Today's Management Challenges: Issues for the Keys Marine Ecosystem

Linking Science to Management
A Conference & Workshop on the Florida Keys Marine Ecosystem

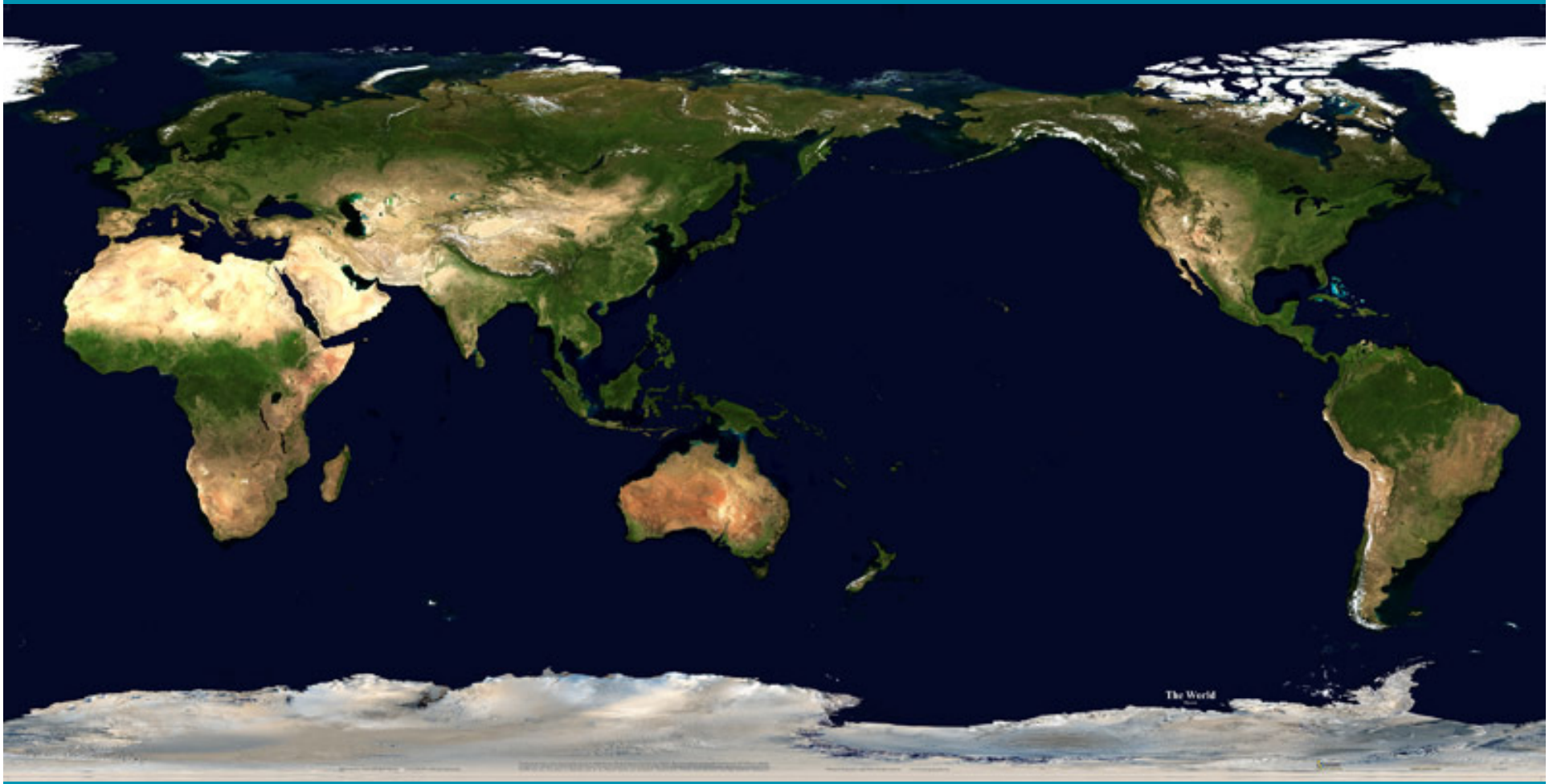
October 19-22, 2010
Hawk's Cay, Duck Key, Florida

Billy D. Causey, Ph.D.
Southeast Regional Director
NOAA's Office of National Marine Sanctuaries

Outline of Talk

- **Characterize the Setting**
  - **Biogeography of the Region**
  - **Biodiversity**
  - **Connectivity**
- **Social Economic Setting**
- **Major Threats to Coral Reefs**
- **Synergistic Effects of Stressors**
- **Research Focus – Microbes to Ecosystem Scale**

Pacific - Caribbean Biogeography



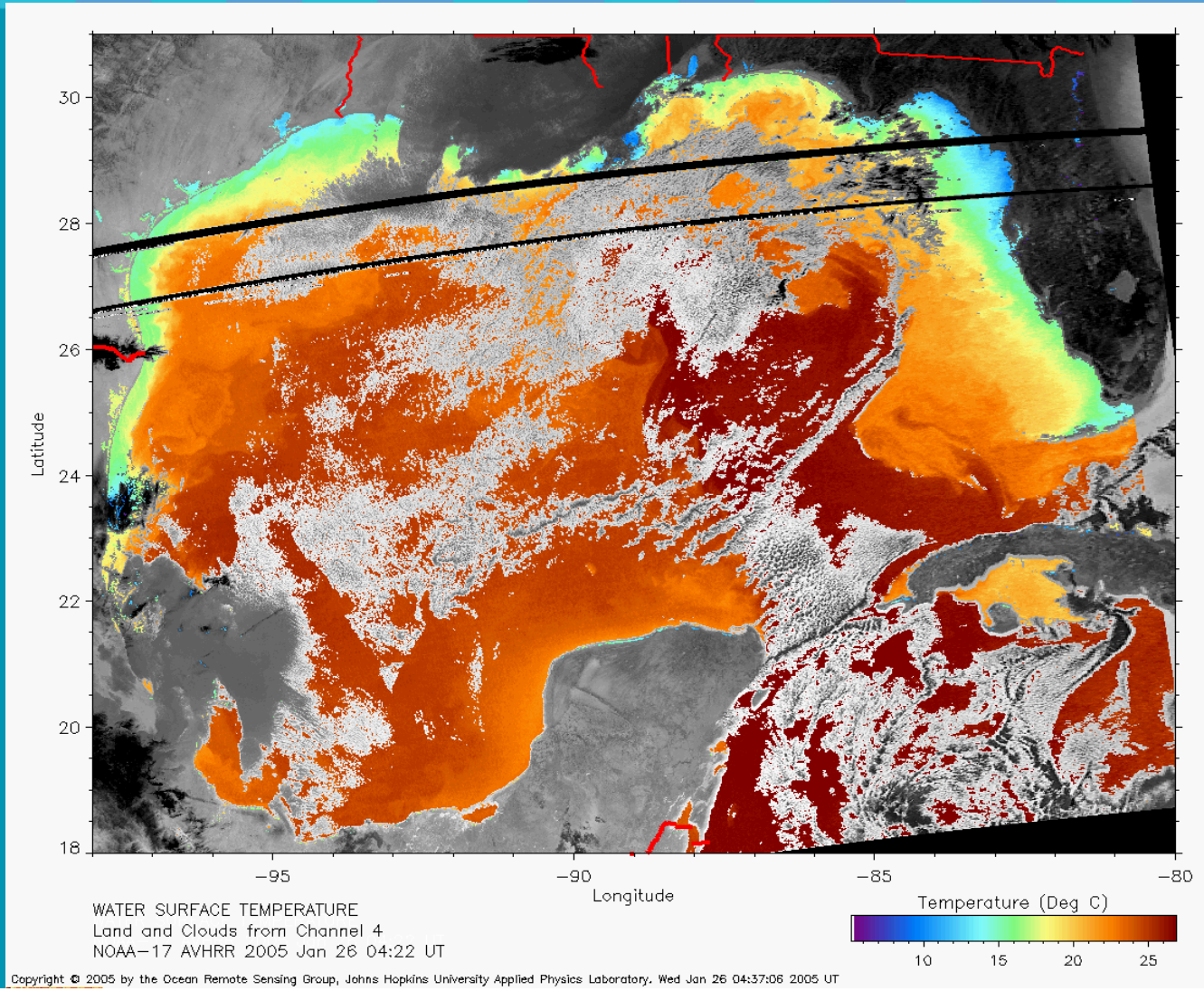

Two semi-enclosed basins
Atlantic Ocean
Gulf of Mexico
Caribbean Sea
90°W
80°W
70°W
60°W
30°N
20°N
10°N
Flower Garden Banks National Marine Sanctuary
Florida
The Bahamas
Cuba
Cayman Islands
Navassa
Haiti
Dominican Republic
Jamaica
Puerto Rico
Virgin Islands
Anguilla
St. Kitts and Nevis
Montserrat
Guadeloupe
Dominica
Martinique
St. Lucia
St. Vincent and the Grenadines
Grenada
Barbados
Trinidad and Tobago
Netherlands Antilles
Mexico
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Costa Rica
Panama
Colombia
Venezuela
Guyana

Florida Keys Biogeography

January 26, 2005

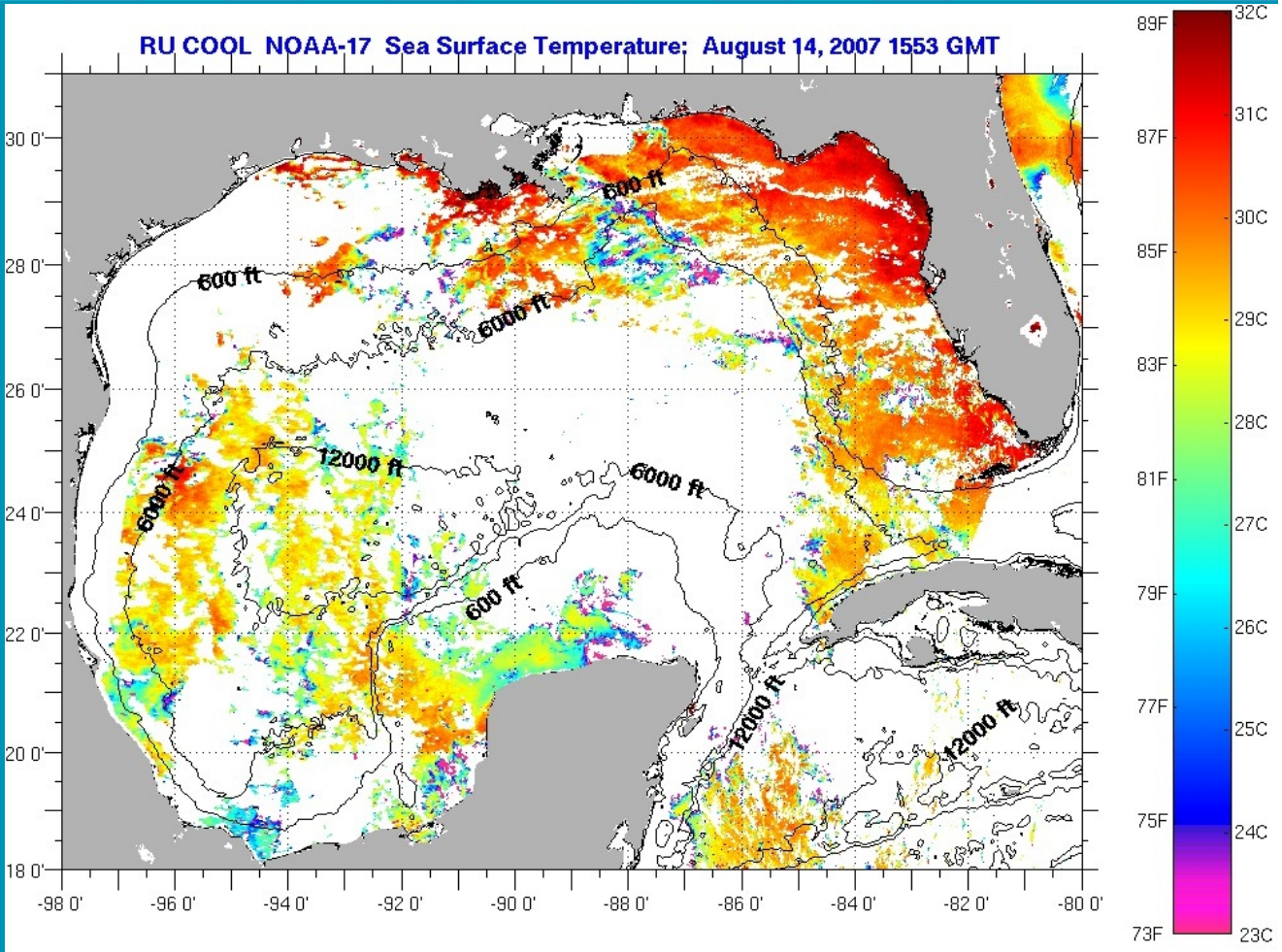
Florida Bay & Gulf are colder in the winter

