

A Spatial Framework for Quantifying Reef Resilience and Response to Disturbance in Florida

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The Nature Conservancy**

Previous FL coral bleaching data



Data were *semi-quantitative*

Studies used a wide *variety of techniques*

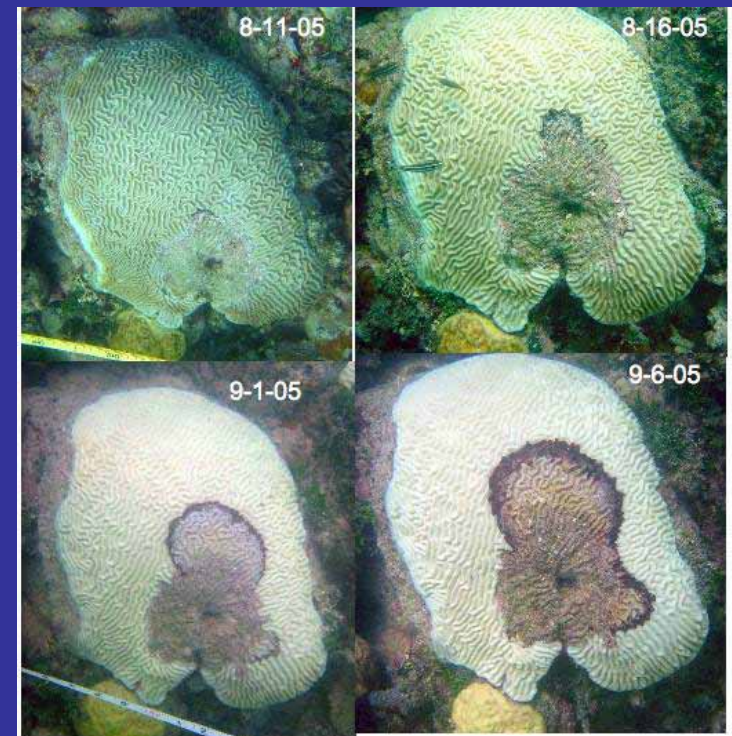
Sampling *not representative* of all reef types

Scale *too small*

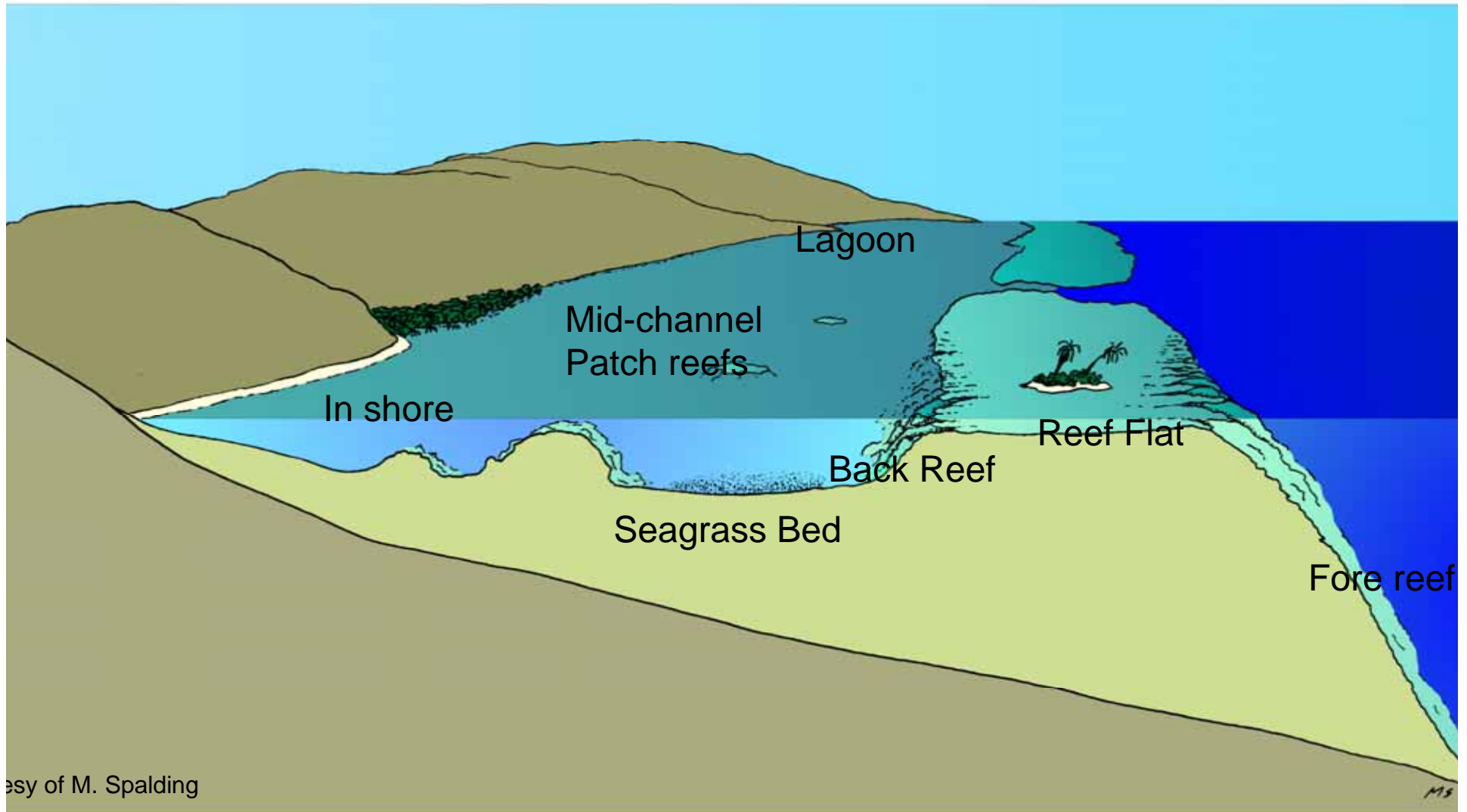
Results *unreliable*

Poor *links* to long-term monitoring

BUT...data rich history in FL



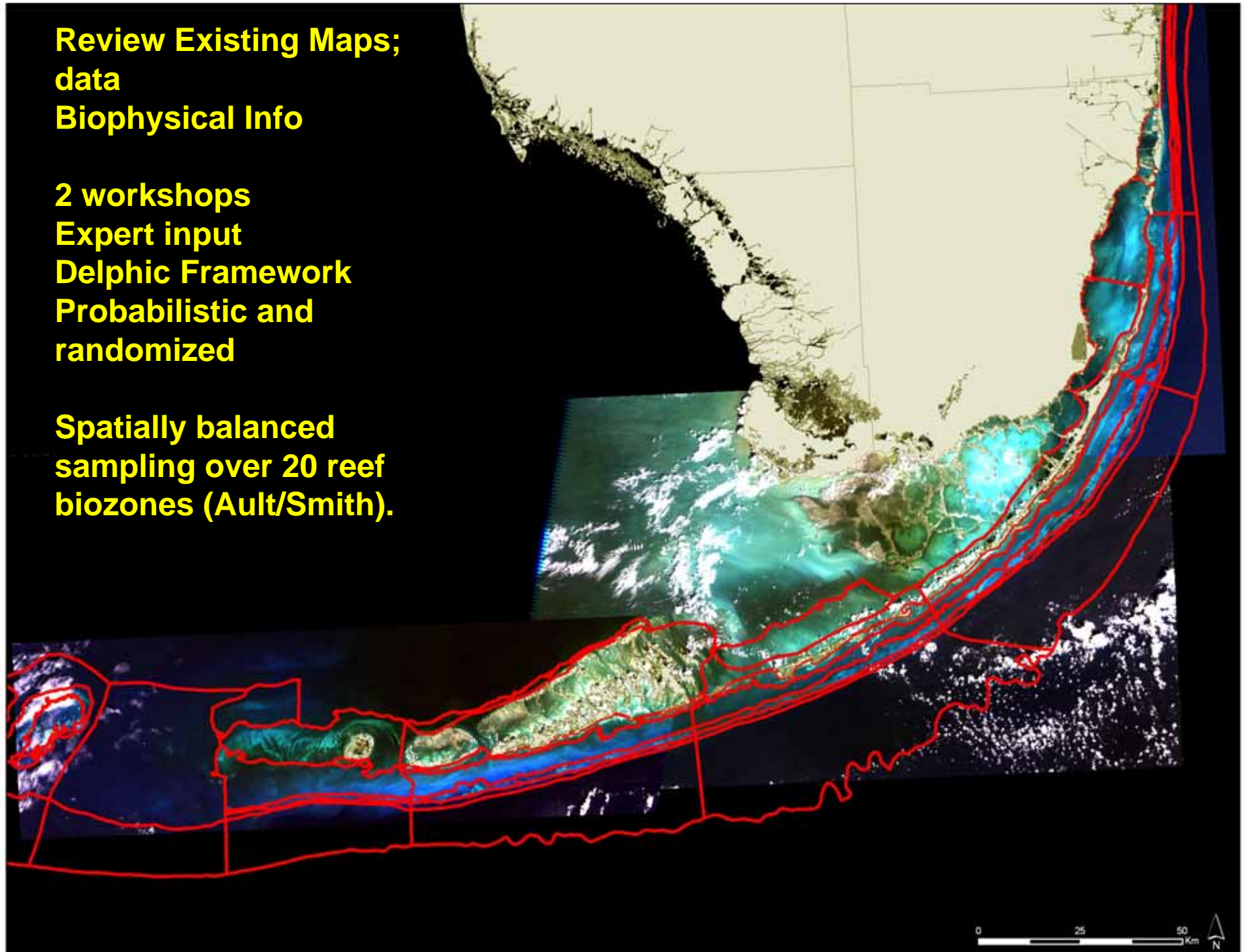
Spatial framework: All reefs are not the same



**Review Existing Maps;
data
Biophysical Info**

**2 workshops
Expert input
Delphic Framework
Probabilistic and
randomized**

**Spatially balanced
sampling over 20 reef
biozones (Ault/Smith).**



DRM: Monitoring for management

- **Monitor coral reef health after disturbances- bleaching**
- **Trained experts surveyed corals and bleaching on FL reef tract after peak annual temperatures**
- **Follow-up surveys after moderate/severe bleaching years**
- **Workshops with NOAA and AGRRA program to standardize for Caribbean**

