The Role of Environmental Variables in Coral Reef Resilience in Florida

A component of:

The Climate Change: Linking Environmental Analysis to Decision Support Project

Florida Program World Wildlife Fund

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Climate Change LEADS

Adapting for Climate Change

Natural resource management strategies → Management strategies that include and anticipate climate change

Resilience Strategies

Understanding the resilience of Florida's coral reefs → Using patterns of resilience to focus conservation effort

Pattern, Scale & Process

- ".. the problem of pattern and scale is the central problem in ecology" S. A. Levin (1992)

- The "real" problem is linking biotic data to abiotic data while each may represent processes and patterns that exist at different scales

- Use of 'landscape ecology' techniques offer a solution to a complex problem

Ecology 73(6): 1943-1962

Ecological processes may differ among scales of investigation

Spatial Scale

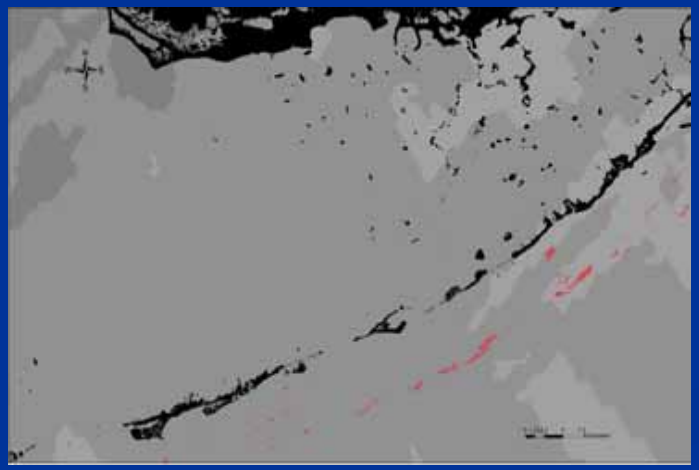
Spatial scale increases
Precision decreases

For example, nutrients, such as dissolved inorganic nitrogen (DIN), vary greatly in the Florida Keys over different spatial scales and may be influenced locally and regionally

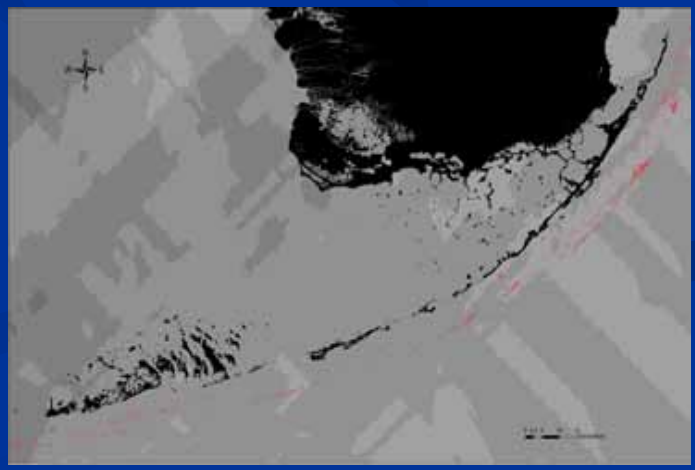
12 km

30 km

75 km



150 km



Landscape Ecology

- Provides a way to determine spatial variability and predictability of environmental parameters
- Provides a way to link disparate datasets sampled at different scales
- Identifies the spatial patterns and the processes that may be driving the homogeneity or heterogeneity of the system
- Helps answer complex questions about inter-relationships between abiotic, or environmental parameters, and population dynamics and community structure

Principle Objectives of Scientific Component of CCLEADS Project

- Identification of primary data sources that best meet spatial and temporal requirements for analysis of environmental parameters
- Evaluation of environmental parameters for predictability into FRRP coral monitoring sites
- Determine the spatial variability of each identified environmental parameter
- Assess bleaching prevalence with respect to environmental parameters parameters via Geographic Information System (GIS) and statistical analyses
- Assist FRRP in identifying possible locations along the reef tract that exhibit degrees of resilience

Identification of Primary Data Sources

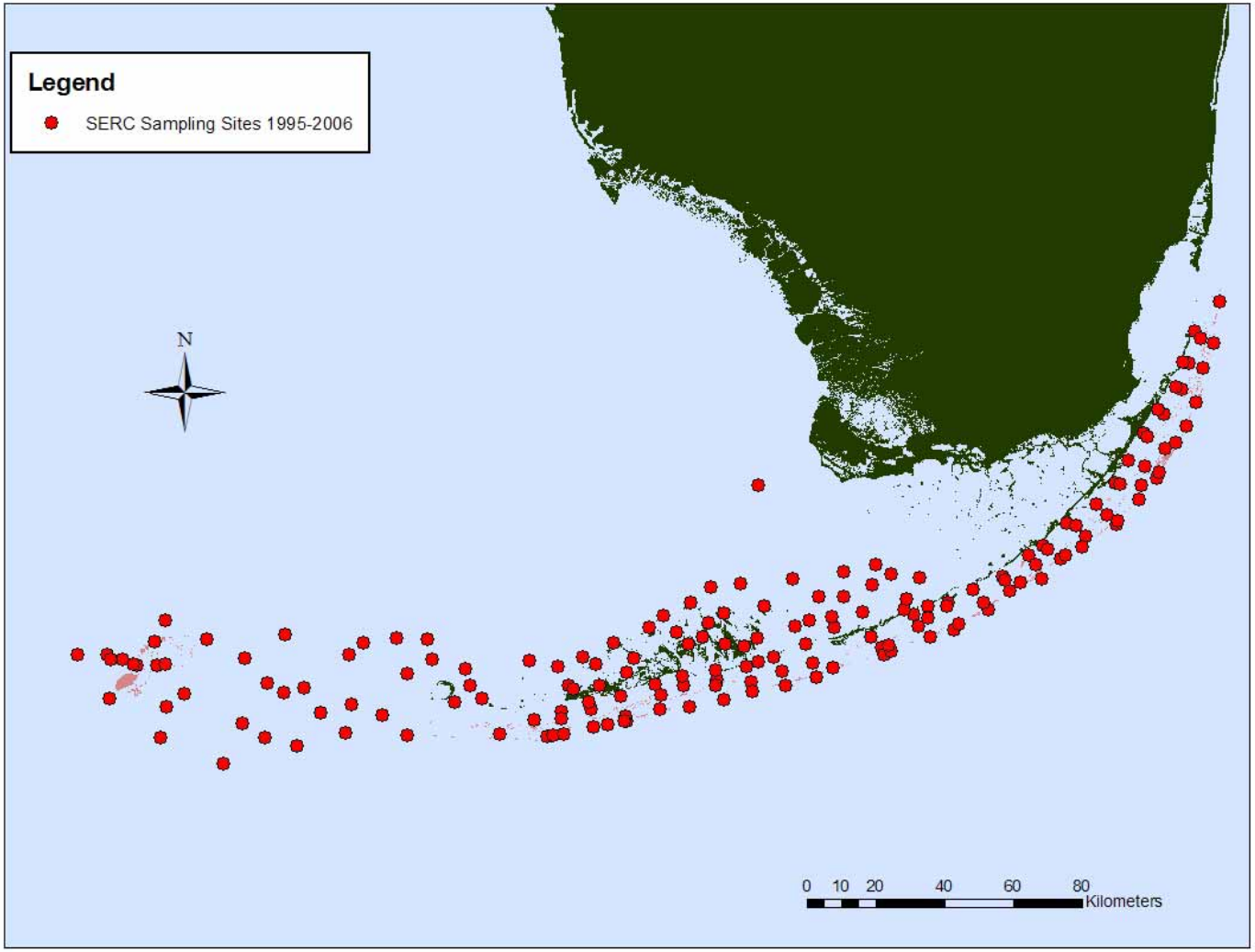
- Requirements:
  - Coverage along the Florida Keys that at least matches the spatial coverage of the FRRP monitoring sites
  - Great enough distribution to capture the inherent variability of each parameter sampled
  - Sampled over sufficient time period to match FRRP monitoring effort and allow for year-to-year comparisons

