Rapid Assessment and Monitoring of Coral Reef Habitats on the Florida Reef Tract, Summer 2002

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Sampling Goals and Objectives
The 2002 sampling of coral reef and hard-bottom habitats throughout the extent of the Florida Reef Tract, including the Biscayne Bay and Dry Tortugas regions, complemented a multi-year effort dating back to 1999 (with pilot studies conducted in 1998) to assess shallow-water (< 21 m) coral reef and hard-bottom habitat types in the Sanctuary, including most of the Sanctuary Fully Protected Marine Zones (FPMZs; Ecological Reserves, Sanctuary Preservation Areas [SPAs], and Research Only Areas [ROAs]) established in 1997 (23) and 2001 (Tortugas Ecological Reserve). The goals of the NURC/UNCW monitoring effort are three-fold:

- To assess community structure and condition of benthic communities at multiple spatial scales, with particular reference to the Sanctuary FPMZs. Variation is assessed among habitat types and among regions for particular habitat types.
- To assess potential changes in coral reef communities due to "no-take" protection from fishing within the Sanctuary FPMZs, as well as from changes caused by larger-scale factors, such as geography and water quality.
- To provide fishery-independent reef fish surveys (conducted at the same time as the benthic surveys) with detailed habitat information, to facilitate modeling efforts to evaluate essential fish habitat.

The 2002 Keys-wide cruise focused on the following tasks:

- To survey multiple coral reef and hard-bottom habitat types in the Biscayne Bay region of the Florida Reef Tract to complement surveys of similar habitat types in the Upper, Middle, and Lower Keys during 1999-2001.
- To survey multiple coral reef and hard-bottom habitat types in the Dry Tortugas to complement surveys of similar habitat types in the Dry Tortugas during 1999-2000.

- To survey deeper (15-21-m depth) low-relief spur and groove and low-relief hard-bottom habitats throughout the Florida Reef Tract to provide a temporal comparison to similar surveys conducted during 1995 from Biscayne Bay to the Dry Tortugas.

Logistics and Methods

A two-stage stratified random sampling design was used to select sites during 2002. A grid system constructed in a geographic information system (GIS) was used to overlay the existing habitat map of the Florida Keys. Sites or "blocks" 200 m x 200 m in dimension were used to randomly select sites from the following regional and habitat strata (Table 1):

- Biscayne Bay region: offshore patch reef, low-relief hard-bottom, and low-relief spur and groove
- Upper to Lower Keys: offshore patch reef, low-relief hard-bottom, and low-relief spur and groove
- Marquesas Keys: medium-profile reefs
- Dry Tortugas National Park: multiple reef and hard-bottom habitats
- Tortugas Bank: deep reef terraces

The 2002 effort included 14 sites east of Biscayne Bay (Fig. 1), 24 sites from Key Largo to Key West (Fig. 2 and 3), two sites south of the Marquesas Keys (Fig. 3), and 24 sites in the Tortugas region (Fig. 4). The 2002 sampling primarily focused on low-relief spur and groove and low relief hard-bottom at 15-21-m depth (Table 2). These two habitat types were sampled during a similar Keys-wide expedition during 1995, and the 2002 surveys were designed to provide a temporal comparison to this earlier study. Three of the low-relief spur and groove sites sampled from Key Largo to Key West were located within FPMZs: Carysfort Reef SPA, Conch Reef ROA, and Western Sambo Ecological Reserve (Table 2). Because many of the Sanctuary FPMZs do not extend beyond 12-m depth, low-relief spur and groove reefs were selected seaward of zone boundaries near 10 FPMZs: Elbow Reef, French Reef, Molasses Reef, Davis Reef, Alligator Reef, Tennessee Reef, Eastern Sambo, Eastern Dry Rocks, Rock Key, and Sand Key. One site or block was assigned to each zone and a total of 64 sites were surveyed between May 30 and June 30 (Table 2).

The 2002 sampling effort (64 sites) required 26 field days underwater from May 30 to June 30. Four days were lost to bad weather or other logistical issues. All 26 days were supported by NURC/UNCW extended operations aboard the M/V *Spree*. The field effort required approximately three or four dives a day by three to four divers. The 2002 sampling involved NURC/UNCW staff surveying the benthos, complemented by concurrent surveys of reef fishes by scientists from RSMAS-UM and NOAA/NMFS and lobster surveys by scientists from FWC/FWRI. Table 3 summarizes the diving statistics for this year. Over 360 hours of surveys by NURC/UNCW and reef fish surveyors were required to complete the sampling.

The 2002 surveys addressed the same variables measured during 1999-2001, in addition to several variables added to the existing design during 2001 (Table 4). Briefly, pre-determined GPS points were used to locate the survey site or block. Four independent, 15-m transects were deployed in each block, labeled in a numbered series from 1 to 4. The length of the transect was reduced from 25 m used in previous years because we optimized our sampling effort based on a statistical review of the existing data. Benthic coverage was estimated on all four transects and

Table 1. Sampling effort by habitat type and region in the Florida Keys during May-June 2002. The survey effort included 27 sites in Biscayne National Park (BNP) and Dry Tortugas National Park (DTNP), three sites within Sanctuary Fully Protected Marine Zones (FPMZs), and 10 sites just seaward of FPMZs.

Habitat type	Regional sector	Management type	No. of sites	Effort (%)
Offshore patch reef	Biscayne	Reference areas	2	3.1
	Lower Keys	Reference areas	2	3.1
Patch reef (Staghorn mound)	Dry Tortugas	DTNP	2	3.1
Reef knoll	Dry Tortugas	DTNP	3	4.7
High-relief spur and groove	Dry Tortugas	DTNP	1	1.6
Medium profile	Dry Tortugas	Reference areas	3	4.7
	Dry Tortugas	DTNP	1	1.6
Patchy hard-bottom in sand	Biscayne	BNP	2	3.1
Low-relief hard-bottom	Biscayne	BNP	6	9.4
	Upper Keys	Reference areas	2	3.1
	Upper Keys	FPMZs	1	1.6
	Dry Tortugas	Reference areas	4	6.3
	Dry Tortugas	DTNP	5	7.8
Low-relief spur and groove	Biscayne	BNP	4	6.3
	Upper Keys	Reference areas	5	7.8
	Upper Keys	FPMZs	1	1.6
	Middle Keys	Reference areas	4	6.3
	Middle Keys	FPMZs	1	1.6
	Lower Keys	Reference areas	7	10.9
	Lower Keys	FPMZs	1	1.6
Low-relief spur and groove	Dry Tortugas	DTNP	1	1.6
Reef terrace	Dry Tortugas	DTNP	1	1.6
	Dry Tortugas	Tortugas North ER	4	6.3
Seagrass matrix	Dry Tortugas	DTNP	1	1.6
Total			64	100.0

was determined every 15 cm to yield 100 points per transect. The number of species of stony corals, gorgonians, and sponges were determined on all four transects within a 0.5-m swath on either side of a 15-m transect (total survey area = 15 m^2 per transect). Gorgonian density was determined along two of the four transects within a 0.5-m swath on either side of the transect to the 8-m mark (total survey area = 8 m^2 per transect). Coral density, size, and condition were also determined along two of the four transects with the length of each swath fixed at 10 m (total survey area = 10 m^2 per transect). The coral condition measurements included identification of bleaching, disease, and an assessment of the extent to which interactions of coral and other taxa caused tissue damage or mortality. Juvenile corals (< 4 cm maximum diameter) were assessed

along two of the four transects by randomly sampling 10 0.68-m x 0.45-m quadrats along each transect (total survey area = 3.12 m^2 per transect). Urchin density and test diameter, as well as the density of incidental marine invertebrates were assessed on all four transects at selected sites. Topographic complexity was measured along the four transects to describe bottom slope, maximum vertical relief, and the coverage of different relief categories along 1.0-m x 15-m swaths.

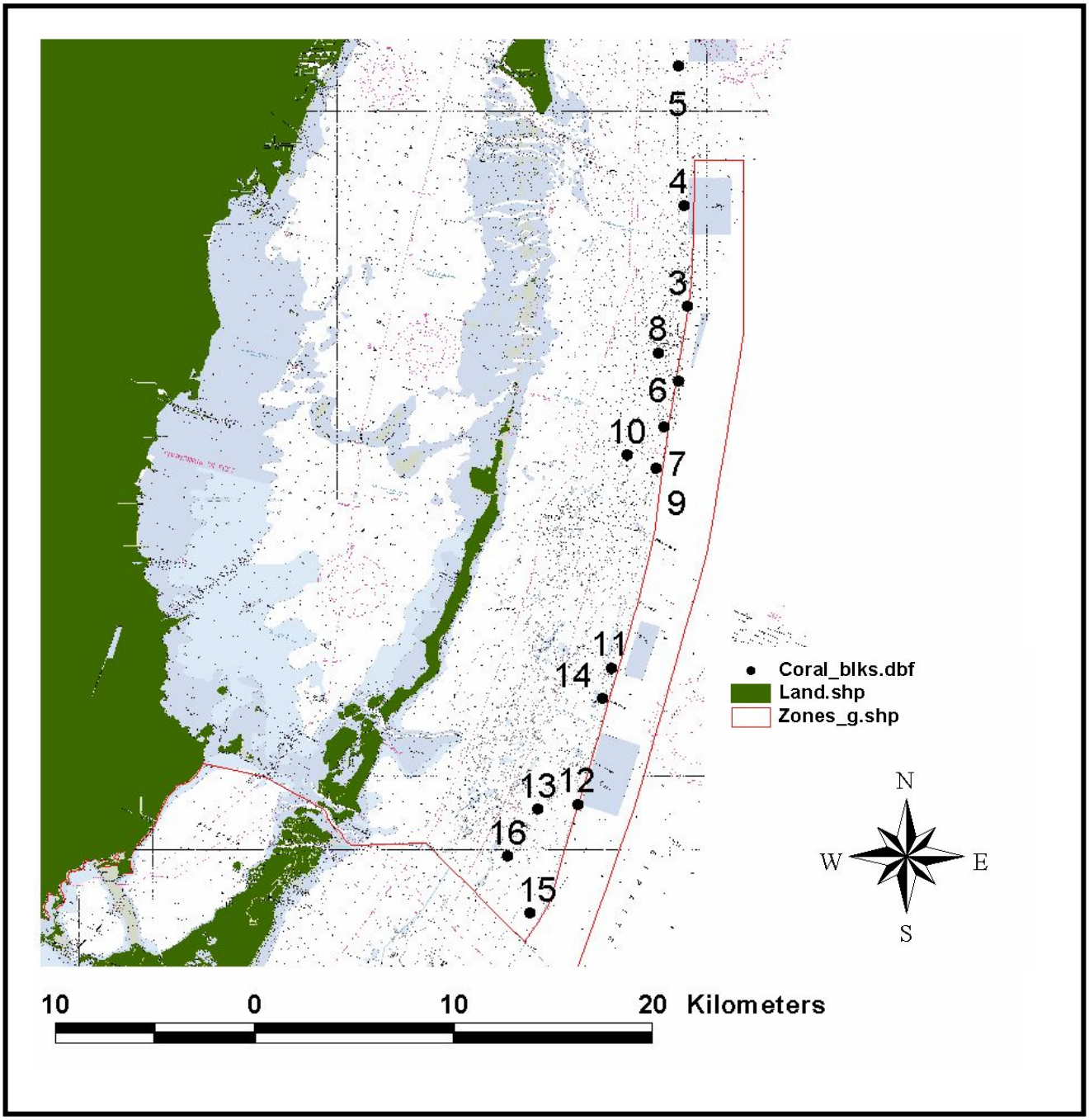

Figure 1. Survey locations in the Biscayne Bay area during 2002.

