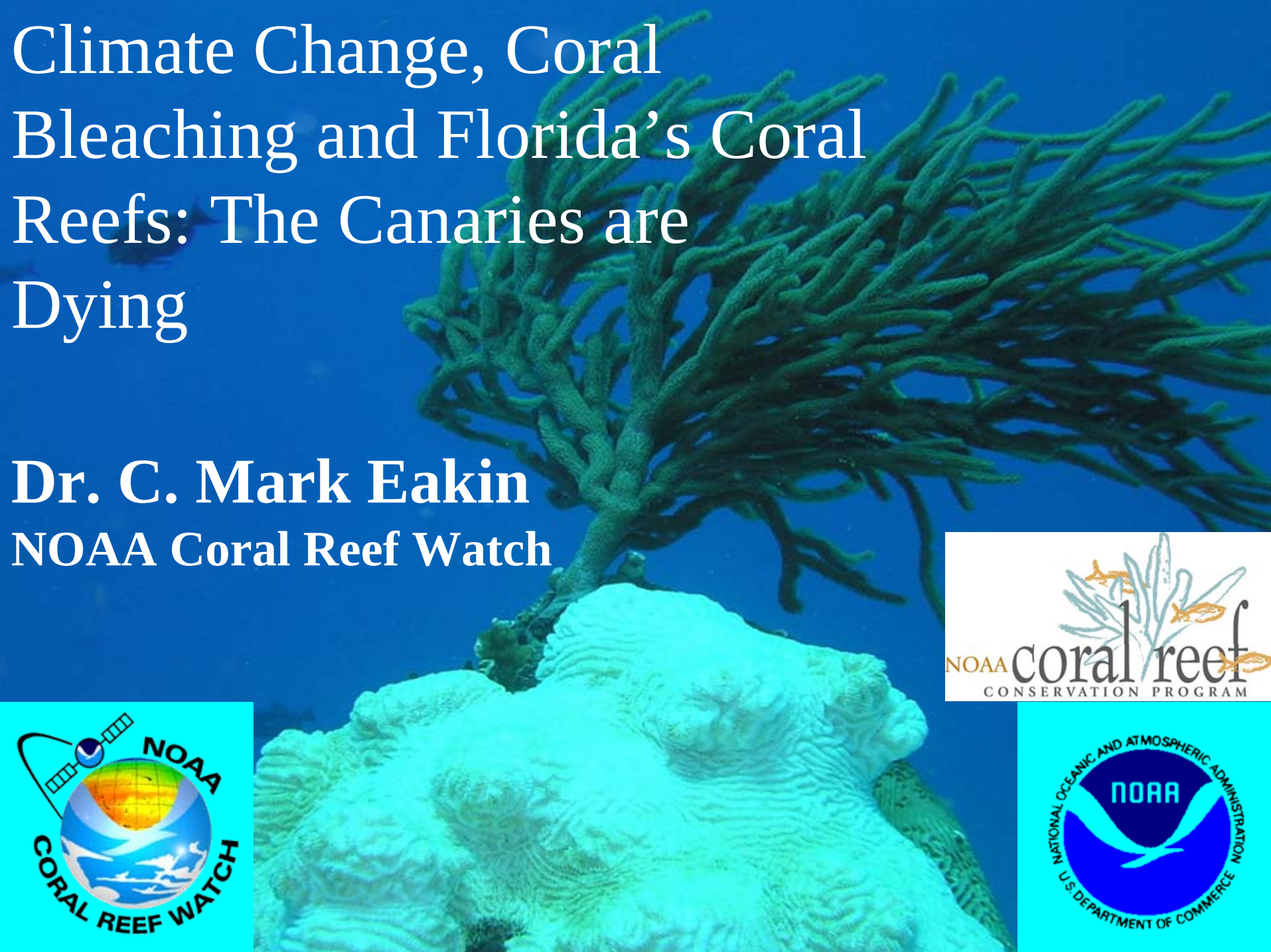
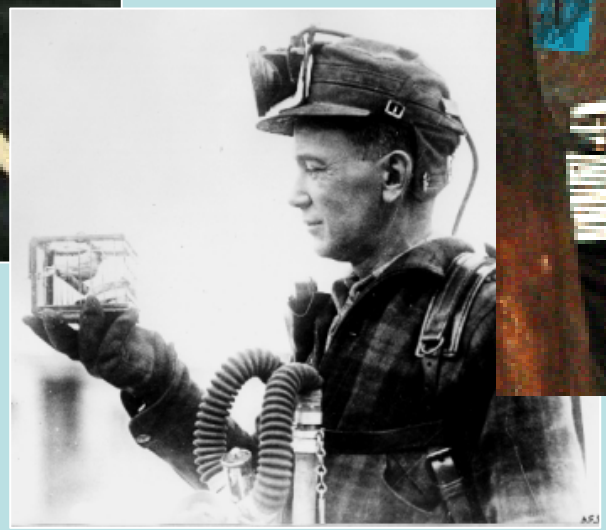
Climate Change, Coral Bleaching and Florida's Coral Reefs: The Canaries are Dying

Dr. C. Mark Eakin
NOAA Coral Reef Watch



the Canaries in the Coal Mines



“Corals: our Canaries in the Coal Mines”

Why Do We Care?

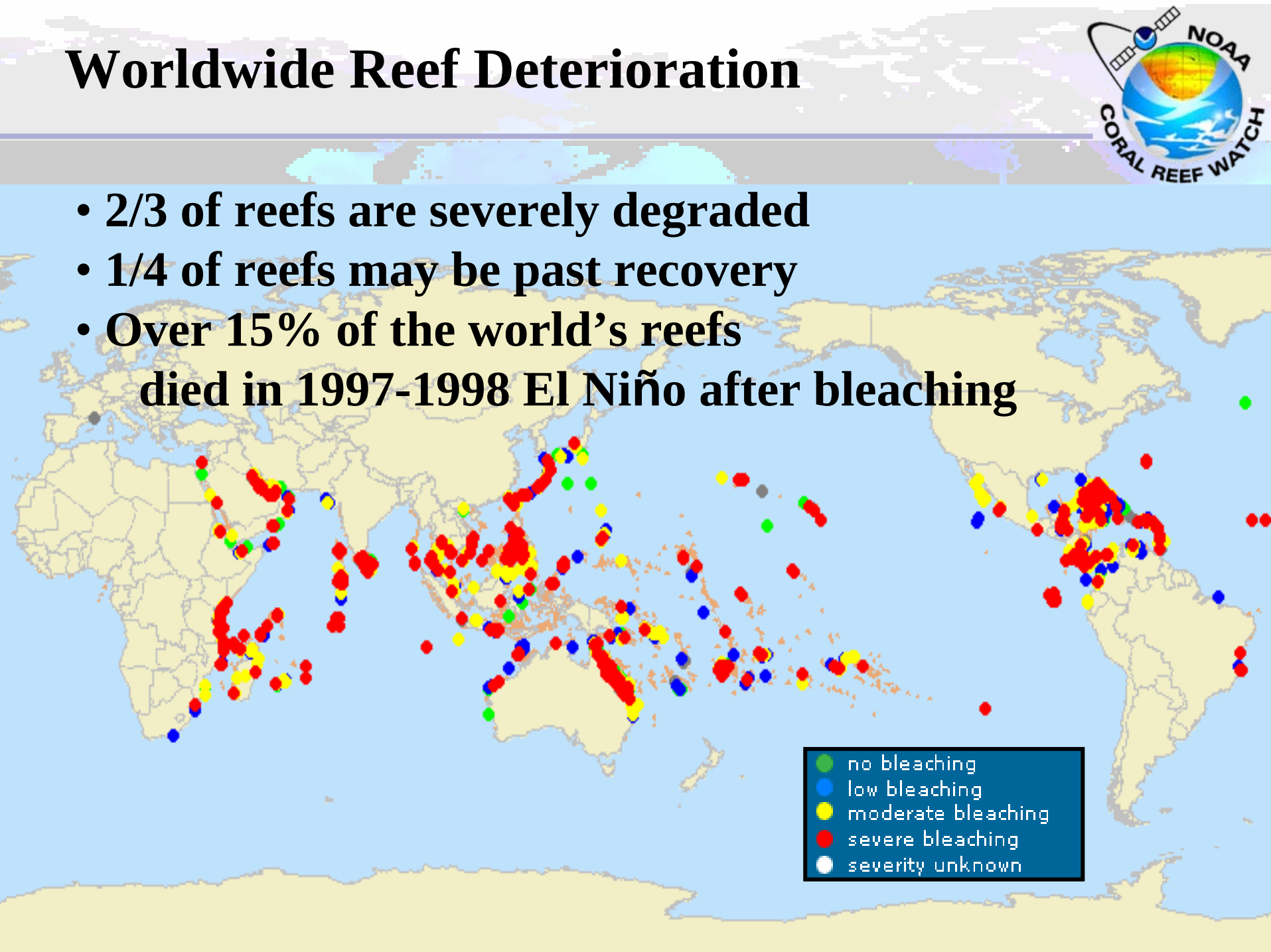
Value of Reefs

- up to $375 billion in fish, seafood, tourism, and coastal protection worldwide $100,000-$600,000 /km^2
- $17 billion in U.S. tourism
- 45 million tourist visits to U.S. reefs
- $247 million in commercial fishing on U.S. reef fish
- 1 billion people rely on reef fish for food
- One of the most diverse systems on earth

Why Do We Care?

Worldwide Reef Deterioration

- 2/3 of reefs are severely degraded
- 1/4 of reefs may be past recovery
- Over 15% of the world's reefs died in 1997-1998 El Niño after bleaching



Top Threats to Reefs:

- Human Population Growth
- Overfishing
- Coastal Development
- Lack of Laws / Enforcement
- Sedimentation (unnatural)
- Lack of Education
- Nutrient Enrichment
- Algal Competition
- Climate Change / Bleaching
- Habitat Destruction
- Tourism

2004 Survey: 276 Coral Reef Scientists
Kleypas and Eakin (2007)

Outline

Introduction
- Why do corals bleach?
- Bleaching warnings from space

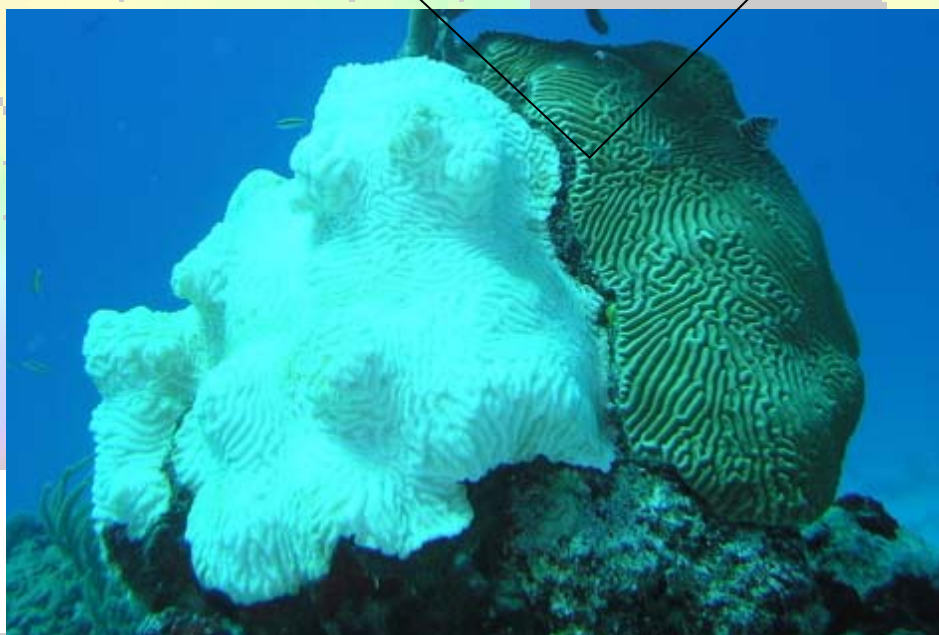
2005 Caribbean Bleaching Event
- Extent of bleaching
- Climate context: why did the corals bleach?

Future Bleaching
- Climate of the 21st Century
- How will corals respond?
- What can we do?

What is Coral Bleaching?

- Most of corals' food comes from photosynthesis

Symbiotic algae



What is Coral Bleaching?

- Most of corals' food comes from photosynthesis

- Corals can "bleach" due to stress

- Corals exposed to high temperatures and/or high light become stressed

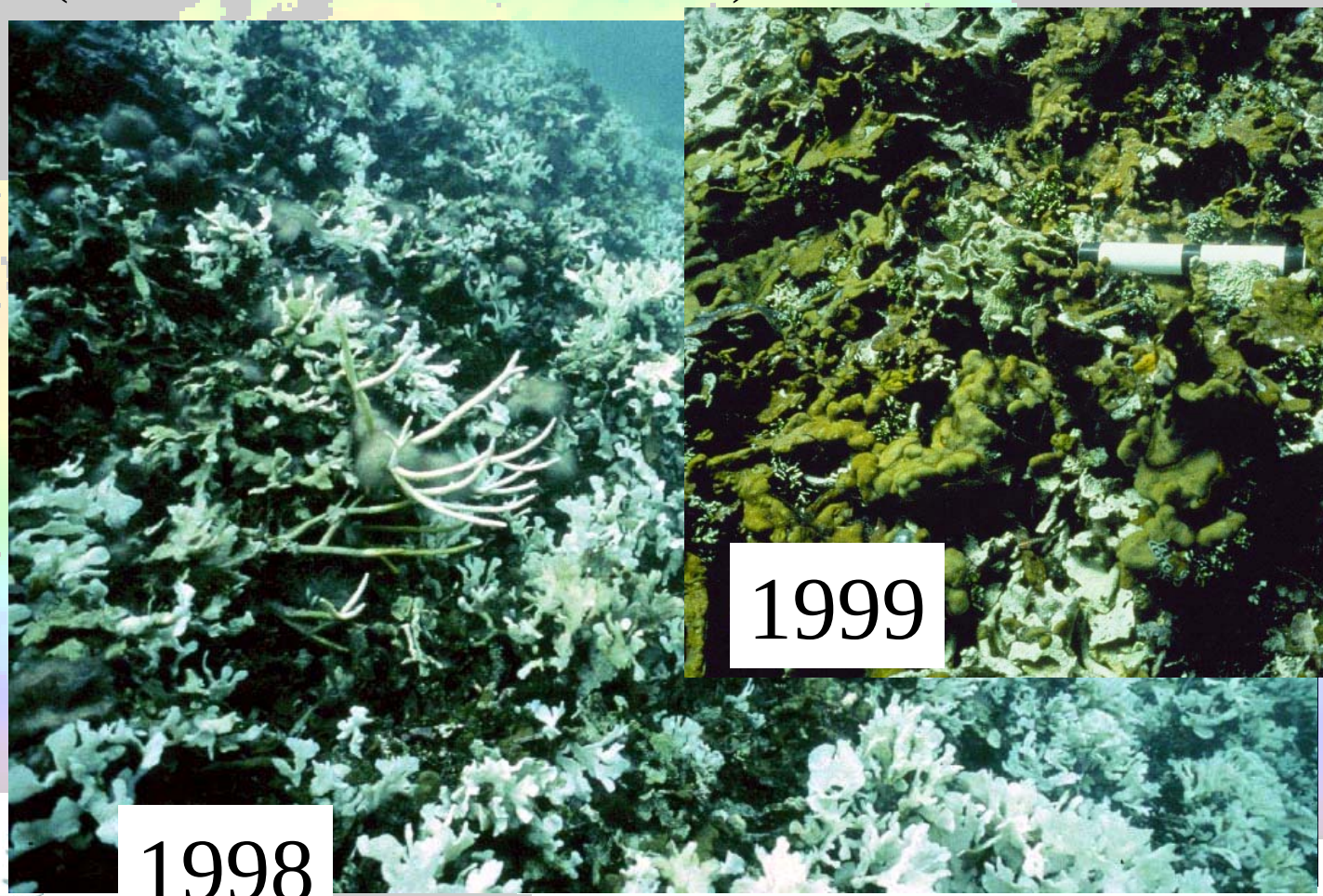
- Corals eject their algae; coral appears "bleached

- If stress is mild or brief, corals recover, otherwise they die

Symbiotic algae

Recent Decades: Catastrophic, Unprecedented Bleaching

Widespread bleaching in Belize
(from Aronson and Precht 1997, 2001)



NOAA Coral Reef Watch Program

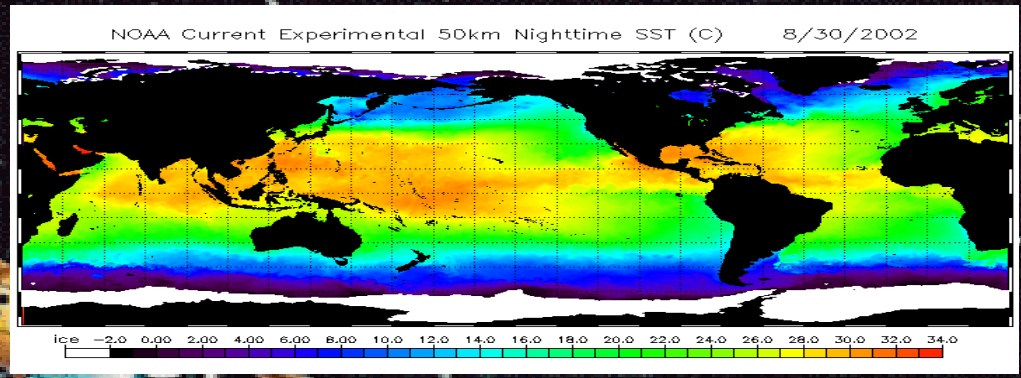
Satellite Near Real-Time Coral Bleaching HotSpot Products

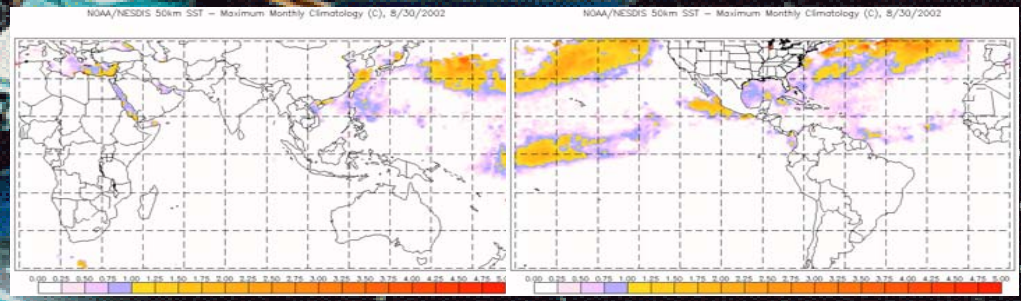
(Twice-weekly at 50km resolution)

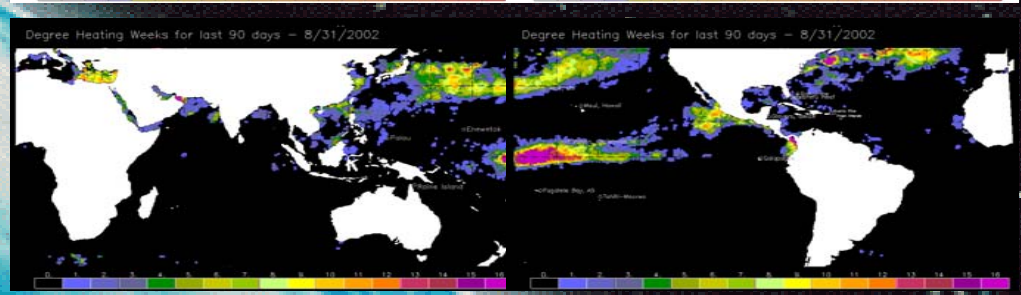
Sea Surface Temperature
(Night-time only)

Bleaching HotSpots

Degree Heating Weeks (DHW)

