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

## Quick Look Report: Summer 2005 Keys-Wide Sampling

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### Project Summary:

This NURC/UNCW quick look report summarizes the accomplishments and significant findings from the 2005 benthic sampling of no-take zones and reference habitats in the Florida Keys National Marine Sanctuary (FKNMS) and Biscayne National Park (BNP). The sampling during 2005 represents a continuation of large-scale surveys of hard-bottom and coral reef habitats in the FKNMS conducted by UNCW since 1998, not including two expeditions to the Tortugas region during 1999 and 2000.

The 2005 effort provides a synoptic picture of the status of hard-bottom and coral reef benthic resources on the inner shelf margin and outer shelf of the Florida Keys, as well as a time series for selected habitats and a subset of the no-take zones designated as Sanctuary Preservation Areas, Ecological Reserves, and Research Only Areas. The 2005 surveys assessed community structure and condition of hard-bottom and coral reef communities in a variety of habitat types from the inshore edge of Hawk Channel to 27 m depth: mid-channel patch reef, offshore patch reef, inner line reef tract, high-relief spur and groove, shallower and deeper hard-bottom, shallower and deeper low-relief spur and groove, patchy hard-bottom, and low-relief spur and groove and rocky outcrops on the deeper fore reef slope. The survey effort

required 73 field days of SCUBA surveys by a three to four person benthic team between May 8 and October 2 and resulted in assessments of 195 sites from southwest of Key West to the northern end of Biscayne National Park. Thirteen of the Sanctuary's 23 zones were sampled. The field sampling was accomplished using NURC/UNCW's Key Largo facilities (R/V *Research Diver*) and a private charter (R/V *Expedition II*). Benthic surveys by the project team were complemented by reef fish surveys conducted by personnel from RSMAS-University of Miami and NOAA-National Marine Fisheries Service at a subset of the 195 sites.

Variables measured during 2005 included coverage, species richness of sponges and benthic cnidarians, gorgonian density, stony coral density and size, coral condition, and still photography for archival purposes. We were also able to continue or add several variables to the 2005 assessment: urchin density and size; density of anemones, corallimorpharians and opisthobranch mollusks; density and predation by the flamingo tongue snails (*Cyphoma gibbosum* and *C. signatum*); *in situ* measurements of topographic complexity; and density and volume measurements for seven common sponges. All of the variables were collected underwater on pre-formatted plastic slates, facilitating relatively rapid data processing for manuscript preparation and report generation. We also took over 2,000 digital photographs for archives of sites and tools for taxonomic identification of Florida Keys coral reef and hard-bottom habitat types.

Below we provide a brief narrative on the overall goals of the UNCW zone monitoring effort and a variable-by-variable summary of significant findings from the 2005 field surveys. We also include a list of published and planned papers and other products developed from this effort. A suite of 21 appending tables summarize site-level coverage, species richness, and density estimates for most of the variables measured during 2005. Time series analysis is planned for 2006 that will compare the 2005 surveys with surveys previously conducted starting in 1999.

## Sampling Goals and Objectives:

The 2005 sampling of coral reef and hard-bottom habitats in the Florida Keys National Marine Sanctuary (FKNMS) and Biscayne National Park (BNP) included both FKNMS no-take zones and corresponding reference habitats that complements a multi-year effort dating back to 1999 to sample all of the shallow-water (< 15) hard-bottom habitat types in the FKNMS, as well as most of the no-take zones established in 1997. The goals of the UNCW zone monitoring effort are four-fold:

- To assess the community structure and condition of reef communities at multiple spatial scales, with particular reference to the no-take zones, but also inter-reef, among habitat type, and among regions (upper, middle, lower Keys).
- To assess coral population structure at multiple scales, including among benthic habitats types, regions, and level of protection.
- To assess the condition of coral reef habitats related to potential changes due to protection from fishing within the zones, but also changes that may occur at larger spatial scales related to regional or global phenomena.
- To complement fishery-independent reef fish surveys with "fine-scale" or detailed habitat information, to facilitate experimental and modeling efforts for evaluating essential fishery habitat (in collaboration with Dr. Jerry Ault and Dr. Jim Bohnsack).

To accomplish these goals, the 2005 sampling built upon existing data collected during 1999-2002 to guide the underwater surveys. Our focus during 2005 was two-fold:

- To survey the complement of hard-bottom and coral reef habitats throughout the Florida Keys region to assess habitat and regional variability in community structure and condition and
- To revisit a subset of habitat types and sites to compare with baselines established in 1999-2001, especially habitat types and sites inside and outside of FKNMS no-take zones protected from fishing.

