III. Distribution and Abundance of *Acropora* Corals

Background

The declines in abundance of two of the principal Caribbean reef-building corals, staghorn coral (*Acropora cervicornis*) and elkhorn coral (*A. palmata*), are often-cited examples of the changes that have occurred on wider Caribbean reefs, including the Florida Keys, during the past several decades (Bruckner 2002; Gardner et al. 2003). The causes of these declines, which began in the late 1970s, include regional phenomena such as coral bleaching and diseases, especially white band disease (Gladfelter 1982; Aronson and Precht 2001), as well as more localized effects from tropical storms, cold fronts, and predation by corallivorous snails, fireworms, and damselfishes (Miller et al. 2002). Both corals were under consideration for addition to the U.S. Endangered Species List (ESA) as of the early 1990s and were formally determined to be "threatened" on the ESA in 2005, based upon range-wide population declines and poor recovery (*Acropora* Biological Review Team 2005).

Populations of both species remain well-below historical levels, including those in the Florida Keys (Dustan and Halas 1987; Porter and Meier 1992). Moreover, localized and regional stressors remain a threat and are likely to inhibit population recovery (*Acropora* Biological Review Team 2005). Monitoring by our program addresses both the potential for further population decline, as well as the potential for recovery, should it occur. We specifically collect data on habitat distribution, colony size, and density, in order to calculate abundance estimates for both species. Using a stratified random sampling design, the goals of the 2011 surveys were to continue our long-term monitoring in the upper and a portion of the middle Florida Keys, but also to use the survey data to prepare for a Keys-wide assessment in 2012, and to help facilitate a regional population assessment effort in the U.S. Caribbean (Puerto Rico and the U.S. Virgin Islands). The 2011 data were used to update population abundance estimates by habitat, management zone, and size class and by habitat.

Acropora Survey Methods

An updated version of our field protocol manual was completed in December 2011 and provides further details on our benthic survey methods, including *Acropora* corals (Miller et al 2011). Briefly, the field methodology for assessing *Acropora* corals during 2011 consisted of the following:

- Two replicate 15-m x 1-m (15-m^2) belts transects were deployed per site for *Acropora* corals, which were sampled for presence-absence, colony numbers, colony sizes, and condition by species. The F1 hybrid, *Acropora prolifera*, was not encountered in the upper Keys during 2011.

- *Acropora* colonies were assessed at both the skeletal unit and physiologic unit levels, as described below, for numbers, size, and condition.

Each colony that was encountered was assessed in three ways: 1) dimensions (maximum branch diameter, secondary branch diameter, and maximum height), percent live tissue vs. dead skeleton, and condition of "skeletal" colonies, defined as continuous skeleton, regardless of whether or not the colony is partitioned into several individual patches of continuous live tissue; 2) overall dimensions (maximum branch diameter, secondary branch diameter, and maximum height) and condition of "physiologic" colonies, defined as individual patches of continuous live tissue that are contained within a skeletal unit; and 3) physiologic colony measurements of individual branches, patches, and bases to more accurately estimate the surface area of live tissue within each colony. For example, if an *Acropora cervicornis* colony was encountered and consisted of two patches of live tissue on one larger skeletal unit, the following measurements were made:

- One skeletal unit assessment of colony size , percent dead tissue, and colony condition;
- Two physiologic unit assessments of overall colony size, percent dead tissue, and colony condition;
- Two physiologic unit assessments of surface area based on all live tissue by measuring individual branches, patches, and bases).

The summary data reported below show density and abundance estimates of skeletal colonies, as well as density, size (surface area of live tissue patches), and condition of physiologic colonies based upon detailed measurements of live tissue surface area (branches, patches, and bases). The reason we take both skeletal and physiologic measurements is because they provide an estimate of population condition, related potentially to fragmentation and the relative proportion of ramets and genets.

2011 *Acropora* Survey Results

Staghorn coral (*Acropora cervicornis*)

A total of 280 sites (560 15-m x 1-m belt transects) were surveyed for *Acropora* corals. Staghorn coral (*A. cervicornis*) (Figure 3-1) was encountered at 8.2% of all sites and 5.5% of all sampled belt transects. Staghorn coral was found in most of the habitats sampled, except for back-reef rubble and the deeper fore reef. Table 3-1 summarizes the site presence, transect frequency, physiologic colony density (live tissue

patches), total surface area, and mean colony size by habitat and management zone, while Figures 3-2 to 3-4 show the spatial distribution of presence-absence and physiologic colony density for the upper Keys study area. Evident from the spatial distribution of colonies is the importance of offshore patch reefs and shallow (< 6 m depth) platform margin habitats, specifically low-relief hard-bottom and high-relief spur and groove. Site presence and transect frequency were more or less similar in these three habitats (Table 3-1, Figure 3-5, top). Historically, staghorn coral occurred on some deeper fore-reef areas (especially low-relief spur and groove) in larger fingers of interlocking colonies, but no such thickets have been encountered during the past decade.

Staghorn coral colonies were measured at the both skeletal (continuous skeleton) and physiologic levels (live tissue patches). Examples of live tissue patches include branches separated from the larger colony by dead tissue, or patches surrounded by dead tissue that could represent either remnant survival or recruitment of a new colony (genet) onto previously dead skeleton. A total of 88 skeletal colonies and 256 physiologic colonies were counted, measured, and assessed for condition; these values indicate that, on average, a given staghorn skeletal colony consisted of three physiologic fragments or patches of contiguous tissue. Mean density (no. per m^2) of staghorn corals at both of these levels showed similar patterns among habitat types (Figure 3-5), with offshore patch reefs, shallow hard-bottom, and high-relief spur and groove yielding the greatest colony densities. Mean tissue surface area of physiologic colonies was nearly two times greater on shallow hard-bottom compared to offshore patch reefs and high-relief spur and groove (Table 3-1). Comparisons of staghorn coral distribution and abundance between FKNMS no-take zones and reference areas are summarized for both skeletal and physiologic colonies in Table 3-1 and Figure 3-6. Transect frequency, density of skeleton colonies, density of physiologic colonies, and mean size were all consistently greater in reference areas compared to no-take zones for all habitats where staghorn coral was encountered. The only no-take zone where we recorded staghorn corals was Dry Rocks SPA.

Population abundance estimates (total numbers of colonies) of staghorn coral were derived for both skeletal and physiologic colonies by habitat, colony size, and management zone (Figures 3-7 to 3-9). These estimates take into consideration the density of colonies and the areas of the habitat types and management zones sampled. Population abundance estimates (± 95% confidence intervals) for skeletal colonies by habitat type (Figure 3-7, top) indicate that there are 2.7 million ± 2.9 million skeletal colonies in the upper Florida Keys. Note that there are relatively similar abundance values for mid-channel and offshore patch reefs, as well as shallow hard-bottom. The high degree of variability in these estimates, at both the skeletal and physiologic colony levels, reflects the patchy distribution of staghorn coral (Figures

3-2 to 3-4). We are investigating potential changes to our sampling protocols to help reduce variance in our 2012 surveys. Sampling more sites is one approach, as is modifying protocols in our second stage design (area or numbers of belt transects). Abundance estimates by habitat for physiologic colonies indicate 8.3 million ± 9.8 million colonies in the upper Keys, which is approximately three times the number of skeletal colonies. Staghorn coral abundance estimates for skeletal colonies by maximum diameter (Figure 3-8, top) and for physiologic colonies by tissue area size class (Figure 3-8, bottom) show a predominance of smaller colonies, a pattern that we have continued to document for over a decade. No thickets larger than about 1 m in maximum dimension (length or diameter) were encountered during 2011. Staghorn coral abundance estimates by habitat and management zone are shown in Figure 3-9 for both skeletal and physiologic colonies. In stark contrast to the pattern evident for *Acropora palmata* (see below), all or nearly all of the staghorn corals present in the upper FKNMS occur outside of Sanctuary no-take zones for mid-channel patch reefs (100%), offshore patch reefs (100%), shallow hard-bottom (100%), and high-relief spur and groove (93%).

Of the condition categories assessed on staghorn coral, bleaching (19 colonies, 7.4%) and predation (primarily damselfishes and snails) were the most common. Obvious signs of predation were found on 65 physiologic colonies or approximately 25% of the sampled staghorn corals. No disease-like symptoms or overgrowth by other organisms were documented. In summary, staghorn corals exhibit a broader habitat distribution than elkhorn corals, yet are also characterized by generally smaller colonies. In addition, most colonies occur outside of FKNMS no-take zones, especially in the patch reef environment.

Elkhorn coral (*Acropora palmata*)

Elkhorn coral (*A. palmata*) (Figure 3-10) was encountered at 3.2% of all sites and 3.0% of all sampled belt transects. Elkhorn coral was only found on high-relief spur and groove reefs. In previous years, we have encountered a few isolated colonies on offshore patch reefs, back-reef rubble, and shallow hard-bottom, but clearly most colonies are restricted to the shallow fore-reef area in the upper FKNMS. Table 3-2 summarizes the site presence, transect frequency, physiologic colony density (live tissue patches), total surface area, and mean colony size by habitat and management zone, while Figures 3-11 to 3-13 illustrate the spatial distribution of presence-absence and physiologic colony density for the upper Keys study area. Evident from the spatial distribution of elkhorn coral is the importance of the shallow platform margin, as well as the concentration of colonies in FKNMS no-take zones. In the high-relief spur and groove habitat, elkhorn coral was present at 22% of all sites and 21% of all transects (Table 3-2, Figure 3-14, top). Several shallow spur and groove reefs continue to support thickets of elkhorn corals, with most

patches approximately 15-m to 20-m in diameter. Reefs where stands (not just isolated colonies) of elkhorn coral occur in the upper Florida Keys include (from north to south):

- South Carysfort Reef,
- Elbow Reef,
- Horseshoe Reef,
- Grecian Rocks,
- French Reef,
- Sand Island, and
- Molasses Reef.