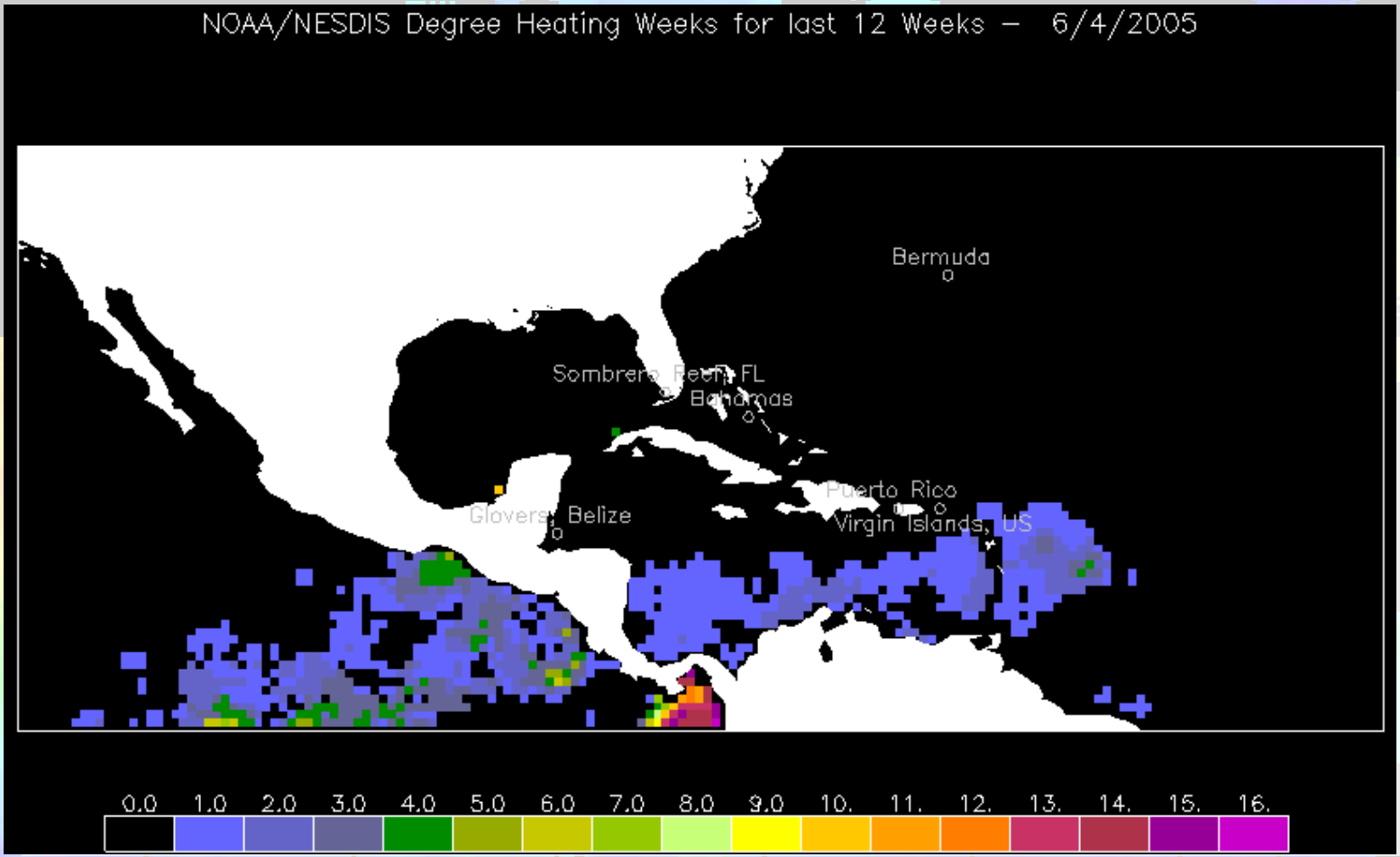






http://coralreefwatch.noaa.gov

Thermal Stress Index: NOAA Degree Heating Weeks



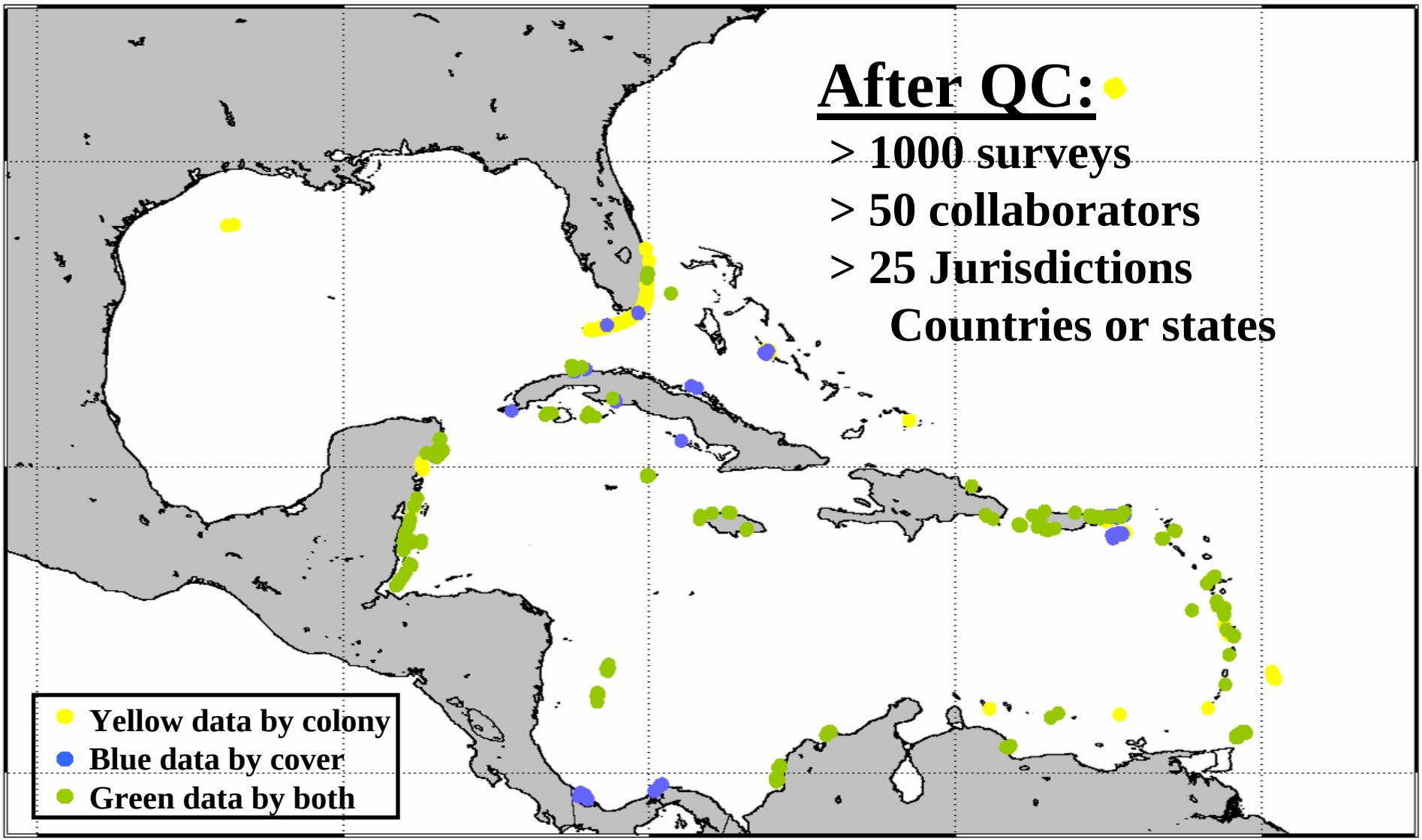
1 DHW = 1°C above maximum monthly mean for 1 week

≥ 4 DHWs → coral bleaching is expected

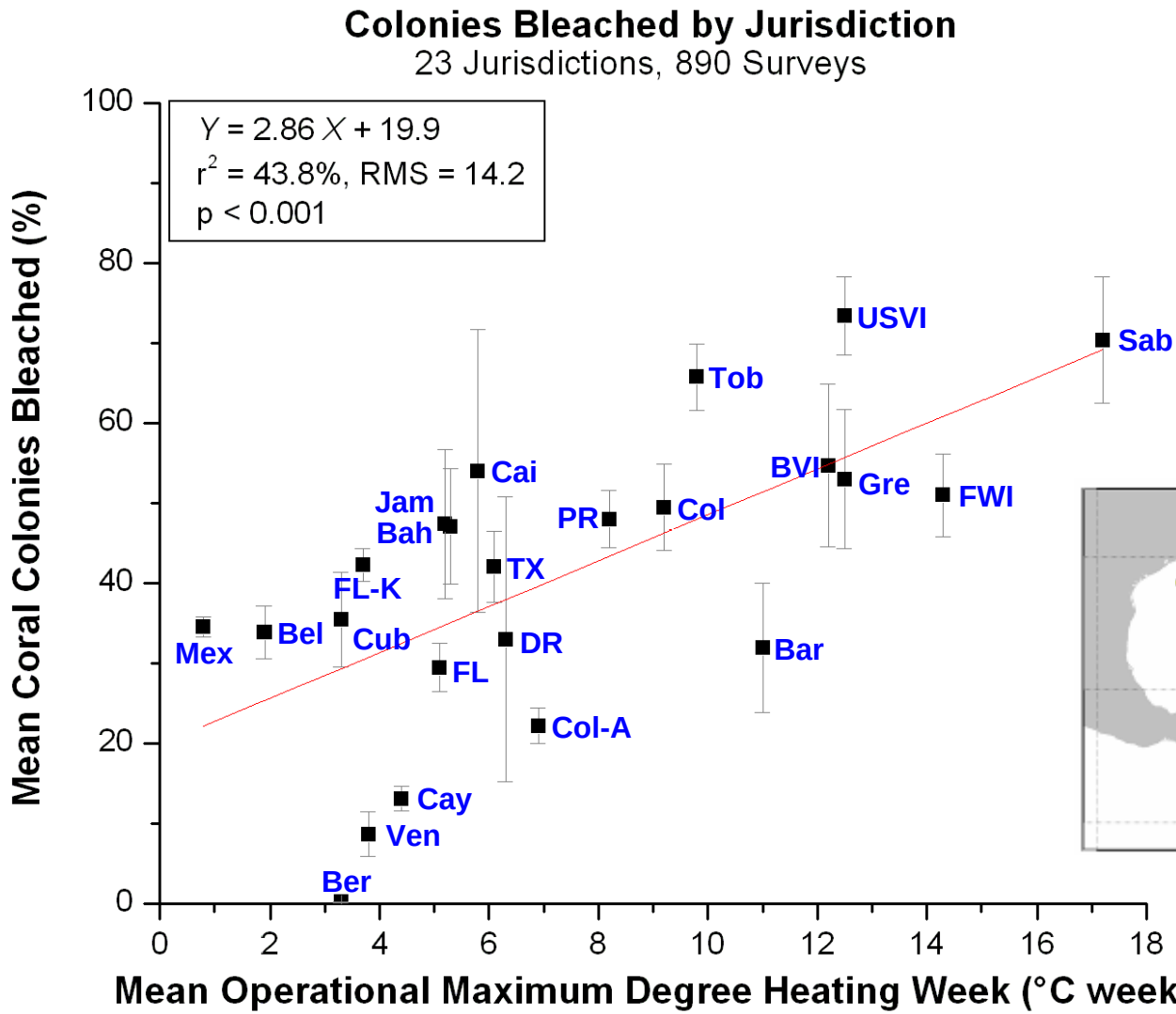
≥ 8 DHWs → mass bleaching and mortality are expected

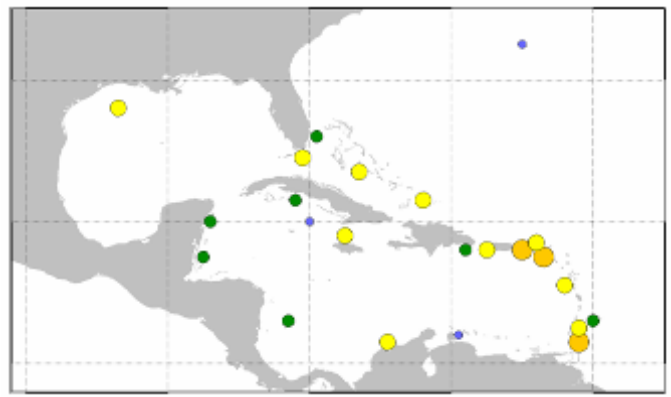
http://coralreefwatch.noaa.gov

Contributed Bleaching Reports



Percent of Coral Colonies Bleached





NOAA Coral Reef Watch, 9-Jan-07

Error bars indicate Standard Error of the Mean.

Bleaching Can Lead to Disease

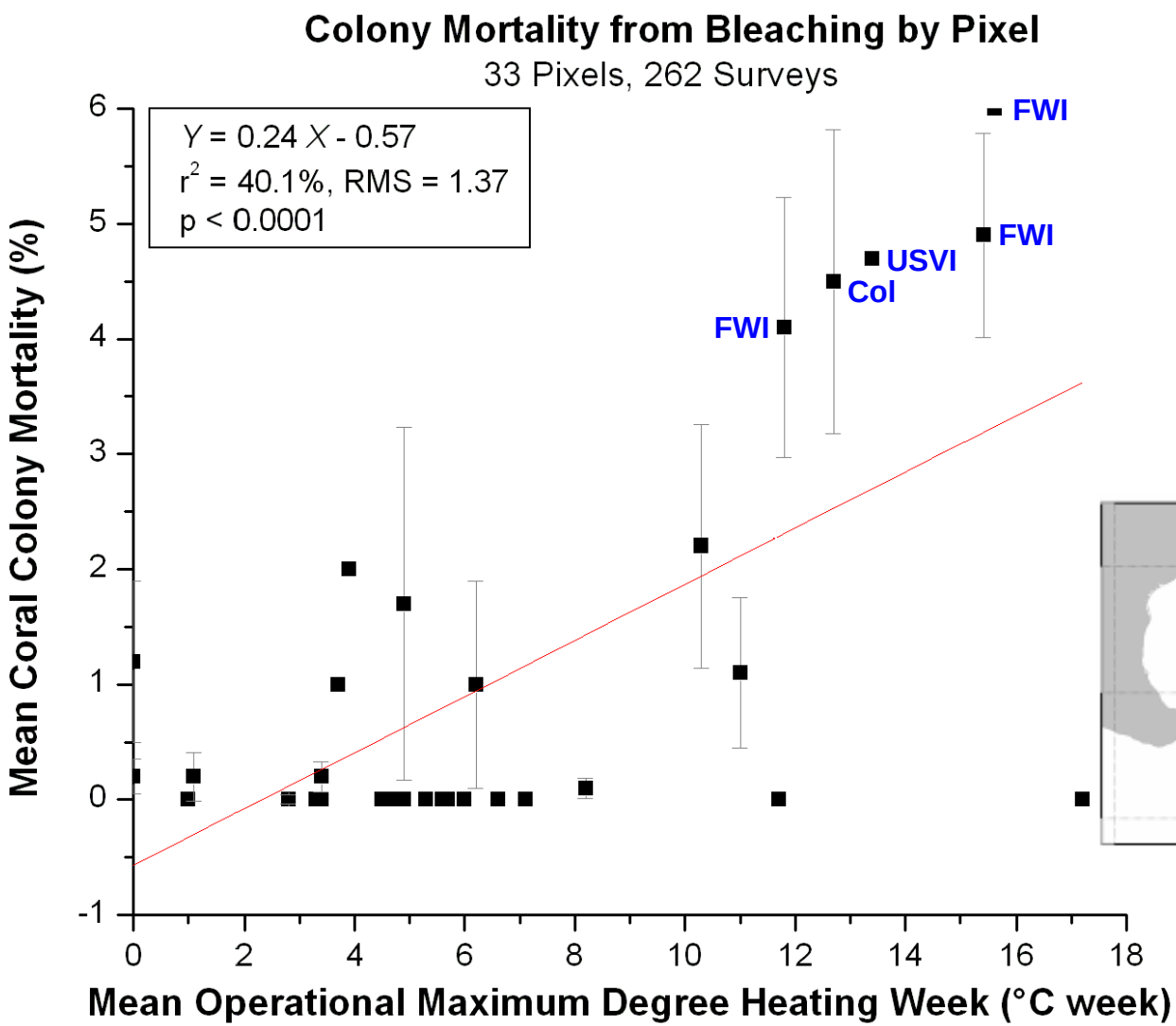
- **Many bleached colonies have become diseased**

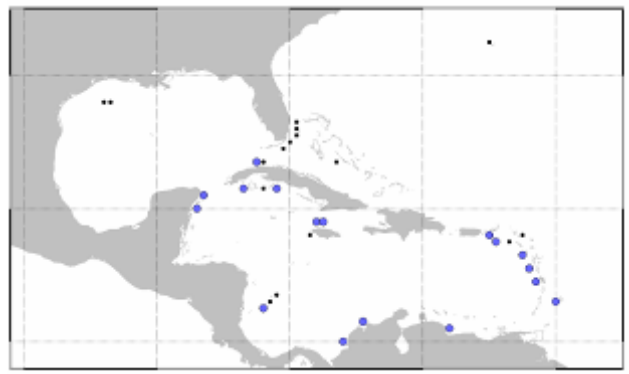
- **Some diseases are rapid and devastating**

Inshore patch reefs
Middle Florida Keys

Marilyn E. Brandt
University of Miami

Immediate Mortality (by Jan. 2006)





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Virgin Islands N.P.
Coral Bleaching Surveys

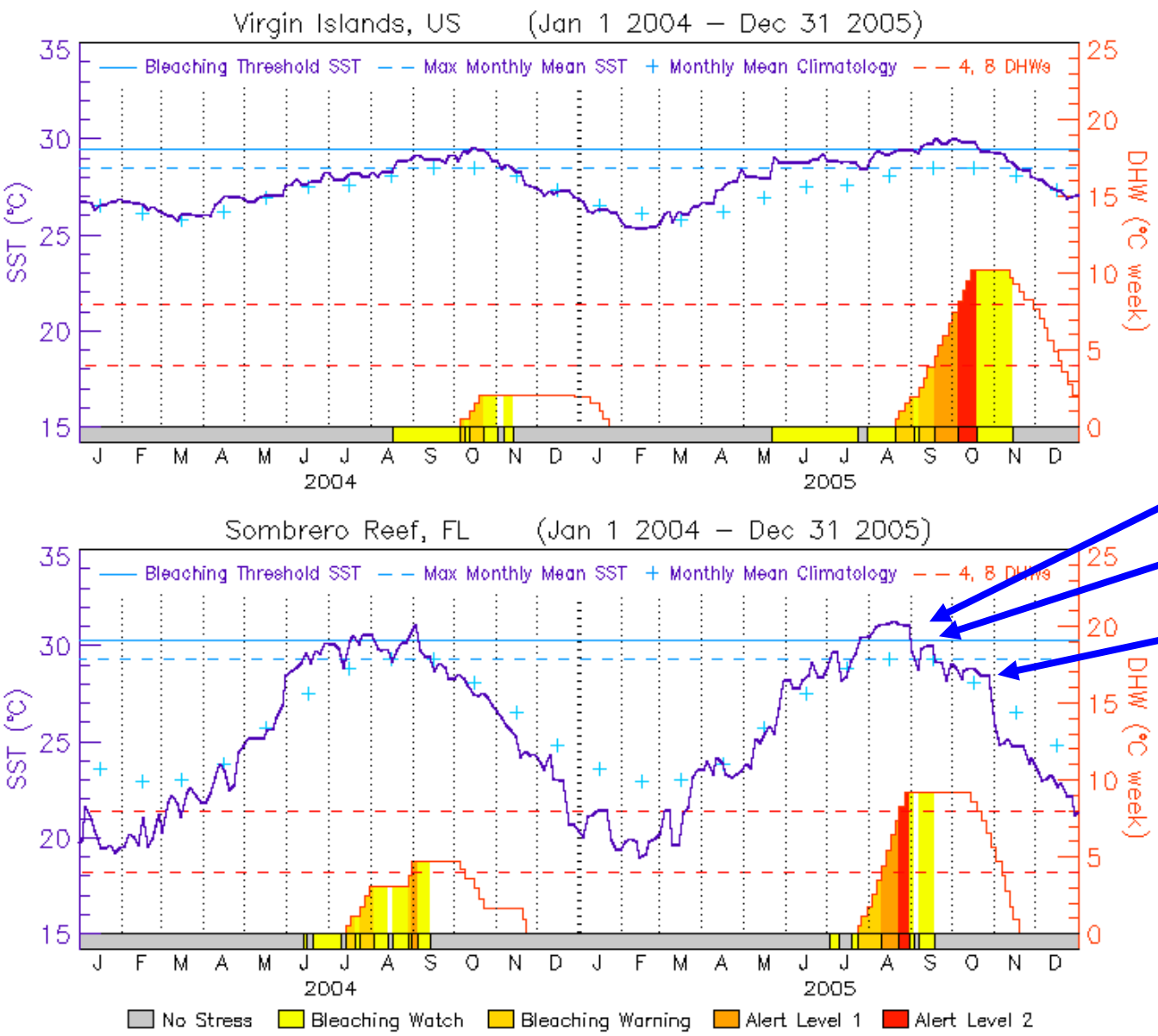
S. Fore Reef, BUIS			96% coral cover bleached 42% coral cover dead
Tektite, VIIS			90% coral cover bleached 54% coral cover dead
Haulover, VIIS			96% coral cover bleached 45% coral cover dead
Mennebeck, VIIS			94% coral cover bleached 49% coral cover dead
Yawzi, VIIS			71% coral cover bleached 39% coral cover dead
Newfound, STJ			92% coral cover bleached 53% coral cover dead

