disturbance and abundant particulate matter in Hawk Channel relative to the wave-swept environment of the reef tract. Many of the patch reef sites had abundant and speciose assemblages of rope and sprawling sponges. Comparisons of sponge cover between no-fishing zones and reference areas by habitat type did not illustrate any clear patterns. Sponge cover tended to be greater on patch reefs in no-take zones, while reference areas offshore had greater sponge cover.

Estimates of mean percent algal cover, representing all functional groups, clearly demonstrate that algae are the dominant components of the substratum (> 70% for 5 of the 7 habitat types). Lower mean

algal cover on mid-channel and aggregate offshore patch reefs reflects the predominance of sand combined with large areas of large coral colonies. Nearshore hard-bottom and offshore fore reef habitats had the greatest algal cover (> 75%). Comparisons between no-fishing zones and reference areas indicated that total algal cover was mostly similar for the majority of the habitat types. To further explore patterns in algal cover, patterns for three dominant functional groups were plotted with respect to habitat and management types (Figure 3). Algal turf cover was similar among all habitat types except nearshore hard-bottom, which, in contrast, was dominated by green calcareous algae (predominately *Penicillus* spp.) and red frondose algae (predominantly *Laurencia* spp.). Few differences were evident in the mean coverage of three of the algal functional groups between no-take zones and reference areas. One notable exception was the relatively high cover (50%) of brown frondose algae (especially *Dictyota* spp.) in deeper fore reef sites within no-take zones. This pattern is probably indicative of the algal colonization of former staghorn coral (*Acropora cervicornis*) terraces in many locations in the lower Keys (e.g. Sand Key, Western Sambo, Eastern Sambo).

Species richness (Figure 4)

Species richness or species density (no. species per 20 m^2) was quantified by counting the number of species of stony corals, gorgonians, and sponges on four paired transects per site. For stony corals, a range of 10-18 species per 20 m^2 occurred among the seven habitat types (Figure 3). Mid-channel and aggregate offshore patch reefs had the greatest species richness, while nearshore hard-bottom and back reef habitats had the lowest (6-8 fewer species per 20 m^2 than most patch reefs). Generally greater species richness of stony corals was found in nearshore hard-bottom, aggregate offshore patch reef, shallow fore reef, and deeper fore reef sites within no-take zones compared to reference areas. In contrast, species richness between no-take zones and reference areas was more similar for mid-channel and offshore patch reefs. Cross-shelf patterns in gorgonian and sponge species richness were similar to stony corals (Figure 3). An average of 12-19 species per 20 m^2 were found among the habitat types, with the greatest species richness on mid-channel and aggregate offshore patch reefs, and the lowest on nearshore hard-bottom and back reef habitats (6-8 fewer species). Greater gorgonian species richness was found on nearshore hard-bottom, aggregate offshore patch, shallow fore reef, and deeper fore reef sites within no-take zones compared to reference areas. An average of eight to 27 sponge species per 20 m^2 were recorded among the habitat types, with the greatest richness on aggregate offshore patch reef and deeper fore reef (8-12 m) habitat types. Like stony corals and gorgonians, the lowest sponge species richness was documented in hard-bottom and back reef habitats (10-19 fewer species). Nearshore hard-bottom, mid-channel patch reef, and offshore patch reef sites within no-take zones had greater sponge species richness than reference areas. In contrast, reference aggregate patch reefs and deeper fore reef sites had greater sponge species richness than sites within no-take zones.

Gorgonian density (Figure 5)

An average of nine to 18 gorgonian colonies per m^2 was recorded among the seven habitat types (Figure 4). Nearshore hard-bottom, back reef, and shallow fore reef habitats had the lowest gorgonian densities, while all three patch reef types had the greatest, in many cases twice the densities of other habitat types. Mean gorgonian density was lower in reference sites compared to no-take zones for offshore (back reef to deeper fore reef) habitats, while no-take zones had greater densities for nearshore hard-bottom to offshore patch reef types.

Coral density (Figure 5)

Mean densities of scleractinian corals ranged from 2-14 per m^2 among habitat types, with the greatest densities on mid-channel and aggregate offshore patch reefs (Figure 4). Lowest densities were found on

nearshore hard-bottom, especially reference sites east of Western Sambo Ecological Reserve. For five of the habitat types, mean coral density was relatively similar between no-take zones and reference sites.

Juvenile coral density (Figure 5)

Mean densities of juvenile corals (those less than 4 cm diameter) ranged from 4-10 per m^2 among habitat types. Contrary to expectations, highest densities were recorded nearshore, but consisted mostly of small colonies of *Siderastrea radians* and *Cladocora arbuscula*. Lowest juvenile densities were found in back reef and fore reef habitat types.

Urchin density and size (Figure 6)

Five species of urchins were sampled in belt transects. Low densities were found for all species, especially *Diadema antillarum* (< 0.02 individuals per m2). *Echinometra viridis* was locally abundant on mid-channel patch reefs north of Maryland Shoal.

Anemone and corallimorpharian density (Figures 7-8)

Five actinians and two corallimorpharians were sampled in belt transects during 2000. Forty-six individuals of *Bartholomea annulata* were recorded, and site-level density was as high as 0.08 individuals per m^2. The highest site-level density was recorded from a deeper fore reef site within Western Sambo Ecological Reserve. *B. annulata* was recorded within transects at 49% of the sites and found in all habitat types except offshore patch reefs. Mean densities were greatest on mid-channel patch reefs, followed by deeper fore reef and aggregate offshore patch reef habitats. Mid-channel patch reef and back reef habitats had greater mean densities than offshore patch reefs. Like platform margin surveys in the middle and upper Keys during 1999, *Condylactis gigantea* was also relatively rare in the lower Keys. Only five individuals were recorded, and the maximum site-level density was only 0.025 individuals per m^2 in the Middle Sambo back reef. *C. gigantea* was absent from over 90% of the sites sampled, and only occurred in two of the seven habitat types (aggregate offshore patch reef and back reef). Similar to two other actinians (*C. gigantea* and *S. helianthus*), *Epicystes crucifera* was rarely encountered in the lower Keys. Only four individuals were found within transects, and none were recorded at 42 of the 45 sites (93%) and four of the seven habitat types. Interestingly, *E. crucifera* was present in all three patch reef types surveyed. The greatest mean site-level density was recorded from a mid-channel patch reef north of Maryland Shoal. *Lebrunia danae* was the second most frequently encountered actinian (35 individuals found) in the lower Keys and was recorded from 18 of the 45 sites (40%) surveyed. The maximum site-level density was 0.08 individuals per m^2 in the deeper fore reef habitat of Sand Key SPA. Mean densities in shallow and deeper fore reef habitats were greater than in nearshore hard-bottom. Additionally, this species was only recorded from aggregate patch reef, shallow fore reef, and deeper fore reef habitat types. Of the actinians surveyed in this study, *Stichodactyla helianthus* was the most rare, with only one individual recorded from 45 sites. The single specimen, 19 cm in diameter, was found in a rubble-hard-bottom matrix community north of Pelican Shoal.