Together with the data collected during 1999-2002, this project has amassed an unprecedented data set on the abundance and habitat utilization patterns of algae and several invertebrate taxa, including stony corals, gorgonians, other benthic cnidarians, sponges, mollusks, echinoderms, and crustaceans. This information describes larger scale patterns relative to the presently small area of no-take zones within the FKNMS. These data are also timely for providing population abundance estimates and trends for reef-building invertebrates, especially stony corals, as well as a temporal comparison of changes in benthic community structure inside and outside of areas protected from fishing.

## Logistics and Methods:

A two-stage stratified random sampling design was used to randomly select sites during 2005. A grid system constructed in a geographic information system (GIS) was used to overlay the existing habitat map of the Florida Keys, including Biscayne National Park (BNP). Cells or blocks 200 m x 200 m in dimension were used to randomly select sites from the following habitat strata in four regional sectors (Table 1):

- Mid-channel patch reefs in the lower Keys, middle Keys, upper Keys and BNP
- Offshore patch reefs in all four regions
- High-relief spur and groove (< 6 m depth) in all four regions
- Low-relief hard-bottom (< 6 m depth) in the middle Keys, upper Keys and BNP
- Low-relief hard-bottom (6-15 m depth) in all four regions
- Low-relief spur and groove (< 6 m depth) in BNP
- Low-relief spur and groove (6-15 m depth) in all four regions
- Patchy hard-bottom (6-15 m depth) in all four regions
- Low-relief spur and groove (15-21 m depth) in all four regions
- Low-relief spur and groove (21-33 m depth) in all four regions

Thirteen of the Sanctuary's 23 zones were sampled during 2005, with all but two of the zones (Looe Key RO and Cheeca Rocks SPA) located on the outer platform margin or reef tract. Two sites or blocks were assigned to each no-take zone and a total of 195 sites were surveyed between May 8 and October 2 (Table 2). Figures 1 to 5 show the locations of the sampling locations Keys-wide and for all four regional sectors. In 2005 we were fortunate to be able to sample nearly all of the sites slated for surveying in the original sample design, including multiple sites Keys-wide on the deeper fore reef slope.

The 2005 sampling effort (195 sites) required 73 field days from early May to early October (Table 3). Fortunately, only three scheduled field days were lost to inclement weather: one day due to Hurricane Dennis in early July and two days in late August due to Hurricane Katrina. Of the 73 days, 40 days (55%) were supported by day-boat operations from NURC-Key Largo (77 sites) or extended operations using a NURC/UNCW boat anchored at Biscayne National Park (29 sites). A private charter (R/V *Expedition II*) supported the remaining field time (33 days or 45% of field time), in which 88 sites (45% of total site effort) were sampled. Our field effort depended upon 6-7 hours in the water daily by three to four divers. The 2005 sampling involved not only UNCW staff surveying the benthos, but fisheries scientists from RSMAS-UM and

NOAA/NMFS who conducted four reef fish censuses at a subset of sites. Table 4 summarizes the diving statistics for this year. Benthic surveys of the 195 sites required 647 dives comprising more than 1,000 hours of underwater bottom time.

The 2005 surveys addressed many of the same variables measured during 1999-2002, in addition to several variables added to the existing design (Table 5). Briefly, at each site pre-determined GPS points were used to locate the position of transect deployment. Four 15 m transects were deployed at each site. Along each transect, coverage was determined every 15 cm to yield 100 points per transect. The numbers of species of stony corals, gorgonians, and sponges were determined in a 0.5 m swath on each side of the four transects, yielding a total sample area of 60 $m^2$ per site. Gorgonian density for all species and maximum colony height for select species (*Gorgonia ventalina*, *Eunicea tourneforti*, *Muricea muricata*, *Plexaura homomalla*, and *Plexaurella nutans*) were determined along two transects in 1 m x 8 m swaths. Stony corals more than 4 cm in maximum diameter were counted, measured, and assessed for condition along two of the transects in 1 m x 10 m swaths. The condition measurements included an assessment of competition between corals and other taxa, and the extent to which interactions caused tissue damage or mortality. For selected stony corals, additional density, size, and condition measurements were made on the remaining two transects in 10 m x 1 m swaths. Juvenile corals (< 4 cm maximum diameter) were assessed along two transects by randomly sampling ten 0.68 m x 0.45 m quadrats along each transect. Urchin density and test diameter, as well as the density of incidental marine invertebrates (see Table 4) were assessed on all four transects (total sample area = 60 $m^2$/site).

