**I.**

# The Florida Reef Resilience Program 2006-2007 Bleaching Response Final Report

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NOAA Award Grant Number: NA06NMF4630113

## II. Executive Summary

The NOAA grant funding was used to implement and analyze the results of coral bleaching surveys during 2006 and 2007 bleaching periods as part of the Florida Reef Resilience Program (FRRP). The coral bleaching surveys were based on a pilot program conducted in the summer of 2005 with follow-up surveys in January of 2006. The assessment area covers the reef tract from the Dry Tortugas to Martin County. The FRRP spatial framework divided the reef-tract into sub-regions from north to south and zones from nearshore to offshore (Fig. 1). During the final reporting period, the implementation of the 2007 bleaching surveys was completed and the 2005, 2006 and 2007 FRRP coral bleaching data were analyzed. As part of the data analysis, the bleaching results for 2005, 2006 and 2007 were then weighted based on the amount of reef area for each zone in a sub-region.

## III. Purpose

The primary goals of the Florida Reef Resilience Program (FRRP) is to understand where and why some Florida reefs prosper while others succumb to stresses, and then translate this information into management recommendations. A way to achieve this goal is to improve the understanding of how coral species and discrete reefs respond to a disturbance. Coral bleaching is one disturbance that can be measured synoptically across the project area using a coordinated assessment approach.

In 2005, the Conservancy coordinated "pilot" response during the 2005 bleaching event (August/September) to test the methodology and feasibility of implementing a broad-scale synoptic monitoring of a bleaching event. The data from this pilot assessment clearly shows spatial patterns between regions, habitats, and species that illustrate differences in bleaching stress and tolerance to stress. The 2006 and 2007 bleaching response implementation were designed to identify factors that explain how reefs respond to disturbance which can be used to support management for long term ecosystem resilience. The following questions were to be addressed

- **What is the extent and severity of mass bleaching/disease event in south Florida?**
- **How has the bleaching event affected the condition of south Florida coral reefs?**
- **How have south Florida reefs recovered in the wake of an event?**

## IV. Approach

The 2006 and 2007 FRRP bleaching response efforts were focused on the broad-scale component because this scale and random approach is seen as a major gap in current monitoring programs. The broad-scale in-water rapid assessment design used by the FRRP Disturbance Response Monitoring was developed by Dr. Jerry Ault and Dr. Steven Smith from RSMAS (Rosenstiel School of Marine and Atmospheric Science)-University of Miami (UM). A spatial framework was developed for the South Florida reef-tract that divided the entire FRRP region into sub-regions from north to south and zones from nearshore to offshore (Fig. 1).

The sampling design is orientated to provide between 10 and 15% Coefficient of Variation (CV) or power to detect change across the FRRP region, sub-regions, and zones. Furthermore, the design is focused on sub-sampling the coral population based on how corals are distributed spatially within and across different zones. This

is a demographic approach as opposed to habitat (e.g., cover) approach and will provide much more information on the size-frequency population size structure.

Field methodology for the project consisted of two independent 10x1 m belt transects randomly placed within a 200x200 m area with reef. Four main indicators were recorded for all stony corals greater than 4 cm including: 1) live coral cover, 2) hard coral density, 3) hard coral size, 4) hard coral condition (bleaching, disease, partial mortality). For more field methodology details see Appendix I.

The project was divided into three phrases (A) Preparation, (B) Implementation and (C) Analysis.

A) Preparation

*Evaluation of the Sampling Design Performance:*

The sampling design was updated in 2006 and 2007 by the scientist at RSMAS-UM with new randomly selected primary and secondary sites for each of the identified zones. The updates of the sampling design were based on the previous years (2005 and 2006) collected data with contributions and assistance from the FRRP benthic working group members; Rob Von Woesik, Dione Swanson, Margaret Miller, Mark Chiappone, Diego Lirman and Judy Lang.

*In-water training sessions for all field teams*

Three training sessions were conducted for the FRRP consortium members for the 2006 bleaching surveys. These trainings took place at Mote Marine Laboratory in Summerland Key, Nova Southeastern University in Ft. Lauderdale, and the Florida Fish and Wildlife Conservation Office in West Palm Beach. Four (4) training sessions took place during August of 2007 in the same venues as the 2006 trainings with an addition of one more training taking place in the Florida Keys National Marine Sanctuary Office in

Key West. The FRRP consortium members were trained in the survey methodology and identification of the different coral species, bleaching and disease.