The two corallimorpharians recorded from the lower Keys, *Discosoma sanctithomae* (169 individuals) and *Ricordea florida* (2,930 individuals) were very abundant, at least locally in some sites, relative to the five actinians encountered. The greatest site-level densities of *D. sanctithomae* were from two back reef sites (1.31-1.88 individuals per m^2) north of Pelican Shoal and one mid-channel patch reef (1.13 individuals per m^2) north of Maryland Shoal. These sites accounted for 82% of all *D. sanctithomae* observed in the lower Keys. Although locally abundant (13% of sites had mean densities > 0.1 per m^2), *D. sanctithomae* was not found in 36 of the 45 sites (80%) and three of the seven habitat types (nearshore hard-bottom, aggregate patch reef, and shallow fore reef habitat types). With the exception of significantly greater mean densities on reference mid-channel patch reefs relative to no-fishing zones

(Table 3), no differences by management type were apparent for other habitat types. Like some of the actinians, the distribution of *D. sanctithomae* suggested high habitat specificity; a disproportionate number of individuals were found on mid-channel patch reefs (30% of individuals versus 4% of sampling effort) and back reef habitats (60% of individuals versus 22% of effort). *Ricordea florida* was clearly the most abundant corallimorpharian, with nearly 3,000 individuals recorded from 45 sites. The mean site-level density was as high as 8.45 individuals per m^2. Four aggregate patch reefs, with mean densities ranging from 6.2-8.45 individuals per m^2, accounted for nearly 80% of *R. florida* recorded. *R. florida* was present in 33 of the 45 sites (73%) and all seven habitat types, and nearly 50% of the sites had mean densities > 0.1 individuals per m^2. Mean densities were significantly greater on aggregate patch reefs than all other habitat types. Differences by management type were only apparent for mid-channel patch reefs, where mean density was greater in reference areas (Table 3).

Fishing gear and other marine debris (Figure 9)

We collected preliminary data on fishing gear and other marine debris that relates to three issues. First, what is the spatial extent or frequency of ghost fishing gear and other debris at multiple spatial scales in the Florida Keys? Second, what factors, such as habitat type (depth) or management regime (closed or open to fishing) affect the spatial variability of marine debris occurrence? Third, what are the biological impacts of marine debris, especially from remnant commercial and recreational fishing gear, on reef-associated organisms such as corals and sponges? Nine major categories representing 18 individual types of debris items were recorded from 45 sites encompassing 8,040 m^2. Of the 110 debris occurrences, monofilament line (38%), wood from remnant lobster pots (20%), combined fishing weights, leaders, and hooks (16%), and rope from lobster traps (13%) were the most frequently encountered, representing nearly 90% of all debris recorded. Not surprisingly, except for back reef sites, all other habitat types had greater mean debris density than nearshore hard-bottom. Aggregate offshore patch reefs had more debris than mid-channel patch reef, back reef, and deeper fore reef habitats. The mean occurrence of hook-and-line gear was greater on deeper fore reef habitats relative to nearshore hard-bottom and back reef habitats. Although we assumed that no-fishing zones would have lower debris densities, especially for fishing gear, no apparent differences in mean occurrence for combined debris types, hook-and-line gear, and remnant lobster traps were evident between no-fishing zones and reference sites by habitat type (Figure 8).

Debris types causing the greatest frequency of biological impacts were hook-and-line gear (68%), especially monofilament line (58%), followed by debris from remnant lobster traps (26%), especially rope (21%). Hook-and-line gear accounted for the majority of impacts to branching gorgonians (69%), fire coral (83%), sponges (64%), and colonial zoanthids (77%) relative to other debris types. Remnant lobster traps were also important, accounting for 64% of the stony corals impacted, 22% of gorgonians, and 29% of sponges. Branching gorgonians and sponges were disproportionately more affected than other biota, while scleractinian corals and colonial zoanthids were less so.

Plans for Use of the Data:

We have prepared a draft proposal for sampling during the summer of 2001 that includes three objectives:

- To determine the structure and condition of nearshore hard-bottom and coral reef communities Sanctuary-wide, focusing on nearshore hard-bottom, mid-channel patch reef, and offshore patch reef communities in the lower, middle, and upper Keys regions.
- To determine the structure and condition of shallow fore reef (< 5 m depth) communities Sanctuary-wide, focusing on reefs built by elkhorn coral (*Acropora palmata*) in the lower, middle, and upper Keys regions.
- To determine the structure and condition of deeper fore reef (15-20 m depth) communities throughout the Florida Keys.

Details of the proposal are available in a separate document. Part of the effort in 2001 will be to further optimize our sampling design, which will help us implement another Keys-wide sampling of the majority of the no-take zones in 2002. The 2002 effort, combined with the previous three years of work, is directed to provide important information for the review of the zoning action plan.