We additionally assessed density and predation by flamingo tongue snails (*Cyphoma gibbosum* and *C. signatum*), by noting the number of individuals, gorgonian prey, and gorgonian height on all transects deployed. *In situ* measurement of topographic complexity along the four transects were undertaken to provide an assessment of substratum angle, maximum vertical relief, and the coverage of different relief categories along 1 m x 15 m swaths. Finally, we measured the number of individuals and approximate dimensions of seven species of common sponges to provide density and volume estimates in 1 m x 8 m swaths along two transects per site. Surveyed species included: *Callyspongia vaginalis*, *Cliona delitrix*, *Ircinia felix*, *I. campana*, *I. strobilina*, *Niphates digitalis*, and *Xestospongia muta*.

## Summary of Significant Results:

Hurricanes

The summer of 2005 witnessed the passage of four category one or stronger hurricanes that affected benthic communities on the south Florida shelf to varying degrees. The passage of Hurricane Dennis during the second week of July delayed our continued sampling of the lower Keys by only one day. Although the path of Dennis was well west of Key West, significant scouring, sediment transport, gorgonian toppling, and sponge mortality across the shelf down to at least 27 m was observed (Figure 6). On mid-channel and offshore patch reefs on the inner shelf margin (inshore of the main reef tract), the principal affects of Dennis, Katrina, and Rita were the toppling of gorgonians, the severing of sponges, in some cases from the base, and the removal of macroalgae and even algal turfs to produce temporarily bare substratum. On the fore reef slope to at least 27 m, we observed in several locations the significant transport of sediment up the slope, revealing in some instances the base of the reef that had been previously buried by at least 15 cm of sediment (Figure 6).

Bleaching

The summer of 2005 started with doldrums-like conditions during mid-May, with light and variable winds from the west-southwest. By June, predominant winds returned to their seasonal east-southeasterly orientation, but conditions relative to previous summers were unusually calm.

By early August while working in the lower Keys, we first noticed the usual occurrence of bleaching on the shallow fore reef (< 6 m depth), principally by lettuce (*Agaricia agaricites*) and golf ball corals (*Favia fragum*), and to a lesser extent *Porites astreoides*. By the end of the first week of August, the area between Big Pine Key and Key West was yielding surface to bottom temperatures of 31.1° to 32.2°C (88° to 90°F), with paling and moderate bleaching of several stony coral species. This pattern was evident both offshore and on inner shelf margin patch reefs, but was less severe on the deeper fore reef slope. By the middle of August and extending into mid-September, we observed moderately severe bleaching while working in both the lower Keys and Biscayne National Park (Figure 7). We would characterize the 2005 bleaching as moderately severe in that many stony coral and gorgonian species were observed as pale, partially bleached, or completely bleached, but densities of affected colonies were usually not more than 25% per site. Efforts are currently underway to summarize the coral bleaching data in terms of densities of affected colonies by condition (pale, partially bleached, completely bleached), species, size, and habitat/depth.

Benthic cover

Tables 5 and 6 summarize mean percent coverage data for fire corals, stony corals, sponges, the colonial zoanthid *Palythoa mammilosa*, and different algal categories (turfs, crustose corallines, macroalgae) for the 195 sites. Patterns in coverage exhibited significant differences among the sampled habitat types surveyed as found in previous years. Mid-channel patch reefs exhibited some of the highest coral cover we have surveyed in the Florida Keys. The greatest site level coral coverage of 43.3% was recorded from a mid-channel patch reef south of Marathon. Coral cover on mid-channel patch reefs was dominated by massive reef-building corals, namely *Montastraea cavernosa*, *M. faveolata*, *Colpophyllia natans*, and *Siderastrea siderea*, as well *Diploria* spp. on some sites. Sponges also exhibited the greatest coverage on mid-channel patch reefs, especially at several sites south of Vaca Key.