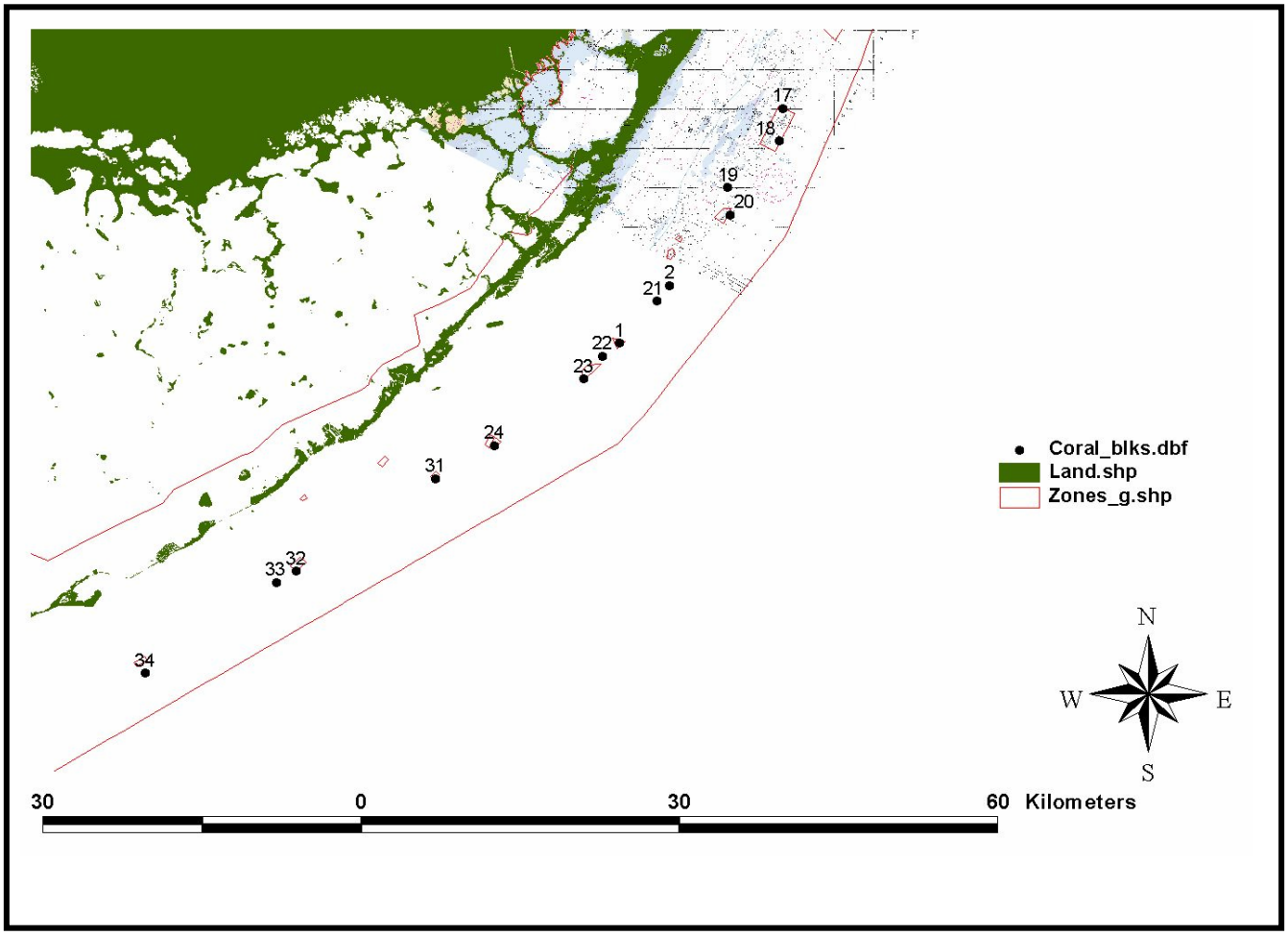

Figure 2. Survey locations in the upper and middle Florida Keys regions during 2002.

Summary of Results

The summary results presented below describe the principal variables measured during 2002 and focus on regional differences in the low-relief spur and groove habitat type from the Biscayne Bay region to the Tortugas. This latter discussion will be the focus of a paper comparing the recent Keys-wide survey with a similar study conducted in 1995.

Benthic Cover

Mean percent coverage data for scleractinian corals, fire coral (*Millepora* spp.), sponges, macroalgae, and algal turf are presented in Table 5. Patterns in coverage exhibited differences among the habitat types and broad regions surveyed. Overall, survey locations within the Biscayne region, across most of the habitat types, exhibited the lowest coral cover of the sites surveyed during 2002. Similar to earlier expeditions, offshore patch reefs exhibited some of the highest coral cover in the Biscayne and Florida Keys regions, ranging from 4% to nearly 28%. High-relief spur and groove (Bird Key Reef) and reef terrace habitats exhibited the highest coral cover in the Tortugas region and reef terraces exhibited the highest coral cover among all sites surveyed in 2002, ranging from 12% to 51%.

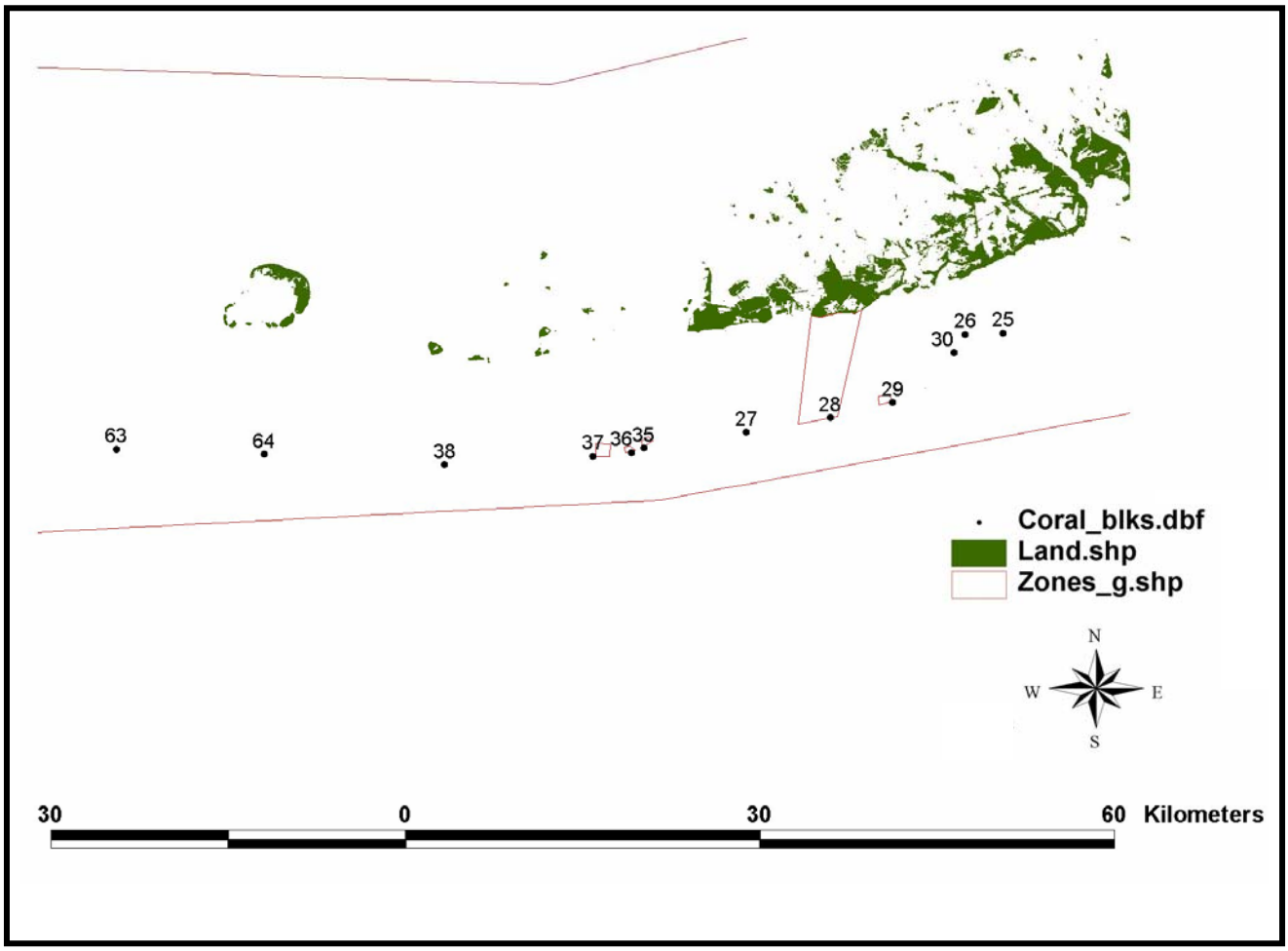

Figure 3. Survey locations in the lower Florida Keys and Marquesas Keys areas during 2002.