(B) Implementation

The 2006 and 2007 bleaching assessments were conducted by the following partner agencies with The Nature Conservancy:

- Florida Department of Environmental Protection's (FDEP)- Southeast Florida Coral Reef Initiative (SEFCRI) ,
- FDEP's-John Pennekamp State Park,
- Florida Fish and Wildlife Conservation Commission's (FWC)-Division of Habitat and Species Conservation,
- Biscayne National Park,
- Broward County- Environmental Protection Department,
- Miami-Dade County- Environmental Restoration and Enhancement Section,
- Mote Marine Laboratory
- Nova Southeastern University-National Coral Reef Institute (NCRI),
- University of Miami-Rosenstiel School of Marine and Atmospheric Science (RSMAS).
- NOAA-Florida Keys National Marine Sanctuary staff (FKNMS)
- FWC's-Fish and Wildlife Research Institute staff. (FWRI)

*2006 Coral bleaching surveys*

A total of 124 sites were surveyed by eleven participating teams within the South Florida reef tract (Lower Keys to Martin County) minus the Dry Tortugas for the 2006 sampling effort. The teams surveyed the reef tract from August 26, 2006 to October 12, 2006. The Florida Department of Environmental Protection's (FDEP's) Aquatic Preserves of the Southern Indian River Lagoon team conducted surveys on 6 sites in the reef complex

offshore of Martin County. The FWC's Habitat Protection Office in West Palm Beach did 3 sites off Palm Beach County. The FWC's team was limited by inclement weather and high current conditions offshore of West Palm Beach during the survey timeframe.

The NSU and Broward County teams surveyed 14 sites in the reefs offshore of Broward County. The Southeast Florida Coral Reef Initiative (SEFCRI) and the Miami-Dade County teams surveyed a total of 13 sites in the reef area off Dade County. Several of the primary sites that were visited by SEFCRI and Miami Dade County teams turned out to be sand bottom areas. Therefore, most sites surveyed were secondary sites.

The University of Miami and Biscayne Bay National Park teams surveyed 28 sites on the reef tract offshore of Dade County and in Biscayne Bay. The FDEP-John Pennekamp Park staff surveyed 6 sites within the Park in the Upper Keys. The TNC and Mote teams surveyed 67 sites within the Florida Keys reef tract including the Marquesas. A total of 124 new sites were surveyed by eleven participating teams from the Marquesas to Martin County.

*2007 Coral bleaching surveys*

The 2007 FRRP bleaching surveys included the previous 2006 survey area (from Martin County to the Lower Keys). In addition, the 2007 survey season included areas in the Marquesas (West of Key West) and the Dry Tortugas. The FRRP coral bleaching surveys started August 29, 2007 and ended October 19, 2007. A total of 162 new sites were surveyed by eleven participating teams from the Marquesas to Martin County.

The Florida Fish and Wildlife Commission's (FWC)- Habitat Protection Office in West Palm Beach did 11 sites off Palm Beach County. The NSU and Broward County teams surveyed 13 sites in the reefs offshore of Broward County. The Southeast Florida Coral Reef Initiative (SEFCRI) and the Miami-Dade County teams surveyed a total of 13 sites in the reef area off Dade County.

The University of Miami and Biscayne Bay National Park teams surveyed 25 sites on the reef tract offshore of Dade County and in Biscayne Bay. The FDEP-John Pennekamp Park staff surveyed 15 sites within the Park and the Florida Keys National Marine Sanctuary (FKNMS) surveyed 2 sites in the Upper Keys. The FWC's- Fish and Wildlife Research Institute surveyed 6 sites in the Middle Keys. The Nature Conservancy and Mote Marine Laboratory teams surveyed 62 sites within the Florida Keys reef tract including the Marquesas. The FKNMS and Environmental Protection Agency (EPA) Disease Cruise completed 15 sites in the Dry Tortugas.