Elkhorn coral colonies were also measured at the both skeletal (continuous skeleton) and physiologic levels (live tissue patches). A total of 109 skeletal colonies and 300 physiologic colonies were counted, measured, and assessed for condition. Like staghorn coral, these values indicate that, on average, a given elkhorn skeletal colony consisted of three physiologic colonies or patches of contiguous tissue. Mean density (no. per m^2) of elkhorn corals at both of these levels is shown in Figure 3-14. Comparisons of elkhorn coral distribution and abundance between FKNMS no-take zones and reference areas are summarized for both skeletal and physiologic colonies in Table 3-2 and Figure 3-15. Transect frequency, density of skeleton colonies, density of physiologic colonies, and mean size were all consistently greater in no-take zones. Most, but not all (e.g. Horseshoe Reef and Sand Island), of the reefs listed above with extant thickets of elkhorn coral are located in FKNMS no-take zones.

The overall size distribution of elkhorn corals encountered in the high-relief spur and groove habitat at the skeletal (maximum diameter) and physiologic (live tissue surface area) levels is illustrated in Figure 3-16. The 107 skeletal colonies ranged in maximum diameter from 3 to 268 cm and averaged (± 1 SE) 268 ± 66 cm. The size distribution of skeletal colonies reflected a mixture of various size classes (Figure 3-16, top), including both small (< 20 cm) and larger colonies (> 90 cm). Approximately 36% of the colonies were less than 20 cm in maximum diameter. However, approximately 24% were larger than 90 cm. The size distribution of elkhorn coral physiologic colonies based upon live tissue surface area also illustrated a large range of colony sizes and essentially a U-shaped size distribution, with large numbers of both smaller (< 100 cm^2) and larger (> 1,000 cm^2) colonies (Figure 3-16, bottom). The 289 physiologic colonies ranged in tissue surface area from 1 to 44,185 cm^2, averaging 1,452 ± 217 cm^2. Although nearly 32% of elkhorn corals encountered were less than 100 cm2 in surface area, approximately 29% were larger (> 1,000 cm^2).

Of the condition categories assessed for elkhorn coral, bleaching (65 colonies, 21.7%) and predation (47 colonies, 15.7%) were the most common adverse conditions encountered. No disease-like symptoms or overgrowth by other organisms that was causing tissue loss were documented.

Calculating population abundance estimates (total numbers of colonies) for *Acropora palmata* presents several challenges: 1) the species has a limited distribution, with nearly 90% of the population present in the high-relief spur and groove habitat and specifically within Sanctuary no-take zones with this habitat type; 2) within these spur and groove habitats in the no-take zones, when the species is present, it is primarily found at the shallower end of the depth range for the habitat type; and 3) when present, it often grows in relatively well-defined thickets or stands in sufficient abundance that it is difficult to identify individual colonies. Therefore, extrapolating density measurements to obtain population estimates is not straight forward and results typically include large variance terms. Therefore, we are evaluating refinements to how we calculate population estimates for *A. palmata*. The refinements include adding additional stratification to our habitat designations based on depth and *a priori* knowledge about the limited distribution of the species in the upper Keys. The practical result of the refinements will be to reduce the amount of habitat used to scale up the density measurements, which will improve precision. Further, we are considering whether or not to reduce our primary sample units to cell sizes from 200 m x 200 m (40,000 m^2) to something smaller, perhaps as small as 100 m x 100 m (10,000 m^2), which would allow us to locate more of the primary sample units into the zones. More primary sample units per habitat type will significantly reduce variance.

An additional element that impacts population estimates for a species with patchy distribution, such as *A palmata*, is the random assignment of primary sample units. For example, within the 280 sites we randomly sampled in 2011 were six sites considered to be "hotspots" for *A. palmata*, or "remnant" patches of high density. Including or excluding these six sites, impacts the population estimate by more than an order of magnitude. Obviously, picking and choosing what sites to include in the analysis is not appropriate. Therefore, we are currently assessing how best to refine our population estimates for *A. palmata*.

Discussion

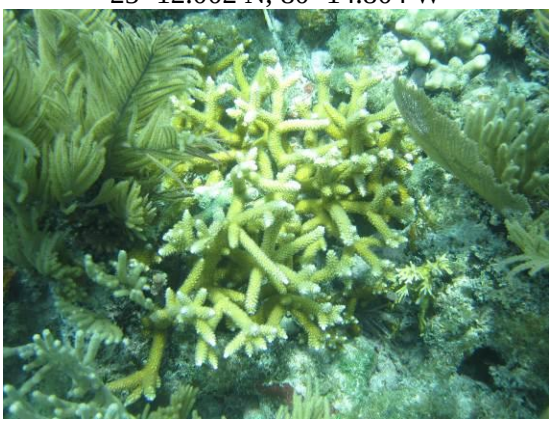
Results from the 2011 sampling effort add to a growing spatial and temporal data set on the status and trends in Florida Keys *Acropora palmata* and *A. cervicornis* populations. Our earlier Keys-wide sampling in previous years was not optimized for *Acropora* corals, but was instead optimized for a few of the most

abundant species (e.g. *Montastraea cavernosa*, *Porites astreoides*, and *Siderastrea siderea*, see Smith et al. 2011). However, the benthic data still provide important opportunities to compare populations across multiple habitat types, including managed areas in the FKNMS. What is apparent from the *Acropora* surveys is that the distribution and abundance patterns of these two species are significantly different. Although most, if not all, of the high-relief spur and groove reefs in the upper Keys were sampled during 2011, results for elkhorn coral indicate that significant stands remain at only a handful of sites. Although many of these reefs are already within existing FKNMS no-take zones, predation by snails and damselfishes is still prevalent. In contrast, the distribution pattern of *A. cervicornis* reflects the importance of patch reefs and shallow hard-bottom to the possible recovery of this species. The absence of staghorn corals in fore-reef habitats, where they were previously abundant, suggests that recovery in the upper Florida Keys has not started. Still, it is reasonable to suggest that for staghorn corals the remaining population appears relatively stable, at least for the last ten years. The large number of small colonies compared to large colonies and the absence of these corals in fore-reef habitats is a concern. Further, their abundance on patch reefs, with over 5000 in the Florida Keys, is both good news and bad news. The good news is that patch reefs are abundant. The bad news is that many of them are located close to shore and are susceptible to stress caused by cold-water, such as the 2010 event. The situation for elkhorn coral is more problematic, since population numbers are much smaller and aggregations are confined mostly to one habitat. Finally, the mismatch between the distribution and abundance of staghorn corals and the location of no-take-zones in the upper Keys is noteworthy. Whether or not no-take-zones might provide meaningful protection to *A. cervicornis* is uncertain, and remains a major topic of ongoing research and management interest.

Figure 3-1. Examples of staghorn coral (*Acropora cervicornis*) observed in hard-bottom and coral reef habitats in the upper Florida Keys National Marine Sanctuary observed during May-September 2011.

Mid-channel patch reef, 3.0-4.3 m
Site #22, Turtle Rocks
25° 17.477 N, 80° 13.624 W

Offshore patch reef, 2.7-3.4 m
Site #80, North of Watsons Reef
25° 12.002 N, 80° 14.804 W



Offshore patch reef, 9.8-10.4 m
Site #108, Watsons Reef
25° 09.727 N, 80° 15.512 W

Inner line reef tract, 3.4-5.8 m
Site #23, Turtle Reef
25° 17.603 N, 80° 13.258 W

Inner line reef tract, 4.6-6.1 m
Site #124, North of Horseshoe Reef
25° 08.648 N, 80° 17.657 W

Low-relief hard-bottom, 1.8-2.4 m
Site #250, Conch Reef
24° 57.663 N, 80° 27.420 W

Figure 3-2. Densities (no. per m^2) of physiologic colonies of staghorn coral (*Acropora cervicornis*) in the upper Florida Keys National Marine Sanctuary from the southern boundary of Biscayne National Park to Carysfort/S. Carysfort Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

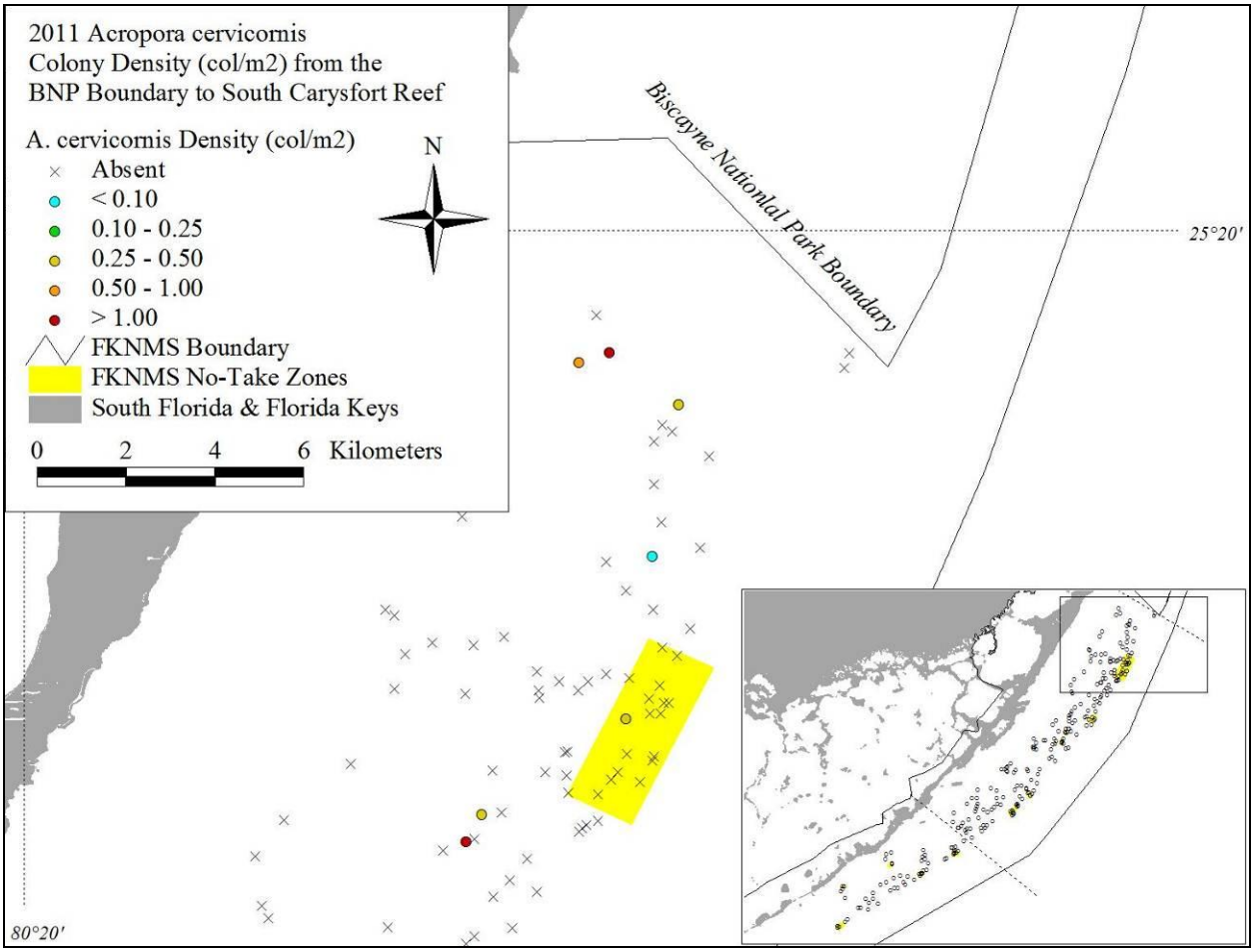


Figure 3-3. Densities (no. per m^2) of physiologic colonies of staghorn coral (*Acropora cervicornis*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