Data

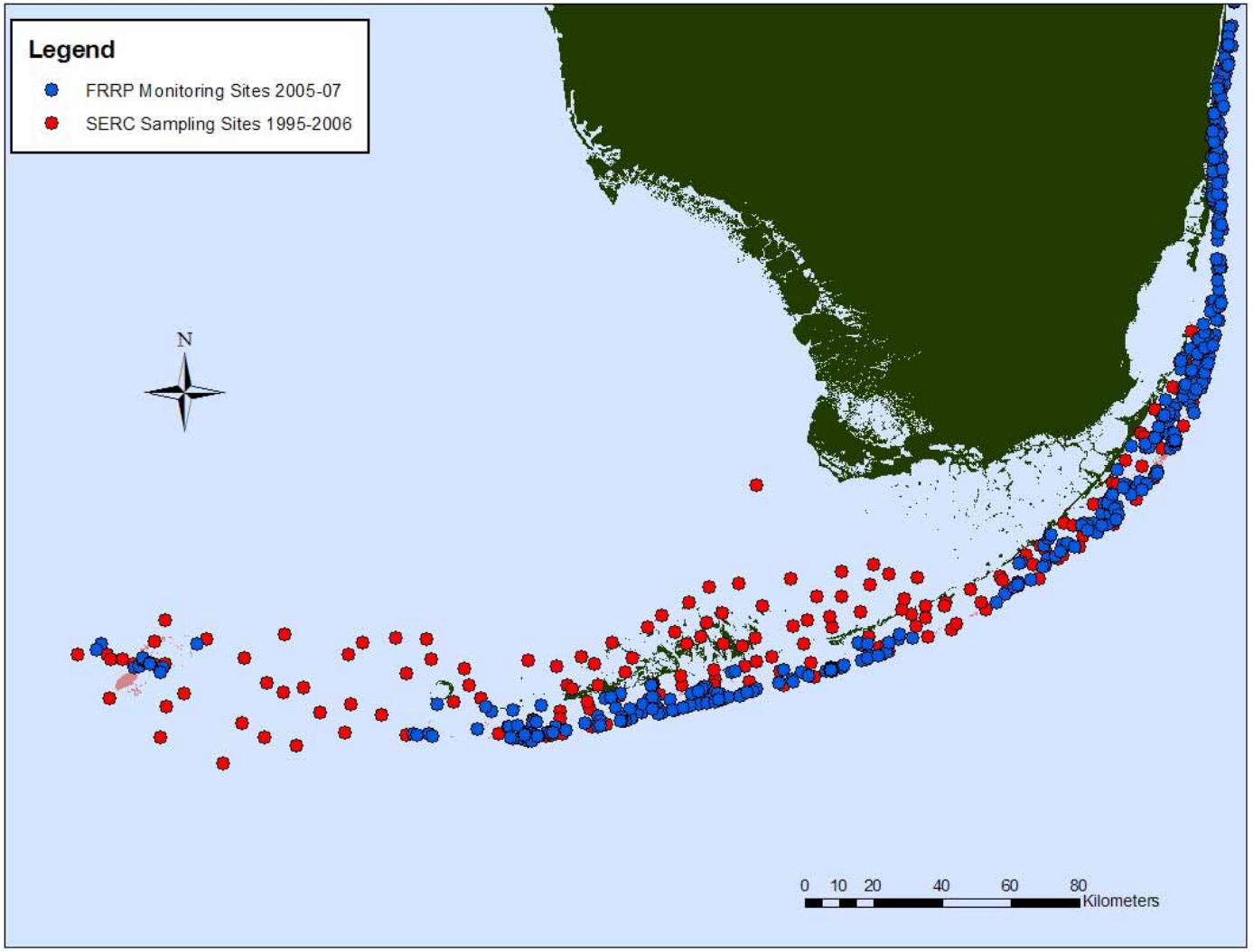
- **Environmental data** – 125 sites along reef tract (26 environmental parameters parameters) (Southeast Environmental Research Center (SERC), STORET data from the Environmental Protection Agency (EPA))

- **Coral data** – 432 sites along entire extent of Florida Keys reef tract (density, disease, coverage, colony size, mortality) (Florida Reef Resilience Program (FRRP), The Nature Conservancy

