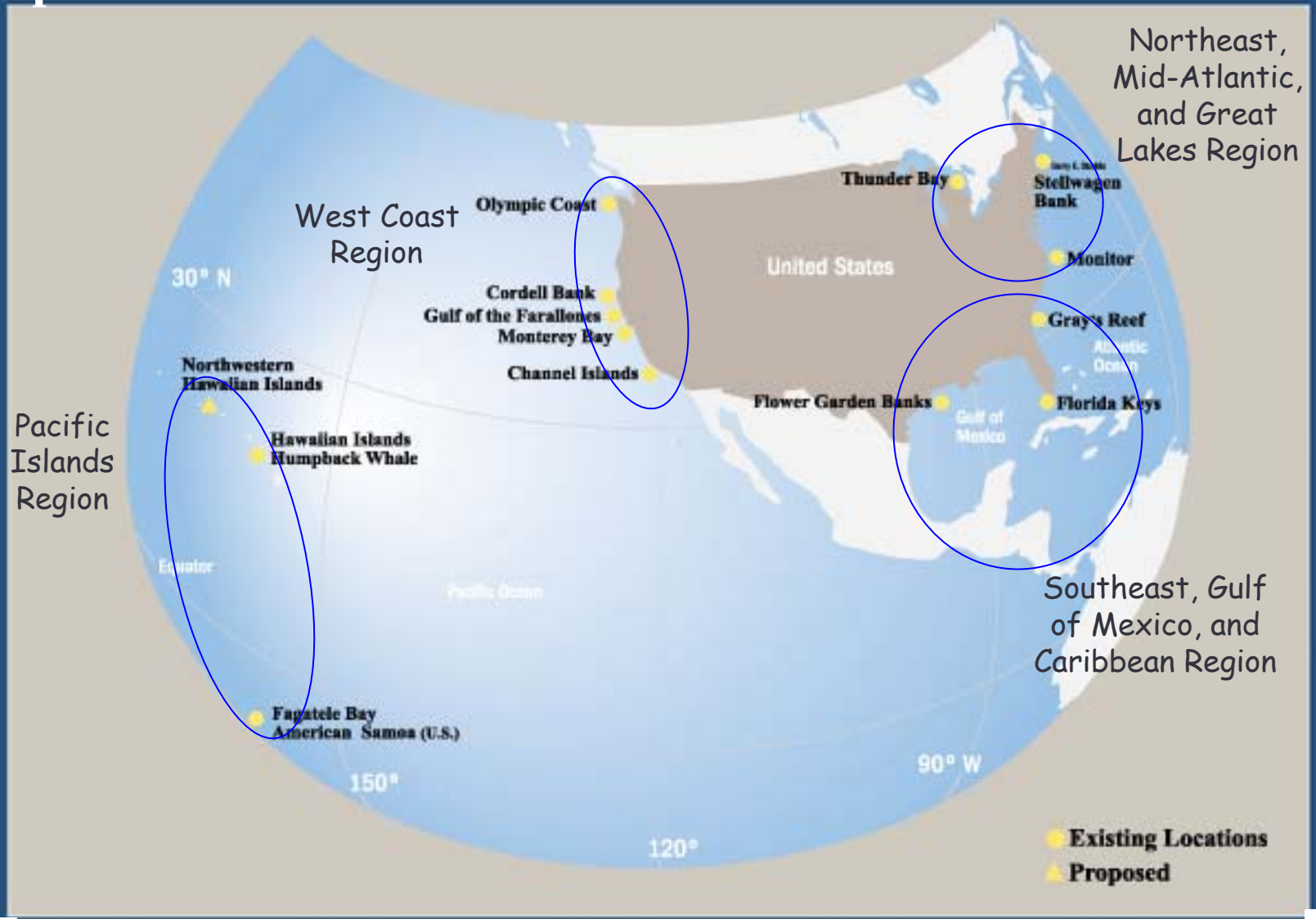
Intensification of Climate Change Impacts on Ecosystem Components of the Florida Keys

Climate Change Conference

May 9-11, 2007
Tampa, Florida

Billy D. Causey, Ph.D.
Regional Director
Southeast Atlantic, Gulf of Mexico and
Caribbean Region

4 Regions - 13 National Marine Sanctuaries & Papahanaumokuakea Coral Reef Marine National Monument



Conserve, protect, and enhance biodiversity, ecological integrity, and marine heritage.

First National Marine Sanctuaries in the Keys

Key Largo National Marine Sanctuary
353 square kilometers - Designated in 1975

Looe Key NMS
18km ^{2}
1981

Multiple Stressors Affecting Coral Reefs

Habitat Destruction

Coral Diseases

Pollution

Global Climate Change

Coral Bleaching

Overfishing

Intense Coastal Development

Ocean Dumping

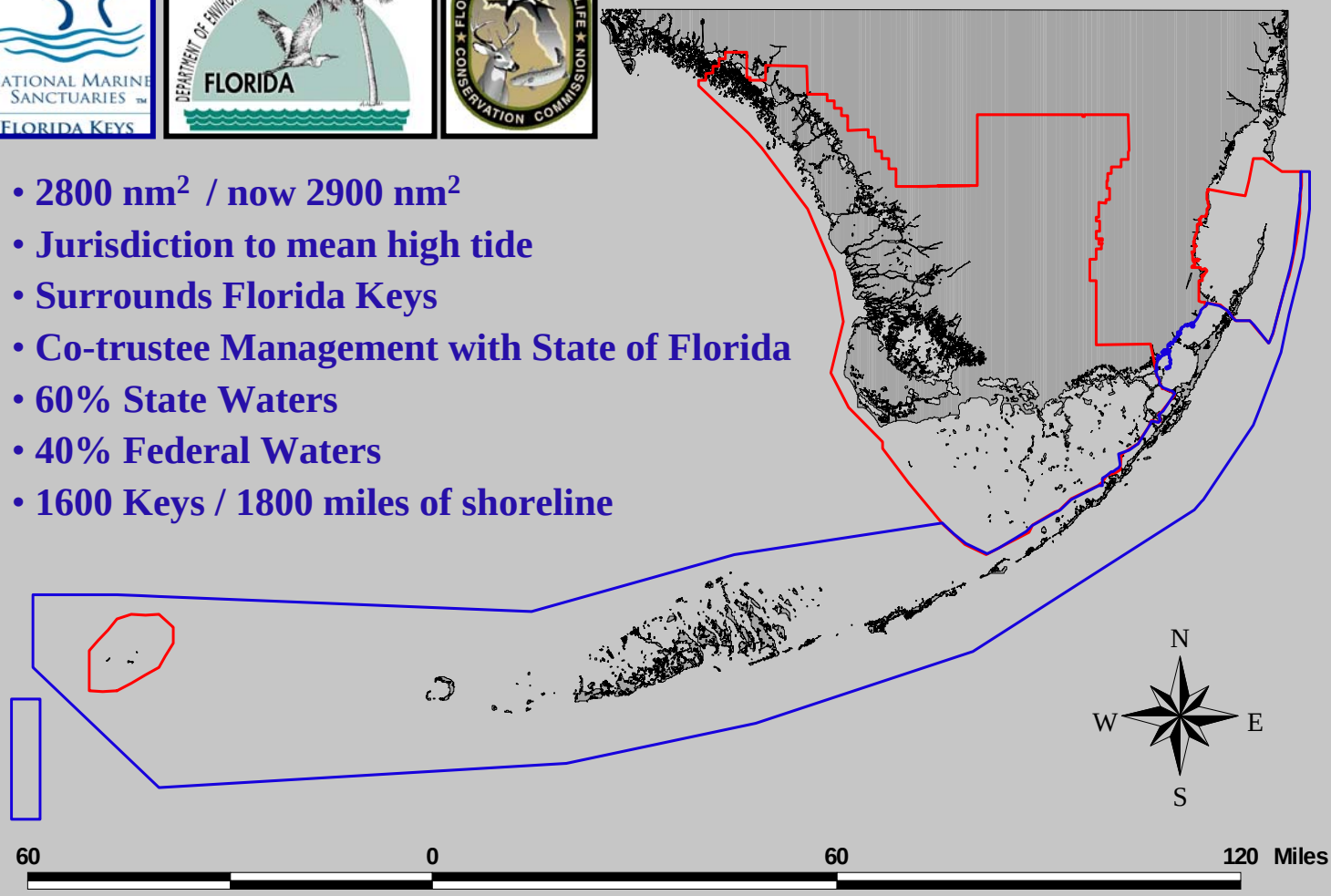
Massive Algal Blooms

Introduction of Marine Exotics

Florida Keys National Marine Sanctuary and Protection Act - 1990

(Passed By United States Congress)

- **2800 nm² / now 2900 nm²**
- **Jurisdiction to mean high tide**
- **Surrounds Florida Keys**
- **Co-trustee Management with State of Florida**
- **60% State Waters**
- **40% Federal Waters**
- **1600 Keys / 1800 miles of shoreline**



NATIONAL MARINE SANCTUARIES
FLORIDA KEYS

Keys Coral Reef Community

Includes the Full Seascape

Keys Coral Reef Community

Full-Range of Habitats

And All of the Marinelife

Keys Coral Reef Community

- Coral reefs are an indicator of ecosystem change
- Coral reef community of the Florida Keys was among the first to respond to elevated sea surface temperatures

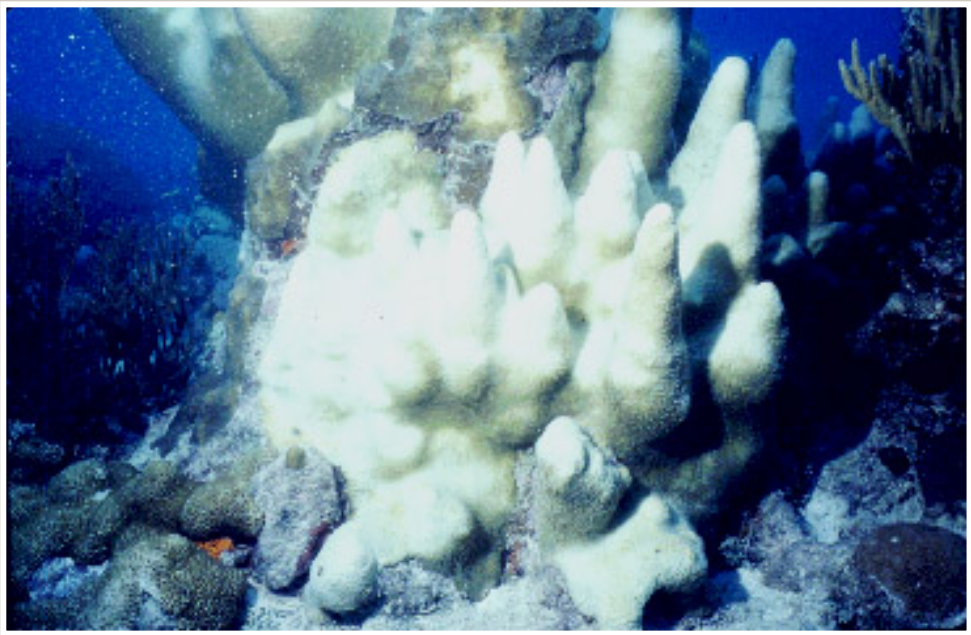
Climate Trends

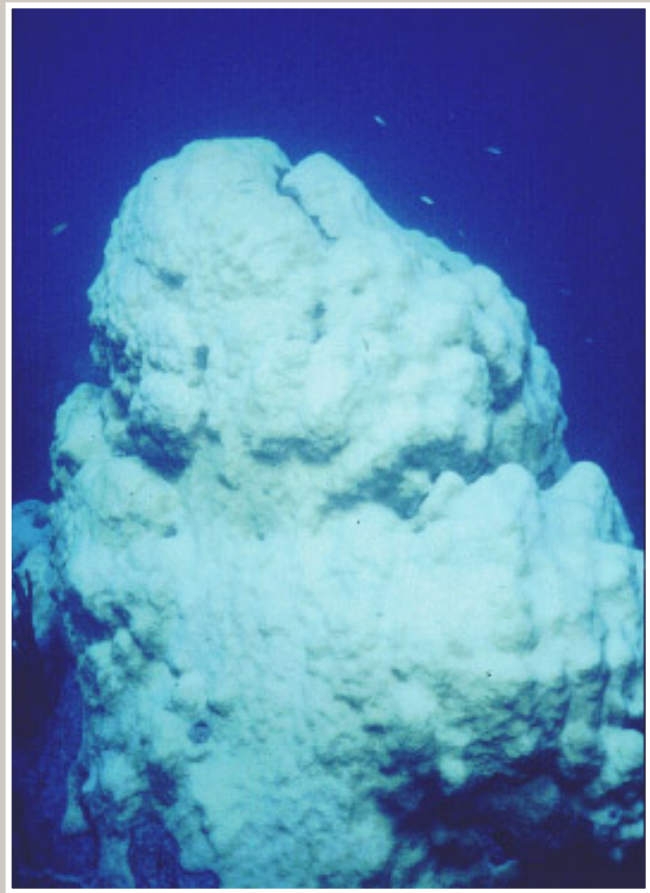
Status

- 16 warmest years on record have occurred since 1980 (1880 - began keeping records)
- 5 warmest years (1998, 2001 2002, 2004 & 2005) in the past 5 years
- Fastest global warming rate in 10,000 years

What is coral bleaching?

Mark Eakin will describe coral bleaching





- Corals Responding to some form of stress
- Thermal Stress / Shading / Chemical
- Focus of talk is on response to elevated sea surface temperatures

Coral Bleaching

- Intensified over the past 2 ½ decades
- “Seems to be synchronized around El Niño events” …….(*Peter Glynn, 1984)*
- Elevated ocean temperatures
- Related secondary impacts (e.g. diseases, loss of diversity ....)

Predicting Coral Bleaching Events

Common Observations Leading to Coral Bleaching

- **Doldrum conditions for extended periods**
- **Low Cloud cover**
- **Minimal water circulation**
- **Elevated Sea Surface temperatures**

Climate Change Impacts

1979

- **Massive die-off of barrel sponges (*Xestospongia muta*) in the Lower Florida Keys**

1980

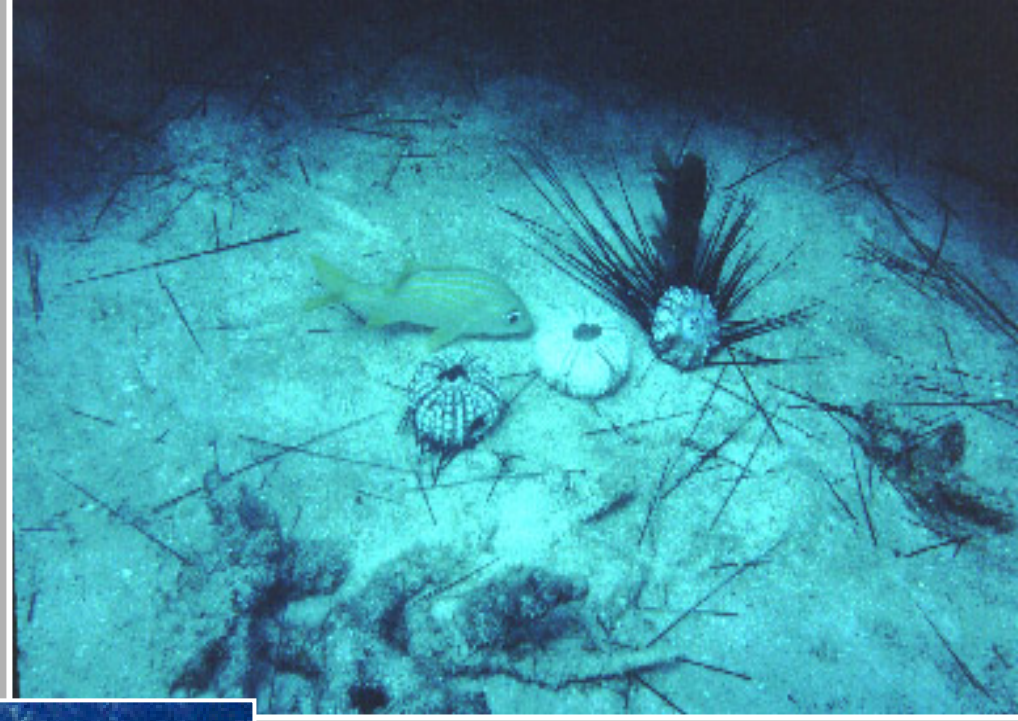
- 6 weeks of doldrum-like weather (slick-calm sea)
- Massive fish kill along reef tract
- Minor bleaching

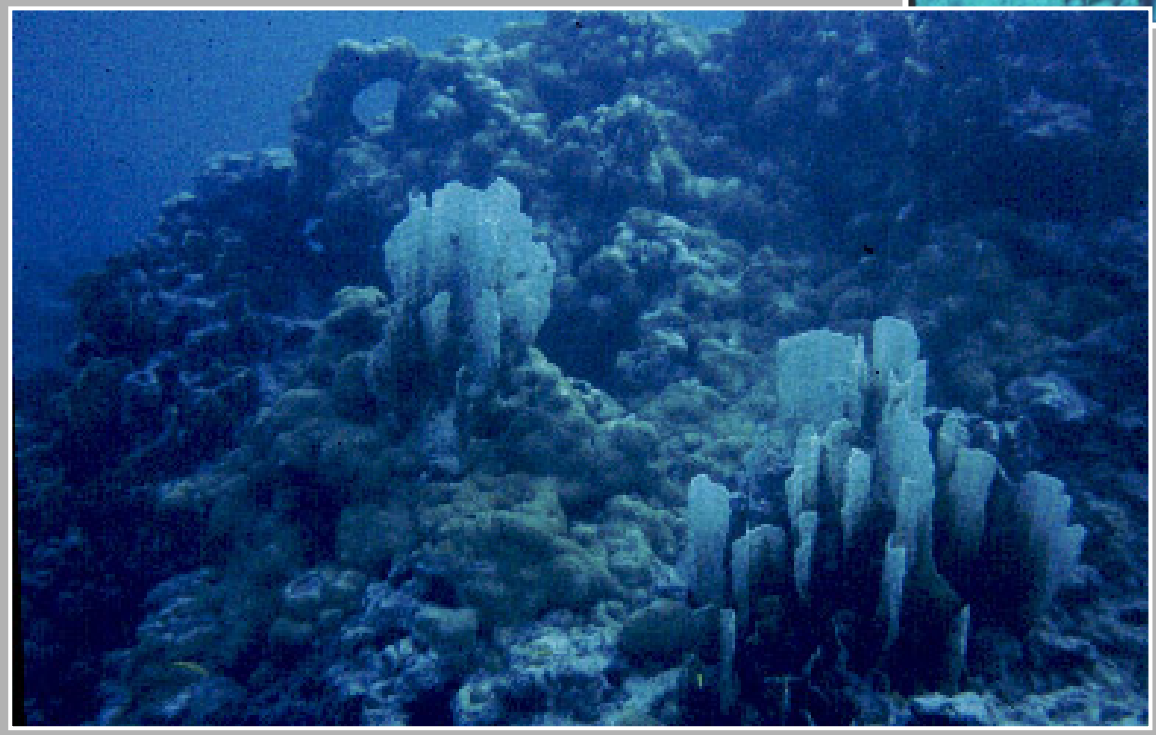
1983

- 4 weeks of doldrum-like weather
- Large-scale coral bleaching on Lower Florida Keys outer reefs
- Long-spined sea urchin die-off
- Yellow Sponge Die-off