J. Miller (unpublished)

Photo by Judd Patterson

South Florida/Caribbean Network I&M Program

Florida: Missing the Worst



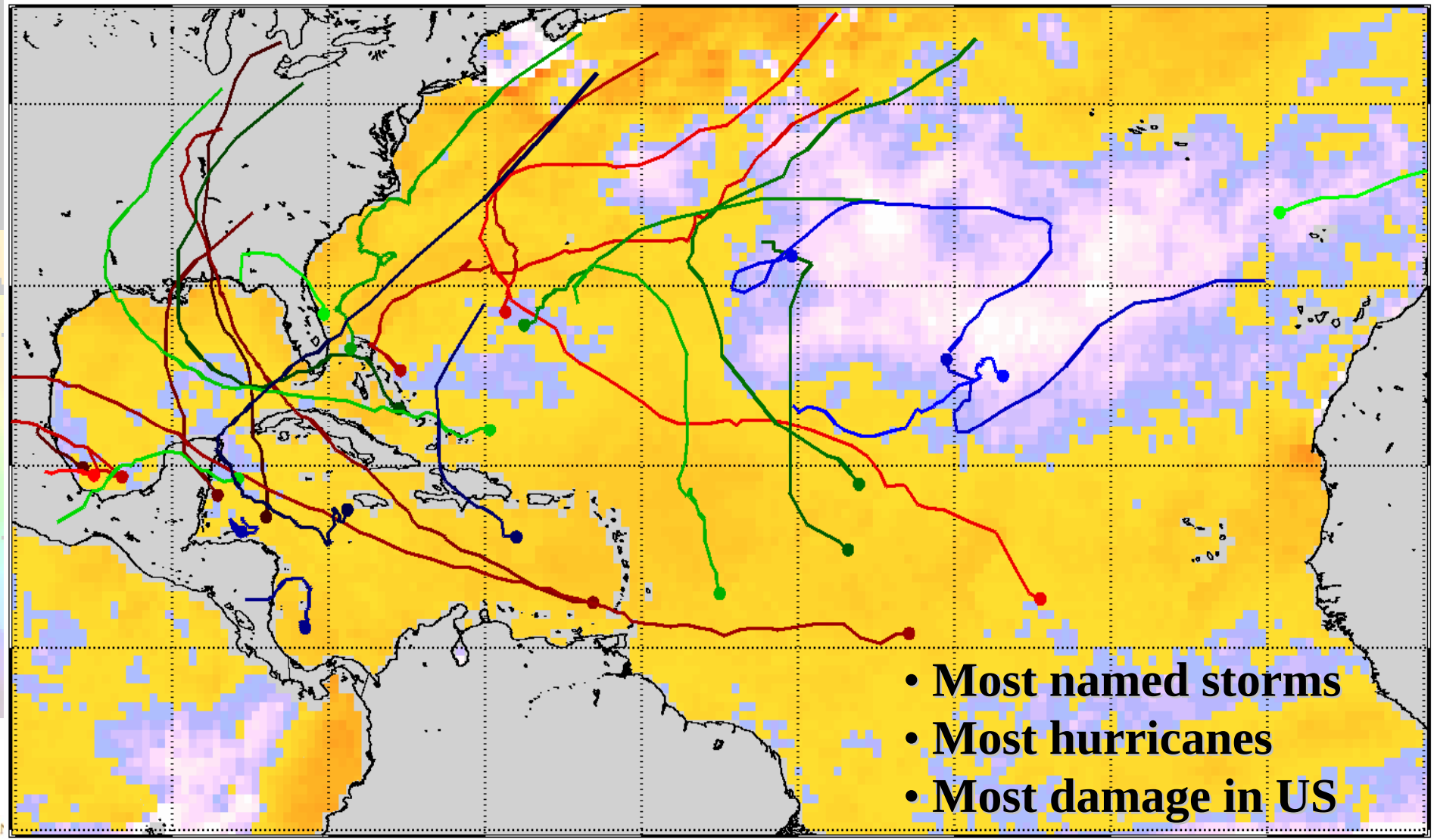
Katrina

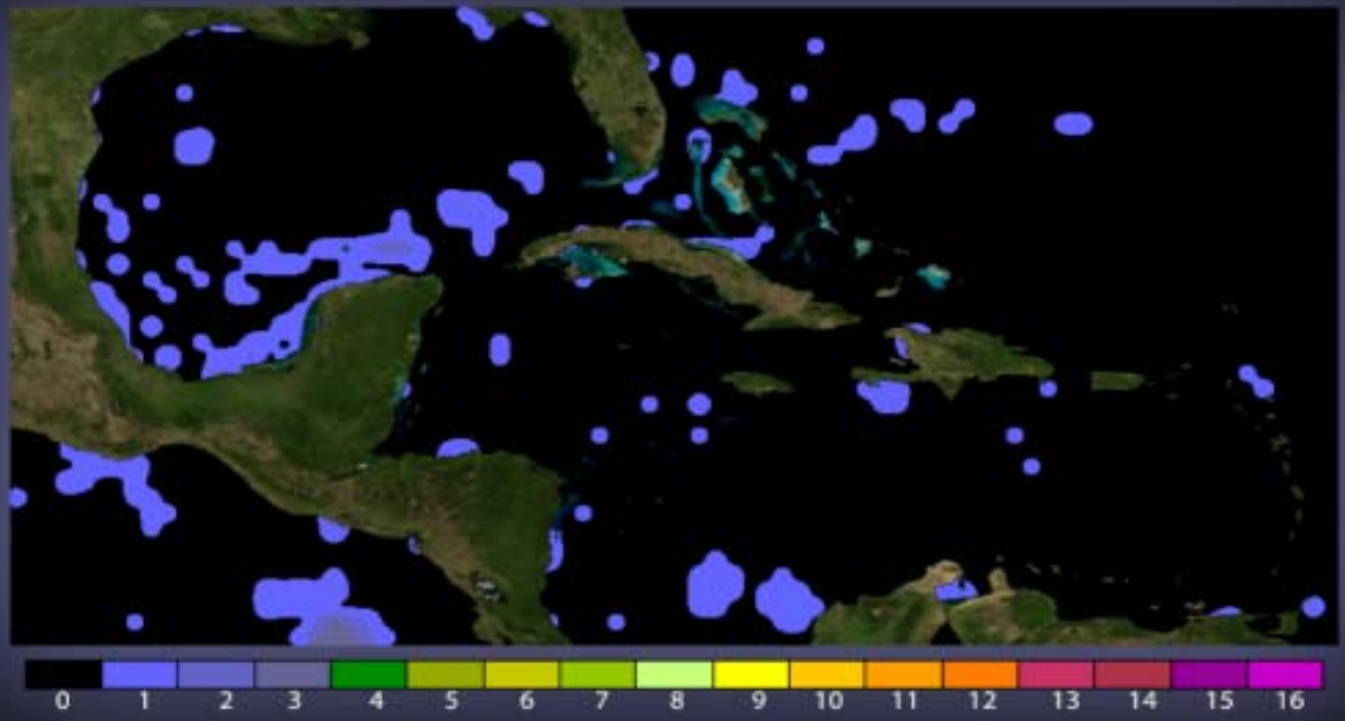
Rita

Wilma

oralreefwatch.noaa.gov

2005 Hurricane Season



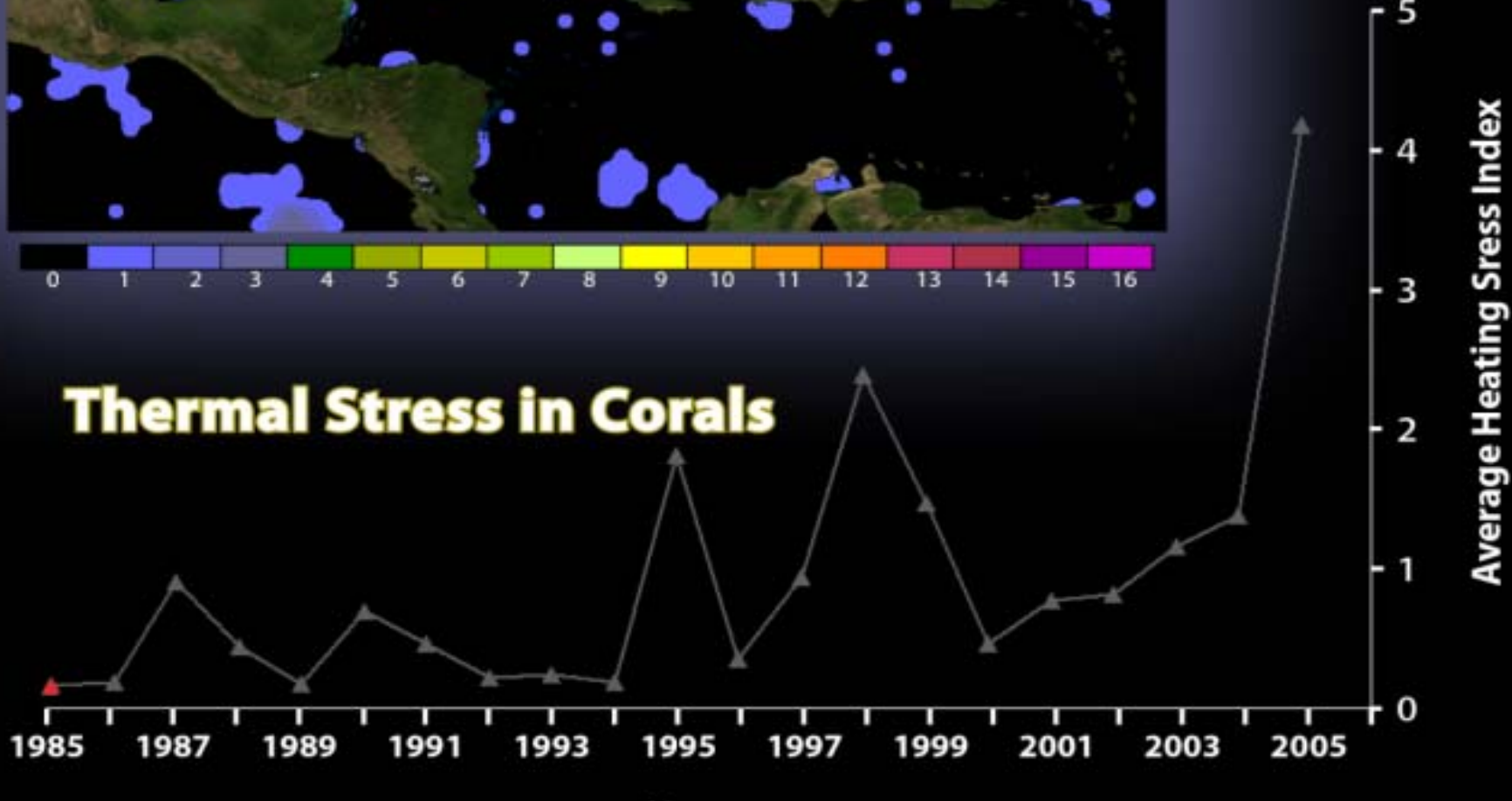


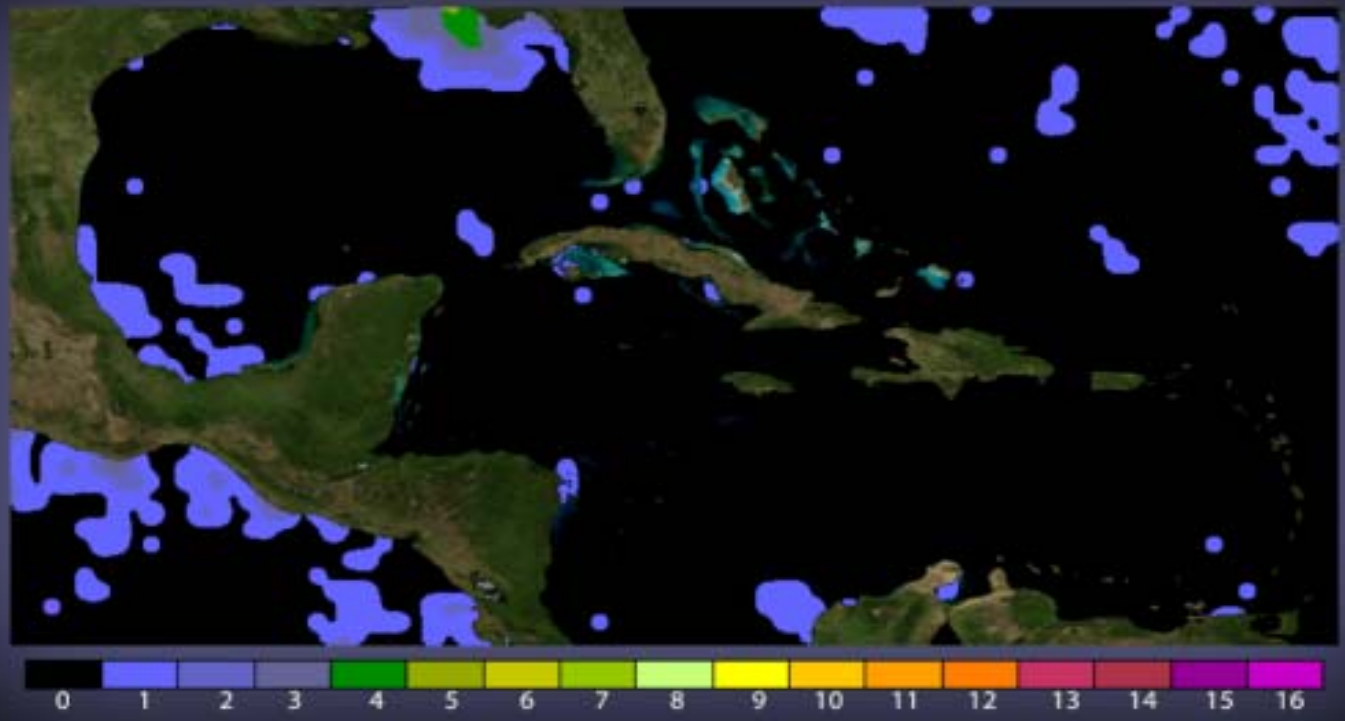
NOAA

Bleaching Expected

Mass Bleaching and Mortality

Thermal Stress in Corals





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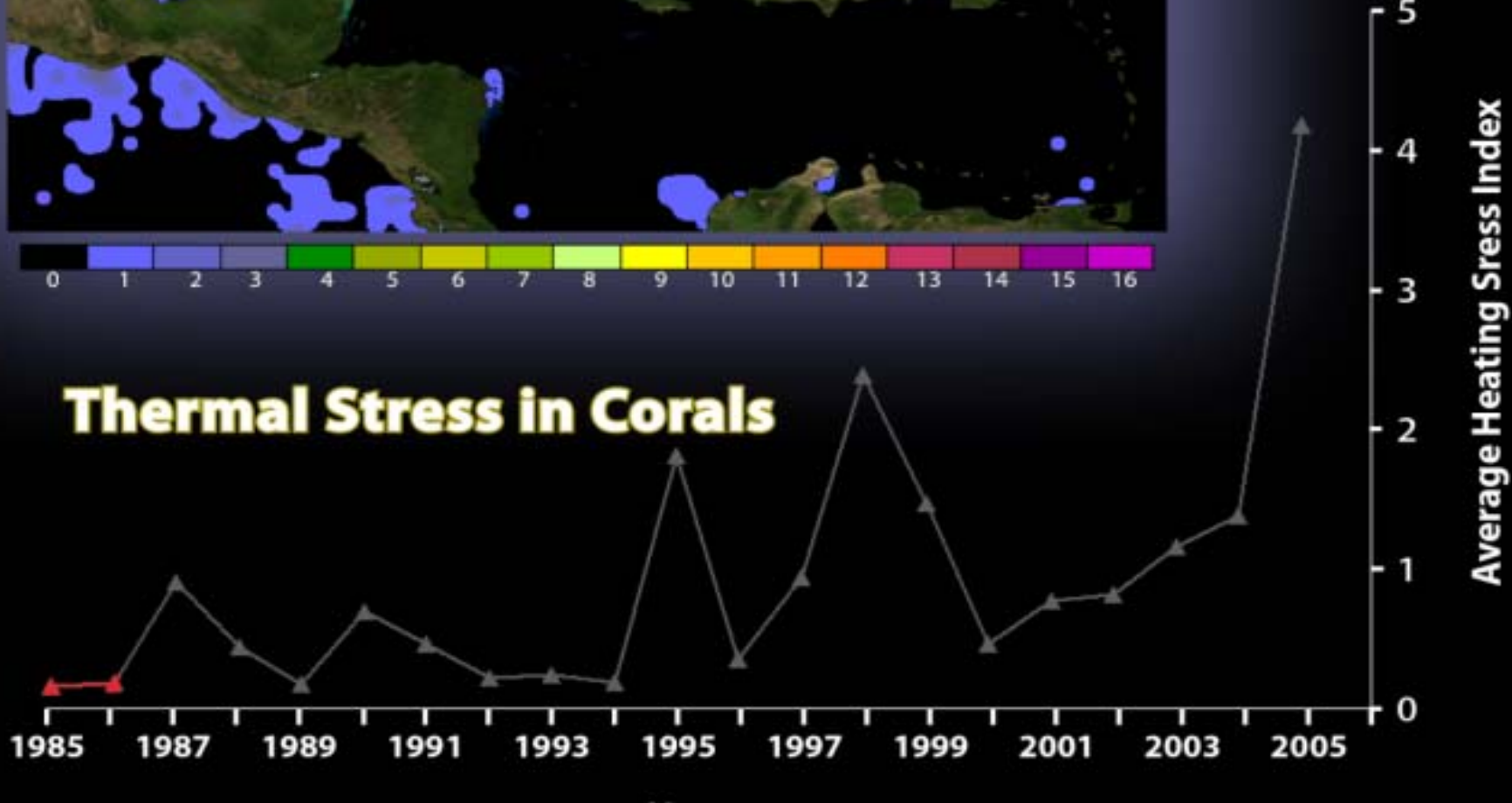