Offshore sampling locations in the Biscayne region and the Keys included three habitat types: low-relief spur and groove, low relief hard-bottom, and patchy hard-bottom in sand. Not unexpectedly, coral cover offshore was greatest on low-relief spur and groove reefs, ranging from about 1% to nearly 15%. Surprisingly, coral cover did not tend to be greater within Fully Protected Marine Zones (FPMZs). This contrasts with 2001 surveys of high-relief spur and groove reefs, in which sites within FPMZs tended to have greater coral cover than adjacent reference sites. These results point to the value of sampling multiple habitat types, which often vary significantly even within the boundaries of individual Sanctuary FPMZs.

Sampling locations in the Dry Tortugas region included patch reefs or dead *Acropora cervicornis* mounds, low-relief hard-bottom, low-relief spur and groove, medium-profile reefs, high-relief spur and groove, reef knolls, and reef terraces. Reef terraces on the Tortugas Bank and on the western rim of Dry Tortugas National Park had the greatest coral cover measured among all habitat types during 2002. Algal cover in this habitat type was composed largely of brown foliose algae, especially *Lobophora variegata*.

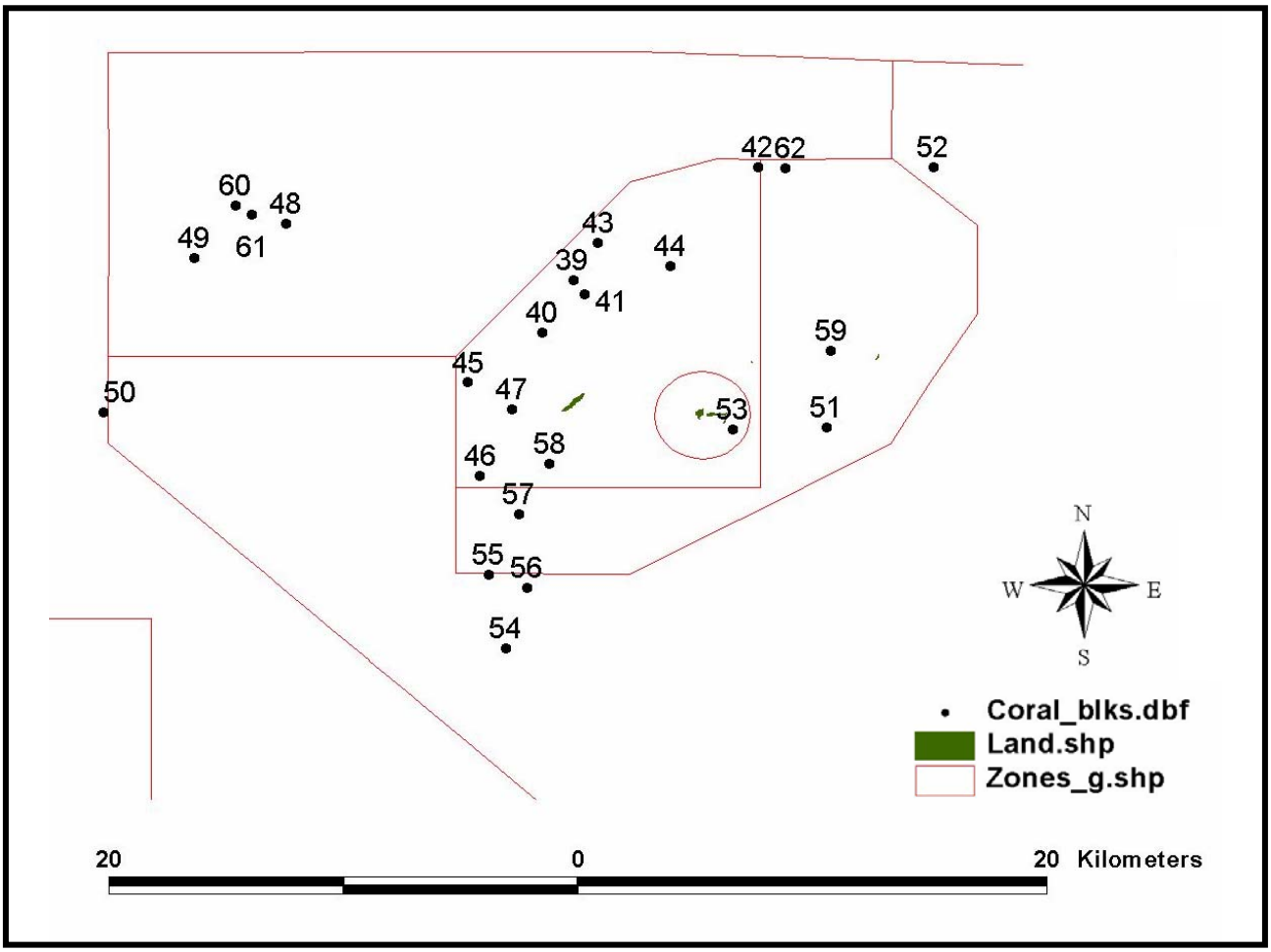

Figure 4. Survey locations in the Tortugas region during 2002.

Among the four regions surveyed in low-relief spur and groove habitat, coral cover was greatest in the Dry Tortugas (one site, 20.3%), followed by the Middle Keys (mean of 7.4% among five sites), the Lower Keys (6.8%), and the Upper Keys (3%), the latter including sites east of Biscayne Bay. While coral cover varied the most among sites in the Middle Keys (3.7% to 14.6%), we did not expect greater coral cover in this region relative to previous surveys in 1995. In fact, the pattern on deeper spur and groove reefs is opposite to that observed for shallower spur and groove reefs surveyed during 2001, in which reefs in the Upper and Lower Keys yielded the greatest coral cover. These results provide further support for broad geographic sampling across multiple habitat types and depths.

Species Richness

Surveys of the number of species of stony corals, gorgonians, and sponges continued during the 2002 surveys. Table 6 lists the coral, gorgonian, and sponge species surveyed from all sites during 2002. A total of 46 coral species, 33 gorgonians, and 80 sponge species were found. The total numbers of species surveyed by site for these three invertebrate groups are summarized by habitat and region in Table 7. Similar to results from 2000 and 2001, patch reefs in the Keys and

Table 2. Survey locations along the Florida Reef Tract during May-June 2002. Sites are arranged from northeast to southwest within each habitat type. Sites within Sanctuary FPMZs are noted with a single asterisk (*) and those adjacent to and seaward of zone boundaries are double asterisked (**).

Habitat type/site location	Region	Latitude	Longitude	Depth (m)
Offshore patch reef				
Inshore and SW of Pacific Reef	Biscayne	25.19.817	80.10.385	8.23-10.36
Inshore of Pacific Reef	Biscayne	25.21.095	80.09.551	10.06-10.97
West of W. Washerwoman Shoal	Lower Keys	24.32.579	80.36.076	5.18-7.01
West Washerwoman Shoal	Lower Keys	24.32.637	81.34.341	6.10-7.62
Patch reef (Staghorn mound)				
Dry Tortugas National Park	DTNP	24.36.537	82.55.831	9.45-10.36
Dry Tortugas National Park	DTNP	24.37.798	82.56.704	7.62-8.23
Reef knoll				
Dry Tortugas National Park	DTNP	24.37.378	82.49.468	14.02-17.98
Dry Tortugas National Park	DTNP	24.38.408	82.57.709	22.25-23.77
Dry Tortugas National Park	DTNP	24.41.616	82.54.714	10.97-11.89
High-relief spur and groove				
Bird Key Reef	Park	24.37.319	82.51.627	11.89-14.63
Medium-profile reef				
Coal Bin (East of Cosgrove Shoal)	Marquesas	24.27.014	82.08.089	16.76-17.37
Cosgrove Shoal	Marquesas	24.27.338	82.14.830	19.81-21.94
Pulaski Shoal (just outside DTNP)	Reference	24.43.367	82.47.006	17.07-17.37
Dry Tortugas National Park	DTNP	24.43.365	82.51.045	19.51-20.12
Patchy hard-bottom in sand				
Between Star & Triumph Reef	Biscayne	25.30.668	80.07.149	7.32-7.62
North of Fowey Rocks	Biscayne	25.37.442	80.05.600	10.67-11.58
Low-relief hard-bottom				
SW of Pacific Reef	Biscayne	25.18.272	80.09.772	11.89-11.89
Ajax Reef	Biscayne	25.24.093	80.07.796	6.10-7.32
North of Ajax Reef	Biscayne	25.24.914	80.07.580	7.01-8.84
Star Reef	Biscayne	25.31.448	80.06.142	11.28-12.19
Ledberry Reef	Biscayne	25.32.671	80.05.744	14.63-15.24
East of Biscayne Bay	Biscayne	25.41.200	80.05.746	8.84-10.36
Carysfort Reef*	Upper Keys	25.14.015	80.12.594	7.62-7.92
Seaward of Watson's Reef	Upper Keys	25.09.985	80.15.375	10.36-10.97
Between Molasses & French Reef	Upper Keys	25.01.438	80.21.732	10.97-11.89
S. DTNP (just outside park)	Reference	24.32.294	82.56.846	17.37-17.37
Dry Tortugas National Park	DTNP	24.33.690	82.56.353	14.33-14.94
Dry Tortugas National Park	DTNP	24.33.982	82.57.235	15.85-17.37
Dry Tortugas National Park	DTNP	24.35.383	82.56.541	12.80-13.72
Dry Tortugas National Park	DTNP	24.36.272	82.57.437	13.11-14.02
Dry Tortugas National Park	DTNP	24.40.434	82.55.023	9.14-10.36
DTNP (NW of Loggerhead Key)	Reference	24.40.772	82.55.278	15.24-16.15
Dry Tortugas National Park	DTNP	24.41.076	82.53.059	10.06-11.28
Tortugas Bank	Tortugas Bank	24.37.725	83.06.100	22.56-23.16

Table 2. continued.