Species richness

Surveys of the number of species of stony corals, gorgonians, and sponges continued during the 2005 surveys. Table 8 summarizes the number of species per site and average number of species per 15 $m^2$ transect for stony corals, gorgonians, and sponges. The species richness of stony corals was relatively high closer to shore on patch reefs (18-20 species/site), lower on offshore and shallower spur and groove and hard-bottom, and increased to values similar to patch reefs on the deeper reef slope. For most habitat types surveyed, the average number of stony coral species encountered per site tended to be greatest in either the middle Keys or lower Keys. The species richness of gorgonians exhibited a slightly different pattern, with mid-channel patch reefs, offshore patch reefs, and shallow (< 6 m) to deeper (6-13 m) low-relief hard-bottom and spur and groove habitats yielding the greatest number of species per site. In contrast to corals, the number of gorgonian species tended to decrease with depth on the deeper fore reef slope. Of the three broad taxa groups, sponges were clearly the most speciose, with as many as 49 species recorded from a single site (60 $m^2$). In many sites, the number of sponge species encountered was equivalent or greater than the number of stony coral and gorgonian species combined. Among habitat types across the continental shelf, sponge species richness followed a fairly predictable pattern, with relatively high numbers of species on patch reefs (28.9-34.7 per site), relatively low numbers of species on the shallowest, most wave-exposed habitats (22.1-26.5 species), and then increasing numbers of species with depth from 6 m to 27 m.

Coral density, disease and bleaching

Coral density, size, and condition measurements were made using the same techniques applied in 1998-2002. The total area surveyed for corals greater than 4 cm in maximum

diameter during 2005 was 3,900 $m^2$, in which 32,664 stony corals were identified, counted, measured for size, and assessed for colony condition (Table 9). Of the total colonies assessed, 9,030 or 28% were *Millepora alcicornis* or *M. complanata*, while the remainder was scleractinian species. Similar to previous years, densities of fire coral were relatively similar among most habitat types, usually averaging one to four colonies per $m^2$. Site-level scleractinian coral density was as high as 25.40 ± 0.28 colonies/$m^2$, the highest density recorded from a mid-channel patch reef southeast of Margot Fish Shoal, BNP, due to the prevalence of branching *Porites* colonies. Scleractinian corals exhibited marked differences in density and species composition among the habitat types sampled. In general, mid-channel and offshore patch reefs had the greatest scleractinian coral densities, followed by habitats on the deeper fore reef slope between 15 m and 27 m depth. We were encouraged to find several locations on the deeper fore reef slope with large and dense corals, even in areas with relatively poor visibility such as near the Key West Ship Channel.

The condition measurements during 2001 included assessments of competition, predation, bleaching, and disease. As in previous years, disease incidence in the habitats and depth range surveyed was very low, especially black band, "white diseases" and abnormal tissue coloring (Table 10). Four disease or disease-like conditions were noted during 2005: 1) dark or gray spots affecting primarily *Siderastrea siderea* and *Stephanocoenia michelini*, 2) black band disease, 3) colonies with chalky margins, and 4) colonies with white splotches. The prevalence of these conditions on the 23,634 scleractinian colonies assessed was 0.91%, of which dark or gray spots accounted for nearly 99% of the disease-like observations. Abnormal tissue condition, not including bleaching, tended to be proportional to the number of scleractinian colonies in a site. In particular, mid-channel patch reefs exhibited a greater proportion of colonies with disease-like symptoms, as these were the sites that also exhibited the greatest density and size of scleractinian corals. It is notable that of the nearly 24,000 colonies assessed, only one incidence of active black band was documented during 2005.

In contrast to previous years of sampling, a moderately severe bleaching event affected most coral reef and hard-bottom habitats beginning in early August. The event could be classified "moderately severe" in the sense that numerous stony coral and gorgonian species were affected by paling, partial bleaching, or complete pigment loss, but moderate in the sense that usually only 20-25% of all colonies were affected at the time of the surveys. Table 11 provides a synopsis of 30 sites (site #155-184) sampled in Biscayne National Park during part of the bleaching event (August 16-September 10) in terms of numbers of scleractinian coral colonies for all species encountered exhibiting no symptoms or varying degrees of bleaching symptoms. Of the 2,743 colonies measured at these 30 sites, a total of 321 colonies or 11.7% exhibited symptoms of bleaching. By habitat type, the greatest proportion of bleached colonies was observed among patch reefs and shallow, high-relief spur and groove, where ~9% to 15% of all scleractinian corals were affected to varying degrees. A low prevalence of bleaching was found on more offshore habitat types, especially those on the deeper fore reef slope below 6 m depth.