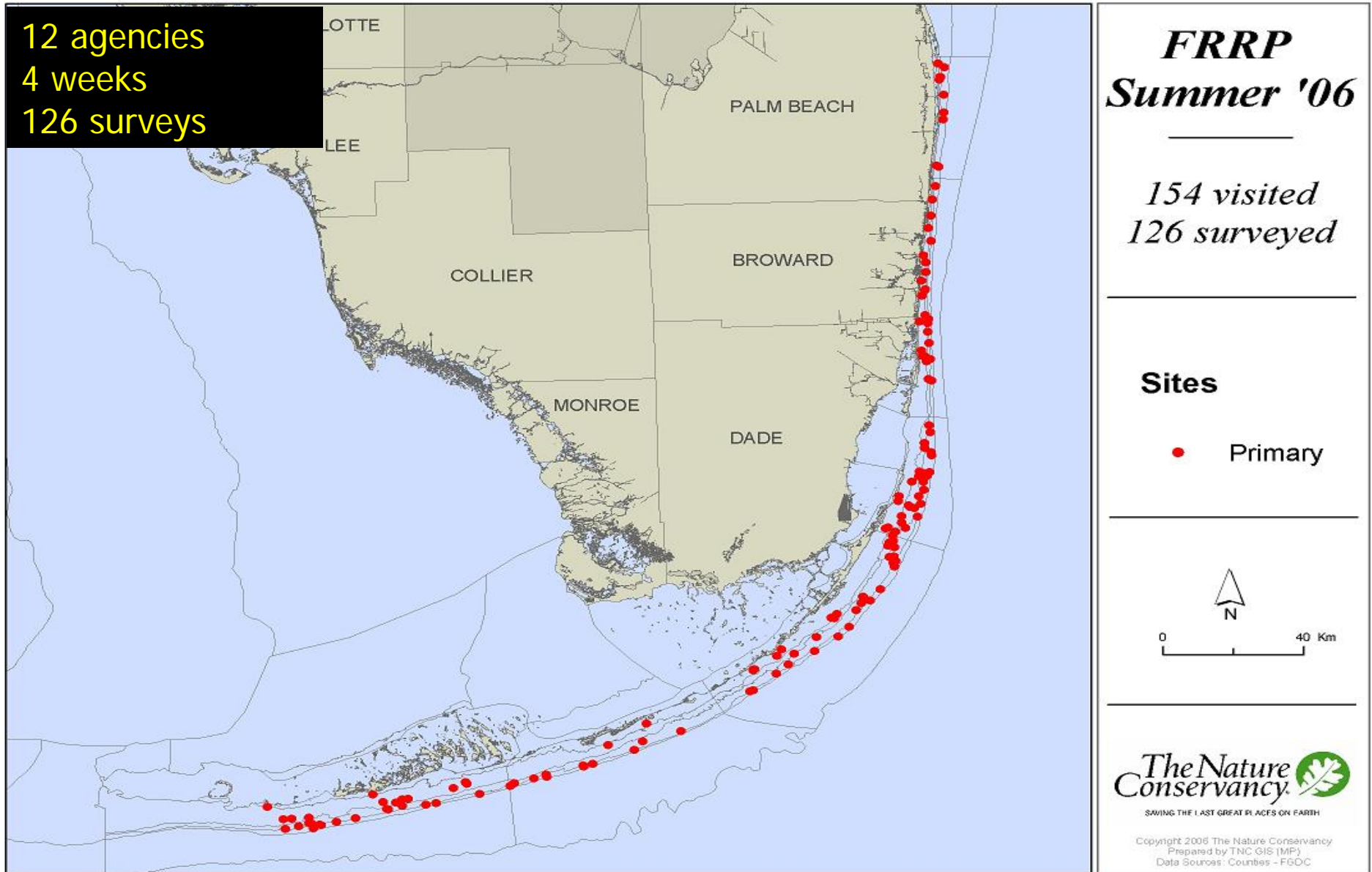


DRM Field Methods

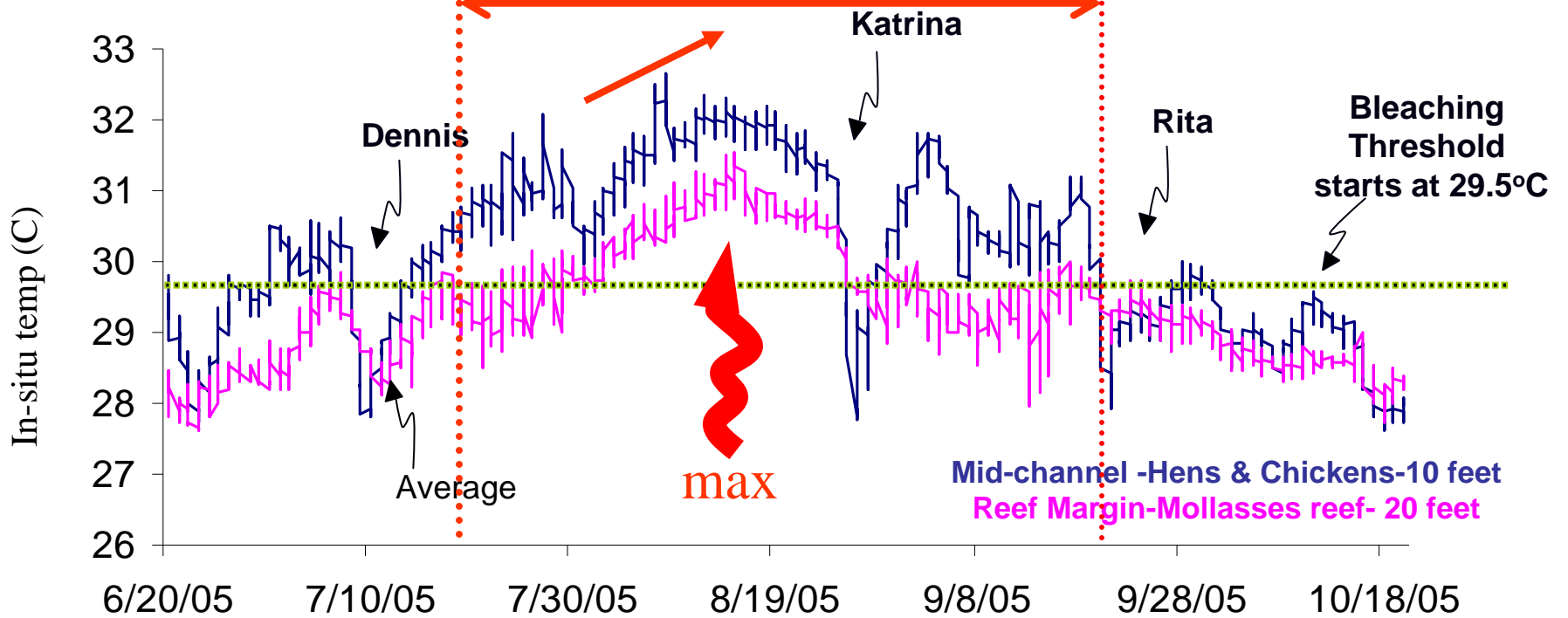
- Random sites generated and assigned to teams
- 1 x 10m belt transects (2/site)
- Measure/assess all corals (≥ 4 cm)
- Species level identification
- Bleaching and disease (visually)
- Data entered online
- Database queried for results



DRM: Annual bleaching assessment

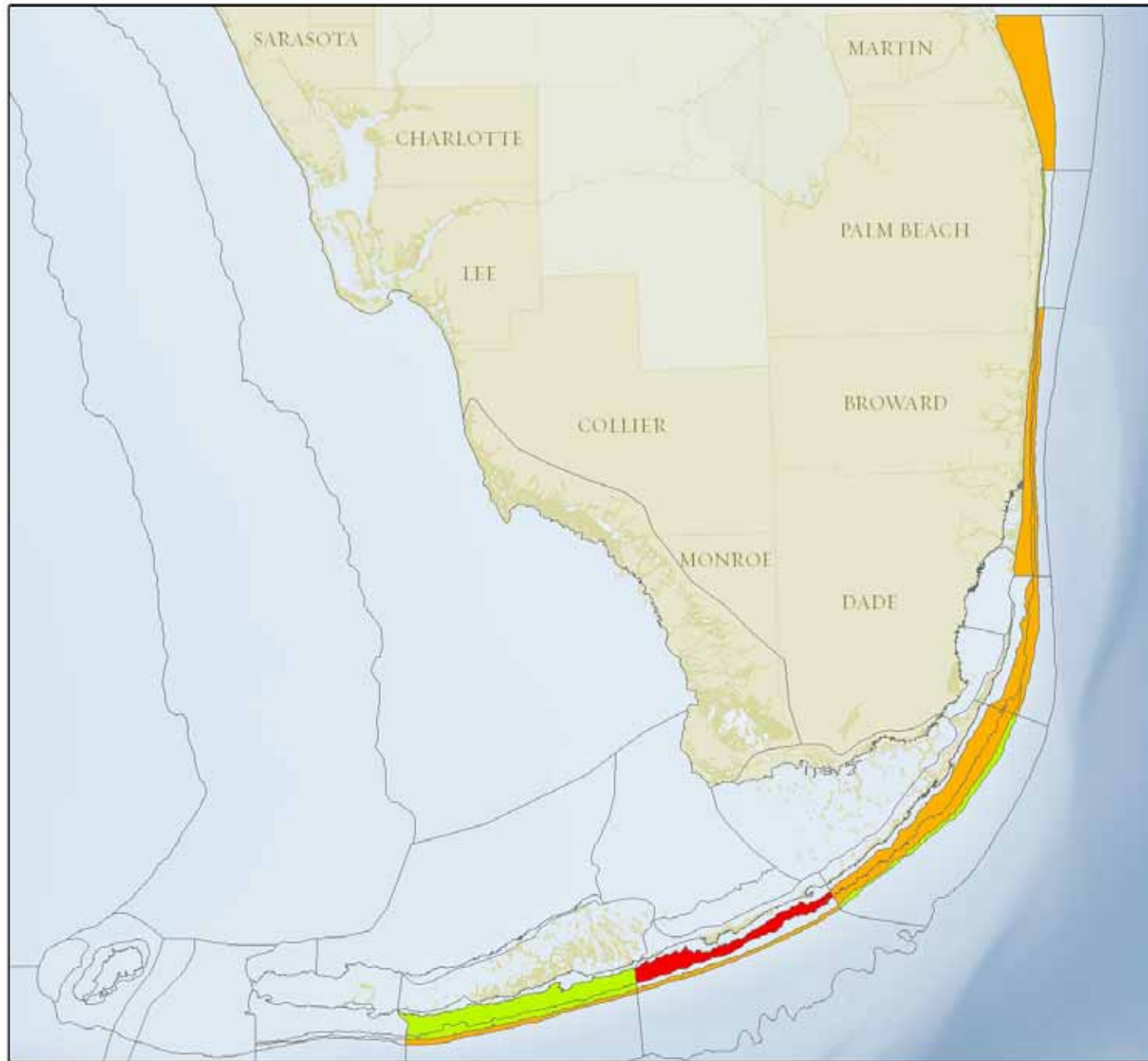


2005 Temperature stress



In-situ temp data from
Harold Hudson
FKNMS

Survey period



FRRP
Subregion-Zone

2005

Percent
Bleach/Pale

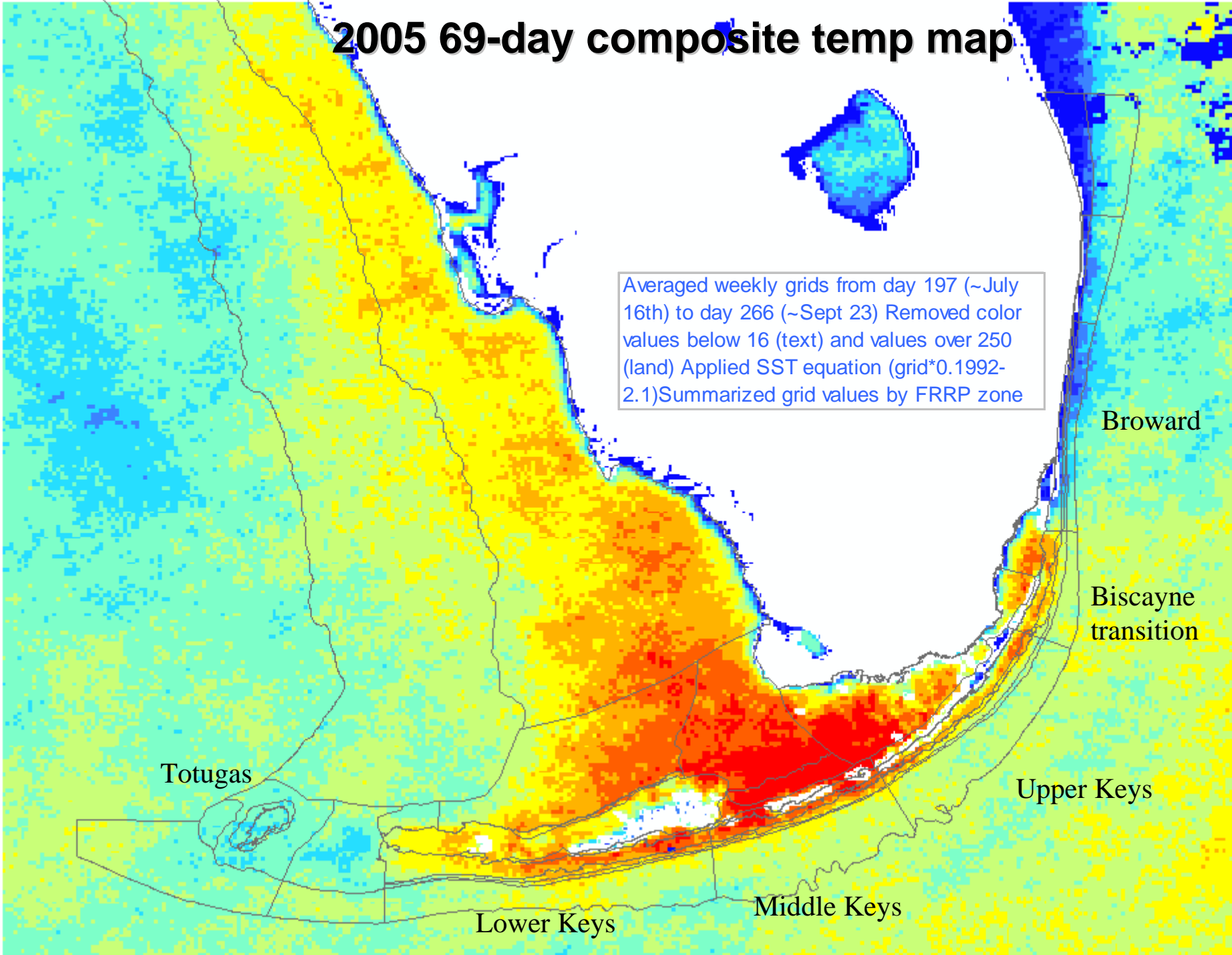
- 0 - 20%
- 21 - 50%
- > 50%

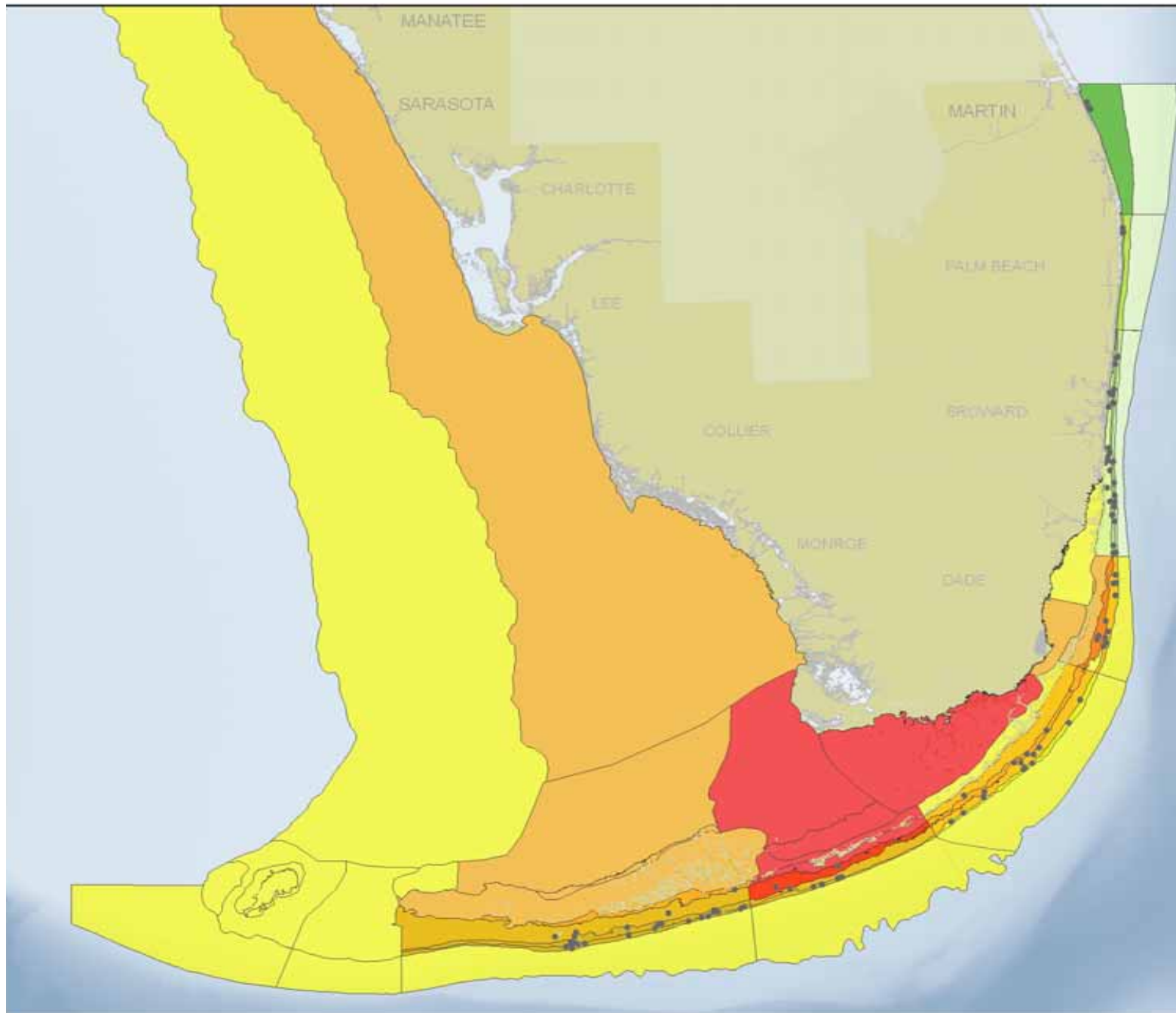


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Prepared by J. E. Knowles
Data
Counties (FODL)
Zones (TNC)

2005 69-day composite temp map

Averaged weekly grids from day 197 (~July 16th) to day 266 (~Sept 23) Removed color values below 16 (text) and values over 250 (land) Applied SST equation (grid*0.1992-2.1) Summarized grid values by FRRP zone