Habitat type/site location	Region	Latitude	Longitude	Depth (m)
Low-relief spur and groove				
Offshore Pacific Reef	Biscayne	25.21.226	80.08.489	15.85-17.68
Between Star and Triumph Reef	Biscayne	25.30.334	80.06.348	10.97-12.50
SW of Brewster Reef	Biscayne	25.33.441	80.06.304	5.18-6.10
South of Fowey Rocks	Biscayne	25.34.699	80.05.519	15.54-19.20
Carysfort Reef SPA*	Upper Keys	25.12.371	80.12.780	16.76-18.90
Elbow Reef SPA**	Upper Keys	25.08.615	80.15.251	16.15-17.07
North Dixie Shoal	Upper Keys	25.05.032	80.18.337	14.63-16.46
Dixie Shoal	Upper Keys	25.04.232	80.18.995	14.63-15.85
French Reef**	Upper Keys	25.02.103	80.20.908	16.46-19.51
Molasses Reef**	Upper Keys	25.00.292	80.22.728	15.85-18.59
Conch Reef R-OA*	Middle Keys	24.56.903	80.27.250	14.33-15.54
Davis Reef**	Middle Keys	24.55.223	80.30.243	15.54-17.07
Alligator Reef**	Middle Keys	24.50.504	80.37.319	16.76-17.98
Between Tennessee & Alligator	Middle Keys	24.49.953	80.38.336	15.24-15.54
Offshore of Tennessee R-OA**	Middle Keys	24.45.331	80.45.021	15.24-16.76
East of Pelican Shoal	Lower Keys	24.30.274	81.36.000	11.89-13.41
Eastern Sambo**	Lower Keys	24.29.467	81.39.396	14.02-15.24
Western Sambo*	Lower Keys	24.28.771	81.42.240	14.94-15.85
Between W. Sambo & E. Dry Rocks	Lower Keys	24.28.113	81.46.068	17.37-18.59
Eastern Dry Rocks**	Lower Keys	24.27.386	81.50.750	15.54-17.68
Rock Key**	Lower Keys	24.27.188	81.51.320	13.41-16.15
Sand Key**	Lower Keys	24.27.025	81.53.069	14.63-15.85
SW of Western Dry Rocks	Lower Keys	24.26.636	81.59.849	14.93-16.46
Dry Tortugas National Park	DTNP	24.43.326	28.50.408	14.94-15.54
Reef terrace				
Loggerhead Forest	Park	24.39.558	82.56.005	16.46-17.37
Sherwood Forest	Tortugas Bank	24.41.274	83.04.010	23.16-23.77
Sherwood Forest	Tortugas Bank	24.42.052	83.01.899	24.99-26.21
Sherwood Forest	Tortugas Bank	24.42.275	83.02.671	21.64-22.25
Sherwood Forest	Tortugas Bank	24.42.469	83.03.055	23.77-24.38
Seagrass matrix community				
DTNP	Park	24.39.129	82.49.369	6.10-6.10

Biscayne regions typically yielded the greatest number of species of reef-building corals (Table 7). The number of sponges found on patch reefs in 2002 was similar or less than the number found on offshore forereef areas.

Overall, coral species numbers surveyed in the low-relief spur and groove habitat were highest in the Middle and Lower Keys. Fully Protected Marine Zones did not have significantly greater species numbers. Gorgonian species numbers were highest on patch reefs. On low-relief spur and groove reefs, gorgonian species richness was slightly higher in the Lower Keys. Sponge species numbers were similar throughout the region, among habitats, and between levels of protection. In the Dry Tortugas, coral species numbers were similar among all habitat types with low-relief hard-bottom at the low end of the range. Both gorgonian and sponge species numbers were lowest in reef terrace habitats, but similar among all other habitats.

Table 3. SCUBA diving effort in the Florida Keys during May-June 2002. Reef fish surveys reported are for dives conducted in conjunction with the benthic surveys.

Diver	Affiliation	No. of dives	Depth (ft.)	Bottom time (hrs.)
Benthic surveys				
Steven Miller	CMSR/UNCW	37	26-86	49.58
Mark Chiappone	CMSR/UNCW	21	19-66	23.48
Dione Swanson	CMSR/UNCW	60	17-86	75.53
Mark Vermeij	RSMAS/UM	55	10-85	67.5
Dave Eaken	FWC/FWRI	17	26-76	22.58
Subtotal		190	10-86	238.67
Reef fish surveys				
Steve Smith	RSMAS/UM	42	17-81	41.33
Mike Judge	NOAA/NMFS	21	30-79	21.67
Nicholas Farmer	RSMAS/UM	13	33-62	10.63
Mike Larkin	RSMAS/UM	22	28-65	17.77
Aaron Bartholomew	NOAA/NMFS	5	28-59	3.68
Lance Jordan	Nova Southeastern	12	22-70	11.58
Rob Waara	NPS/Virgin Islands	5	53-83	4.83
Brian Ettinger	Nova Southeastern	12	26-63	10.33
Subtotal		132	17-83	121.82
Total all divers		**322**	**10-86**	**360.49**

Table 4. Variables measured during 2002. Transects 15 m in length were used in all sites. Note that the width of the survey area along transects varied among variables.

Variable	Method	Factors assessed
Percent cover	Point-intercept along 4 transects (100 points/transect)	Percent cover
Species richness	1.0 m x 15 m swaths along 4 transects	Species presence & total number
Coral density and size	1.0 m x 10 m swaths along 2 transects	Density, size, condition
Juvenile coral density	Twenty 0.68 m x 0.45 m quadrats	Species composition, density & size
Gorgonian density	1.0 m x 8 m swaths along 2 transects	Density
Urchin density and size	1.0 m x 15 m swaths along 4 transects	Density, test diameter
Marine ornamentals	1.0 m x 15 m swaths along 4 transects	Density
Spiny lobster density	1.0 m x 15 m swaths along 4 transects	Density
Topography	1.0 m x 15 m swaths along 4 transects	Maximum relief & substratum slope

In the low-relief spur and groove habitat from east of Biscayne Bay to the lower Florida Keys, the mean number of coral species per site was greatest in the Middle Keys (22.2), followed by the Lower Keys (21.9) and the Upper Keys (16.9). This is similar to findings from shallower spur and groove reefs surveyed during 2001, in which the Upper Keys yielded the lowest species richness of corals. Similar to findings from 1999 and 2001, sponge species richness was, on average, greatest in the Middle Keys (39.6 species per site), compared to the Upper (37.8) and Lower Keys (35.9). Gorgonian species richness did not vary significantly among the three regions within this particular habitat type, ranging from an average of 14.9 to 16.9 species per site.

Table 5. Mean (1 SE) percent coverage of scleractinian corals, fire coral (*Millepora* spp.), sponges, macroalgae, and algal turf. Noted are sites within Sanctuary Fully Protected Marine Zones (FPMZs) (*) and those adjacent to and seaward of FPMZs (**). Data are based upon 100 points surveyed along each of four transects.

Habitat type/site location	Scleractinia	*Millepora*	Sponges	Macroalgae	Algal turf
Offshore patch reef					
Inshore and SW of Pacific Reef	3.8 (4.8)	1.3 (1.7)	0.3 (0.3)	35.9 (30.7)	21.2 (22.3)
Inshore of Pacific Reef	5.3 (6.6)	0.0 (0.0)	4.8 (6.0)	21.8 (22.7)	23.3 (23.8)
West Washerwoman Shoal	27.3 (26.4)	0.8 (1.0)	0.0 (0.0)	1.8 (2.3)	39.0 (31.7)
West of West Washerwoman	24.8 (24.8)	0.3 (0.3)	0.0 (0.0)	0.5 (0.7)	49.3 (33.3)
Patch reef (Staghorn mound)					
Dry Tortugas National Park	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	72.8 (26.4)	9.0 (10.9)
Dry Tortugas National Park	0.3 (0.3)	0.5 (0.7)	0.0 (0.0)	47.3 (33.2)	4.3 (5.4)
Reef knoll					
Dry Tortugas National Park	14.0 (24.1)	0.5 (1.0)	3.0 (5.8)	7.0 (13.0)	27.0 (39.4)
Dry Tortugas National Park	31.7 (32.5)	0.0 (0.0)	0.0 (0.0)	22.7 (26.3)	22.3 (26.0)
Dry Tortugas National Park	2.5 (3.2)	0.5 (0.7)	0.0 (0.0)	43.7 (32.8)	7.0 (8.7)
High-relief spur and groove					
Bird Key Reef	25.8 (25.5)	0.8 (1.0)	0.0 (0.0)	11.3 (13.3)	24.5 (24.7)
Medium-profile reef					
Coal Bin (East of Cosgrove Shoal)	5.0 (6.3)	0.0 (0.0)	0.0 (0.0)	56.5 (32.8)	21.3 (22.3)
Cosgrove Shoal	9.3 (11.2)	0.0 (0.0)	0.0 (0.0)	56.8 (32.7)	25.3 (25.2)
Dry Tortugas National Park	16.8 (18.6)	0.0 (0.0)	0.0 (0.0)	15.8 (17.7)	37.3 (31.2)
Pulaski Shoal	7.5 (13.9)	0.0 (0.0)	6.0 (11.3)	26.5 (39.0)	12.5 (21.9)
Patchy hard-bottom in sand					
Between Star & Triumph Reef	3.0 (3.9)	0.0 (0.0)	2.3 (2.9)	7.5 (9.3)	25.5 (25.3)
North of Fowey Rocks	0.0 (0.0)	0.8 (1.0)	0.3 (0.3)	6.3 (7.8)	49.3 (33.3)
Low-relief hard-bottom					
SW of Pacific Reef	0.8 (1.0)	0.5 (0.7)	0.5 (0.7)	21.3 (22.4)	50.7 (33.3)
Ajax Reef	1.5 (2.0)	0.5 (0.7)	3.8 (4.8)	34.8 (30.2)	37.8 (31.3)
North of Ajax Reef	0.8 (1.0)	0.0 (0.0)	2.0 (2.6)	30.8 (28.4)	45.0 (33.0)
Star Reef	0.5 (0.7)	0.3 (0.3)	0.8 (1.0)	21.5 (22.5)	48.5 (33.3)
Ledberry Reef	0.5 (0.7)	1.0 (1.3)	0.0 (0.0)	13.0 (15.1)	47.3 (33.2)
East of Biscayne Bay	2.0 (2.6)	0.5 (0.7)	0.8 (1.0)	8.5 (10.4)	53.5 (33.2)
Carysfort Reef*	2.5 (3.3)	0.5 (0.7)	1.2 (1.6)	36.0 (30.7)	34.1 (30.0)
Seaward of Watson's Reef	2.8 (3.6)	0.3 (0.3)	1.5 (2.0)	41.4 (32.4)	31.5 (28.8)
Between Molasses & French Reef	3.0 (3.9)	0.3 (0.3)	0.0 (0.0)	33.8 (29.8)	42.8 (32.6)
Southern DTNP (outside park)	2.5 (3.3)	0.3 (0.3)	0.0 (0.0)	42.0 (32.5)	12.0 (14.1)
Dry Tortugas National Park	3.3 (4.2)	0.5 (0.7)	0.0 (0.0)	42.3 (32.5)	13.3 (15.3)
Dry Tortugas National Park	3.5 (4.5)	0.3 (0.3)	0.0 (0.0)	44.0 (32.9)	17.5 (19.3)
Dry Tortugas National Park	4.0 (5.1)	1.3 (1.6)	0.5 (0.7)	35.0 (30.3)	37.8 (31.3)
Dry Tortugas National Park	8.3 (10.1)	1.3 (1.6)	0.0 (0.0)	33.8 (29.8)	6.0 (7.5)
Tortugas Bank	2.0 (2.6)	0.0 (0.0)	0.0 (0.0)	56.4 (32.8)	3.5 (4.5)
Dry Tortugas National Park	2.0 (2.6)	1.3 (1.6)	0.0 (0.0)	36.8 (31.0)	21.8 (22.7)
NW of Loggerhead Key	2.0 (2.6)	0.3 (0.3)	0.0 (0.0)	34.0 (29.9)	27.5 (26.6)
Dry Tortugas National Park	0.5 (0.7)	0.0 (0.0)	0.0 (0.0)	42.5 (32.6)	14.3 (16.3)