1983 Coral bleaching Lower Florida Keys

"From a distance, spurs looked like snow-draped ridges." …Walt Jaap(1985)





1983 *Diadema* die-off Long Spine Sea Urchin

Credit: H.A. Lessios (1984)

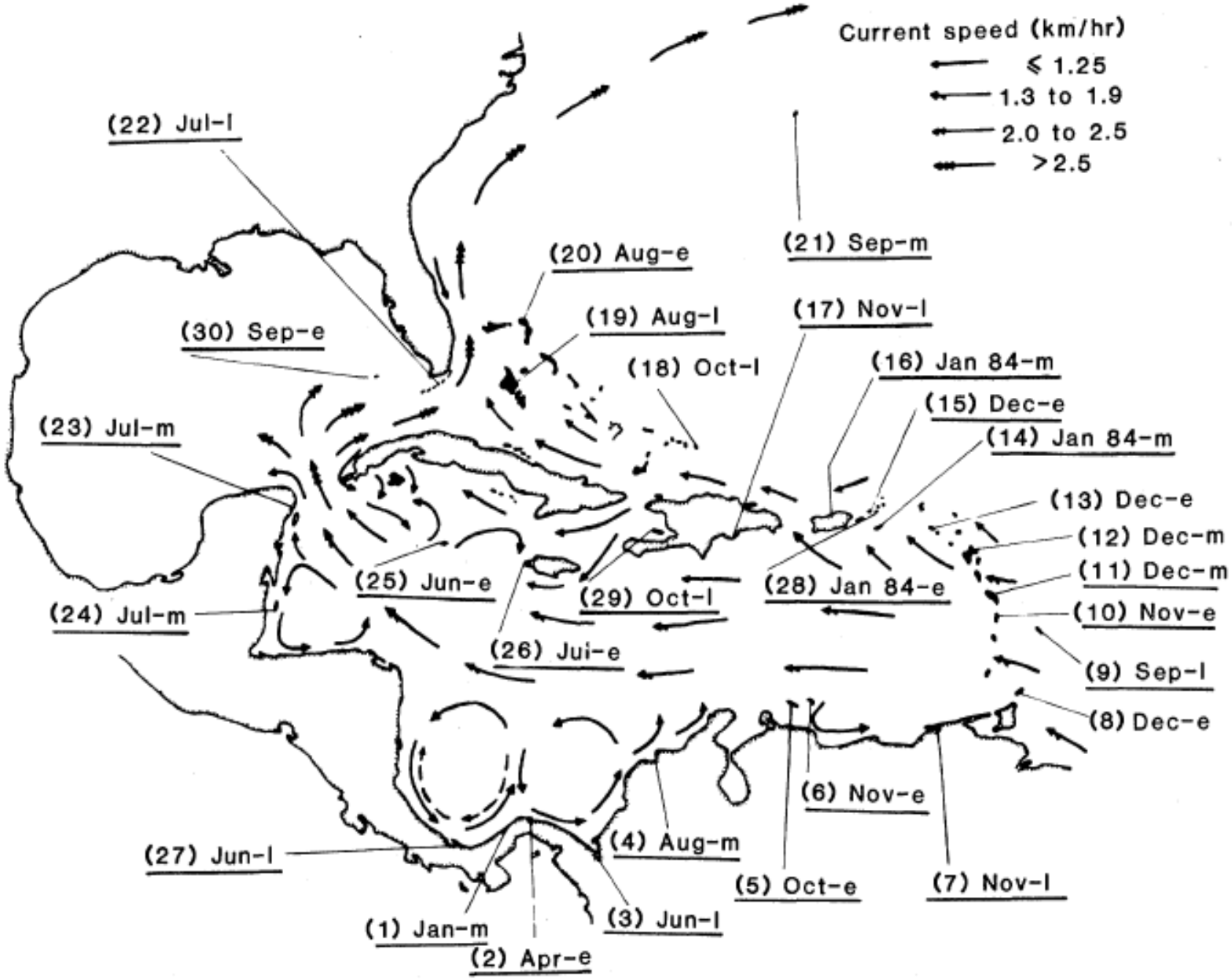
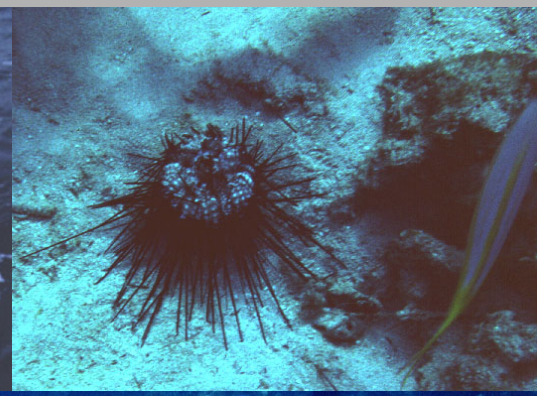
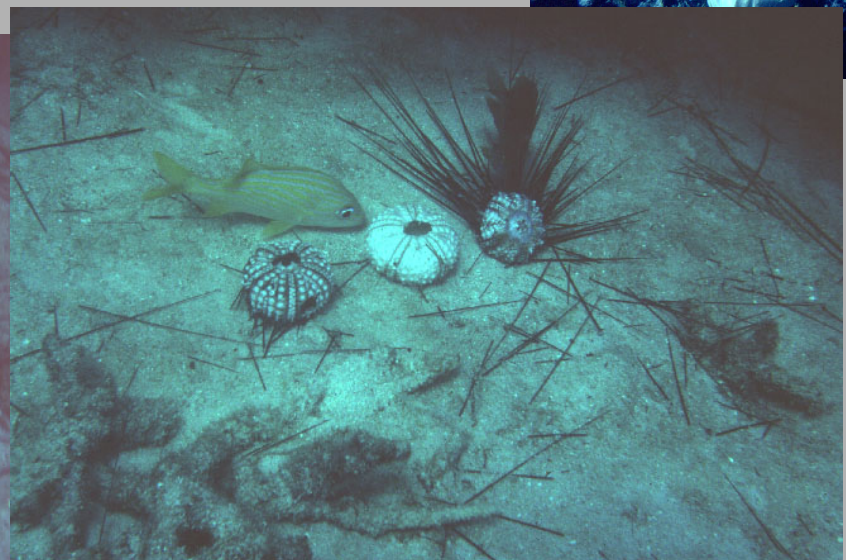


Fig. 2. Spread of *Diadema* mass mortality through the Caribbean and the western Atlantic. Underlined dates indicate the first time mortality was noted at each locality.

Harilaos Lessios - *Diadema* die-off - Looe Key NMS



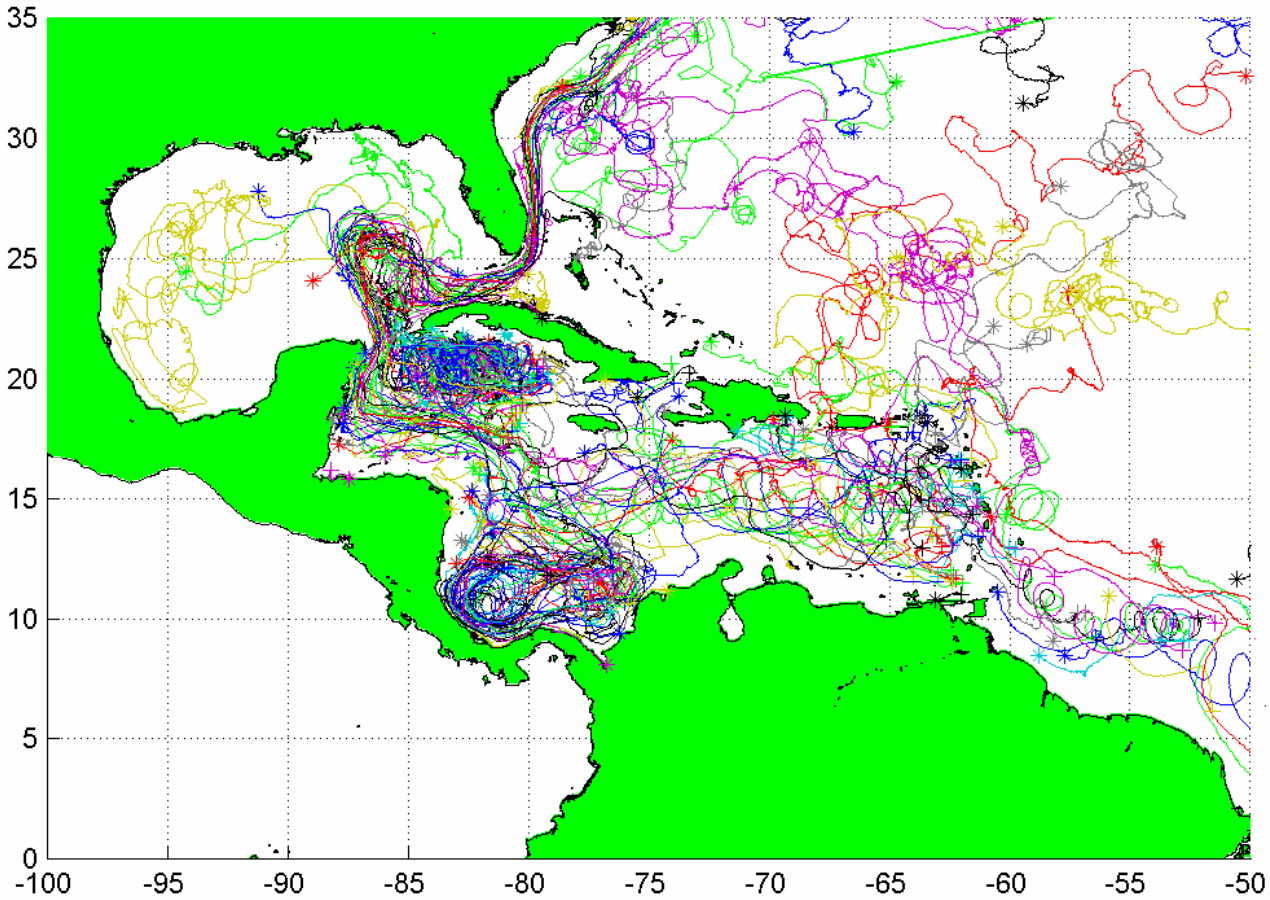


July 1983

NATIONAL MARINE SANCTUARIES

Current Drifters (1998-2000)

Credit: Kevin Leaman (UM/RSMAS)



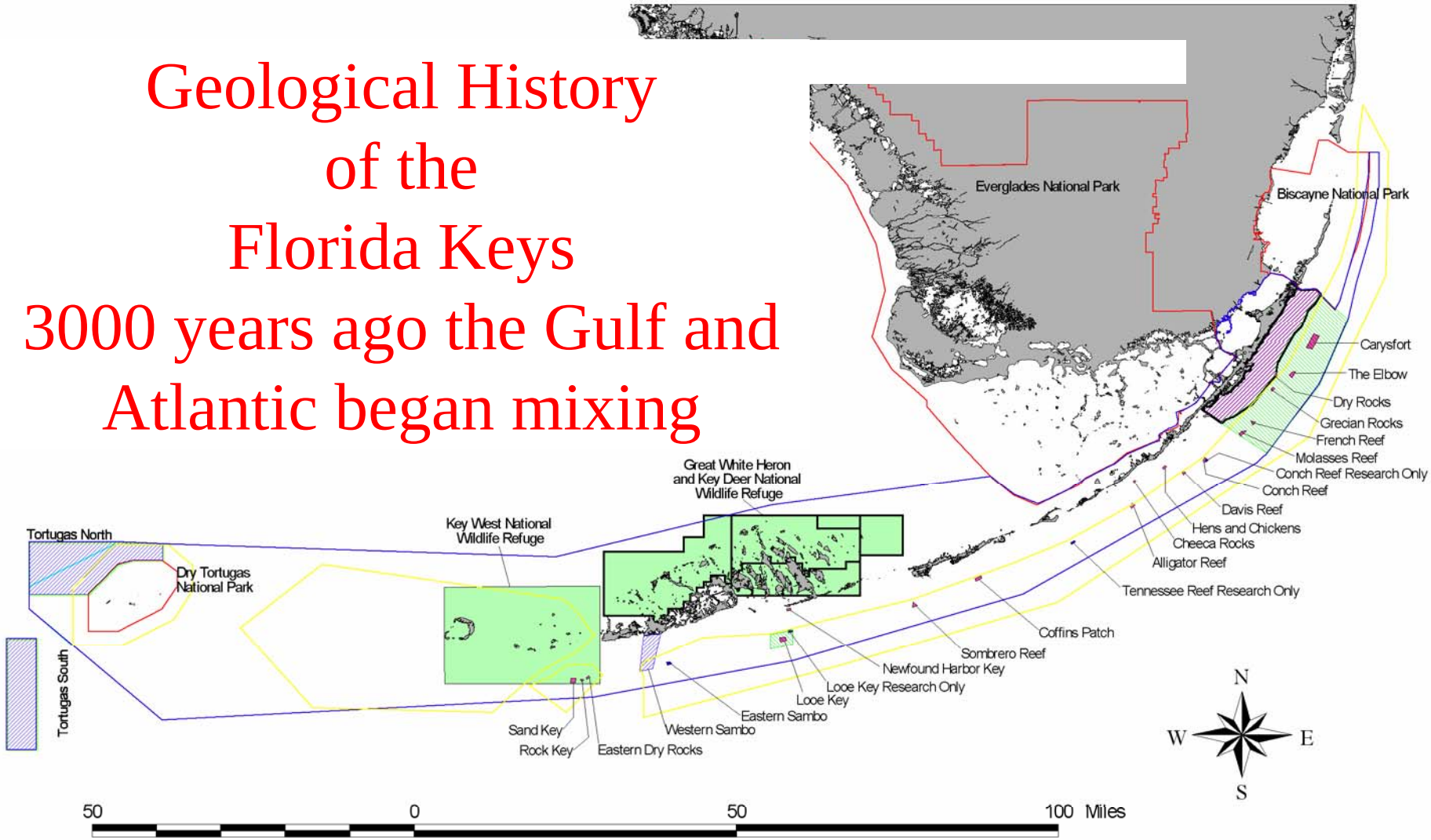
NATIONAL MARINE SANCTUARIES ™
FLORIDA KEYS

Florida's Coral Reefs

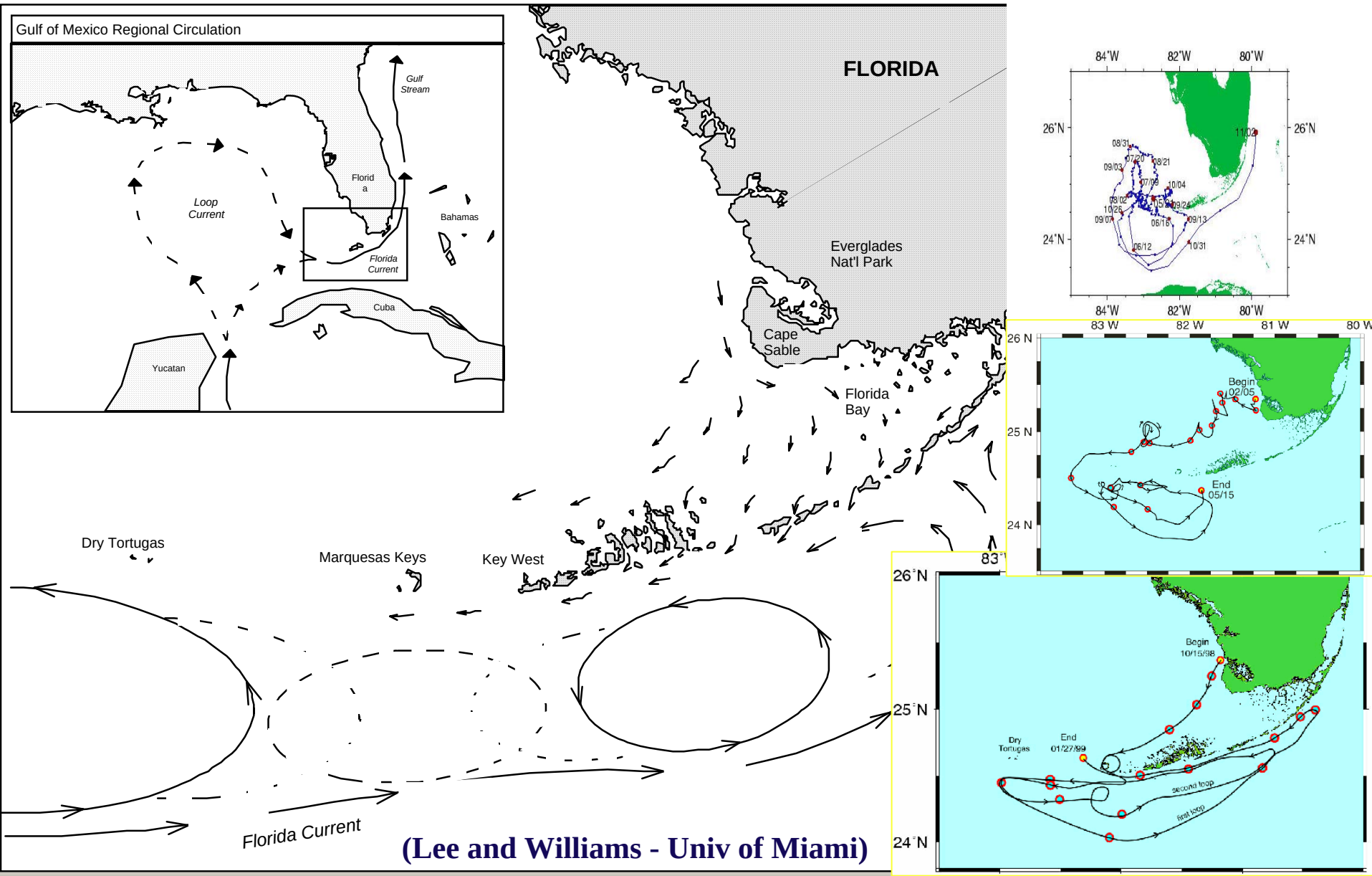
- Unique zoogeographic setting
- Warm-temperate Gulf waters
- Tropical waters to the South

Florida Keys National Marine Sanctuary

Geological History
of the
Florida Keys
3000 years ago the Gulf and
Atlantic began mixing