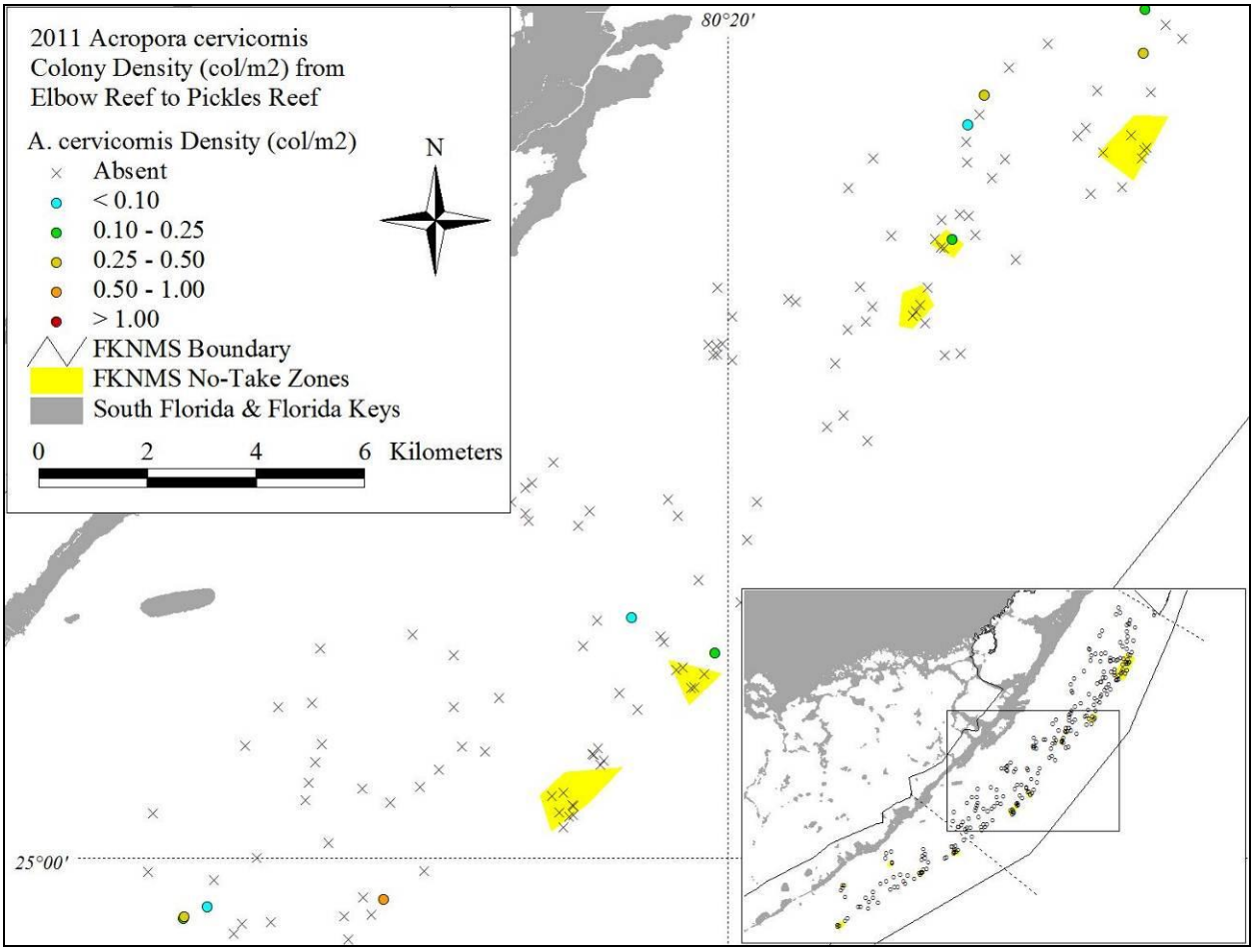


Figure 3-4. Densities (no. per m^2) of physiologic colonies of staghorn coral (*Acropora cervicornis*) in the upper Florida Keys National Marine Sanctuary from Conch Reef to Alligator Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

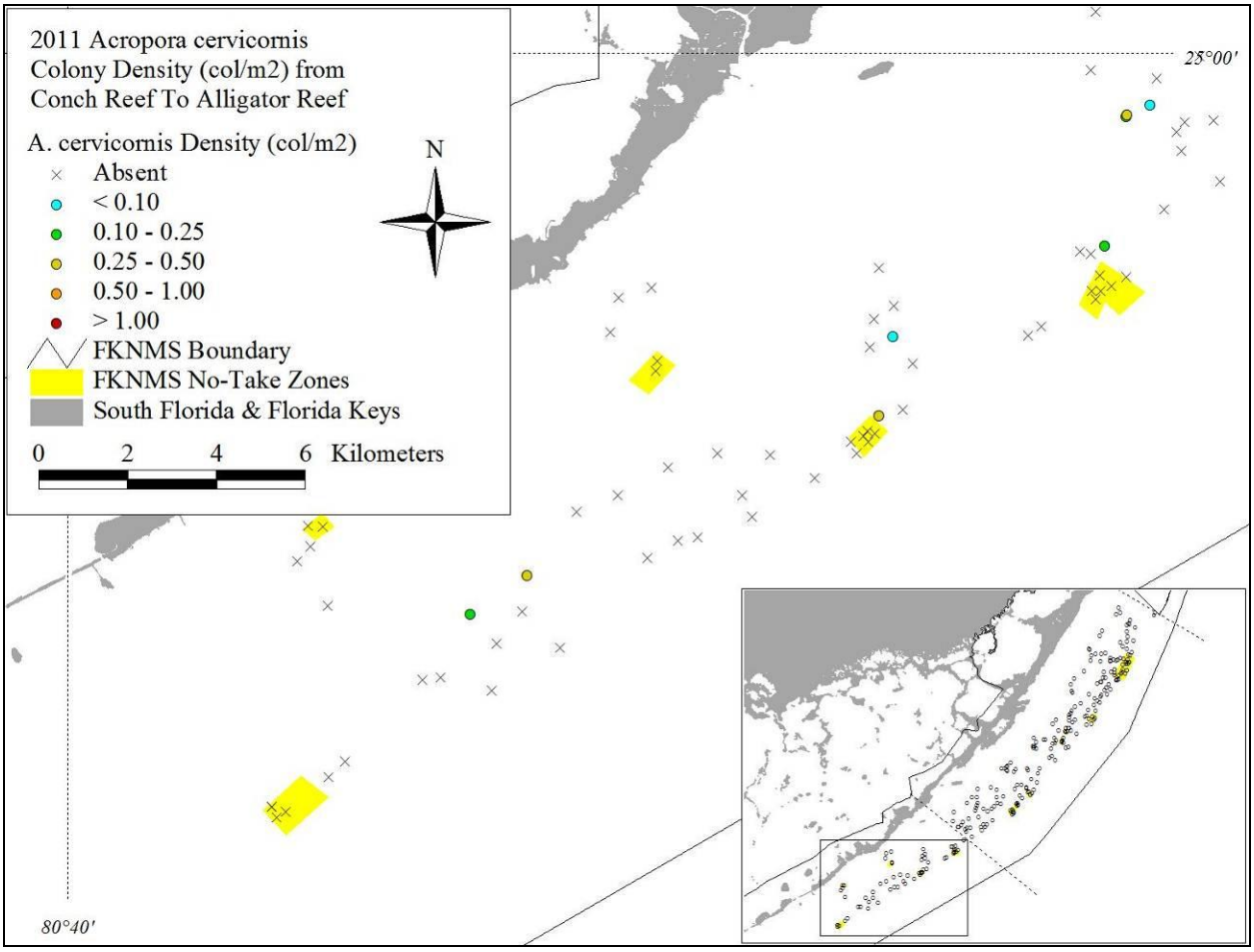


Figure 3-5. Mean (+ 1 SE) transect frequency (top), density (no. per m^2) of skeletal colonies (middle), and density (no. per m^2) of physiologic colonies of staghorn coral (*Acropora cervicornis*) by habitat type in the upper Florida Keys, as determined from surveys of replicate 15-m x 1-m belt transects per site at 280 sites. Domain-wide (upper Keys) values are weighted averages and standard errors. Values on the x-axis in parentheses are the number of sites surveyed in each habitat type. A physiologic colony is defined as a patch of contiguous live tissue, while a skeletal colony is defined as contiguous skeleton that may contain one or more physiologic colonies.