The following list identifies progress made with publications:

Manuscripts completed and/or submitted

Chiappone M, Swanson DW, Miller SL. Large-scale abundance and distribution patterns of anemones and corallimorpharians in coral reef habitats of the Florida Keys. *Bulletin of Marine Science*

Chiappone M, White A, Swanson DW, Miller SL. Occurrence and biological impacts of fishing gear and other marine debris in the Florida Keys. *Marine Pollution Bulletin*

Miller SM, Swanson DW, Chiappone M. Multiple spatial scale assessment of coral reef and hard-bottom community structure in the Florida Keys National Marine Sanctuary. *Proceedings of the Ninth International Coral Reef Symposium*, Bali, Indonesia

Miller SM, Swanson DW, Chiappone M, Ault JS, Smith SG, Meester G, Luo J, Franklin EC, Bohnsack JA, Harper D, McClellan D. An extensive deep reef terrace on the Tortugas Bank, Florida Keys National Marine Sanctuary. *Coral Reefs*

Manuscripts planned for completion by April 2001

Chiappone M, Swanson DW, Miller SL (in preparation) Urchin density and size distribution in the Florida Keys: Platform margin and cross-shelf patterns. *Marine Ecology Progress Series*

Chiappone M, Swanson DW, Miller SL, Ault JS, Smith SG (in preparation) Comparatively high densities of the long-spined sea urchins in the Dry Tortugas, Florida. *Coral Reefs*

Chiappone M, Swanson DW, Miller SL, Smith SG (in preparation) Large-scale surveys indicate poor recovery of *Diadema antillarum* on offshore reefs in the Florida Keys. *Coral Reefs*

Miller SM, Swanson DW, Chiappone M (in preparation) Dynamics of acroporid reefs in the Florida Keys at multiple spatial and temporal scales: Implications of a regime shift. *Coral Reefs*

Miller SM, Swanson DW, Chiappone M, Smith SG, Ault JS (in preparation) Rapid assessment methods and rationale for ecological assessment and monitoring of hard-bottom communities in no-take zones of the Florida Keys National Marine Sanctuary. NOAA/NOS, Marine Sanctuaries Division, Silver Spring

Smith SG, Ault JS, Miller SL, Swanson DW, Chiappone M (in preparation) An efficient sampling design methodology for multiple spatial scale assessment and monitoring of coral reefs in the Florida Keys. *Marine Ecology Progress Series*

Swanson DW, Chiappone M, Miller SL (in preparation) Landscape distribution patterns of anemones and corallimorpharians (Anthozoa, Zoantharia) in the Florida Keys. *Coral Reefs*

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Table 1. NURC/UNCW sampling effort in the lower Keys region during June-September 2000.

Habitat type	**Management regime**	**No. sites (% total effort)**
Nearshore hard-bottom	Western Sambo Ecological Reserve	2 (4.4)
	Reference sites	
	East of Western Sambo ER	2 (4.4)
Mid-channel patch reef	Western Sambo Ecological Reserve	2 (4.4)
	Reference sites	
	North of Maryland Shoal	2 (4.4)
Offshore patch reef	Western Sambo Ecological Reserve	2 (4.4)
	Reference sites	
	North of Sand Key SPA	2 (4.4)
Offshore aggregate patch reef	Looe Key Research Only	2 (4.4)
	Reference sites	
	West of Looe Key RO	2 (4.4)
Back reef rubble/matrix community	Western Sambo Ecological Reserve	1 (2.2)
	Sand Key SPA	1 (2.2)
	Reference sites	
	West of Sand Key SPA	1 (2.2)
	West of Middle Sambo Reef	1 (2.2)
	Middle Sambo Reef	1 (2.2)
	North of Pelican Shoal	2 (4.4)
	North of Maryland Shoal	2 (4.4)
Shallow fore reef (4-7 m depth)	Looe Key SPA	2 (4.4)
	Reference sites	
	Marker 32	1 (2.2)
	Middle Sambo Reef	1 (2.2)
	American Shoal	1 (2.2)
Deeper fore reef (8-12 m depth)	Sand Key SPA	2 (4.4)
	Western Sambo Ecological Reserve	2 (4.4)
	Eastern Sambo Research Only	2 (4.4)
	Reference sites	
	Western Dry Rocks	1 (2.2)
	South of Sand Key SPA	2 (4.4)
	Southwest of Western Sambo	1 (2.2)
	East of Maryland Shoal	1 (2.2)
	West of American Shoal	1 (2.2)
	American Shoal	1 (2.2)
	East of American Shoal	1 (2.2)
	Big Pine Shoal	1 (2.2)
Total		45 (100.0)

Table 2. Methods and variables measured by NURC/UNCW in the lower Keys region of the FKNMS during June-September 2000. Except for mid-channel and offshore patch reefs (10 m long transects), 25 m transects were used in all other habitat types.

Variable	**Method**	**Sampling size (units) per site**
Cover (*in situ*)	Linear intercept (100 points)	4 transects (% cover)
Stony corals by species		
Algal functional groups		
Gorgonian morphology		
Sponges		
Other biota		
Abiotic components		
Cover (archival)	Video of 0.4 m x 25 m	4 transects
Species richness	0.4 m x 25 m	4 paired transects (no. species/20 m^2)
Stony corals		
Gorgonians		
Sponges		
Gorgonian and coral density	0.4 m x 25 m	2 (no. colonies per m^2)
Coral size and condition	0.4 m x 25 m	2 (size distribution, condition frequency)
Juvenile coral density and size	0.65 m x 0.48 cm quadrats	10 quadrats per transect (no. juveniles/m^2)
Other cnidarian abundance	0.4 m x 25 m	4 paired transects (no. individuals/20 m^2)
Urchin abundance and size	0.4 m x 25 m	4 paired transects (no. individuals/20 m^2)
Topographic complexity	0.4 m x 25 m	4 transects (vertical relief, relief distribution)
Gorgonian height distribution	0.4 m x 25 m	2 transects (height distribution)
Debris density and impacts	2 m x 25 m	4 transects (no. items and impacts/m^2)

Table 3. Statistical differences ($P < 0.05$) in mean percent cover, species richness (no. species/20 m^2) or density (no./m^2) for variables measured in the lower Keys region during 2000 between pooled no-take zones (NTZ) and reference areas (REF) by habitat type. No significant differences for any of these variables were detected between no-take zones and reference areas in offshore patch reef, back reef rubble, shallow fore reef, and deeper fore reef habitat strata.

Variable	**Habitat strata**		
	Nearshore hard-bottom	**Mid-channel patch reef**	**Aggregate offshore patch reef**
Percent cover			
Total algae			
Stony corals			
Sponges			
Species richness			
Stony corals			
Gorgonians		NTZ > REF	
Sponges			
Gorgonian density	NTZ > REF		
Stony coral density	NTZ > REF		
Juvenile coral density	NTZ > REF		
Urchin density			
Diadema antillarum			
Echinometra lucunter			
E. viridis			
Eucidaris tribuloides	NTZ > REF		
Anemone density			
Bartholomea annulata			
Condylactis gigantea			
Epicystes crucifera			
Lebrunia danae			
Corallimorpharian density			
Discosoma sanctithomae		REF > NTZ	
Ricordea florida		REF > NTZ	
Spiny lobster density			
Marine debris density			
Combined debris			
Lobster traps			
Hook-and-line gear			
Marine debris impacts			
Scleractinian corals			NTZ > REF
Sponges		NTZ > REF	
Palythoa mammilosa		NTZ > REF	

Figure 1. Sampling locations in the lower Keys region of the FKNMS during June-September 2000 by NURC/UNCW, with location of designated no-fishing zones (Ecological Reserve, ER and Sanctuary Preservation Areas, SPAs).