Water Circulation

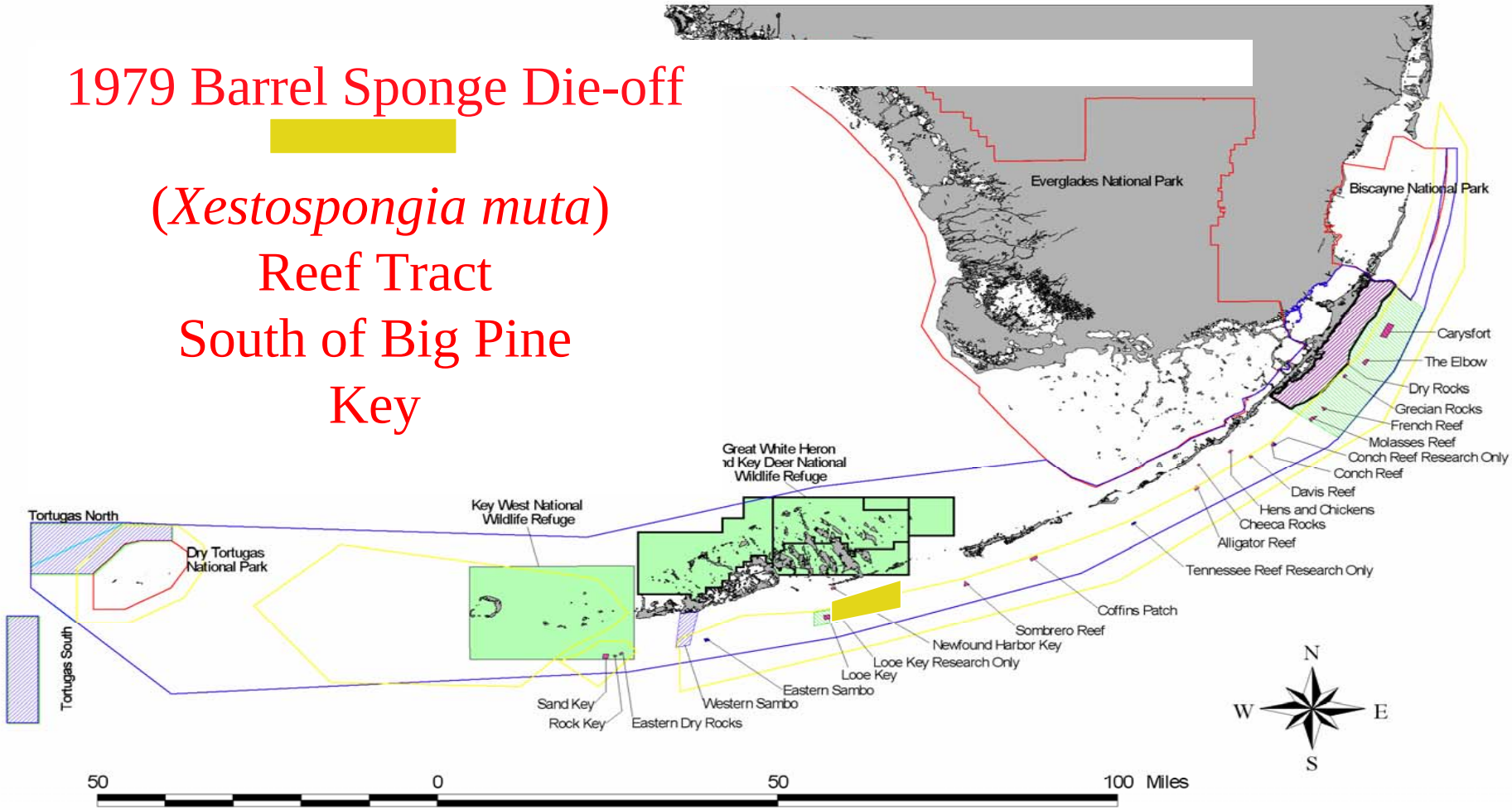


(Lee and Williams - Univ of Miami)

Florida Keys National Marine Sanctuary

1979 Barrel Sponge Die-off

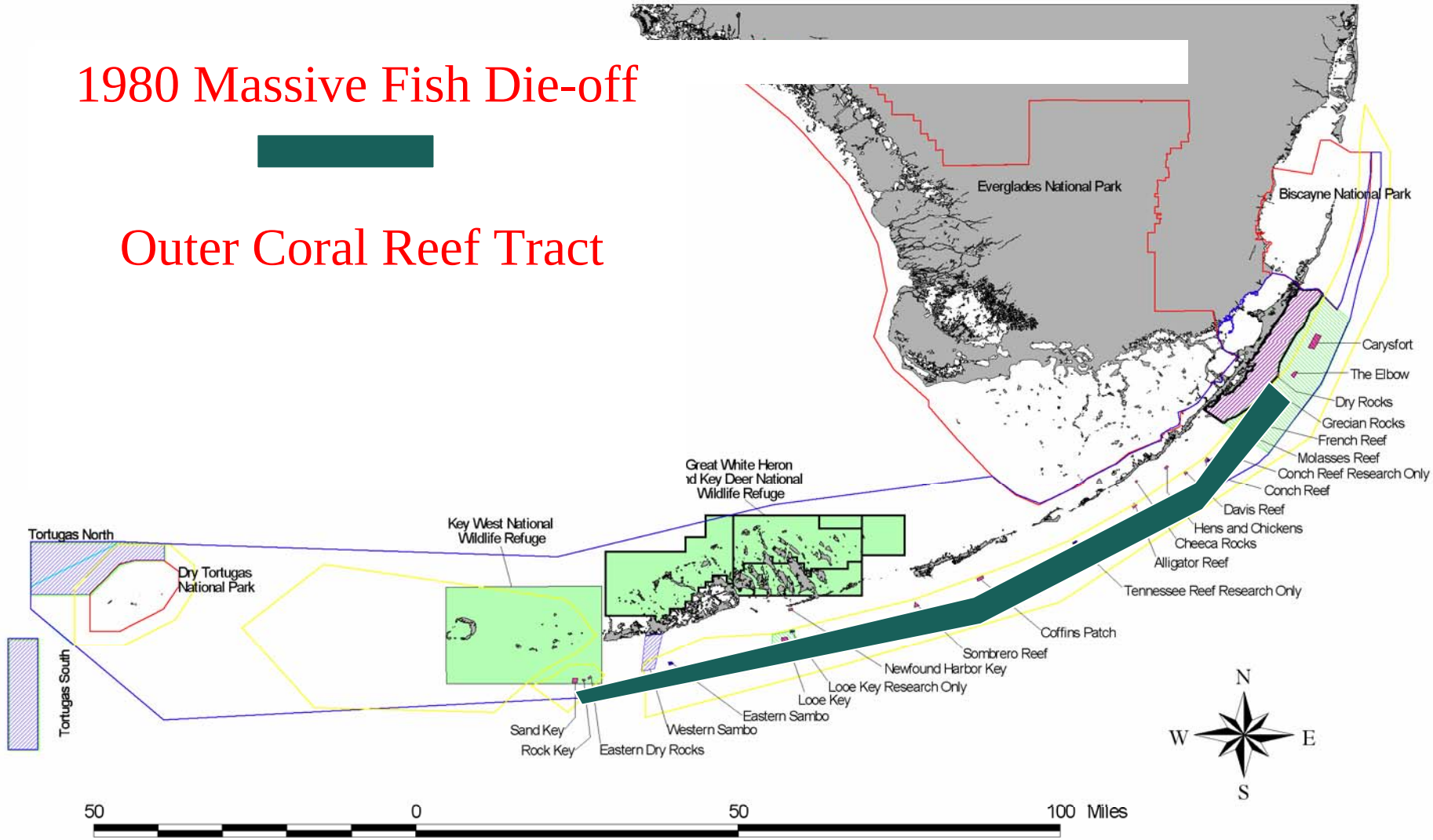
(*Xestospongia muta*)
Reef Tract
South of Big Pine
Key



Florida Keys National Marine Sanctuary

1980 Massive Fish Die-off

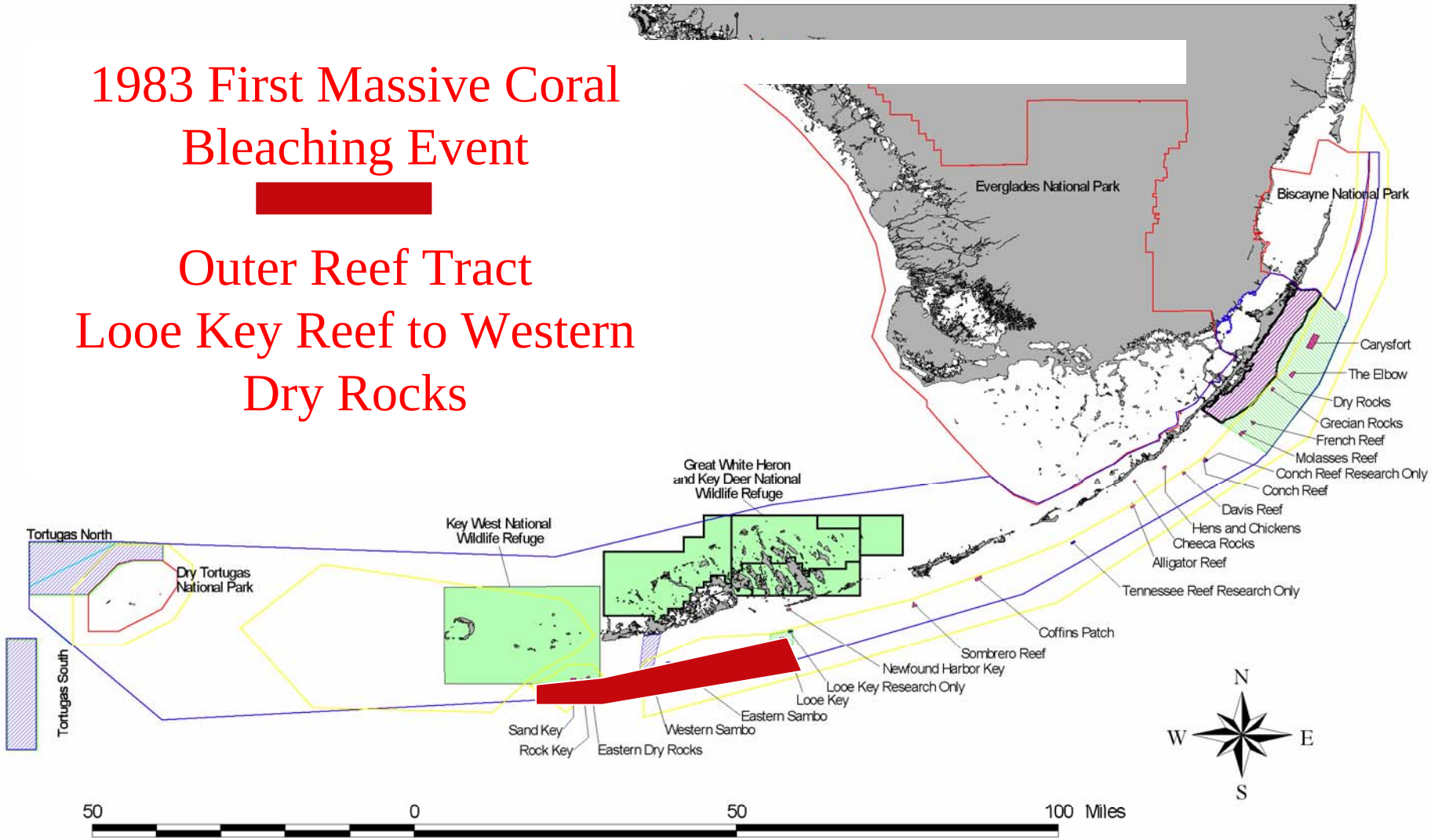
Outer Coral Reef Tract



Florida Keys National Marine Sanctuary

1983 First Massive Coral Bleaching Event

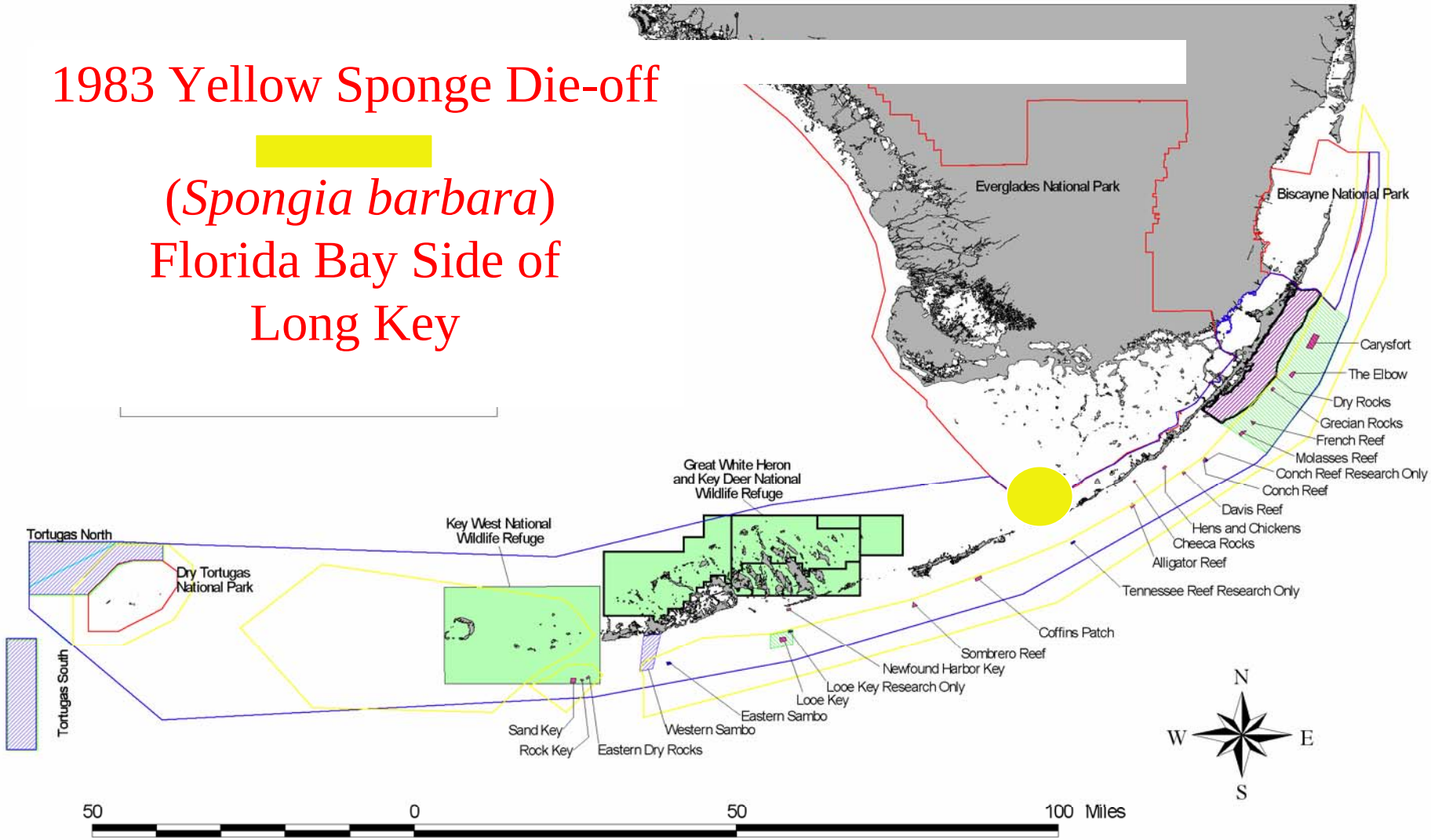
Outer Reef Tract
Looe Key Reef to Western Dry Rocks



Florida Keys National Marine Sanctuary

1983 Yellow Sponge Die-off

(*Spongia barbara*)
Florida Bay Side of
Long Key



Coral Bleaching Trends (Cont.)

1986

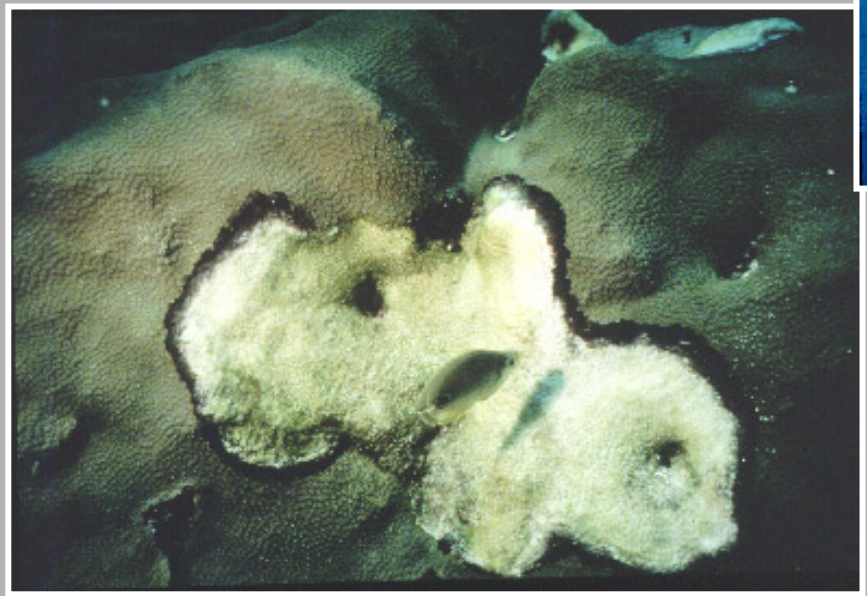
- Large-scale black-band disease outbreak in the Lower Florida Keys

1987

- Doldrum weather patterns
- Massive bleaching throughout the Florida Keys
- Restricted to outer reef tract

* Local, regional, and global
* Atlantic & Pacific bleaching event
* Massive Seagrass Die-off