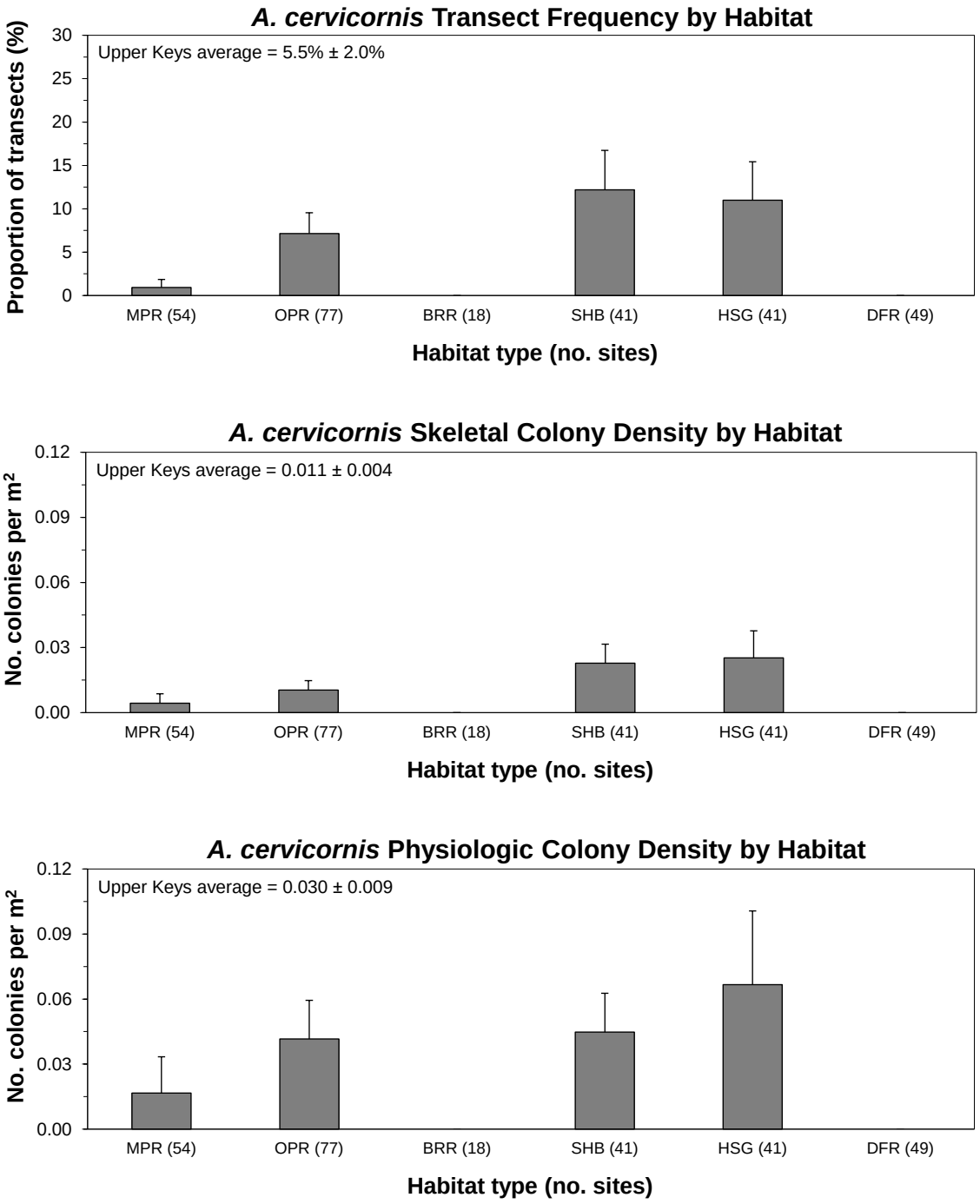


Figure 3-6. Mean (+ 1 SE) transect frequency (top), density (no. per m^2) of skeletal colonies (middle), and density (no. per m^2) of physiologic colonies of staghorn coral (*Acropora cervicornis*) by habitat type and management zone in the upper Florida Keys. Open bars = reference areas (Ref), filled bars = no-take zones (NTZ). Domain-wide (upper Keys) values are weighted averages and standard errors. Habitat abbreviations are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back-reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats. Numbers in parentheses on the x-axis are the number of sites surveyed.

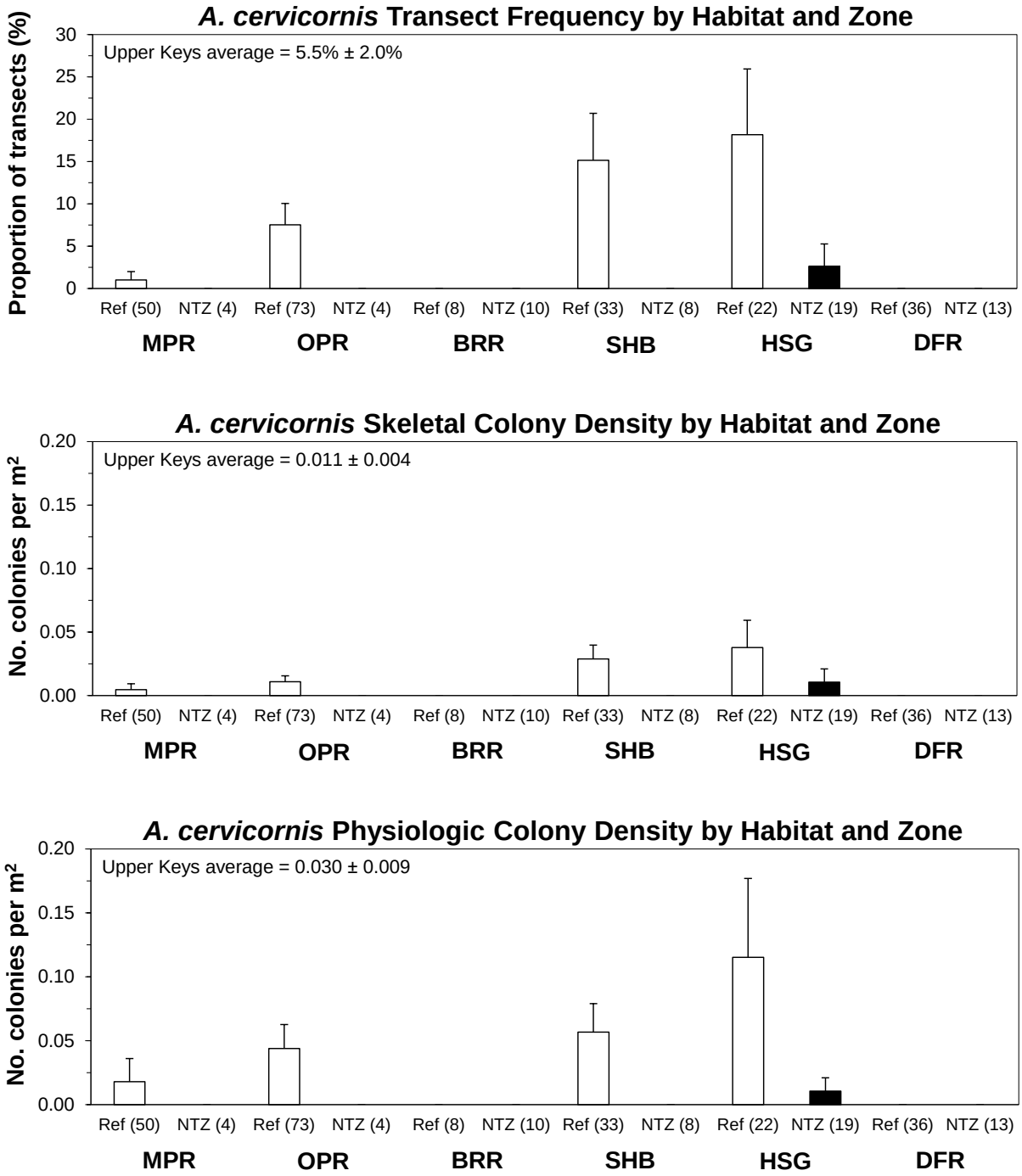
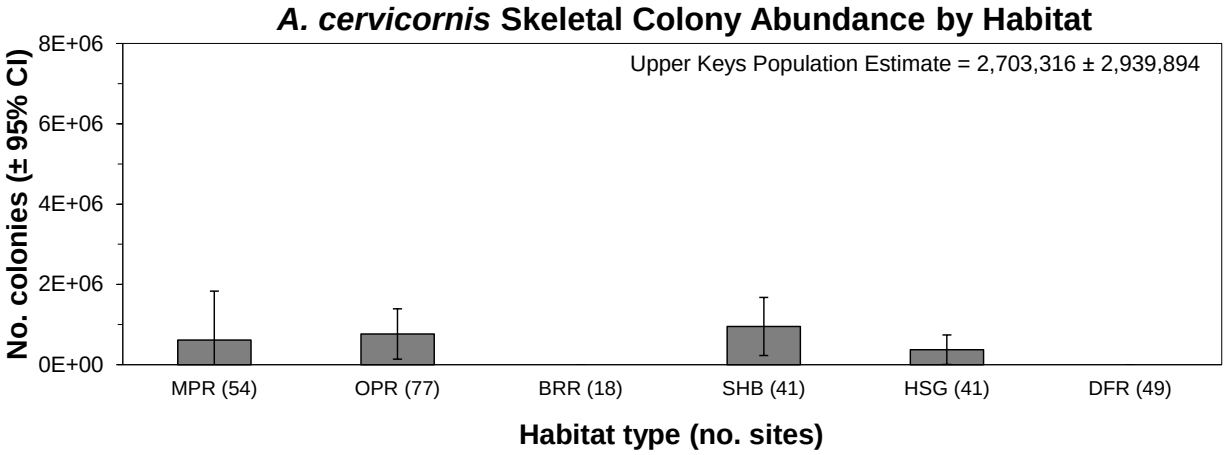


Figure 3-7. Abundance estimates (± 95% CI) of staghorn coral colonies (*Acropora cervicornis*) by habitat type for both skeletal (top) and physiologic colonies (bottom) in the upper Florida Keys (northern Key Largo to Alligator Reef). A physiologic colony is defined as a patch of contiguous live tissue, while a skeletal colony is defined as contiguous skeleton that may contain one or more physiologic colonies.