Sub Temperate



Florida Keys Biogeography

SSTs in Florida Bay & Gulf of Mexico are Warmer in the Summer

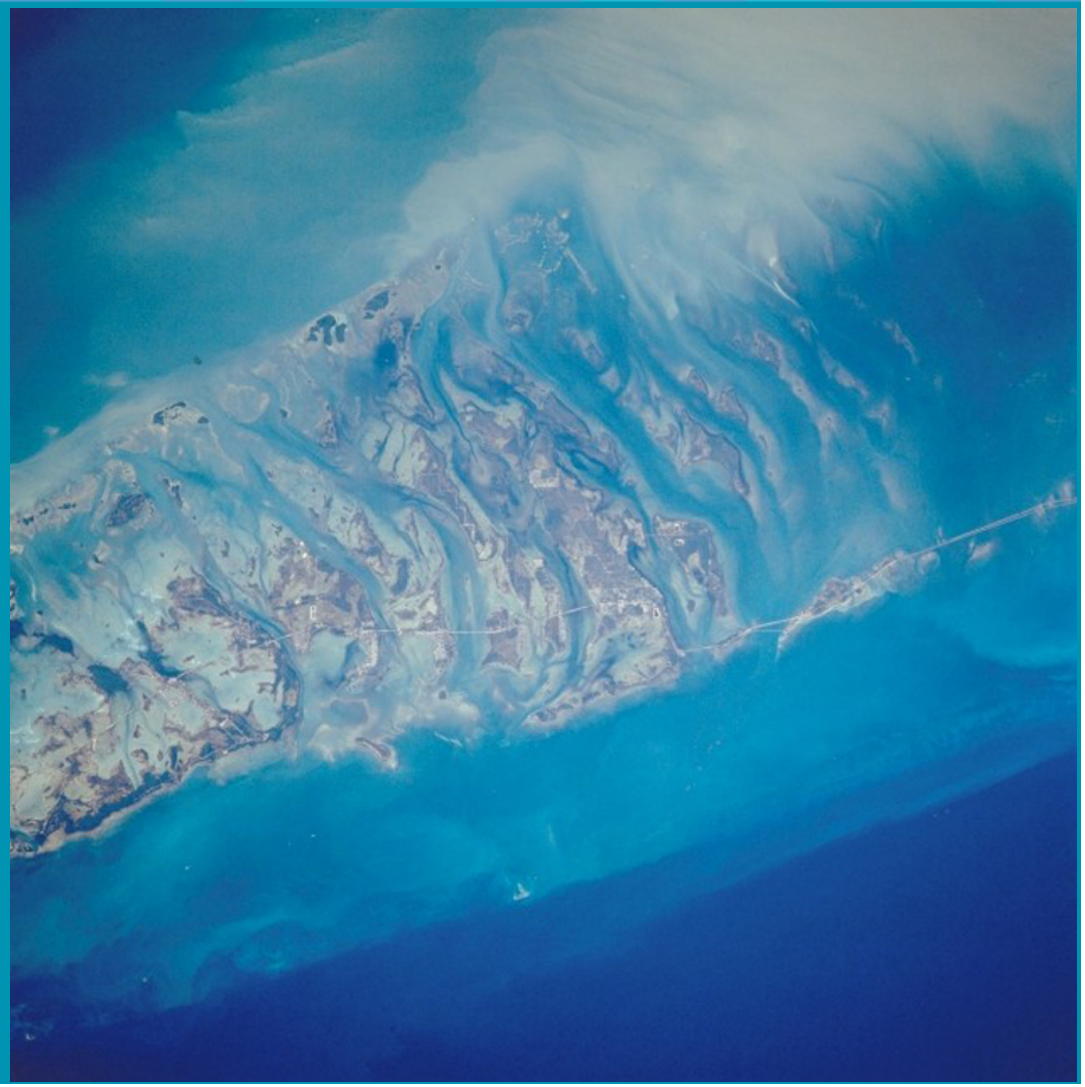


SST August 14, 2007

Florida Keys Biogeography

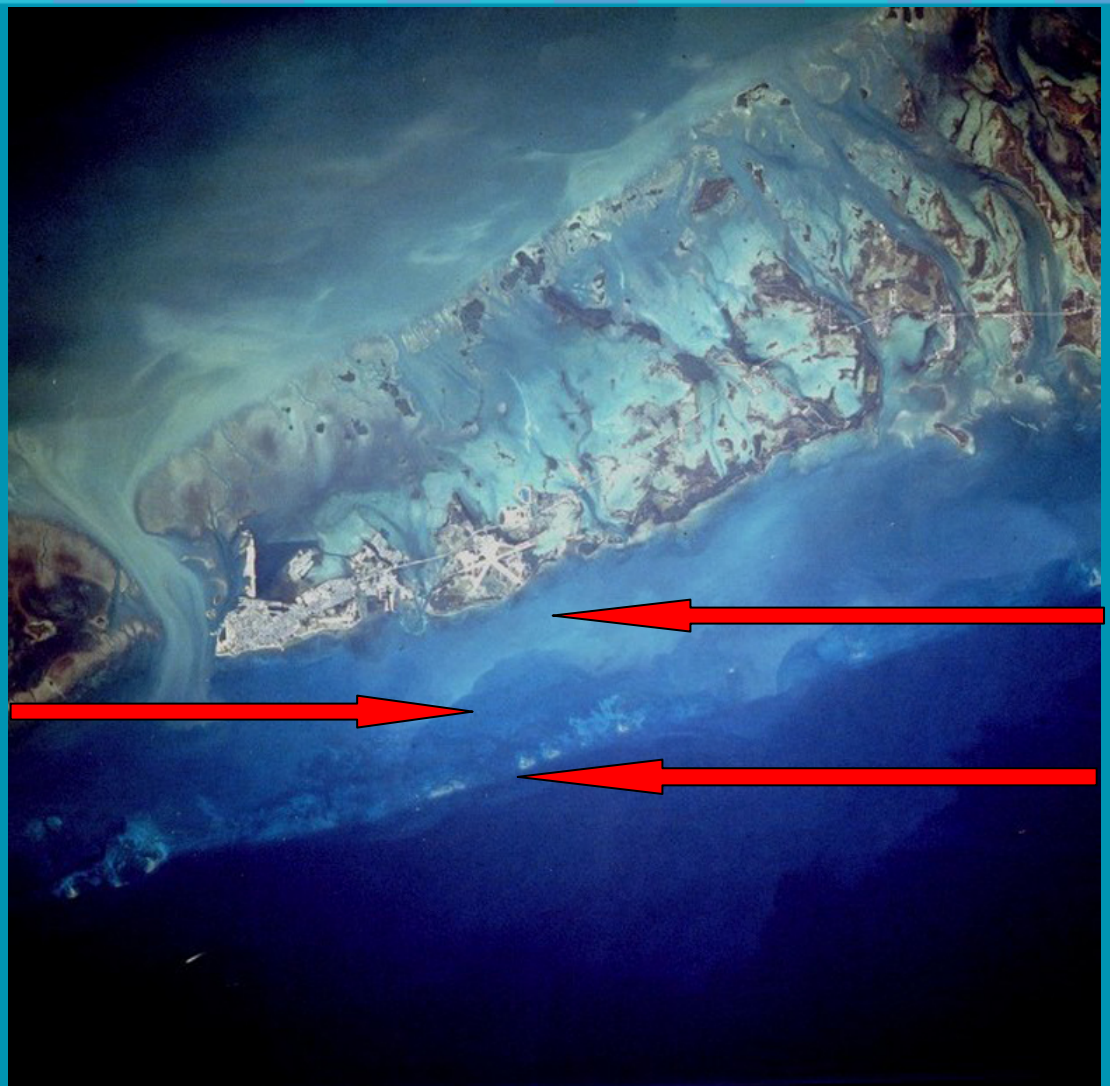
Gulf and Atlantic Waters began mixing about 3000 years ago

- Net flow is from the Gulf toward the Ocean
- Turns and heads west
- Turbidity higher
- Seasonal temperatures vary more inshore



Florida Keys Biogeography

Western Sambo Ecological Reserve

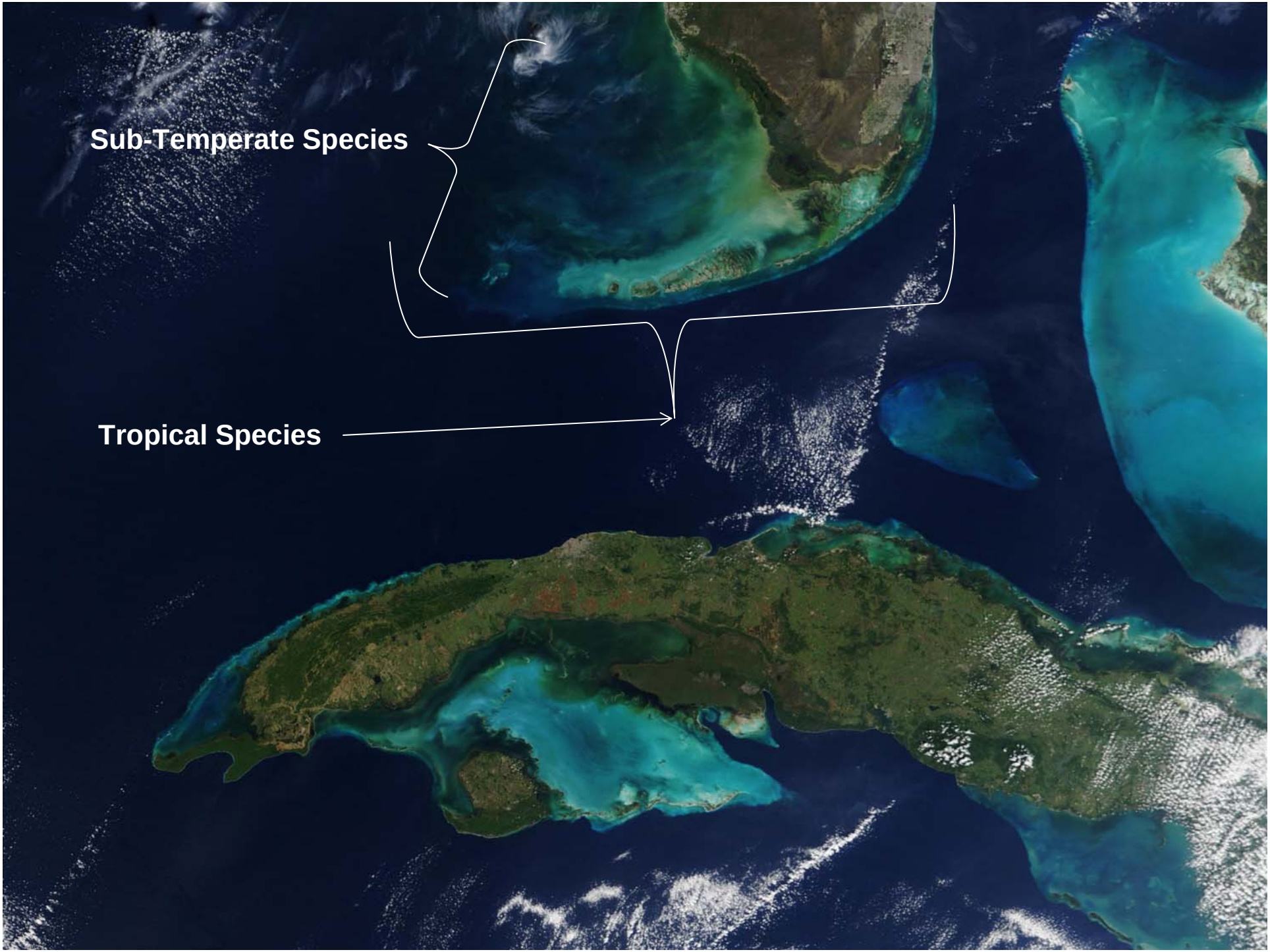


Mid-Channel Patch Reefs

Inshore Patch Reefs

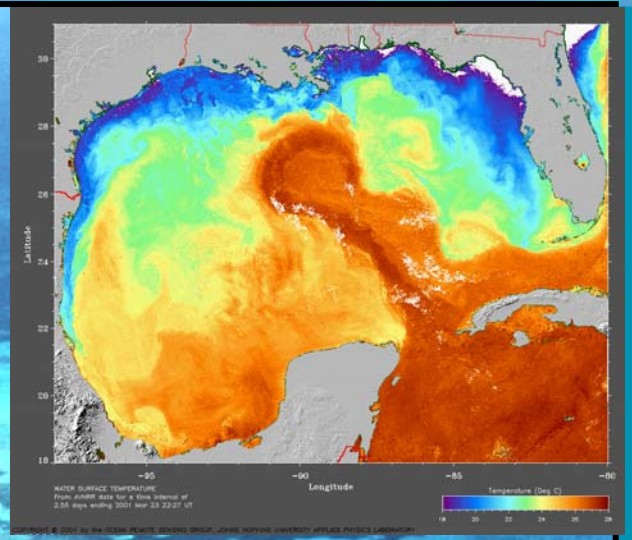
Fore Reef Shallow Reefs

Florida Keys Biogeography


Sub-Temperate Species
Tropical Species

Florida Keys Biogeography

Outer Reefs have acclimated to less extremes in environmental conditions (e.g. temperatures, turbidity,salinities)



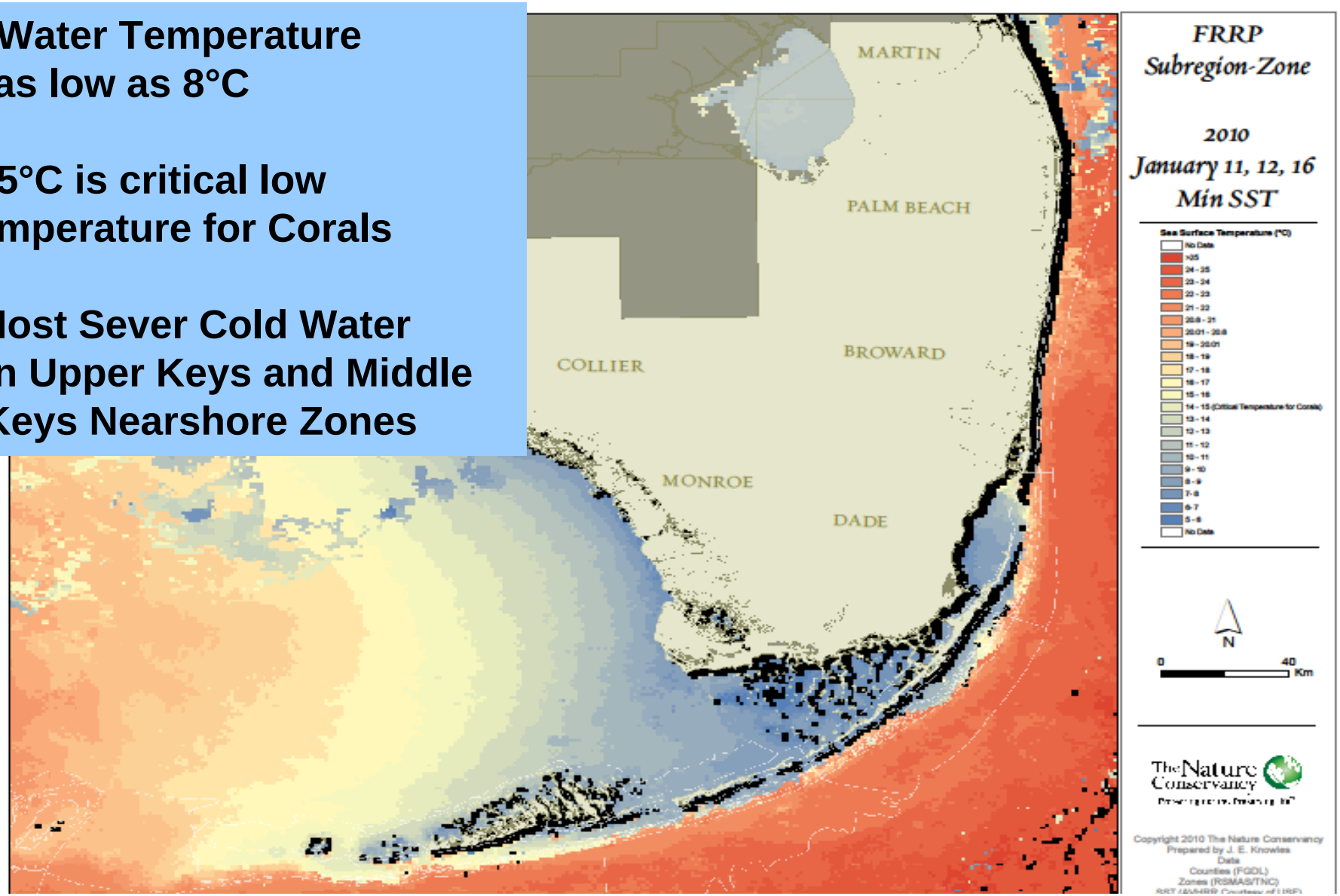
The Nature Conservancy
Protecting nature. Preserving life.™