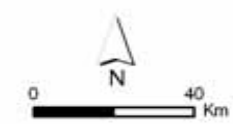


SST Mean by Zone

69 day period

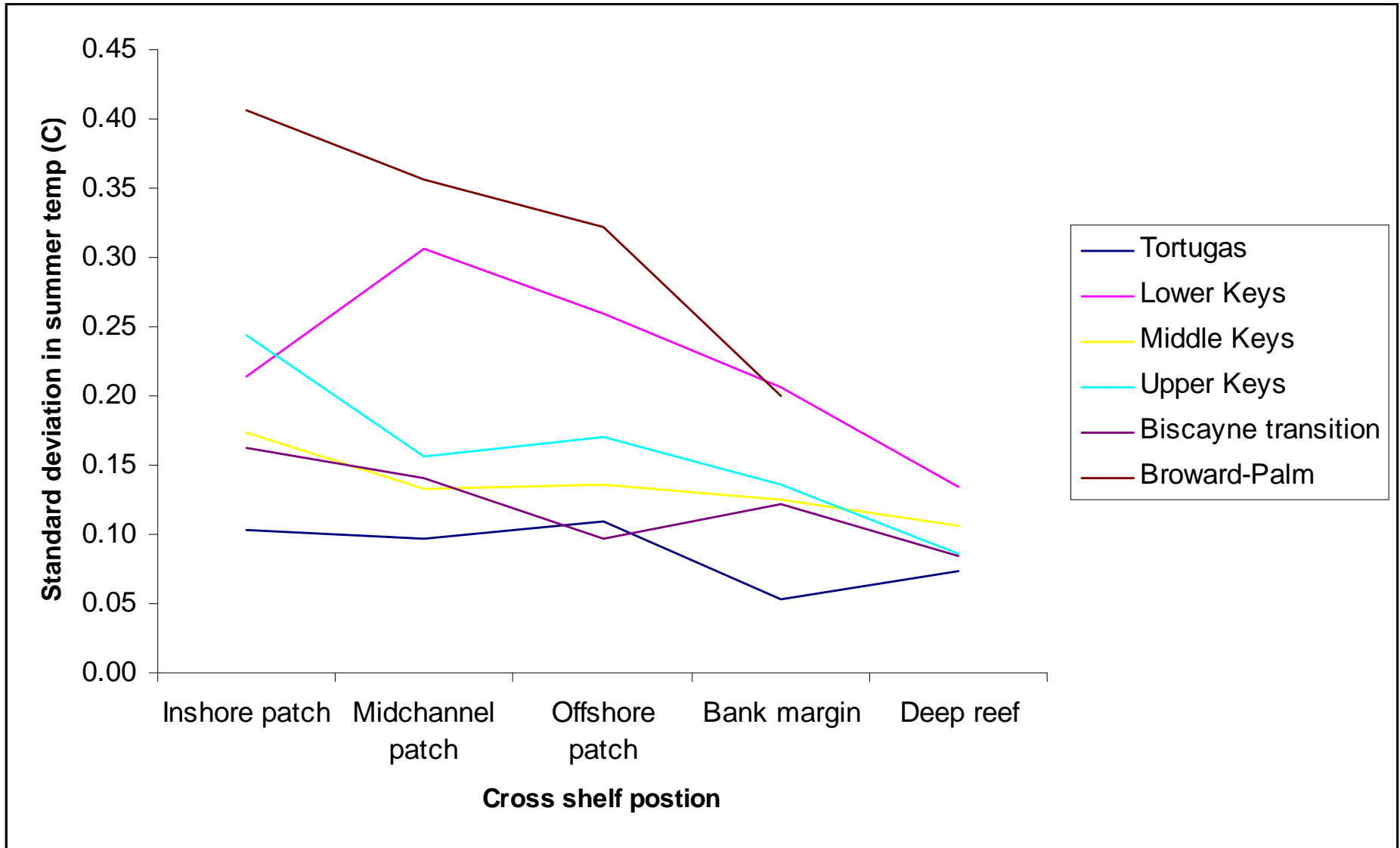
MEAN SST (C)

- 27.27 - 27.67
- 27.68 - 28.07
- 28.08 - 28.47
- 28.48 - 28.86
- 28.87 - 29.26
- 29.27 - 29.66
- 29.67 - 30.06



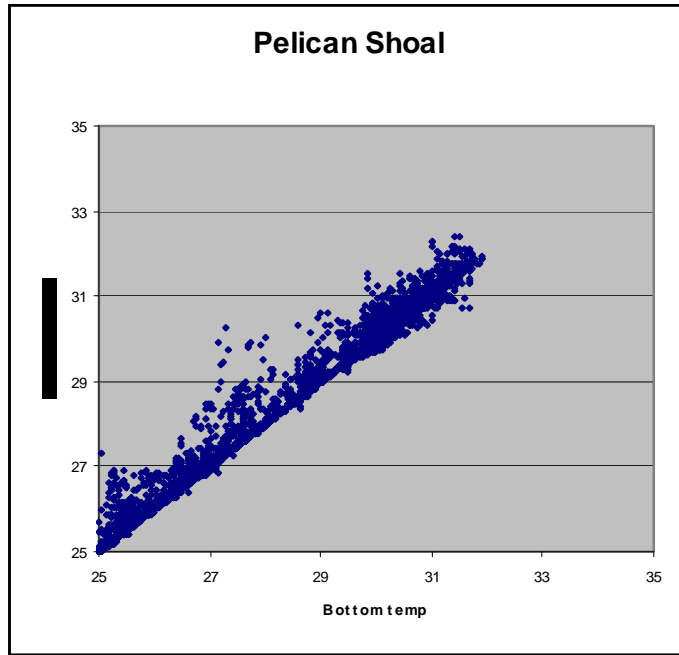
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 Prepared by TNC GIS (MP)
 Data
 Counties (FGDL)
 Zones (TNC)