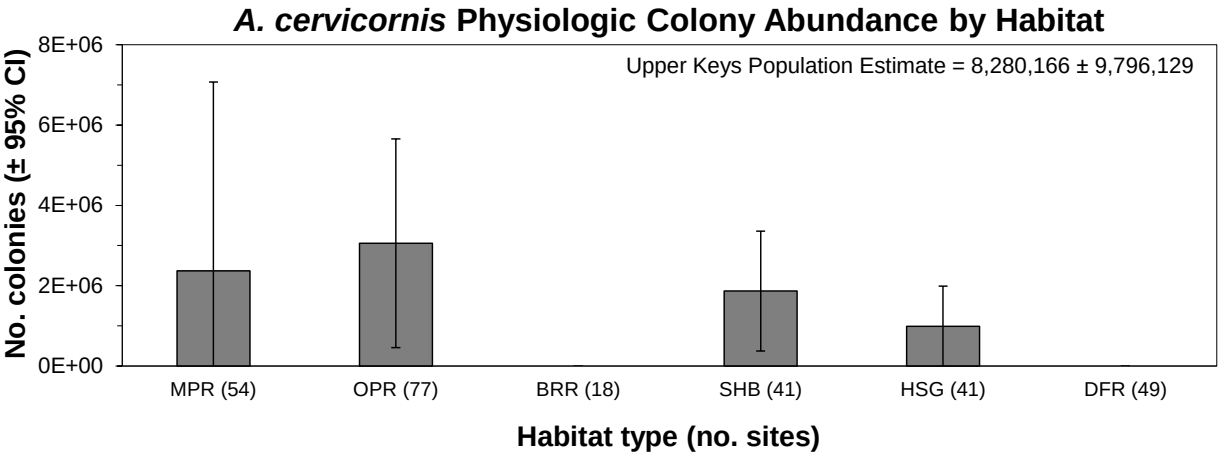
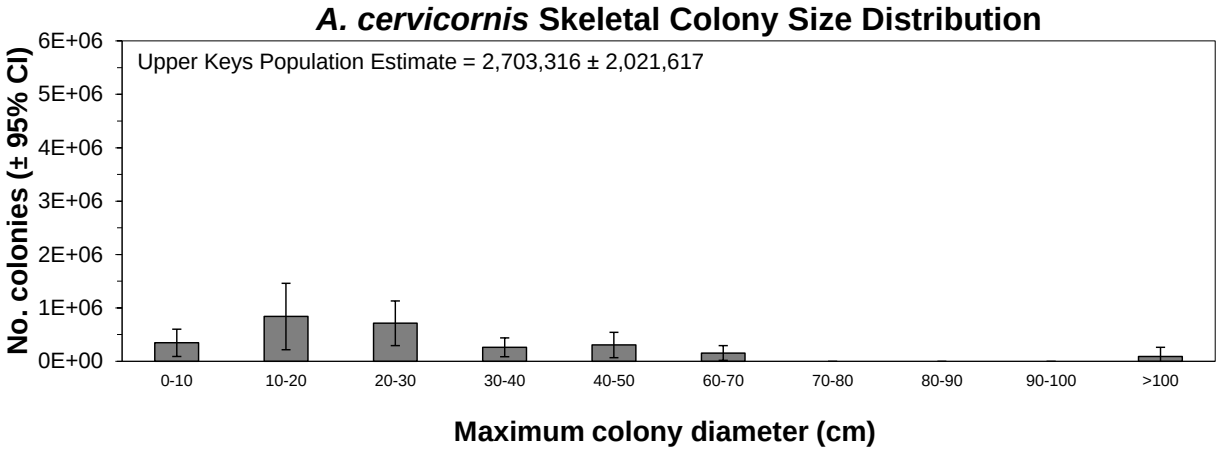


Figure 3-8. Abundance estimates (± 95% CI) of staghorn coral colonies (*Acropora cervicornis*) by maximum diameter of skeletal colonies (top) and by tissue surface area of physiologic colonies (bottom) in the upper Florida Keys (northern Key Largo to Alligator Reef). A physiologic colony is defined as a patch of contiguous live tissue, while a skeletal colony is defined as contiguous skeleton that may contain one or more physiologic colonies.



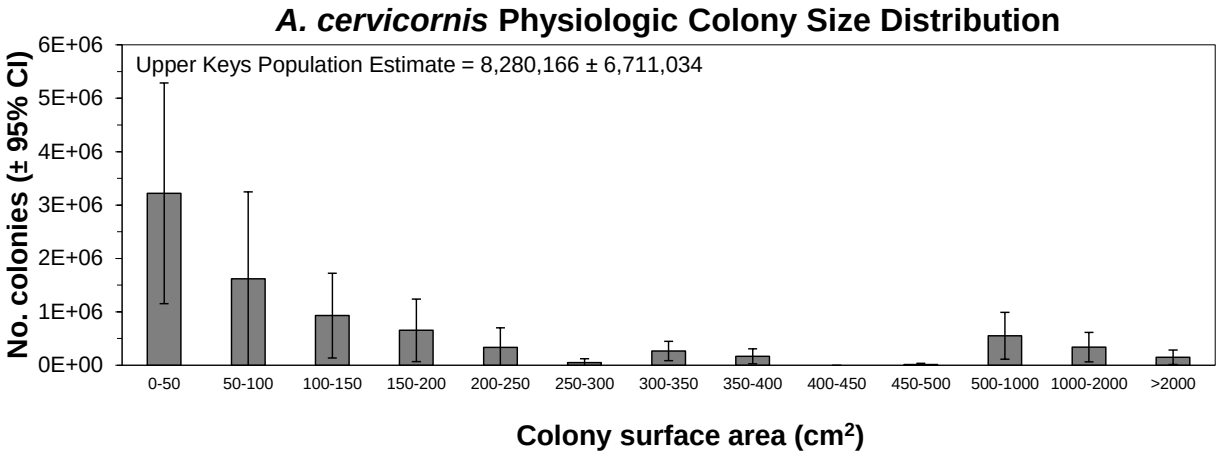
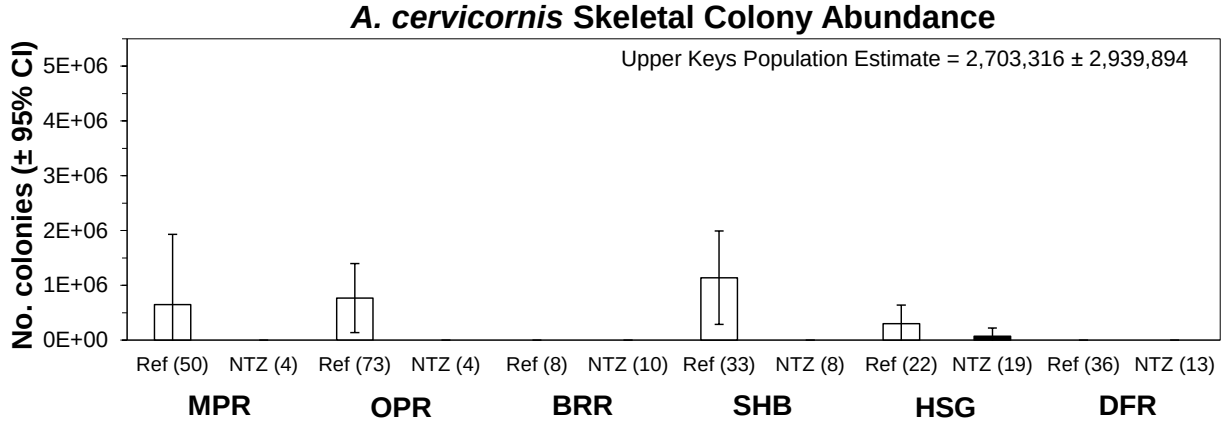


Figure 3-9. Abundance estimates (± 95% CI) of staghorn coral colonies (*Acropora cervicornis*) by habitat type and management zone for skeletal colonies (top) and physiologic colonies (bottom) in the upper Florida Keys (northern Key Largo to Alligator Reef). A physiologic colony is defined as a patch of contiguous live tissue, while a skeletal colony is defined as contiguous skeleton that may contain one or more physiologic colonies. Open bars = reference areas (Ref), filled bars = no-take zones (NTZ). Domain-wide (upper Keys) values are weighted averages and standard errors. Habitat abbreviations are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back-reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats. Numbers in parentheses on the x-axis are the number of sites surveyed.



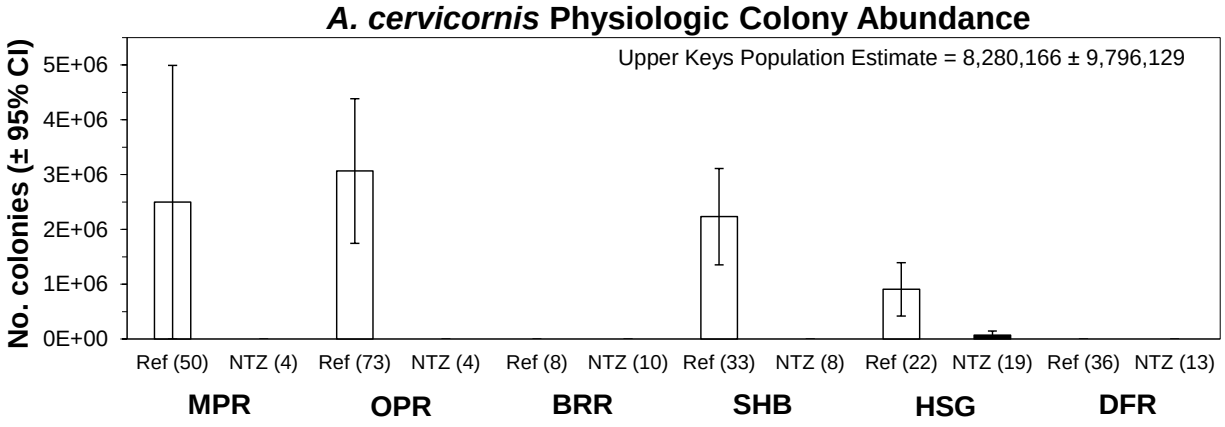


Figure 3-10. Examples of *Acropora palmata* in hard-bottom and coral reef habitats in the upper Florida Keys National Marine Sanctuary observed during May-September 2011.