1986 Black band disease
Looe Key Reef



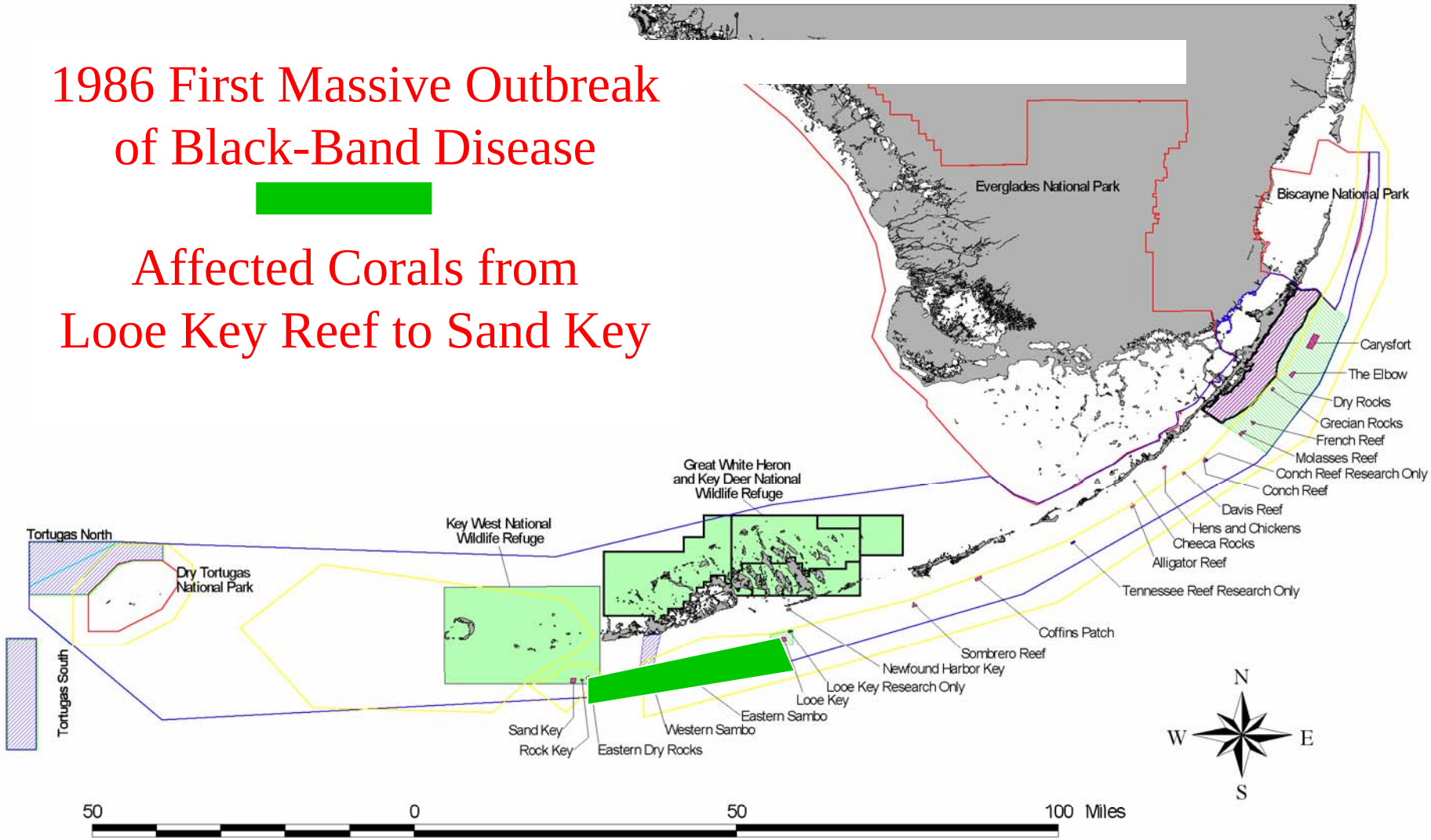
1987 Global coral bleaching event

Looe Key Reef

Florida Keys National Marine Sanctuary

1986 First Massive Outbreak of Black-Band Disease

Affected Corals from Looe Key Reef to Sand Key

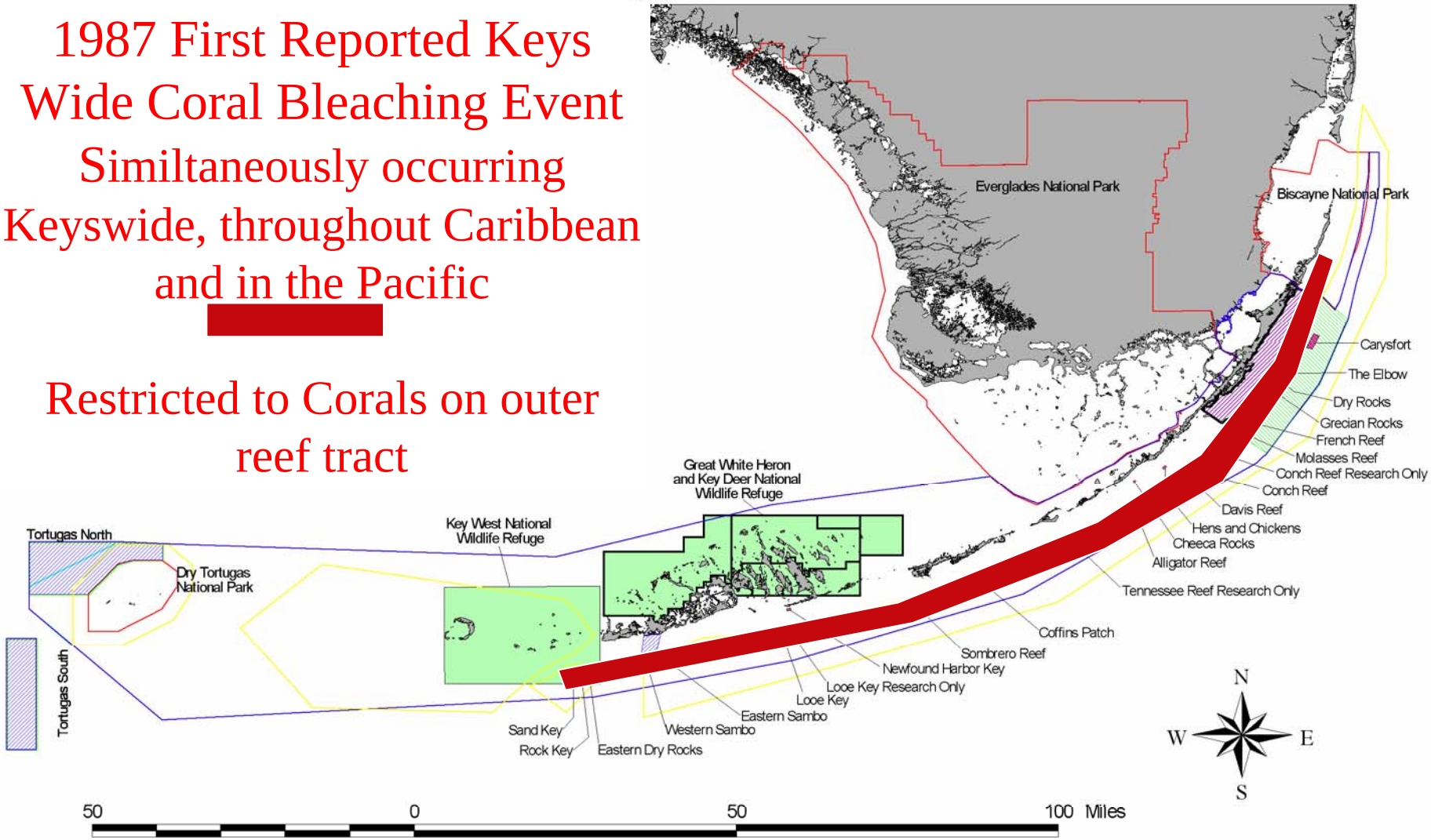


Florida Keys National Marine Sanctuary

1987 First Reported Keys Wide Coral Bleaching Event

Similtaneously occurring Keyswide, throughout Caribbean and in the Pacific

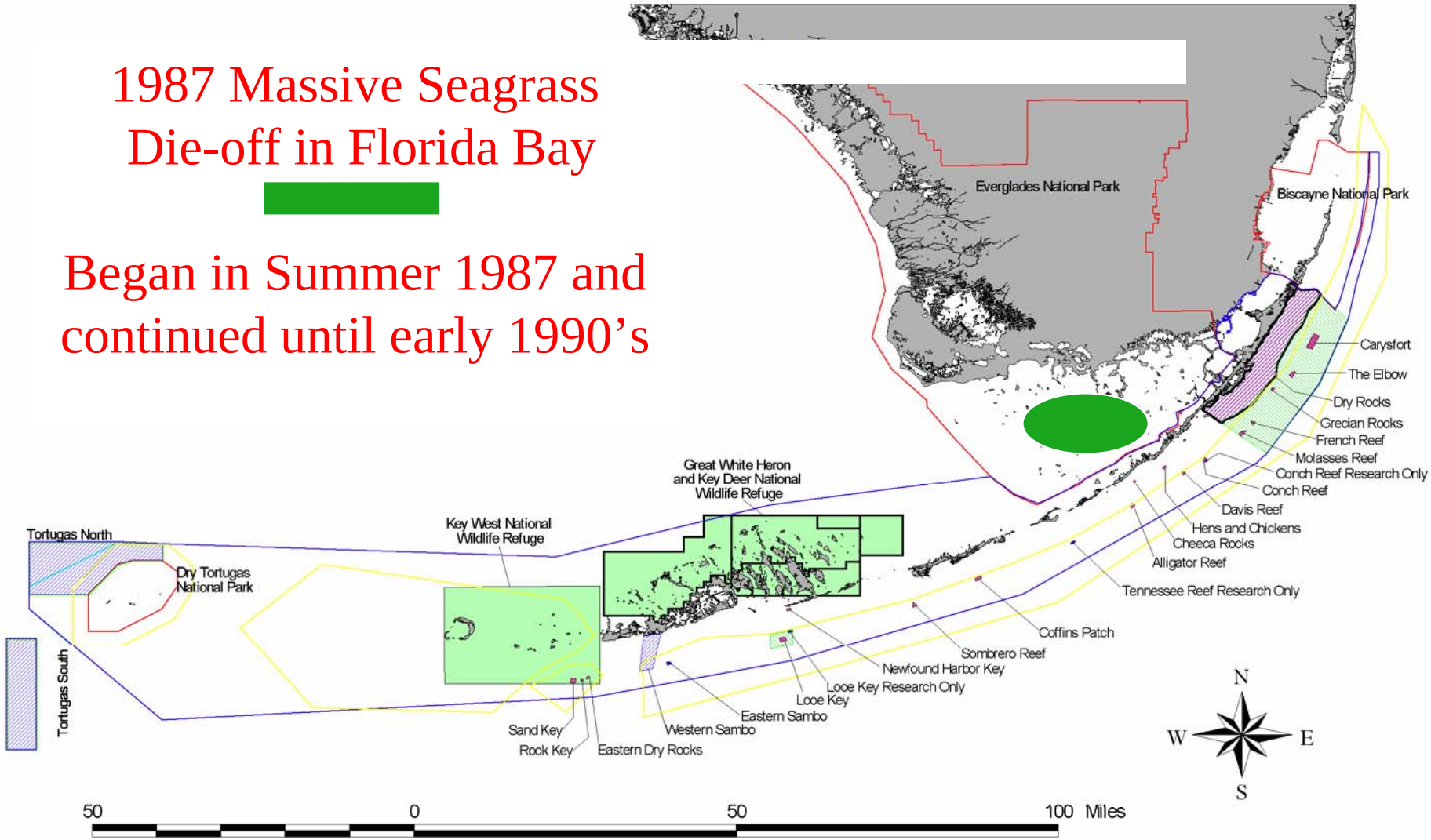
Restricted to Corals on outer reef tract



Florida Keys National Marine Sanctuary

1987 Massive Seagrass Die-off in Florida Bay

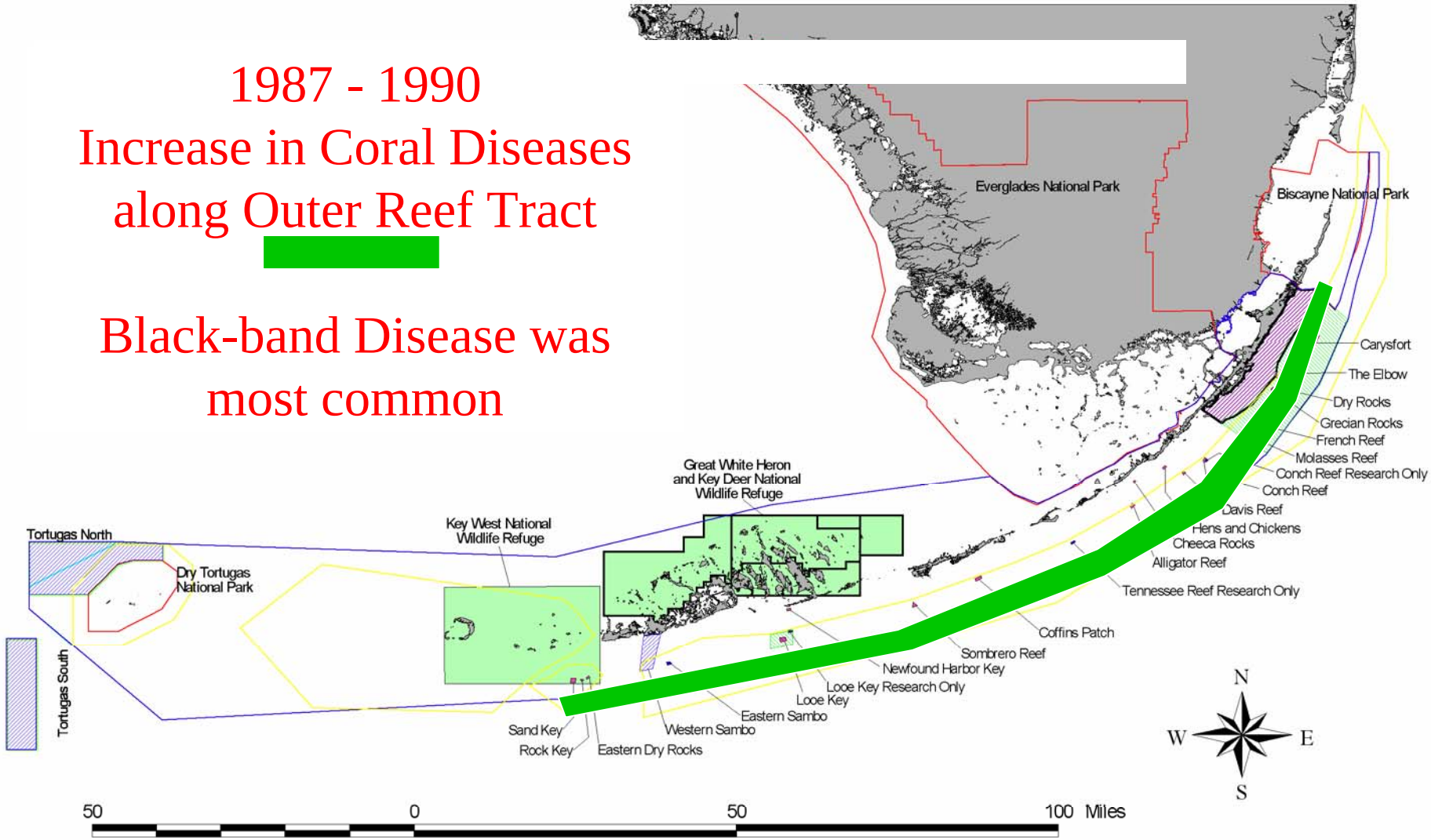
Began in Summer 1987 and continued until early 1990's



Florida Keys National Marine Sanctuary

1987 - 1990
Increase in Coral Diseases
along Outer Reef Tract

Black-band Disease was
most common



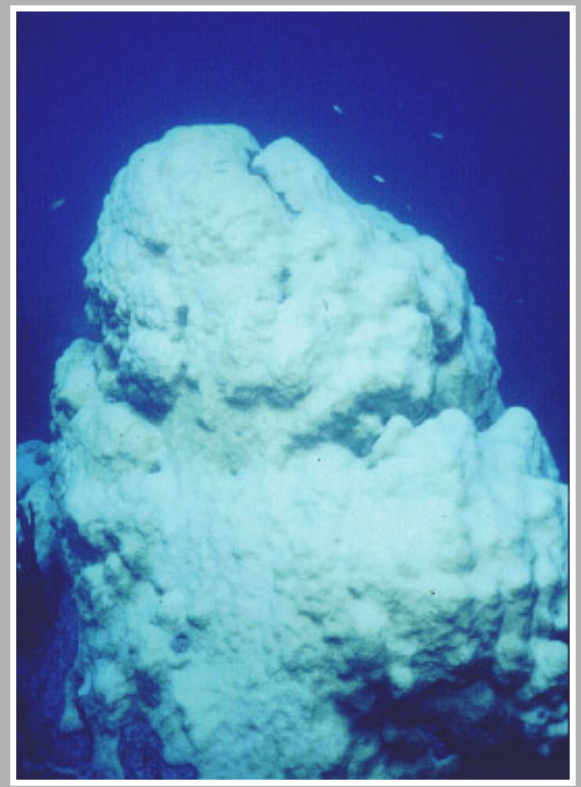
Coral Bleaching Trends (Cont.)

1990

- Doldrum weather patterns in July
- Massive bleaching

* Coral bleached inshore for the first time
* Large-scale coral mortality for the first time
* - Implemented monitoring protocol
  - 65% of fire coral on some reefs

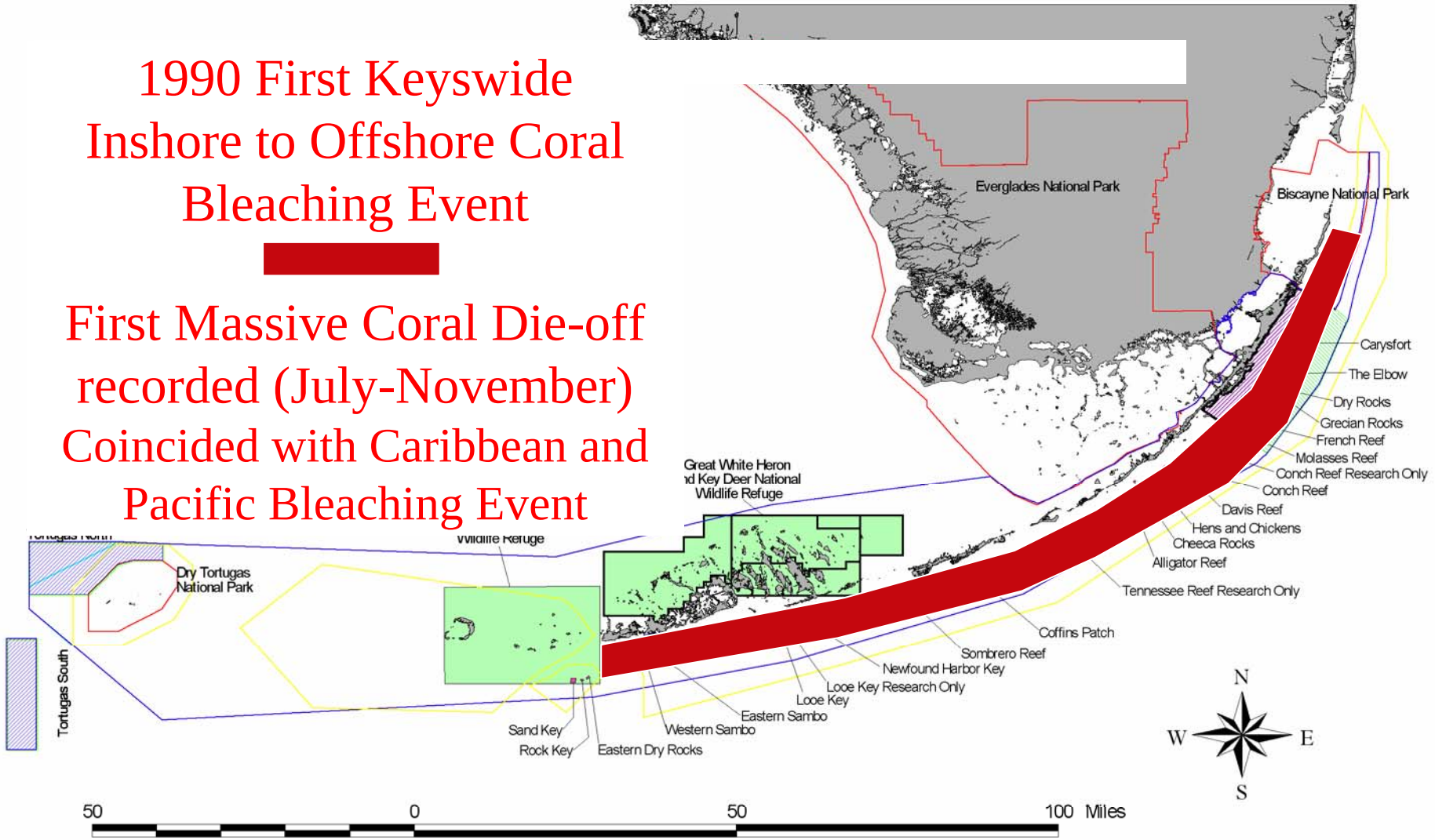
- Global bleaching event



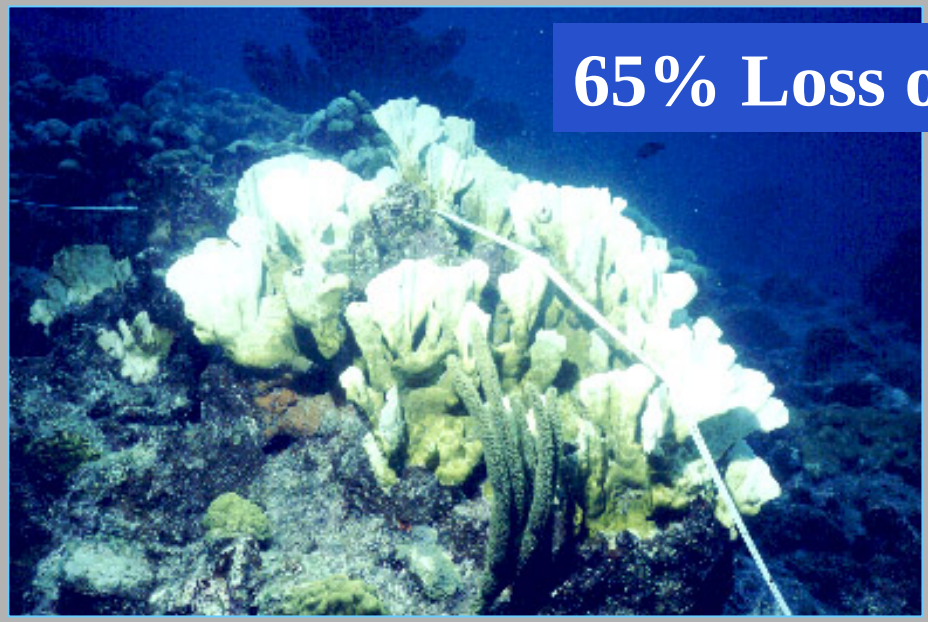
Florida Keys National Marine Sanctuary

1990 First Keyswide Inshore to Offshore Coral Bleaching Event

First Massive Coral Die-off recorded (July-November) Coincided with Caribbean and Pacific Bleaching Event