Mean temp. standard deviation by FRRP subregion cross shelf zone



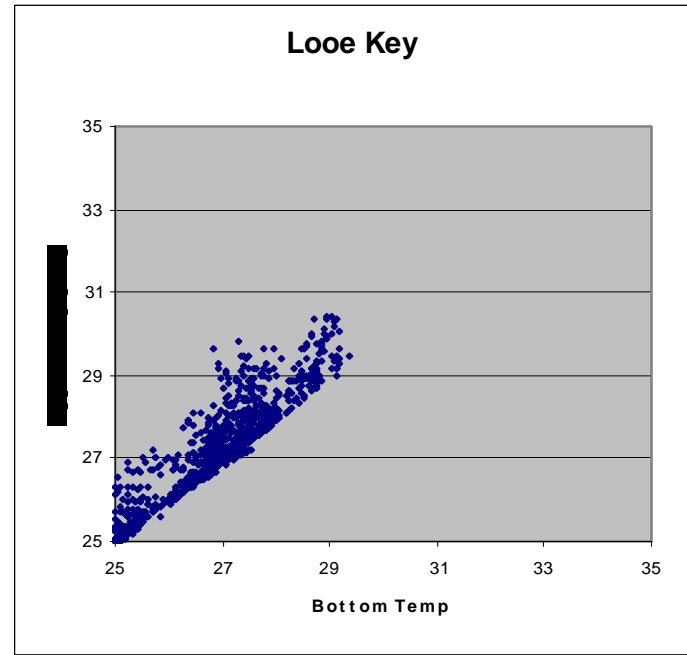
South

Reef Margin

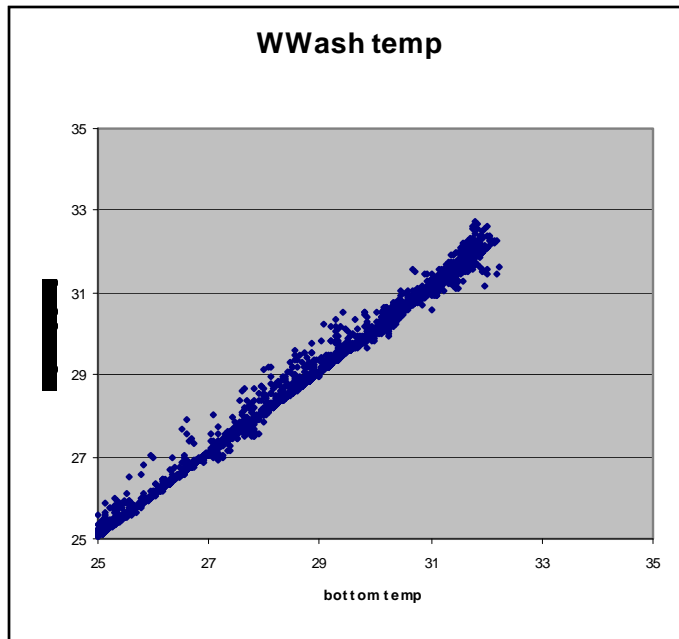


North

Reef Margin

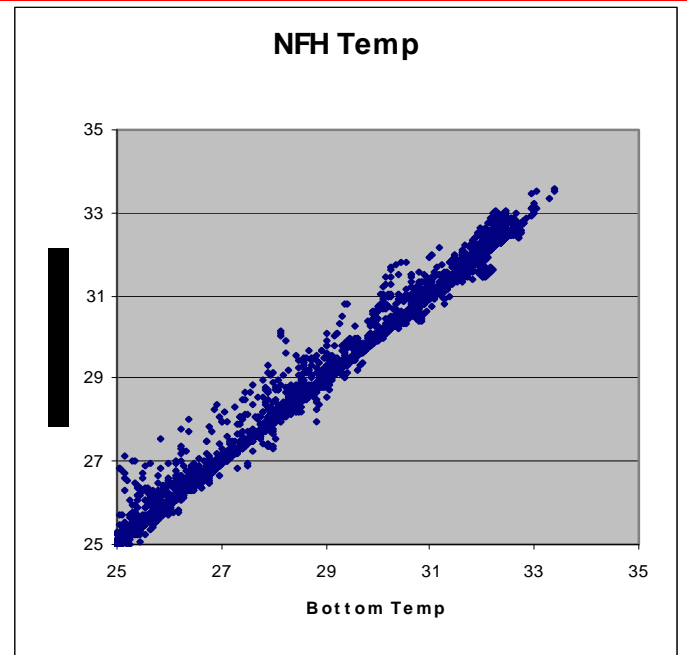


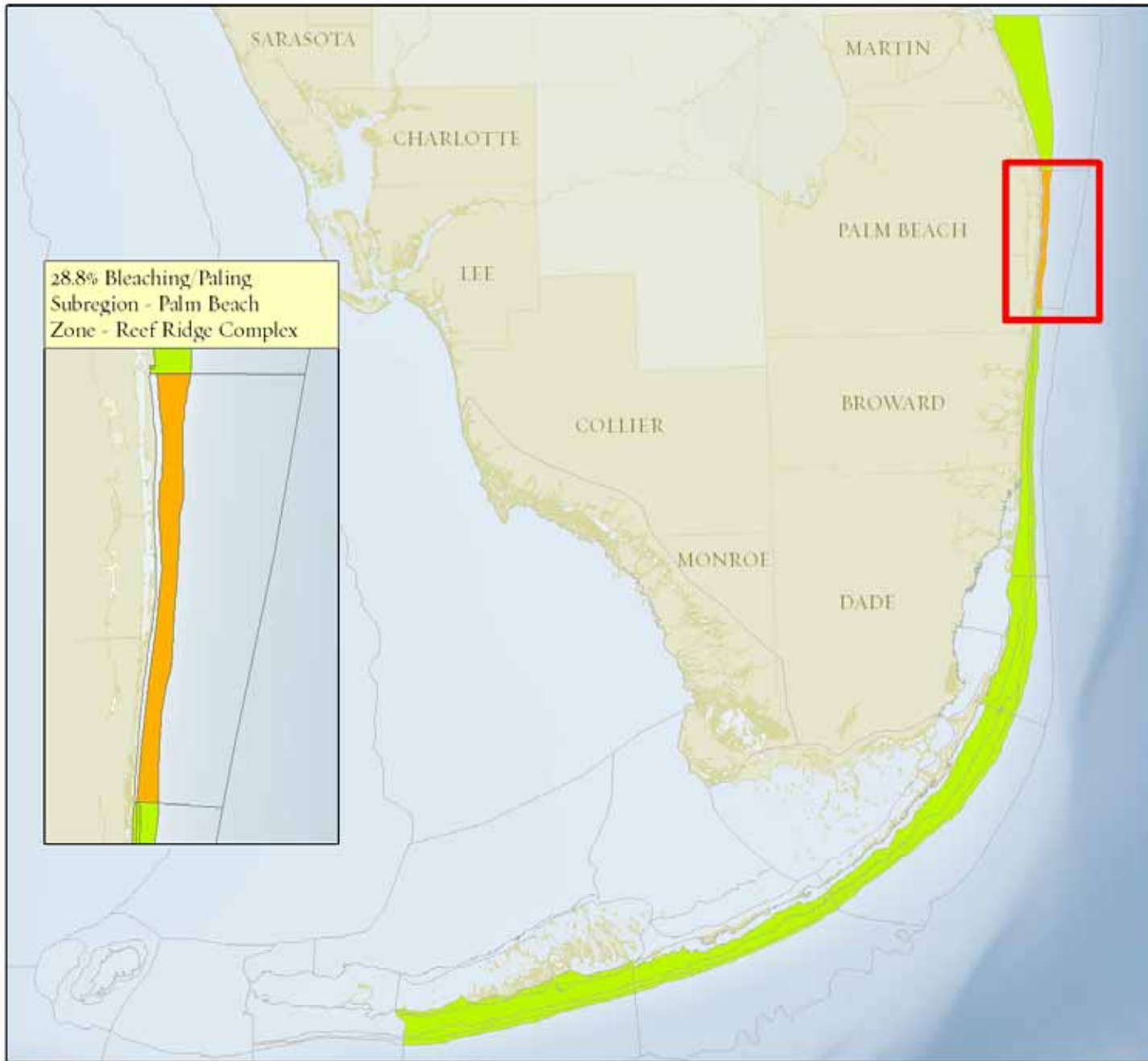
Mid-channel



NFH Temp

Inshore





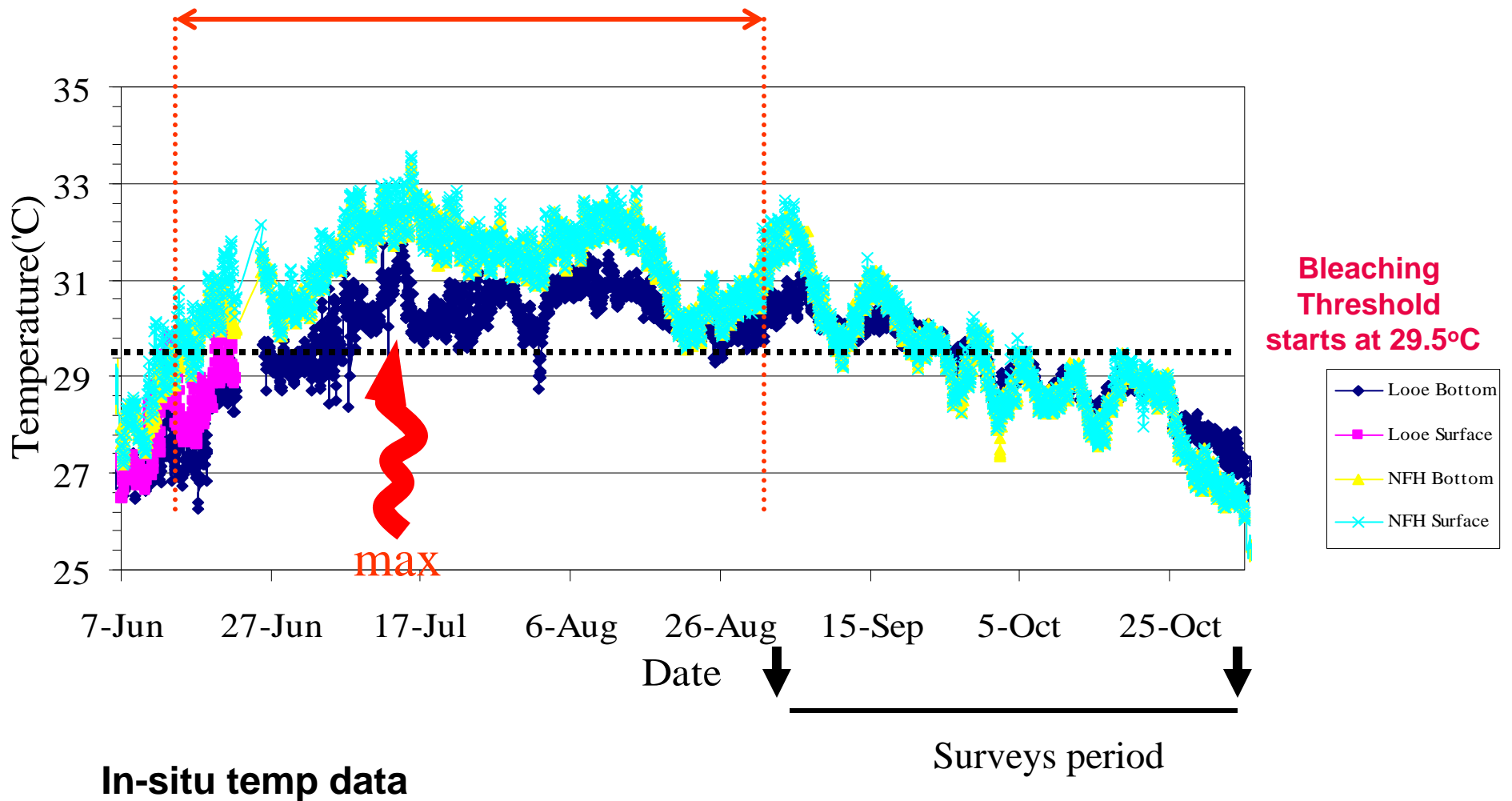
FRRP
Subregion-Zone

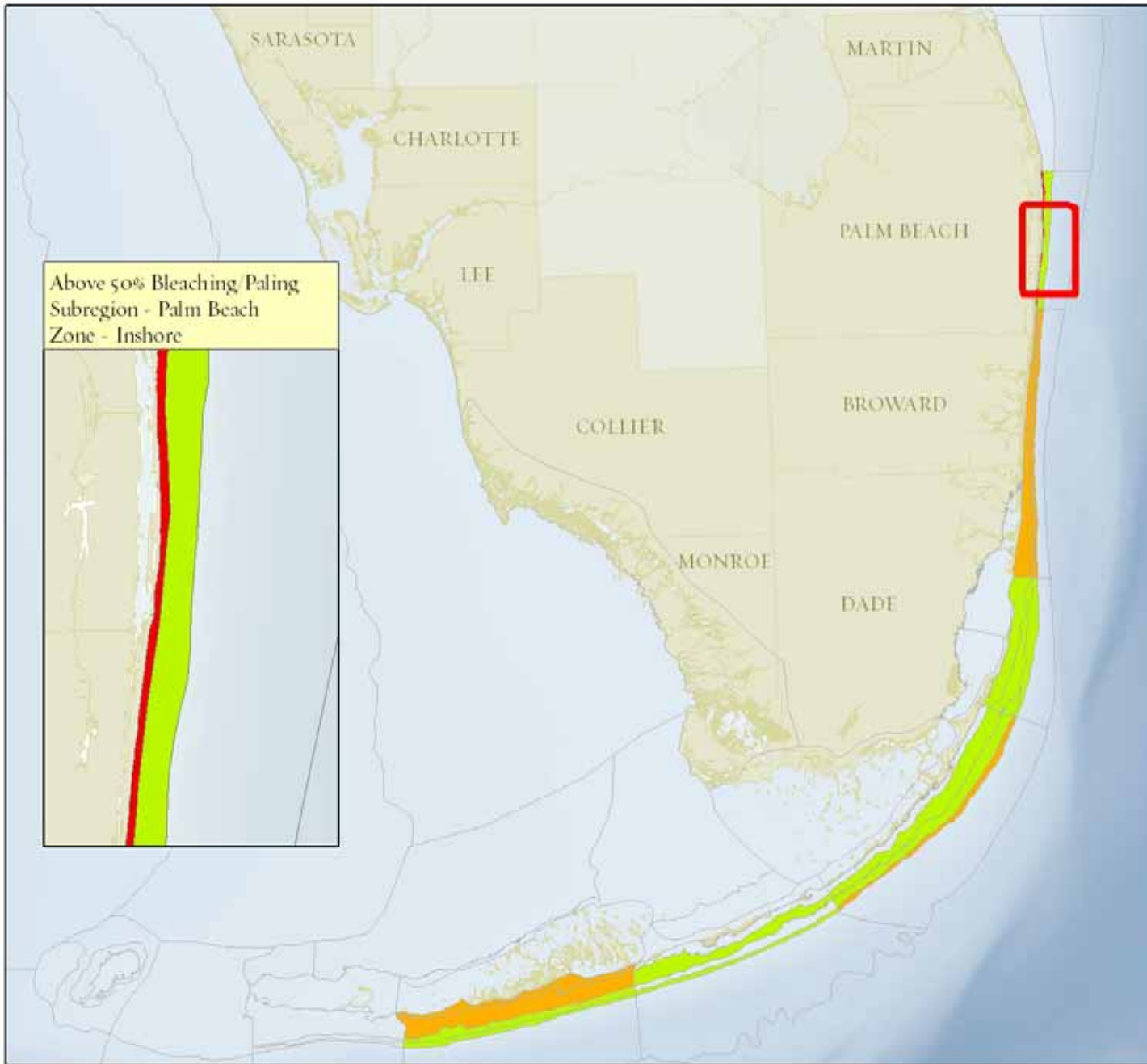
2006



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Data
Counties (FODL)
Zones (TNC)

2007 Lower Keys Temperatures





FRRP
Subregion-Zone

2007

**Percent
Bleach/Pale**



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Data
Counties (FGDL)
Zones (TNC)

Table 2. Survey results of prevalence of paling and bleaching within stony corals for each sub-region and zone surveyed within the Florida reef tract for 2005-07. n=total number of sites per year. Based on weighted data generated by Steve Smith.

Location		2005			2006			2007		
Sub-region	Zone	% Paling	% Bleaching	n	% Paling	% Bleaching	n	% Paling	% Bleaching	n
Martin	Undetermined	30.3	3.9	3	10.7	9.8	6			
Palm Beach	Inshore	6.5	0.0	3				4.5	52.3	4
Palm Beach	Reef Ridge Complex				9.0	19.8	3	8.7	10.6	7
Broward	Inshore	20.1	22.7	10	4.6	6.0	15	15.9	15.1	12
Broward	Inner Reef	16.9	13.2	10	7.1	4.6	7	21.7	13.3	8
Broward	Outer Reef	12.6	14.9	8	4.0	6.9	5	8.9	22.8	6
Biscayne	Inshore				0.0	0.5	2	5.2	5.8	2
Biscayne	Mid Channel	30.3	13.9	12	3.3	0.9	8	3.6	11.8	9
Biscayne	Offshore Patch Reef	21.5	4.8	4	6.8	2.3	2	3.9	8.7	2
Biscayne	Forereef	22.1	13.9	20	5.8	2.6	13	2.0	9.3	12
Upper Keys	Mid Channel	26.9	23.3	4	7.6	2.1	10	14.7	4.9	7
Upper Keys	Offshore Patch Reef	20.4	27.6	3	10.3	3.6	3	3.7	8.4	2
Upper Keys	Forereef	12.8	2.6	11	7.7	7.7	8	7.4	15.2	7
Middle Keys	Mid Channel	32.2	20.5	4	8.9	3.6	3	5.5	6.4	6
Middle Keys	Offshore Patch Reef				8.6	5.6	2			
Middle Keys	Forereef	15.4	5.6	15	8.7	8.7	9	9.3	6.4	16
Lower Keys	Inshore				5.3	0.0	3	14.5	16.9	4
Lower Keys	Mid Channel	8.8	4.6	24	7.1	1.7	7	14.6	10.4	6
Lower Keys	Offshore Patch Reef	13.4	3.9	3	6.9	2.0	3	7.1	2.9	2
Lower Keys	Forereef	14.7	6.3	32	10.5	2.5	10	9.9	9.4	20