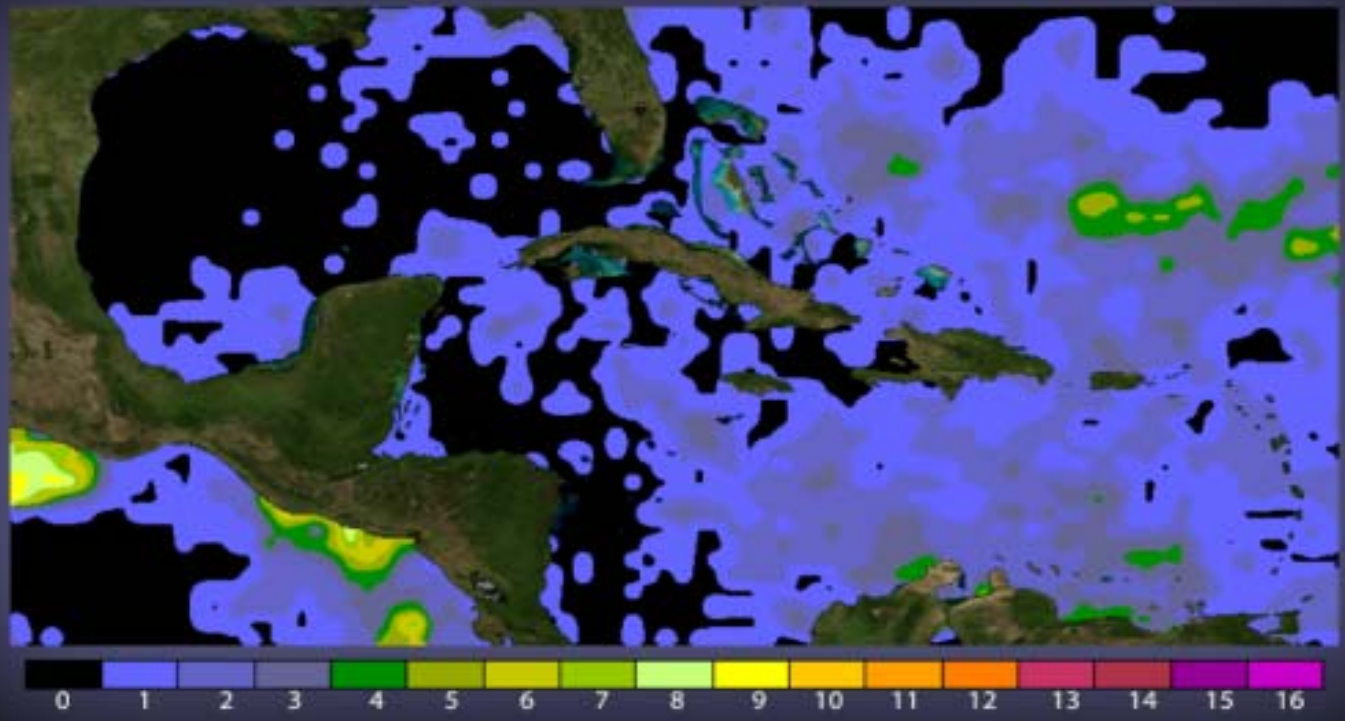

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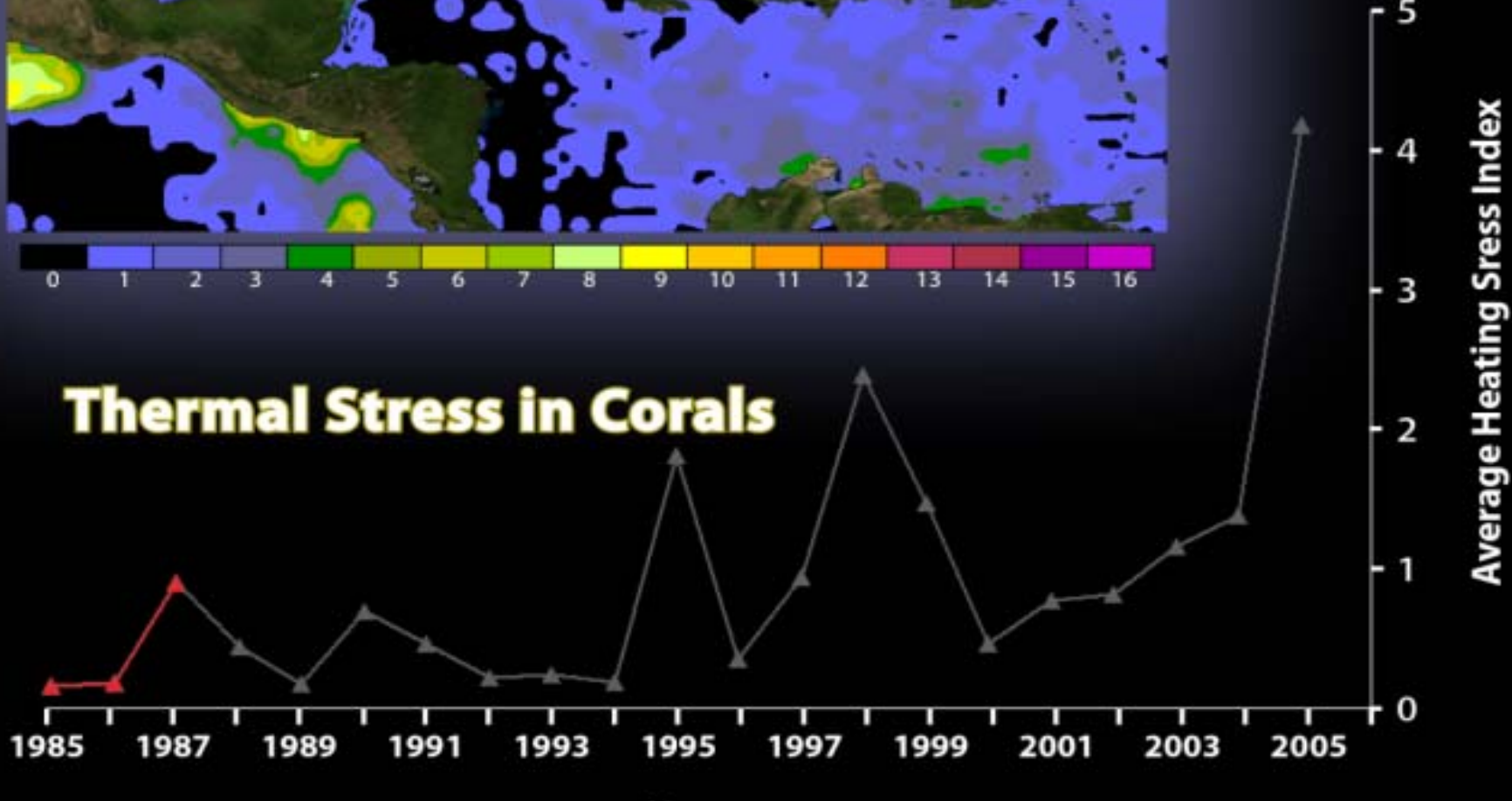

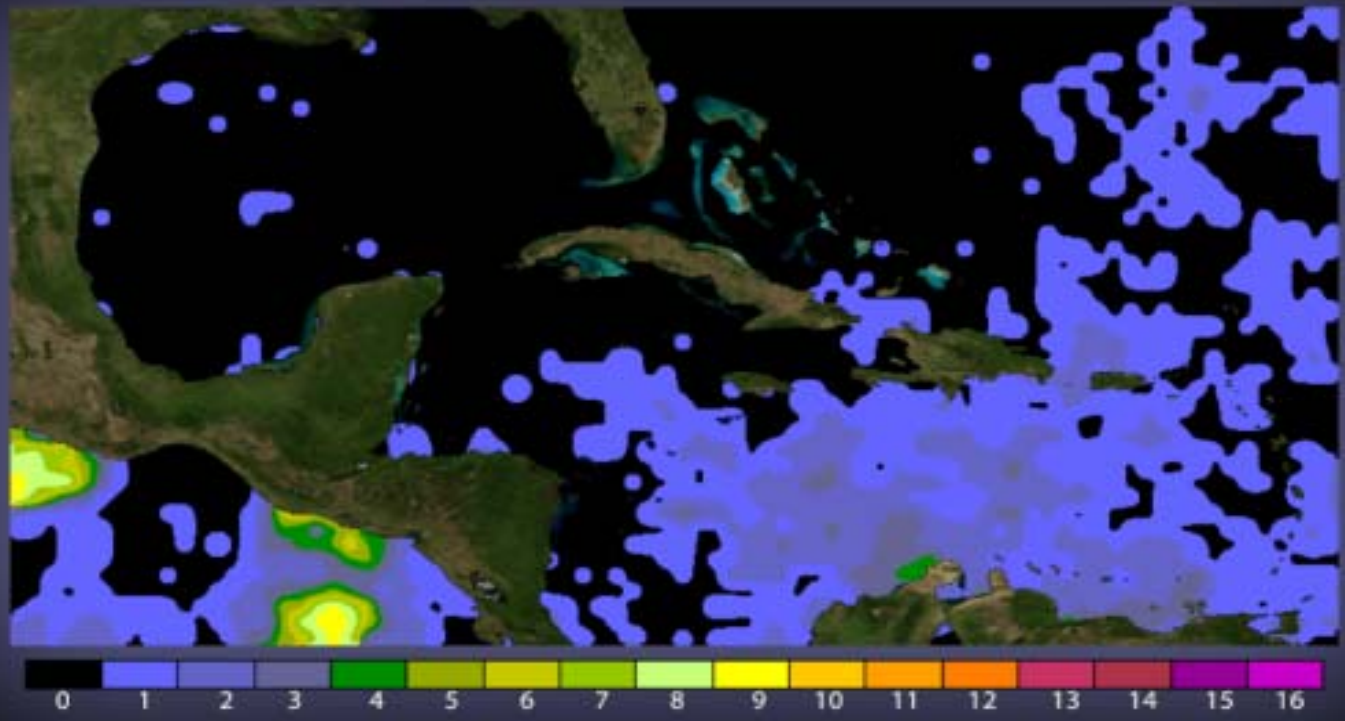

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0 1 2 3 4 5

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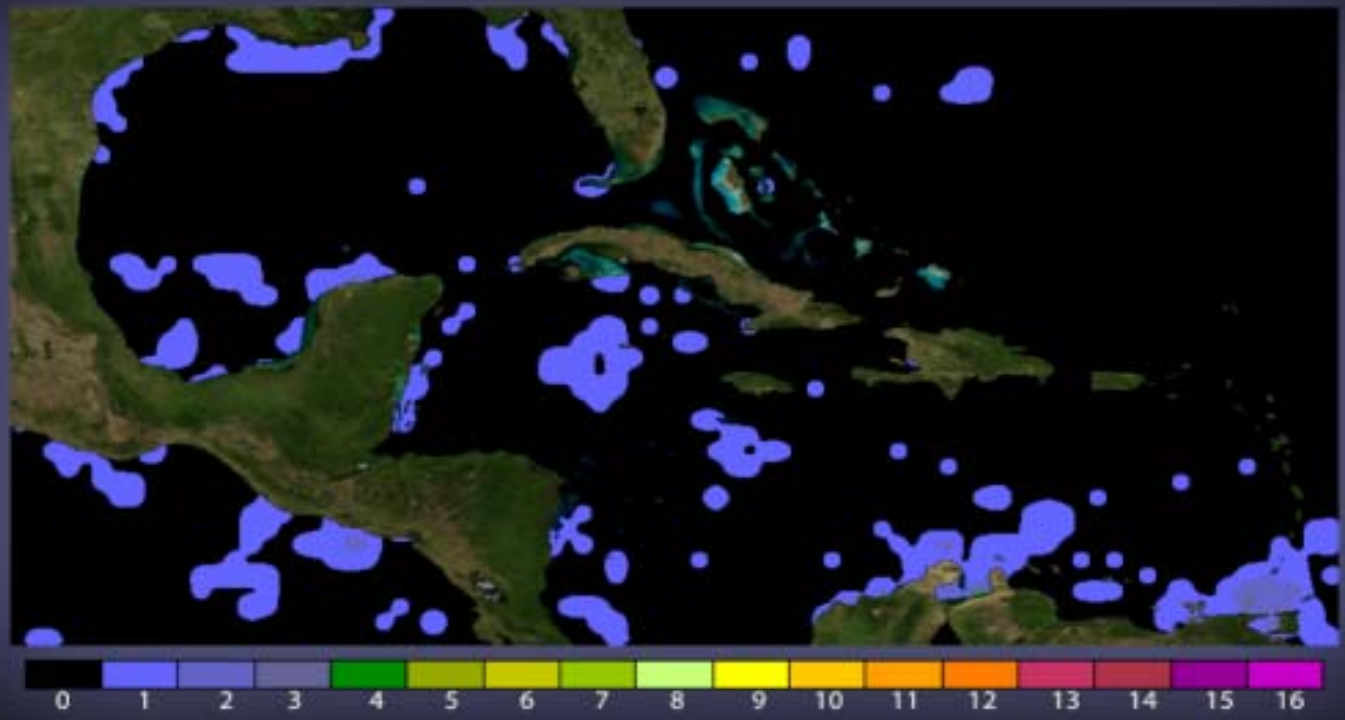

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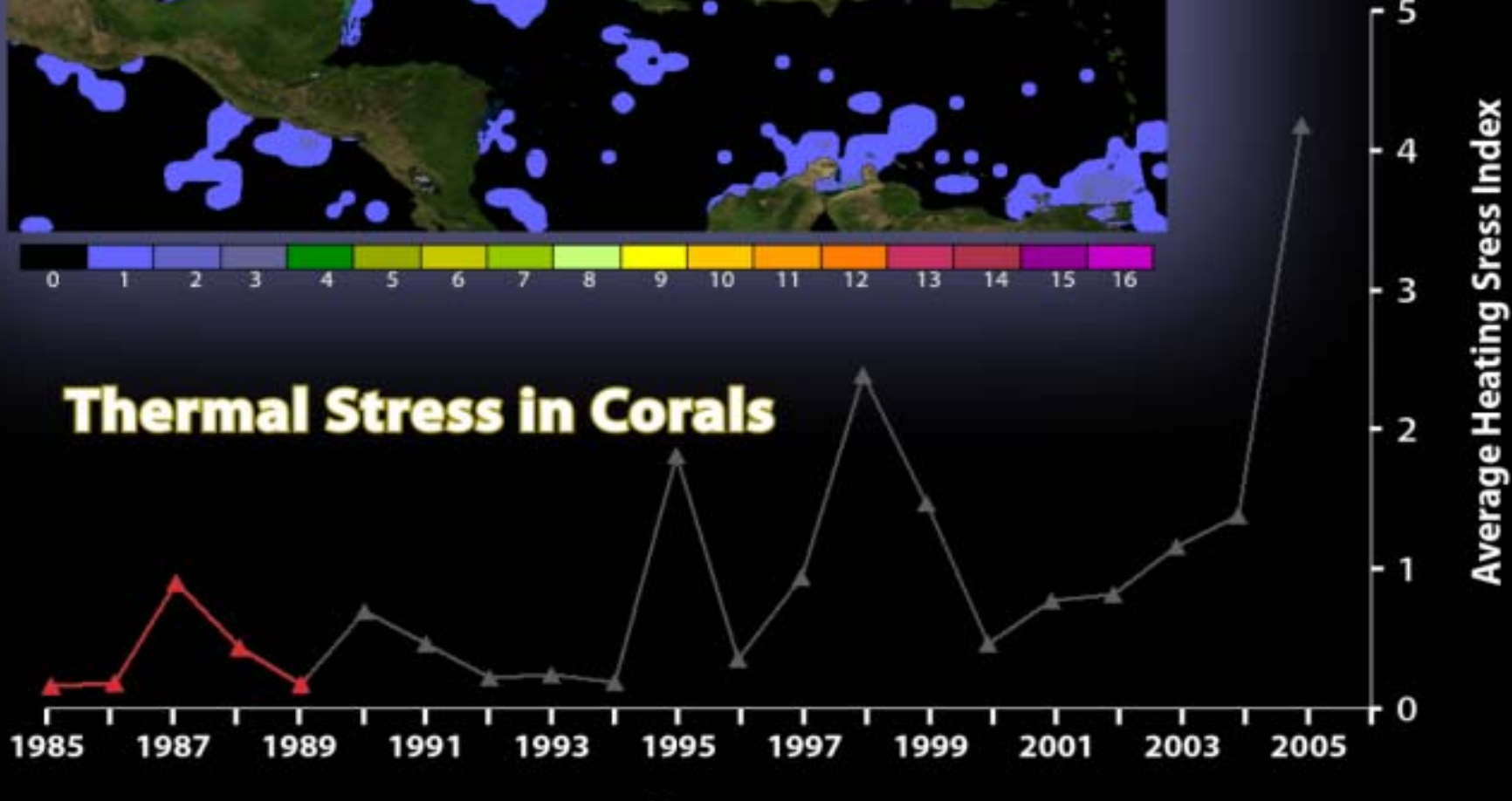

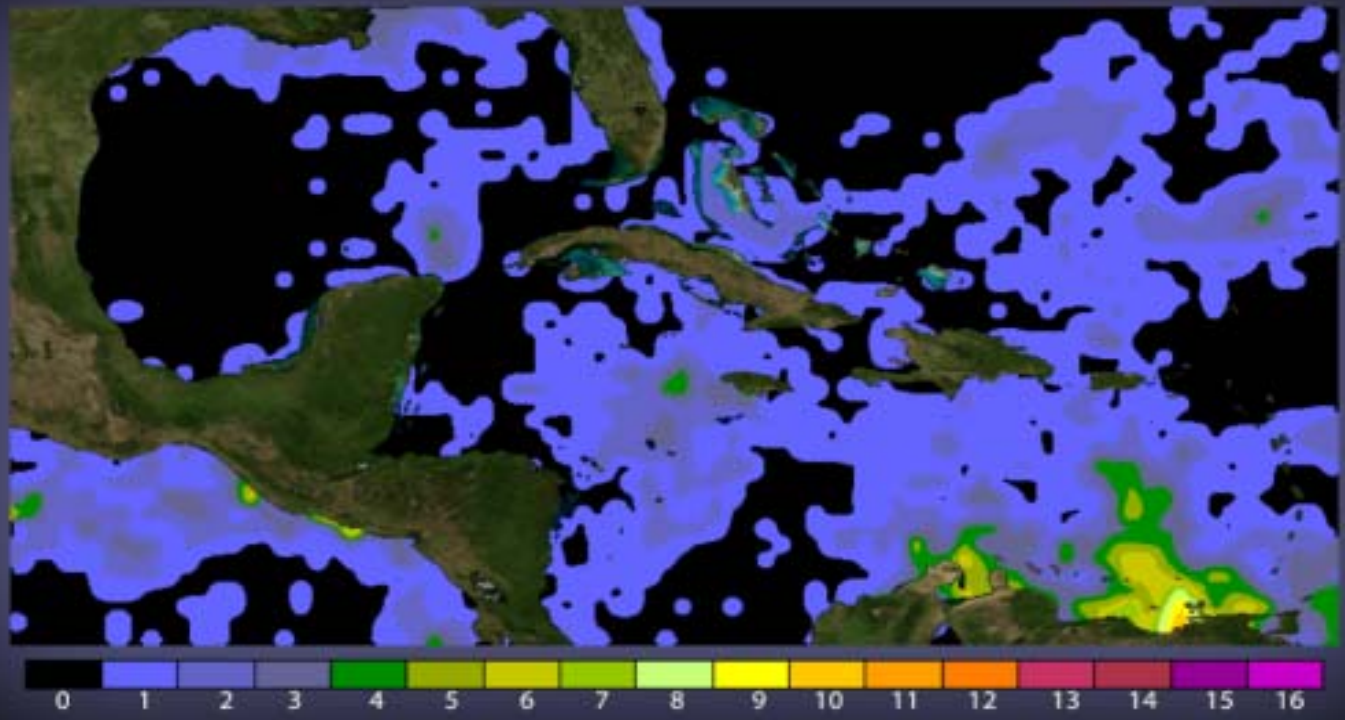

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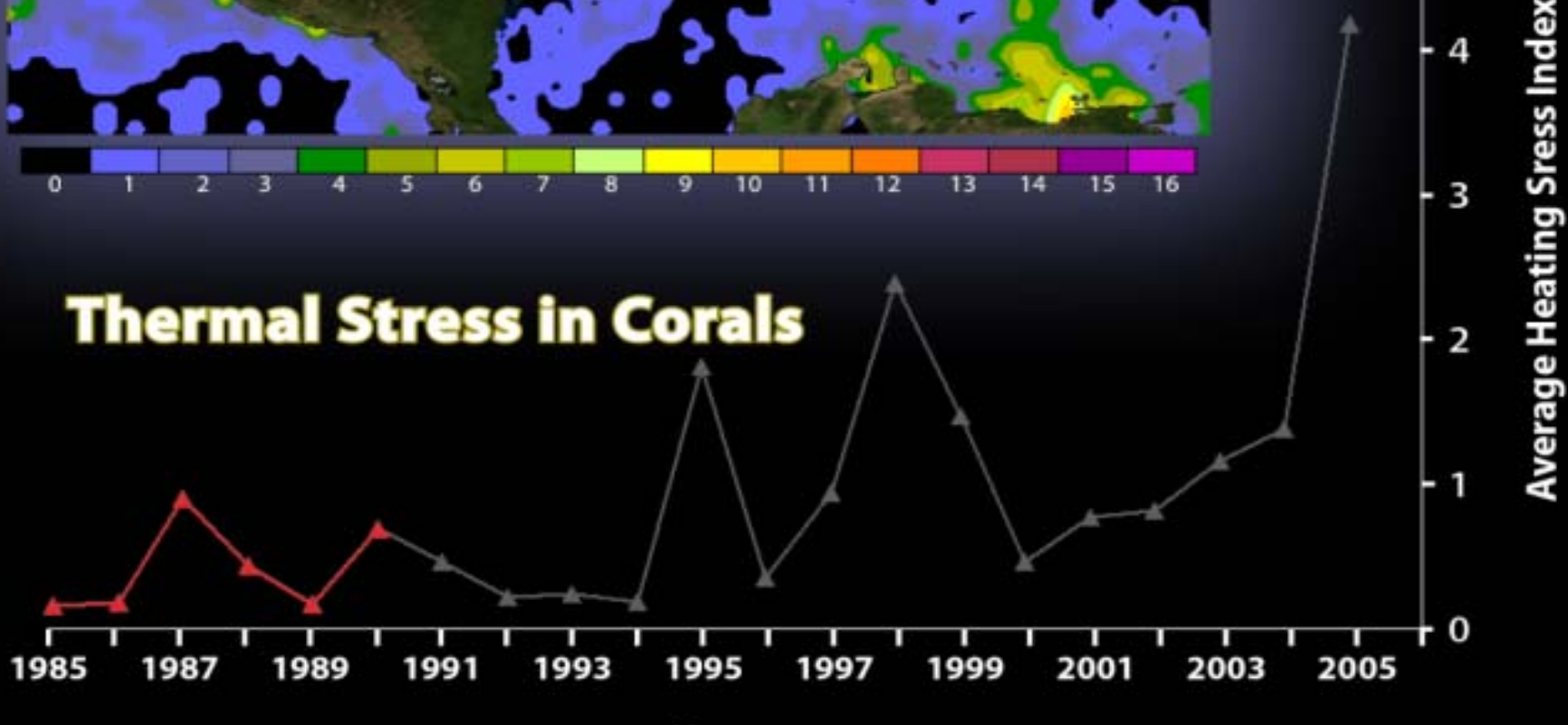