High-relief spur and groove, 1.2-3.0 m
Site #272, South Carysfort Reef
25° 12.517 N, 80° 13.158 W

High-relief spur and groove, 3.4-6.1 m
Site #273, Elbow Reef
25° 08.544 N, 80° 15.540 W

High-relief spur and groove, 5.2-7.0 m
Site #276, Molasses Reef
25° 00.591 N, 80° 22.426 W

High-relief spur and groove, 3.0-4.9 m
Site #277, Sand Island
25° 01.804 N, 80° 22.097 W

High-relief spur and groove, 4.9-8.5 m
Site #278, French Reef
25° 02.026 N, 80° 20.960 W

High-relief spur and groove, 1.8-4.0 m
Site #280, Grecian Rocks
25° 06.536 N, 80° 18.312 W

Figure 3-11. Densities (no. per m^2) of physiologic colonies of elkhorn coral (*Acropora palmata*) in the upper Florida Keys National Marine Sanctuary from the southern boundary of Biscayne National Park to Carysfort/S. Carysfort Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

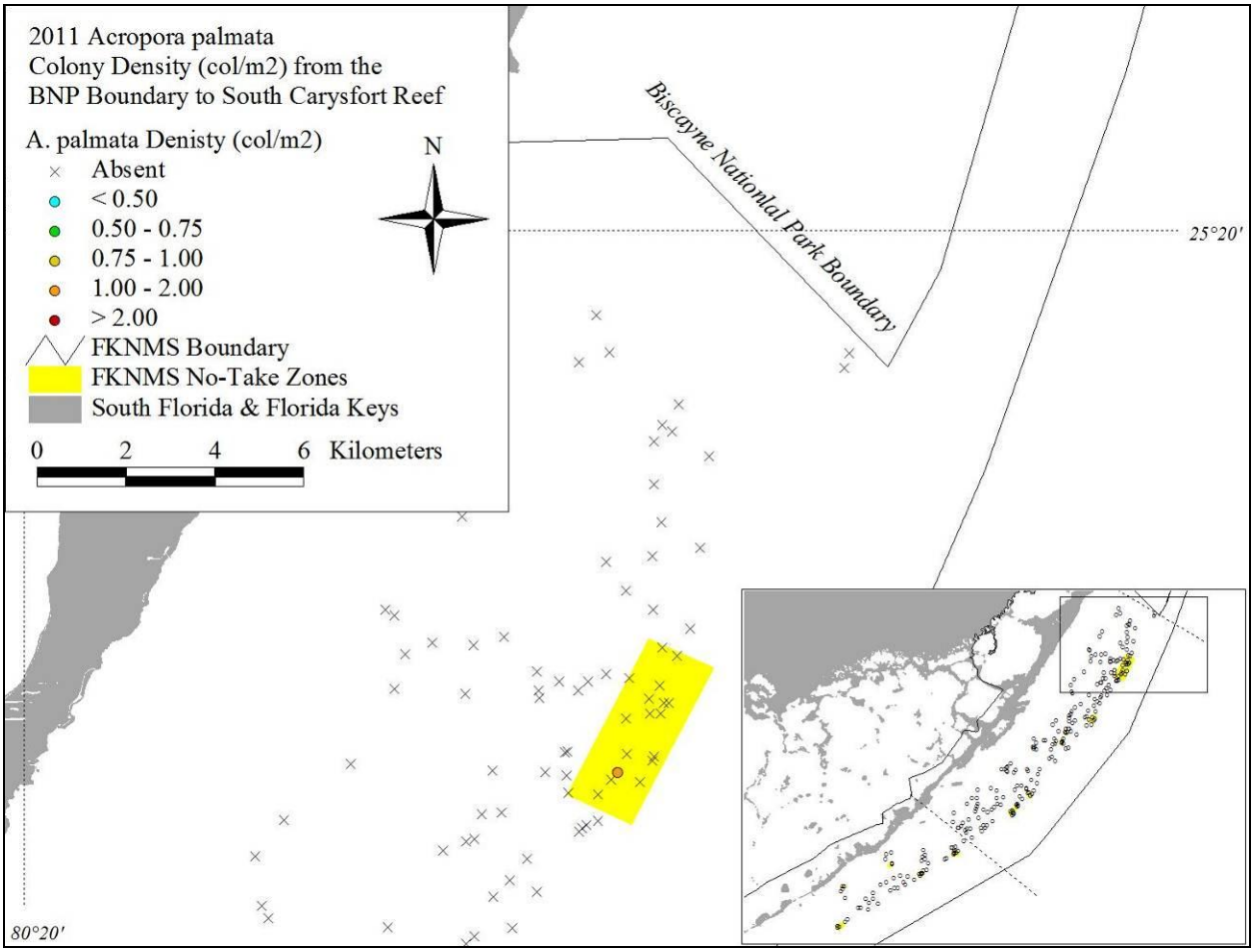


Figure 3-12. Densities (no. per m^2) of physiologic colonies of elkhorn coral (*Acropora palmata*) in the upper Florida Keys National Marine Sanctuary from Elbow Reef to Pickles Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

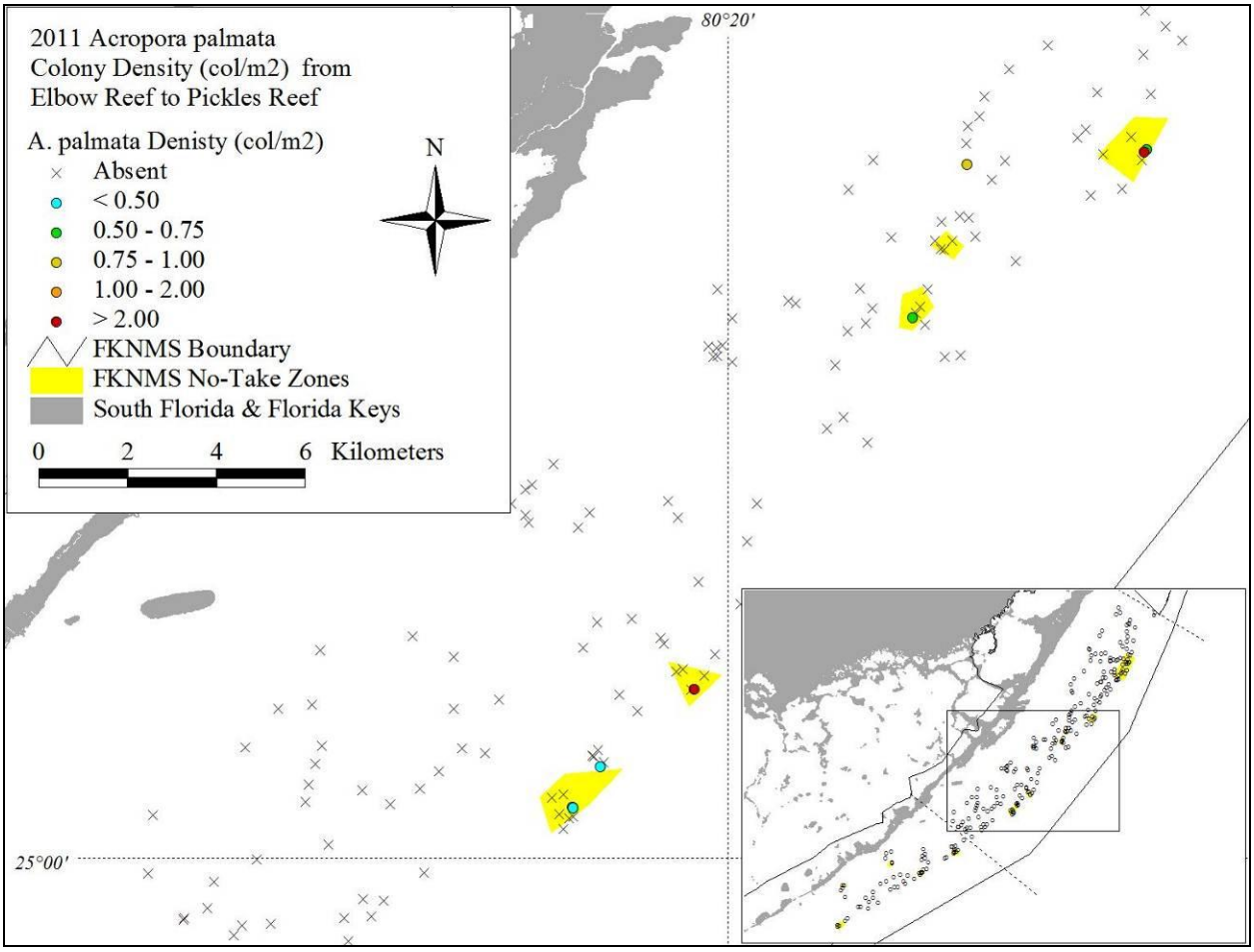


Figure 3-13. Densities (no. per m^2) of physiologic colonies of elkhorn coral (*Acropora palmata*) in the upper Florida Keys National Marine Sanctuary from Conch Reef to Alligator Reef surveyed during May-September 2011. A physiologic colony is defined as a patch of contiguous live tissue.