2010 January Cold Water Event

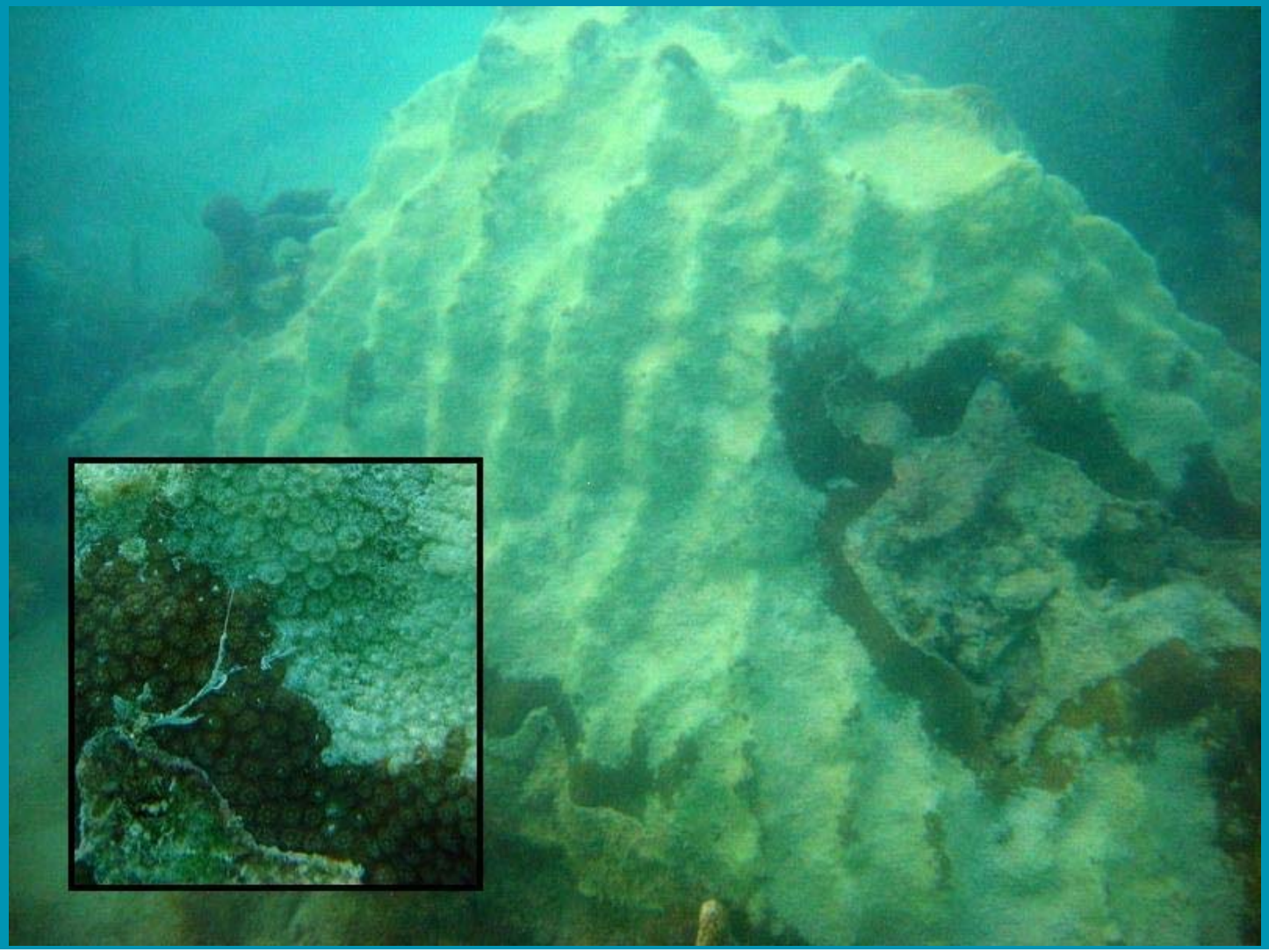
- **Water Temperature as low as 8°C**

•15°C is critical low temperature for Corals

•Most Sever Cold Water in Upper Keys and Middle Keys Nearshore Zones

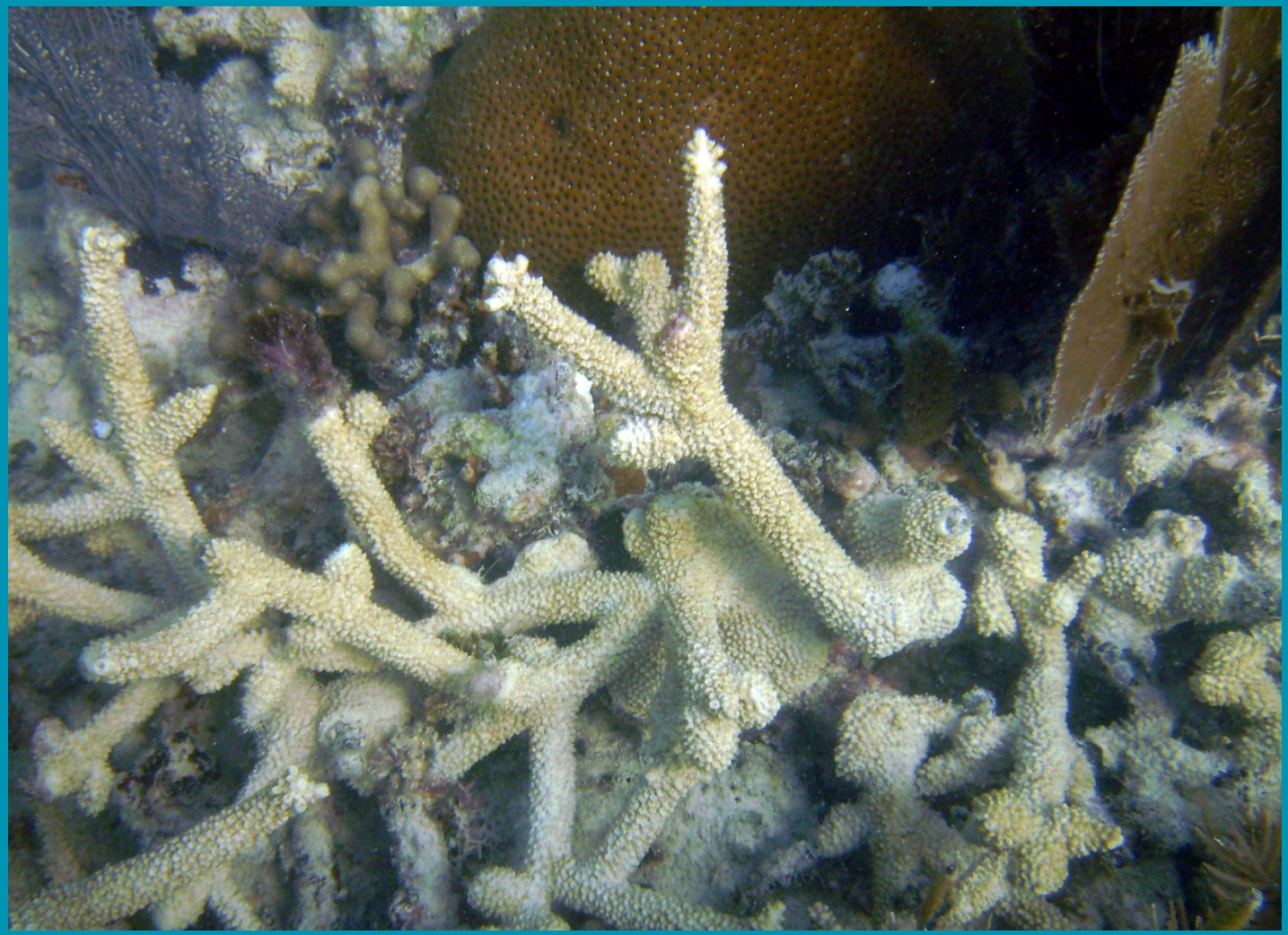


January 2010 Cold Water Event
Florida Keys National Marine Sanctuary
Big Pine Key Area

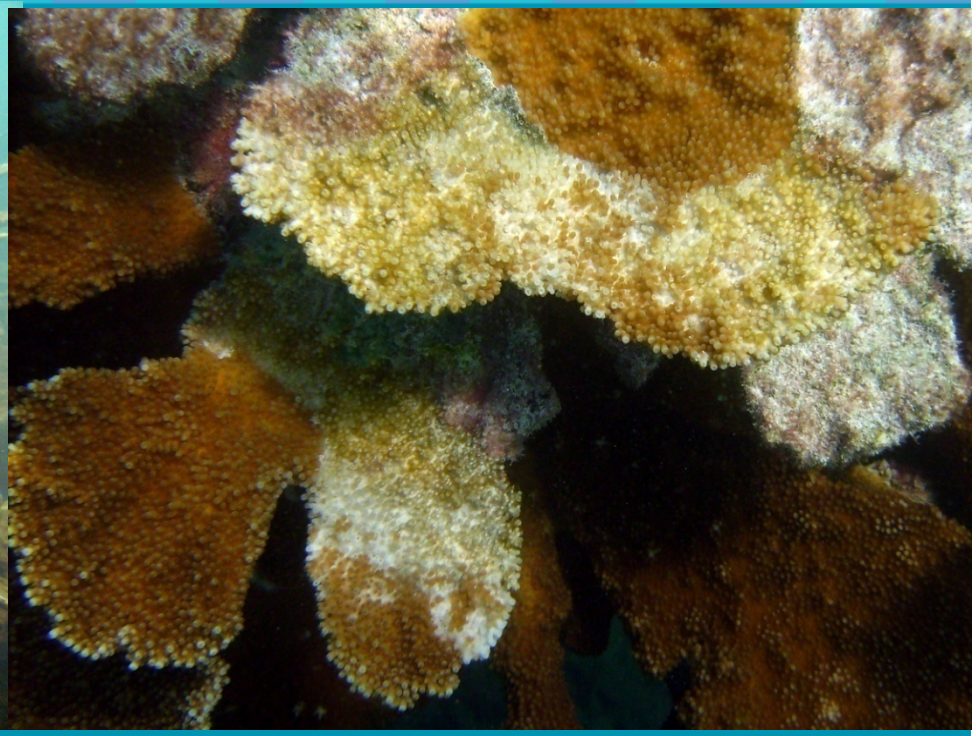


January 2010 Cold Water Event
Florida Keys National Marine Sanctuary
Upper Keys Sites

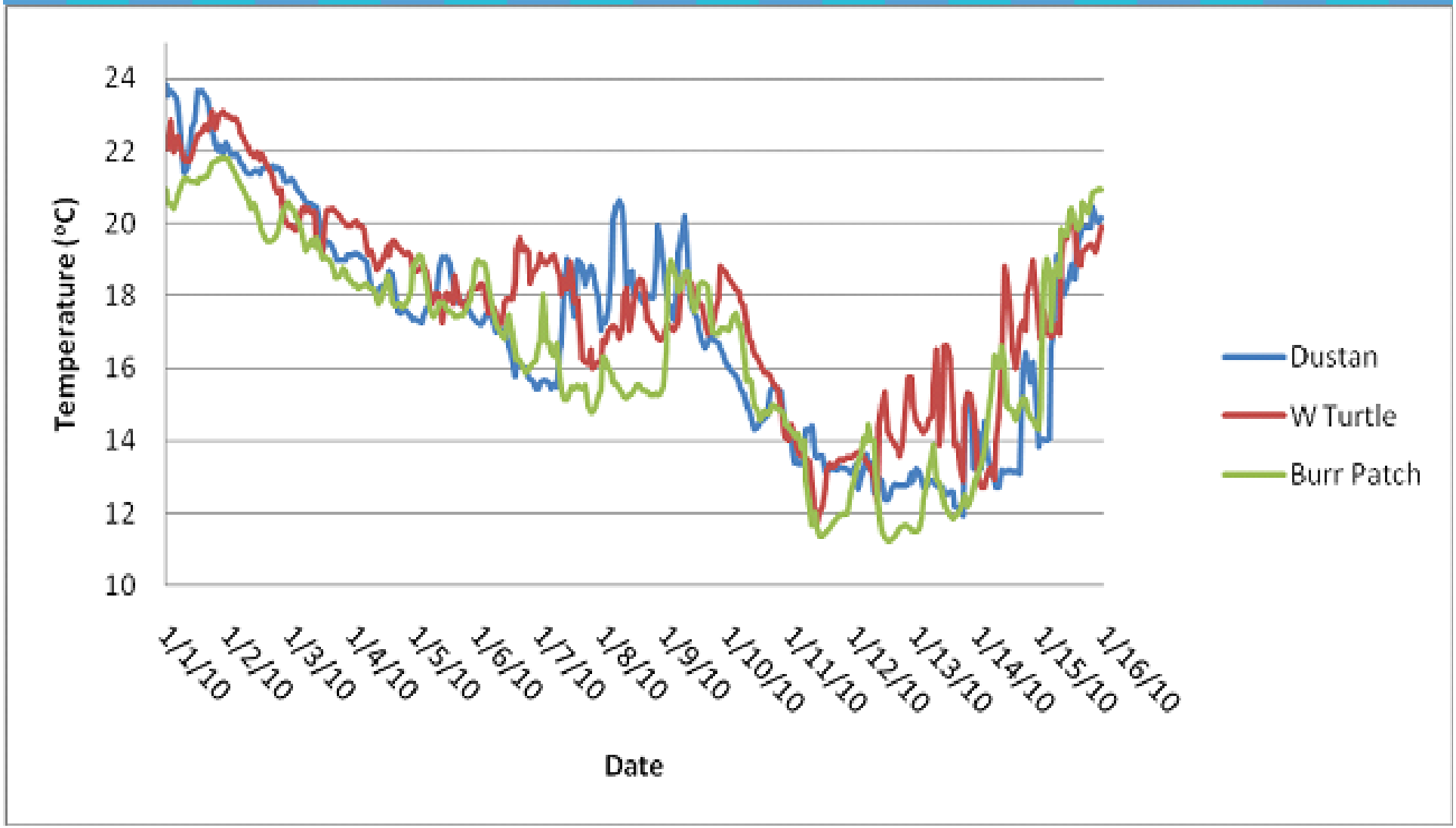
January 2010 Cold Water Event
Florida Keys National Marine Sanctuary
Upper Keys Sites



January 2010 Cold Water Event
Florida Keys National Marine Sanctuary
Upper Keys Sites



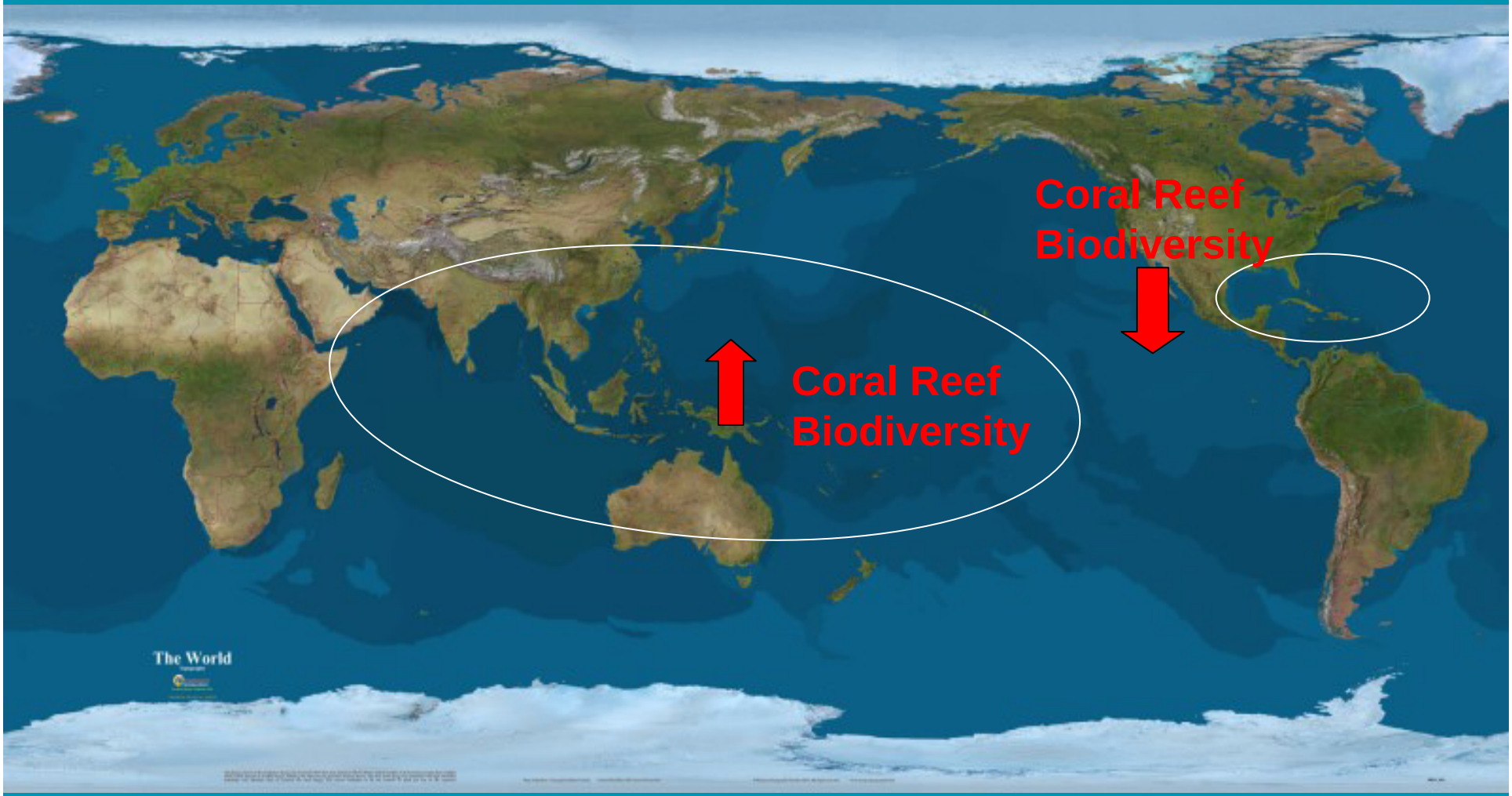
January 2010 Cold Water Event
Florida Keys National Marine Sanctuary
Upper Keys Sites



Pacific vs Caribbean Biodiversity

Characteristics of Coral Reef Biodiversity in the Pacific vs Caribbean

Atlantic vs Pacific Biodiversity



Biodiversity

Caribbean ~ 65 species of Corals

Acropora palmata –
2 species of *Acropora* in the Caribbean
Florida Keys National Marine Sanctuary
Margaret Miller August 2006

Pacific > 400 species of Corals

Acropora species –
>185 species in the Indo West Pacific
Great Barrier Reef Marine Park Authority
Healthy Reef