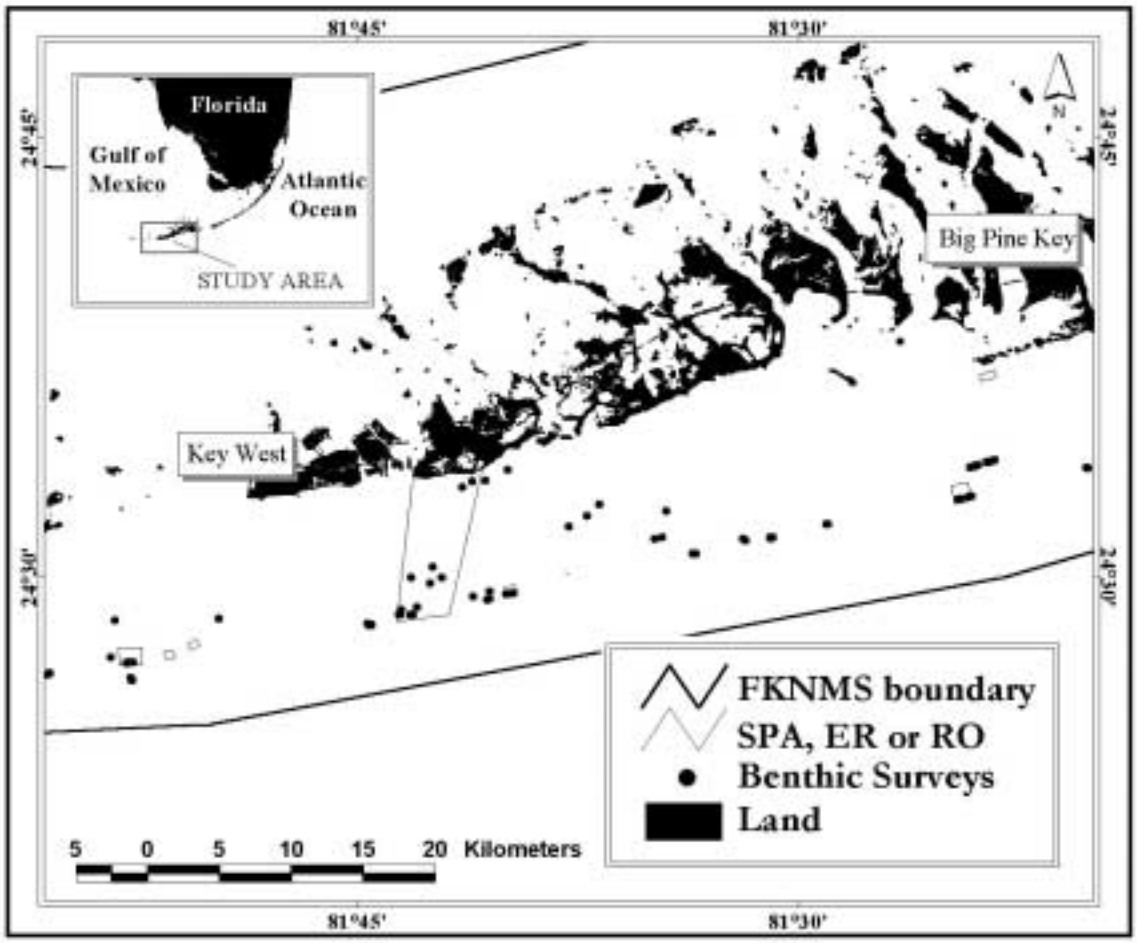

Figure 2. Mean (± 1 SE) percent cover of stony corals, sponges, and total algae by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. Habitat types are: HB = nearshore hard-bottom, MC = mid-channel patch reef, OP = offshore patch reef, AP = aggregate offshore patch reef, BR = back reef rubble, SF = shallow fore reef (4-7 m), and DF = deeper fore reef (8-12 m).