1990



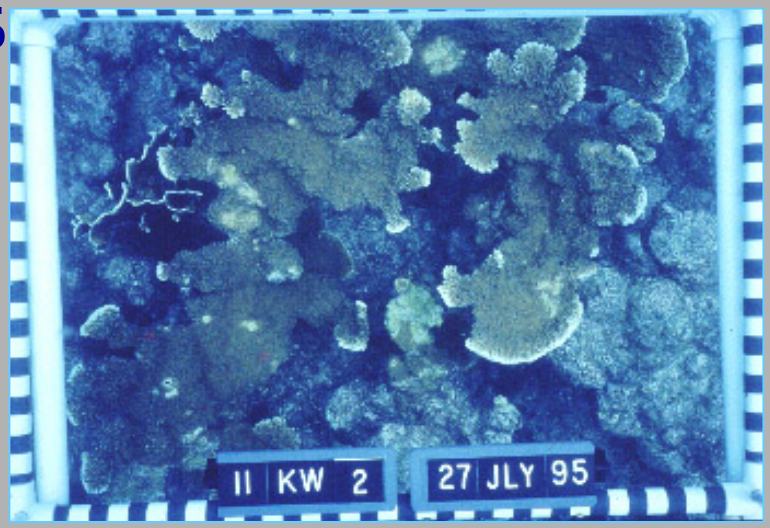
Fire coral bleaching

1990

Fire coral mortality

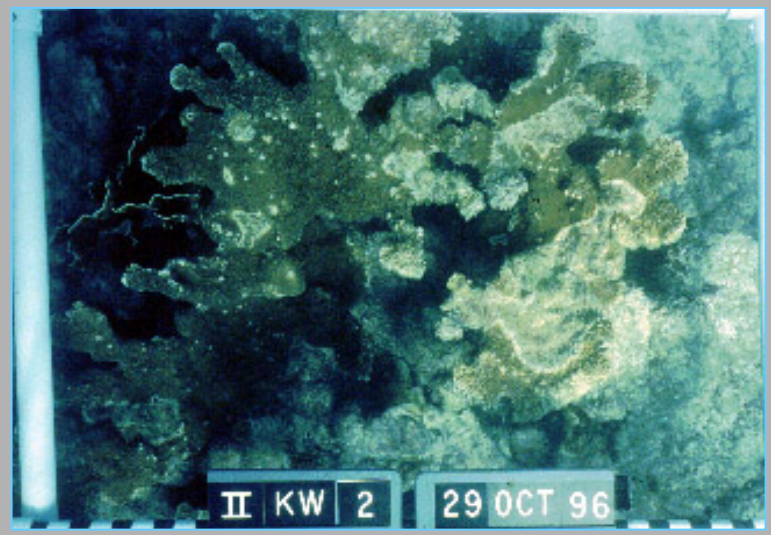
65% Loss of Fire coral

1995



Healthy coral

1996

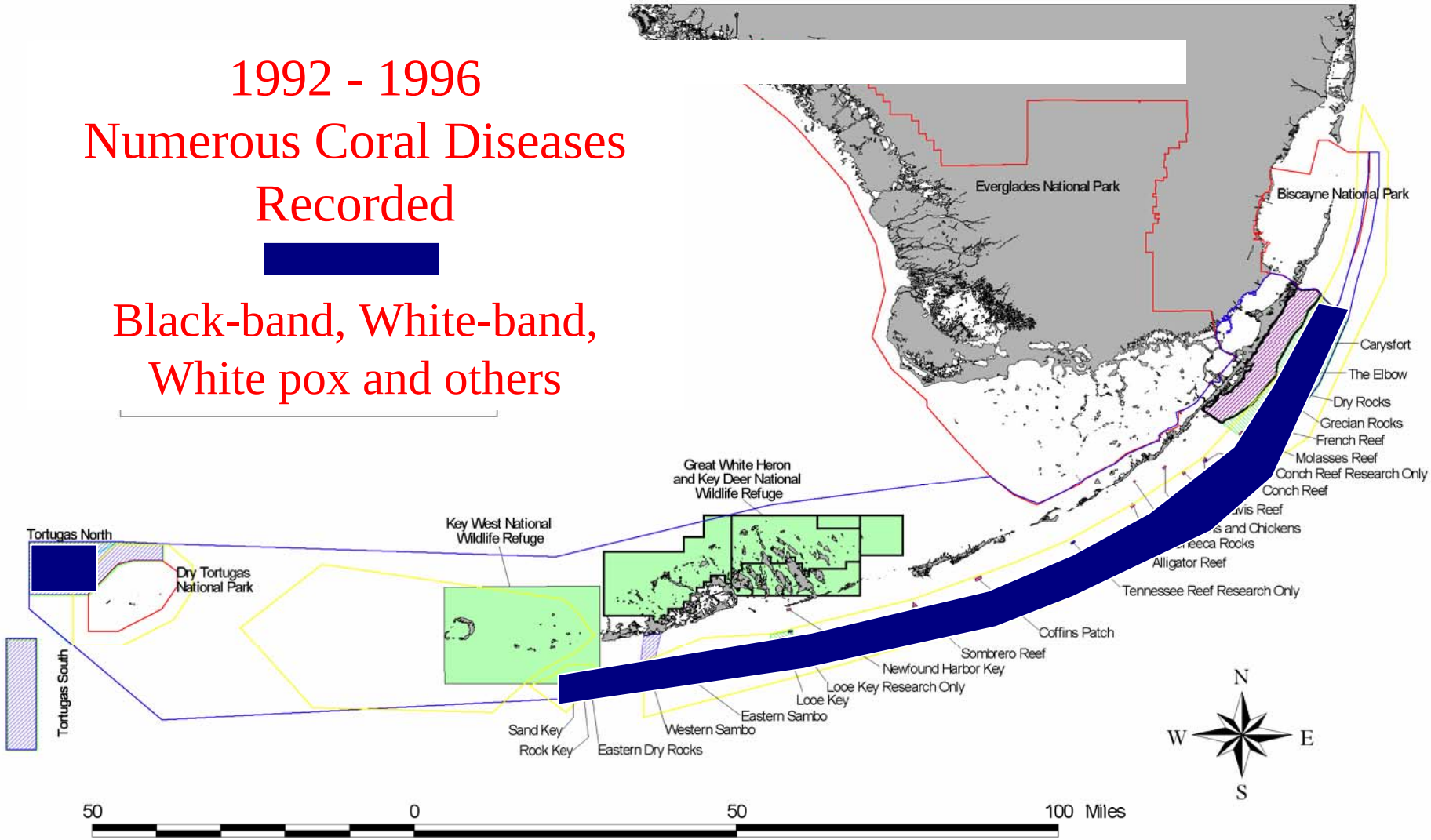


Diseased coral

Florida Keys National Marine Sanctuary

1992 - 1996
Numerous Coral Diseases Recorded

Black-band, White-band, White pox and others



Coral Bleaching Trends (Cont.)

1997

- Doldrum weather patterns
- Massive bleaching
- Inshore and offshore corals affected
- Alerts from 3rd generation Florida Keys residents
- Large loss of living corals
- Global bleaching event

Coral Bleaching Trends (Cont.)

1998

- Water remained warm from 1997
- Massive bleaching continued
- Inshore and offshore corals affected
- Continued loss of living corals
- Global bleaching event

* First back-to-back annual coral bleaching

- Hurricane Georges

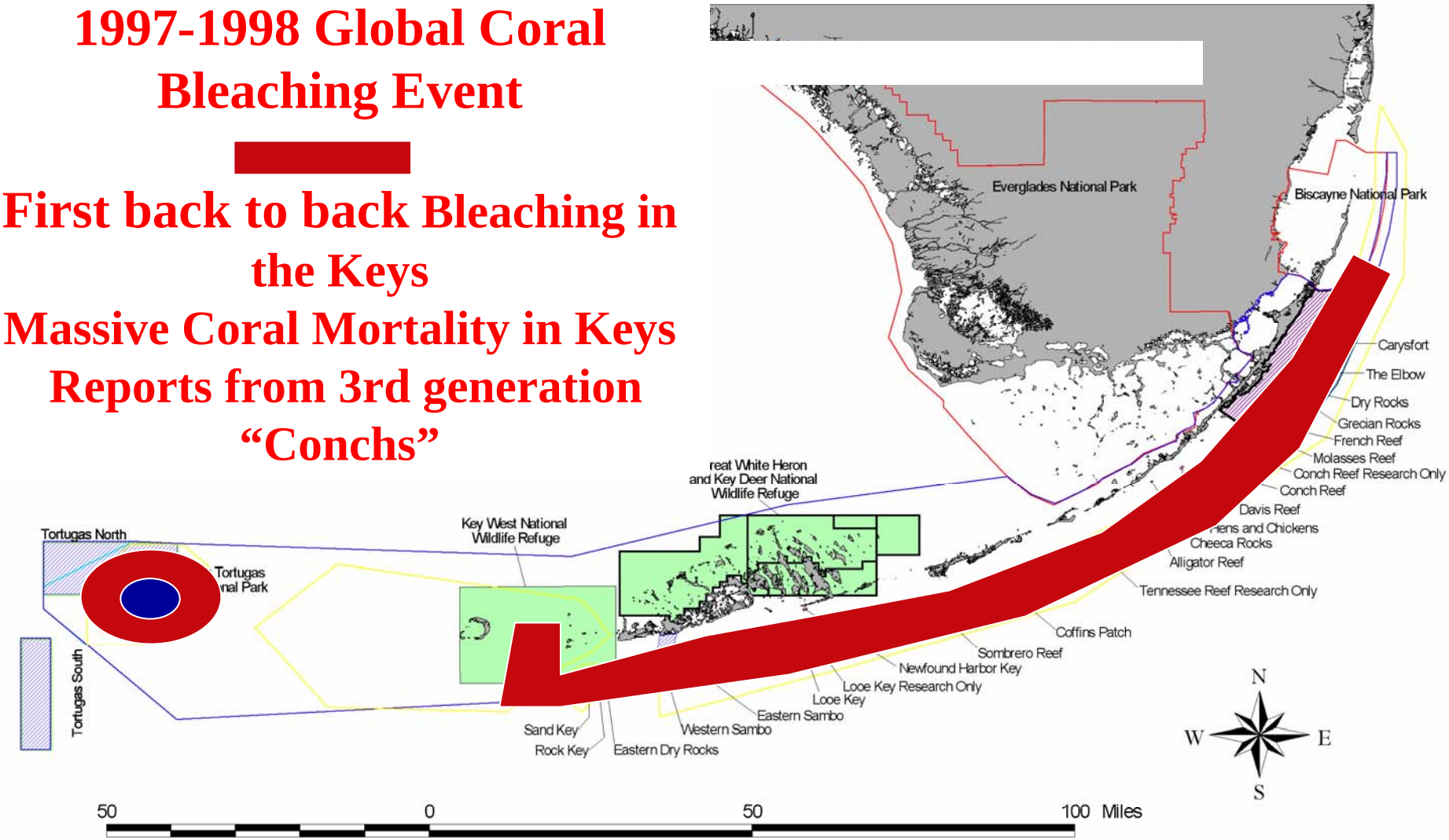
Florida Keys National Marine Sanctuary

1997-1998 Global Coral Bleaching Event

First back to back Bleaching in the Keys

Massive Coral Mortality in Keys

Reports from 3rd generation "Conchs"

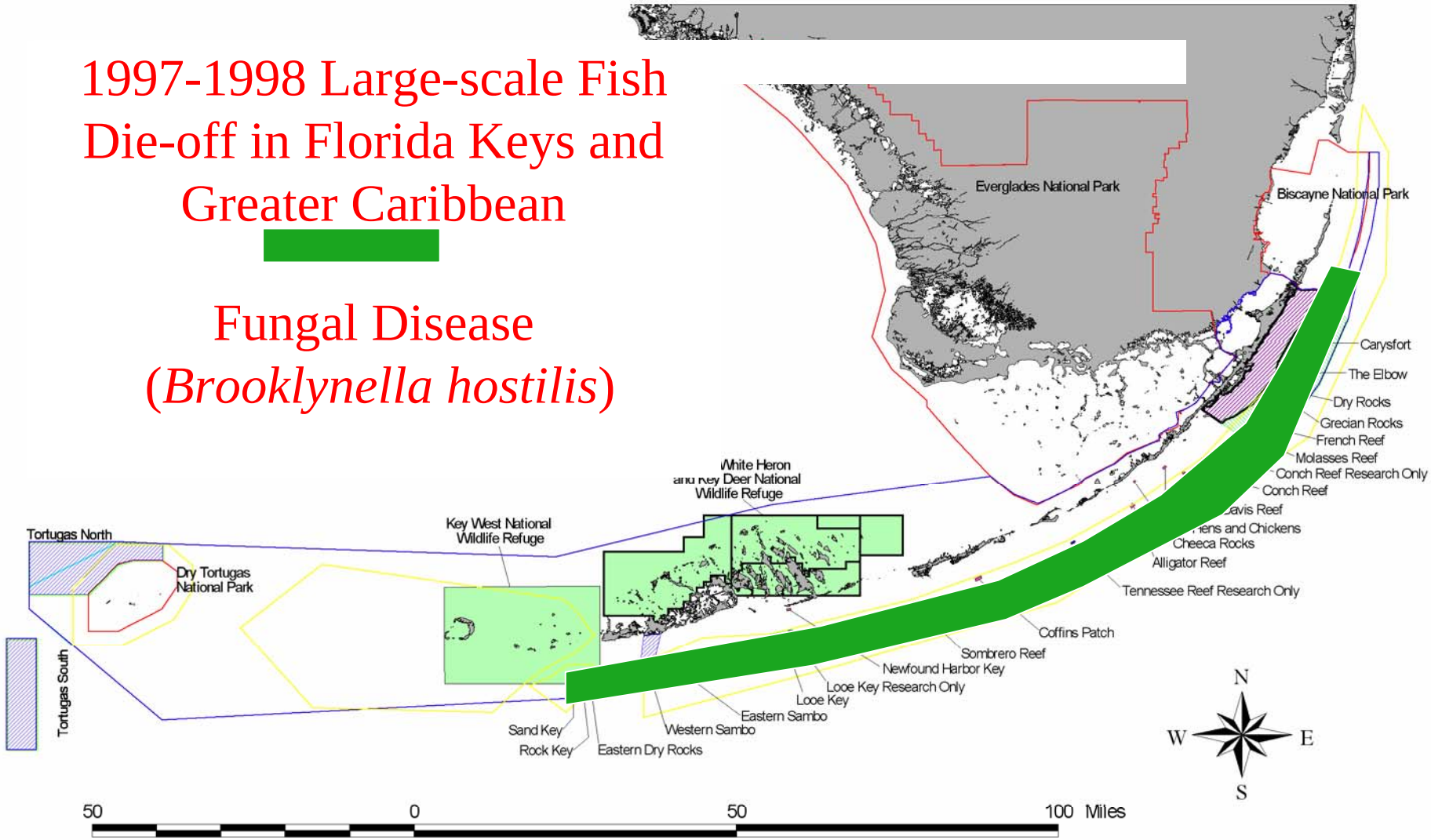


*Footnote: Sept to Nov 1998 - Hurricane Georges and Tropical Storm Mitch hit Florida Keys

Florida Keys National Marine Sanctuary

1997-1998 Large-scale Fish Die-off in Florida Keys and Greater Caribbean

Fungal Disease (*Brooklynella hostilis*)



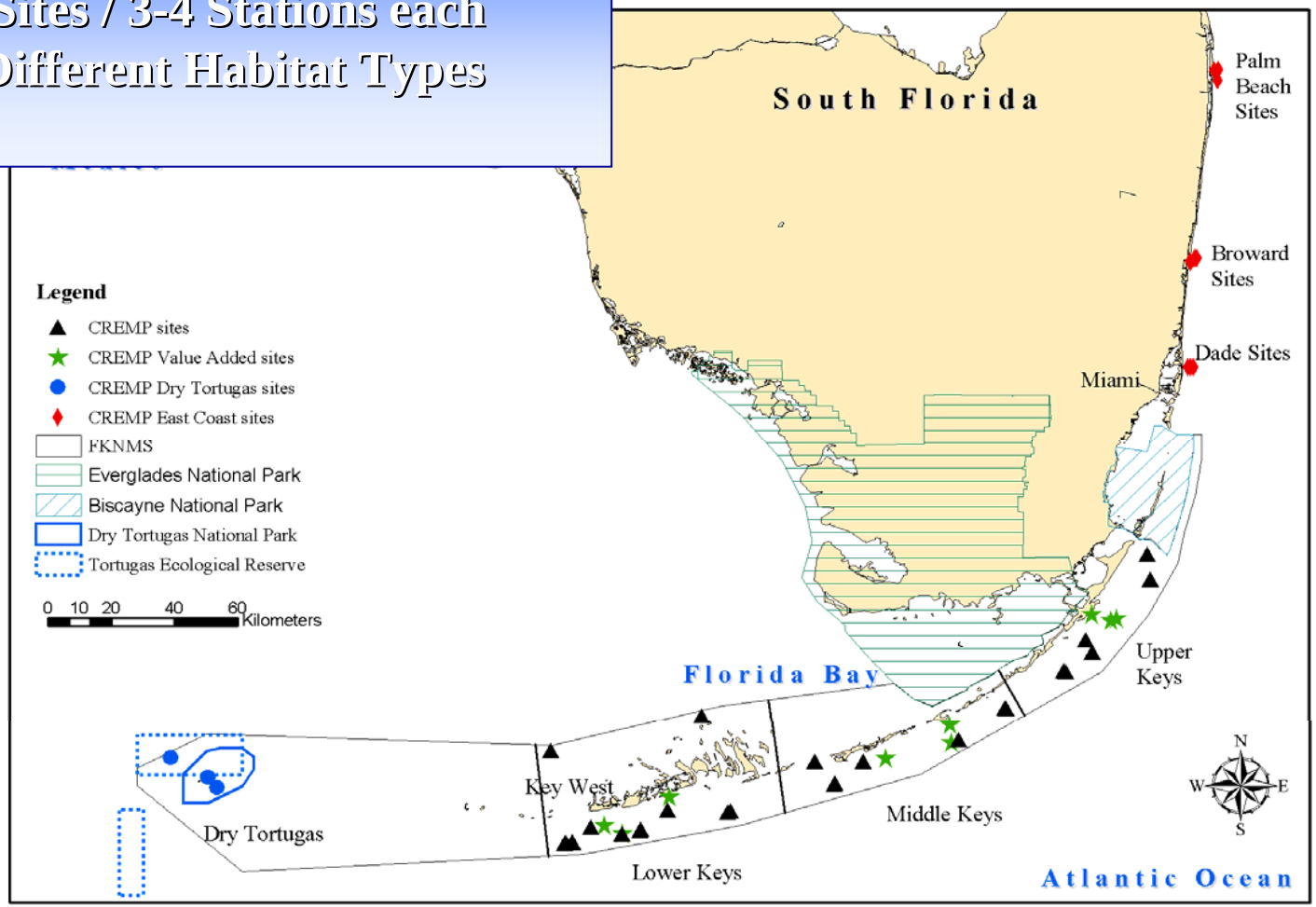
Coral Bleaching Trends Summary

- Local patterns of increased duration
- Patterns of geographical expansion
- Coral reefs are responding to warming trends