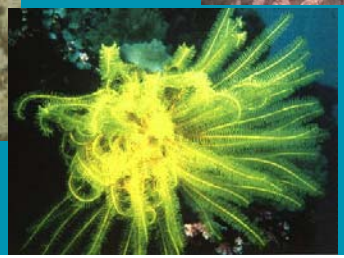
Biodiversity

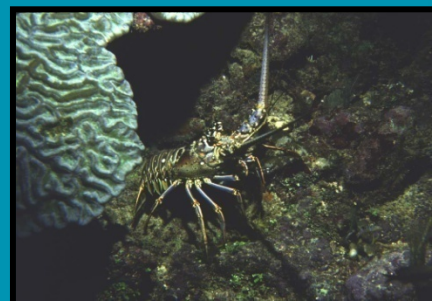
< 550 species in Florida Keys

>1,500 species on GBR

Biodiversity

Importance of Biodiversity on Coral Reefs is more than Stony Corals and Fishes

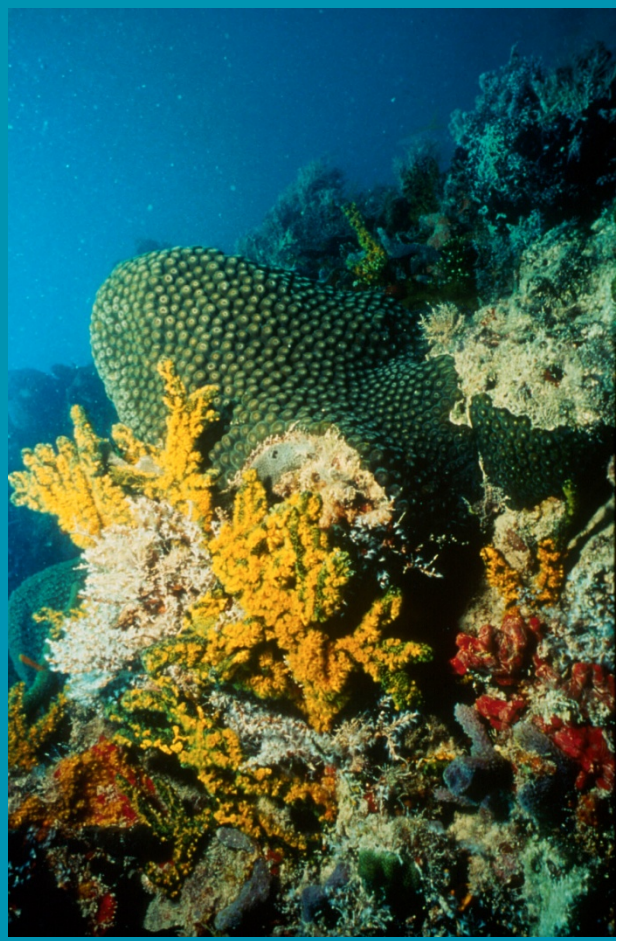




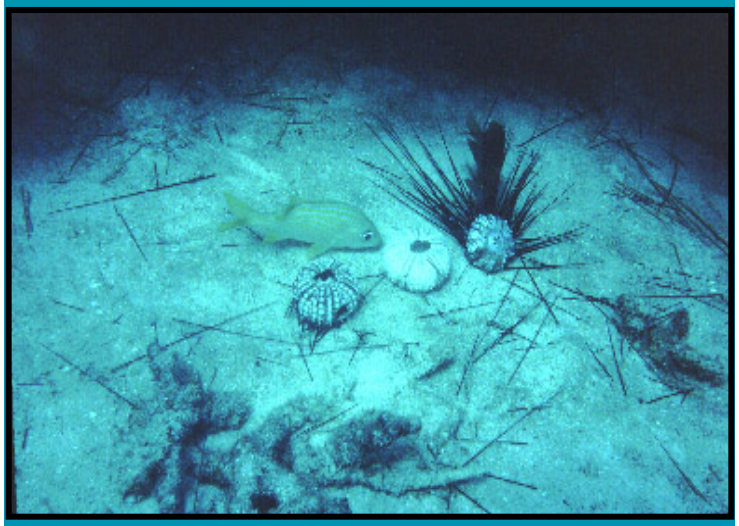
Biodiversity

Still Much to Learn

- **BIODIVERSITY**
  - **- Species interactions**
  - **- Genetic diversity**
  - **- Pharmaceuticals**



Caribbean Connectivity



1983 *Diadema* die-off
Long Spine Sea Urchin

Credit: H.A. Lessios (1984)

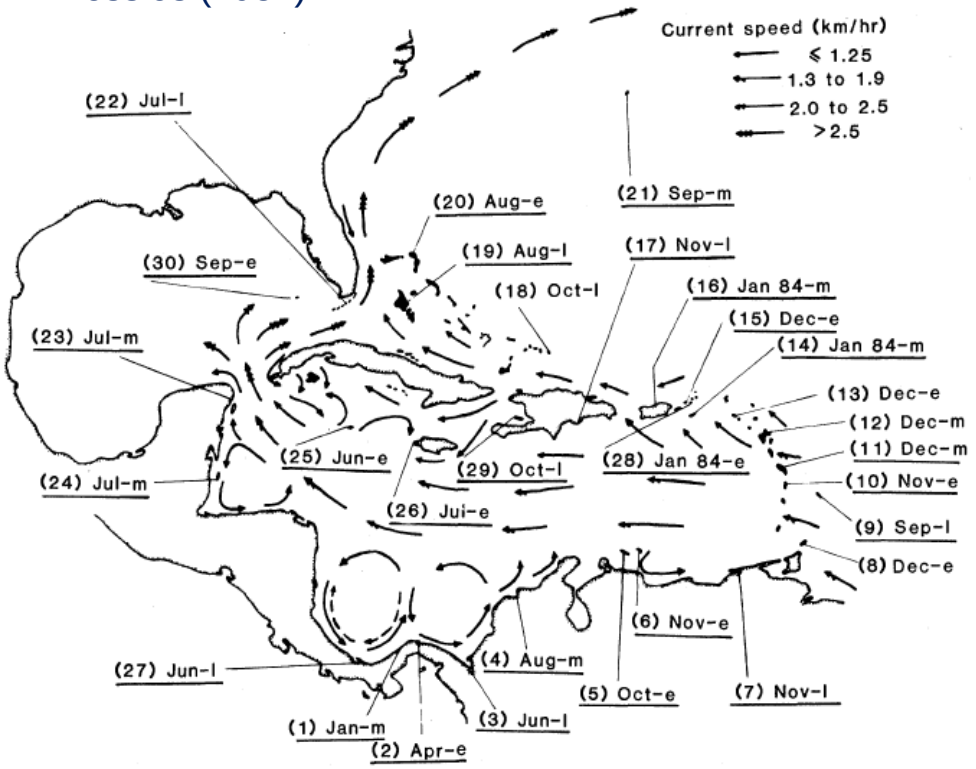
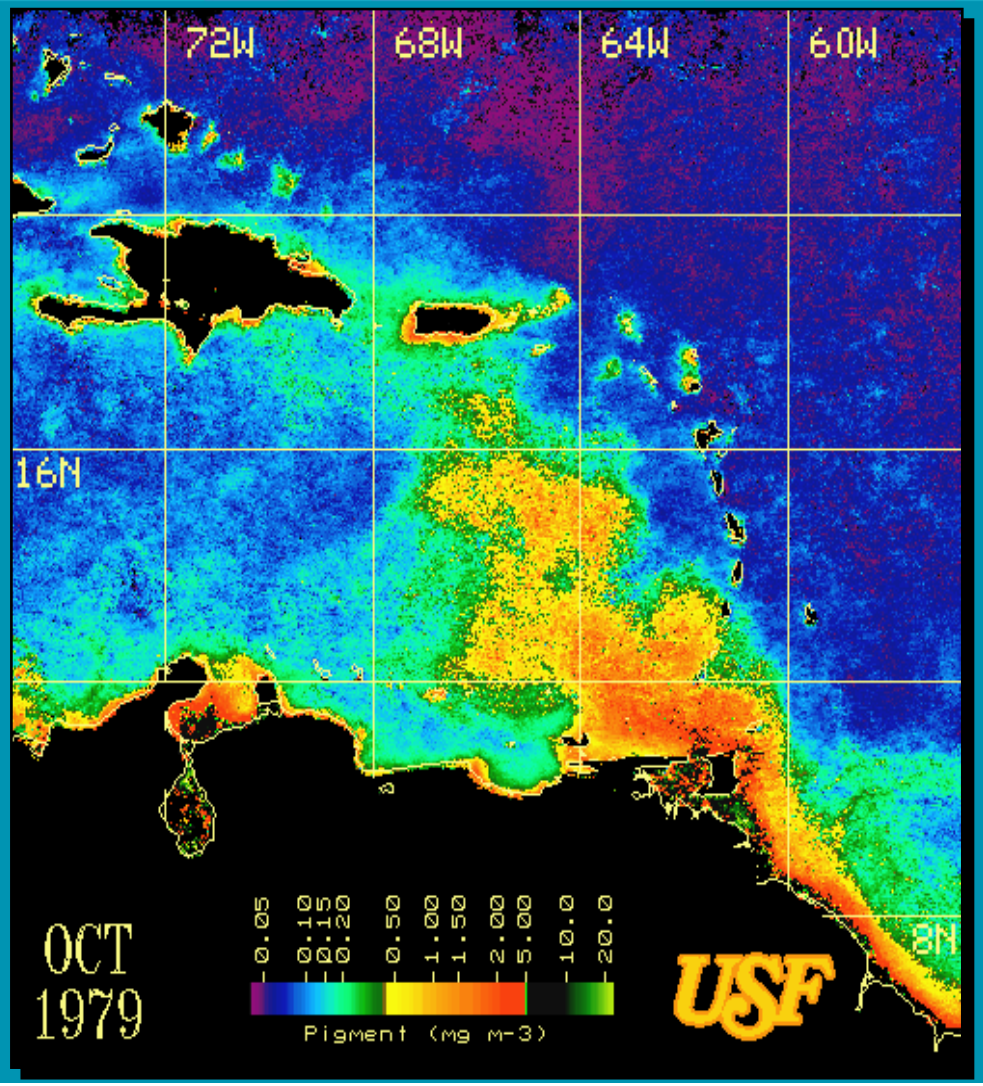


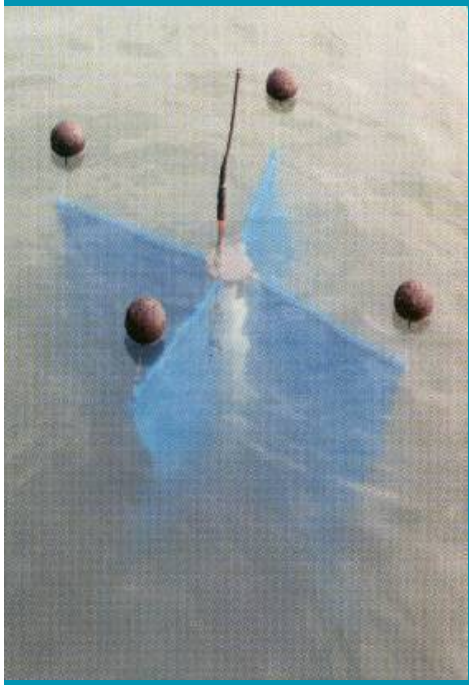
Fig. 2. Spread of *Diadema* mass mortality through the Caribbean and the western Atlantic. Underlined dates indicate the first time mortality was noted at each locality. Dates without

Caribbean Connectivity



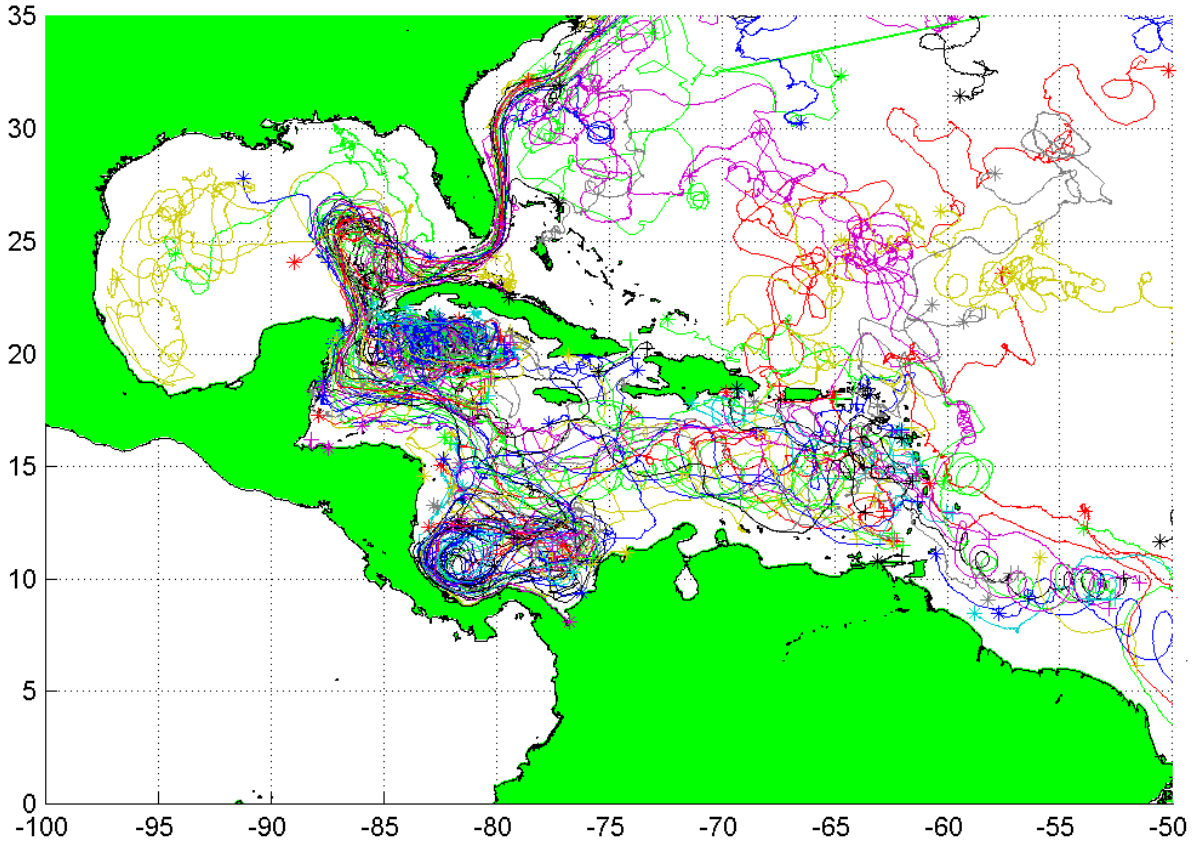
Credit: F. Muller-Karger for slide

Caribbean Connectivity

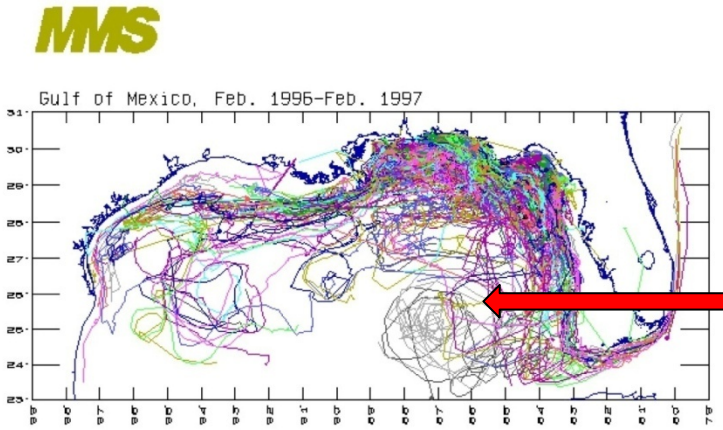


Drifter

Current Drifters (1998-2000)
Credit: Kevin Leaman (UM/RSMAS)