From the 162 total number of sites surveyed, thirty (30) surveys were completed at strategic sites. Strategic sites were created outside the randomly generated set of FRRP-DRM survey points. These strategic points were created to take advantage of other coral surveys taking place at fixed locations or to fix problems encountered with sampling some of the randomly generated sites. Because there was no mapped area of the Marquesas from which to randomly generate sites, all Marquesas surveys were considered strategic sites. All surveys from the Dry Tortugas were also strategic sites

because they were the fixed sites for the Florida Keys National Marine Sanctuary (FKNMS) Coral Disease Cruise.

An Online Data Entry System was newly created for the 2007 FRRP-DRM sampling season. This system allowed surveyors to enter data directly on the www.frrp.org website. The online data entry system facilitated the quicker turnaround of data and to reduce the number of errors in the data. Various quality assurance checks were performed as data were entered, thus increasing feedback and reducing the time and effort needed to correct errors.

## V. Findings

*Findings and Data Analysis:*

The collected bleaching and paling data were weighted and averaged for the 2005, 2006, and 2007 bleaching season (Figure 2 and Table 2). The data did not include the 2007 Marquesas and Dry Tortugas regions, because the surveys were not random and the sample size was limited. A comparison of paling and bleaching prevalence within the domain for the past 3 years (2005-2007) show the 2005 season as having the highest combined prevalence for paling and bleaching followed by the 2007 season. This trend follows the temperature from the NOAA sea surface temperature charts and data temperature loggers from 2005 and 2007 season. Bleaching and paling prevalence were mild for the 2006 season.

A map of the bleaching and paling prevalence for 2007 across the domain averaged 19.5%. The 2007 survey results showed the Palm Beach and Broward sub-regions

having severe and moderate bleaching results (Figure 4). It is likely that the Palm Beach and Broward sub-regions may have another source of disturbance such as freshwater inputs or cold water upwelling that occurred during the survey period. The 2007 survey also showed a moderate bleaching event in two zones, Upper Keys Forereef (15.2% bleaching) and the Lower Keys Inshore (16.9% bleaching). A comparison between the results of the 2005 (Figure 4) surveys to the 2006 and 2007 surveys show different bio-zones and sub-regions having a variable response to bleaching.

Visual assessments of disease prevalence were low throughout the reef tract averaging less than 2% for 2005, 2006 and 2007. Coral mortality averaged less than 5% for 2005, 2006 and 2007 for the entire domain. The low prevalence of disease and mortality was likely due to the fact that bleaching events were mild to moderate for the past three years.

Trends in the paling and bleaching data indicate that the following corals were susceptible to bleaching:

Siderastrea radians
Porites furcata
Agaricia agaracites
Agaricia lamarki
Porites diverculata
Porites porites

The following corals were moderately susceptible corals:

Montastreae annularis
Montastreae faveolata
Montastreae franksi
Siderastrea siderea

The following corals were considered resistant:

Montastreae cavernosa
Diploria strigosa
Diploria labirynthiformis
Diploria stokesii

*Demographics:*

Mid-channel patch reefs make up a small percentage (7.2%) of total reef area in South Florida but support a very large proportion (42.6%) of all coral colonies and many of Florida's largest corals (See Figures 5 and 6). In much of the Florida reef tract, these patch reefs receive very limited protection.

Reefs offshore from Biscayne Bay and southern Miami-Dade County represent 12.3% of total reef area in South Florida but this area supports more than one quarter (25.5%) of all corals in the region (See Figure 7 and 8).

## VI. Applications and Evaluation

*Outputs and Management Outcomes:*

The Florida Reef Resilience Program (FRRP) Disturbance Response Monitoring effort, administered by The Nature Conservancy, is the largest annual in-water monitoring of coral response to heat stress in the world. It makes it possible for the first time to compare coral condition and response to stress across the entire geographic extent of shallow water corals in Florida. Seventy-one people from 16 agencies and organizations participate in surveying corals from Martin County to Key West during the hottest time of year when corals are most likely to be stressed from high water temperatures.