Table 5. continued.

Habitat type/site location	Scleractinia	*Millepora*	Sponges	Macroalgae	Algal turf
Low-relief spur and groove					
Offshore Pacific Reef	1.0 (1.3)	1.8 (2.3)	0.3 (0.3)	7.5 (9.3)	29.5 (27.7)
Between Star & Triumph Reef	2.5 (3.3)	0.0 (0.0)	1.5 (2.0)	32.3 (29.1)	35.8 (30.6)
SW of Brewster Reef	4.3 (5.4)	1.0 (1.3)	1.3 (1.6)	11.3 (13.3)	35.3 (30.4)
South of Fowey Rocks	3.2 (4.2)	0.6 (0.9)	0.6 (0.9)	21.0 (22.1)	28.5 (27.2)
Carysfort Reef SPA*	0.3 (0.3)	0.0 (0.0)	0.0 (0.0)	24.3 (24.5)	60.5 (31.9)
Elbow Reef SPA**	1.7 (2.3)	0.3 (0.3)	0.0 (0.0)	39.3 (31.8)	28.1 (26.9)
North Dixie Shoal	2.3 (2.9)	0.8 (1.0)	1.3 (1.6)	54.0 (33.1)	4.8 (6.0)
Dixie Shoal	6.5 (8.1)	0.5 (0.7)	0.0 (0.0)	49.1 (33.3)	26.2 (25.8)
French Reef**	4.0 (5.8)	0.3 (0.5)	0.3 (0.5)	51.7 (37.5)	10.3 (13.9)
Molasses Reef**	3.8 (4.8)	0.3 (0.3)	0.0 (0.0)	46.5 (33.2)	25.0 (25.0)
Conch Reef RO*	4.5 (5.7)	0.8 (1.0)	0.0 (0.0)	42.8 (32.6)	13.5 (15.6)
Davis Reef**	4.0 (5.1)	0.3 (0.3)	0.0 (0.0)	46.5 (33.2)	28.8 (27.3)
Alligator Reef**	3.7 (4.8)	1.7 (2.3)	0.0 (0.0)	19.6 (21.0)	20.3 (21.6)
Between Tennessee & Alligator	14.7 (16.7)	0.7 (1.0)	0.0 (0.0)	35.6 (30.6)	34.3 (30.0)
Offshore of Tennessee RO**	10.3 (12.3)	0.0 (0.0)	0.0 (0.0)	41.5 (32.4)	38.0 (31.4)
East of Pelican Shoal	0.8 (1.0)	1.0 (1.3)	0.0 (0.0)	37.2 (31.1)	16.2 (18.1)
Eastern Sambo Reef**	7.8 (9.5)	0.0 (0.0)	0.0 (0.0)	39.0 (31.7)	21.0 (22.1)
Western Sambo Reef*	10.3 (12.3)	0.0 (0.0)	0.0 (0.0)	42.0 (32.5)	19.8 (21.1)
Between W. Sambo & E. Dry Rocks	13.3 (15.3)	0.3 (0.3)	0.0 (0.0)	50.0 (33.3)	11.0 (13.1)
Eastern Dry Rocks**	7.5 (9.3)	0.5 (0.7)	0.0 (0.0)	45.8 (33.1)	38.0 (31.4)
Rock Key**	6.5 (8.1)	0.3 (0.3)	0.0 (0.0)	34.8 (30.2)	51.0 (33.3)
Sand Key**	3.3 (4.2)	0.0 (0.0)	0.0 (0.0)	63.0 (31.1)	27.3 (26.4)
SW of Western Dry Rocks	4.8 (6.0)	0.5 (0.7)	0.0 (0.0)	45.3 (33.0)	37.5 (31.3)
Dry Tortugas National Park	20.3 (21.5)	1.3 (1.6)	0.0 (0.0)	38.0 (31.4)	24.8 (24.8)
Reef terrace					
Loggerhead Forest	50.5 (33.3)	0.8 (1.0)	0.0 (0.0)	27.5 (26.6)	10.3 (12.3)
Sherwood Forest	29.8 (27.9)	0.3 (0.3)	0.0 (0.0)	35.0 (30.1)	0.5 (0.7)
Sherwood Forest	32.7 (33.0)	0.0 (0.0)	0.0 (0.0)	32.9 (33.1)	0.5 (0.8)
Sherwood Forest	24.0 (24.3)	0.0 (0.0)	0.0 (0.0)	41.3 (32.3)	10.0 (12.0)
Sherwood Forest	11.5 (13.6)	0.3 (0.3)	0.0 (0.0)	56.9 (32.7)	12.5 (14.6)

Coral Density, Size, and Condition

Coral density, size, and condition measurements were made using methods similar to previous years. Table 8 lists the density of scleractinian corals by site. The total area surveyed during 2002 was approximately 1,280 m^2. Over 7,250 corals were counted and measured from the 64 sites, of which 2,098 or 29% were fire coral (*Millepora alcicornis*) and 5,161 or 71% were scleractinian corals.

Although scleractinian coral densities are highly variable, there were some patterns. In the broad Biscayne and Keys area, scleractinian corals exhibited differences in density among habitat types and regional sectors. Coral density was highest on offshore patch reefs in the Lower Keys. Densities were relatively similar among all other habitats in the Lower, Middle, and Upper Keys, while density values in the Biscayne region were lower than the Keys for all habitat types sampled. In the Dry Tortugas, the highest coral densities were found on reef terraces, reef knolls, high-relief spur and groove (Bird Key Reef), and low-relief spur and groove. Within the low-relief spur and groove habitat, mean coral densities within particular regions were greatest in the Dry Tortugas (one site, 9.55 colonies/m^2), followed by the Middle Keys (5.49 colonies/m^2). Size

and condition data were not analyzed for this report.

Table 6. Coral, gorgonian, and sponge species surveyed during May-June 2002. Listed are only those species recorded within four 15-m^2 plots per site.

Stony corals	Gorgonians	Sponges	
Acropora cervicornis	*Briareum asbestinum*	*Adocia sp.*	*Pandaros acanthifolium*
Agaricia agaricites	*Erythrop. caribaeorum*	*A. carbonifera*	*Pseudoaxinella lunaecharta*
A. fragilis	*Eunicea calyculata*	**Agelas clathrodes**	*Pseudoceratina crassa*
A. grahamae	*E. fusca*	*A. conifera*	*Ptilocaulis* sp.
A. humilis	*E. laciniata*	*A. schmidti*	*Rhaphidophlus juniperinis*
A. lamarcki	*E. mammosa*	*A. wiedenmayaari*	*R. venosus*
Colpophyllia natans	*E. palmeri*	*Amphimedon compressa*	*Siphon. coralliphagum*
Dichocoenia stokesi	*E. succinea*	*A. viridis*	*S. siphonum*
Diploria clivosa	*E. tourneforti*	*Anthosigmella varians*	*Spheciospongia vesparium*
D. labyrinthiformis	*Gorgonia ventalina*	*Aplysina archeri*	*Spinosella tenerrima*
D. strigosa	*Iciliogorgia schrammi*	*A. cauliformis*	*Spirastrella coccinea*
Eusmilia fastigiata	*Muricea atlantica*	*A. fistularis*	*Spongia* sp.
Favia fragum	*M. elongata*	*A. fulva*	*Strongylacidon* sp.
Isophyllastrea rigida	*M. muricata*	*A. lacunosa*	*Tedania ignis*
Isophyllia sinuosa	*M. pinnata*	*Callyspongia plicifera*	*Tethya crypta*
Leptoseris cucullata	*Muriceopsis flavida*	*C. vaginalis*	*Ulosa ruetzleri*
Madracis carmabi	*Plexaura flexuosa*	*Chondrilla nucula*	Unknown blue tube #1
M. decactis	*P. homomalla*	*Cinachyra* sp.	Unknown blue tube #2
M. formosa	*Plexaurella dichotoma*	*Clathria* sp.	Unknown brown *Cliona*
M. mirabilis	*P. grisea*	*Clathrina canariensis*	Unknown brown encrusting
M. senaria	*P. nutans*	*Cliona* sp.	Unknown brown lumpy
Manicina areolata	*P. pumila*	*C. deletrix*	Unknown brown smooth
Meandrina meandrites	*Pseudoplexaura crucis*	*C. langae*	Unknown brown tube
Millepora alcicornis	*P. flagellosa*	*Cribochalina vasculum*	Unknown carmine red
M. complanata	*P. porosa*	*Diplastrella megastellata*	Unknown encrusting
Montastraea annularis	*P. wagenaari*	*Dysidea etheria*	Unknown mauve lumpy
M. cavernosa	*Pseudopt. acerosa*	*Ectyoplasia ferox*	Unknown orange encrusting
M. faveolata	*P. americana*	*Erylus formosus*	Unknown red encrusting
M. franksi	*P. bipinnata*	*Geodia neptuna*	Unknown red lumpy
Mussa angulosa	*P. rigida*	*Haliclona hogarthi*	Unknown red squishy
Mycetophyllia aliciae	*Pterogorgia anceps*	*Halisarca* sp.	*Verongula gigantea*
M. danaana	*P. citrina*	*Holapsamma helwigi*	*V. rigida*
M. ferox	*P. guadalupensis*	*Iotrochota birotulata*	*V. reiswigi*
M. lamarckiana		*Ircinia campana*	*Xestospongia muta*
Oculina diffusa		*Ircinia felix*	
Porites astreoides		*Ircinia strobilina*	
P. branneri		*Monanchora barbadensis*	
P. colonensis		*Monanchora unguifera*	
P. porites divaricata		*Mycale laevis*	
P. porites furcata		*Mycale* sp.	
P. porites porites		*Myrmekioderma* sp.	
Scolymia sp.		*Neofibularia notilangere*	
Siderastrea radians		*Niphates amorpha*	
S. siderea		*N. digitalis*	
Solenastrea bournoni		*N. erecta*	
Steph. michelinii		*Oligoceras hemorrhages*	