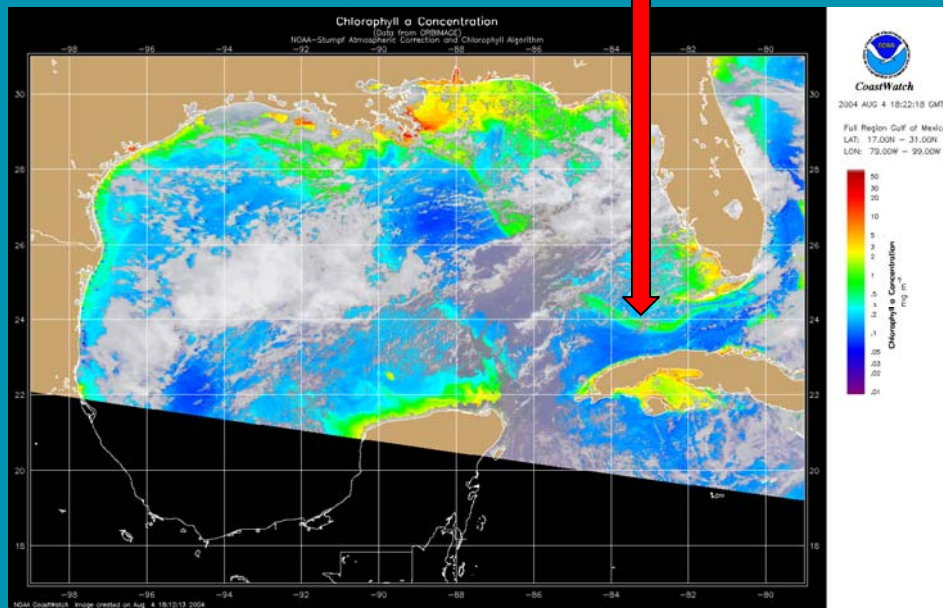


Connectivity within the Gulf of Mexico



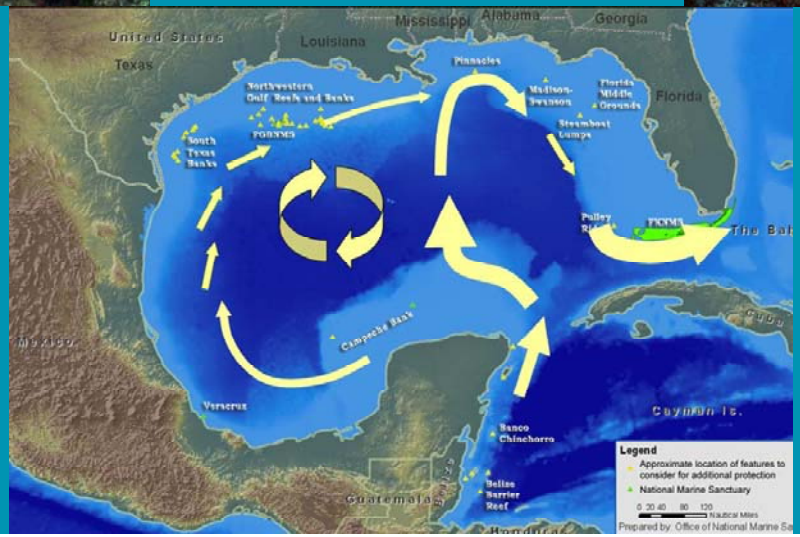
Satellite Current Trackers

Mississippi River Runoff

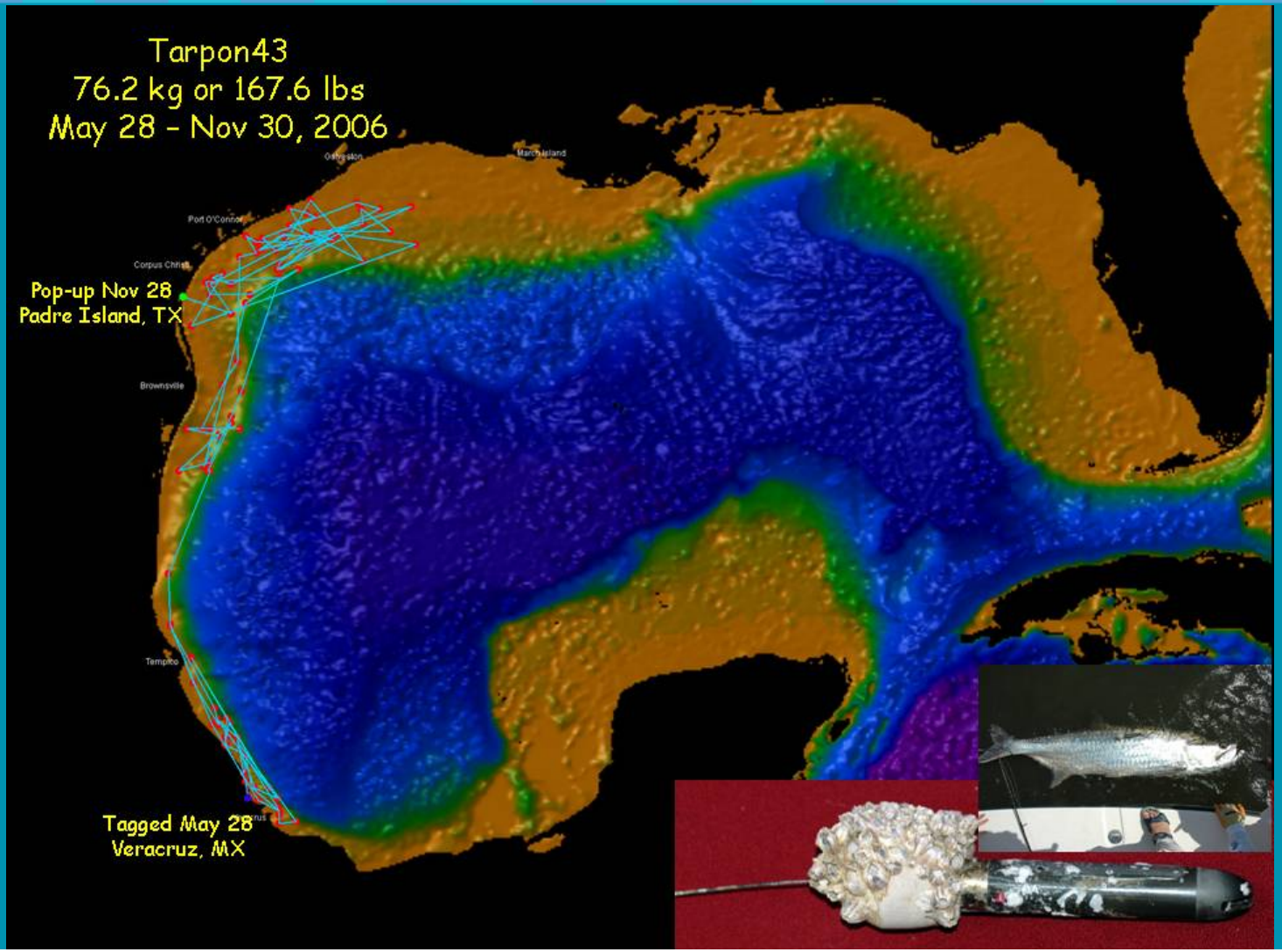


Connectivity with the Gulf of Mexico

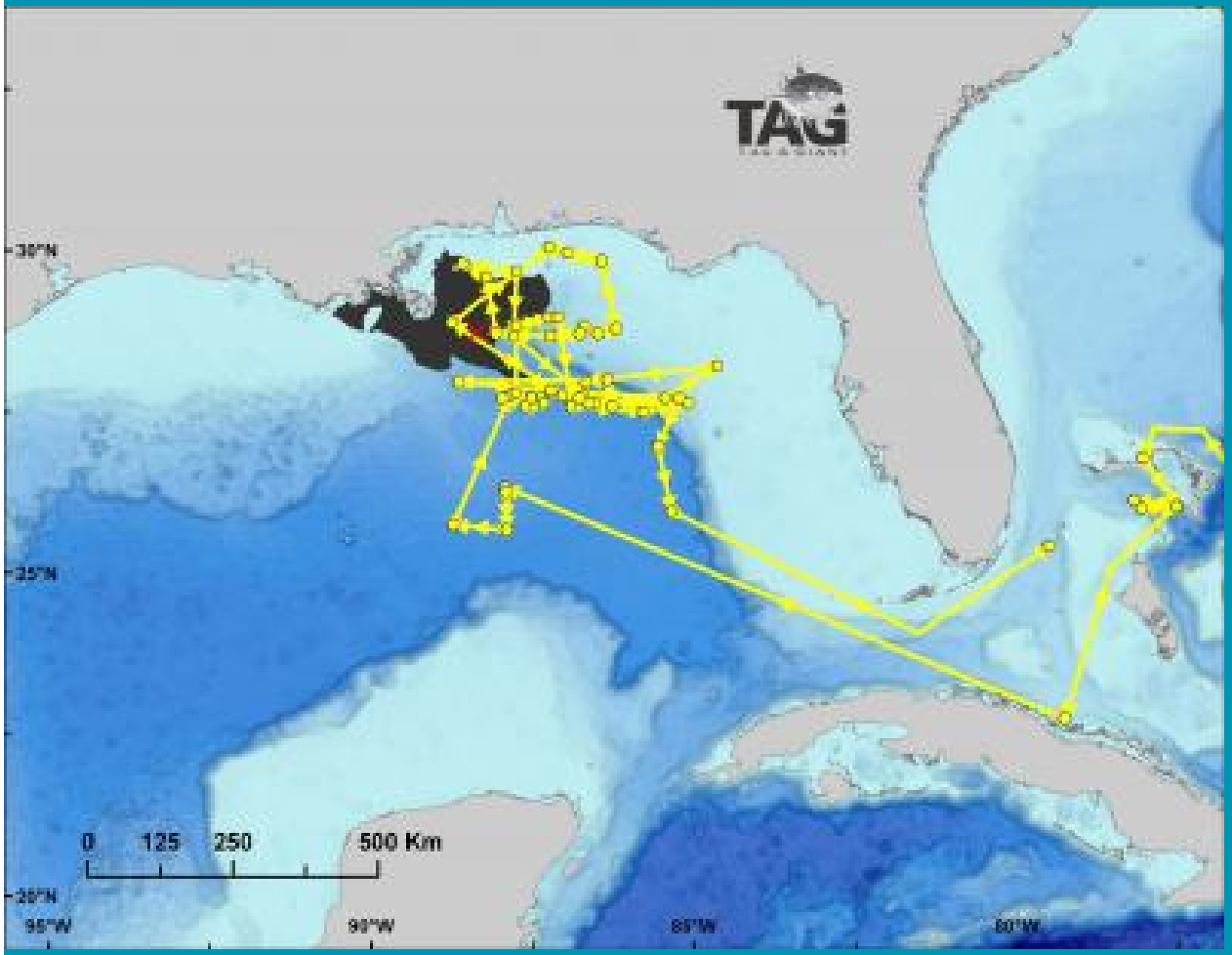
Example of Connectivity: *Acropora palmata*



Connectivity with the Gulf of Mexico



Connectivity with the Gulf of Mexico



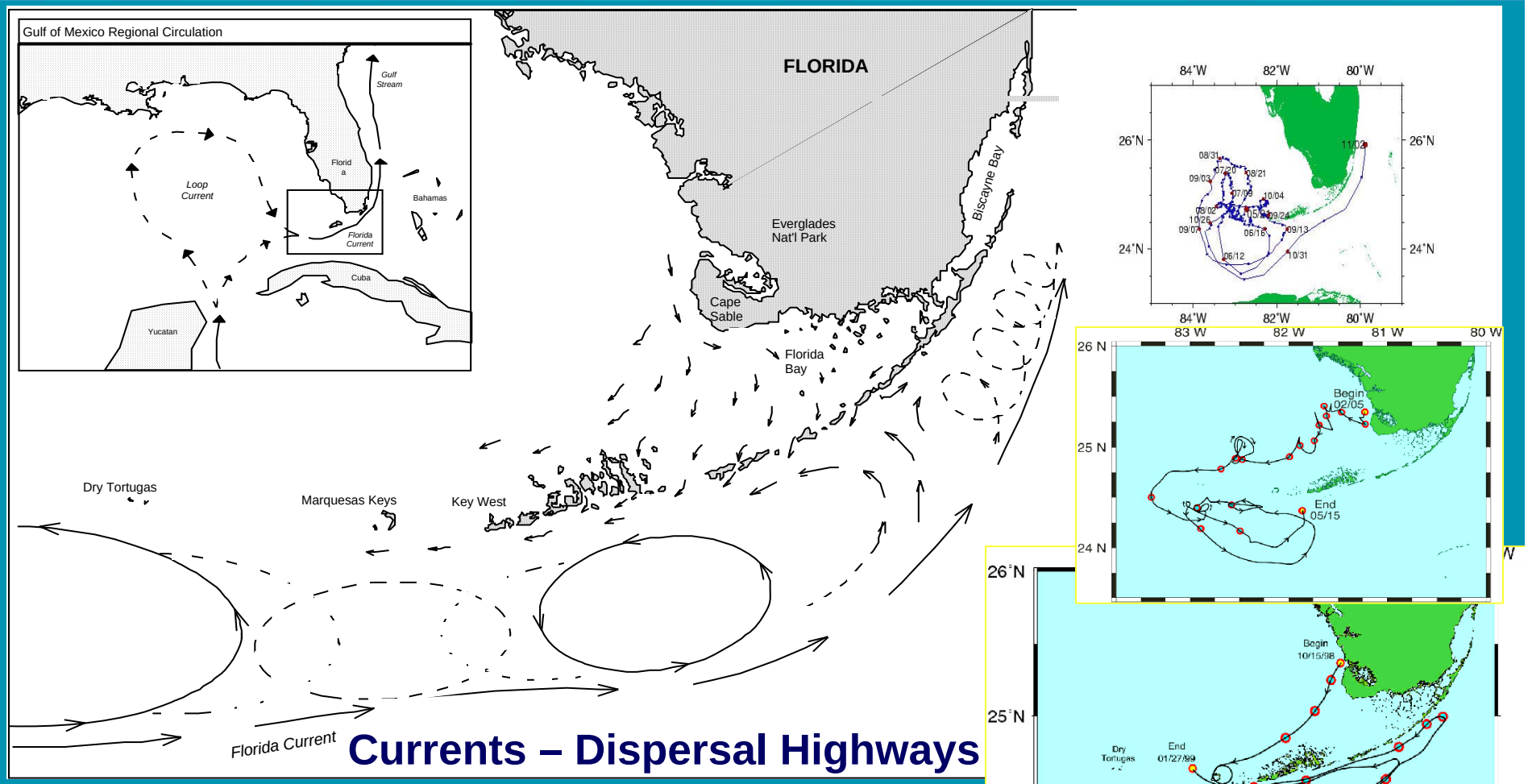
Bluefin Tuna

This shows the track (yellow line) and daily positions (dots) of a giant bluefin tuna electronically tagged off Canada on October 25, 2008 -- which spent the period from March 23-May 24, 2009, in the Gulf of Mexico.

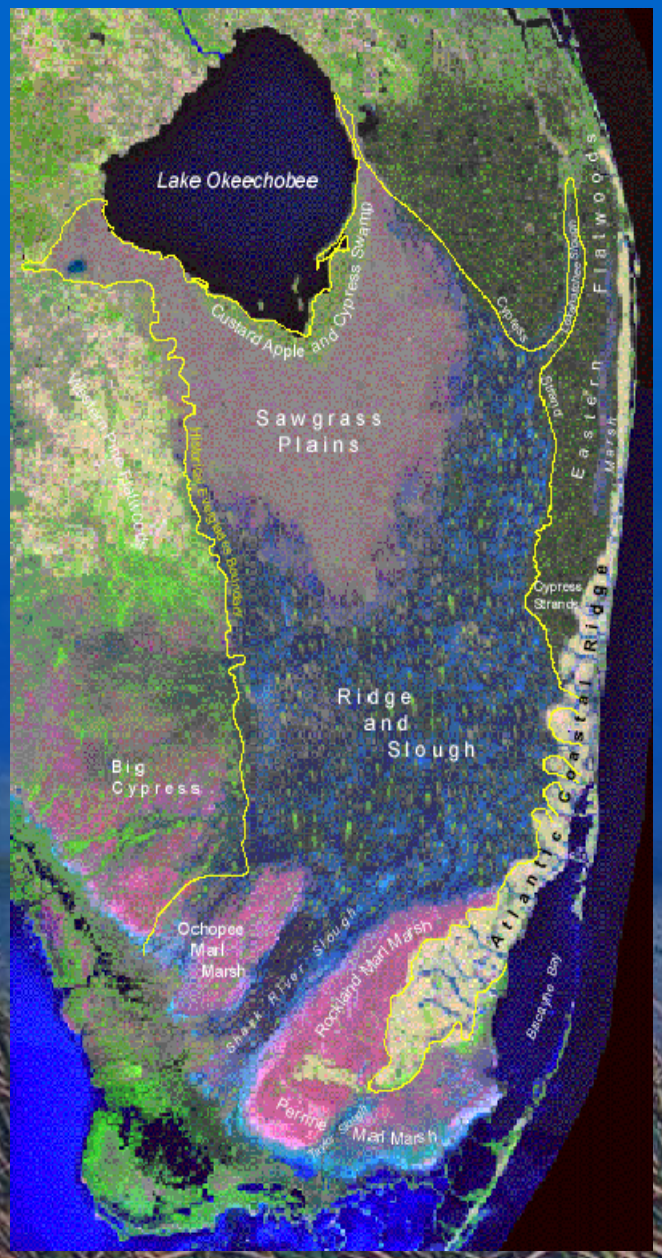
Connectivity with the Gulf of Mexico

Whale Shark movement over 500 miles
From Holbox, Mexico to Bright Bank

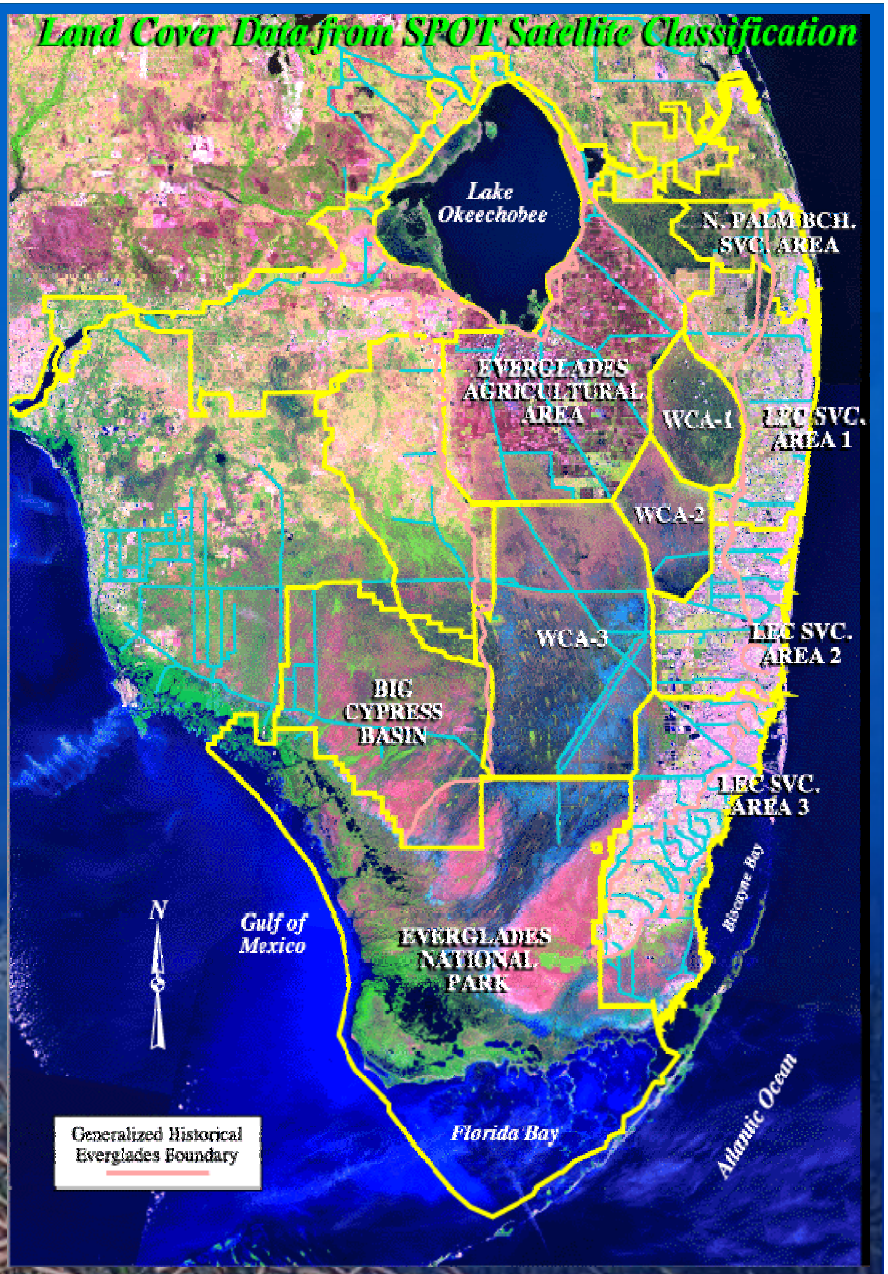
Florida Keys Connectivity



(Lee and Williams - Univ of Miami)