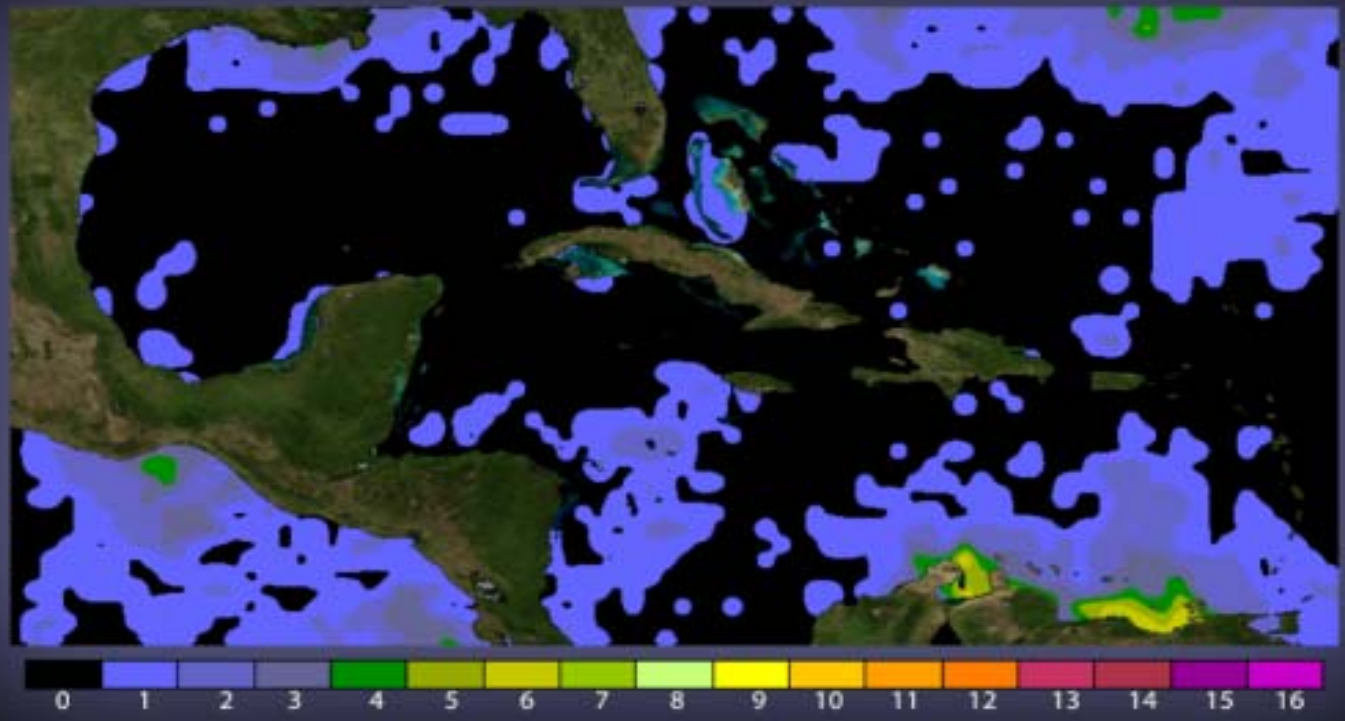

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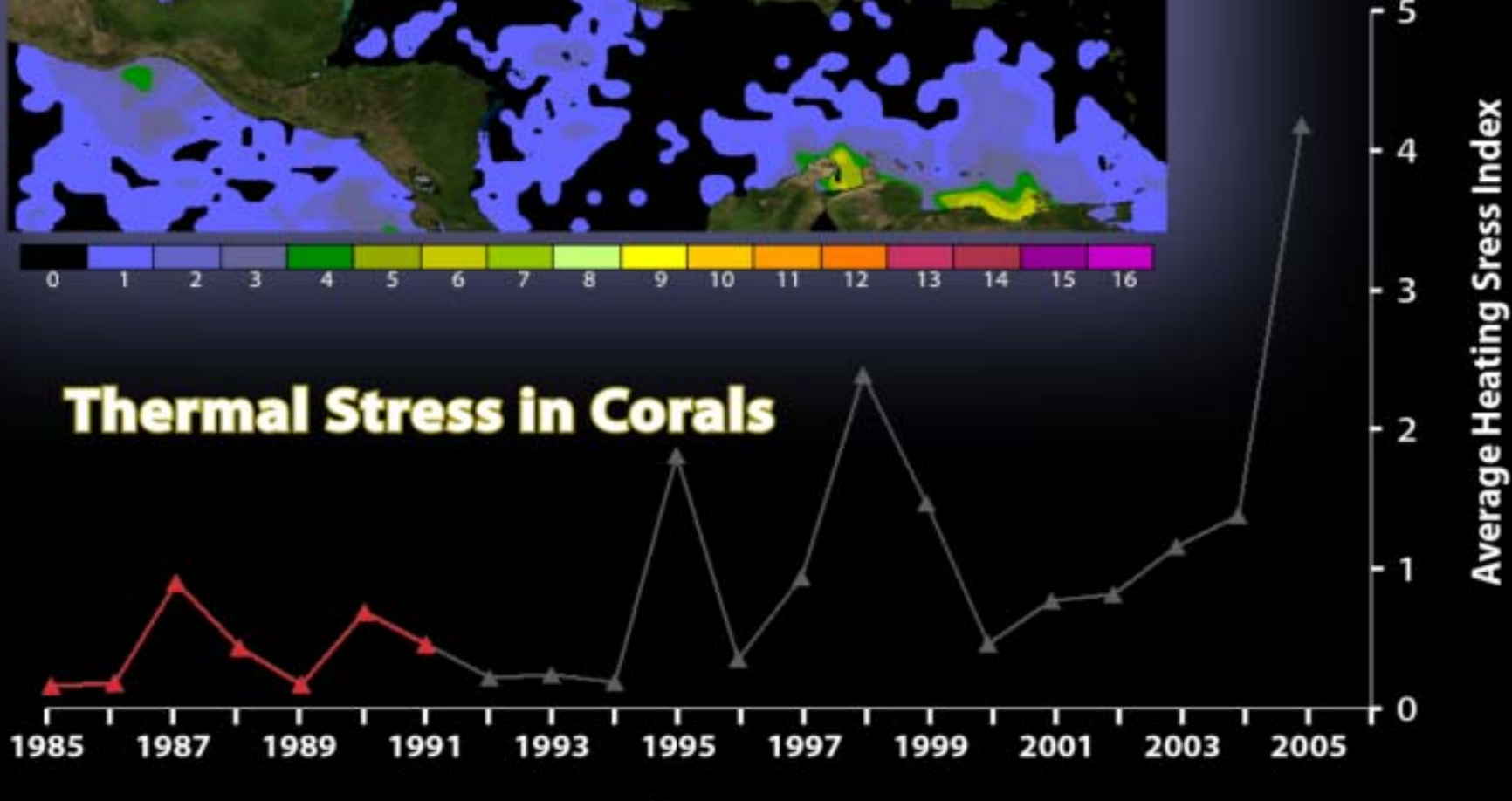

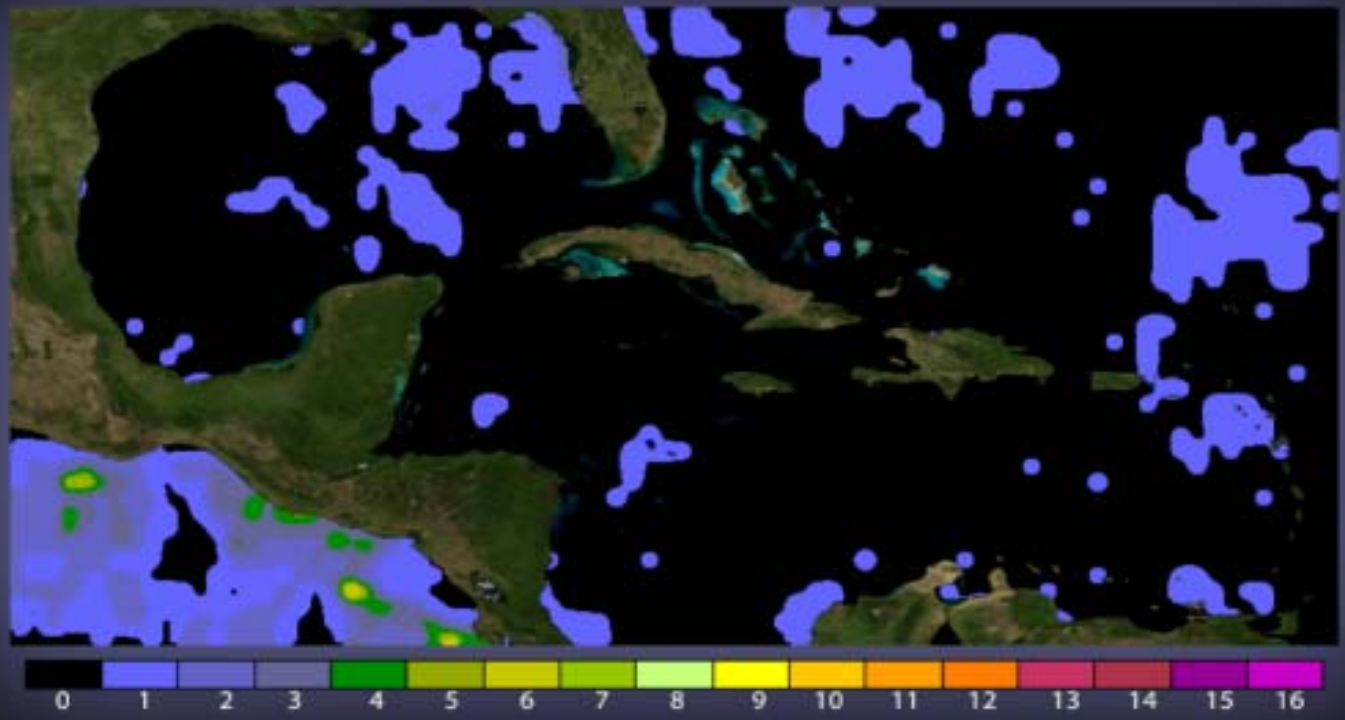

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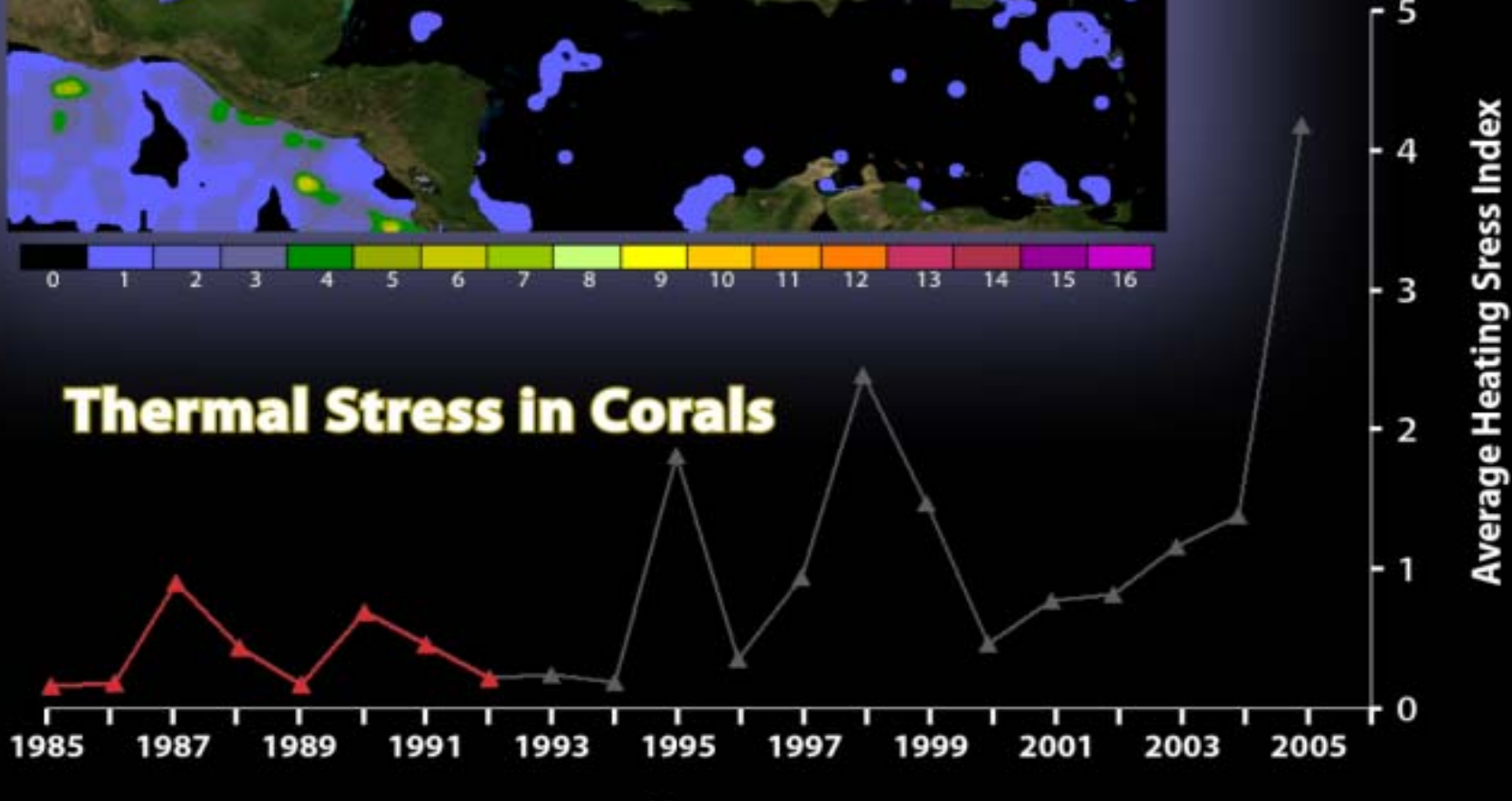

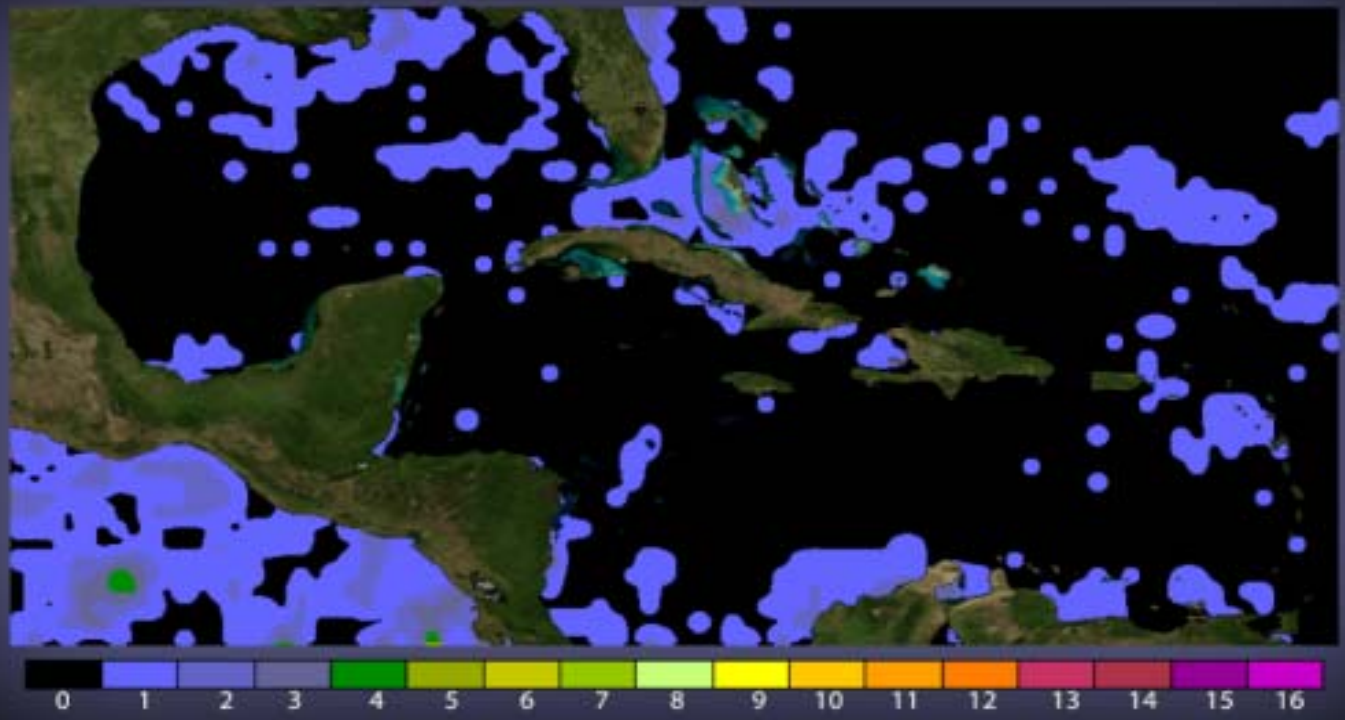

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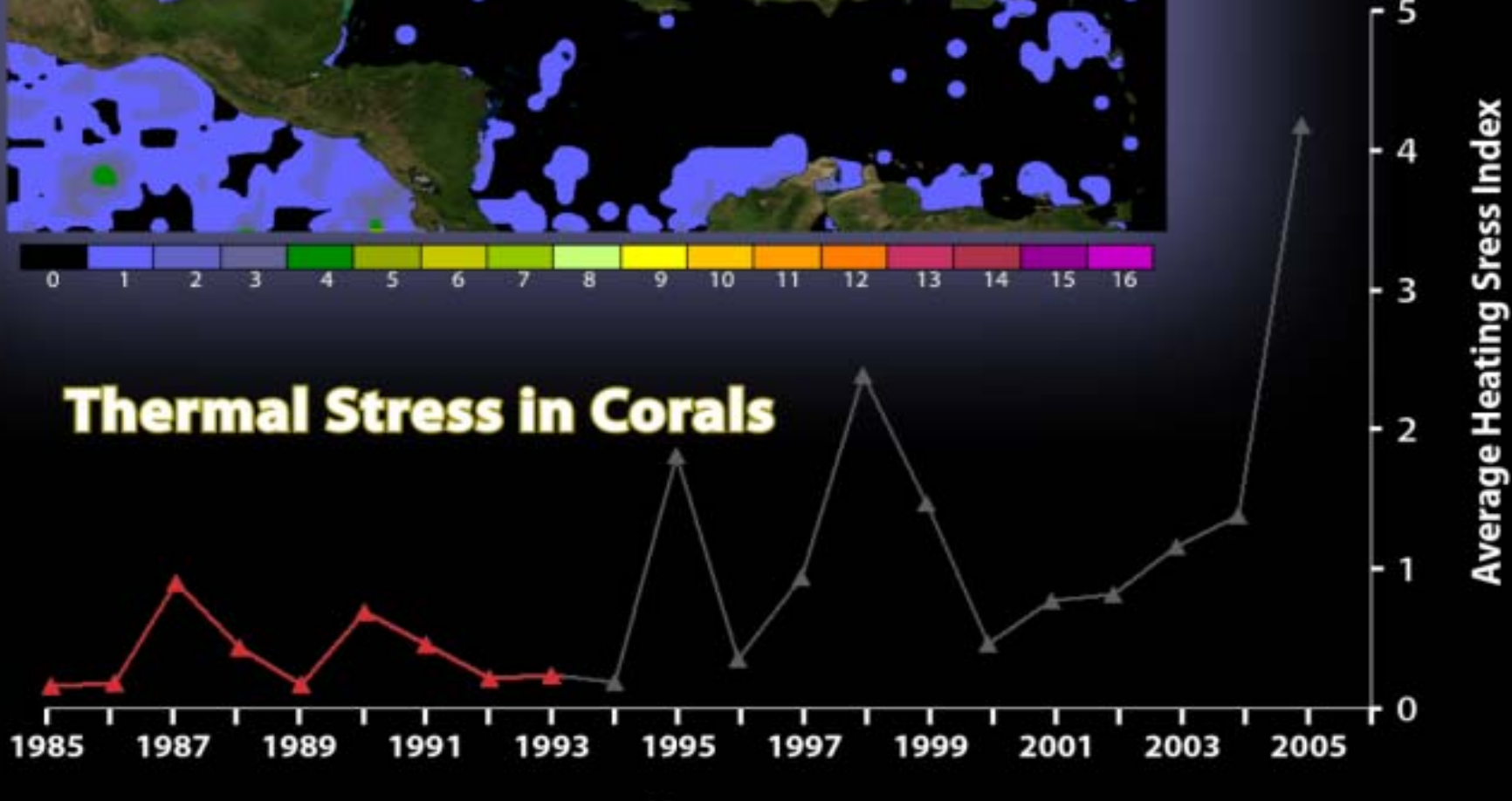