Juvenile coral density

Surveys of juvenile coral species composition, density, and maximum diameter continued during 2005. Table 12 lists the number of juveniles found per site and mean densities reported as the number of juveniles per $m^2$. Surveys of the 195 sites resulted in the sampling of 3,900 quadrats and 1,216.8 $m^2$ of benthic habitat. A total of 8,760 juveniles were counted and identified. Site-level juvenile densities ranged from 0 (no juveniles found within quadrats) to a high of 32.05 ± 20.4 juveniles/$m^2$ at a low-relief hard-bottom site (6-13 m depth) at Vestal Shoal, southwest of Key West. Juvenile densities were greatest on mid-channel and offshore patch reefs, low-relief hard-bottom and spur and groove at 6-13 m depth, and 15-20 m depth on the fore reef slope. Relatively low densities of juveniles (< 5 per $m^2$) were found on shallow spur and

groove reefs, similar to 1999-2002, in areas historically dominated by *Acropora palmata*. For most habitat types, greater juvenile densities were recorded from lower Keys sites. In general and relative to surveys during 1999-2002, our impression was that juvenile densities were in general higher during 2005, especially for *Siderastrea siderea*. As can be viewed in Table 12, multiple locations in several habitat types had mean juvenile densities that rival density data reported for the wider Caribbean.

Gorgonian density and height distribution

Surveys of 3,120 $m^2$ of benthic habitat during 2005 yielded 48,459 gorgonian colonies (Table 12). A subset of species was additionally assessed for maximum colony height at each site: *Eunicea calyculata*, *E. tourneforti*, *Gorgonia ventalina*, *Muricea muricata*, *Plexaura homomalla*, and *Plexaurella nutans*. In nearly all sites and most habitat types surveyed, gorgonians continue to comprise the dominant sessile macro-invertebrates, often two times or greater in density than stony corals. Many of the mid-channel and offshore patch reefs surveyed yielded some of the highest gorgonian densities (> 30 colonies per $m^2$) we have recorded in the southeast Florida region. The greatest density of 49.56 ± 3.80 colonies/$m^2$ was recorded from a mid-channel patch reef inshore of Pacific Reef, Biscayne National Park. On mid-channel patch reefs, offshore patch reefs, and shallow hard-bottom, gorgonian densities tended to be greater in the lower Keys and BNP.

Sponge density and volume

During 2005 we added assessments of abundance and size of some of the more conspicuous sponges in the Florida Keys: *Callyspongia vaginalis* (tube), *Ircinia campana* (vase) *I. felix* (encrusting to amorphous) *I. strobilina* (amorphous), *Niphates digitalis* f. *digitalis* (tube or vase) and *Xestospongia muta* (massive) (Figure 8). Surveys of the 195 sites (3,120 $m^2$) yielded 4,107 individuals of the targeted sponges, of which *I. felix* (1,631 individuals, 40%) and *N. digitalis* (813 individuals, 20%) were the most abundant (Tables 13-18). The sponges surveyed tended to exhibit species-specific patterns in density and volume distribution among the habitat types sampled. Four of the six species had greater mean densities (no. individuals/$m^2$) on habitat types closest to shore (patch reefs), with relatively low densities (< 0.1) on the most wave-exposed habitat types along the reef tract. Densities of *N. digitalis* were generally higher offshore below 6 m depth (Table 17), independent of structural complexity, while densities of *X. muta* increased with depth (Table 18). All six sponges exhibited relatively high densities from 15-27 m, especially *X. muta* (0.39-0.56). Comparisons of density and volume measurements indicated that *C. vaginalis*, *N. digitalis*, and *X. muta* exhibited the greatest average volume in habitats closest to shore or those that were deepest on the fore reef slope. In contrast, each species of *Ircinia* exhibited relatively similar average individual volumes among most of the habitat types, indicating that differences in volume per transect were due to density differences and not variations in size. While many of the patterns in abundance and size documented can be at least partially explained by differences in wave energy across the south Florida shelf, results from this survey comprise a baseline from which other studies may discern how variations in recruitment, predation, predation, recent storm damage, and water quality affect the population ecology of sponges in the Florida Keys. Results from the 2005 surveys of sponge density and volume will be presented in May at the Seventh International Sponge Symposium. Additional analyses of size distribution among habitat types and regional sectors are ongoing.