In April of 2008, the Florida Reef Resilience Program sponsored a meeting in Key Largo to report on the progress and develop strategies to achieve the FRRP vision:

*Marine resource managers and users have new tools that enhance their ability to identify and map the health and status of coral reefs, understand the underlying factors that lead to and maintain resilience, and recognize the economic values associated with reefs. Empowered with this knowledge, managers and users jointly develop, implement, and support management strategies that improve ecological conditions and economic sustainability.*

The first day of the conference focused on discussion of coral reef resilience principles and research the partners have completed to help answer some of the critical questions about resilience. The morning of day two of the Coral Reef Resilience Conference focused on tools and information available to managers for managing coral reefs for resilience. On the final afternoon of the conference, coral reef managers from 12 marine

managed areas in South Florida, Central America, and the Caribbean discussed some of the challenges of coral reef management. The final, and perhaps most important, session of the conference involved participants working in small groups to develop ideas that coral reef managers could employ to protect the region's reefs from the threats of climate change. Each of six groups discussed a set of strategies and ranked those they considered most useful. A summary of those discussions is included as is the total list and rankings of all the strategies, located on the newly developed website www.frrp.org. We hope this list of strategies, developed by managers, reef anglers, conservationists, dive operators, students and public officials will broaden the discussion about how to protect our reefs.

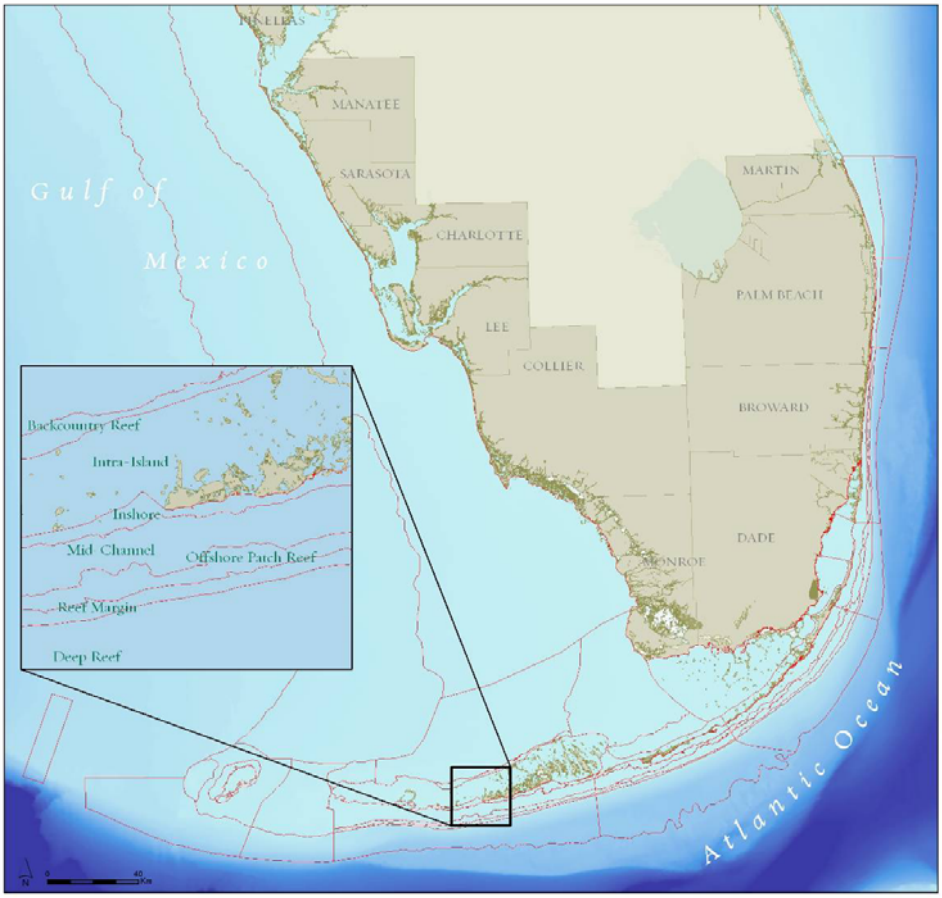


**Figure 1.** The spatial framework of the Florida Reef Resilience Program's Disturbance Response Monitoring effort showing the different sub-regions and zones with the Lower Florida Keys sub-region expanded to show examples of zones (e.g. Inshore, Mid Channel, etc.).