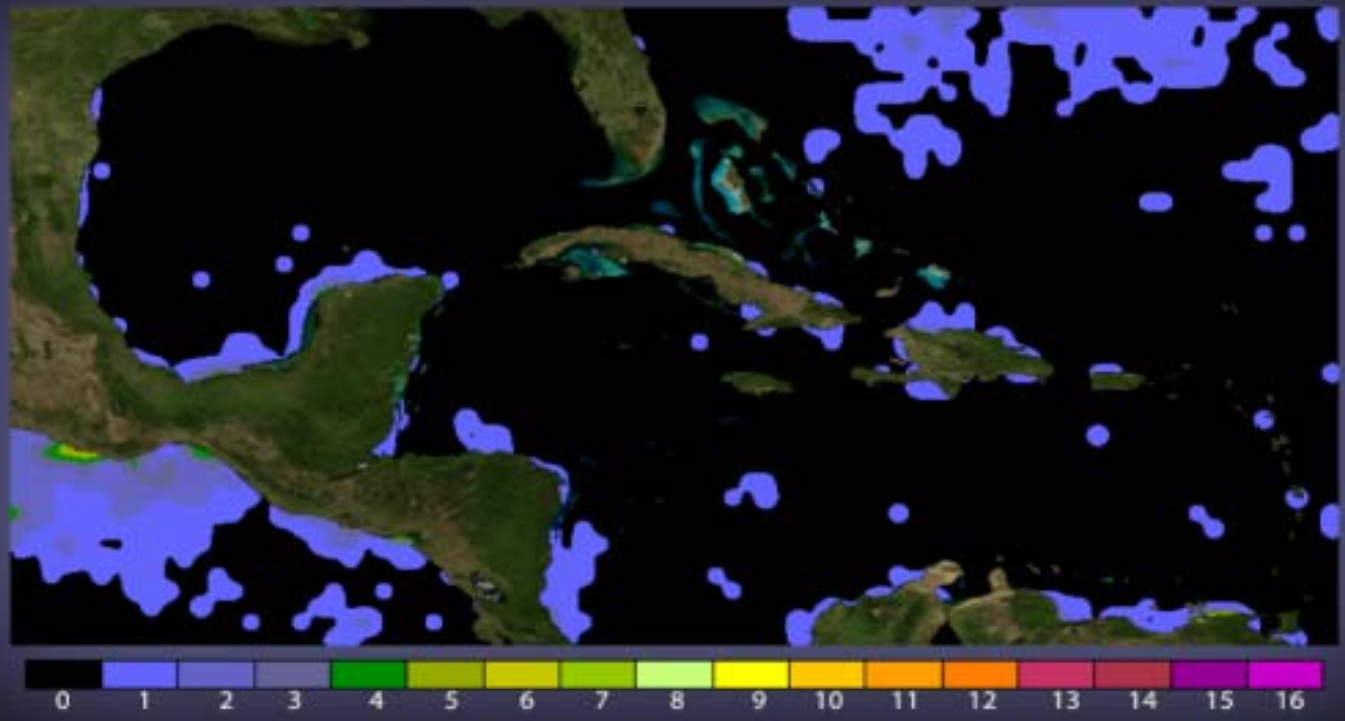

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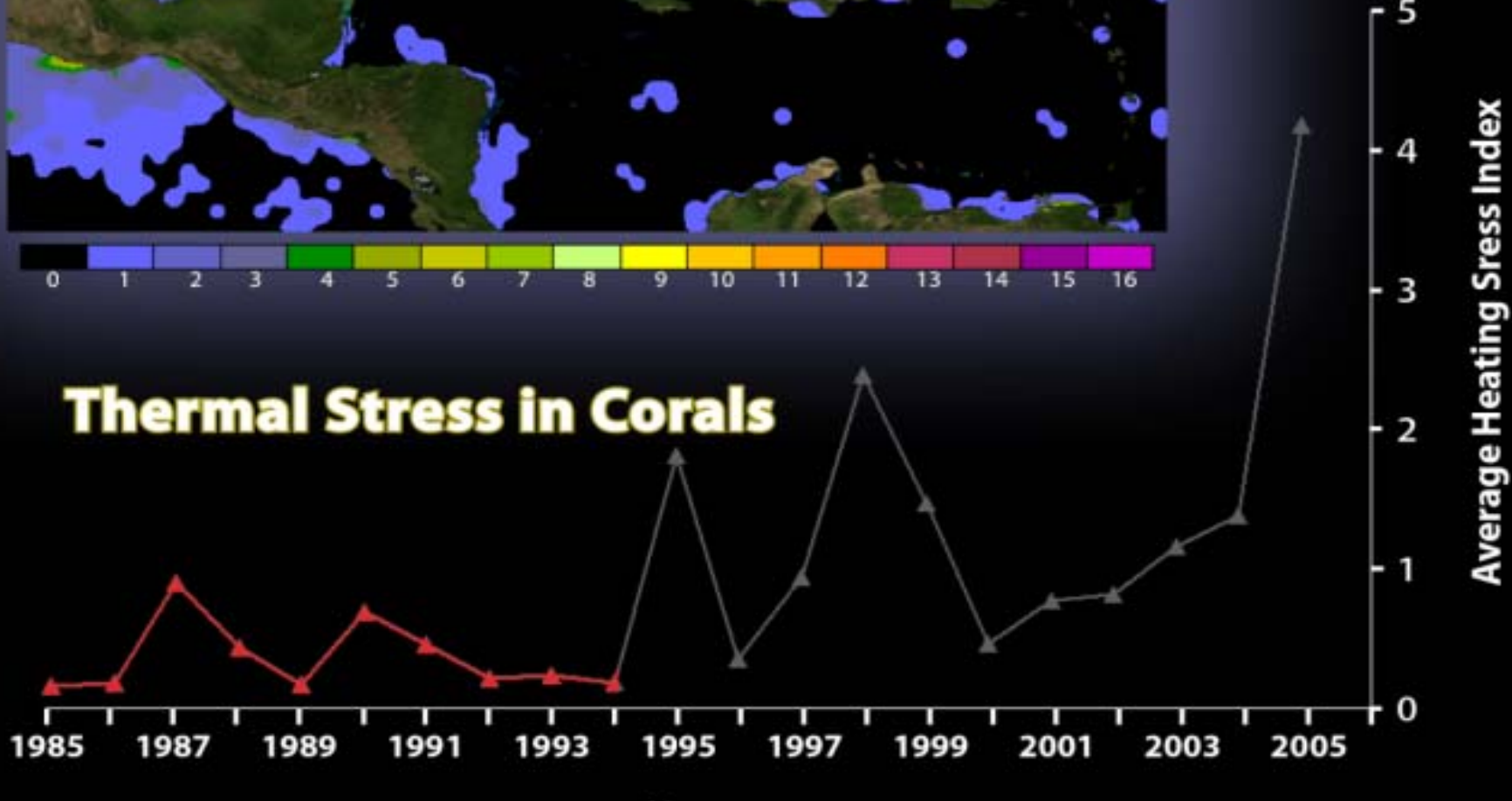

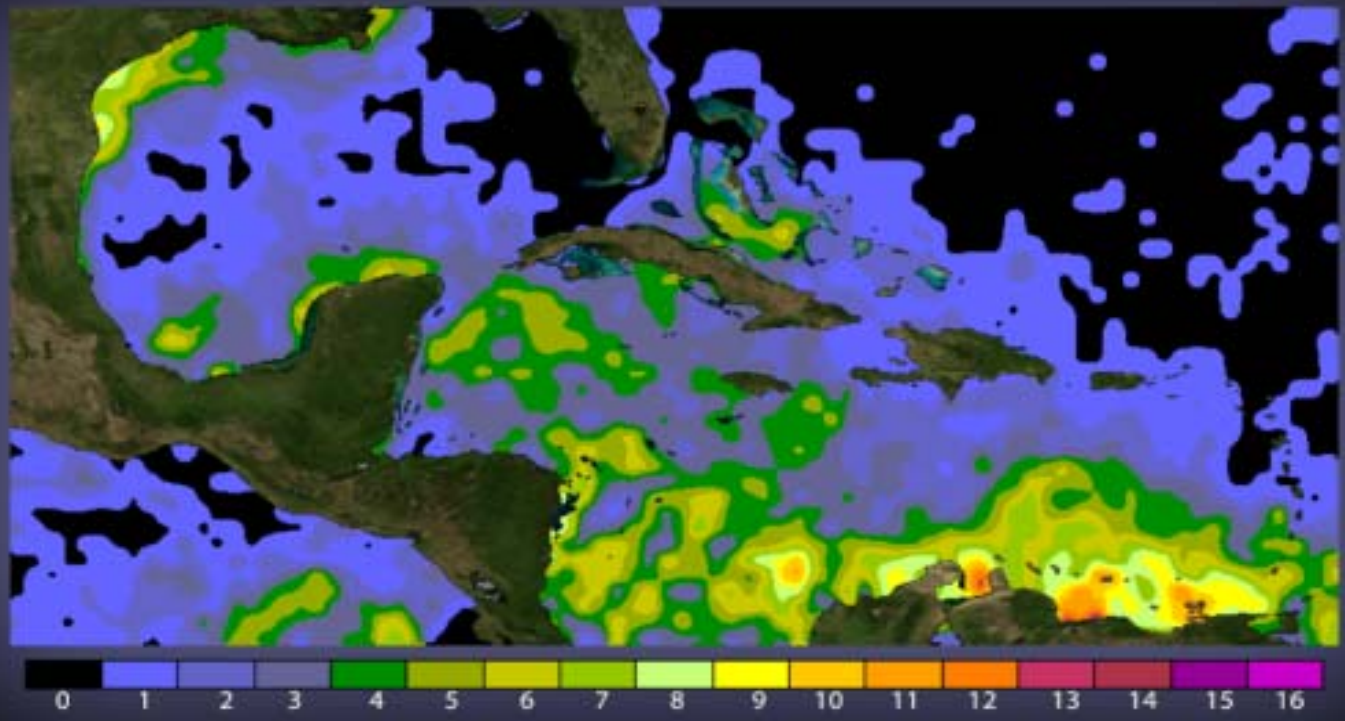

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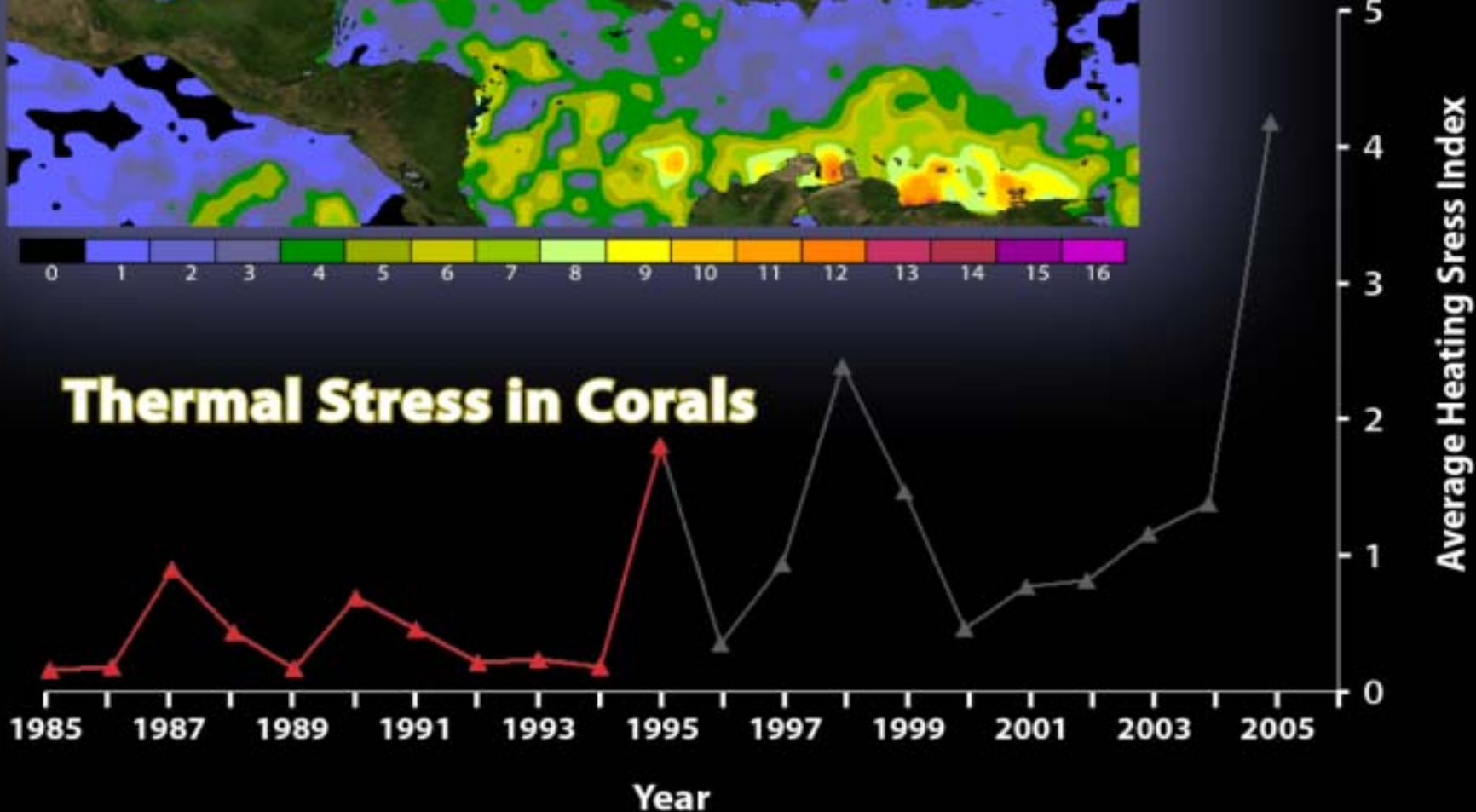

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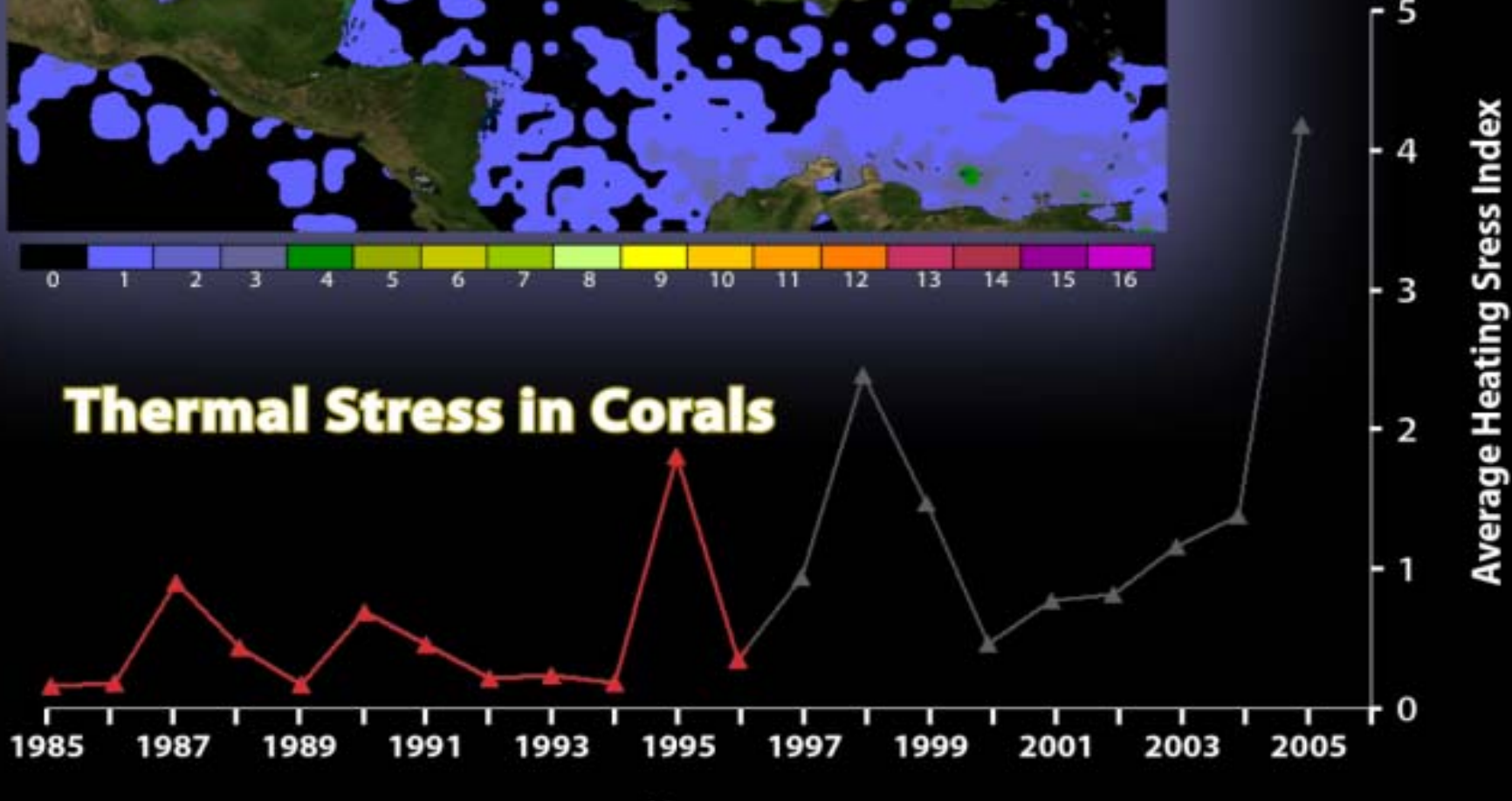