SERC Sampling Sites



SERC Environmental Sampling Site and FRRP Coral Monitoring Sites Combined

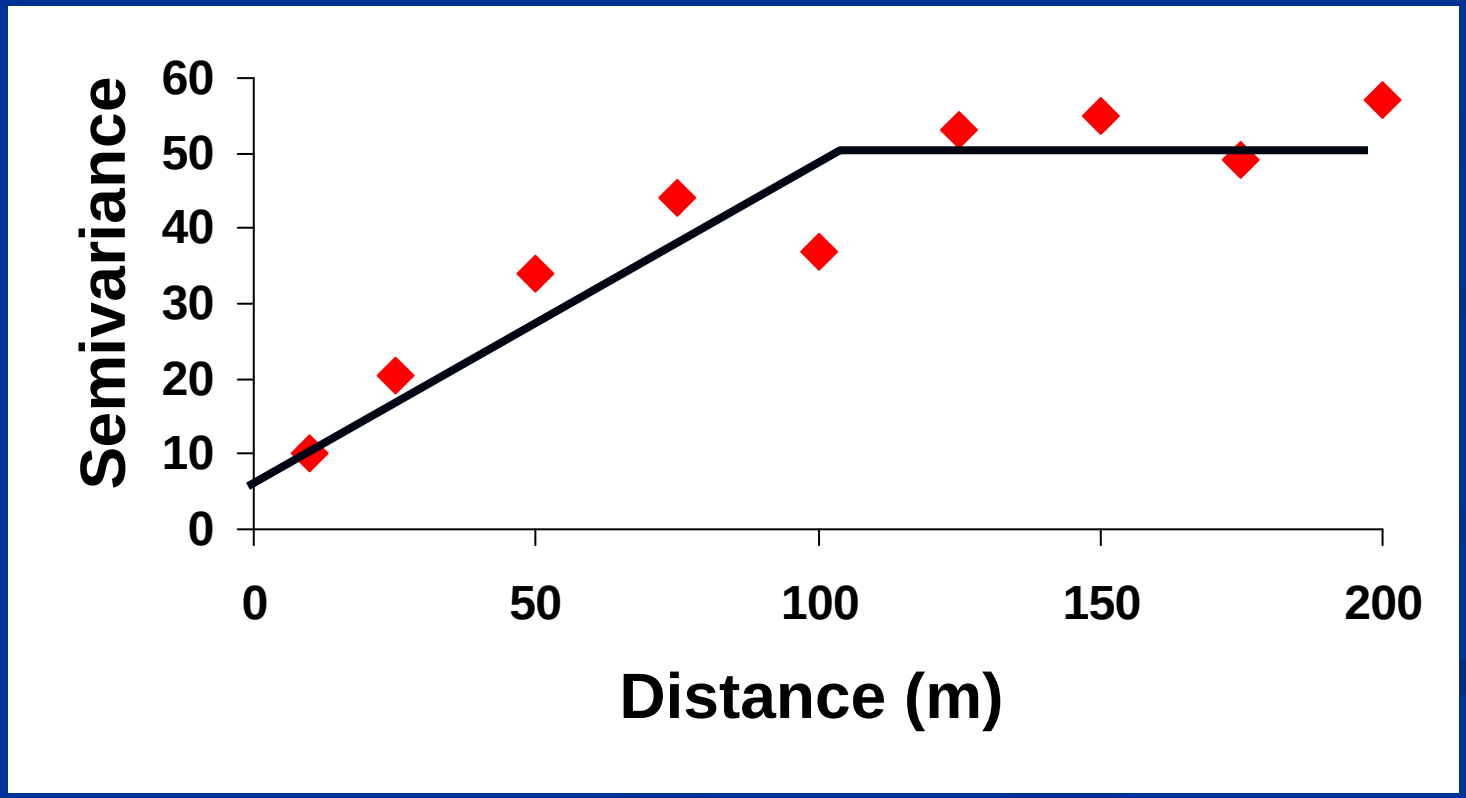


Evaluation of Environmental Parameters for Predictability Into FRRP Coral Monitoring Sites

- What is the variability of each environmental parameters?
- Is each parameter spatially predictable?
- GIS validation tests were applied to the following parameters:
  - water temperature °C (bottom and surface)
  - ammonia (NH4) (bottom and surface)
  - nitrate (NO3) (bottom and surface)
  - total nitrogen (TN) (bottom and surface)
  - total organic nitrogen (TON) (bottom and surface)
  - turbidity (bottom and surface)
  - light attenuation (Kd)
  - salinity (bottom and surface)
  - dissolved inorganic nitrogen (DIN) (bottom and surface)
  - chlorophyll a

Use of Semivariograms as Tools in Analyzing Spatial Structure and Determining Interpolation Potential

Spatially dependent | Spatially independent



Spatially Predictable Parameters

	chi-square
Temp (B)	ns
Temp (S)	ns
SST	ns
Salinity (B)	ns
Salinity (S)	ns
DIN (B)	ns
DIN (S)	ns
Chlorophyll a	ns
Kd	$p < 0.01$
NH_4 (B)	$p < 0.01$
NH_4 (S)	$p < 0.01$
NO_3 (B)	$p < 0.01$
NO_3 (S)	$p < 0.01$
TN (B)	$p < 0.01$
TON (B)	$p < 0.01$
Turbidity (B)	$p < 0.01$
Turbidity (S)	$p < 0.01$

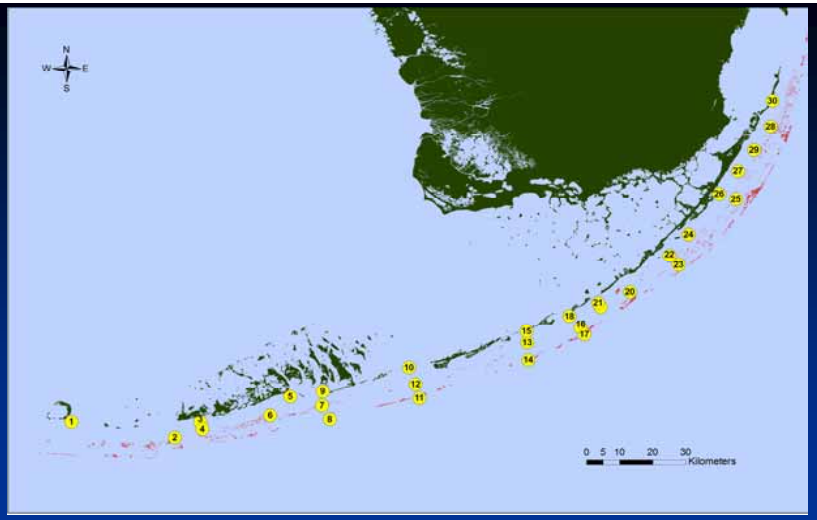
Assessing the Spatial Variability of Each Environmental Parameter

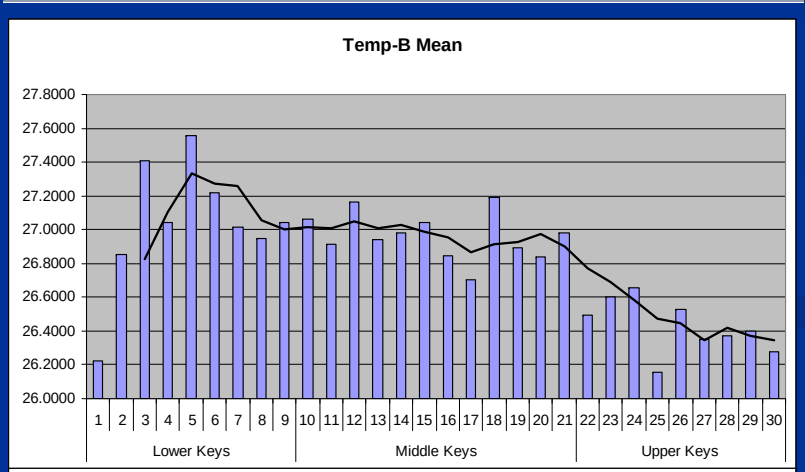
- A combination of statistical methodologies and GIS tools were used to determine the spatial variability of the each environmental parameter previously identified as predictable