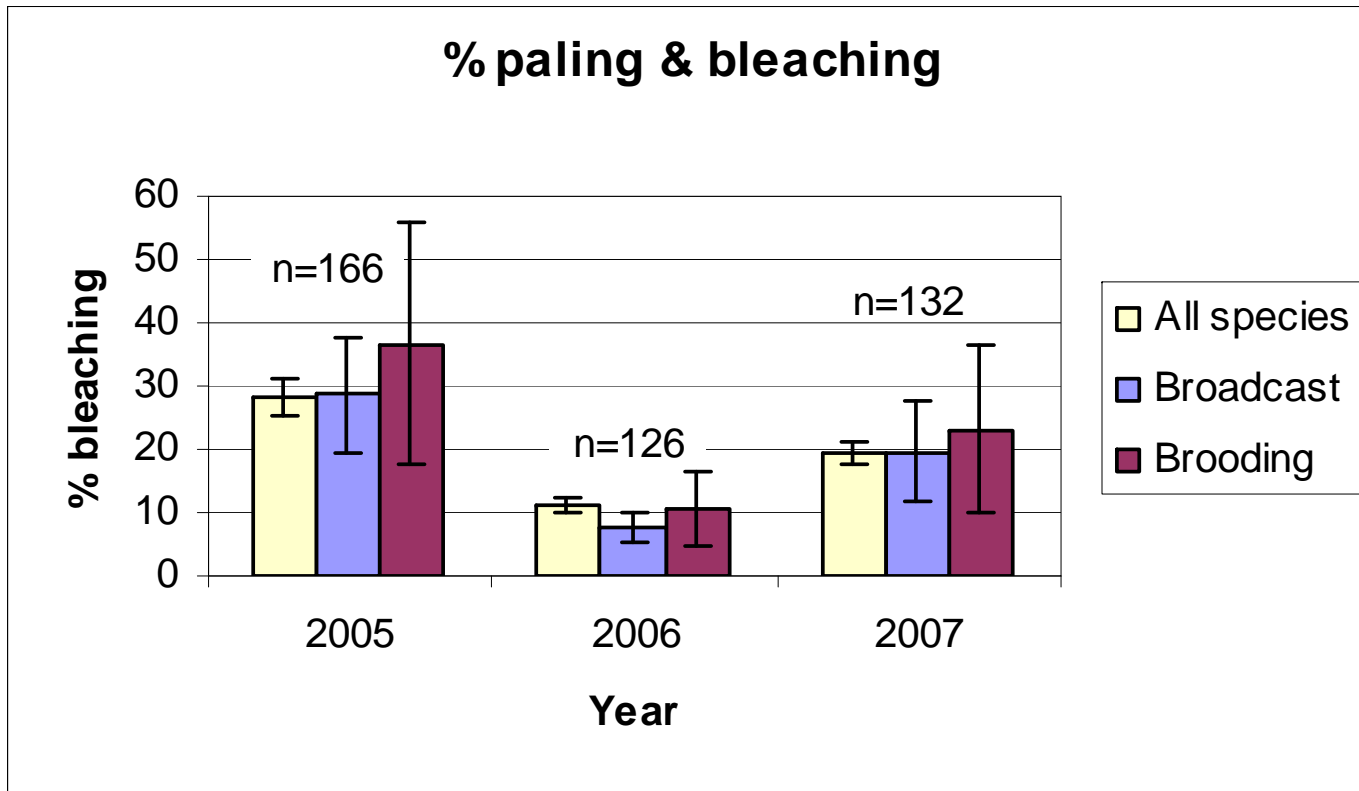


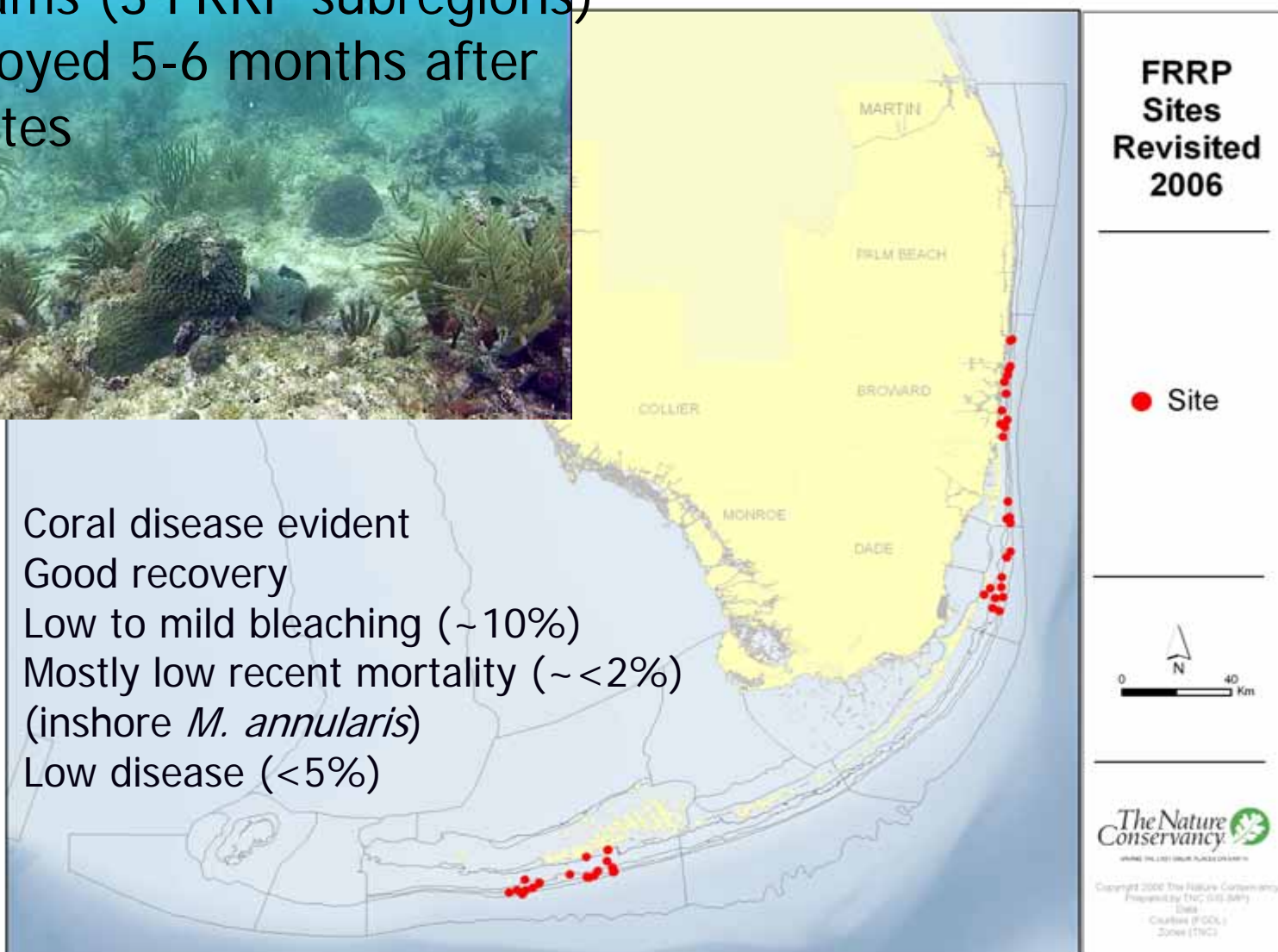
Figure 15. Comparison of bleaching over years for all species, broadcast spawners, and brooding corals (n=number of surveys)

Post bleaching assessment for 2005 bleaching event

4 teams (3 FRRP subregions)
Deployed 5-6 months after
50 sites



Coral disease evident
Good recovery
Low to mild bleaching (~10%)
Mostly low recent mortality (~<2%)
(inshore *M. annularis*)
Low disease (<5%)



Long-term fixed site Coral Monitoring Program- Florida Keys

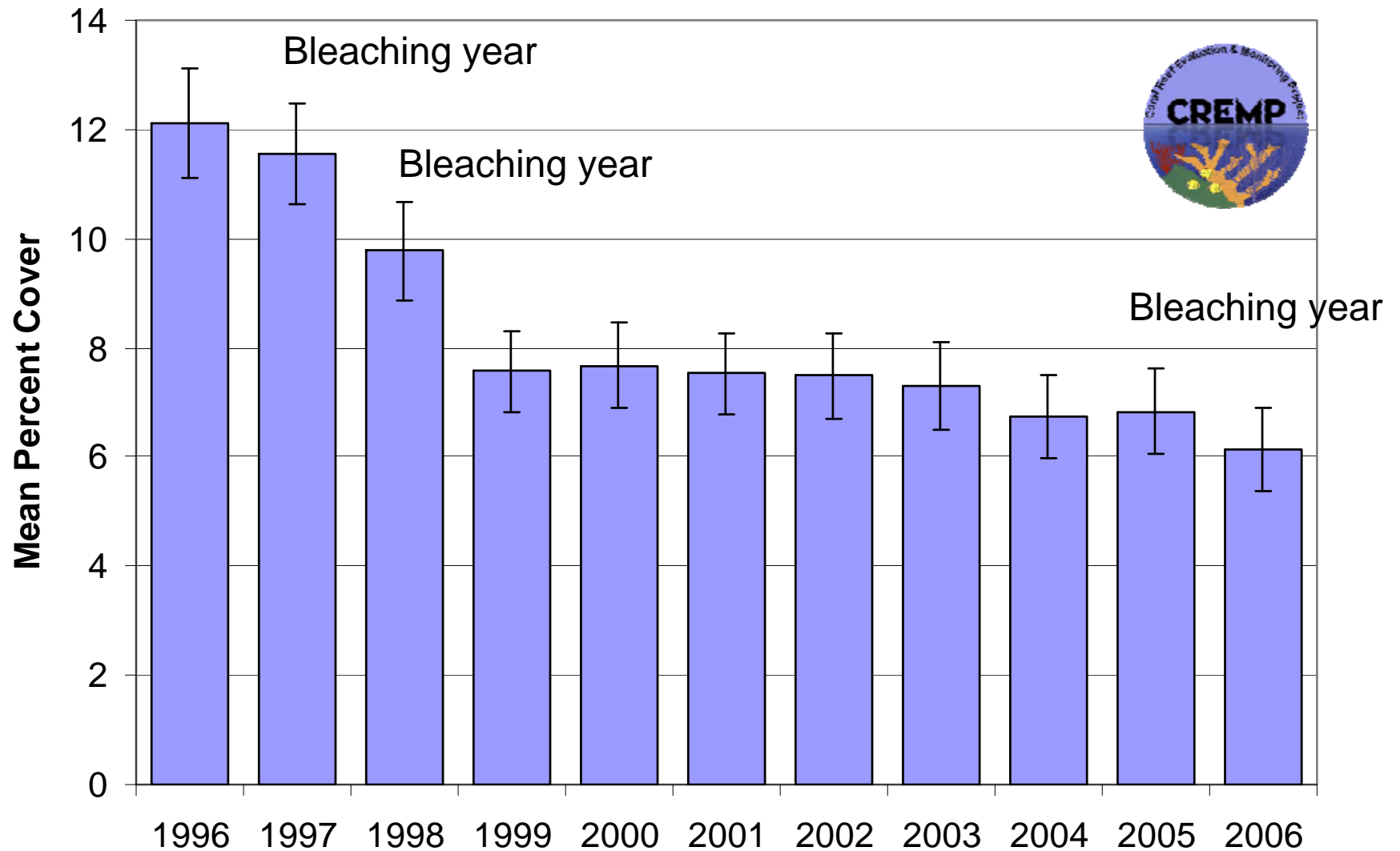


Figure 20. Sanctuary wide mean percent cover by year from CREMP data. Graph supplied by FWC.

Changing coral abundance and size due to disturbance

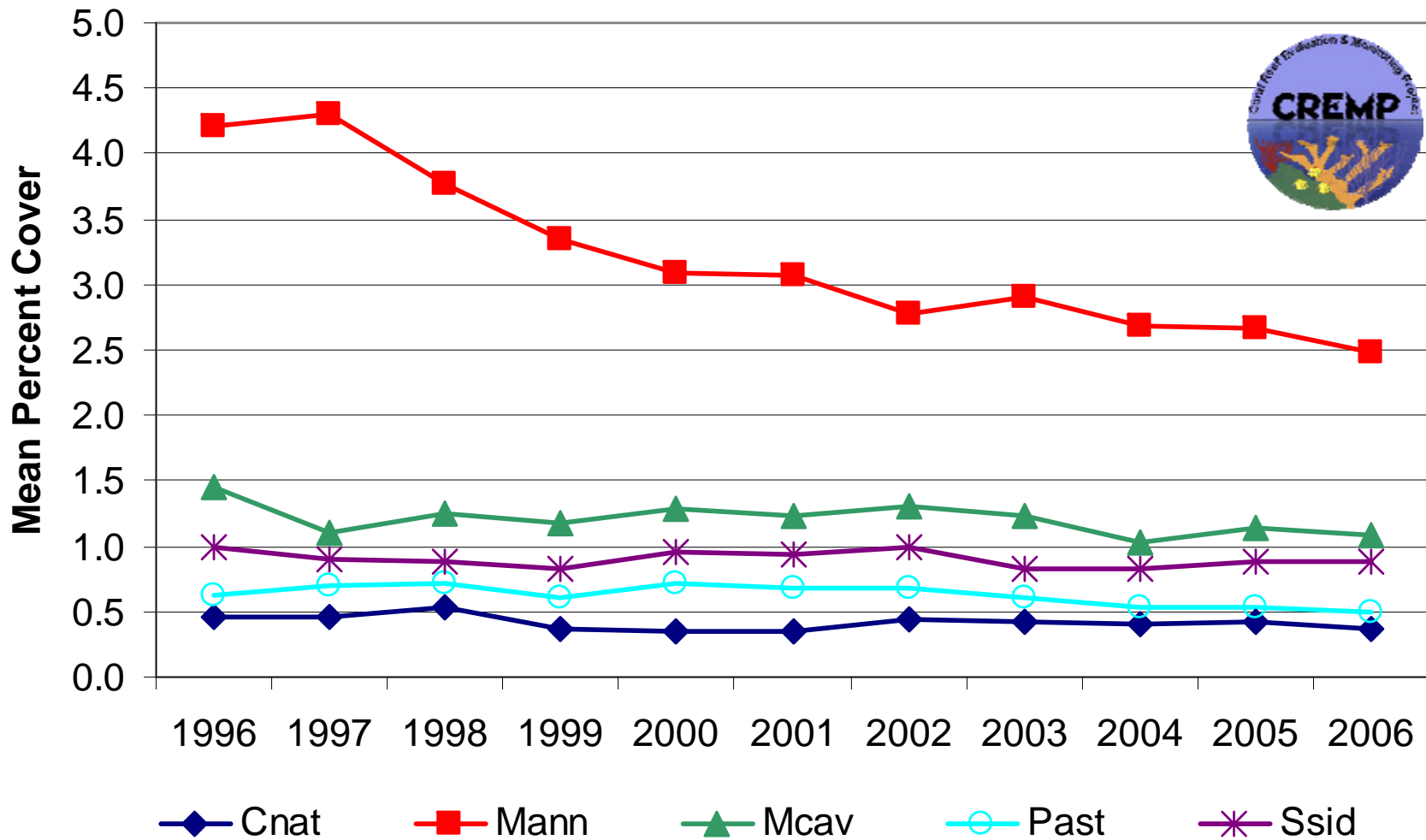
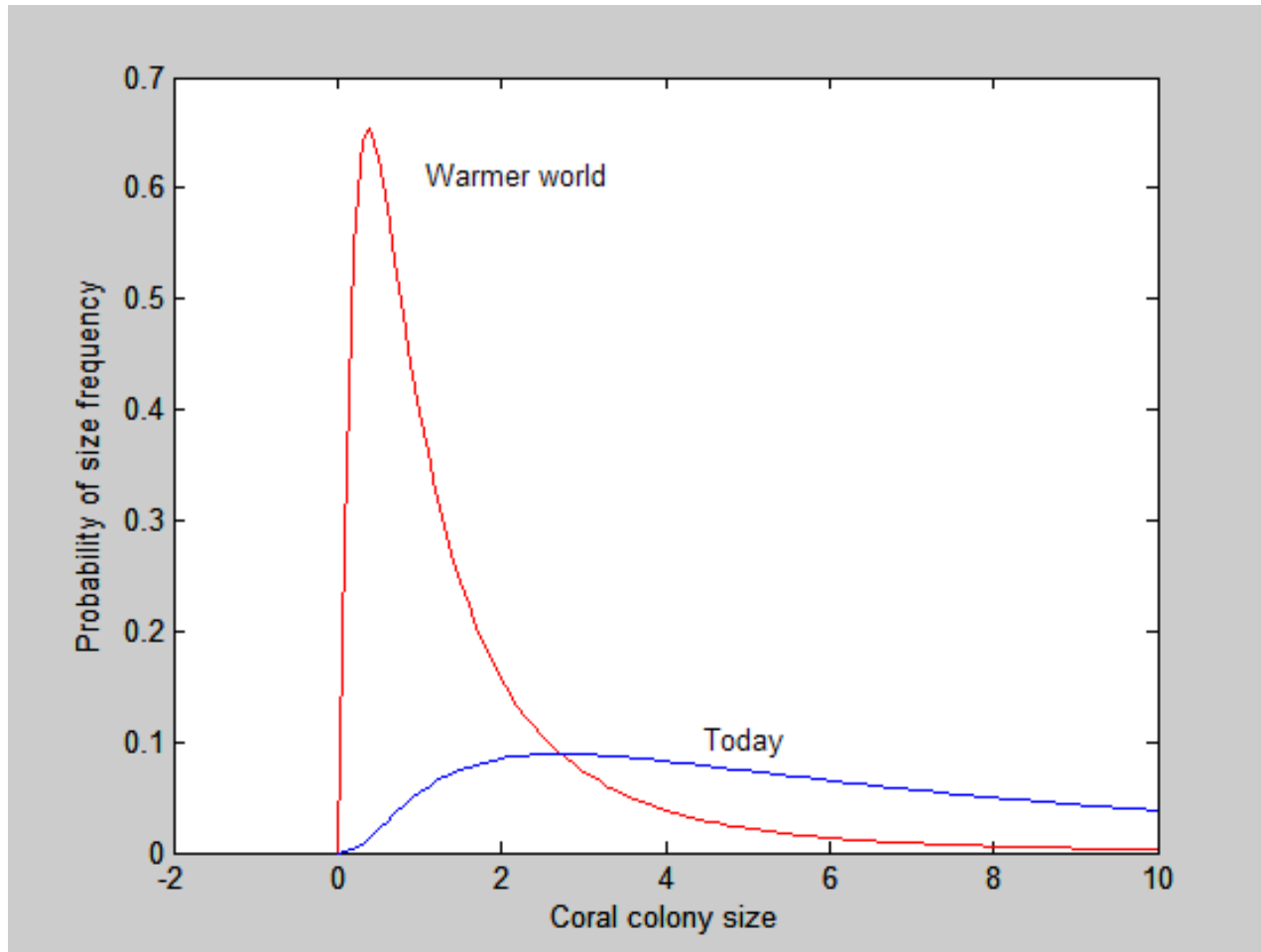


Figure 21. Sanctuary wide mean percent cover by year for 5 most common species. CREMP data graph supplied by FWC.