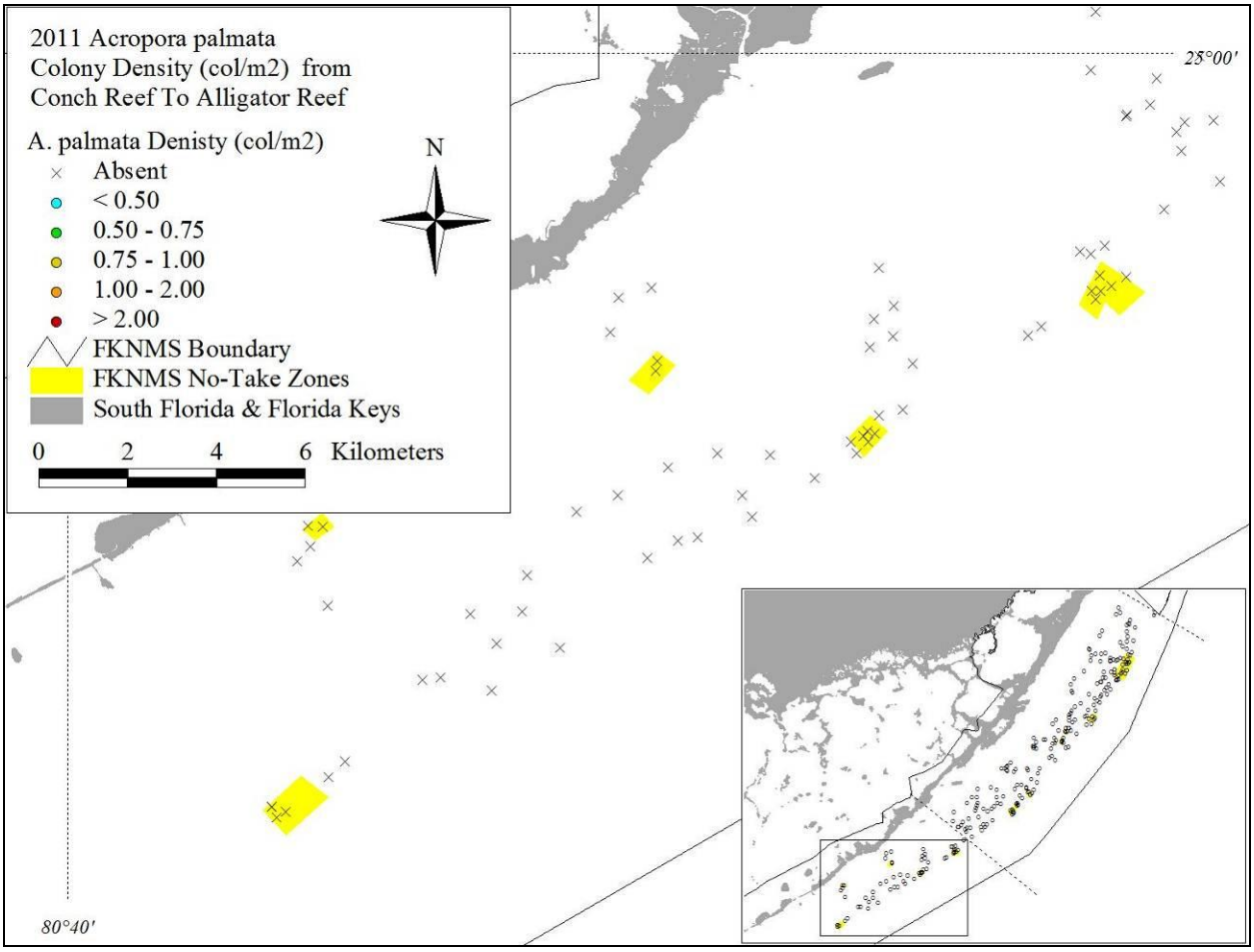
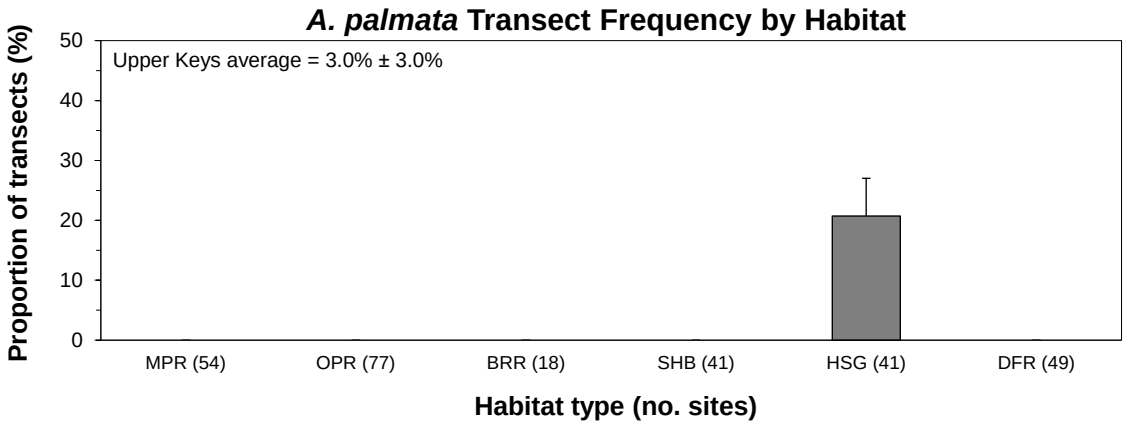
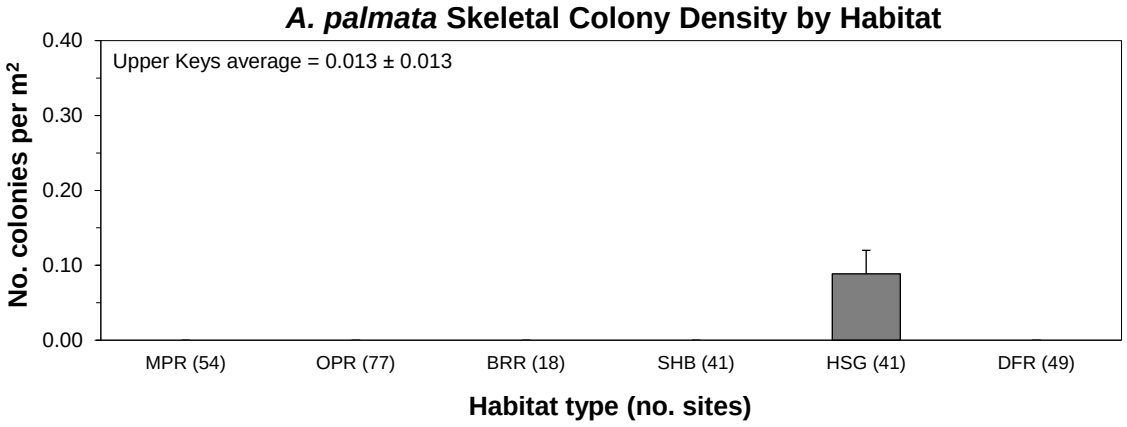


Figure 3-14. Mean (+ 1 SE) transect frequency (top), density (no. per m^2) of skeletal colonies (middle), and density (no. per m^2) of physiologic colonies of elkhorn coral (*Acropora palmata*) by habitat type in the upper Florida Keys, as determined from surveys of replicate 15-m x 1-m belt transects per site at 280 sites. Domain-wide (upper Keys) values are weighted averages and standard errors. Values on the x-axis in parentheses are the number of sites surveyed in each habitat type. A physiologic colony is defined as a patch of contiguous live tissue, while a skeletal colony is defined as contiguous skeleton that may contain one or more physiologic colonies.





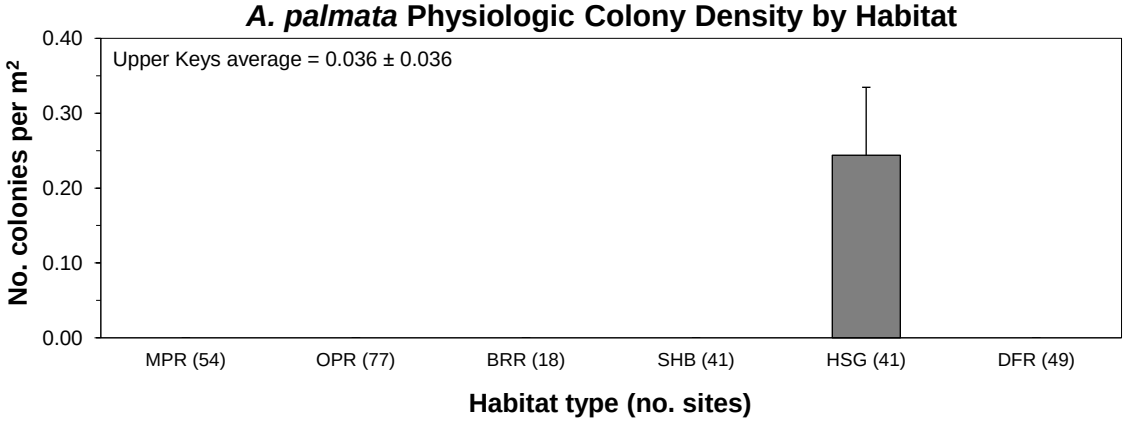


Figure 3-15. Mean (+ 1 SE) transect frequency (top), density (no. per m^2) of skeletal colonies (middle), and density (no. per m^2) of physiologic colonies of elkhorn coral (*Acropora palmata*) by habitat type and management zone in the upper Florida Keys. Open bars = reference areas (Ref), filled bars = no-take zones (NTZ). Domain-wide (upper Keys) values are weighted averages and standard errors. Habitat abbreviations are: MPR = inshore and mid-channel patch reefs, OPR = offshore patch reefs, BRR = back-reef rubble, SHB = shallow (< 6 m) hard-bottom, HSG = high-relief and groove, and DFR = deeper (6-15 m) fore-reef habitats. Numbers in parentheses on the x-axis are the number of sites surveyed.