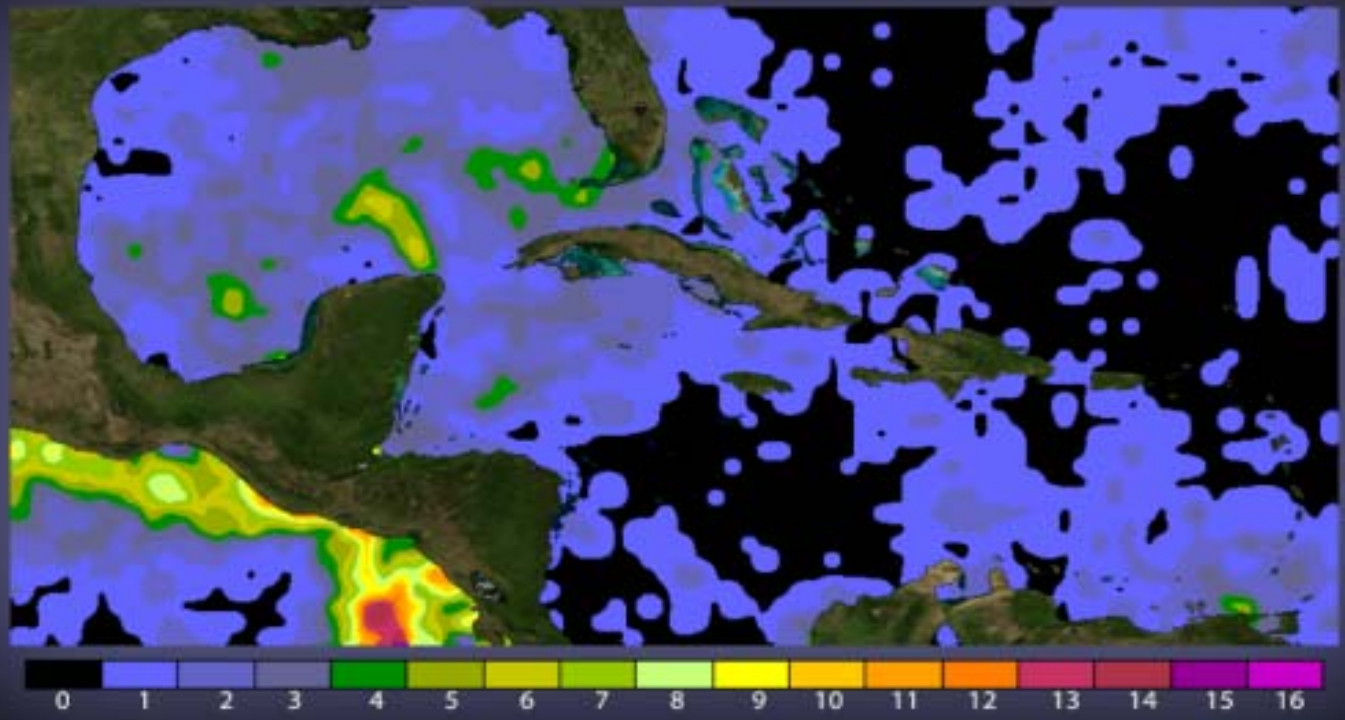

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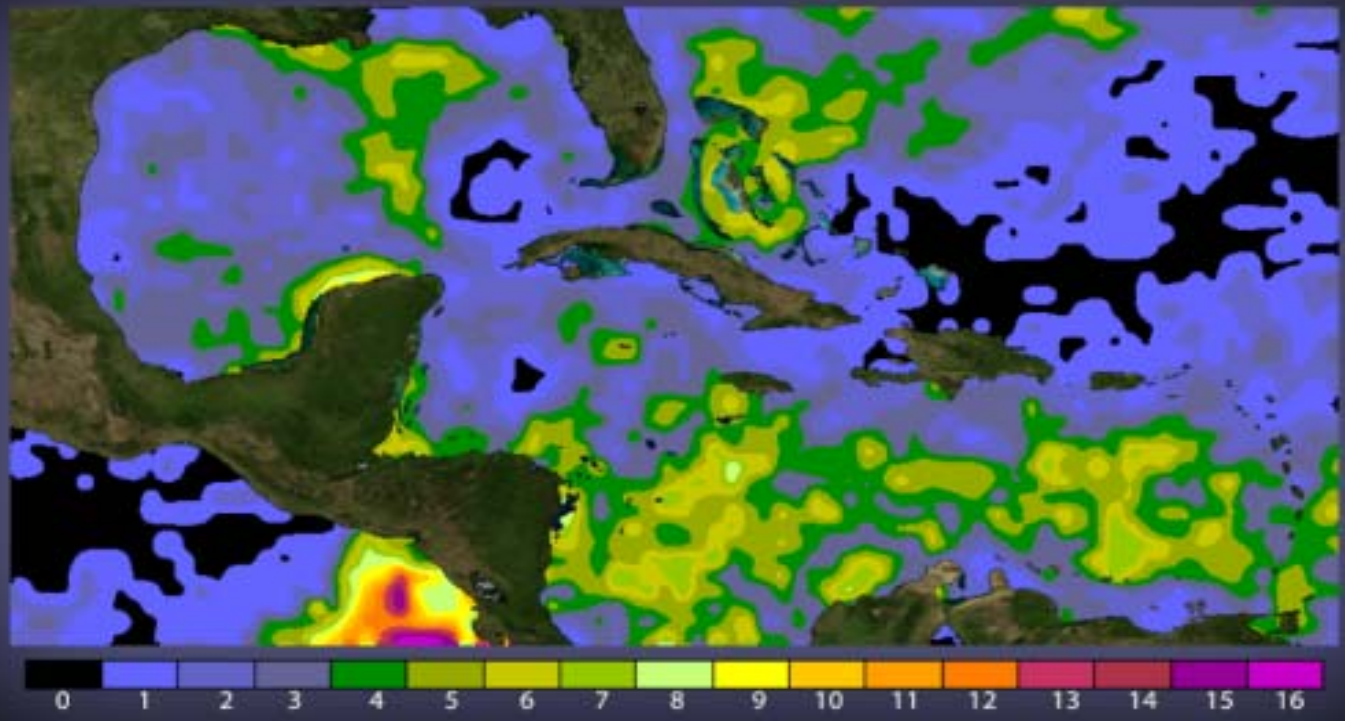

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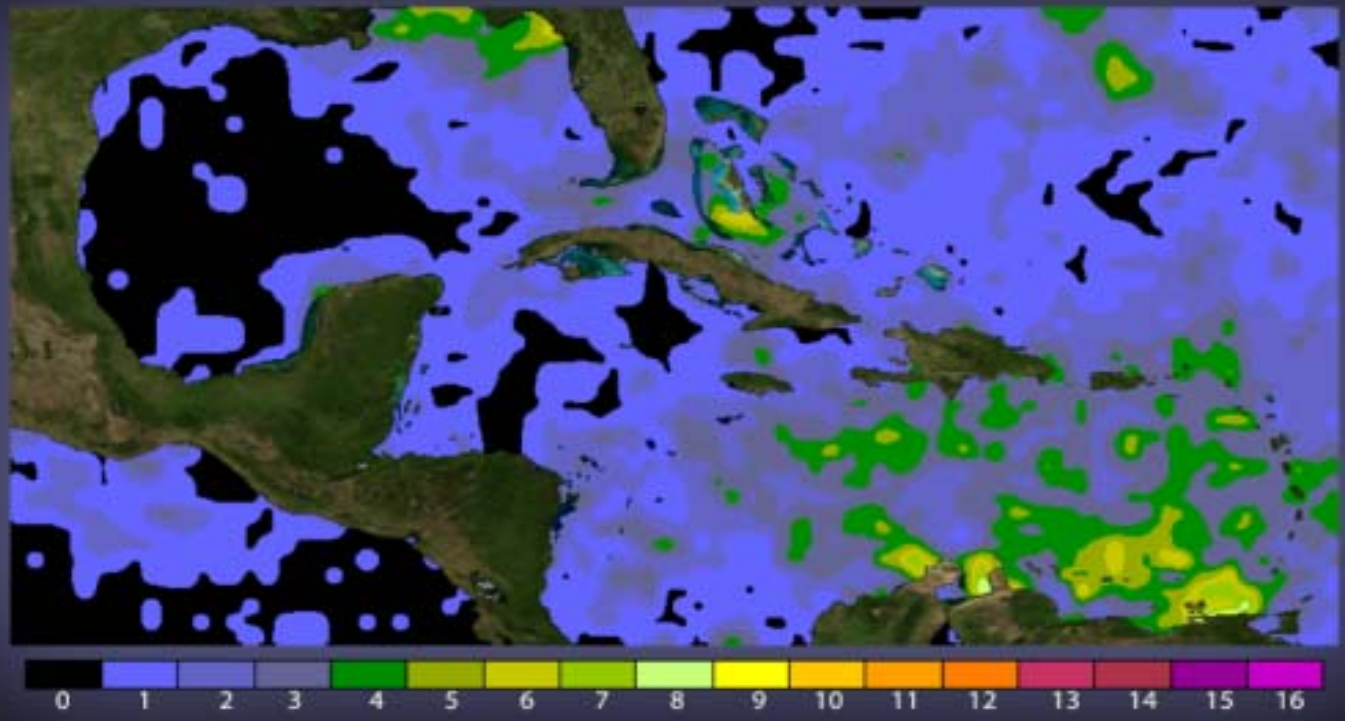

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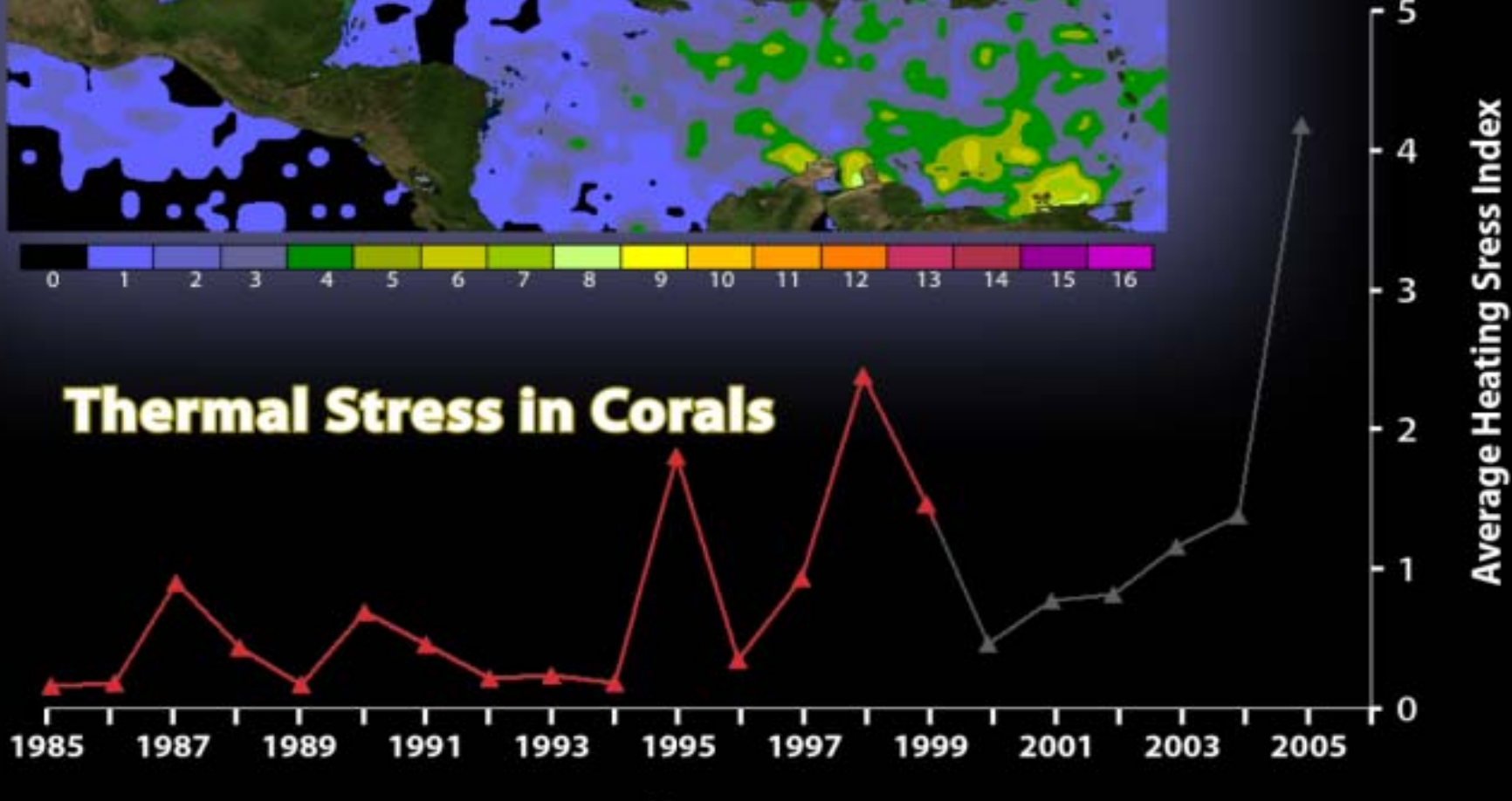

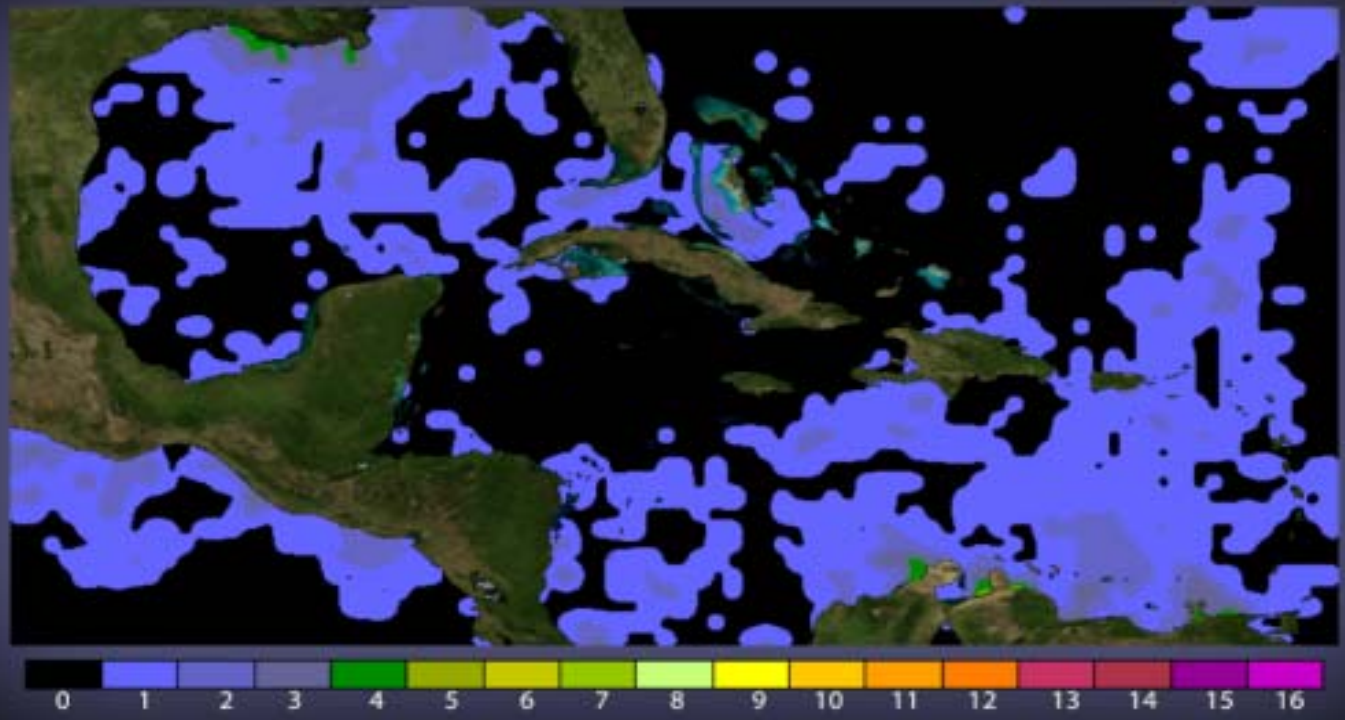

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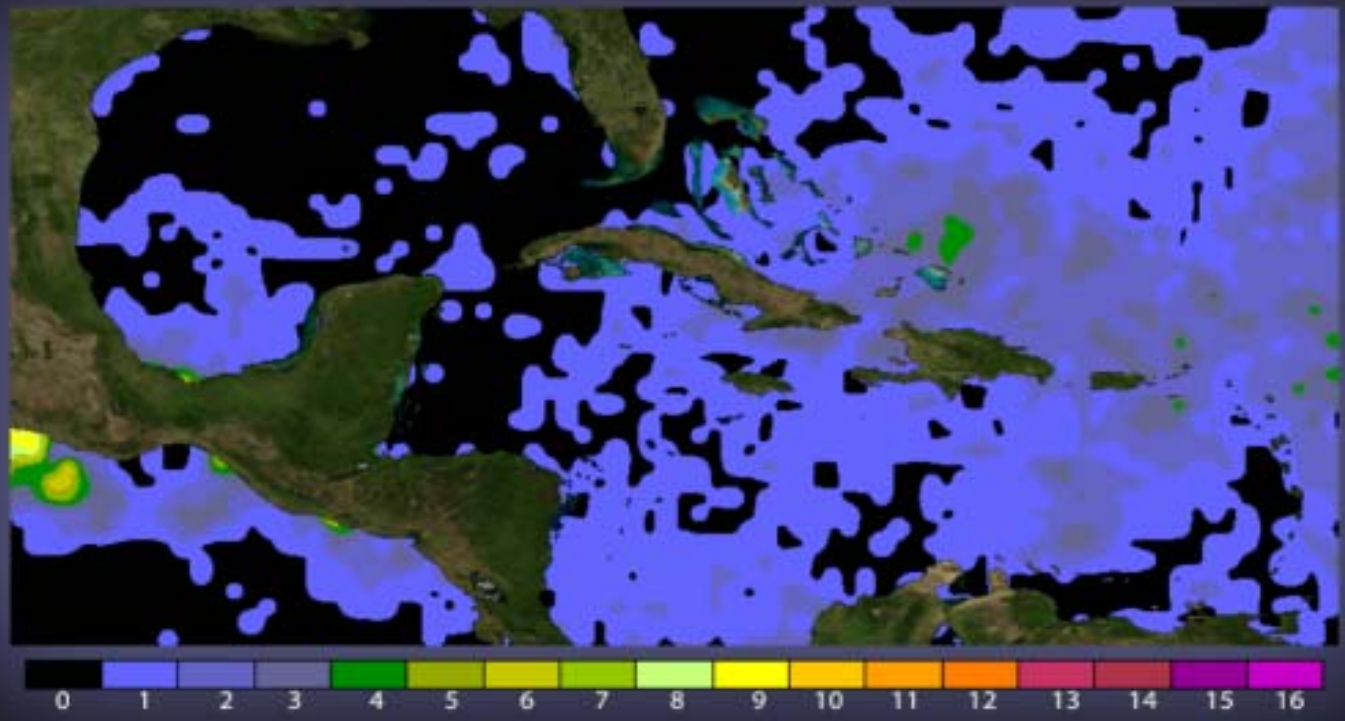

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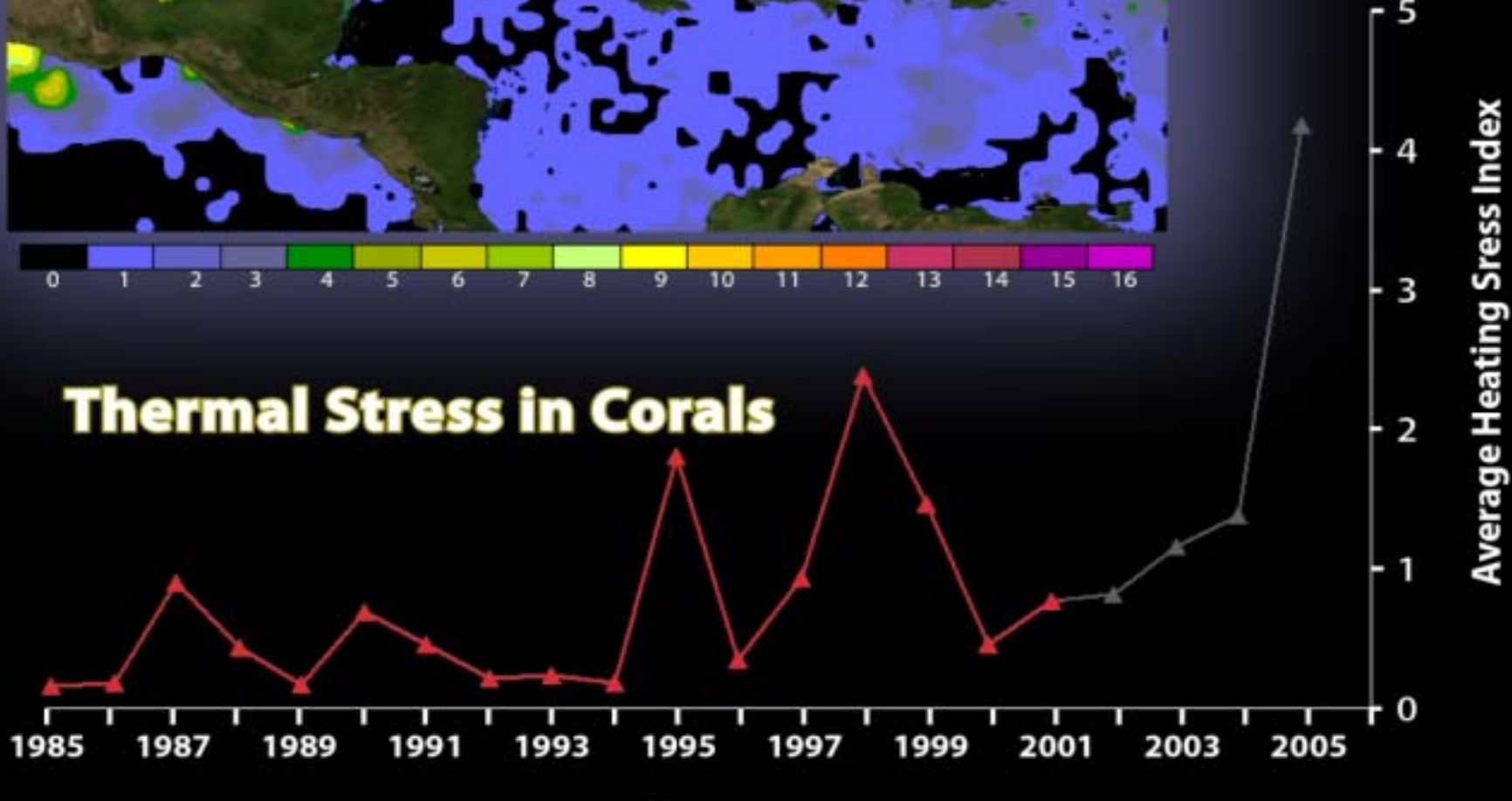