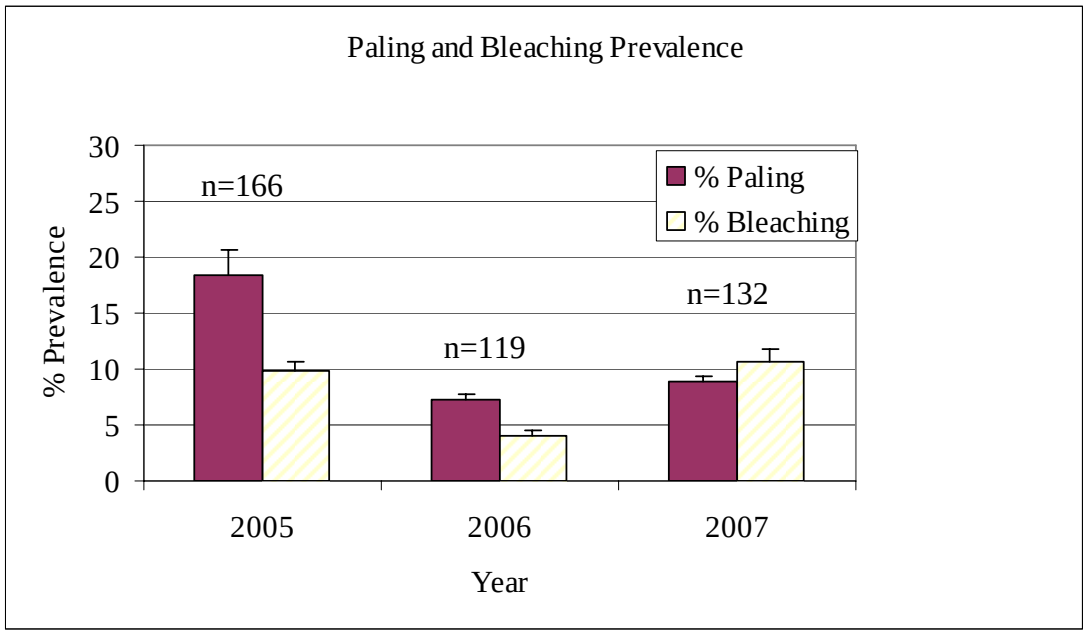


**Figure 2.** Survey results of prevalence of paling and bleaching within stony corals for the Florida reef tract for 2005-07. The number of sites surveyed each year is represented by n. The 2005 data includes the NURC survey data.

**Table 2.** Percentage of paling and bleaching corals annually following peak temperatures from 2005-07 as determined by FRRP surveys on the Florida reef tract.

| *Year* | *% Paling* | *% Bleaching* | *Total Paling & Bleaching (%)* | *Total Sites (n)* |
|---|---|---|---|---|
| **2005** | 18.3 | 9.9 | 28.2 | 166 |
| **2006** | 7.2 | 4.0 | 11.2 | 119 |
| **2007** | 8.8 | 10.7 | 19.5 | 132 |