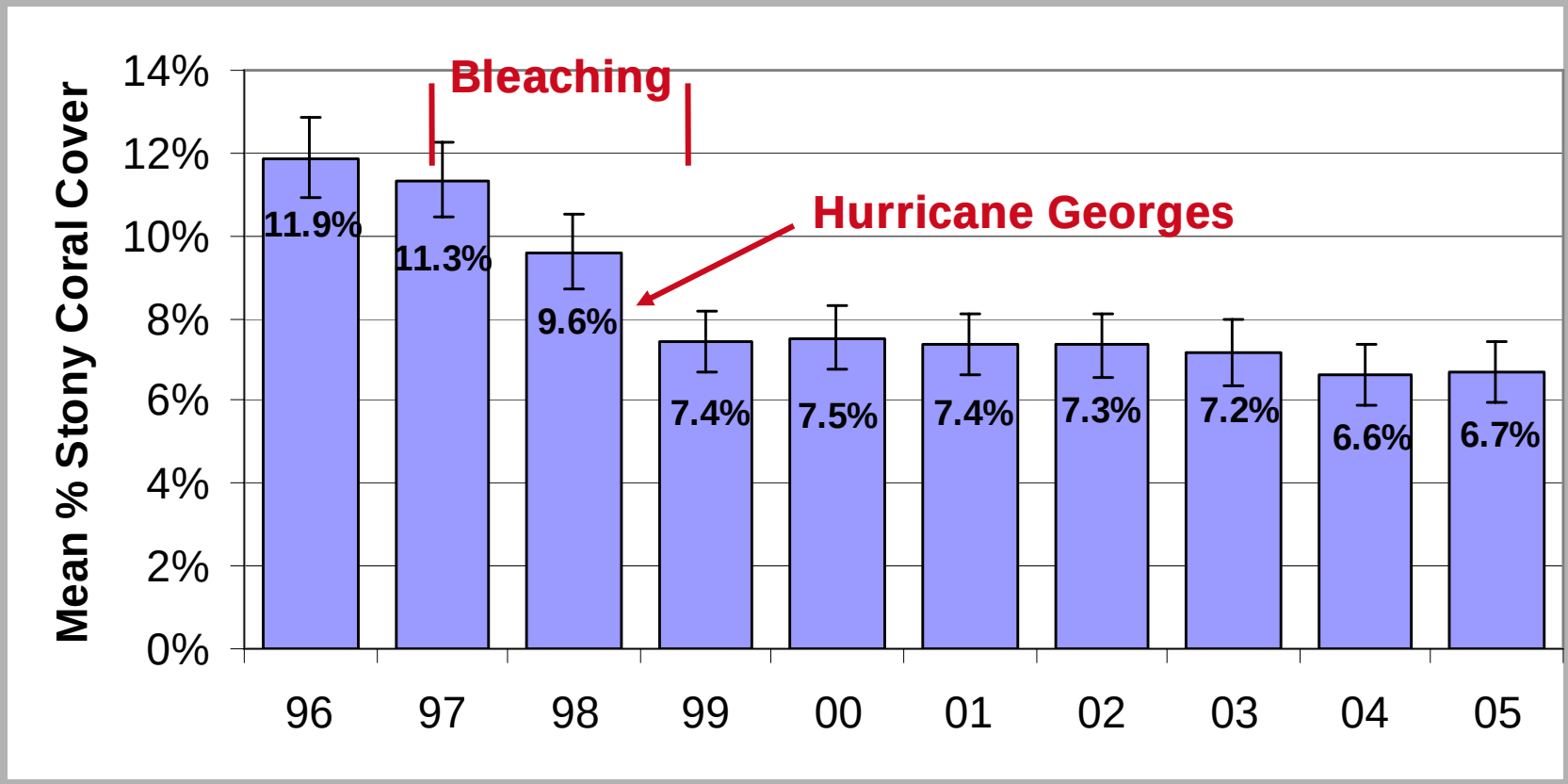
Coral Reef Evaluation and Monitoring Project (CREMP)

FWC Coral Biologists

- 43 Sites / 3-4 Stations each
- 4 Different Habitat Types



Stony Coral Cover Sanctuary-wide 1996-2005



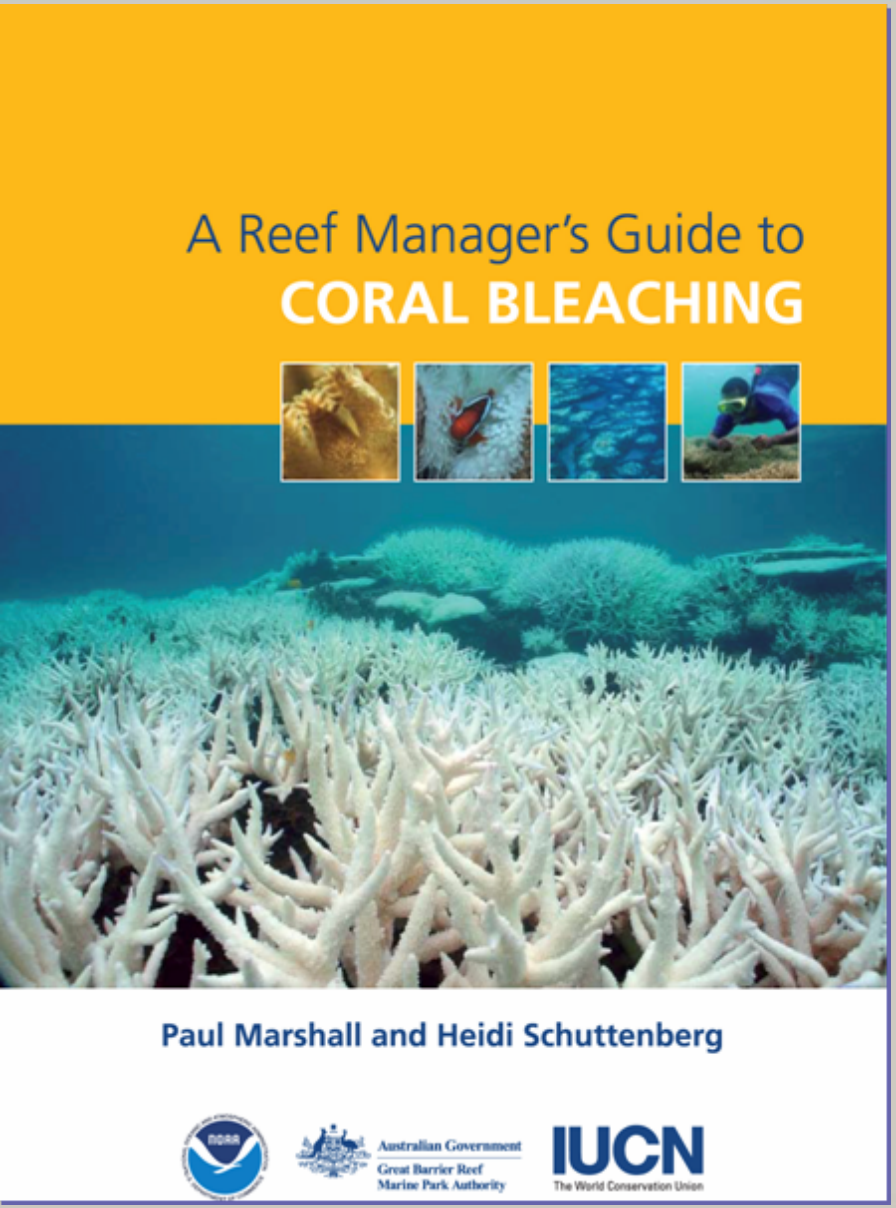
A decrease in stony coral cover was observed sanctuary-wide for each year from 1997 through 1999. Mean percent stony coral cover in 2005 did not change significantly (alpha = 0.05). Sanctuary-wide during 2005, mean stony coral cover was 6.7%.

http://www.floridamarine.org

Impacts of Climate Change

What can coral reef managers do to manage coral reefs in light of climate change?

Reef Manager's Guide



October 2006 Roll-out Of Reef Manager's Guide

- Need for management response
- Guide Offers a Framework
- Local Management Actions
- Examples of Local Actions

Possible Management Actions

- **Utilize *in situ* and remote sensing observations to predict and plan for bleaching events**
- **Communicate observations to the public, scientists and other managers – <u>engage the public</u>**
- **Target research at specific questions**
- **Apply the concept of *Reef Resiliency* in planning**

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Importance of *in situ* observations

In predicting coral bleaching events

- **Doldrum conditions for extended periods**
- **Low Cloud cover**
- **Minimal water circulation**
- **Elevated Sea Surface temperatures**
- **Has increased the public's confidence in science and government**

In-Situ Monitoring

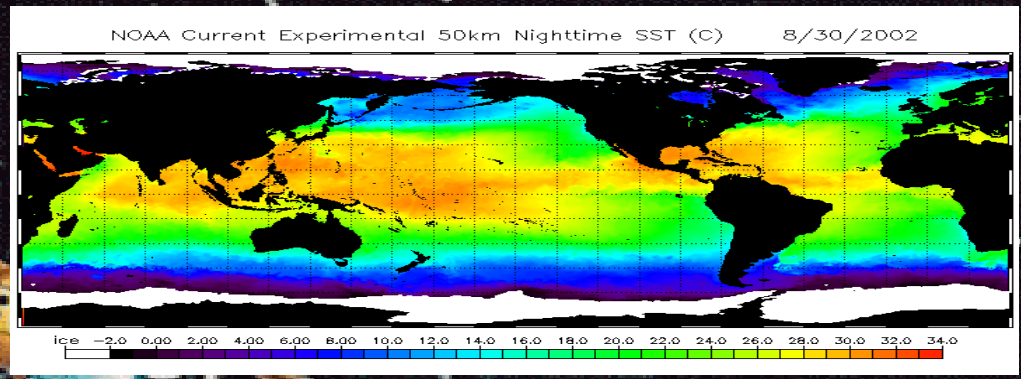
NDBC/FIO/FKNMS/SeaKeys Stations

NOAA Coral Reef Watch Program

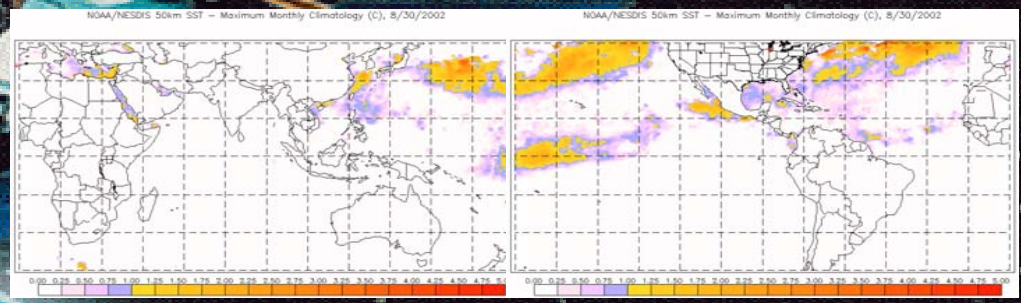
Satellite Near Real-Time Coral Bleaching HotSpot Products

(Twice-weekly at 50km resolution)

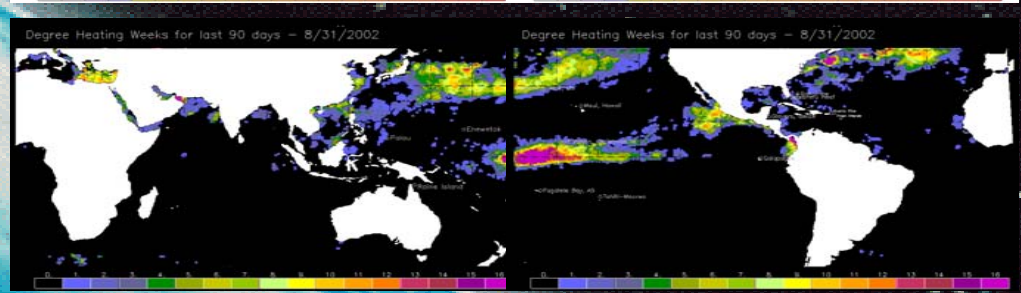
Sea Surface Temperature
(Night-time only)



Bleaching HotSpots



Degree Heating Weeks (DHW)



http://coralreefwatch.noaa.gov

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Florida Keys Coral Bleaching Early Warning Network

"BleachWatch"

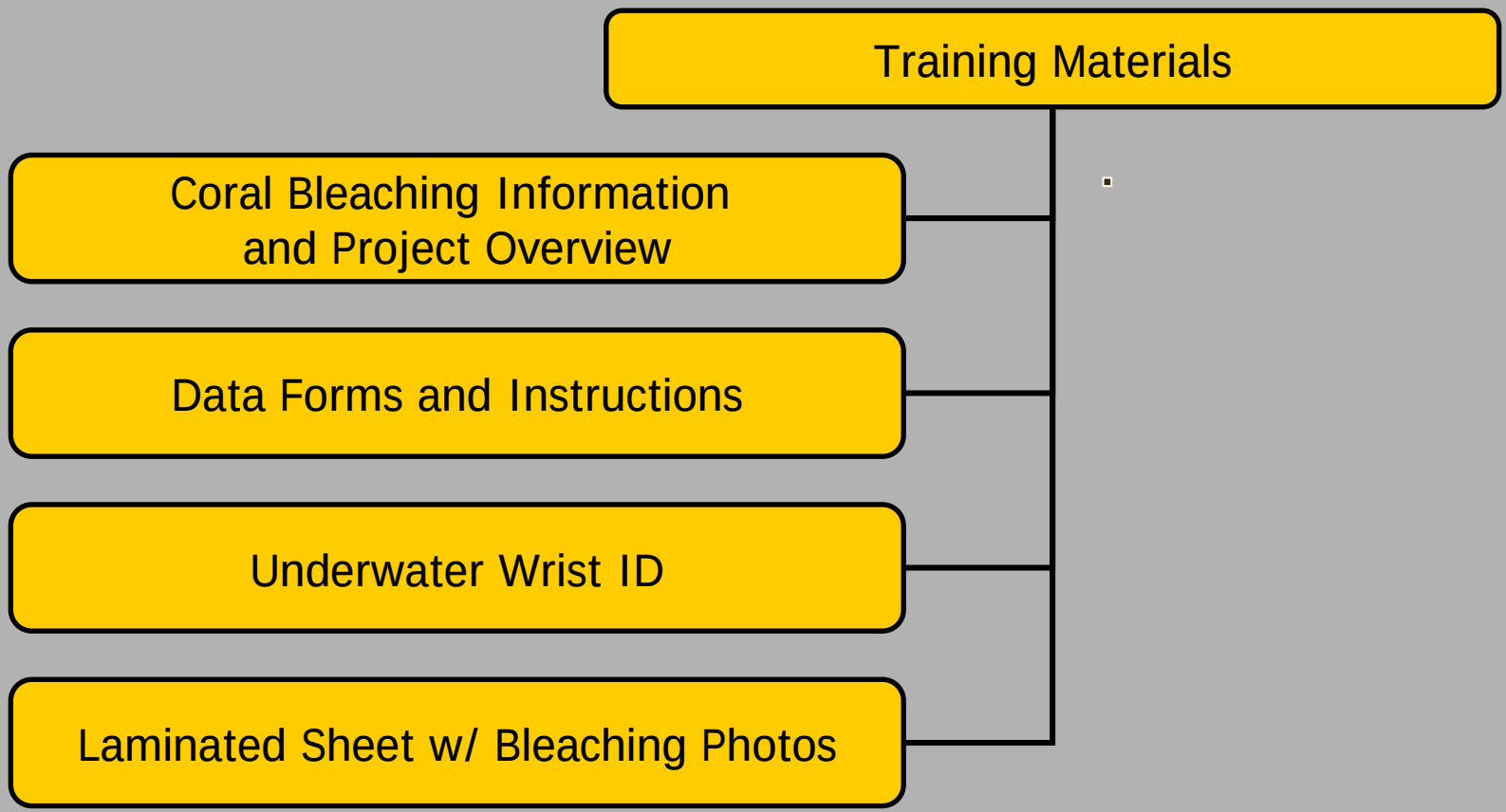
Erich Bartels

Cory Walter

Florida Keys “BleachWatch” Early Warning Network

- Provides an “Early Warning” for coral bleaching events within the FKNMS and surrounding waters.
- Provides FKNMS with a “Current Conditions” overview, including recent volunteer observations and other environmental monitoring data.
- Involves the community in monitoring coral reef health.