Table 7. Total number of species per site for stony corals, gorgonians, and sponges. Data are based upon four 15-m^2 surveys conducted at each site (60 m^2). Noted are sites within Sanctuary Fully Protected Marine Zones (FPMZs) (*) and those adjacent to and seaward of FPMZs (**). ns = no survey conducted.

Habitat type/site location	Region	Stony corals	Gorgonians	Sponges
Offshore patch reef				
Inshore and SW of Pacific Reef	Biscayne	21	21	41
Inshore of Pacific Reef	Biscayne	20	21	42
West Washerwoman Shoal	Lower Keys	28	24	28
West of West Washerwoman	Lower Keys	28	21	33
Patch reef (Staghorn mound)				
Dry Tortugas National Park	Tortugas	5	ns	ns
Dry Tortugas National Park	Tortugas	4	ns	ns
Reef knoll				
Dry Tortugas National Park	Tortugas	23	15	39
Dry Tortugas National Park	Tortugas	17	ns	ns
Dry Tortugas National Park	Tortugas	16	ns	ns
High-relief spur and groove				
Bird Key Reef	Tortugas	29	22	43
Medium-profile reef				
Coal Bin (East of Cosgrove Shoal)	Marquesas	28	17	40
Cosgrove Shoal	Marquesas	20	14	35
Dry Tortugas National Park	Tortugas	20	ns	ns
Pulaski Shoal (just outside DTNP)	Tortugas	25	11	43
Patchy hard bottom in sand				
Between Star & Triumph Reef	Biscayne	13	23	40
North of Fowey Rocks	Biscayne	14	14	30
Low-relief hard-bottom				
SW of Pacific Reef	Biscayne	17	20	37
Ajax Reef	Biscayne	18	18	17
North of Ajax Reef	Biscayne	14	16	25
Star Reef	Biscayne	17	18	36
Ledberry Reef	Biscayne	14	12	35
East of Biscayne Bay	Biscayne	18	14	37
Carysfort Reef SPA*	Upper Keys	22	16	27
Seaward of Watson's Reef	Upper Keys	16	18	44
Between Molasses & French Reef	Upper Keys	19	15	38
Southern DTNP (just outside park)	Tortugas	16	20	43
Dry Tortugas National Park	Tortugas	21	23	38
Dry Tortugas National Park	Tortugas	15	21	42
Dry Tortugas National Park	Tortugas	25	22	48
Dry Tortugas National Park	Tortugas	18	ns	7
Dry Tortugas National Park	Tortugas	16	25	32
NW of Loggerhead Key	Tortugas	16	27	42
Dry Tortugas National Park	Tortugas	13	ns	ns
Tortugas Bank	Tortugas	19	13	35

Table 7. continued.

Habitat type/site location	Region	Stony corals	Gorgonians	Sponges
Low-relief spur and groove				
Offshore Pacific Reef	Biscayne	18	18	37
Between Star & Triumph Reef	Biscayne	18	18	43
SW of Brewster Reef	Biscayne	16	18	33
South of Fowey Rocks	Biscayne	17	7	37
Carysfort Reef SPA*	Upper Keys	16	13	38
Elbow Reef SPA**	Upper Keys	19	17	42
North Dixie Shoal	Upper Keys	18	13	31
Dixie Shoal	Upper Keys	19	18	39
French Reef**	Upper Keys	14	10	32
Molasses Reef**	Upper Keys	14	17	46
Conch Reef Research Only*	Middle Keys	19	12	39
Davis Reef**	Middle Keys	21	15	42
Alligator Reef**	Middle Keys	21	20	46
Between Tennessee & Alligator	Middle Keys	27	21	35
Offshore of Tennessee RO**	Middle Keys	23	16	36
East of Pelican Shoal	Lower Keys	16	24	34
Eastern Sambo**	Lower Keys	18	16	37
Western Sambo*	Lower Keys	27	10	32
Between W. Sambo & E. Dry Rocks	Lower Keys	22	9	22
Eastern Dry Rocks**	Lower Keys	23	18	39
Rock Key**	Lower Keys	22	19	41
Sand Key**	Lower Keys	23	20	38
SW of Western Dry Rocks	Lower Keys	24	19	44
Dry Tortugas National Park	Tortugas	30	14	40
Reef terrace				
Loggerhead Forest	Tortugas	28	7	25
Sherwood Forest	Tortugas	25	10	24
Sherwood Forest	Tortugas	25	9	31
Sherwood Forest	Tortugas	26	9	25
Sherwood Forest	Tortugas	19	ns	ns

Juvenile Coral Density

Surveys of juvenile coral species composition, density, and maximum diameter continued during 2002. Table 8 lists the density of juvenile scleractinian coral for each survey location. The highest juvenile coral densities were found on offshore patch reefs in the Lower Keys. Juvenile coral densities were relatively similar, but variable within and among habitat types in the Lower, Middle, and Upper Keys (excluding offshore patch reefs) and relatively higher than densities within and among habitats in the Biscayne area. The overall range of density values in the Dry Tortugas was similar to Keys-wide values, within and among habitat types. Medium-profile reefs exhibited the highest juvenile scleractinian coral densities overall. Within the low-relief spur and groove habitat among the Upper, Middle, and Lower Keys, mean juvenile densities were greatest in the Lower (7.1 juveniles/m^2) and Middle Keys (7.0 individuals per m^2) and significantly lower in the Upper Keys (4.7 juveniles/m^2) for the 10 sites surveyed in this region.

Table 8. Mean (1 SE) density (no. colonies/m^2) of scleractinian corals, juvenile scleractinian corals (< 4 cm max. diameter), and gorgonians. Noted are sites within Sanctuary Fully Protected Marine Zones (*) and sites adjacent to and seaward of zone boundaries (**). ns = no survey conducted.

Habitat type/site location	Scleractinian corals	SE	Juvenile corals	SE	Gorgonians	SE
Offshore patch reef						
Inshore and SW of Pacific Reef	3.15	0.01	3.21	0.00	19.88	0.03
Inshore of Pacific Reef	4.25	0.61	5.45	0.21	11.00	0.78
West Washerwoman Shoal	13.65	1.13	16.51	37.44	27.88	12.50
West of West Washerwoman	13.75	0.85	13.14	10.07	11.44	9.57
Patch reef (Staghorn mound)						
Dry Tortugas National Park	0.30	0.02	0.16	0.05	ns	ns
Dry Tortugas National Park	0.00	0.00	0.00	0.00	ns	ns
Reef knoll						
Dry Tortugas National Park	7.55	1.45	5.13	0.82	ns	ns
Dry Tortugas National Park	8.15	3.13	4.41	0.00	ns	ns
Dry Tortugas National Park	1.60	0.02	2.40	0.05	ns	ns
High-relief spur and groove						
Bird Key Reef	8.25	0.05	7.05	0.21	31.92	0.35
Medium-profile reef						
Coal Bin (East of Cosgrove Shoal)	4.65	0.41	8.81	6.22	23.00	2.72
Cosgrove Shoal	4.60	0.02	6.41	7.40	12.88	4.50
Dry Tortugas National Park	7.20	8.82	6.09	1.85	ns	ns
Pulaski Shoal (just outside park)	5.30	0.00	7.21	4.16	ns	ns
Patchy hard bottom in sand						
Between Star & Triumph Reef	2.35	0.13	4.81	0.82	10.69	21.95
North of Fowey Rocks	1.70	1.28	5.61	1.28	10.88	0.28
Low-relief hard-bottom						
SW of Pacific Reef	2.15	0.61	3.85	3.29	17.10	27.38
Ajax Reef	2.30	0.32	1.60	0.00	14.81	0.20
North of Ajax Reef	1.40	0.08	5.45	1.85	10.94	0.95
Star Reef	1.20	0.02	4.65	0.05	11.00	4.50
Ledberry Reef	0.95	0.13	3.53	5.14	15.06	0.07
East of Biscayne Bay	3.10	0.18	6.25	2.52	8.94	8.51
Carysfort Reef SPA*	7.15	1.13	9.13	4.16	5.38	4.50
Seaward of Watson's Reef	3.95	3.65	10.74	4.16	16.13	78.13
Between Molasses & French Reef	2.35	0.41	3.53	0.82	10.13	0.13
Southern DTNP (just outside park)	1.95	0.13	3.85	0.82	19.17	0.22
Dry Tortugas National Park	1.40	0.08	4.43	0.96	25.33	26.89
Dry Tortugas National Park	2.30	0.32	5.13	0.00	26.83	2.72
Dry Tortugas National Park	3.90	1.28	6.89	0.46	21.94	35.07
Dry Tortugas National Park	2.05	0.25	4.17	0.21	ns	ns
Tortugas Bank	2.05	0.25	5.93	4.16	ns	ns
Dry Tortugas National Park	0.90	0.00	2.40	2.52	27.85	0.13
NW of Loggerhead Key	0.90	0.18	0.96	0.00	ns	ns
Dry Tortugas National Park	1.60	0.72	2.56	0.00	ns	ns

Table 8. continued.