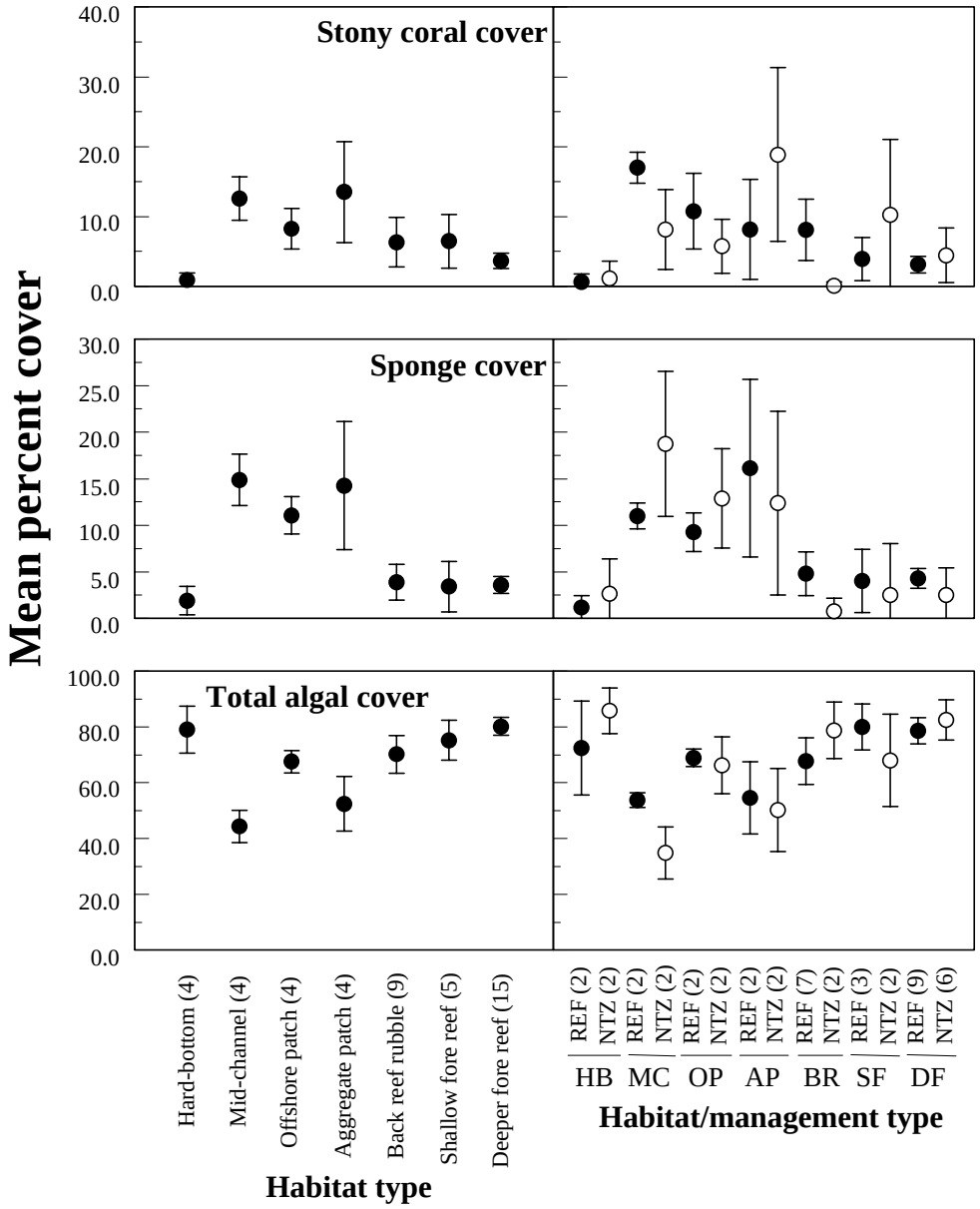

Figure 3. Mean (± 1 SE) percent cover of algal turf, brown frondose algae (e.g. *Dictyota* spp.), and green calcareous algae (e.g. *Halimeda* spp.) by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

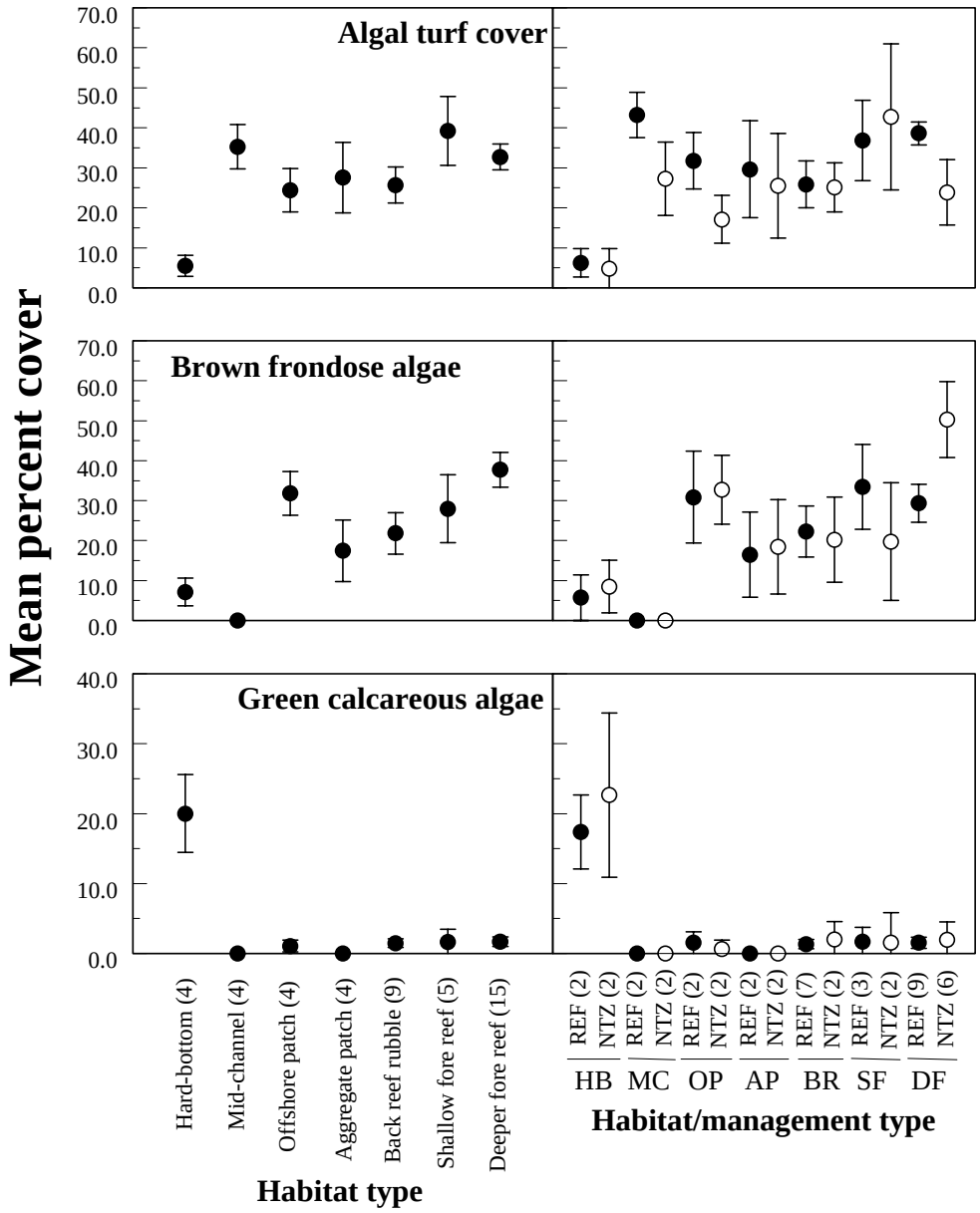

Figure 4. Mean (± 1 SE) species richness (no. of species per 20 m^2) of stony corals, gorgonians, and sponges by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