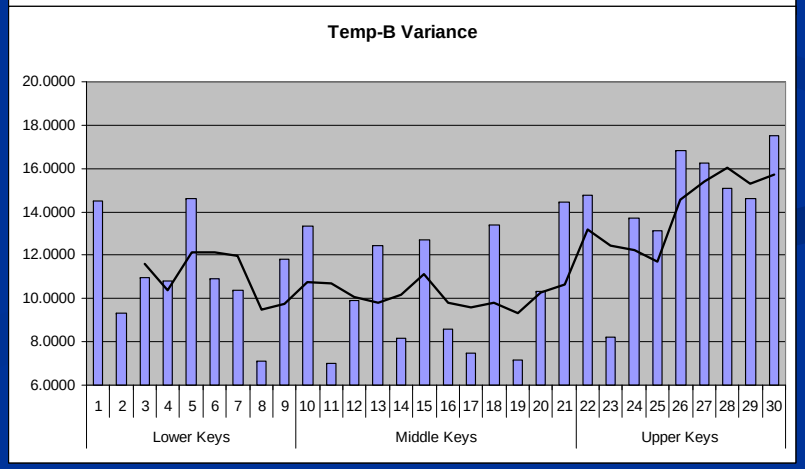
- Important in determining the influence of the environment on coral conditions

Environmental Trends at Regional Scales

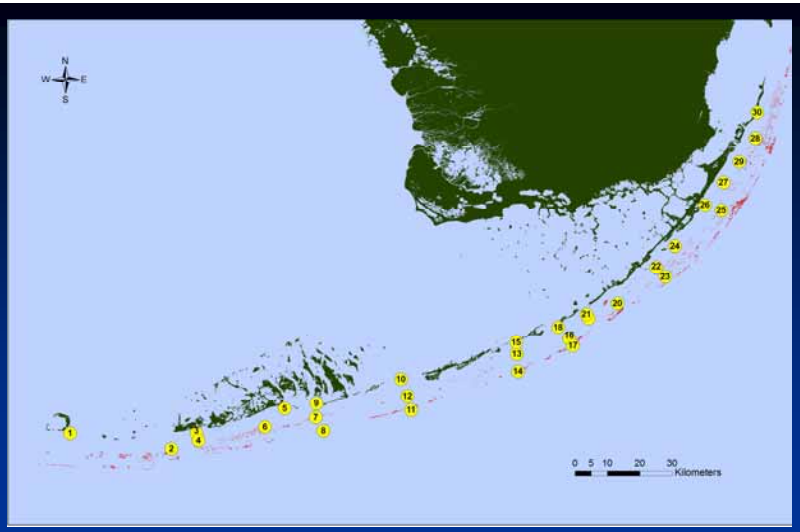
Temperature 1995-2003 (yearly)

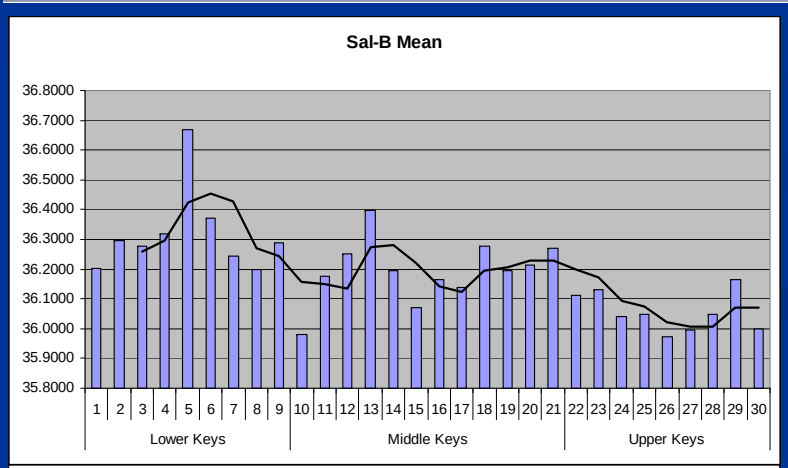


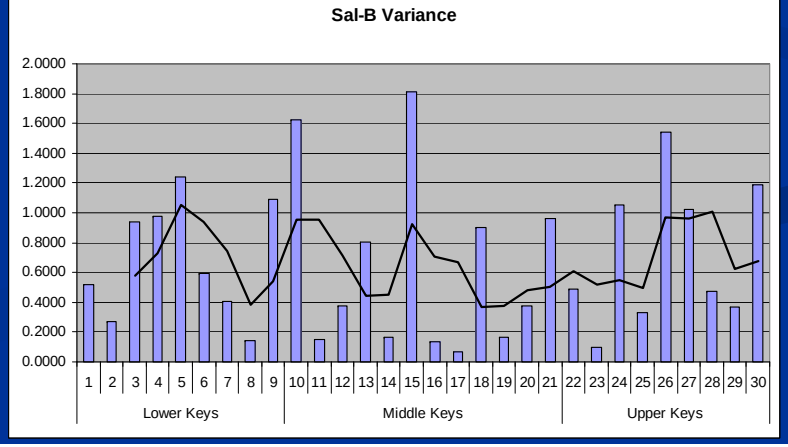




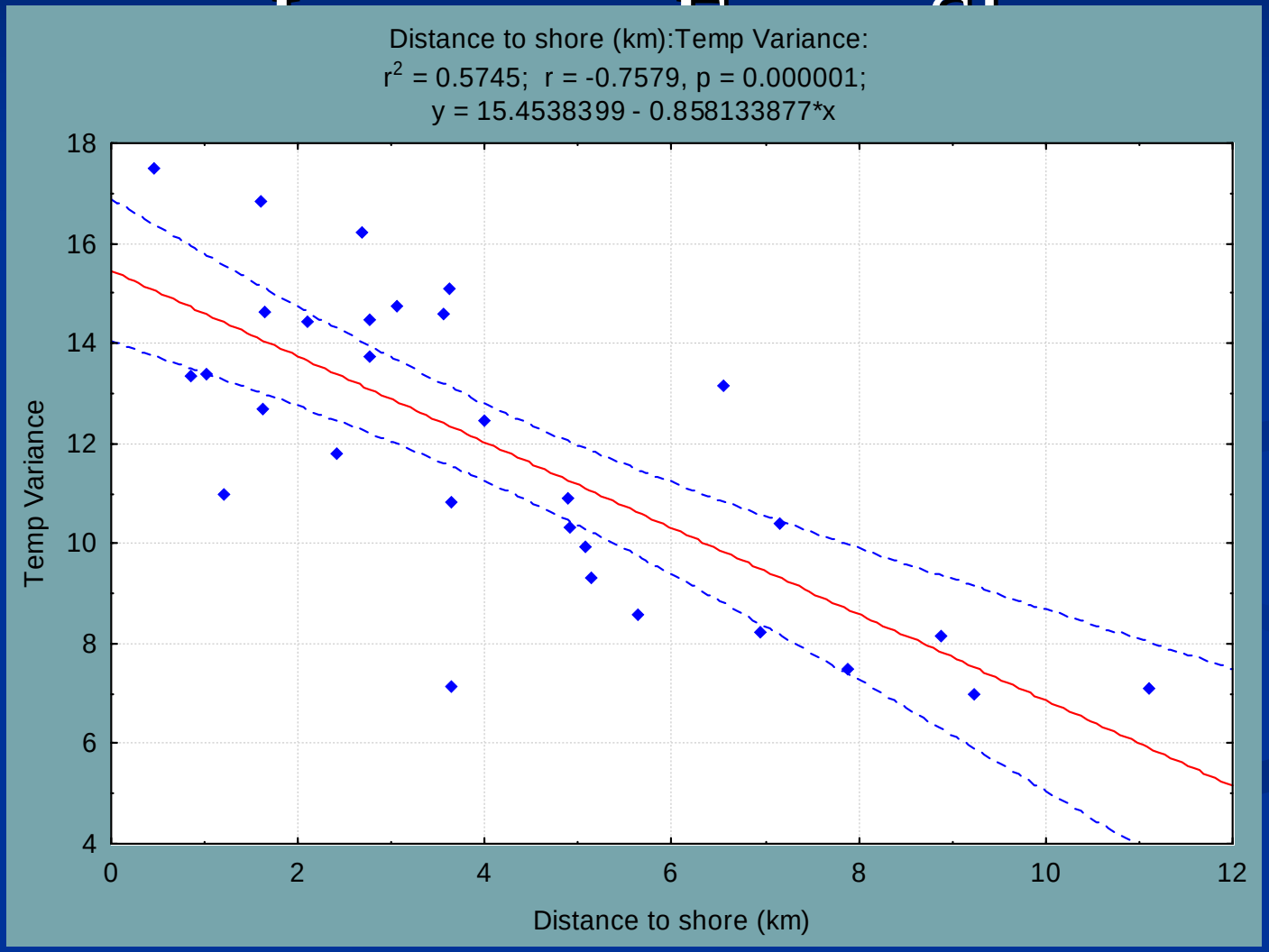
Salinity 1995-2003 (yearly)