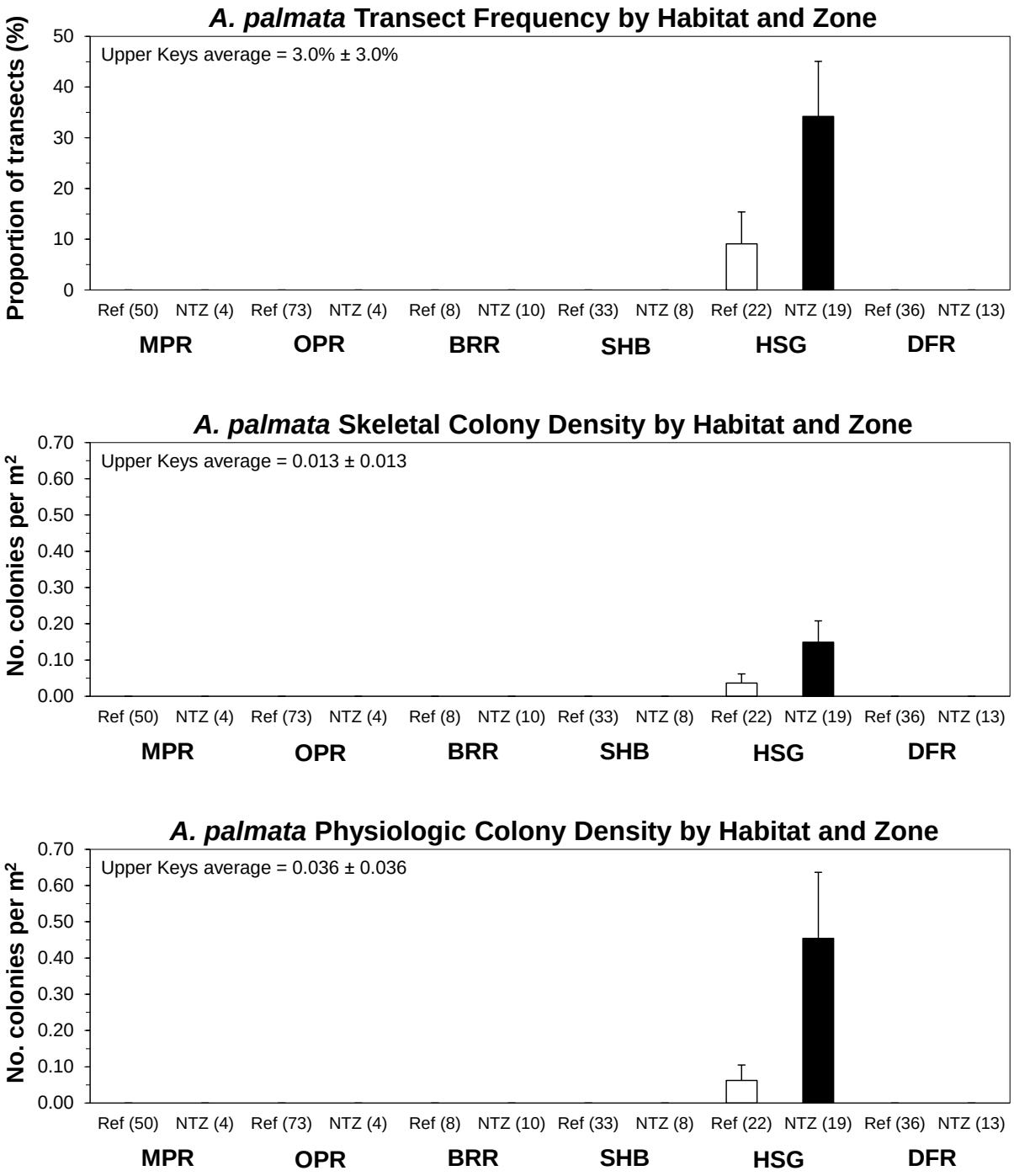


Figure 3-16. Size distribution of elkhorn coral (*Acropora palmata*) by maximum diameter of skeletal colonies (top) and by tissue surface area of physiologic colonies (bottom) in the upper Florida Keys (northern Key Largo to Alligator Reef). A physiologic colony was defined as a patch of contiguous live tissue, while a skeletal colony was defined as contiguous skeleton that may have contained one or more physiologic colonies. N = number of colonies measured.

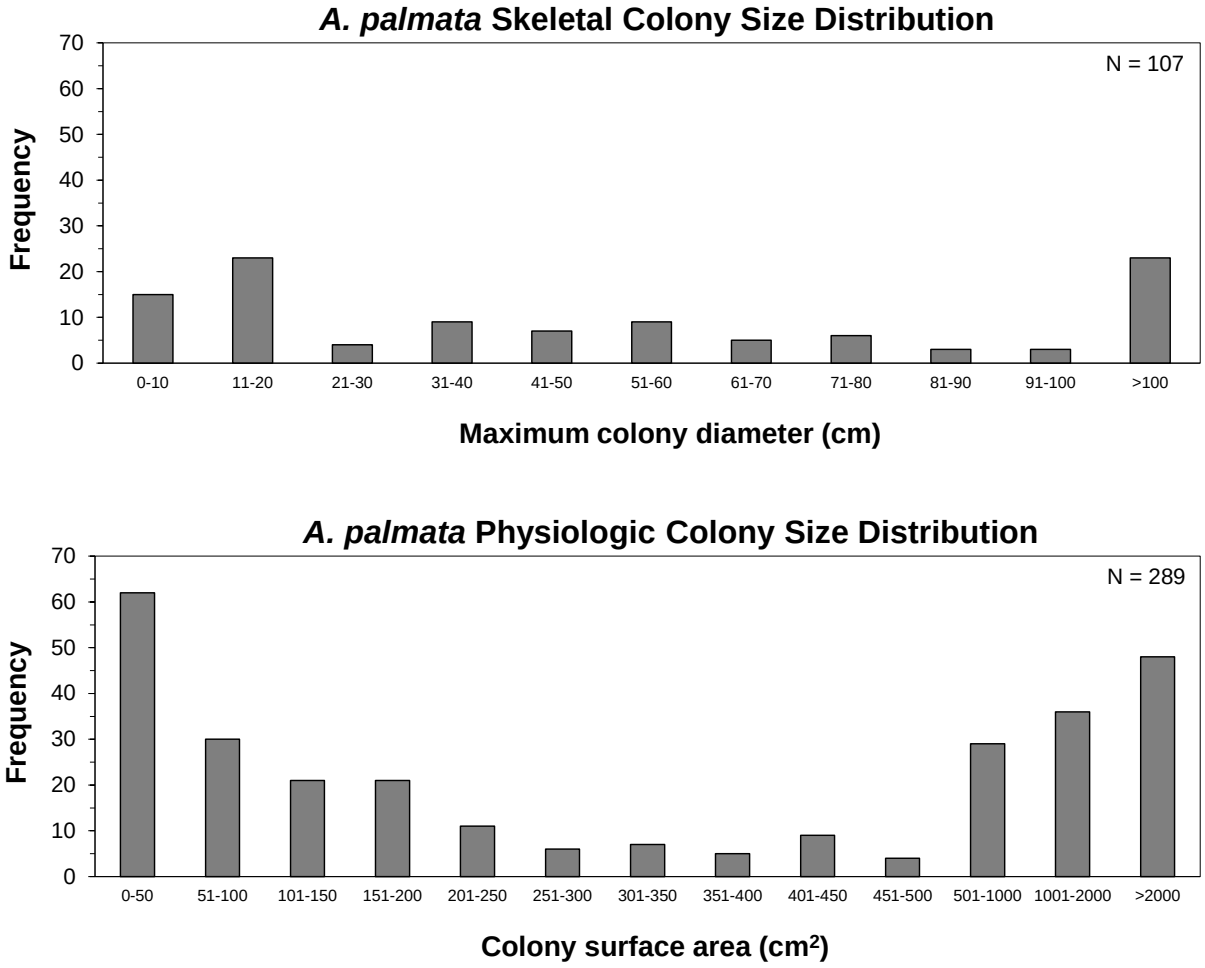


Table 3-1. Summary of habitat distribution, density, and size of *Acropora cervicornis* colonies (physiologic colonies) among habitat types and management zones in the upper Florida Keys, as determined from surveys of two replicate 15-m x 1-m belt transect surveys per site at 280 sites from northern Key Largo to Alligator Reef during May-September 2011. Physiologic colonies are patches of contiguous tissue. Habitat types are arranged from inshore to offshore and no-take zones represent Sanctuary Preservation Areas and Research Only areas. Values represent mean ± 1 SE, except for total surface area, which represent the combined live tissue area of all colonies (number of colonies measured in parentheses).

Habitat/management zone (no. sites)	Site presence (%)	Transect frequency (%)	Colony density (no. per m^2)	Total surface area (cm^2)	Mean size (cm^2)
Inshore and mid-channel patch reefs					
Reference areas (50)	2.0 ± 2.0	1.0 ± 1.0	0.018 ± 0.018	5,259 (27)	195
No-take zones (4)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (54)	1.9 ± 1.9	0.9 ± 0.9	0.017 ± 0.017	5,259 (27)	195
Offshore patch reefs					
Reference areas (73)	12.3 ± 3.9	7.5 ± 2.5	0.044 ± 0.019	17,548 (96)	205 ± 53
No-take zones (4)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (77)	11.7 ± 3.7	7.1 ± 2.4	0.042 ± 0.018	17,548 (96)	205 ± 53
Back-reef rubble					
Reference areas (8)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (10)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (18)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Shallow (< 6 m) hard-bottom					
Reference areas (33)	21.2 ± 7.2	15.2 ± 5.5	0.052 ± 0.021	17,238 (51)	410 ± 95
No-take zones (8)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (41)	17.1 ± 5.9	12.2 ± 4.5	0.041 ± 0.017	17,238 (51)	410 ± 95
High-relief spur and groove					
Reference areas (22)	22.7 ± 9.1	18.2 ± 7.7	0.115 ± 0.065	9,716 (76)	115 ± 28
No-take zones (19)	5.3 ± 5.3	2.6 ± 2.6	0.011 ± 0.011	6,162 (6)	1,027
Habitat total (41)	14.6 ± 5.6	11.0 ± 4.5	0.067 ± 0.036	15,878 (82)	267 ± 154
Deeper fore reef					
Reference areas (36)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (13)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (49)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0

Table 3-2. Summary of habitat distribution, density, and size of *Acropora palmata* colonies (physiologic colonies) among habitat types and management zones in the upper Florida Keys, as determined from surveys of two replicate 15-m x 1-m belt transect surveys per site at 280 sites from northern Key Largo to Alligator Reef during May-September 2011. Physiologic colonies are patches of contiguous tissue. Habitat types are arranged from inshore to offshore and no-take zones represent Sanctuary Preservation Areas and Research Only areas. Values represent mean ± 1 SE, except for total surface area, which represent the combined live tissue area of all colonies (number of colonies measured in parentheses).

Habitat/management zone (no. sites)	**Site presence (%)**	**Transect frequency (%)**	**Colony density (no. per m^2)**	**Total surface area (cm^2)**	**Mean size (cm^2)**
Inshore and mid-channel patch reefs					
Reference areas (50)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (4)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (54)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Offshore patch reefs					
Reference areas (73)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (4)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (77)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Back-reef rubble					
Reference areas (8)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (10)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (18)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Shallow (< 6 m) hard-bottom					
Reference areas (33)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (8)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (41)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
High-relief spur and groove					
Reference areas (22)	9.1 ± 6.3	9.1 ± 6.3	0.061 ± 0.045	40,335 (40)	1,371 ± 522
No-take zones (19)	36.8 ± 11.4	34.2 ± 10.9	0.454 ± 0.192	400,548 (259)	3,275 ± 1,630
Habitat total (41)	22.0 ± 6.5	20.7 ± 6.3	0.243 ± 0.096	440,883 (299)	2,852 ± 1,279
Deeper fore reef					
Reference areas (36)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
No-take zones (13)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0
Habitat total (49)	0 ± 0	0 ± 0	0 ± 0	0 (0)	0 ± 0