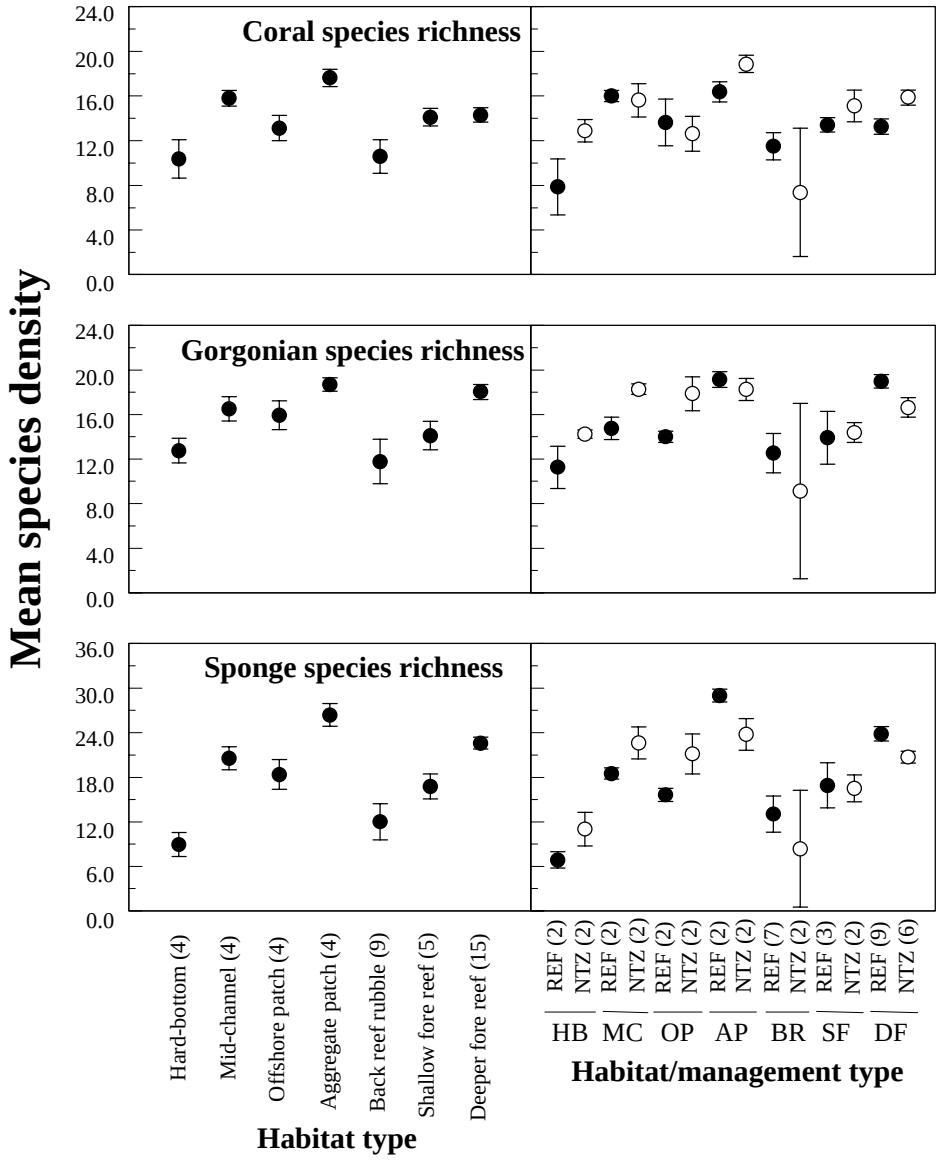

Figure 5. Mean (± 1 SE) density (no. per m^2) of gorgonians, scleractinian corals (> 4 cm diameter), and juvenile scleractinian corals (< 4 cm diameter) by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