Habitat type/site location	Scleractinia	SE	Juvenile corals	SE	Gorgonians	SE
Low-relief spur and groove						
Offshore Pacific Reef	1.95	0.05	3.69	1.28	9.56	20.32
SW of Brewster Reef	5.00	2.00	3.04	4.16	27.19	3.45
South of Fowey Rocks	3.95	2.21	4.81	5.14	4.69	3.45
Between Star & Triumph Reef	1.80	0.18	4.49	3.29	14.06	2.26
Carysfort Reef SPA*	1.20	0.02	4.33	0.46	9.75	0.28
Elbow Reef SPA**	3.35	0.85	7.37	5.14	10.56	0.01
North Dixie Shoal	5.40	0.50	4.81	3.29	6.13	0.03
Dixie Shoal	5.25	0.25	5.93	8.68	10.56	2.26
French Reef **	2.95	3.65	4.49	0.21	19.81	4.88
Molasses Reef**	3.55	0.25	4.01	4.16	10.25	3.78
Conch Reef Research Only*	3.95	1.13	10.26	0.82	8.19	0.95
Davis Reef**	3.95	0.01	6.57	6.22	ns	ns
Alligator Reef**	2.10	2.00	3.85	3.29	ns	ns
Between Tennessee & Alligator	11.31	0.20	10.42	27.17	ns	ns
Offshore of Tennessee RO**	6.13	0.78	3.69	6.22	ns	ns
East of Pelican Shoal	2.85	0.61	10.90	1.85	15.13	0.00
Eastern Sambo**	4.75	0.85	6.57	1.28	ns	ns
Western Sambo*	4.50	0.50	3.77	0.12	ns	ns
Between W. Sambo & E. Dry Rocks	5.48	3.25	ns	ns	ns	ns
Eastern Dry Rocks**	5.50	0.50	3.69	6.22	ns	ns
Rock Key**	3.80	2.00	9.46	1.28	ns	ns
Sand Key**	2.75	1.81	6.53	2.34	ns	ns
SW of Western Dry Rocks	3.80	0.72	7.85	4.16	ns	ns
Dry Tortugas National Park	9.55	0.25	8.01	1.85	13.08	3.13
Reef terrace						
Loggerhead Forest	5.35	1.13	1.32	0.93	ns	ns
Sherwood Forest	7.90	0.72	3.04	6.22	ns	ns
Sherwood Forest	7.75	0.05	ns	ns	ns	ns
Sherwood Forest	7.20	0.08	6.13	12.74	ns	ns
Sherwood Forest	4.70	0.72	2.75	0.07	ns	ns

Gorgonian Density

Total gorgonian density for each site surveyed is listed in Table 8. From Biscayne to the Lower Keys, gorgonian densities were generally similar among habitats, regions, and management protection. The highest densities were recorded from offshore patch reefs in the Lower Keys. Only nine sites in the Dry Tortugas included surveys for gorgonian density due to logistical constraints (three divers instead of four). Among the Tortugas sites, the highest gorgonian densities were found in low-relief hard-bottom and high relief spur and groove (Bird Key Reef) habitats.

Urchin Density and Size

Surveys of urchin density were conducted at 56 of the 64 sites during 2002. Three species were encountered in transect surveys (Table 9). Similar to results from 1999-2001, all of the sampling locations yielded very low densities of urchins, particularly the long-spined sea urchin *Diadema antillarum*. However, we found some locations with relatively high densities of other species, particularly *Echinometra viridis*. Because densities remain low, patterns are difficult to discern,

Table 9. Mean (1 SE) densities of urchins (no. individuals per m^2) from surveys of four 15-m^2 plots per site. Noted are sites within Sanctuary Fully Protected Marine Zones (*) and those adjacent to and seaward of zone boundaries (**). ns = no survey conducted.

Habitat type/site location	***Diadema antillarum***		***Eucidaris tribuloides***		***Echinometra viridis***	
	Mean	SE	Mean	SE	Mean	SE
Offshore patch reef						
Inshore of Pacific Reef	0	0	0.017	0.001	0	0
West Washerwoman Shoal	0	0	0	0	0.711	0.099
West of West Washerwoman	0.017	0.001	0.017	0.001	1.033	0.336
Patch reef (Staghorn mound)						
Dry Tortugas National Park	0	0	0	0	0	0
Reef knoll						
Dry Tortugas National Park	0.017	0.001	0	0	0.150	0.007
High-relief spur and groove						
Bird Key Reef	0	0	0	0	0.217	0.046
Medium-profile reef						
Coal Bin (East of Cosgrove Shoal)	0	0	0	0	0	0
Cosgrove Shoal	0	0	0	0	0.017	0.001
Pulaski Shoal (just outside DTNP)	0	0	0	0	0	0
Patchy hard-bottom in sand						
Between Star & Triumph Reef	0.050	0.004	0	0	0.033	0.001
North of Fowey Rocks	0	0	0	0	0	0
Low-relief hard-bottom						
SW of Pacific Reef	0	0	0	0	0	0
Ajax Reef	0	0	0.017	0.001	0.017	0.001
North of Ajax Reef	0	0	0	0	0	0
Star Reef	0	0	0	0	0	0
Ledberry Reef	0	0	0	0	0	0
East of Biscayne Bay	0	0	0	0	0	0
Carysfort Reef SPA*	0	0	0	0	0	0
Seaward of Watson's Reef	0	0	0	0	0.050	0.010
Between Molasses & French Reef	0	0	0.017	0.001	0.017	0.001
Southern DTNP (just outside park)	0	0	0.017	0.001	0	0
Dry Tortugas National Park	0	0	0.017	0.001	0	0
Dry Tortugas National Park	0	0	0	0	0	0
Dry Tortugas National Park	0	0	0	0	0.017	0.001
Tortugas Bank	0	0	0	0	0	0
Dry Tortugas National Park	0.022	0.001	0	0	0	0
NW of Loggerhead Key	0	0	0	0	0	0

Table 9. continued.

Habitat type/site location	*Diadema antillarum*		*Eucidaris tribuloides*		*Echinometra viridis*	
	Mean	SE	Mean	SE	Mean	SE
Low- relief spur and groove						
Offshore Pacific Reef	0	0	0	0	0	0
Between Star & Triumph Reef	0.017	0.001	0	0	0	0
SW of Brewster Reef	0	0	0.017	0.001	0	0
South of Fowey Rocks	0	0	0	0	0	0
Carysfort Reef SPA*	0	0	0	0	0	0
Elbow Reef SPA**	0	0	0	0	0	0
North Dixie Shoal	0	0	0	0	0	0
Dixie Shoal	0	0	0	0	0	0
French Reef**	0	0	0	0	0	0
Molasses Reef**	0	0	0	0	0	0
Conch Reef Research Only*	0	0	0	0	0	0
Davis Reef**	0	0	0	0	0	0
Alligator Reef**	0	0	0	0	0	0
Between Tennessee & Alligator	0	0	0.017	0.001	0	0
Offshore of Tennessee RO**	0.022	0.001	0	0	0	0
East of Pelican Shoal	0	0	0	0	0	0
Eastern Sambo Reef**	0	0	0	0	0	0
Western Sambo Reef*	0	0	0	0	0	0
Between W. Sambo & E. Dry Rocks	0	0	0	0	0	0
Eastern Dry Rocks	0	0	0	0	0	0
Rock Key**	0	0	0	0	0.017	0.001
Sand Key**	0	0	0	0	0	0
SW of Western Dry Rocks	0	0	0.022	0.001	0	0
Dry Tortugas National Park	0	0	0	0	0	0
Reef terrace						
Loggerhead Forest	0	0	0	0	0	0
Sherwood Forest	0	0	0	0	0	0
Sherwood Forest	0.022	0.001	0	0	0	0
Sherwood Forest	0	0	0	0	0.017	0.001
Sherwood Forest	0	0	0	0	0.017	0.001

although we detected an abundance of *E. viridis* on offshore patch reefs compared to *Eucidaris tribuloides*, from Biscayne Bay to Key West.

Incidental Invertebrates

We assessed density patterns at 18 of the 64 sites surveyed for a variety of sessile and mobile invertebrate species during 2002 (Table 10). These surveys were not included at all sites for logistical reasons (three divers instead of four). In addition to anemones and corallimorpharians (Table 11), three species of shrimp symbionts, the polychaete *Hermodice carunculata*, the basket star *Astrophyton muricatum*, and crustaceans were counted within strip transect surveys at a number of sites (Table 12).

Table 10. Incidental marine invertebrates surveyed for density during 2002. Listed are only those species recorded within four 15-m^2 plots per site.

Invertebrate group	Species name	Common name
Anemones	*Bartholomea annulata*	Ringed anemone
	Condylactis gigantea	Pink-tipped anemone
	Lebrunia danae	
Corallimorpharians	*Ricordea florida*	Florida corallimorph
Polychaetes	*Hermodice caruncullata*	Fire worm
Echinoderms	*Astrophyton muricatum*	Basket star
	Diadema antillarum	Long-spined sea urchin
	Echinometra viridis	Reef urchin
	Eucidaris tribuloides	Red pencil urchin
Crustaceans	*Panulirus argus*	Spiny lobster
	Periclimenes pedersoni	Pederson's cleaner shrimp
	Stenorhyncus seticornis	Arrow crab
	Stenopus hispidus	Red-banded coral shrimp

Table 11. Mean (1 SE) densities (no. individuals per m^2) of anemones and corallimorpharians from surveys of four 15-m^2 plots per survey location. Sites within Sanctuary Fully Protected Marine Zones are noted with a single asterisk (*) and sites adjacent to and seaward of zone boundaries are double asterisked (**). Listed are only the sites surveyed and species recorded within four 15-m^2 plots per site.