Urchin density and size

Sea urchin densities and test sizes were measured at all 195 sites (11,700 $m^2$) during 2005, complementing similar surveys dating back to 1999 that provide a temporal record of urchin habitat distribution and recovery patterns of the once ubiquitous long-spined sea urchin, *Diadema antillarum*. Four species and 1,925 urchin individuals were encountered among the

195 sites (Table 19). *Echinometra viridis* was the most common urchin (1,369 individuals, 71%), followed by *Eucidaris tribuloides* (395 individuals, 21%), *D. antillarum* (122 individuals, 6%), and *E. lucunter* (39 individuals, 2%). Most of the 195 sites surveyed yielded relatively low urchin densities (< 0.1 individuals/$m^2$), particularly for *D. antillarum*. However, relative to previous years, we found more sites with slightly greater densities and larger test sizes of *D. antillarum*. This was especially apparent on mid-channel and offshore patch reefs in several regions, including the lower Keys. The greatest site density for *D. antillarum* of 0.167 ± 0.038 individuals/$m^2$ was recorded from an offshore patch reef west of the Looe Key Research Only Area in the lower Keys, in which 10 individuals were found among the four 15 x 1 m transects. However, densities of *D. antillarum* still remain at least one order of magnitude lower than historical observations before the 1983-84 Caribbean-wide mortality event. Other sea urchins, most notably *E. viridis*, were found in relatively high densities (up to 5.65 ± 0.75 individuals/$m^2$) on mid-channel and offshore patch reef environments as well. There was a clear shift from a predominance of *E. viridis* on patch reefs to *Eucidaris tribuloides* on offshore habitats. *E. tribuloides*, similar to previous years, tended to be found in relatively low densities, but distributed among most habitat types and the broadest depth range of the urchin species encountered.

Ancillary invertebrates

We assessed density patterns for a variety of sessile and mobile invertebrate species during 2005 (Table 20). Surveys of anemones, corallimorpharians, and opisthobranch and nudibranch mollusks continued, in addition to measurements of abundance and gorgonian host occupation patterns of flamingo tongue snails. Five species of opisthobranch and nudibranch mollusks were observed during 2005 (Table 20). Most of these were extremely rare in the habitat types and depth range surveyed. One species, *Glossodoris sedna*, was observed at one location and is presumably an exotic species from the Indo-Pacific. Compared to similar surveys during 2001, we did not observe relatively dense aggregations of the sea slug *Elysia* (*Tridachia*) *crispata* on the shallow spur and groove reefs during 2005. This may have been due to recruitment variability, which is not adequately studied, or to storm effects, or to some other process. We also noted relatively fewer flamingo tongue snails, especially *Cyphoma gibbosum*, relative to 2001, even in similar habitats and sites surveyed in both 2001 and 2005.

Four anemone species (Cnidaria, Actiniaria) were surveyed from the 195 sites representing 11,700 $m^2$ of benthic habitat. Five species were encountered: *Bartholomea annulata*, *Condylactis gigantea*, *Epicystis crucifera*, *Heteryactis lucida*, and *Lebrunia danae*. Table 21 lists site-level abundance and density estimates for the three most common species. *L. danae* was the most common anemone encountered (333 individuals), followed by *B. annulata* (200 individuals) and *C. gigantea* (60 individuals). Similar to results obtained in 1999-2001, *B. annulata* was found to be distributed among most habitat types, but occurred in relatively low densities. *C. gigantea* was usually found in very low densities, except for mid-channel and offshore patch reefs. One moderately dense aggregation yielding a mean density of 0.233 individuals/$m^2$ was recorded in Biscayne National Park near Margot Fish Shoal. *Lebrunia danae* was the most common anemone encountered and appeared to exhibit significant regional variations in density within particular habitat types, especially mid-channel and offshore patch reefs. For example, mean density (±1 SD) on lower Keys mid-channel patch reefs (21 sites) was 0.189 ± 0.127 individuals/$m^2$, which was 23 to 47 times greater than for any other region.