Estimated Pre-drainage System Landscape (circa 1850)

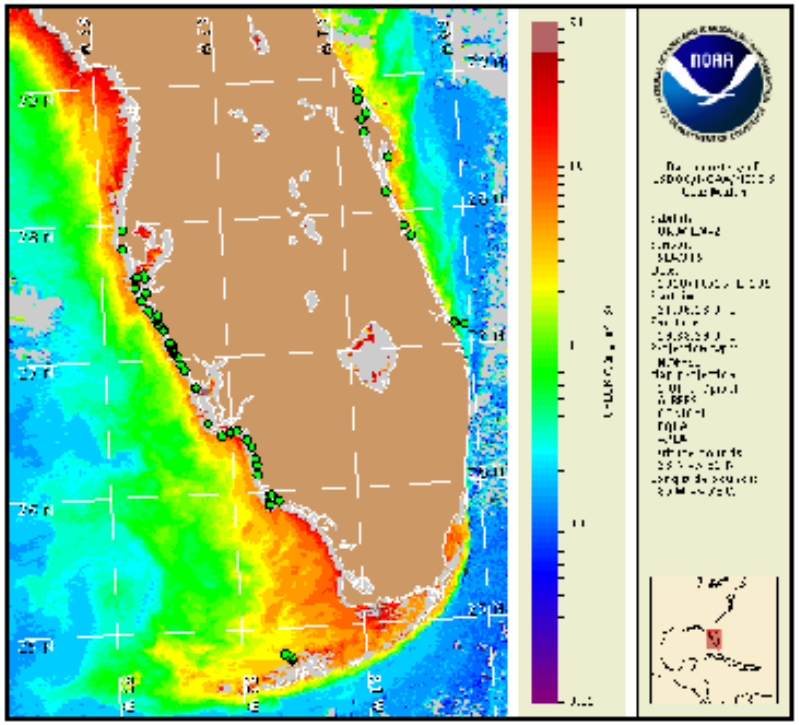


Current System (1995) Landscape

CONNECTIVITY OF SOUTH FLORIDA COASTAL ECOSYSTEMS

Gulf of Mexico Harmful Algal Bloom Bulletin

Region: Southwest Florida
18 October 2010
NOAA Ocean Service
NOAA Satellites and Information Service
NOAA National Weather Service
Last bulletin: October 12, 2010



Satellite chlorophyll image with possible HAB areas shown by red polygon(s). Cell concentration sampling data from October 9 to 14 shown as red (high), orange (medium), yellow (low b), brown (low a), blue(very low b), purple (very low a), pink (present), and green (not present). For a list of cell count data providers and a key to the cell concentration categories, please see the HABFS bulletin guide:

http://tidesandcurrents.noaa.gov/hab/habfs_bulletin_guide.pdf

Conditions Report

There is currently no indication of a harmful algal bloom at the coast in southwest Florida, including the Florida Keys. Harmful algae have been identified offshore Collier County. No impacts are expected alongshore southwest Florida today through Sunday, October 24.

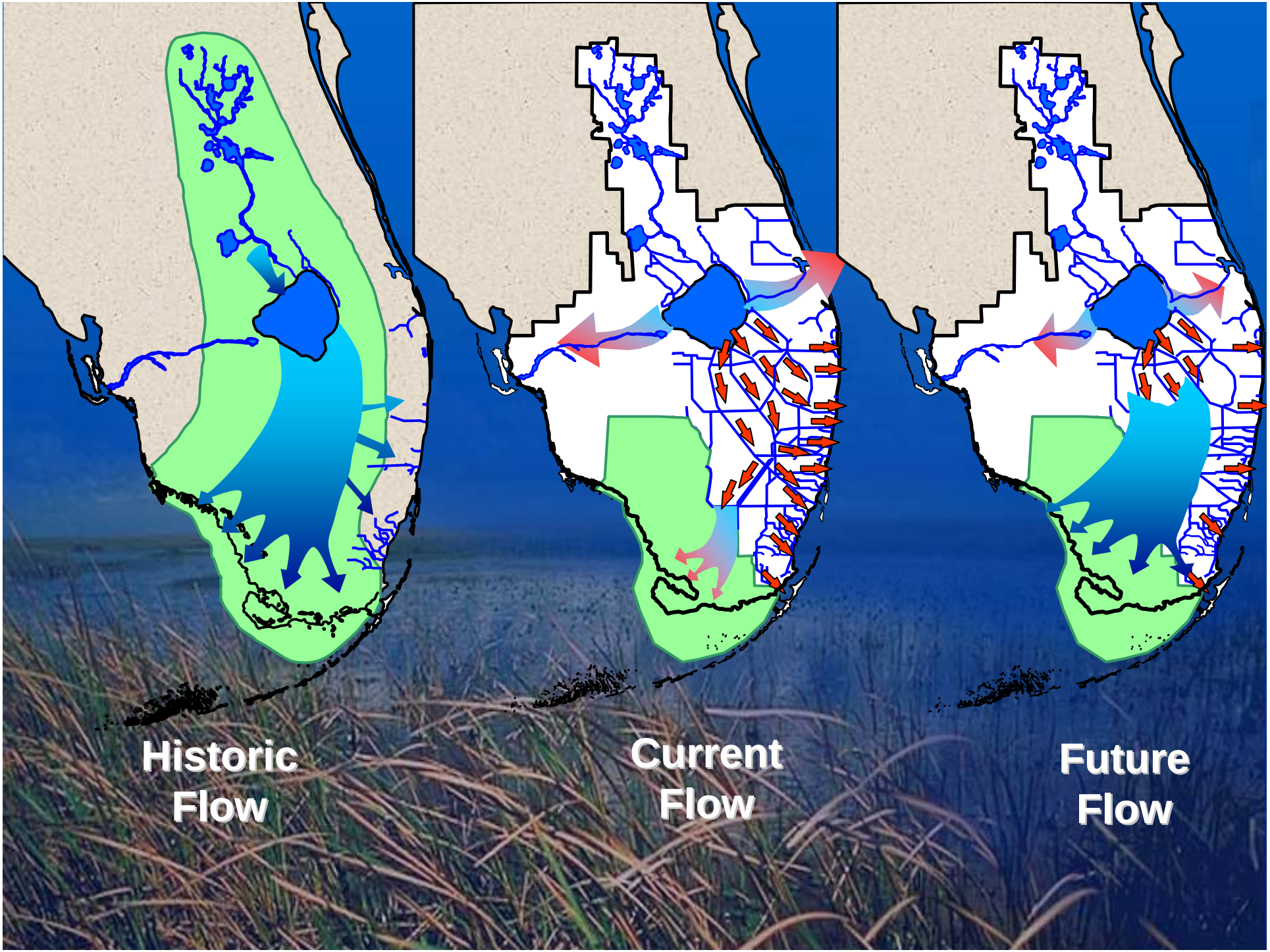
Analysis

There is currently no indication of a harmful algal bloom in southwest Florida, including the Florida Keys. Harmful algae has been identified offshore Collier County west of Wiggins Island ('very low'; FWRI; 10/14; sample not shown at left). One other sample collected on 10/14 offshore Lee County west of Lovers Key contained background concentrations *Karenia brevis* (FWRI). All other samples collected last week alongshore between Pinellas and Monroe counties, offshore Manatee, Sarasota, and Charlotte counties, and in the Florida Keys indicate that *K. brevis* is not present (CCPCPD, FWRI, MML, SCHD; 10/11-15).

Elevated chlorophyll remains visible in recent satellite imagery along and offshore much of the southwest Florida coastline and in the Florida Keys. A narrow band of elevated chlorophyll (2-6 μg/L) stretches along the coast from Pinellas to Lee County where it broadens, with elevated to high chlorophyll (3 to >10 μg/L) extending along and offshore Lee, Collier, and Monroe counties. Elevated to high chlorophyll (3 to >10 μg/L) is also visible in the Florida Keys, surrounding much of the Lower Keys region. A region of high chlorophyll (>10 μg/L) is visible in the Sanibel Island area and alongshore southern Lee County, including the area where the 'very low' *K. brevis* concentration was collected west of Wiggins Island. Other samples collected throughout this area do not indicate the presence of *K. brevis*. A previously reported patch of elevated chlorophyll that may have transported south from Sanibel Island is now located at 25°44'20''N 81°54'30''W (3-4 μg/L). Elevated chlorophyll along the coast is likely the result of confirmed non-harmful algal blooms that continue to be reported throughout southwest Florida (FWRI; 10/13-14). A bloom of *Takayama cf. acrotrocha*, first reported on 9/9, continues to bloom in Collier County and has extended into southern Collier as far as South Marco Beach; no impacts have been reported due to this bloom in the past week (CCPCPD, FWRI; 10/11-12).

Upwelling favorable variable north and east winds are expected through Friday, increasing the potential for bloom formation at the coast.

Derner, Urizar


Historic
Flow
Current
Flow
Future
Flow


Texas
Louisiana
Houston
San Antonio
Florida
Gulf of Mexico
Monterrey
Florida Keys National
Marine Sanctuary
Nassau
The Bahamas
La Habana
(Havana)
Cuba
George Town
Navassa
Jamaica
Kingsto
de México
(Mexico City)
Puebla
Belmopan
Belize
Huatulco Mexico
Caribbe
Guatemala
© 2006 Europa Technologies
Guatemala
Image © 2006 TerraMetrics
duras
Image © 2006 NASA
El Salvador
© 2005 Google
Pointer 22°19'10.13" N 88°01'22.78" W elev -176 ft
San Salvador
Streaming 100%
Eye alt 1400.46 mi

Socioeconomic Characterization

The Environment
and
The Economy
Are <u>Inextricably</u> Linked in the Florida Keys

=

Socioeconomic Characterization



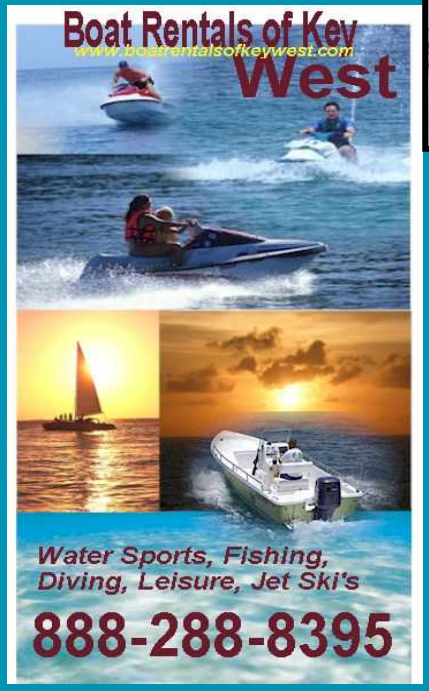

Florida Keys NMS

>4 Million Visitors Annually (> 14 Million Visitor Days)



Socioeconomic Characterization

$1.2 Billion US Annually



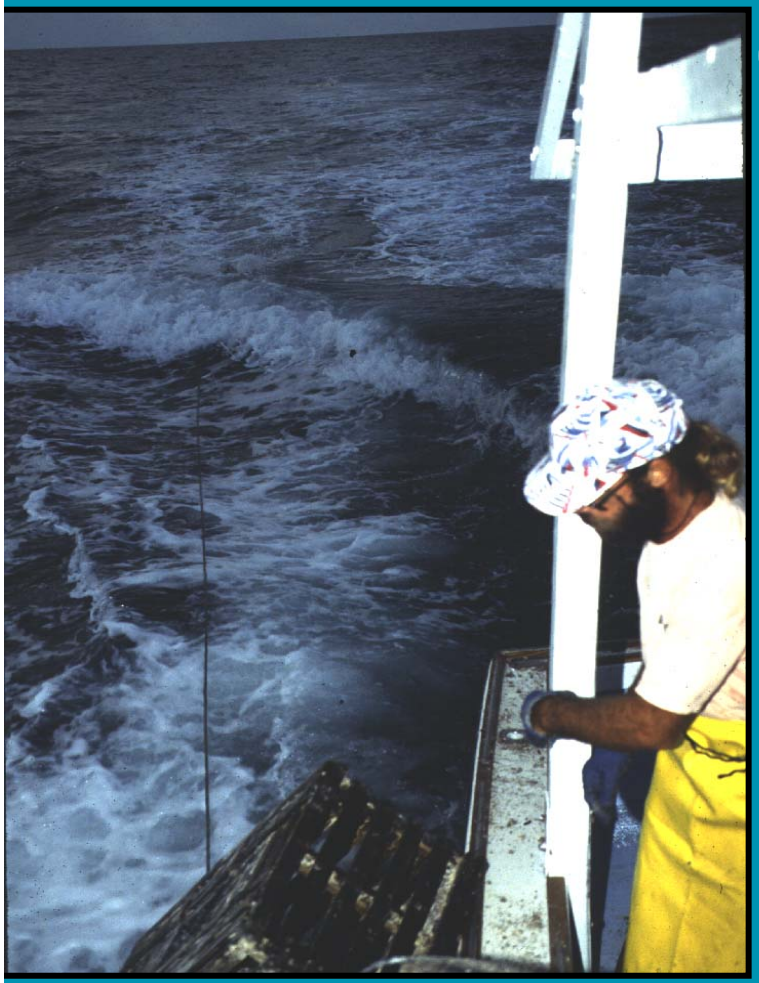
Leeworthy, et al

> 65 Boat & PWC Rental Operations

> 35 Bait & Tackle Stores

Socioeconomic Characterization

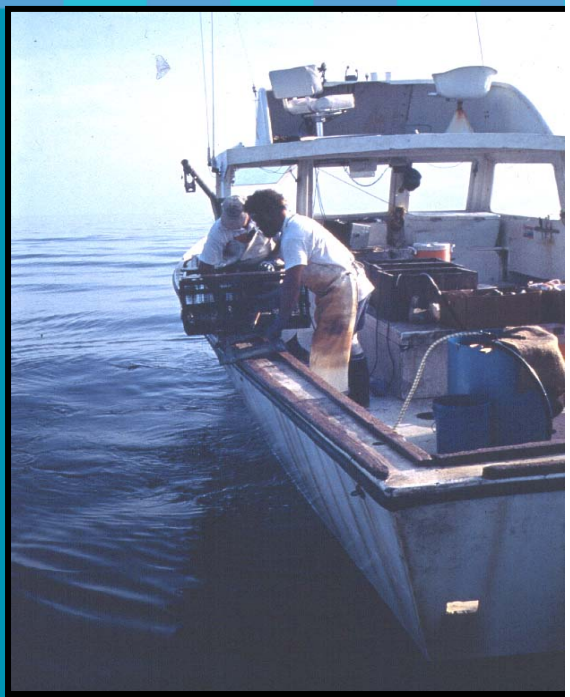
Socioeconomic Characterization



Commercial Fishing

Second Largest Industry

($50-70 Million US Landed Annually)



A Challenge to Management

Florida's Coral Reefs are the most vulnerable in the world:

- Our coral reefs are in a precarious environmental setting …biogeographically, ecologically and biologically.
- They are downstream of everything and everywhere.
- And they are the most-used reefs in the world.