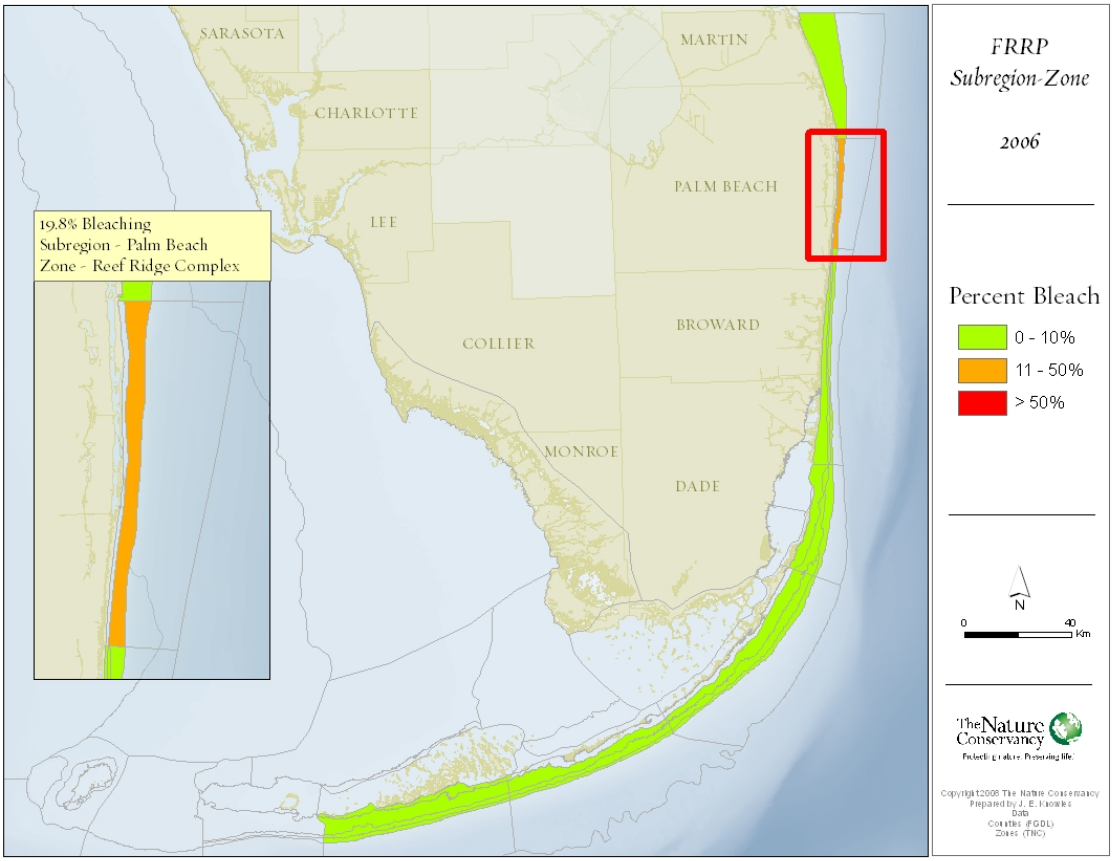


**Figure 3:** Map of the 2006 bleaching results throughout the South Florida reef tract.

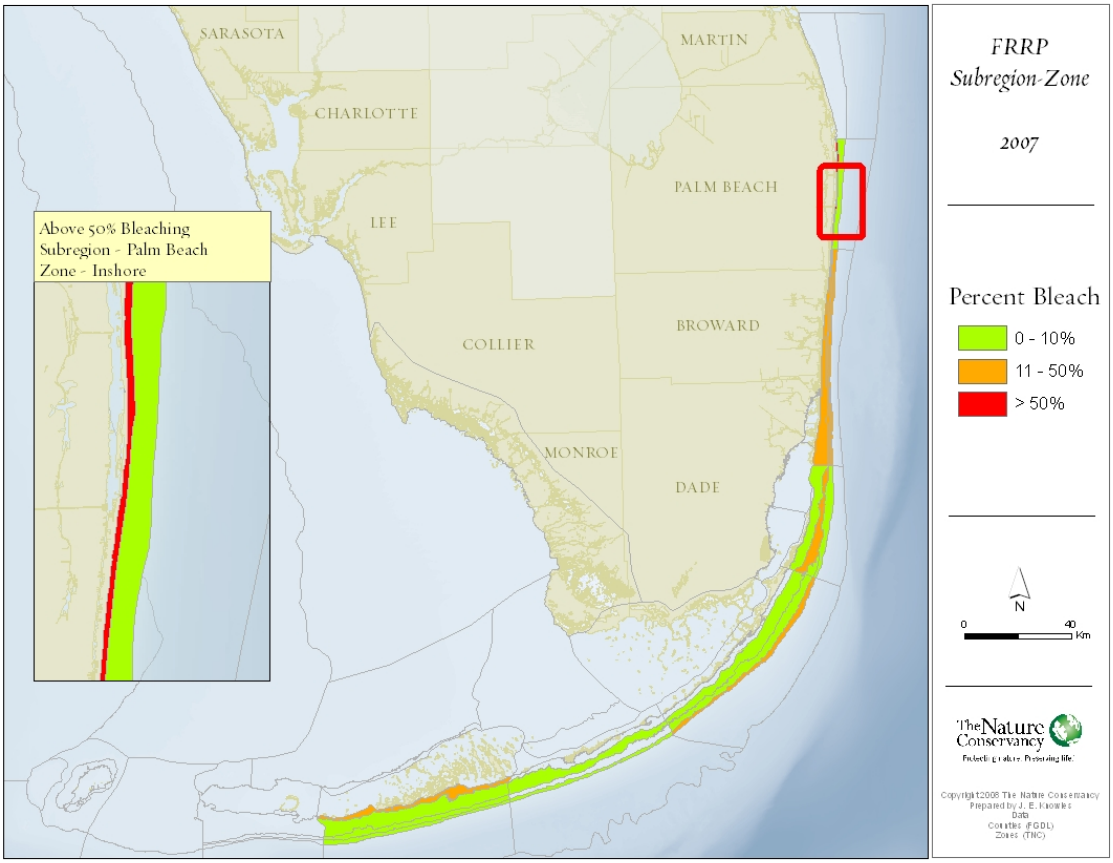


**Figure 4:** Map of the 2007 bleaching results throughout the South Florida reef tract

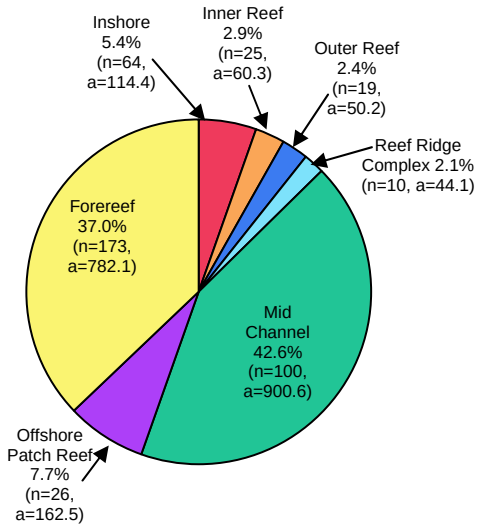


**Figure 5.** Percent of all coral colonies within each zone (n=sites surveyed, a=abundance of colonies in millions)

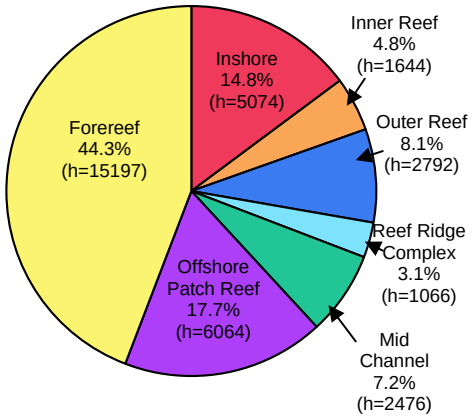