Volunteer Observer Training and Coordination

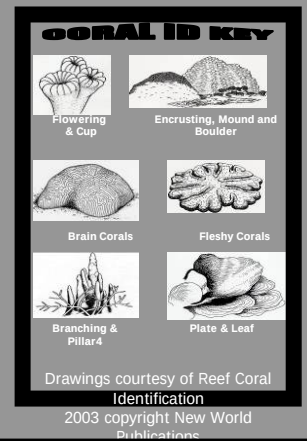


Bleaching Observations

- Severity of Bleaching

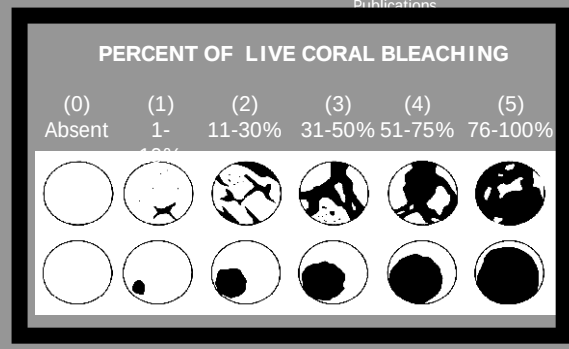
- Types of Corals Bleached

Coral ID Table



- Percent of Bleached Corals

Percent Cover/Bleaching Table



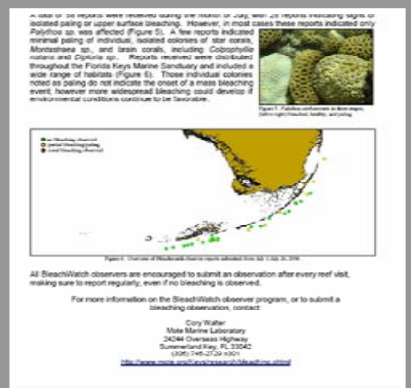
Current Conditions Report

Available online:

www.mote.org/Keys/bleaching.phtml

Updated According to Environmental Conditions

- Sea Temperature Information
- Relevant Weather Conditions
- NOAA's HotSpot Maps and DHW Maps
- Summary of Field Data from Observers
- Photos



All BleachWatch observers are encouraged to submit an observation after every reef visit, making sure to report regularly, even if no bleaching is observed.

For more information on the BleachWatch observer program, or to submit a bleaching observation, contact

Cory Walter
Mote Marine Laboratory
24244 Overseas Highway
Summerland Key, FL 33042

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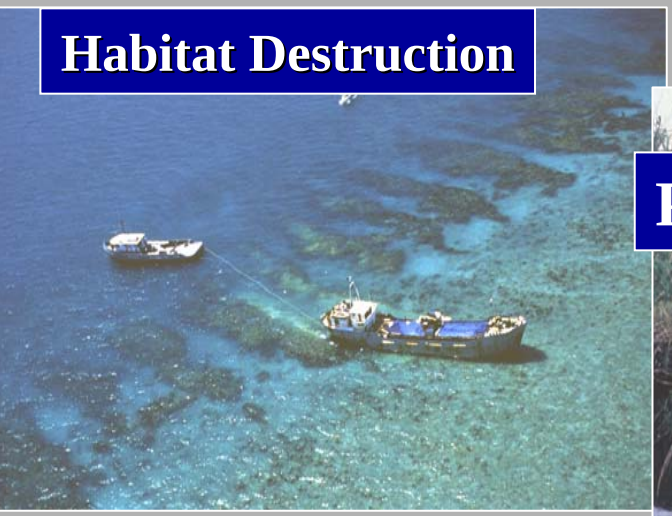
Suspected Causes of Coral Decline

Habitat Destruction

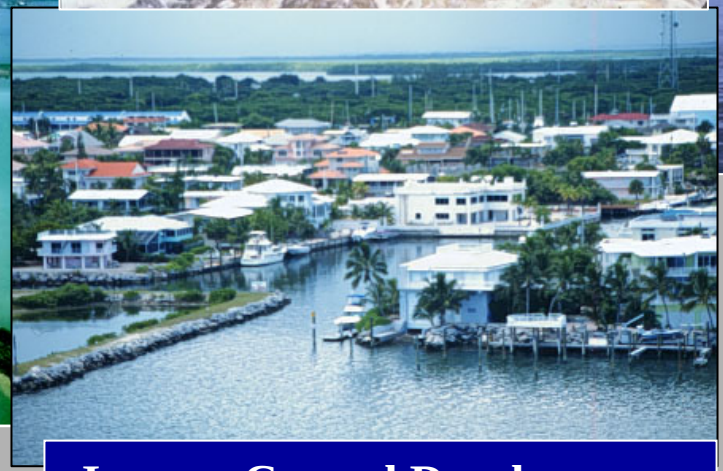


Pollution

Coral Diseases

Overfishing

Massive Algal Blooms



Intense Coastal Development

Ocean Dumping

Introduction of Marine Exotics

Research Directed at the Problems

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FEATURE ARTICLE

Regulation of microbial populations by coral surface mucus and mucus-associated bacteria

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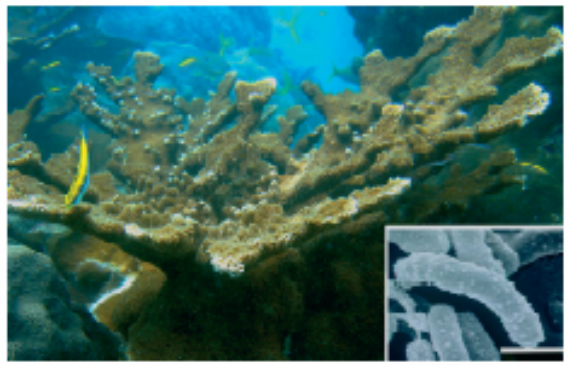
ABSTRACT: Caribbean populations of the elkhorn coral *Acropora palmata* have declined due to environmental stress, bleaching, and disease. Potential sources of coral mortality include invasive microbes that become trapped in the surface mucus and thrive under conditions of increased coral stress. In this study, mucus from healthy *A. palmata* inhibited growth of potentially invasive microbes by up to 10-fold. Among cultured bacteria from the mucus of *A. palmata*, 20% displayed antibiotic activity against one or more tester strains, including the pathogen implicated in white pox disease. A novel mucus-mediated selection for coral symbionts revealed a discrete subset of bacteria and selected for isolates that produce antibiotics. This result suggests that coral mucus plays a role in the structuring of beneficial coral-associated microbial communities and implies a microbial contribution to the antibacterial activity described for coral mucus. Interestingly, antibiotic activity was lost when mucus was collected during a summer bleaching event. Isolates from apparently healthy *A. palmata* tissue during this event lacked



This study found that mucus from healthy *Acropora palmata* (*photo*) inhibits the growth of potentially invasive microbes by up to 10-fold. Conversely, mucus collected during a summer bleaching event lacked antibiotic properties, suggesting that high temperatures reduce the protective function of coral mucus. Inset: *Vibrio* sp., which at high temperatures replace the community of beneficial bacteria (scale bar = 500 nm).

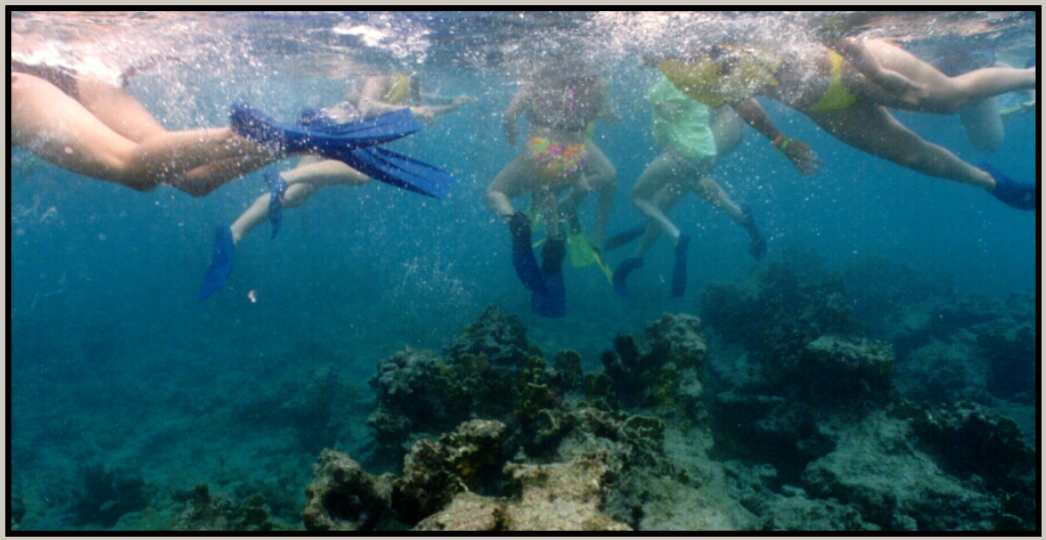
Photos: Kiho Kim (coral), Shawn Polson (inset)

Research Directed at the Problems

In Brief, the results are:

- ***Acropora palmata*** **has antibiotic activity that is lost when temperatures increase**

- **First evidence explaining why corals are more susceptible to disease during warming**

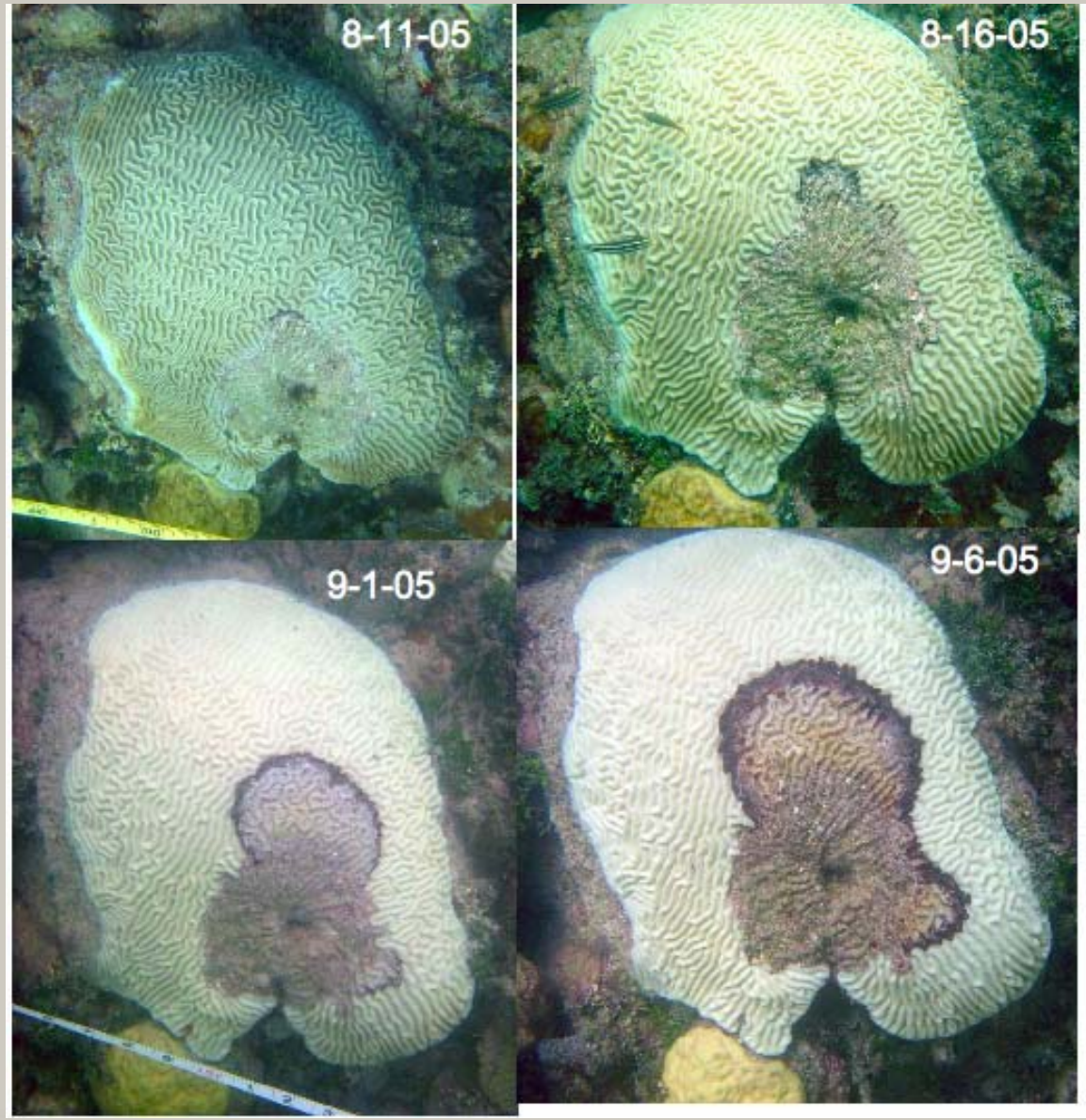


Research Directed at the Problems

Bleaching Can Promote Coral Disease Outbreaks

Inshore patch reefs
Middle Florida Keys

Marilyn E. Brandt
University of Miami

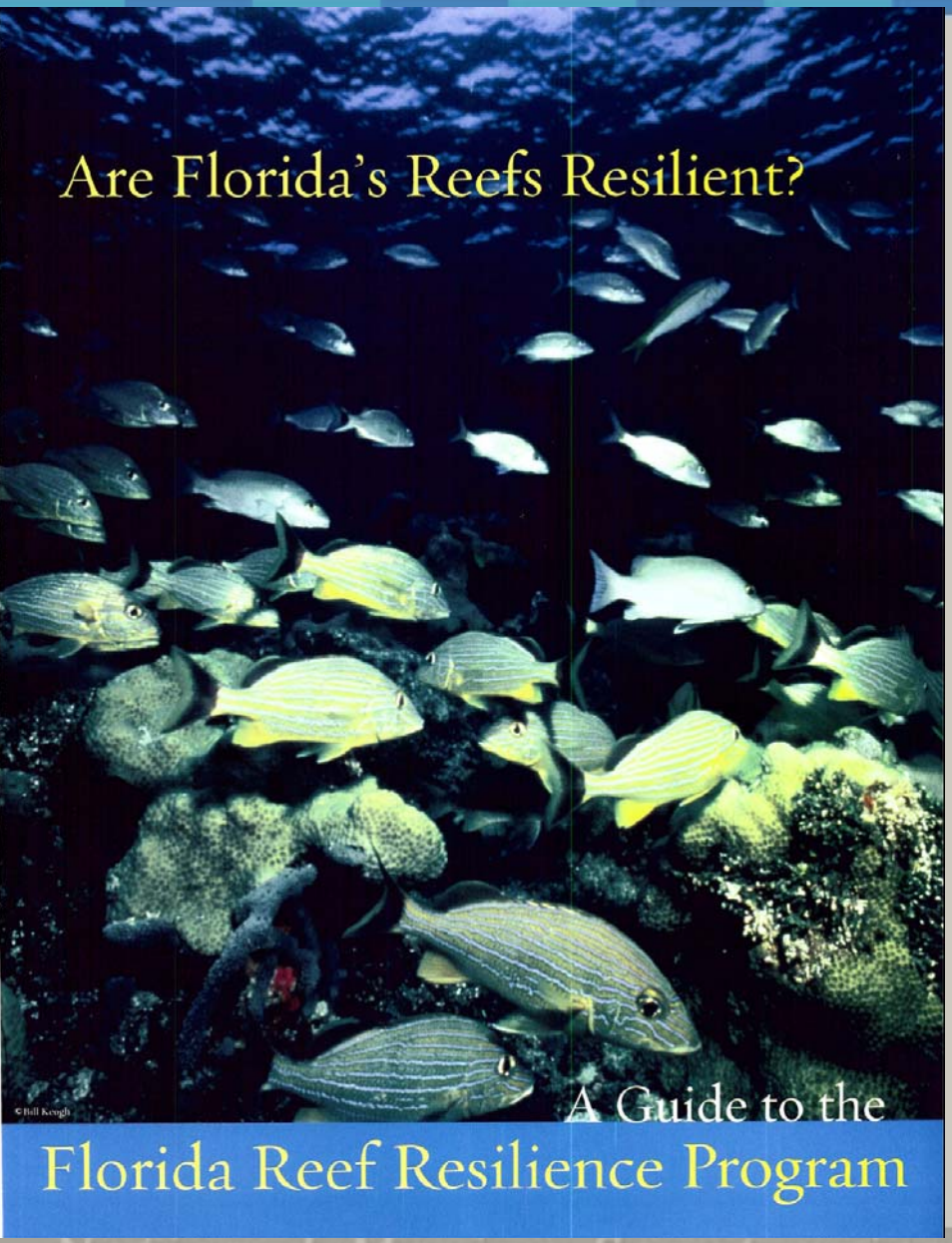


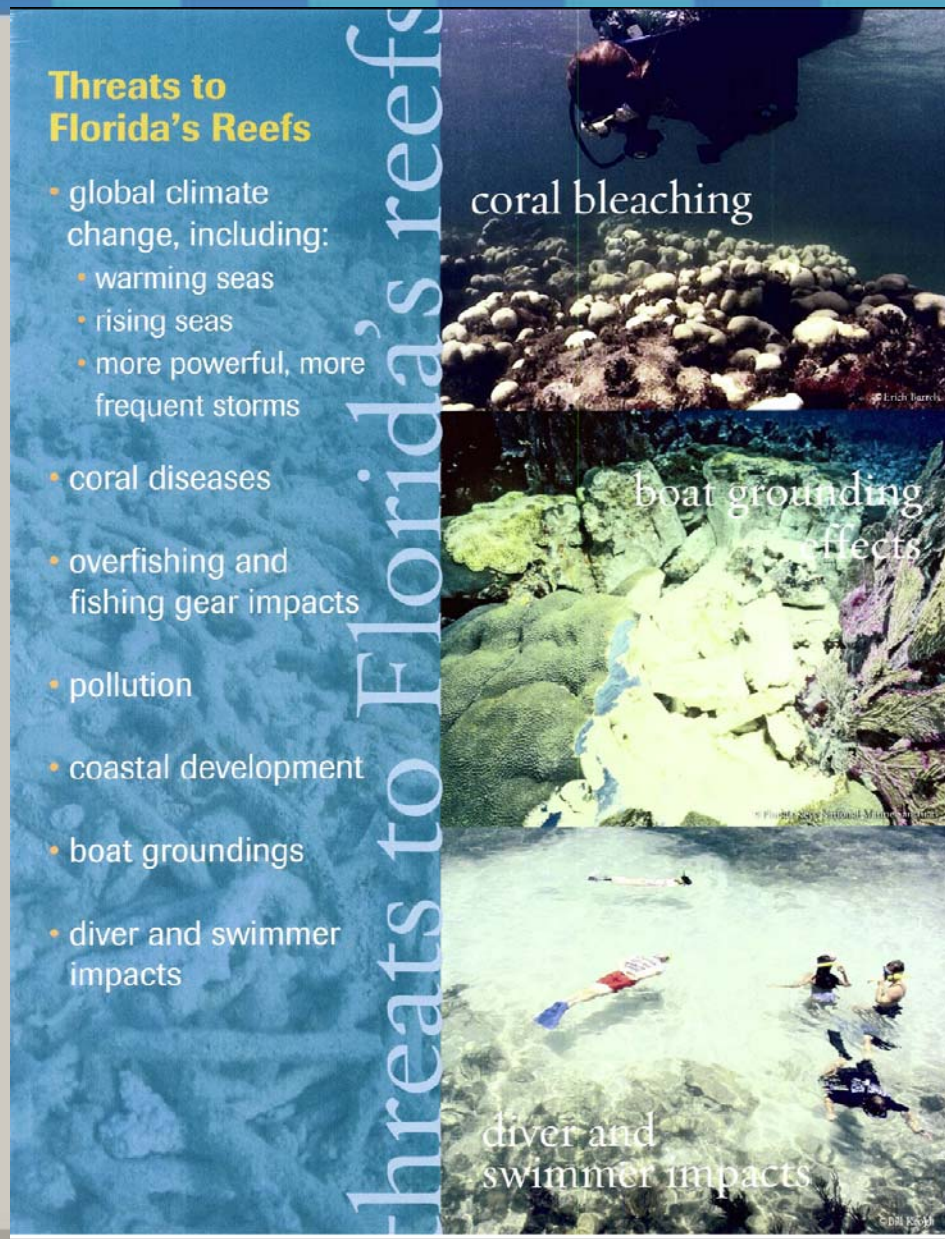
Possible Management Actions

- **Utilize *in situ* and remote sensing observations to predict and plan for bleaching events**
- **Communicate observations to the public, scientists and other managers – <u>engage the public</u>**
- **Target research at specific questions**
- **Apply the concept of *Reef Resiliency* in planning**