Temperature: Variance Decreases as Distance

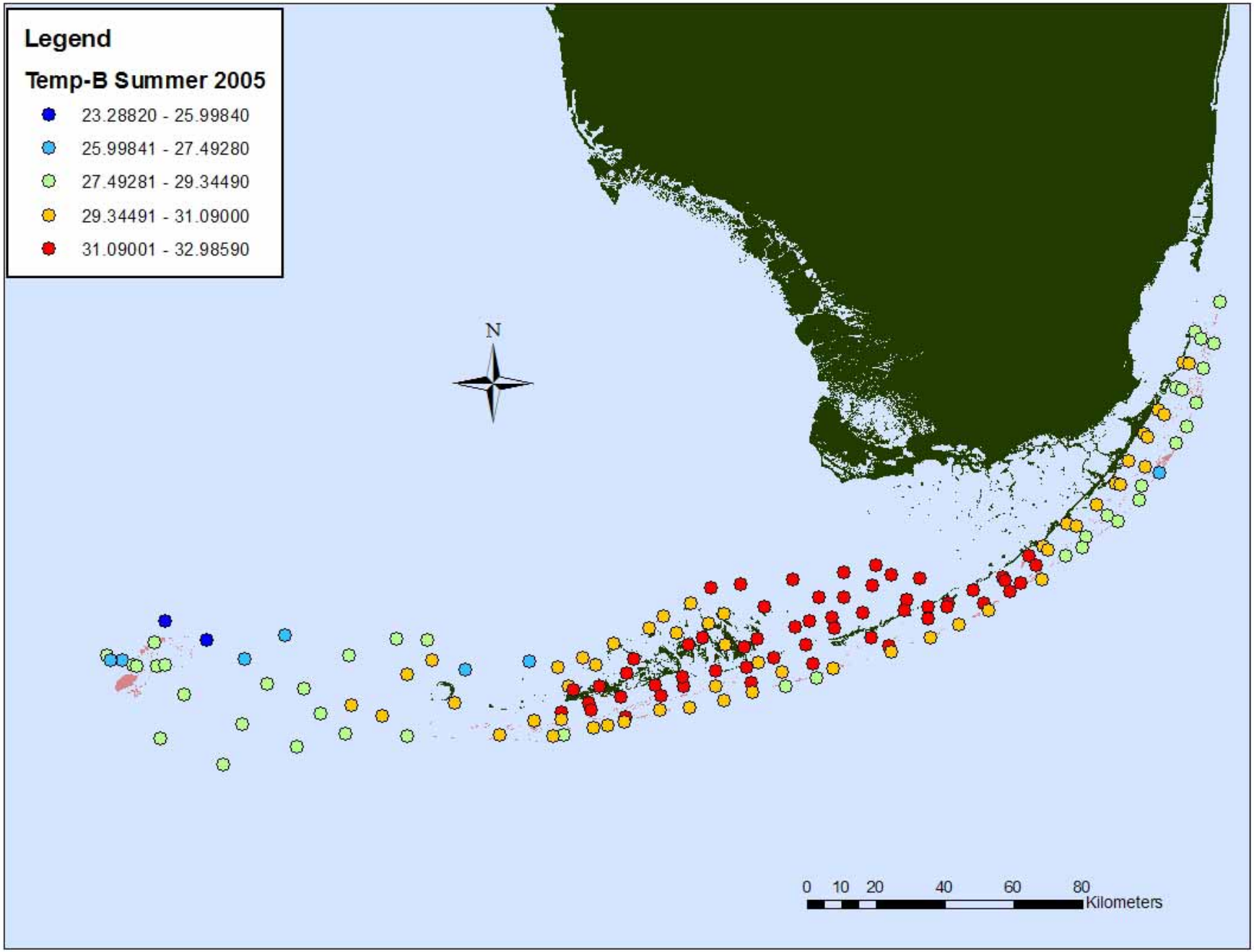


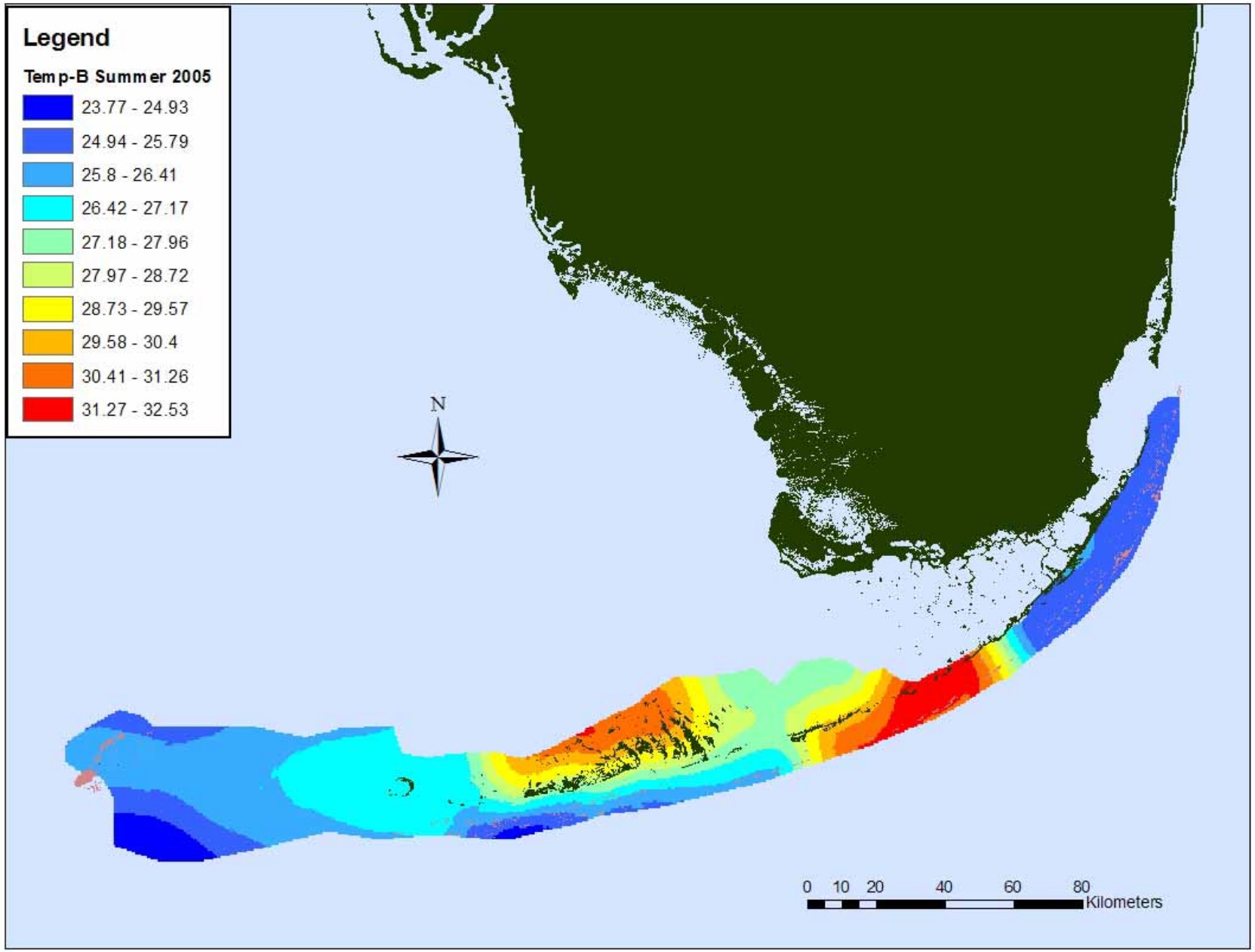
Assess Bleaching Prevalence With Respect to Environmental Parameters

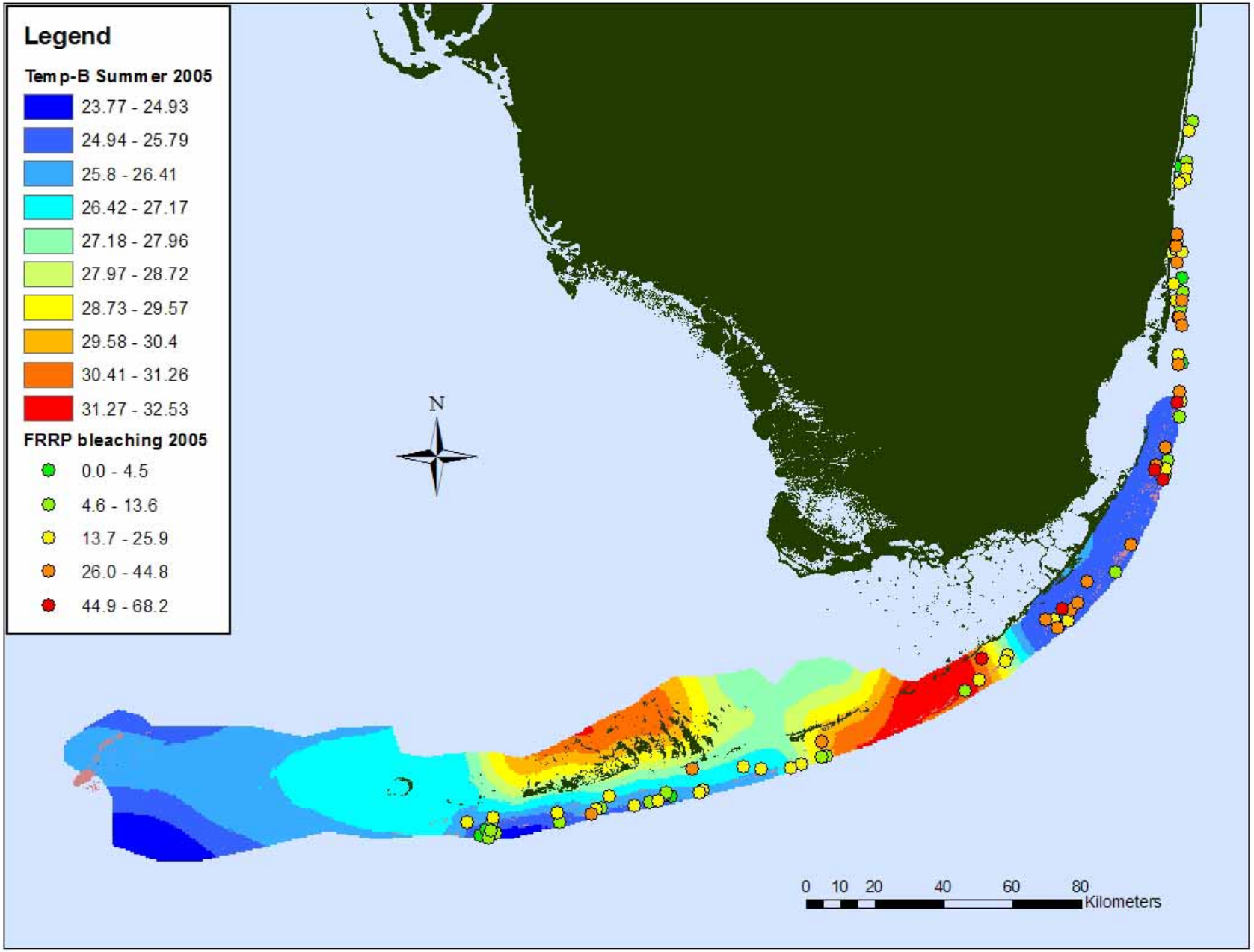
- Geographic Information Systems (GIS) allows scientists to better visualize environmental patterns that may be useful in understanding their influence on reef conditions and perhaps resilience

- Interpolation is a geostatistical technique based on the assumption that two data points are more similar the closer they are to each other

- Use known values at observed locations to predict values at alternate locations; i.e.,


Legend
Temp-B Summer 2005
23.28820 - 25.99840
25.99841 - 27.49280
27.49281 - 29.34490
29.34491 - 31.09000
31.09001 - 32.98590
N
0 10 20 40 60 80
Kilometers