Habitat type/site location	*Bartholomea annulata*	*Condylactis gigantea*	*Lebrunia danae*	*Ricordea florida*
Offshore patch reef				
Inshore of Pacific Reef	0.033 (0.004)	0.017 (0.001)	0.017 (0.001)	0
Patchy hard-bottom in sand				
Between Star & Triumph Reef	0.033 (0.001)	0.033 (0.001)	0	0.150 (0.022)
North of Fowey Rocks	0.017 (0.001)	0	0	0
Low-relief hard bottom				
Ajax Reef	0.050 (0.010)	0	0	0
North of Ajax Reef	0	0	0	0
Star Reef	0	0	0	0
Ledberry Reef	0	0	0	0
East of Biscayne Bay	0.017 (0.001)	0	0	0
Low-relief spur and groove				
Offshore Pacific Reef	0	0	0	0
Between Star & Triumph Reef	0.033 (0.001)	0	0	0
SW of Brewster Reef	0	0	0	0.017 (0.001)
South of Fowey Rocks	0.033 (0.004)	0	0	0
North Dixie Shoal	0.033 (0.001)	0.050 (0.004)	0	0
French Reef **	0	0	0	0
East of Pelican Shoal	0	0	0.017 (0.001)	0
Eastern Sambo**	0	0	0	0
Western Sambo*	0	0	0	0
Between W. Sambo & E. Dry Rocks	0.017 (0.001)	0	0	0

Table 12. Mean (1 SE) densities (no. individuals per m^2) of incidental marine invertebrates from surveys of four 15-m^2 plots per survey location. Noted are sites within Sanctuary Fully Protected Marine Zones (*) and sites adjacent to and seaward of the zones (**). Listed are only those sites surveyed where species were found within four 15-m^2 plots at each site.

Habitat type/site location	*Astrophyton muricatum*	*Periclimenes pedersoni*	*Stenopus hispidus*	*Stenorhyncus seticornis*
Offshore patch reef				
Inshore of Pacific Reef	0	0	0.033 (0.002)	0
Patchy hard-bottom in sand				
Between Star & Triumph Reef	0.133 (0.009)	0	0	0.017 (0.001)
North of Fowey Rocks	0.233 (0.016)	0	0	0
Low-relief hard- bottom				
Ajax Reef	0	0	0	0
North of Ajax Reef	0.067 (0.003)	0	0	0
Star Reef	0.133 (0.033)	0	0	0
Ledberry Reef	0.333 (0.086)	0	0	0.017 (0.001)
East of Biscayne Bay	0	0	0.017 (0.001)	0.033 (0.004)
Low-relief spur and groove				
Offshore Pacific Reef	0.067 (0.018)	0	0	0.017 (0.001)
Between Star & Triumph Reef	0	0	0	0
SW of Brewster Reef	0	0	0	0.017 (0.001)
South of Fowey Rocks	0.083 (0.010)	0.033 (0.004)	0.017 (0.001)	0.033 (0.002)
North Dixie Shoal	0.083 (0.010)	0.017 (0.001)	0.017 (0.001)	0.033 (0.002)
French Reef**	0	0	0	0.017 (0.001)
East of Pelican Shoal	0.017 (0.001)	0	0	0
Eastern Sambo**	0.017 (0.001)	0	0	0
Western Sambo*	0	0	0	0.017 (0.001)
Between W. Sambo & E. Dry Rocks	0	0	0	0

Plans for Use of the Data

We have made significant progress in manuscript development since January 2002. Below is a listing of manuscripts in press or published, those submitted for review, and those we intend to submit for publication by January 2003. We plan on using the 2002 data collected from the deeper fore reef to compare to a similar Keys-wide study conducted in 1995 of low-relief spur and groove habitats at 15-21 m depth.

Manuscripts Published

1. Ault JS, Smith SG, Meester GA, Luo J, Bohnsack JA, Miller SL (2002) *Baseline multispecies coral reef fish stock assessment for the Dry Tortugas*. NOAA Technical Memorandum NMFS-SEFSC-487, 117 p.
2. Ault JS, Smith SG, Meester GA, Luo J, Franklin EC, Bohnsack JA, Harper DE, McClellan DB, Miller SL, Swanson DW, Chiappone M (2002) Tortugas surveyed: Synoptic habitat and reef fish surveys support establishment of marine reserves in the Dry Tortugas, Florida, USA. *Reef Encounter* 31: 22-23.
3. Chiappone M, Miller SL, Swanson DW, Ault JS, Smith SG (2001) Comparatively high densities of the long-spined sea urchin in the Dry Tortugas, Florida. *Coral Reefs* 20: 137-138.

4. Chiappone M, Miller SL, Swanson DW (2001) *Condylactis gigantea* – A giant comes under pressure from the aquarium trade in Florida. *Reef Encounter* 30: 29-31.
5. Chiappone M, Swanson DW, Miller SL (2002) Density, spatial distribution and size structure of sea urchins in coral reef and hard-bottom habitats of the Florida Keys. *Marine Ecology Progress Series* 235: 117-126.
6. Chiappone M, Swanson DW, Miller SL, Smith SG (2002) Large-scale surveys on the Florida Reef Tract indicate poor recovery of the long-spined sea urchin *Diadema antillarum*. *Coral Reefs* 21: 155-159.
7. Chiappone M, White A, Swanson DW, Miller SL (2002) Occurrence and biological impacts of fishing gear and other marine debris in the Florida Keys. *Marine Pollution Bulletin* 44: 597-604.
8. Miller SL, Chiappone M, Swanson DW, Ault JS, Smith SG, Meester GA, Luo J, Franklin EC, Bohnsack JA, Harper DE, McClellan DB (2001) An extensive deep reef terrace on the Tortugas Bank, Florida Keys National Marine Sanctuary. *Coral Reefs* 20: 299-300.

Manuscripts in Press

9. Chiappone M, Dienes H, Swanson DW, Miller SL (In press) Density and gorgonian host-occupation patterns by flamingo tongue snails (*Cyphoma gibbosum*) in the Florida Keys. *Caribbean Journal of Science.*
10. Dienes H, Chiappone M, Miller SL, Swanson DW (In press) Density and fore reef habitat utilization patterns of the lettuce sea slug (*Tridachia crispata*) in the Florida Keys. *Bulletin of Marine Science.*
11. Dienes H, Chiappone M, Swanson DW, Miller SL (In press) Impacts of lost fishing gear on coral reef sessile invertebrates of the Florida Keys National Marine Sanctuary. *Biological Conservation.*
12. Franklin EC, Ault JS, Smith SG, Luo J, Meester GA, Diaz GA, Chiappone M, Swanson DW, Miller SL, Bohnsack JA (In press) Coral reef benthic habitat classification in the Tortugas region, Florida. *Marine Geodesy.*
13. Miller SL, Swanson DW, Chiappone M (In press) Multiple spatial scale assessment of coral reef and hard-bottom community structure in the Florida Keys National Marine Sanctuary. *Proceedings of the 9th International Coral Reef Symposium, Bali.*

Manuscripts in Review

14. Chiappone M, Swanson DW, Miller SL (In review) Density and habitat utilization patterns of anemones and corallimorpharians (Anthozoa, Zoantharia) in the Florida Keys National Marine Sanctuary. *Coral Reefs.*
15. Chiappone M, Swanson DW, Miller SL (In review) Large-scale density patterns of anemones and corallimorpharians on offshore coral reef habitats in the Florida Keys. *Bulletin of Marine Science.*
16. Dienes H, Chiappone M, Swanson DW, Miller SL (In review) Spatial distribution and density of fishing gear in Florida Keys National Marine Sanctuary no-take zones. *Coral Reefs.*
17. Precht WF, Miller SL (2002) Ecological shifts along the Florida reef tract: Is the past the key to the future? In *The destruction of coral reef ecosystems: Paleoecological perspectives on the human role in a global crisis*. Aronson RB (ed), Springer Verlag, NY.

Manuscripts in Progress

18. Chiappone M, Swanson DW, Miller SL (In progress) Impacts to coral reef sessile invertebrates from lost lobster trap gear in the Florida Keys National Marine Sanctuary. *Symposium on Effects of Fishing Activities on Benthic Habitats, American Fisheries Society.*
19. Chiappone M, Swanson DW, Miller SL (In progress) Spatial distribution and impacts of lost hook-and-line fishing gear to sessile invertebrates in the Florida Keys National Marine Sanctuary. *Symposium on Effects of Fishing Activities on Benthic Habitats, American Fisheries Society.*
20. Chiappone M, Swanson DW, Miller SL, Sullivan-Sealey KM (In progress) A hierarchical structural classification of Florida Keys coral reef and hard-bottom habitats. *Aquatic Conservation: Marine and Freshwater Ecosystems.*
21. Chiappone M, Swanson DW, Miller SL, White A, Dienes H (In progress) A rapid method for assessing topographic complexity of coral reef and hard-bottom habitats. *Journal of Experimental Marine Biology and Ecology.*
22. Miller SL, Chiappone M, Swanson DW (In progress) Long-term dynamics of Florida Keys acroporid reefs: History and implications of a phase shift. *Coral Reefs.*
23. Miller SL, Chiappone M, Swanson DW, Ault JS, Smith SG, Franklin EC (In progress) Design-based surveys of coral reef and hard-bottom habitats in Dry Tortugas National Park and the Tortugas Bank, Florida. *Ecological Applications.*
24. Miller SL, Gittings S, Chiappone M, Causey B, Swanson DW, White A (In progress) Changes (1994-2000) to benthic cover on a deep coral reef in the Florida Keys. *Coral Reefs.*
25. Smith SG, Swanson DW, Miller SL, Ault JS, Chiappone M (In progress) Sampling survey approaches for coral reef assessment and monitoring in the Florida Keys. *Coral Reefs.*
26. Swanson DW, Chiappone M, Miller SL (In progress) Habitat and regional variations in coral species richness and coverage in the Florida Keys. *Coral Reefs.*
27. Swanson DW, Chiappone M, Miller SL (In progress) Disease prevalence on reef-building corals in the Florida Keys National Marine Sanctuary. *Marine Ecology Progress Series.*