Florida's Reef Resilience Program

www.nature.org/florida





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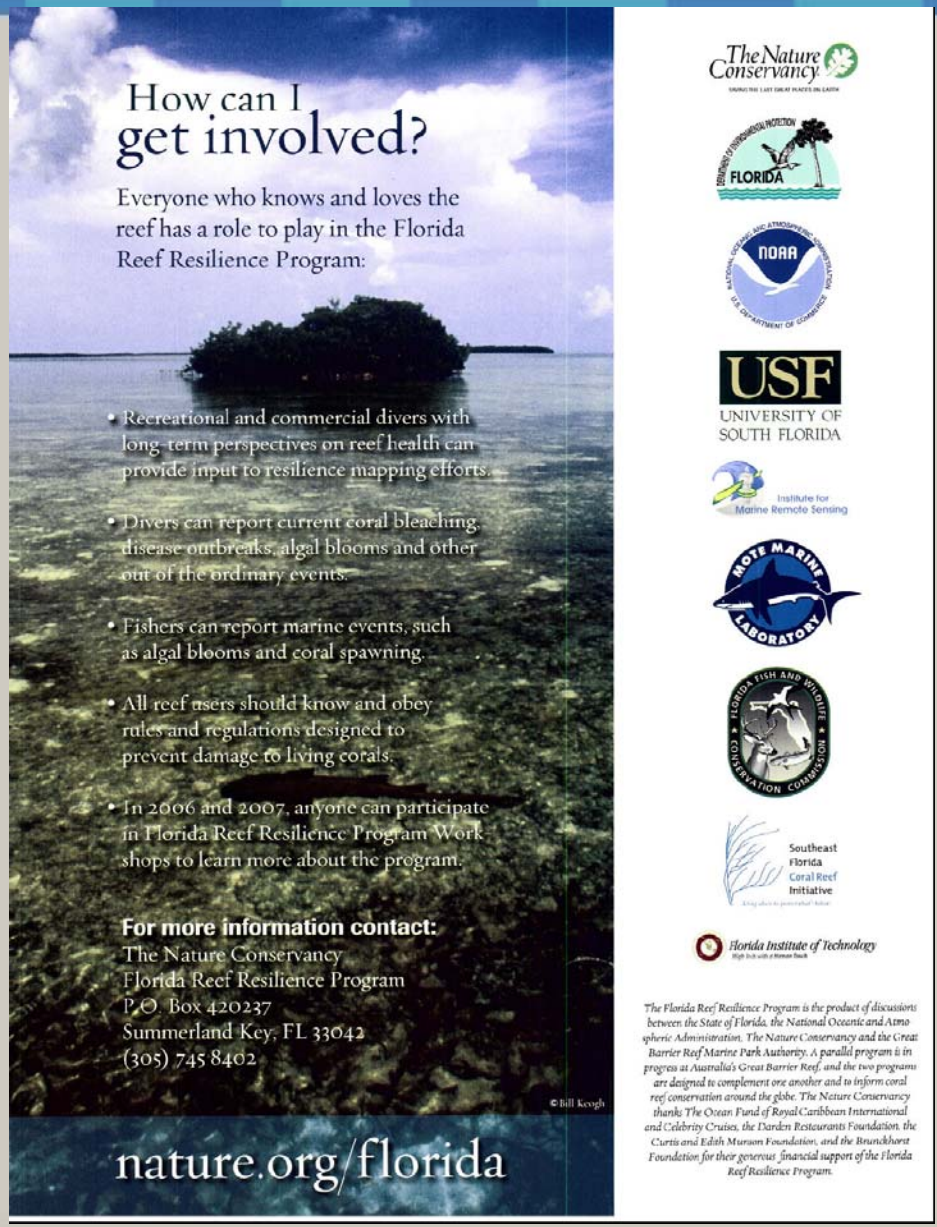
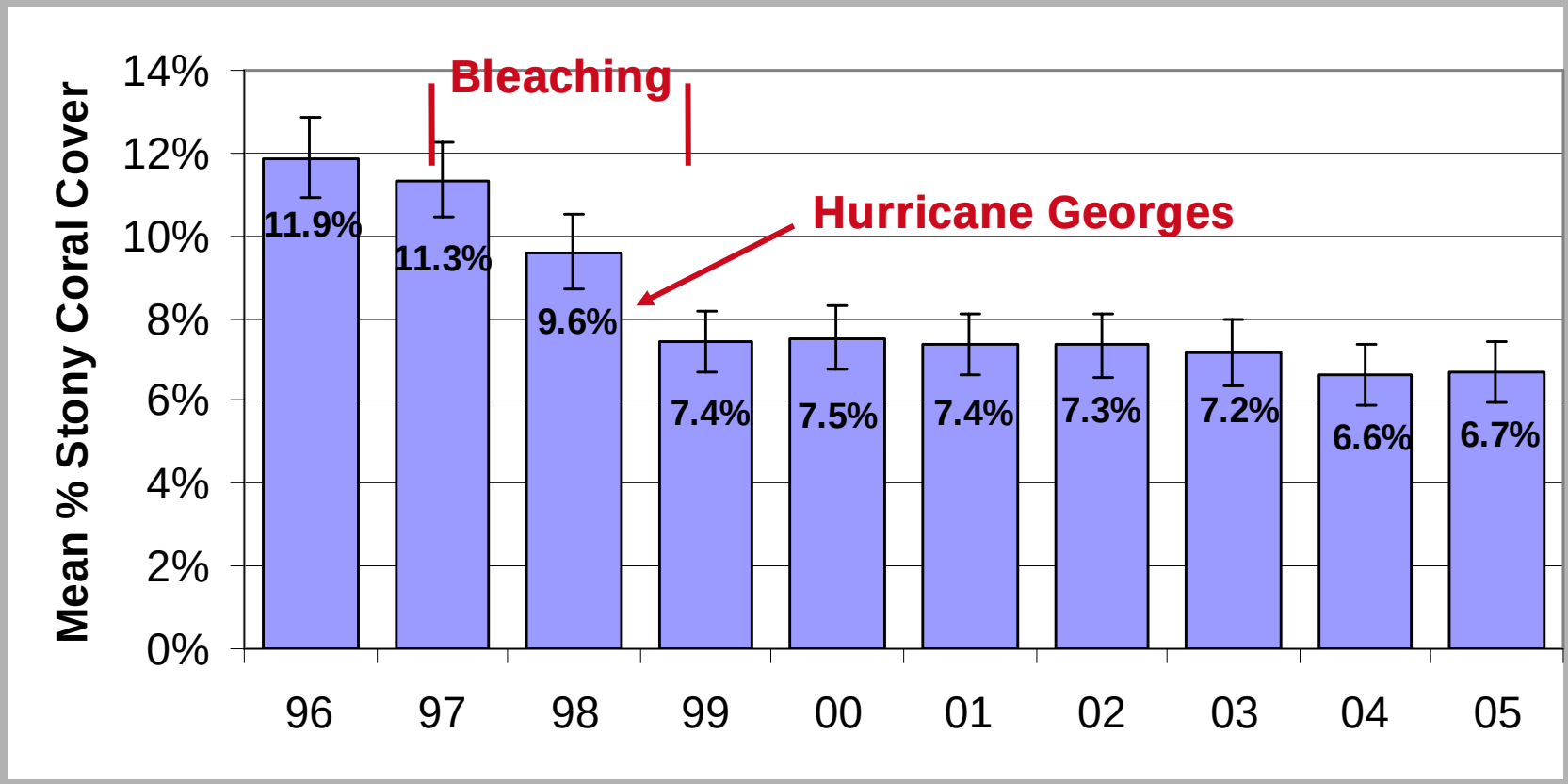


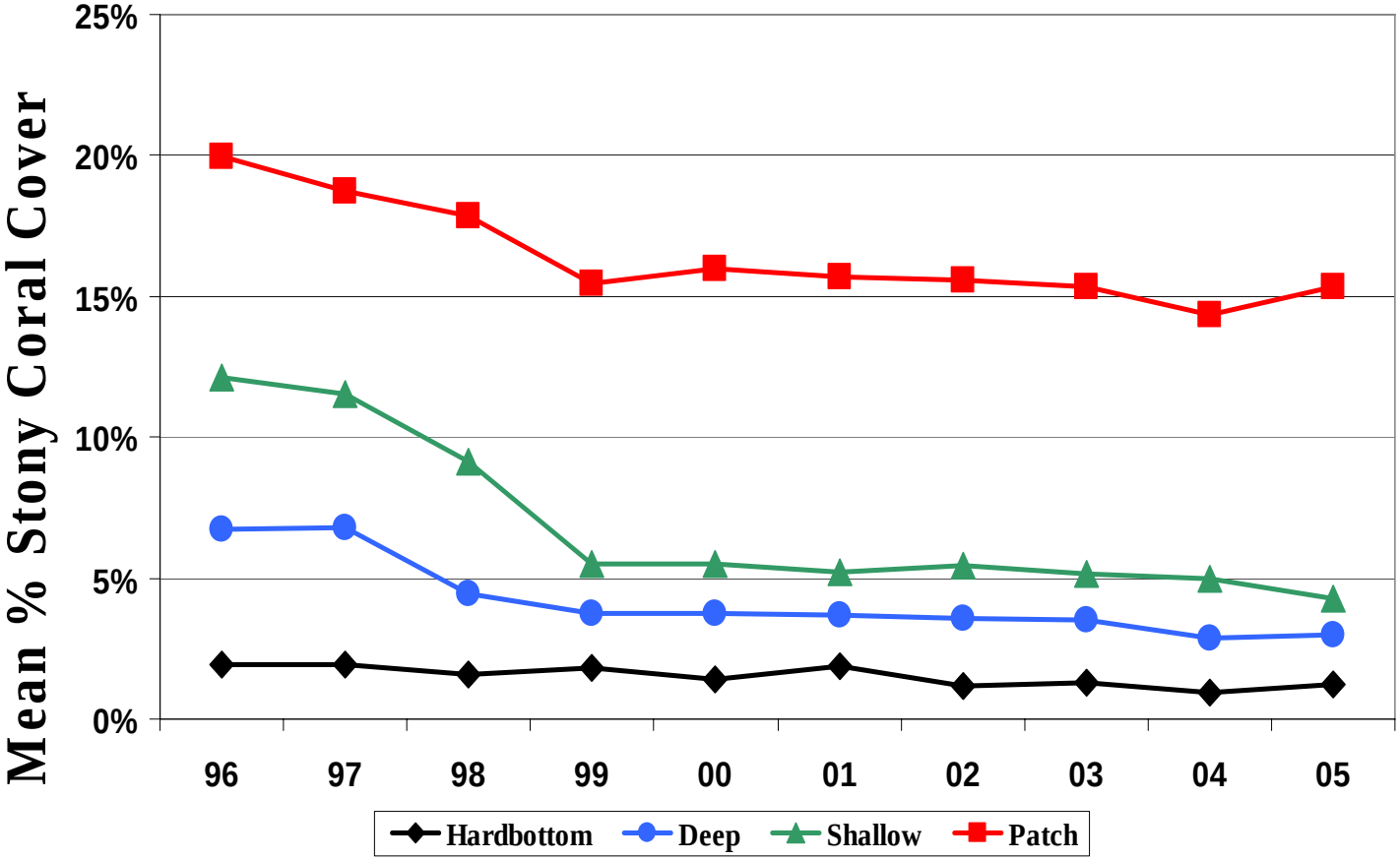
Stony Coral Cover Sanctuary-wide 1996-2005

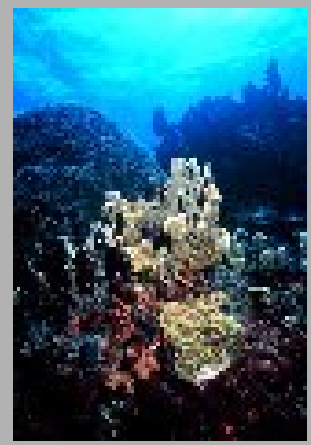


A decrease in stony coral cover was observed sanctuary-wide for each year from 1997 through 1999. Mean percent stony coral cover in 2005 did not change significantly (alpha = 0.05). Sanctuary-wide during 2005, mean stony coral cover was 6.7%.

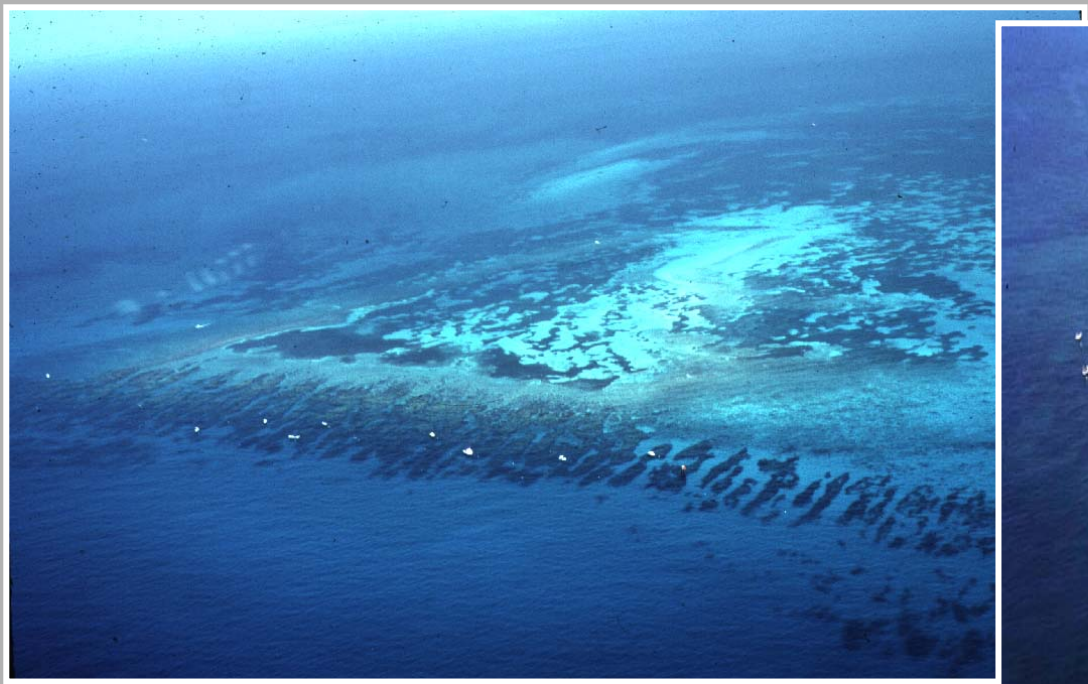
http://www.floridamarine.org

Stony Coral Cover by Habitat Type, 1996-2005



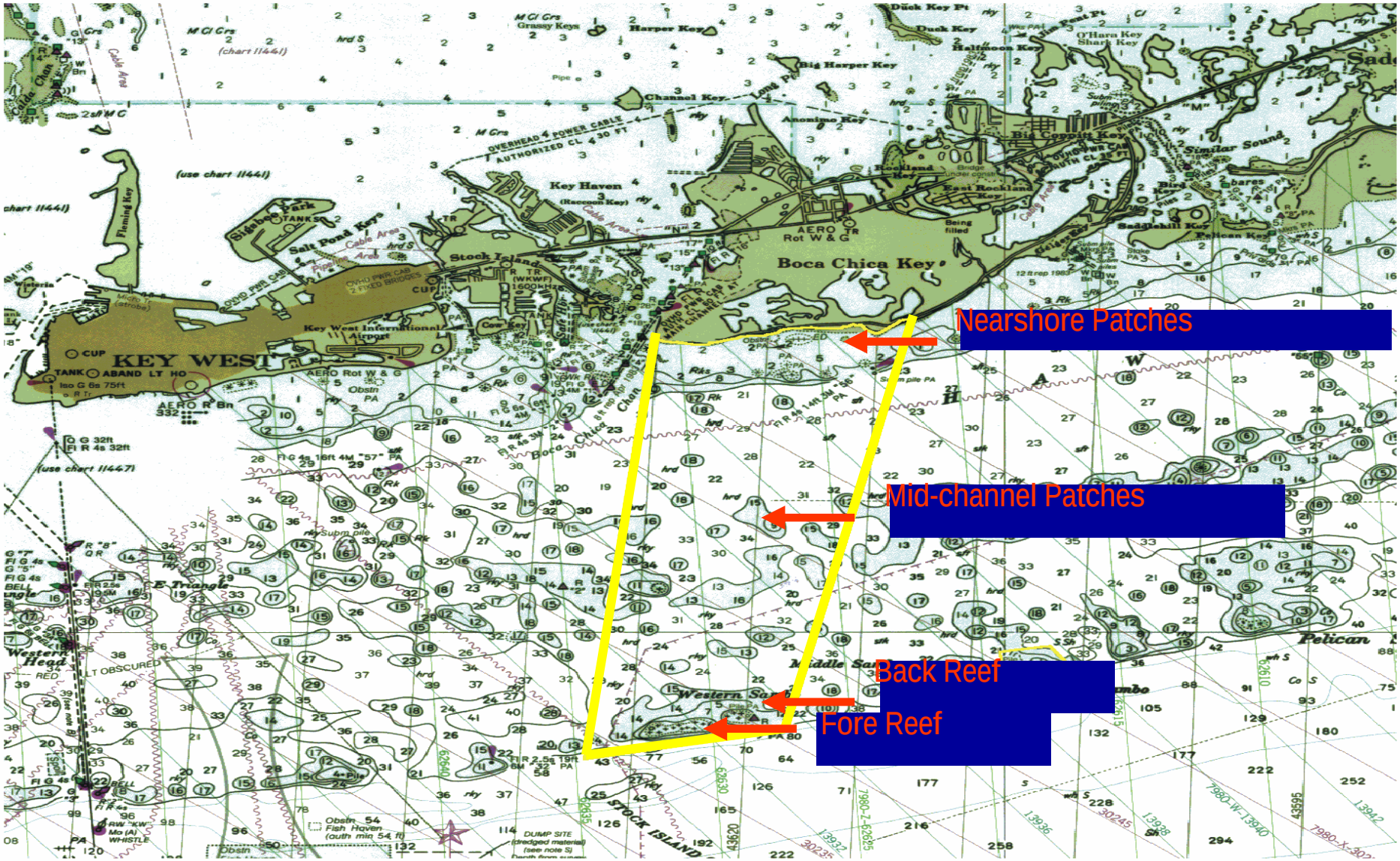


During 2005, stony coral cover increased at patch reef habitats, decreased at shallow reef habitats and remained unchanged at hard bottom & deep reef habitats.



Western Sambo Ecological Reserve

Examples of Resilient Reefs



Mid-channel Patch Reefs

Summary

- **Impacts of climate change observed in the late 1970's in the Keys and continues to intensify**
- **Scientists and Managers were divided in 1980's and 1990's about the cause of coral reef decline**
- **Has become apparent that climate change is the overarching impact affecting the health of the coral reef community of the Keys**
- **Other impacts such as: land-based sources of pollution; habitat destruction; and overfishing have to be addressed**

Questions?