Climate change causes partial coral mortality- changes coral size

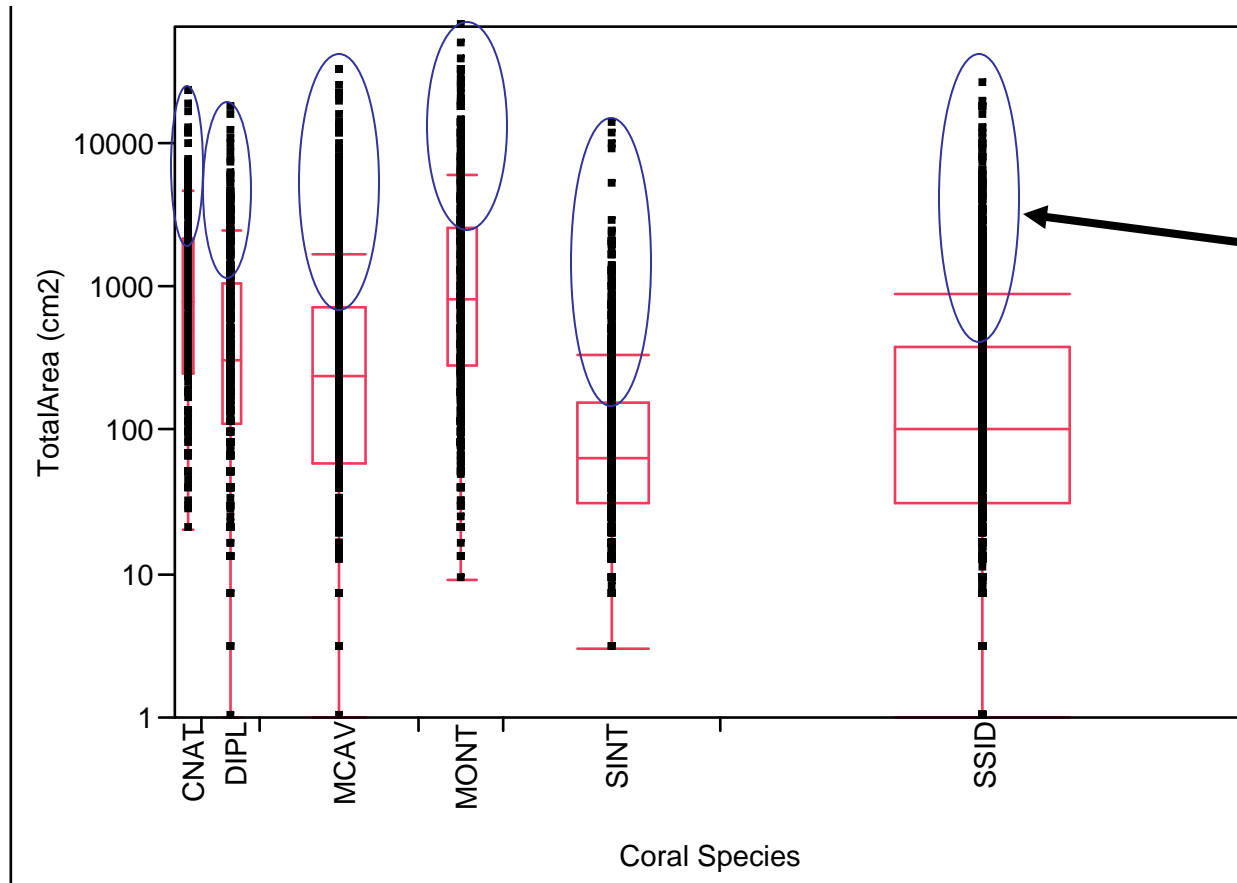


Global climate change appears to be altering coral populations to become increasingly right *skewed* -- *toward smaller colonies*

Where are the remaining large, live corals found in Florida?



Defining large live corals



Top
quartile
(25%)
Broadcast
Spawners

**FRRP
Sub-region-Zone**

Lower Keys

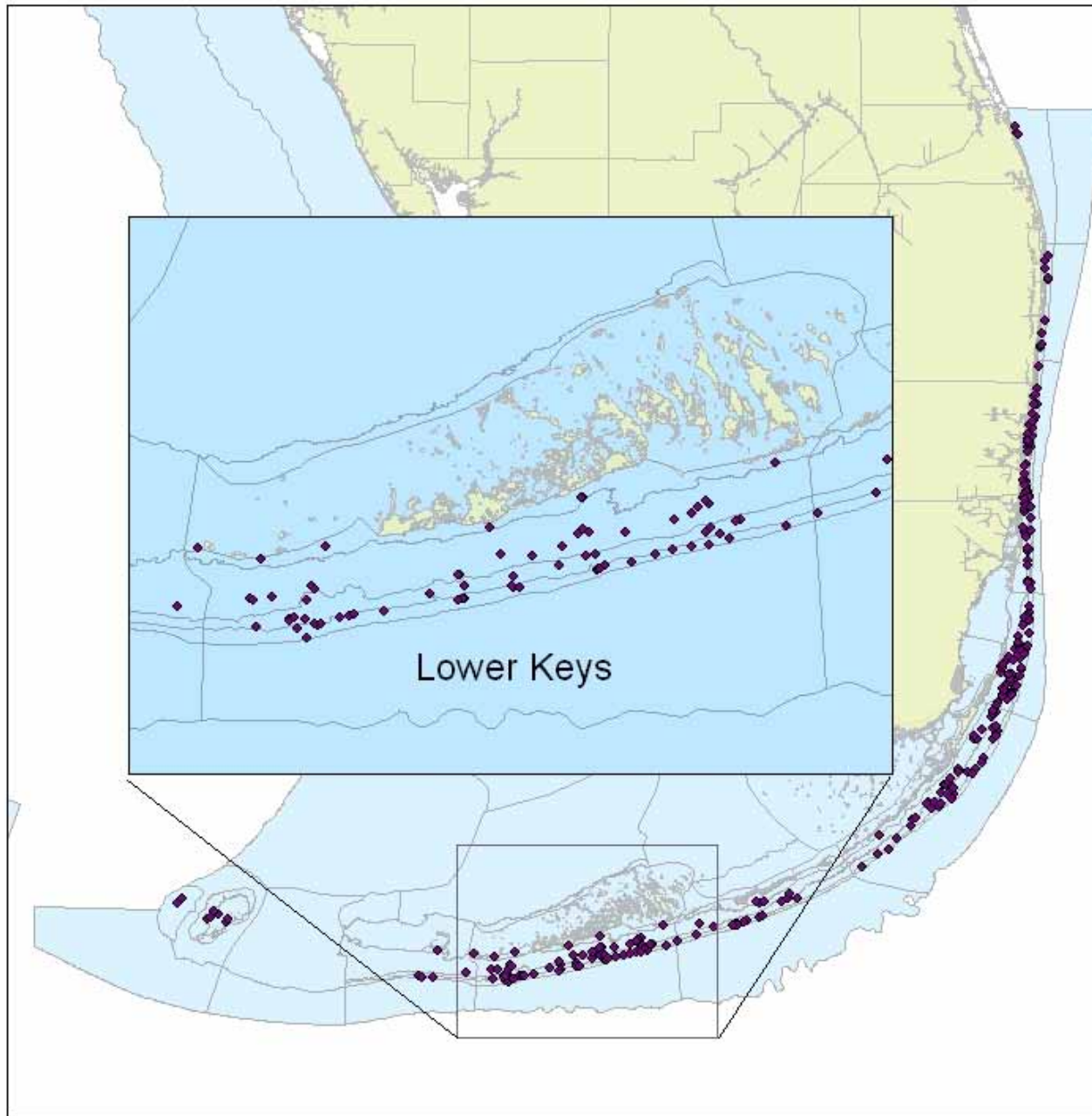
2005-2007

Top Quartile
Total Area
Broadcast Spawners

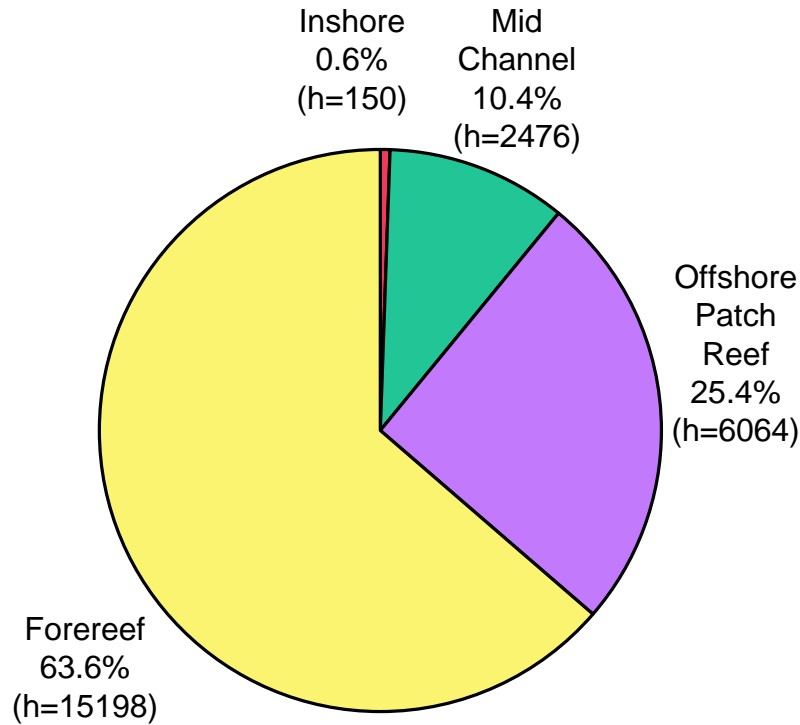
◆ Large corals



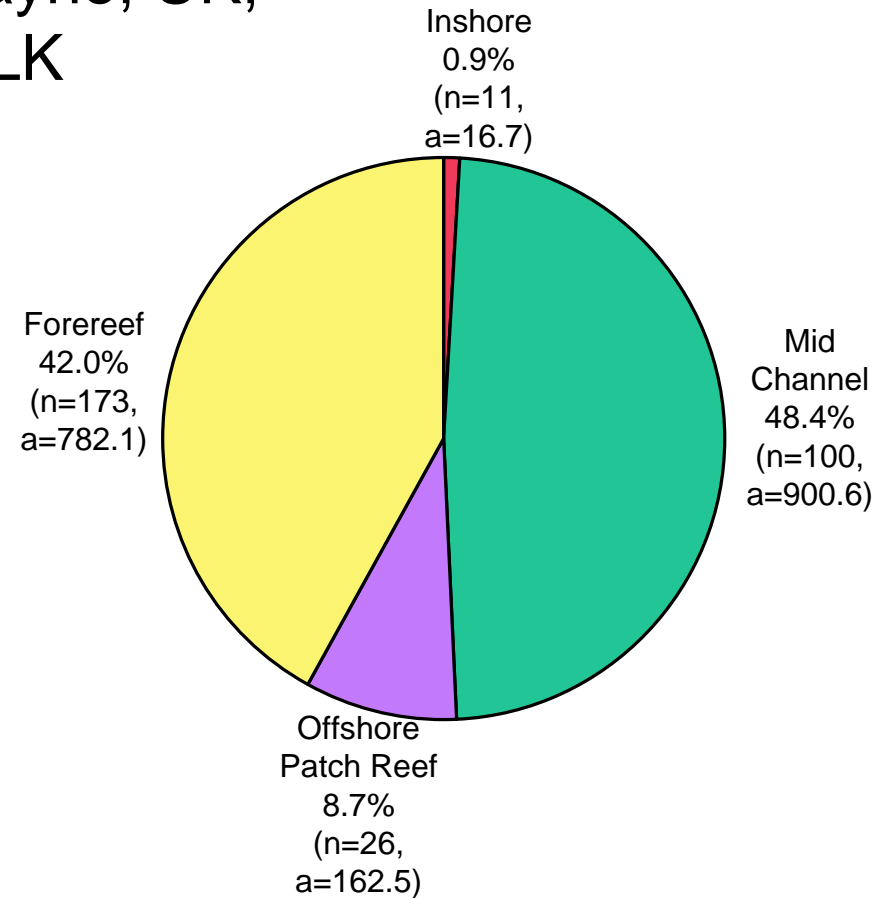
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Estimated Abundance: Zones-Biscayne, UK, MK, LK



Percent of total reef area within each zone (h=hectares of reef area)



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

Top quartile Broadcast Spawners

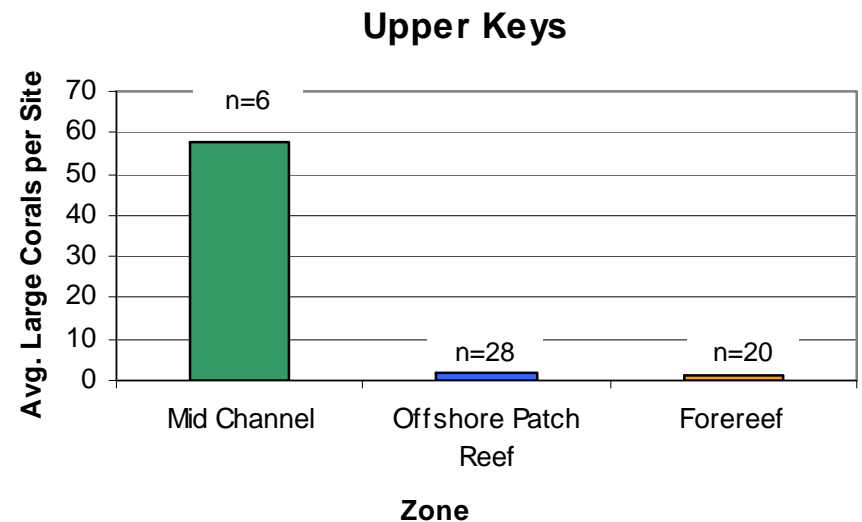
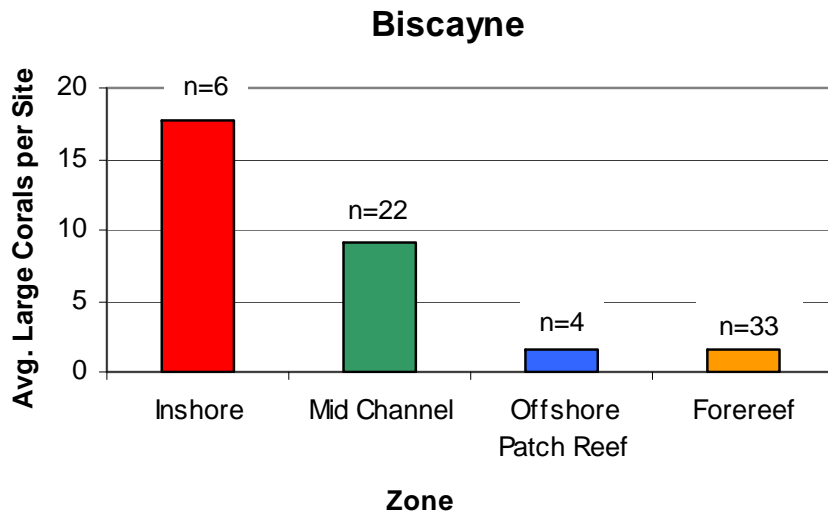