Status of Coral Reefs

- Coral reefs are in a global state of decline as a result of human activities.
- Many of us in this room have witnessed firsthand …the decline of our coral reefs.

Status of Coral Reefs

- In the 50 years that I have dived on coral reefs, I have witnessed change that can hardy be described.
- For the first 2 decades (late 1950's – 1970's) we treated coral reefs like …. an infinite resource.
- Now…. we are witnessing their vulnerability.

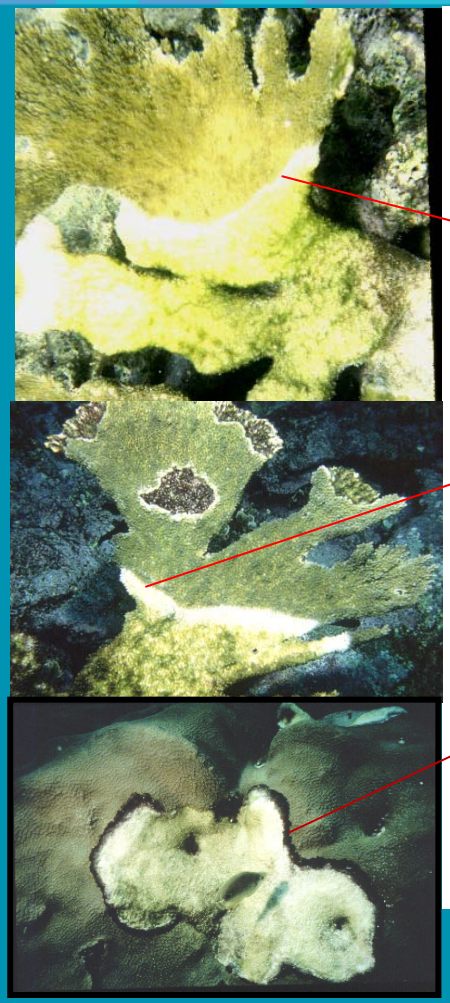
Threats to Coral Reefs

REEFS WORLDWIDE ARE THREATENED

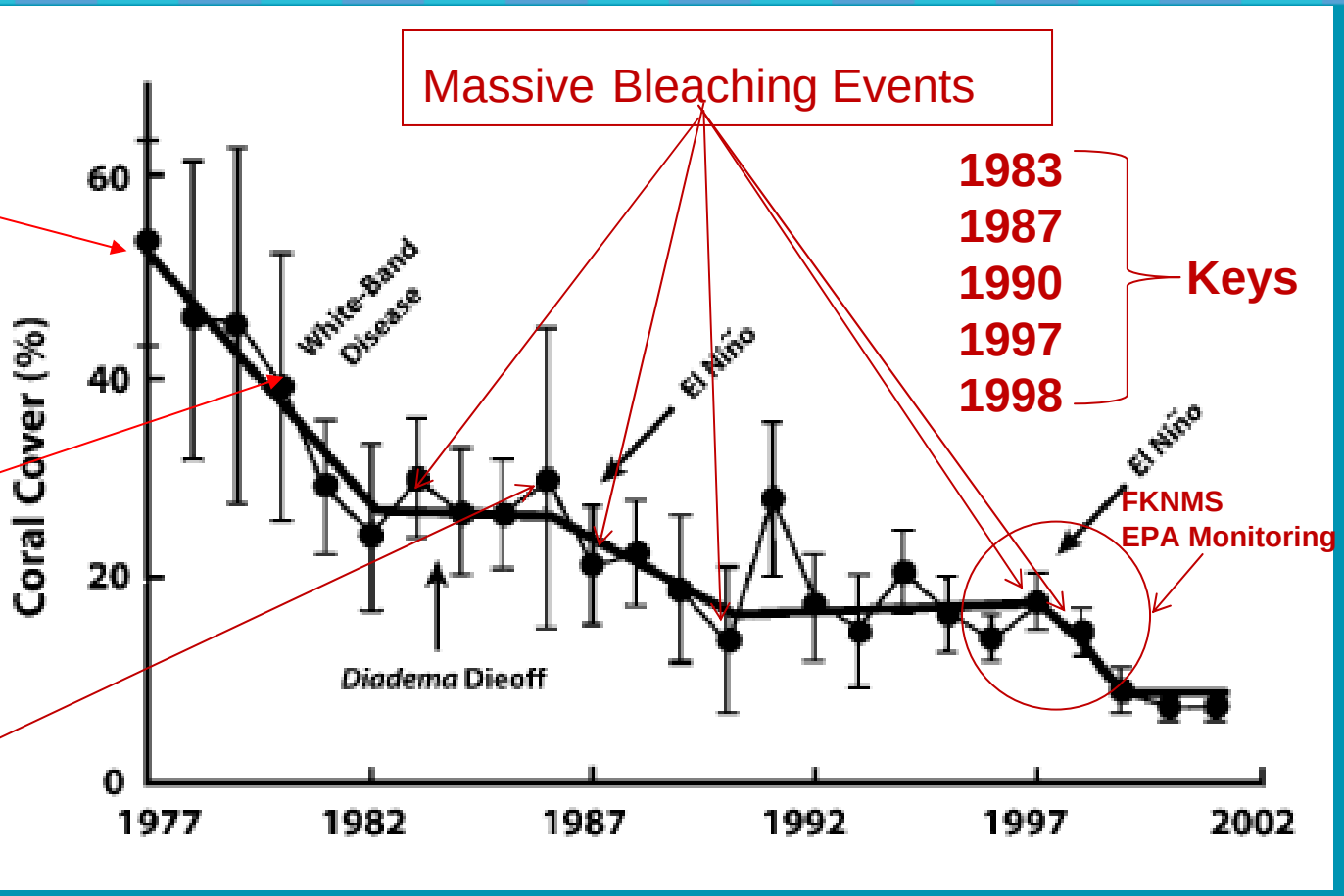
- 11% of reefs have been lost
- 16% of reefs severely damaged
- ~60% of studied reefs are threatened by human activities

Ref: Lauretta Burke
World Resources Institute (WRI)

Threats to Coral Reefs



Photos are for example



Long-term trajectory of coral cover on Caribbean reefs, based on a meta-analysis of ecological studies. Redrawn from Gardner et al (2003).

Threats to Coral Reefs

- Climate Change
- Land-based Sources of Pollution
- Habitat Loss and Degradation
- Overfishing

Challenges for Management

- After recognizing the 4 major sources of decline, managers and scientists are still faced with the realization that humans have played and continue to play a major role in the decline of the Keys marine ecosystem.

- Knowing the complexity of how these four major stressors have interacted and have been exacerbated by one another has presented another of the major management challenges for the Florida Keys coral reef ecosystem.

Challenges for Management

As resource managers:

- Managing the activities of humans and the impacts their uses have on the environment are among our greatest challenges.
- The next greatest challenge has been to manage the public's expectations created by a vocal minority group of scientists regarding the causes or stressors for coral decline.
- And…. it has been challenging to obtain funding for sustained research and monitoring.

Challenges for Management

One of our greatest management challenges has been that:

- We have often ignored or overlooked the accumulative effect of more than one of these stressors on the coral reefs of the Florida Keys.
- The tendency has been to look solely at the local stressors on the coral reefs, while ignoring the greater influences of the regional and global stressors ….. and the synergistic complexities of the four major sources of stress.

Challenges for Management

Other management challenges have been:

- Moving away from the “silver bullet syndrome.”
- Explaining the complexities of coral reef health to the public.
- Convincing people that climate change is the major stressor affecting coral reef health.

Multiple Stressors Affecting Coral Reefs

Habitat Destruction

Coral Diseases

Pollution

Coral Bleaching

Overfishing

Intense Coastal Development

Massive Algal Blooms

Ocean Dumping

Introduction of Marine Exotics

Global Climate Change

Effects of Coral Bleaching

Bleaching Can Promote Coral Disease Outbreaks

Inshore patch reefs
Middle Florida Keys

Marilyn E. Brandt
University of Miami

Accumulative Effects of Coral Bleaching

Coral decline threatens fish biodiversity in marine reserves. **Jones, G. P. et. al. 2004.**

- Death due to bleaching reduces coral reef biodiversity by decreasing coral species and coral cover.

- Declines in coral cover can cause a decrease in abundance of reef fish and a large decline in the number of reef species.

Accumulative Effects of Coral Bleaching

Coral reef loss in Caribbean leads to ongoing fish declines **by Jeremy Hance (April 30, 2009)**

- Analyzed 48 surveys of Caribbean fish populations over fifty years, from 1955-2007
- New meta-study has found that fish populations began to drop in the mid-90s
- Leading to a consistent decline that hasn't stopped.

Accumulative Effects of Elevated SST

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FEATURE ARTICLE

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

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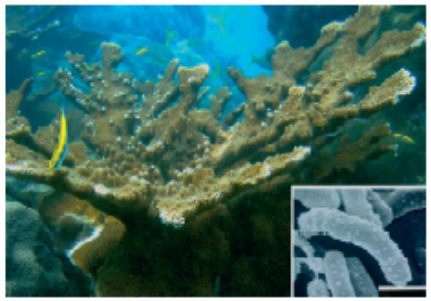
ABSTRACT: Caribbean populations of the elkhorn coral *Acropora palmata* have declined due to environmental stress, bleaching, and disease. Potential sources of coral mortality include invasive microbes that become trapped in the surface mucus and thrive under conditions of increased coral stress. In 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

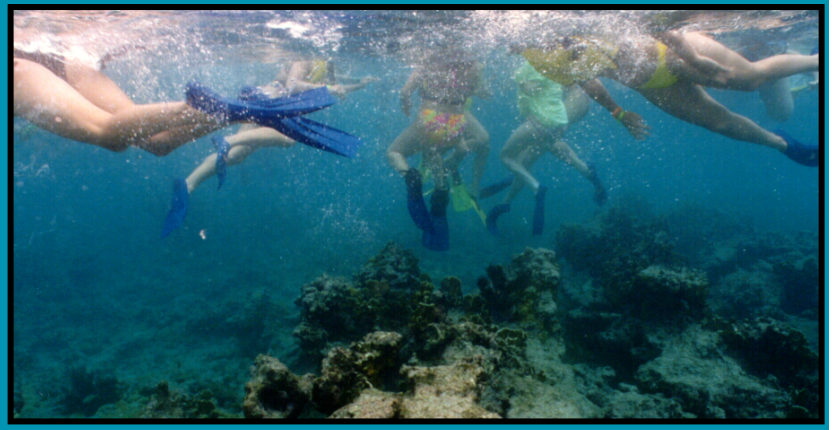


This study found that mucus from healthy *Acropora palmata* (photo) inhibits the growth of potentially invasive microbes by up to 10-fold. Conversely, mucus collected during a summer bleaching event lacked antibiotic properties, suggesting that high temperatures reduce the protective function of coral 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)

In Brief, the results are:

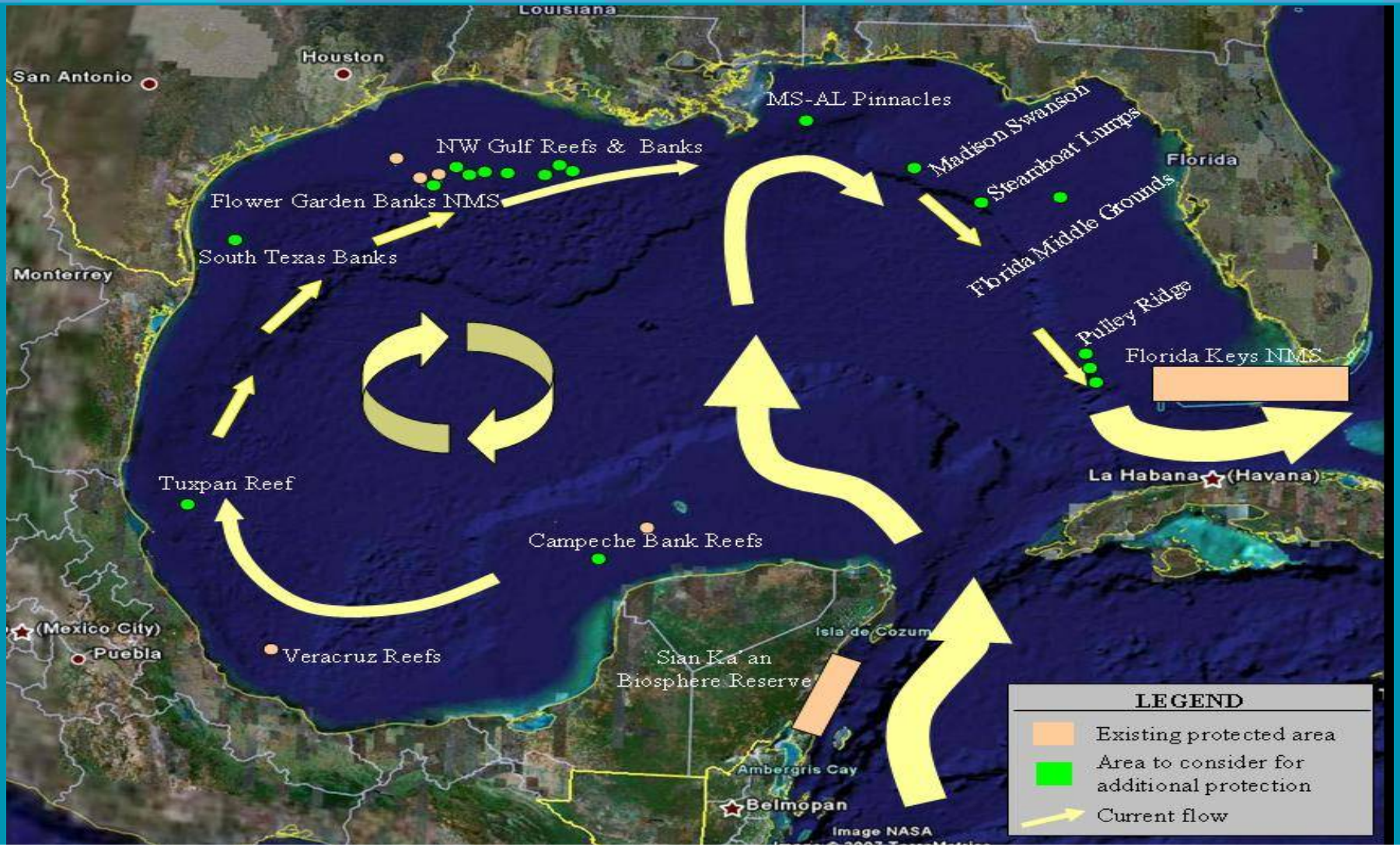
- ***Acropora palmata* has antibiotic activity that is lost when temperatures increase**
- **First evidence explaining why corals are more susceptible to disease during warming**



Connectivity with the Gulf of Mexico

- I am encouraged by what we know today
- I am encouraged by the advanced technology
- Through improved remote sensing capabilities, we comprehend the vast connectivity that exists
- We know more about the far reaching influences of stressors on our coral reef ecosystems.
- We have to apply an ecosystem-based approach, working across domestic and international boundaries

Gulf of Mexico MPA Network
(*Islands in the Stream MPA Network*)



Challenge to Unravel Scientific Secrets

- It's exciting and encouraging to see so many young scientists here today – and such a diversity of talks
- In recent years, great strides have been made in improving scientific collaborations at all spatial and temporal scales.
- As a result, we know more about coral reef than ever before - from the microbes to the community scales
- I challenge you to reach out to others…. share, collaborate, and don't believe in simple-solutions
- We need you to unravel the scientific secrets that coral reefs hold

National Marine Sanctuaries
National Oceanic and Atmospheric Administration

http://sanctuaries.noaa.gov

Summary of Local Actions to Address the 4 Threats to Coral Reefs

- Climate Change
- Land-based Sources of Pollution
- Habitat Loss and Degradation
- Overfishing

Climate Change

Climate Change Stressors

- Sea surface temperature / ocean heat content
- Sea level rise
- Tropical storms
- Alteration of circulation patterns, currents, upwelling
- Likely effects on El Niño-Southern Oscillation and other ocean oscillations
- Carbon dioxide effects on ocean chemistry / calcification – Ocean Acidification

Climate Change

Florida Reef Resilience Program

What is FRRP?