Three species of corallimorpharians were recorded within the transect surveys: *Discosoma carlgreni*, *D. sanctithomae*, and *Ricordea florida* (Table 22). Of the three species, *R. florida* was clearly the most abundant (13,113 individuals recorded), followed by *D. sanctithomae* (1,155) and *D. carlgreni* (162). The two species of *Discosoma*, especially *D. sanctithomae*, exhibited significant habitat and regional density variation, similar to results in 2000 and 2001. For example, the mean (± 1 SD) density of *D. sancithomae* on lower Keys mid-channel patch reefs

was 0.889 ± 0.970 individuals/$m^2$, three orders of magnitude greater than in any other region or habitat type sampled during 2005. In fact, nearly 97% of all *D. sancithomae* during 2005 were recorded from lower Keys mid-channel patch reefs. Similar results were evident for *D. carlgreni*, in which mean density on lower Keys mid-channel patch reefs (0.117 ± 0.227) was several orders of magnitude greater than any other region or habitat type. Just over 91% of all individuals of this species were found on lower Keys mid-channel patch reefs. Densities of the most common corallimorpharian, *Ricordea florida*, exhibited similar habitat and regional variation. Nearly 90% of 7,744 individuals recorded on mid-channel patch reefs were found in the lower Keys, and nearly 95% of individuals on offshore patch reefs were found in this regional sector. Several mid-channel and offshore patch reefs in the region yielded more than 1,000 individuals in a 60 $m^2$ area. For example, over 3,500 individuals were recorded from a patch reef north of Eastern Sambo RO, yielding a mean density of 58.9 ± 34.6 individuals/$m^2$. In most other habitat types, while lower densities were found compared to patch reefs, significantly greater densities were documented in the lower Keys.

## Plans for Use of the Data:

Significant progress in manuscript development has been made. Below is a list of manuscripts in press or published, those submitted for review, and those we intend to submit for publication by the middle of 2006. While many of these reports are descriptive in nature, many of the variables measured by this program have never been assessed at so many sites representing the complement of shallow-water hard-bottom and coral reef habitats in the Florida Keys. Synthesis papers are also in progress related to the methods developed for this assessment and monitoring program, as well as large-scale survey results in Dry Tortugas National Park and the Tortugas Bank. A suite of papers will be produced from an extensive series of analyses that use the demographic aspects of coral population structure and the background community structure which they reside as a critical step toward understanding how coral populations are spatially structured within the ecosystem and the factors that contribute to their spatial patterns. In addition, these population surveys will be used in a validation step of a demographic model developed for the most abundant coral species. These models will provide a better understanding of what the coral populations, as they exist today, could be in the future under different test scenarios.

In addition to specific analyses for manuscripts, a concerted effort will be made to re-evaluate our existing habitat classification for future surveys. This will be accomplished in a multivariate context and will help to further define habitat strata and thus will assist us in optimal allocation of future surveys. We also intend to continue to work closely with NMFS, RSMAS-UM, and FIU to compare community structure and condition variables with existing water quality, geological, and reef fish survey data. Other products planned for 2006 include the development and dissemination of digital photographs on CD-ROM taken in 2005 and refinement of our project web page with site descriptions and summarized data from 1999-2001, including links and pdf versions of manuscripts published. Posters and/or papers will be presented at both the Florida Bay Science Symposium (December 2005, Key West) and the Seventh International Sponge Symposium (May 2006, Rio de Janeiro).

Manuscripts in press or published

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## Manuscripts submitted for review

Chiappone M, Swanson DW, Miller SL (submitted) Density and habitat utilization patterns of anemones and corallimorpharians (Anthozoa, Zoantharia) in the Florida Keys National Marine Sanctuary. *Coral Reefs*

Chiappone M, Swanson DW, Miller SL (submitted) Large-scale density patterns of anemones and corallimorpharians on offshore coral reef habitats in the Florida Keys. *Bulletin of Marine Science*

## Manuscripts in progress (*second drafts complete)

Chiappone M, Rutten LM, Swanson DW, Miller SL (In progress) Spatial patterns of benthic coral reef organisms in the Florida Keys National Marine Sanctuary. 2. Gorgonian species density, richness, and colony density. *Coral Reefs**

Chiappone M, Rutten LM, Swanson DW, Miller SL, Franklin EC (In progress) Spatial patterns of benthic coral reef organisms in the Florida Keys National Marine Sanctuary. 3. Sponge cover and species richness. *Coral Reefs**

Chiappone M, Swanson DW, Franklin EC, Miller SL (In progress) A hierarchical structural classification of Florida Keys coral reef and hard-bottom habitats. *Aquatic Conservation: Marine and Freshwater Ecosystems*

Chiappone M, Swanson DW, Miller SL (In progress) A rapid method for assessing topographic complexity and its application to Florida Keys coral reef and hard-bottom habitats. *Journal of Experimental Marine Biology and Ecology*

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**

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*

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