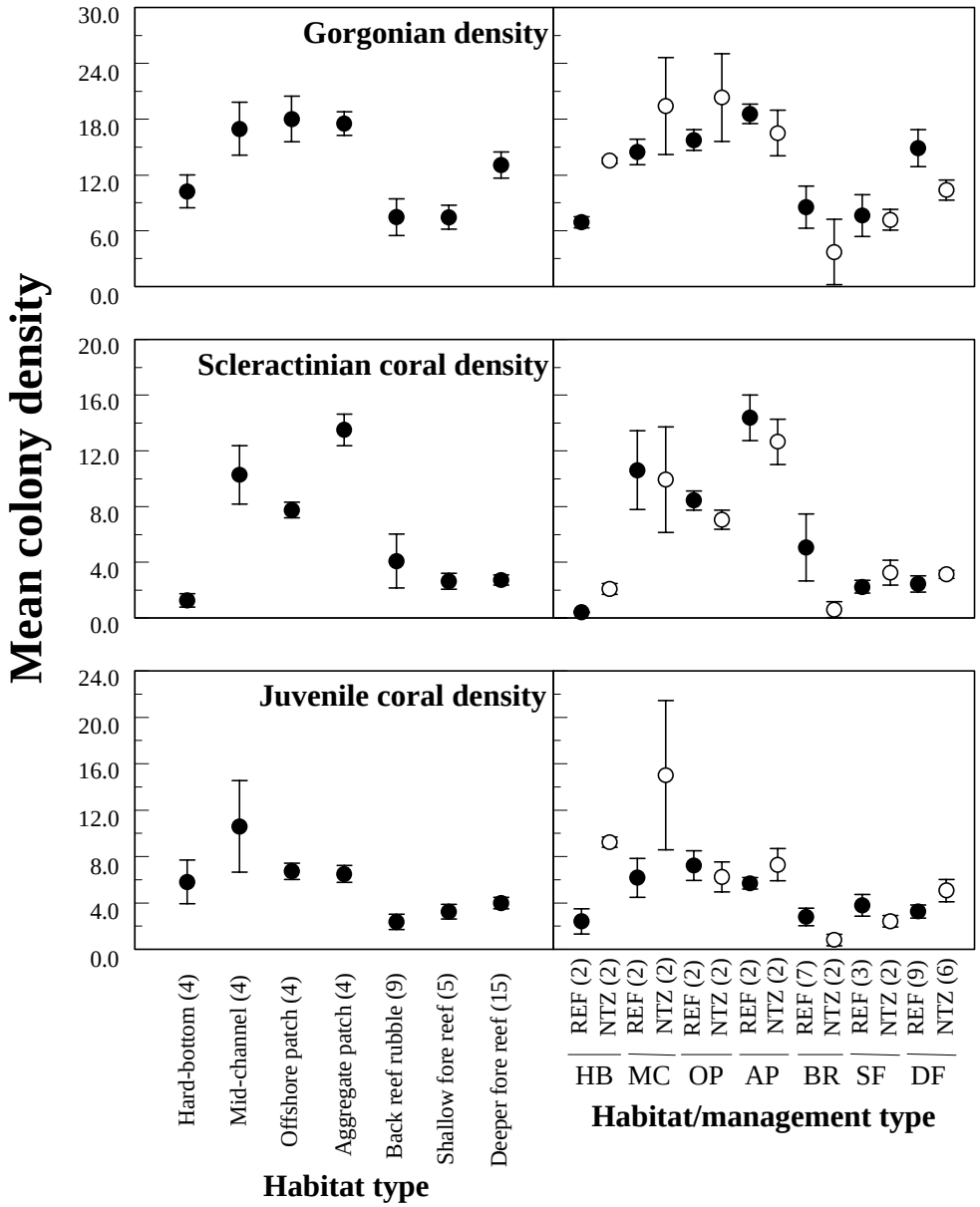

Figure 6. Mean (± 1 SE) densities (no. per m^2) of the urchins (Echinometra, Echinoidea) *Diadema antillarum*, *Echinometra viridis*, and *Eucidaris tribuloides* by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

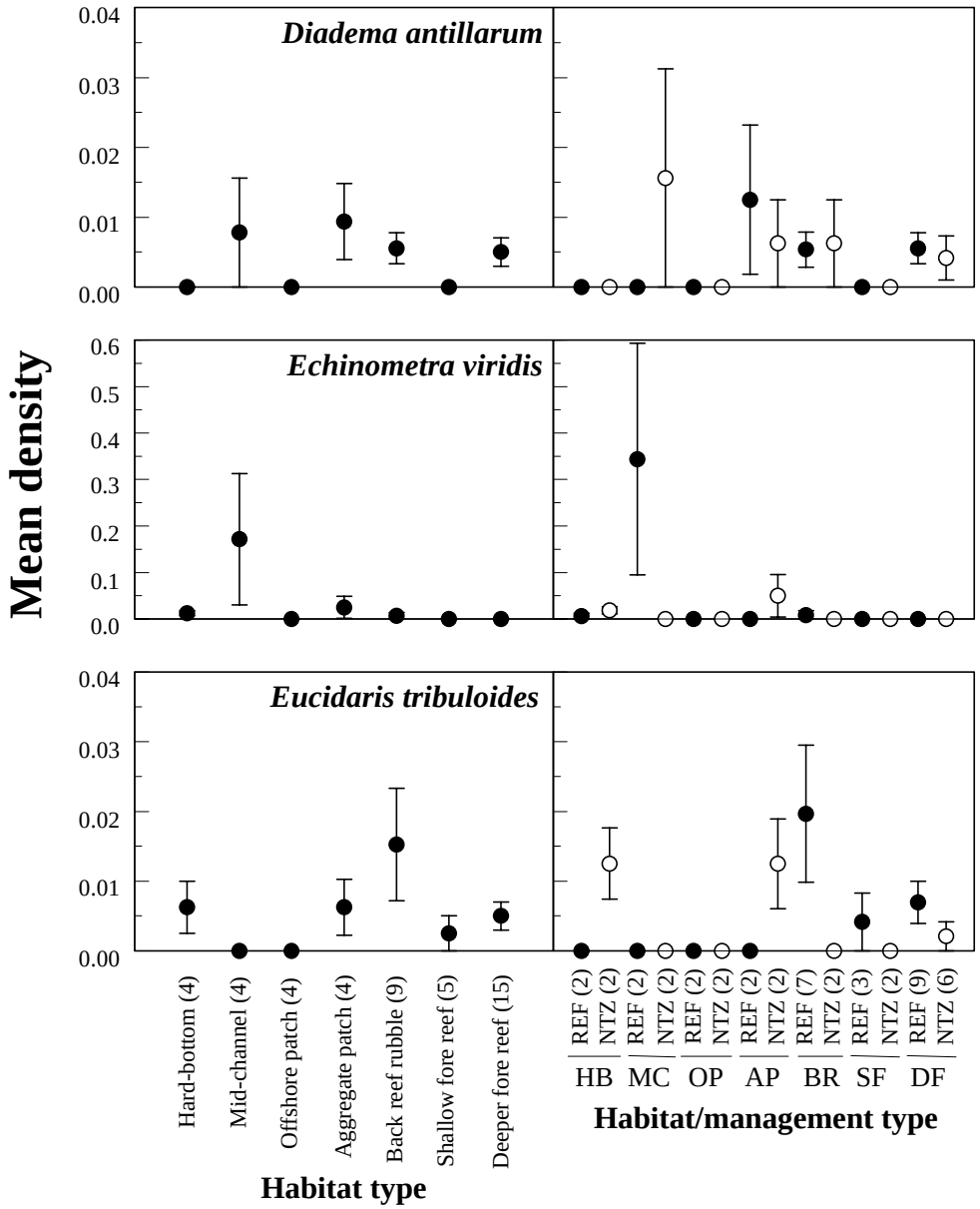

Figure 7. Mean (± 1 SE) densities (no. per m^2) of the anemones (Zoantharia, Actiniaria) *Bartholomea annulata*, *Condylactis gigantea*, *Epicystes crucifera*, and *Lebrunia danae* by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