Florida Reef Resilience Program

Origin: Discussions between NOAA, GBRMPA, State of Florida, TNC

- Resilience based management concept
- Stratified sampling of entire reef tract
- Goals
  - Find reefs that are likely to resist or recover from bleaching
  - Guide protection & management of those areas

Australian Government
Great Barrier Reef Marine Park Authority

DEPARTMENT OF ENVIRONMENTAL PROTECTION
FLORIDA

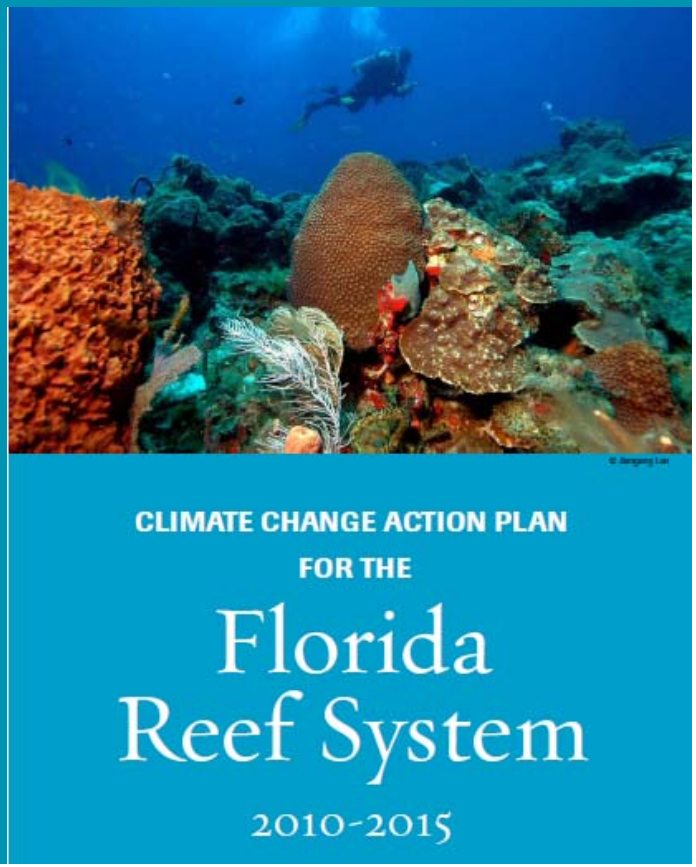
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

The Nature Conservancy
Protecting nature. Preserving life.™

Florida Reef Resilience Program

Climate Change Action Plan for the Florida Reef System 2010-2015

Recognizes the need to reduce local impacts to increase resilience and offers a framework of adaptable actions throughout the entire 300 nm of the FL Reef Tract to comprehensively address the complex factors associated with climate change.

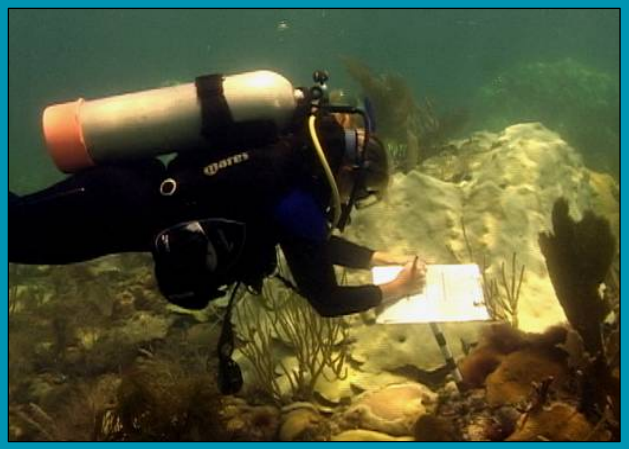


The Action Plan

- 6 Overarching Enabling Conditions
- Detailed Actions
  - 22 Management
  - 10 Social/Outreach
  - 8 Research

www.FRRP.org

Marine Ecosystem Event Response and Assessment (MEERA)



Community-Based Reporting and Response to Events in the Florida Keys Coastal Marine Environment

Erich Bartels, Project Manager

Cory Walter, Project Coordinator

Florida Keys Coral Bleaching Early Warning Network

BleachWatch

MOTE MARINE LABORATORY

NATIONAL MARINE SANCTUARIES ™
FLORIDA KEYS

Threats to Coral Reefs

While we work on Climate Change impacts at the global scale, it becomes even more important to address impacts to coral reefs at the regional and local scales.

Land-based Sources of Pollution

Water Quality Protection Program

Keys-wide No Discharge Zone

Boot Key Harbor

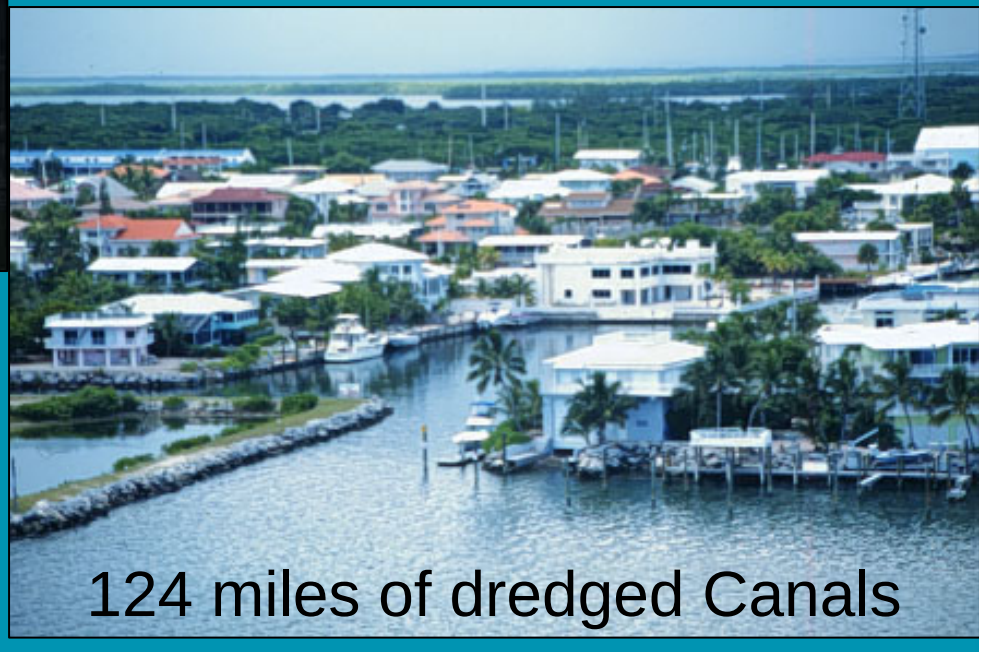
Live-aboard Anchorage

> 250,000 gallons of sewage pumped out since 2005

Had in 1990:

- 25,000 Septic Tanks
- 9,000 Cess Pits

By 2011 – 70% of Equivalent Dwelling Units will be compliant



124 miles of dredged Canals

Land-based Sources of Pollution

City of Key West
- ATW Standards
- Deep-well injection

Wastewater Master Plan
&
Stormwater Master Plan

Within a Year
70%
of Equivalent Dwelling Units
will be on Central System

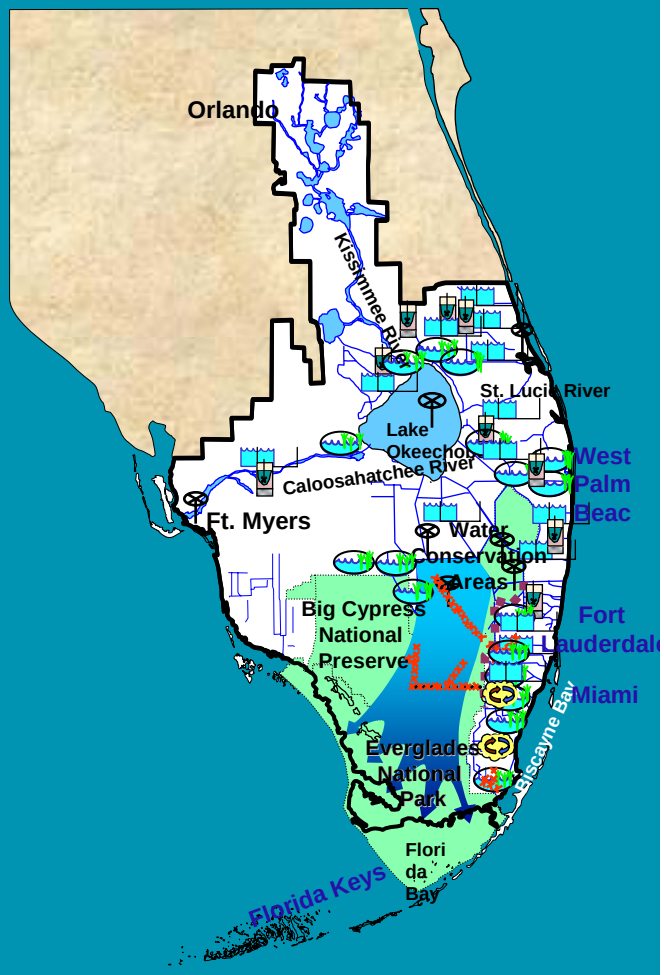
Key Largo and Marathon
Online within a year!

Land-based Sources of Pollution

Comprehensive Everglades Restoration Plan

68 Components

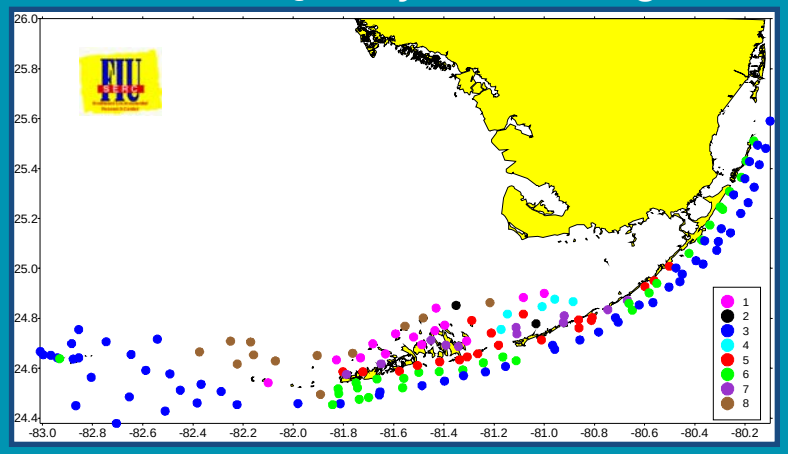
- 6 pilot projects
- 15 surface storage areas (~170,000 acres)
- 3 in-ground reservoirs (~11,000 acres)
- 330 aquifer storage and recovery wells
- 19 stormwater treatment areas (~36,000 acres)
- 2 wastewater reuse plants
- Removal of over 240 miles of canals, levees and structures
- Operational changes



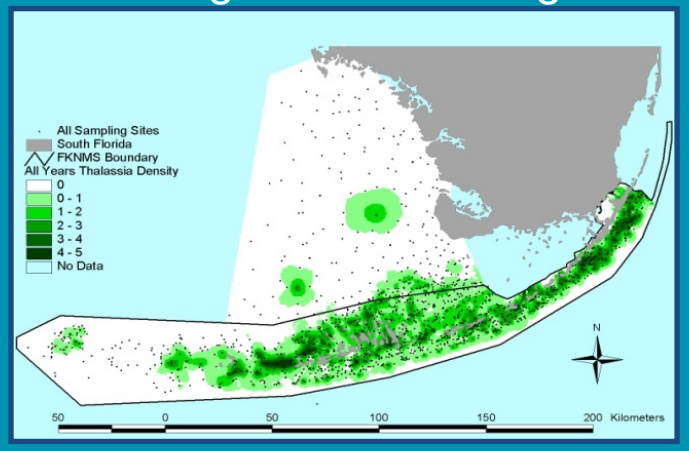
Land-based Sources of Pollution

FKNMS Water Quality Protection Program

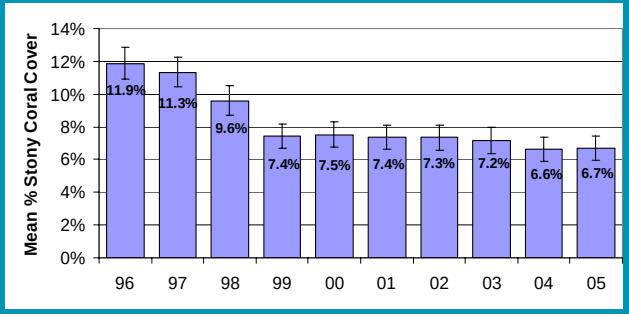
Water Quality Monitoring



Seagrass Monitoring



Coral Monitoring

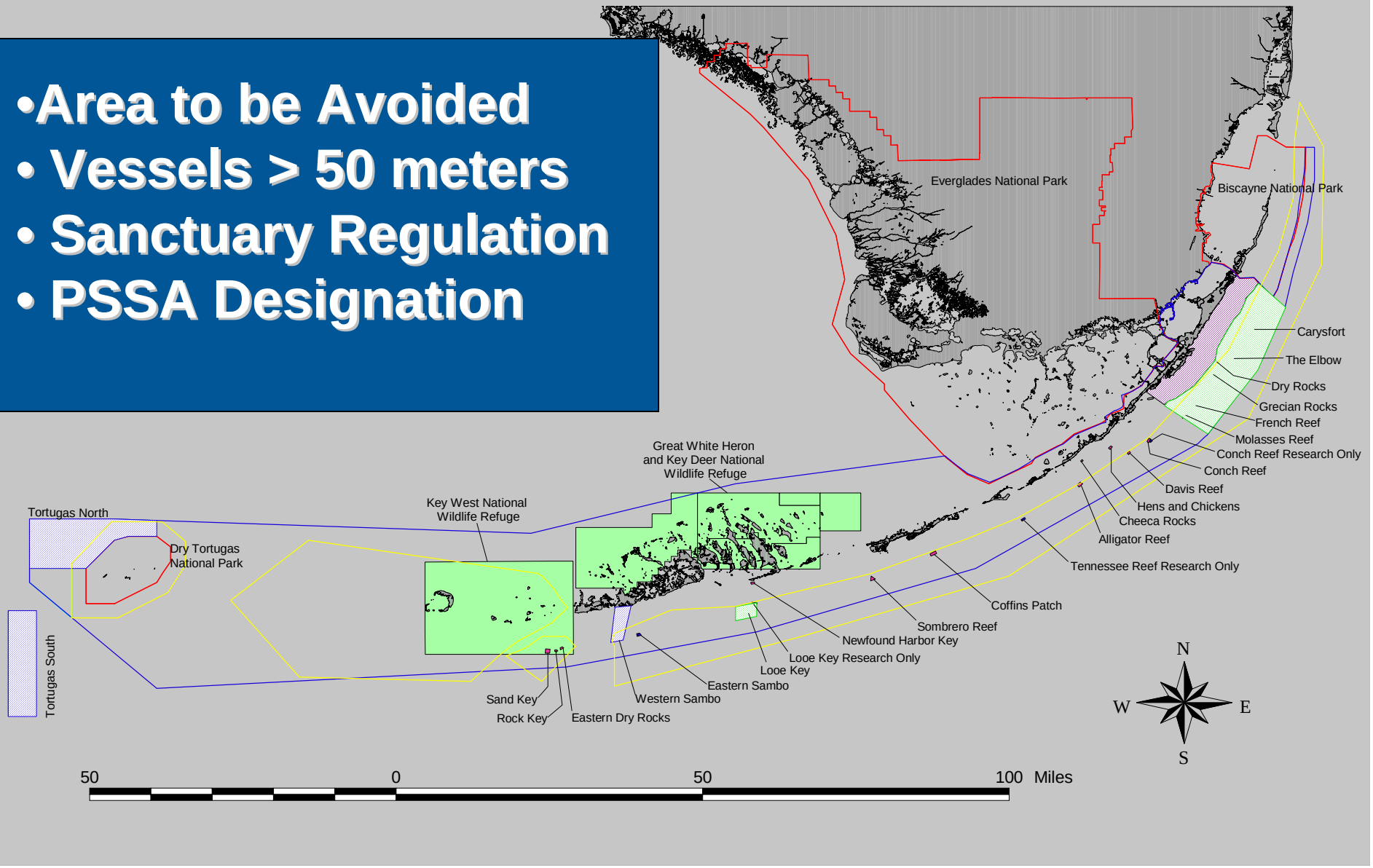


Habitat Loss and Degradation

Disturbance to the Seafloor is Prohibited and Regulated / Managed

International Maritime Organization Designated ATBA

- Area to be Avoided
- Vessels > 50 meters
- Sanctuary Regulation
- PSSA Designation



Marine Spatial Planning and National Marine Sanctuaries

Marine Zones

- **Sanctuary Preservation Areas**
- **Special-Use Areas**
- **Ecological Reserves**
- **Wildlife Management Areas**
- **Existing Management Areas**