Figure 18. Large selected corals within Biscayne and Upper Keys by zone. Top quartile total area of broadcast spawning corals.

n=number of sites surveyed

(*C. natans*, *Diploria* spp., *M. cavernosa*, *M. annularis*

complex, *S. siderea*, *S. intersepta*)

Top quartile Broadcast Spawners

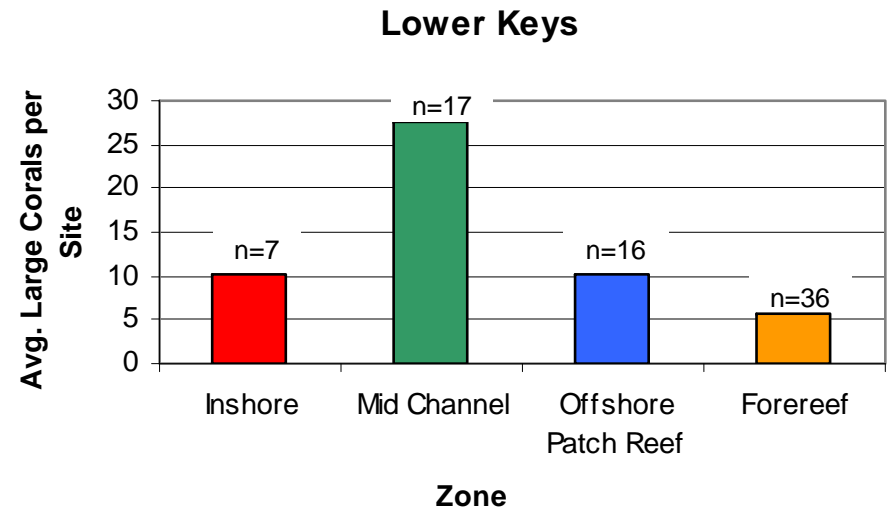
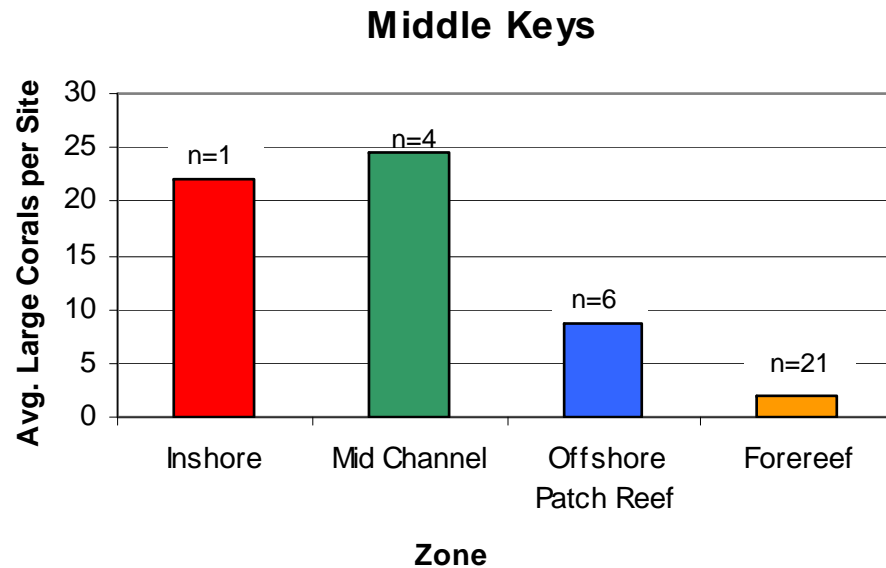
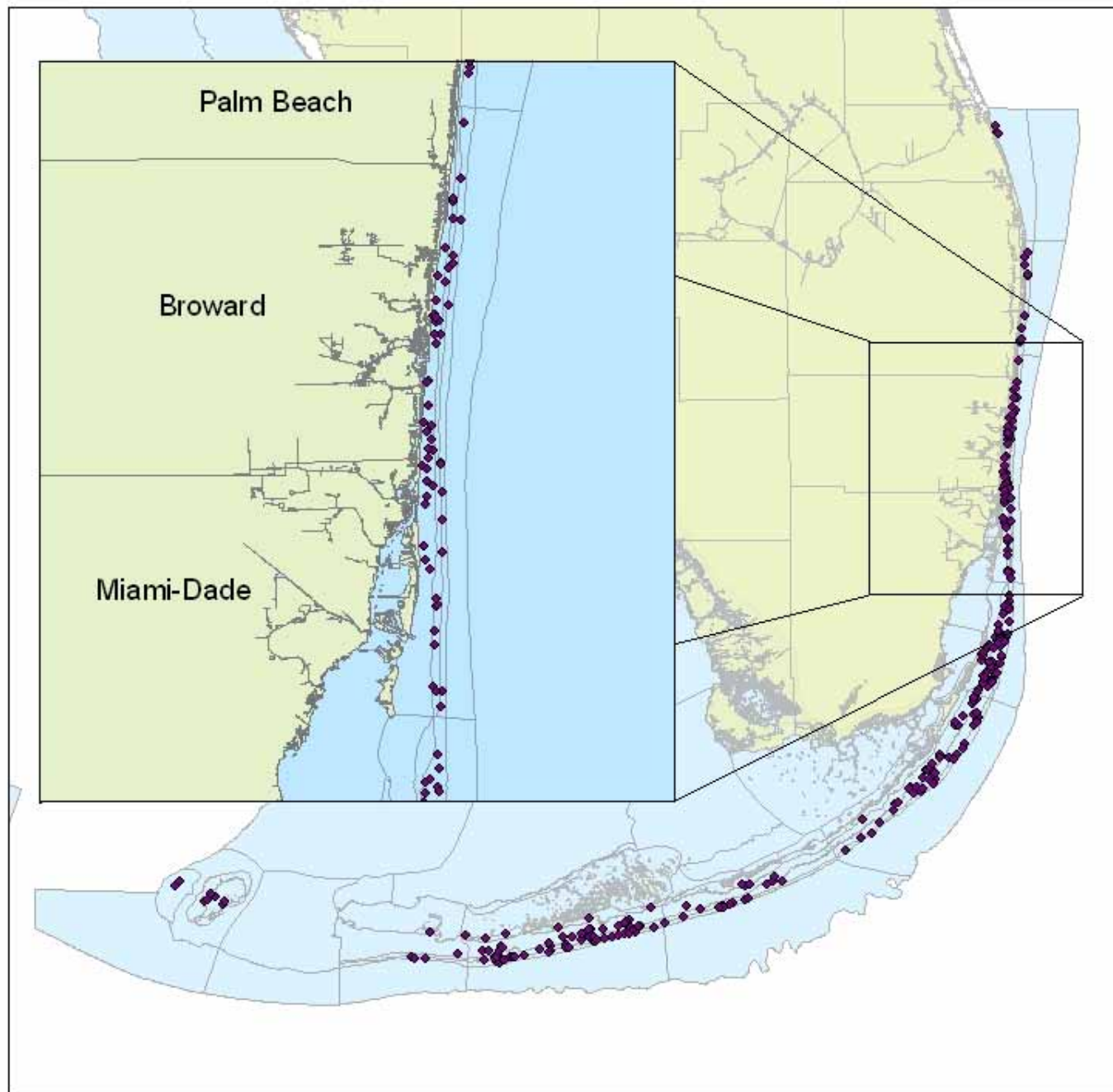


Figure 19. Large selected corals within Middle and Lower Keys by zone. Top quartile total area of broadcast spawning corals.

n=number of sites surveyed

(*C. natans*, *Diploria* spp., *M. cavernosa*, *M. annularis*

complex, *S. siderea*, *S. intersepta*)



FRRP
Sub-region-Zone

Broward

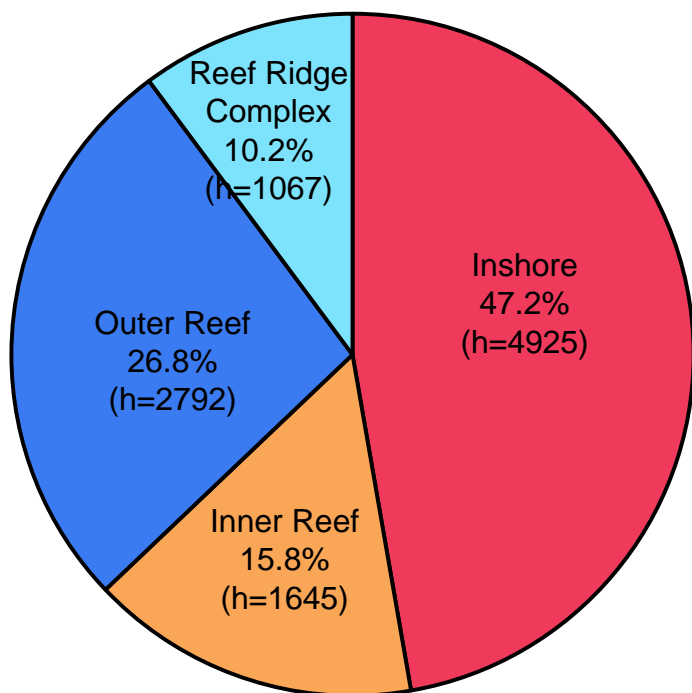
2005-2007

Top Quartile
Total Area
Broadcast Spawners

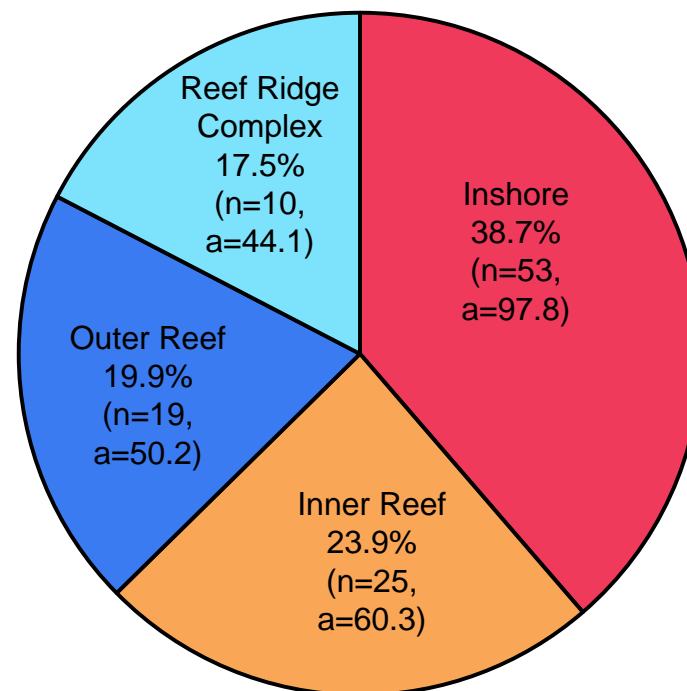
◆ Large corals



Estimated Abundance: Zones-Martin, Palm Beach, Broward



Percent of total reef area within each zone (h=hectares of reef area)



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

Top quartile Broadcast Spawners

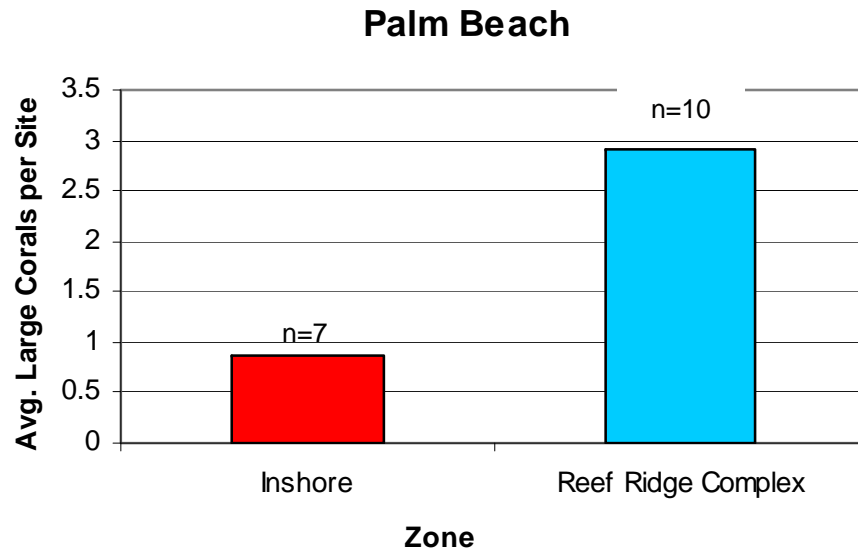
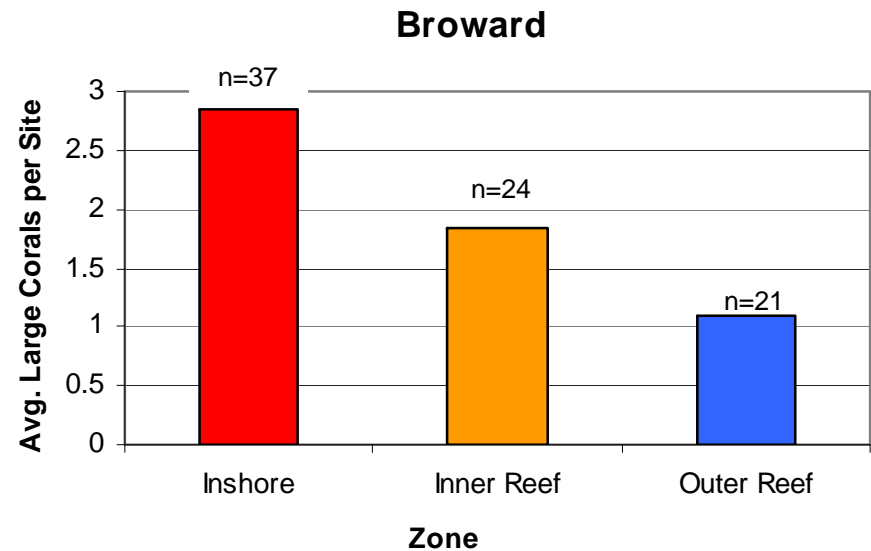


Figure 17. Large selected corals within Palm Beach and Broward by zone. Top quartile total area of broadcast spawning corals.