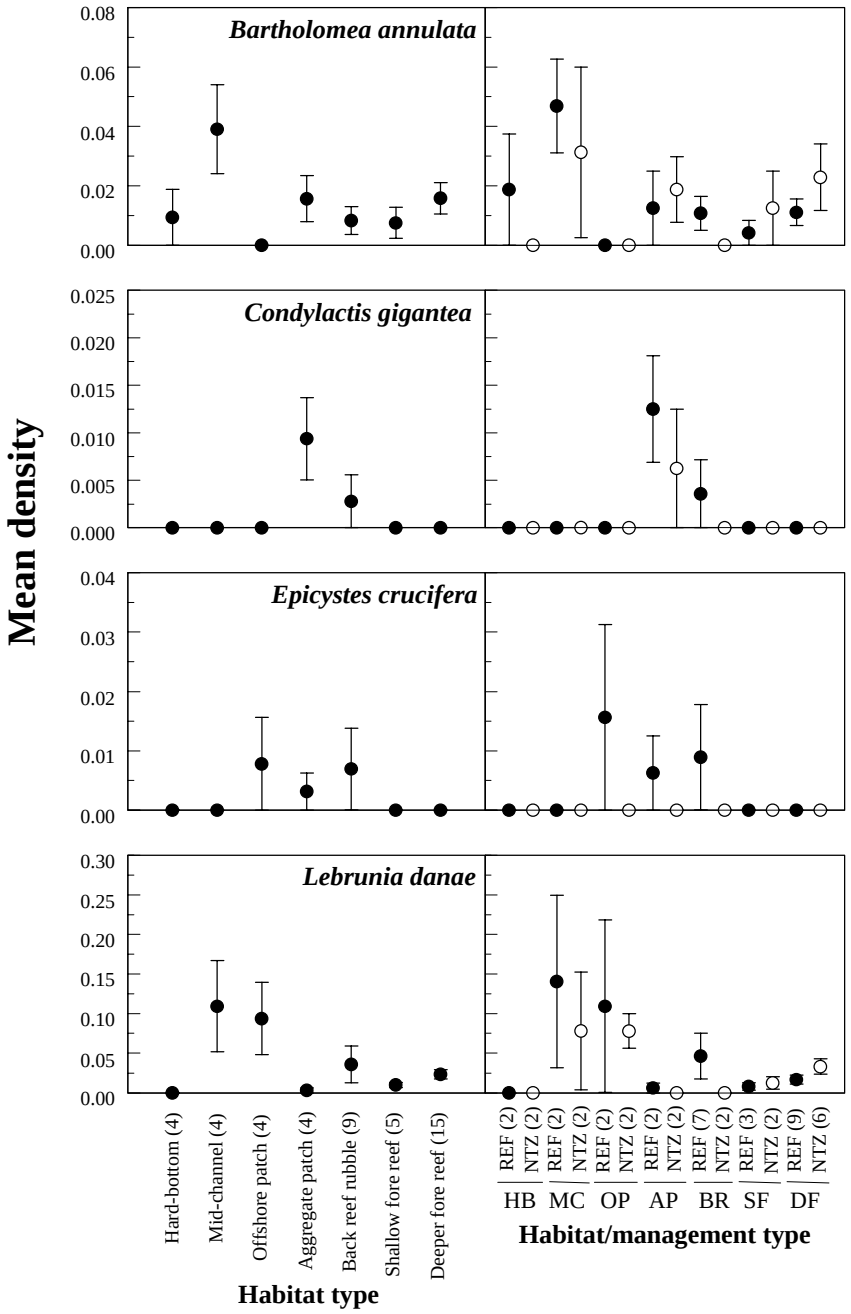

Figure 8. Mean (± 1 SE) densities (no. per m^2) of the corallimorpharians (Zoantharia, Corallimorpharia) *Discosoma sanctithomae* and *Ricordea florida* by habitat type (left-side) and between no-fishing zones (open circles) and reference areas (filled circles) in the lower Florida Keys during 2000. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.

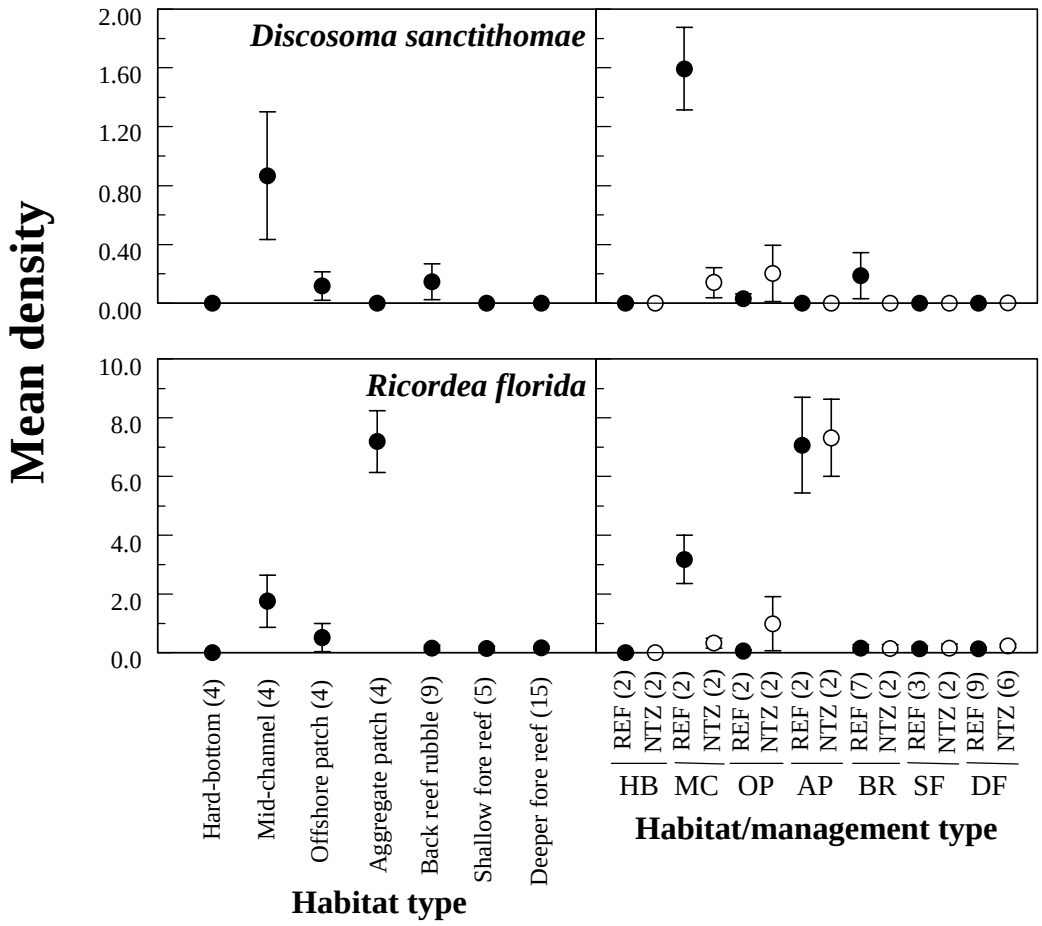

Figure 9. Mean (± 1 SE) frequency (no. per 100 m^2) of combined debris types, combined hook-and-line gear, and combined lobster trap debris in the Florida Keys by benthic habitat type and inside (NTZ, open circles) and outside (REF, filled circles) of no-fishing zones. Numbers of sites sampled in each stratum are in parentheses. See Figure 2 legend for habitat codes.