Legend
Temp-B Summer 2005
23.77 - 24.93
24.94 - 25.79
25.8 - 26.41
26.42 - 27.17
27.18 - 27.96
27.97 - 28.72
28.73 - 29.57
29.58 - 30.4
30.41 - 31.26
31.27 - 32.53
N
0 10 20 40 60 80
Kilometers


Legend
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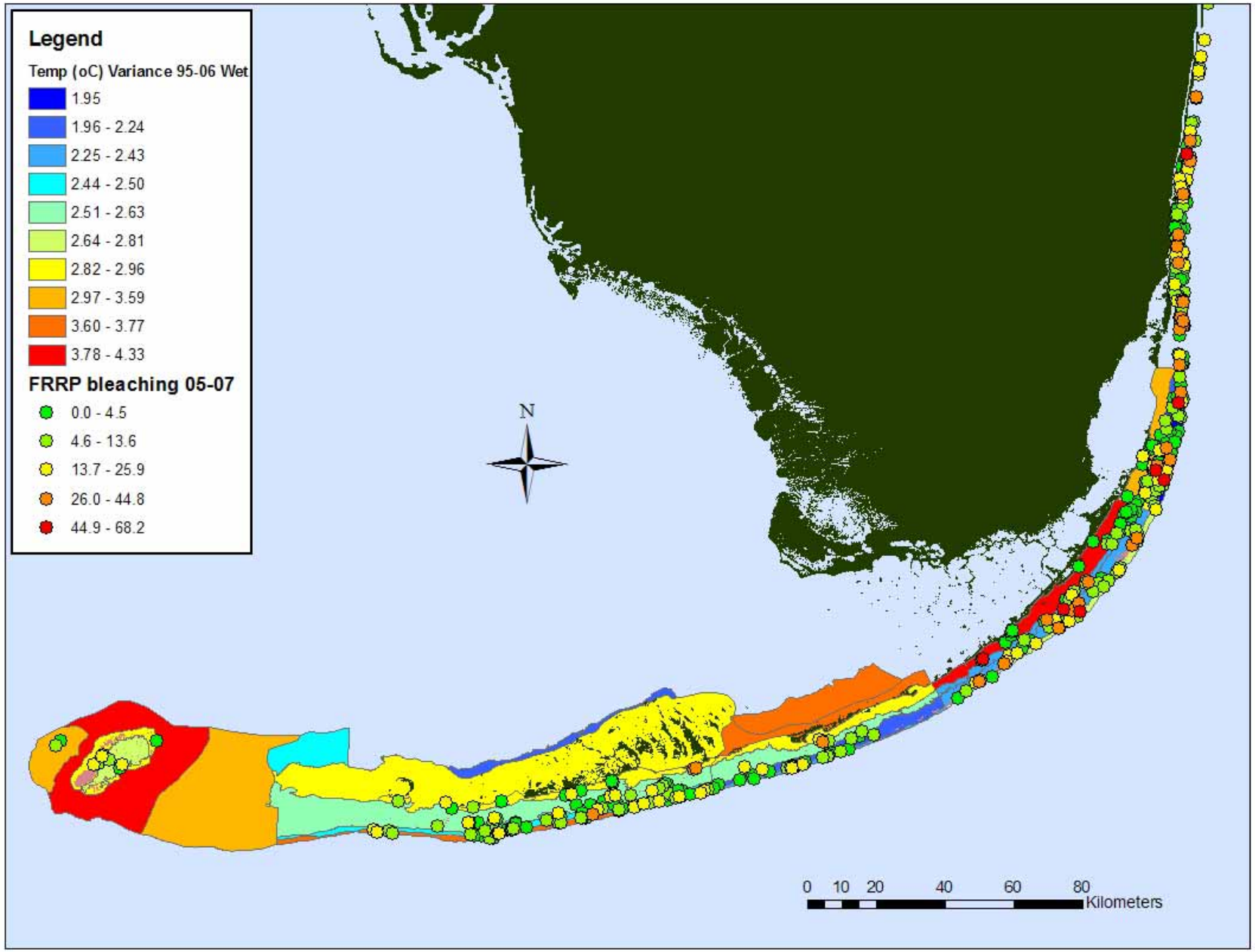
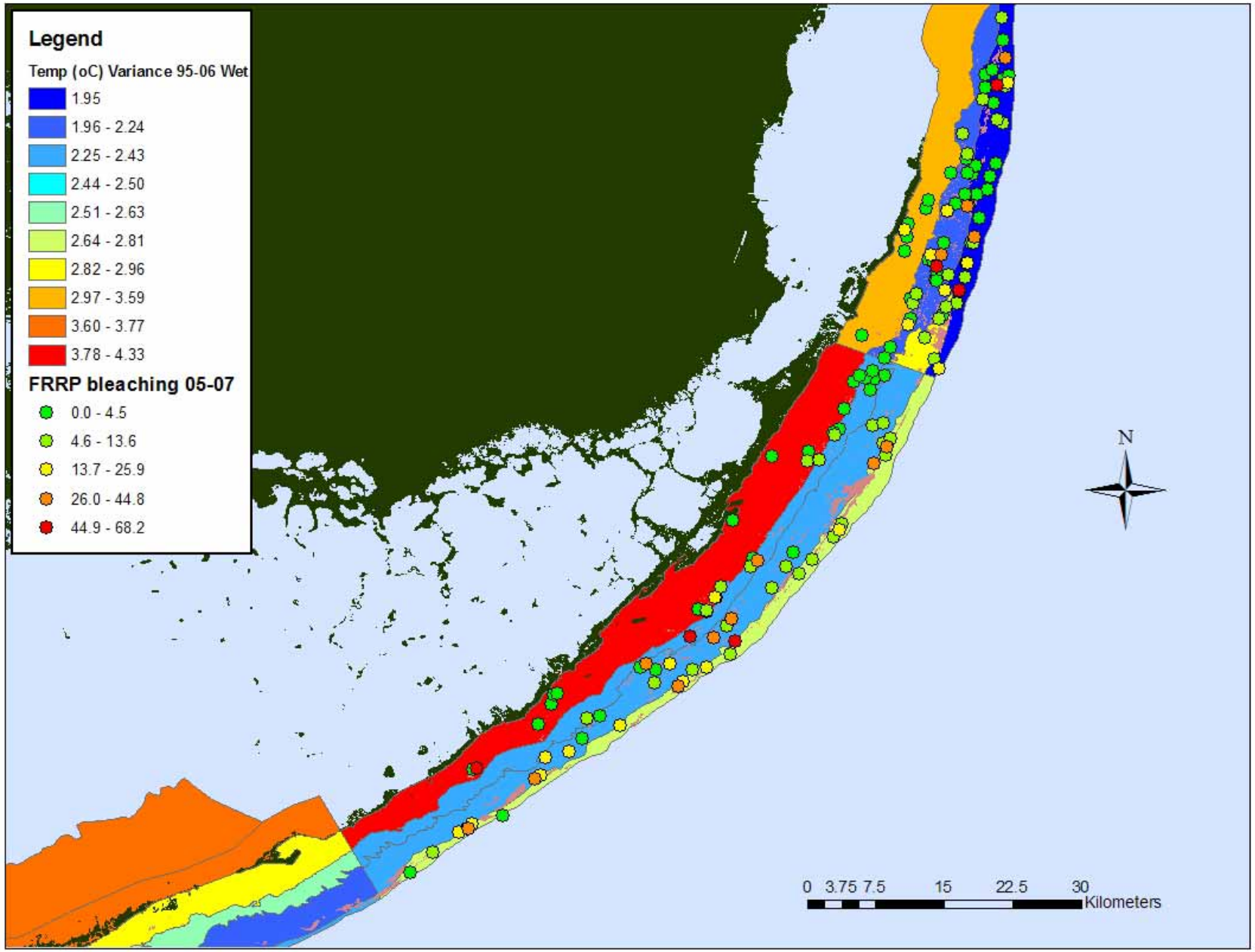
23.77 - 24.93
24.94 - 25.79
25.8 - 26.41
26.42 - 27.17
27.18 - 27.96
27.97 - 28.72
28.73 - 29.57
29.58 - 30.4
30.41 - 31.26
31.27 - 32.53
FRRP bleaching 2005
0.0 - 4.5
4.6 - 13.6
13.7 - 25.9
26.0 - 44.8
44.9 - 68.2
N
0 10 20 40 60 80
Kilometers