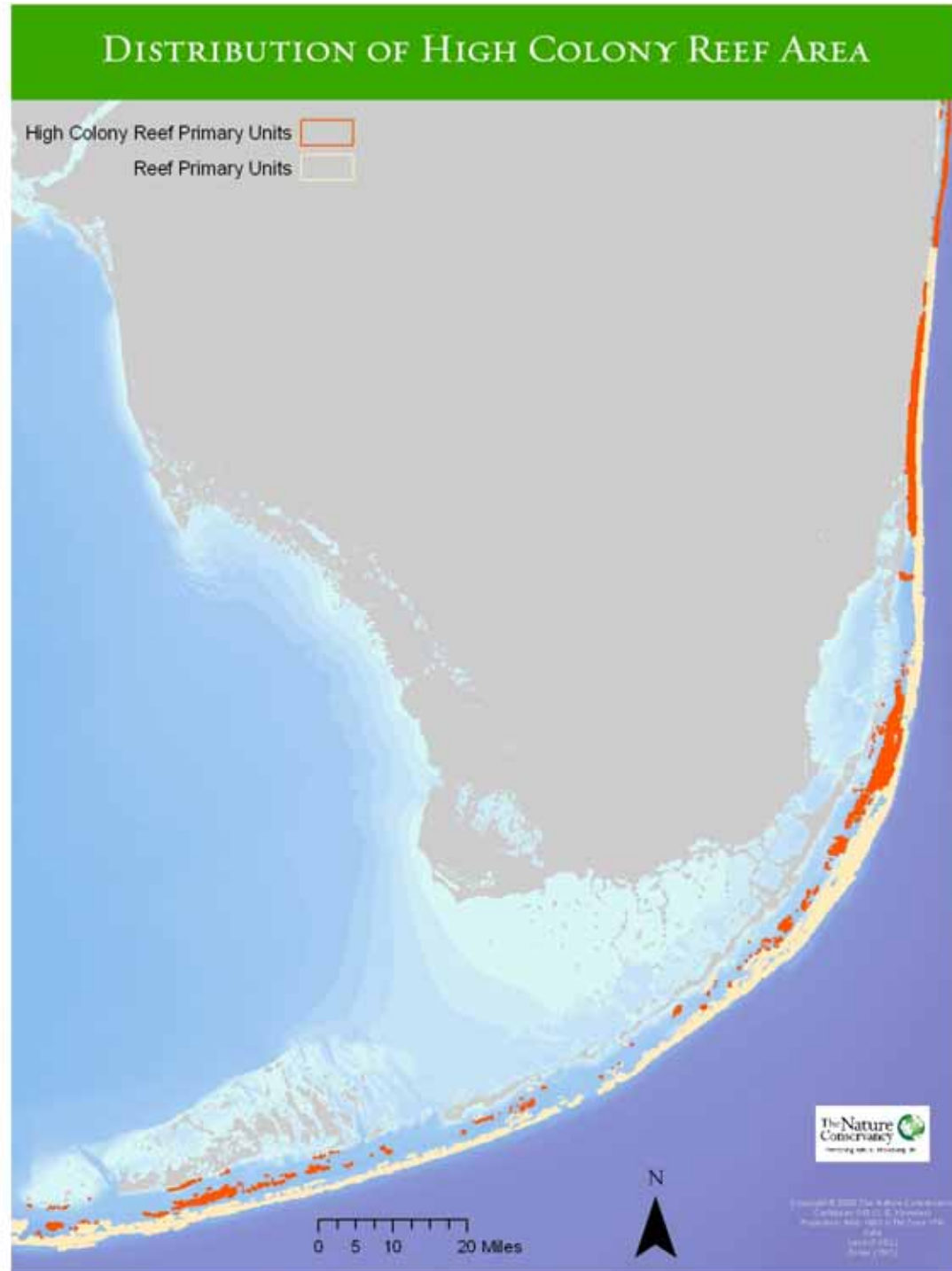
n=number of sites surveyed

(*C. natans*, *Diploria* spp., *M. cavernosa*, *M. annularis* complex, *S. siderea*, *S. intersepta*)



Why are areas in red appear to be doing better than areas in pink?

Flow
Zooplankton
Reduced light
Adaptation to warmer water

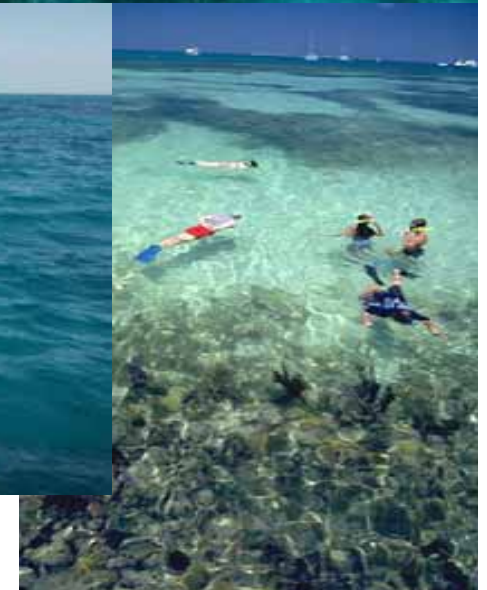


Inshore/mid-channel coral reefs



Current human impacts to inshore/mid channel reefs

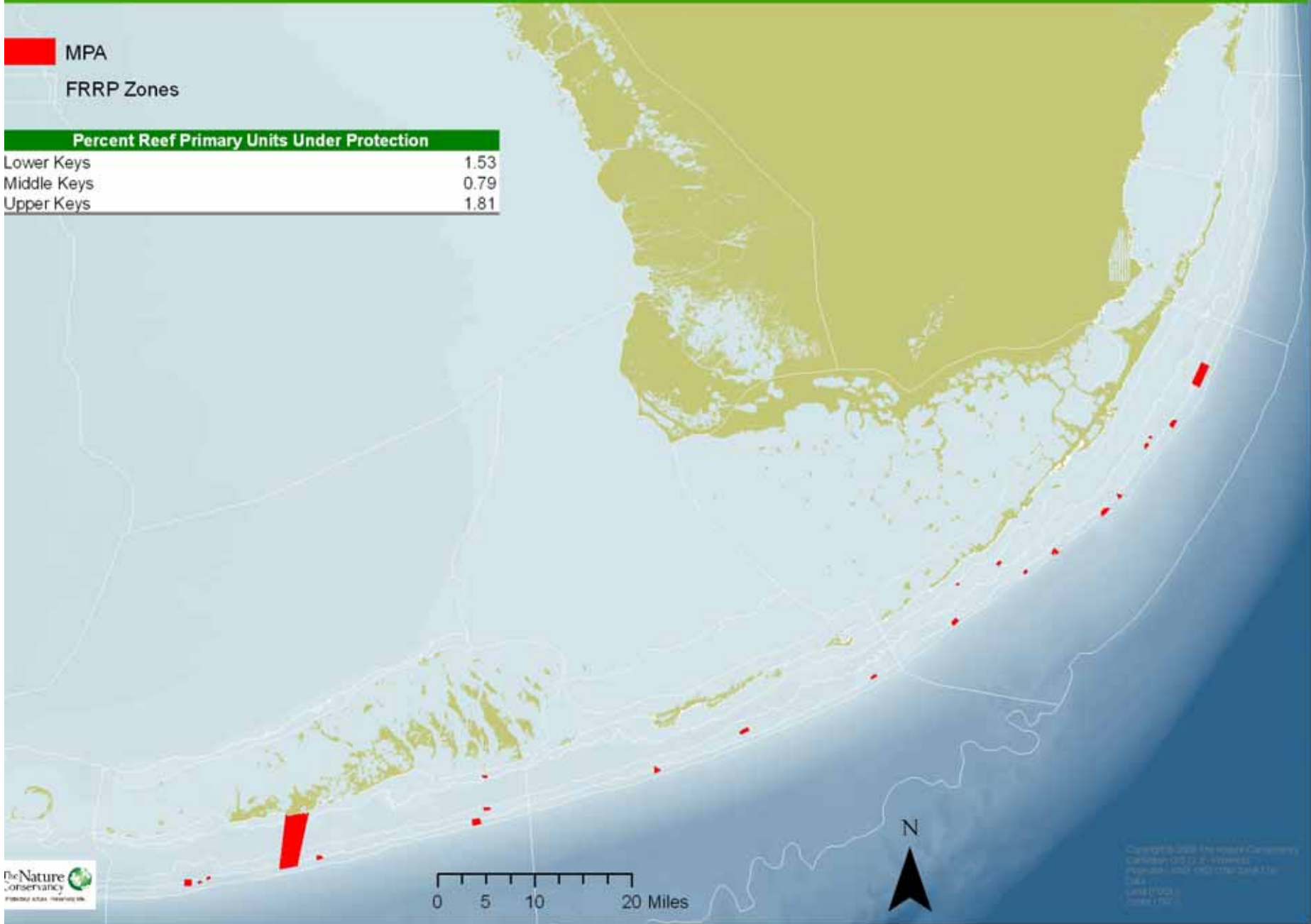
Lobster traps (setting/lost/debris)
2-day lobster mini season
Small boat groundings/anchoring
Recreational fishing (line/debris)
Commercial fishing (line/debris)



MARINE PROTECTED AREA DISTRIBUTION WITHIN FRRP ZONES

MPA
FRRP Zones

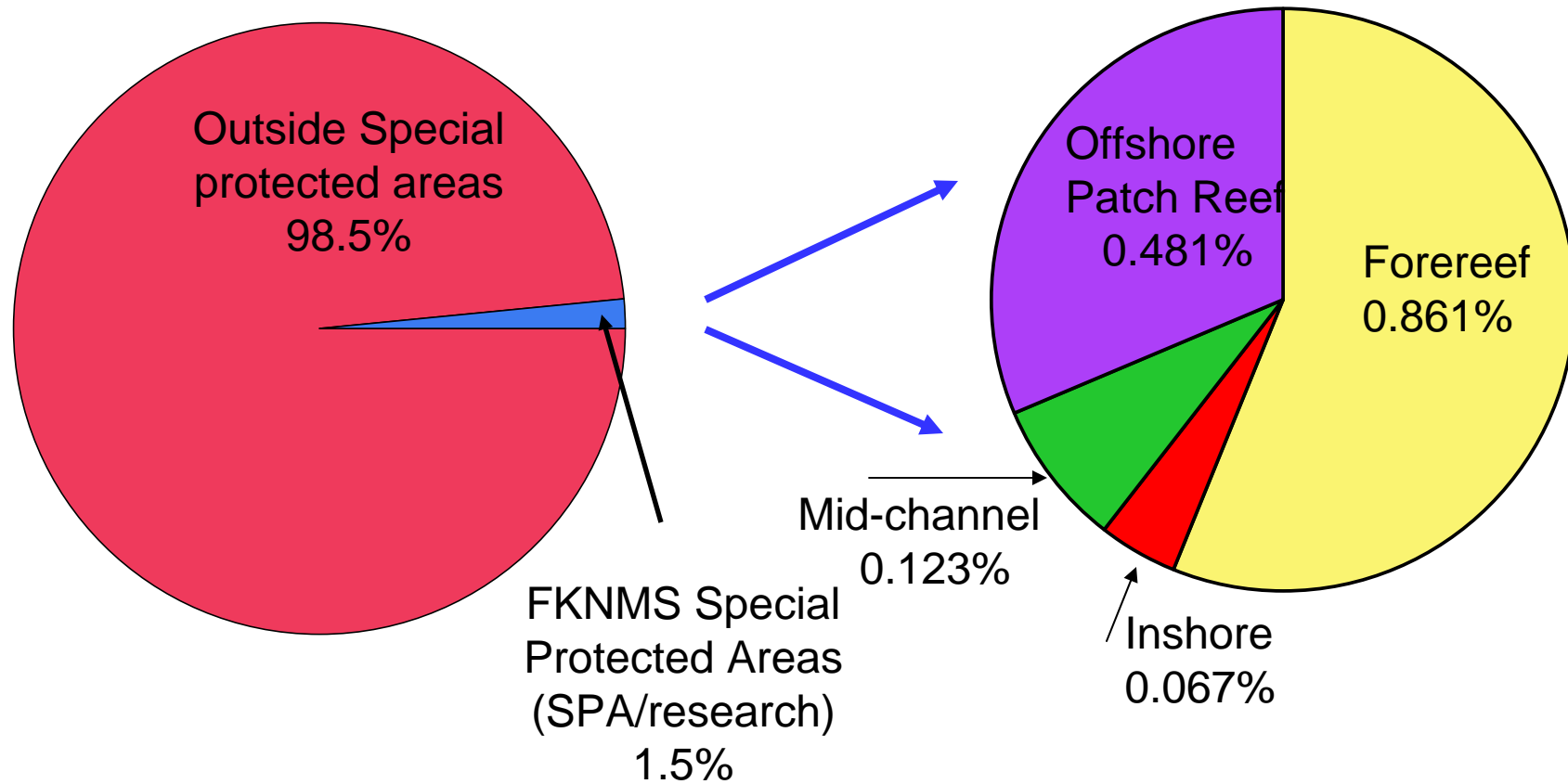
Percent Reef Primary Units Under Protection	
Lower Keys	1.53
Middle Keys	0.79
Upper Keys	1.81



Analysis of current protection to coral benthos for the Florida Reef Tract



Analysis: what coral reef is currently protected



Conclusions

- FRRP bleaching disturbance response proven to be an effective tool to quantify bleaching events. Continue. Extend to Tortugas.
- All areas sampled showed signs of bleaching during the three years. Bleaching refuges, if they exist, are likely quite small in scale or deeper than 20m.
- Urgent need to reduce additional human impacts to Florida coral reefs given increased frequency intensity of bleaching.
- Large live corals that have recovered/survived are disproportionately found in inshore and mid-channel reefs where significant impacts are presently occurring.

Conclusions

- Existing protection for corals/reefs is inadequate across south Florida (both amount and representation of reef zones)
- Focus on Northern reef tract! New management zoning efforts should be undertaken- use spatial framework -including inshore and mid channel reefs.
- Continue scientific analysis/data collection to refine understanding of environmental conditions (flow, light, zooplankton) and intrinsic factors (genetics, zooks, adaptation) and their role in reef resilience. Continue to explore new management tools.
- Improve water quality
- Reduce CO2 output
- Increase regional reef conservation efforts

FRRP partnership



Acknowledgements- FRRP Benthic working group

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Eric Bartels

Dave Gilliam

Erin McDebbit

Chris Moses

Steph Wear

Mark Chiappone

Steven Miller

Dione Swanson

Ken Banks

Jamie Monte

John Knowles

Robert Ginsburg

Judy Lang

Bill Fisher

Jerry Ault

Steve Smith

Mike Palmer

Chantall Collier

Scott Donahue

Janice Duquesnel

Jim Kidney

Brooke Gintert

Corey Walter

Rod Salm

Paul Marshall

Andrew Baker

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