**Figure 6.** Percent of total reef area within each zone (h=hectares of reef area)

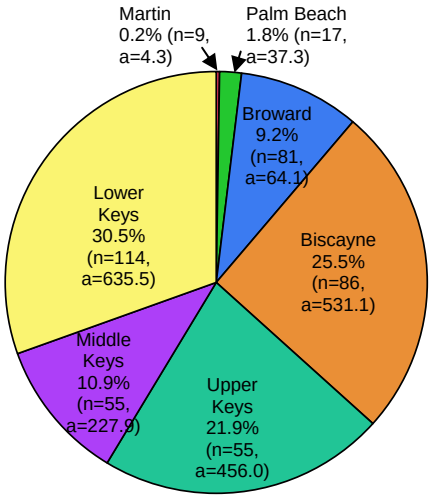


**Figure 7:** Percent of all coral colonies within each zone (n= sites surveys, a=abundance of colonies in millions)

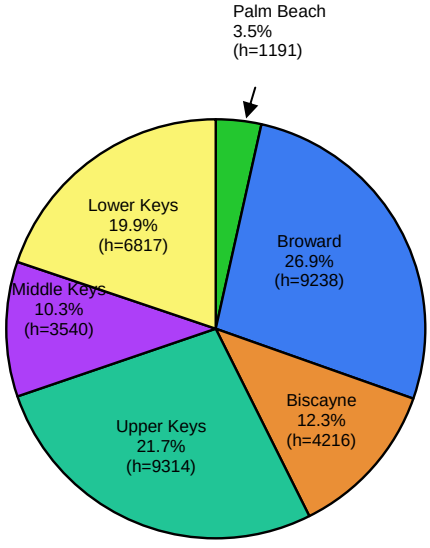


**Figure 8:** Percent of total reef area within each zone (h=hectares of reef)