Legend
Temp (oC) Variance 95-06 Wet
1.95
1.96 - 2.24
2.25 - 2.43
2.44 - 2.50
2.51 - 2.63
2.64 - 2.81
2.82 - 2.96
2.97 - 3.59
3.60 - 3.77
3.78 - 4.33
FRRP bleaching 05-07
0.0 - 4.5
4.6 - 13.6
13.7 - 25.9
26.0 - 44.8
44.9 - 68.2
N
0 10 20 40 60 80
Kilometers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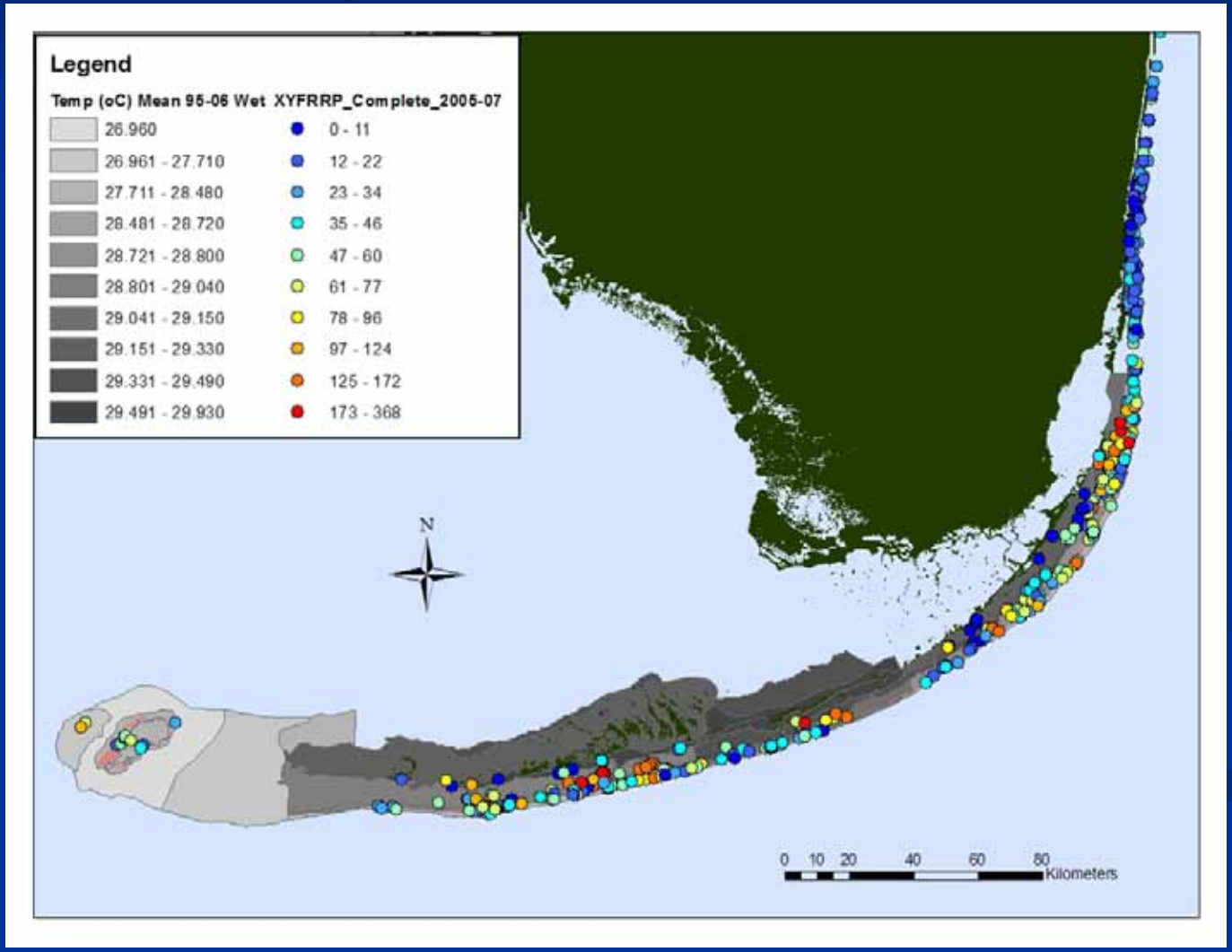
2.64 - 2.81
2.82 - 2.96
2.97 - 3.59
3.60 - 3.77
3.78 - 4.33
FRRP bleaching 05-07
0.0 - 4.5
4.6 - 13.6
13.7 - 25.9
26.0 - 44.8
44.9 - 68.2
N
0 3.75 7.5 15 22.5 30
Kilometers

Conclusions

- Temperature and salinity variance decreases across the shelf from near shore areas to deep reef locations
- Temperature and salinity variance is greatest in near shore zones, intra-island areas along the reef tract, and the Tortugas
- Depth explains the greatest portion of coral bleaching variance, followed by temperature

Future Analyses: Linking Long-Term Environmental Trends to Coral Composition Along the Florida Keys Reef Tract



Using These Results

Next steps: Linking results to resilience

- How can we best use the emerging relationship between environmental variability and bleaching, and depth and bleaching to identify resilient assemblages of coral in Florida?
- How does the local environment influence coral population structure and does population structure play a significant role in resilience in Florida?
  - Protect resilient and vulnerable but “valuable” coral assemblages.

Climate Change LEADS

Users

Resilience Based Solutions!

Research

Managers

- Accessible tools to help put all this together