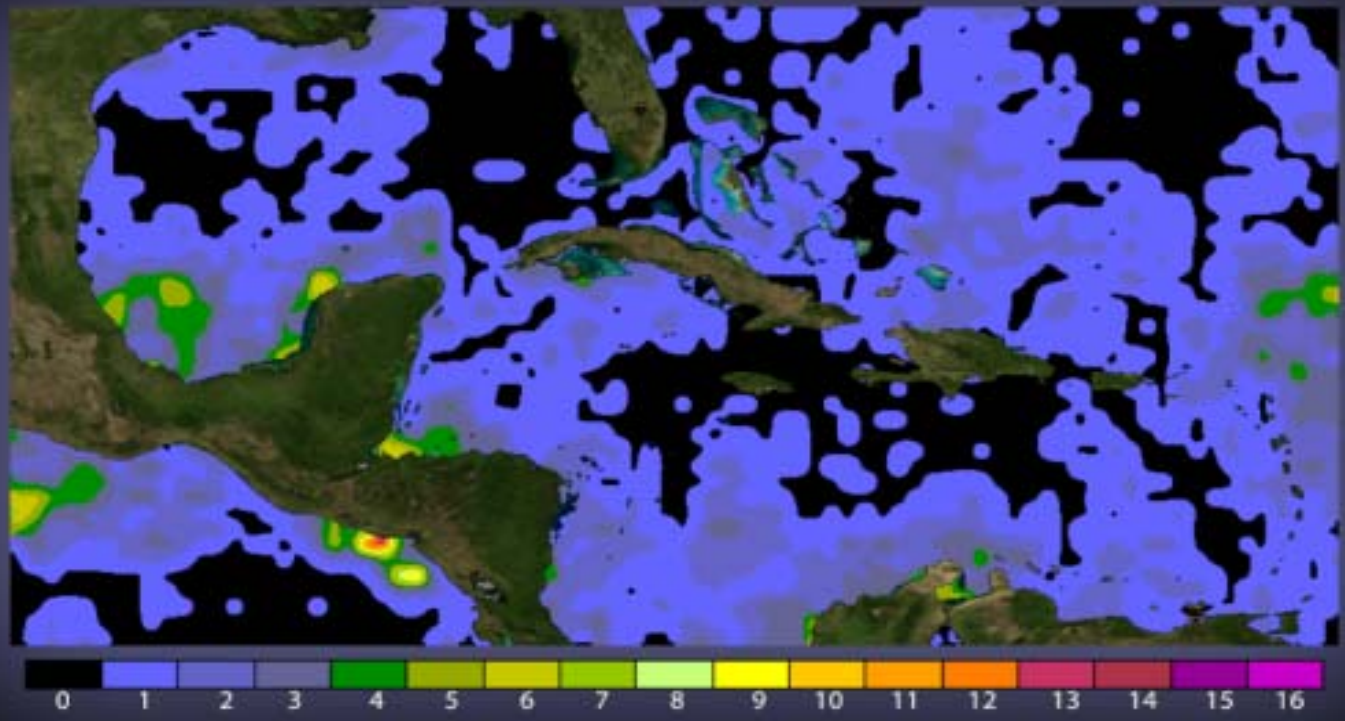

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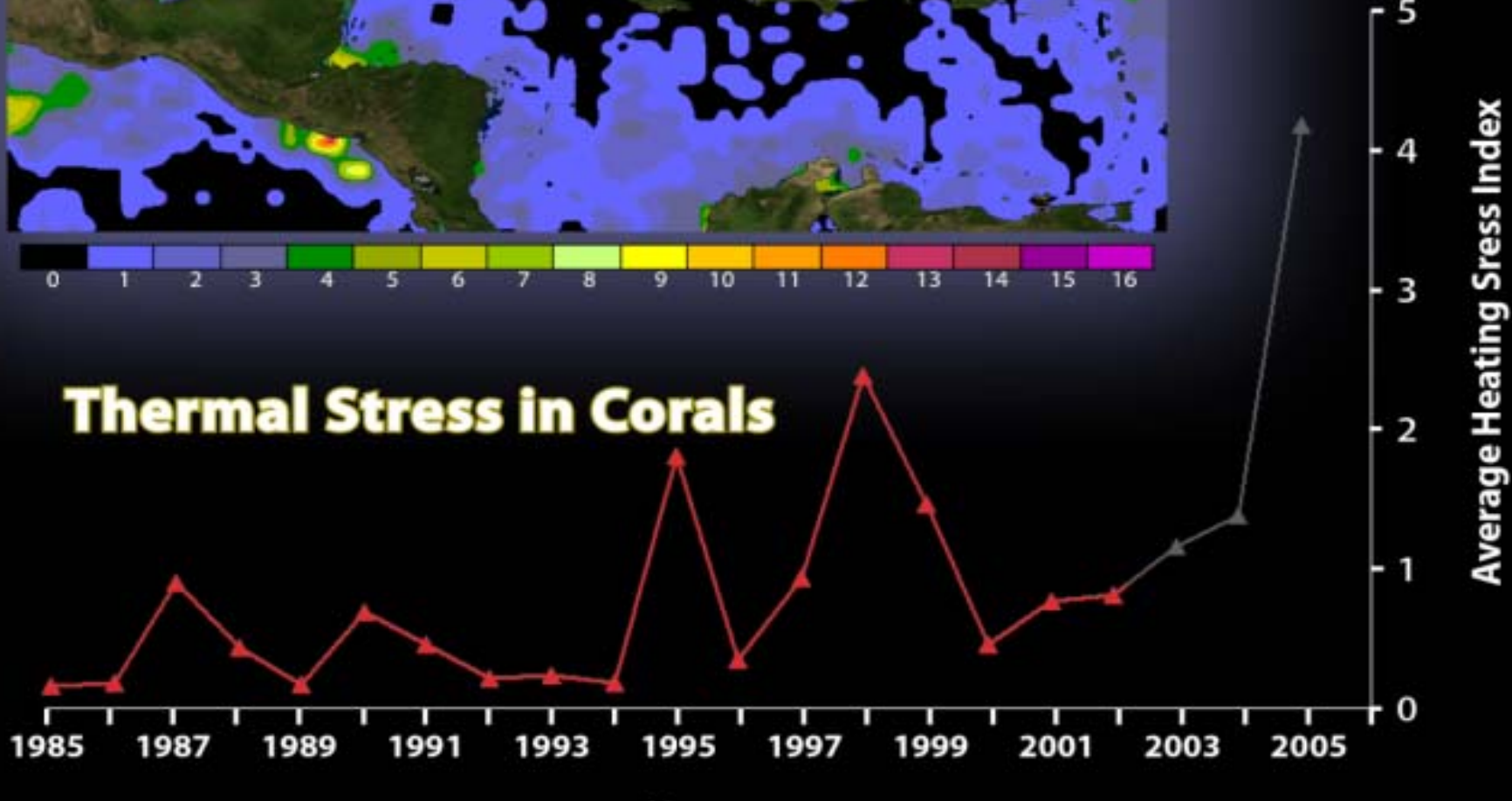

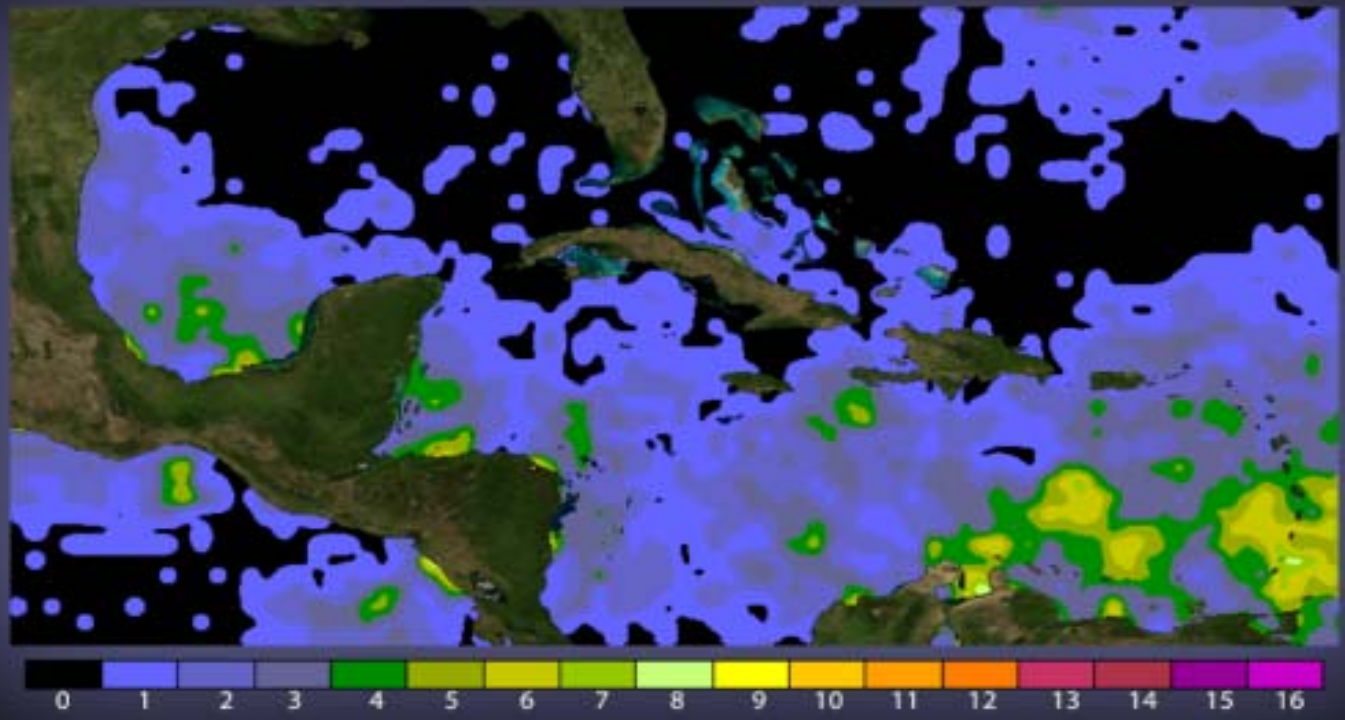

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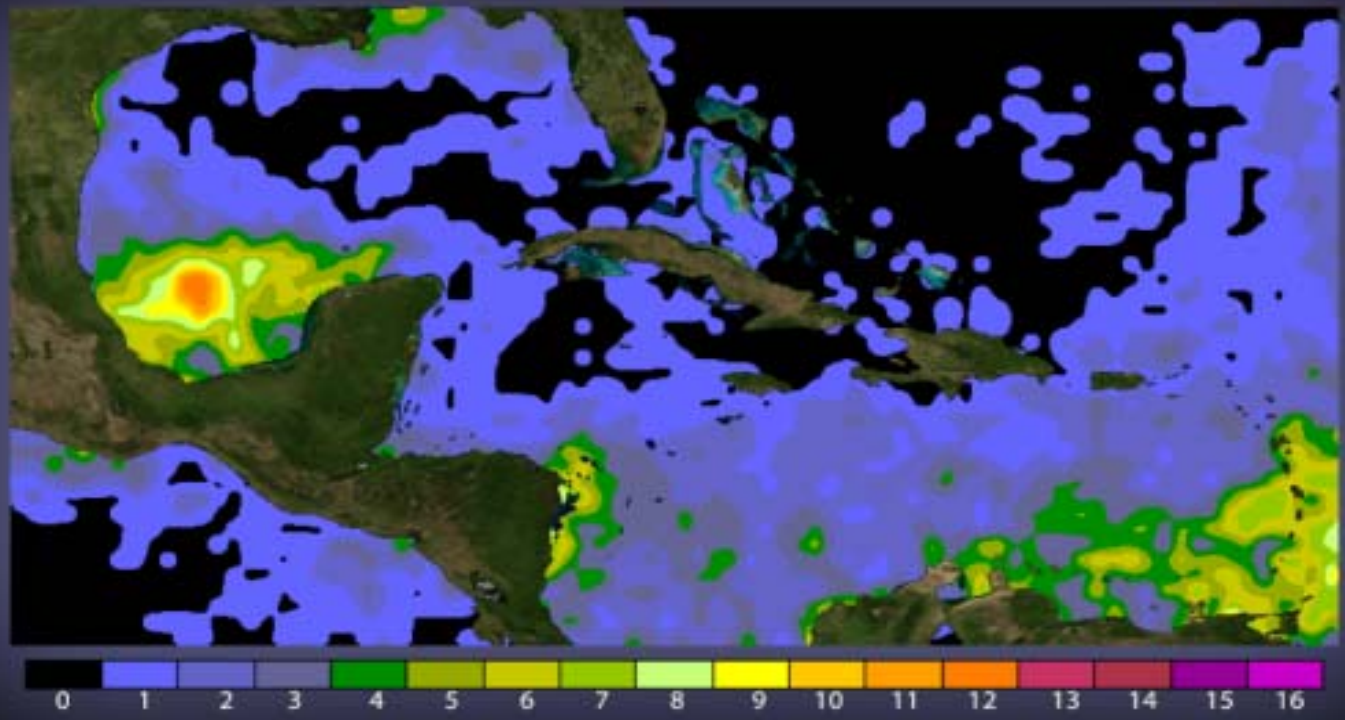

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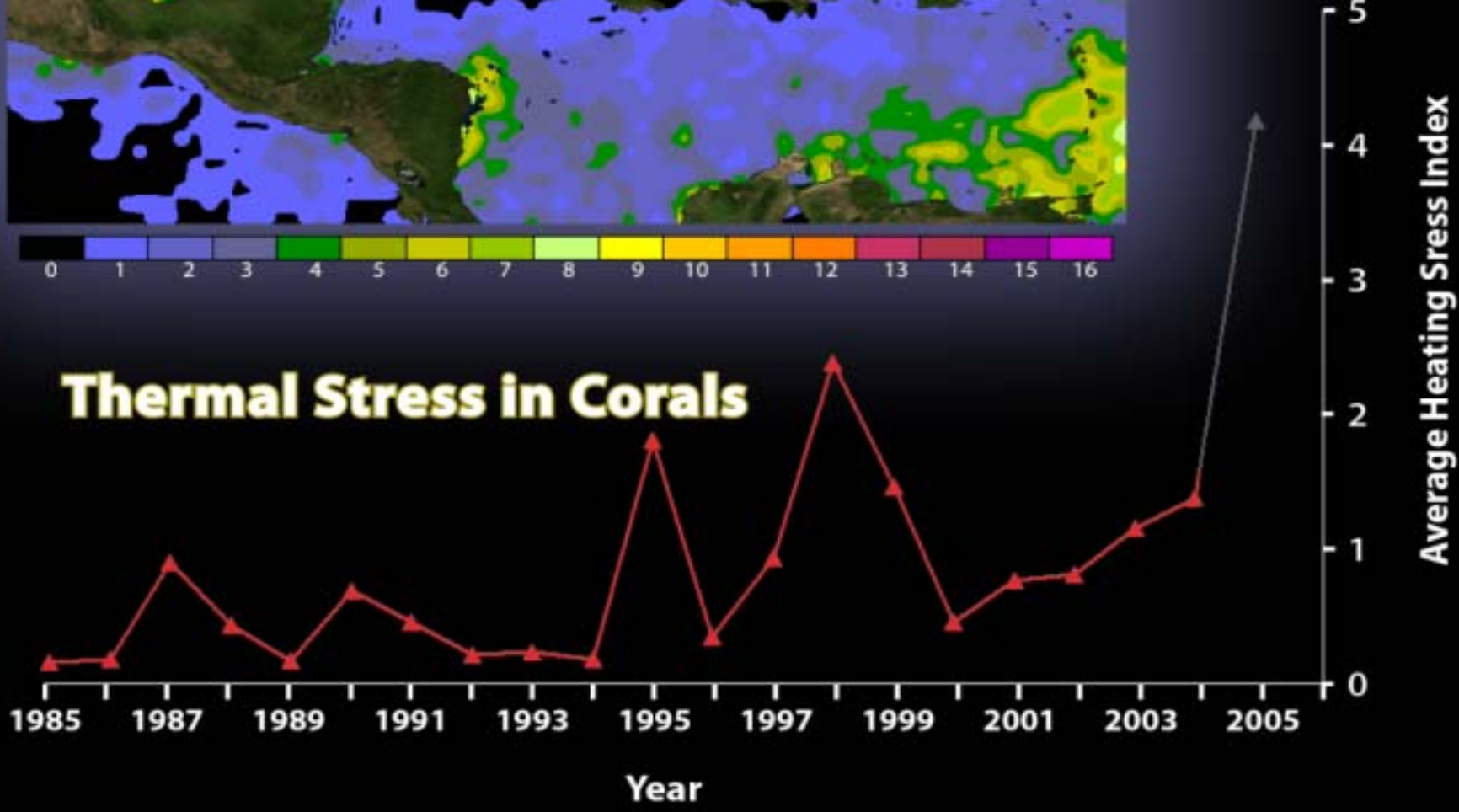
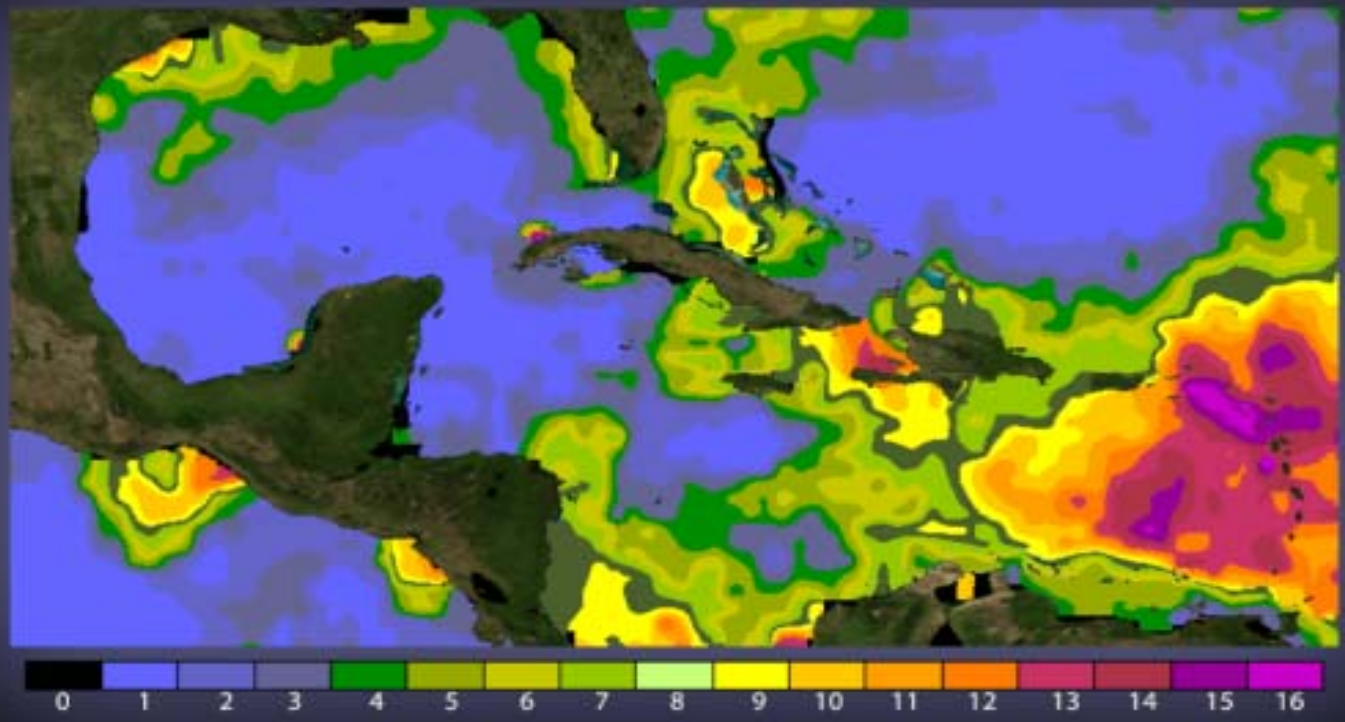
Mass Bleaching and Mortality

Thermal Stress in Corals





NOAA

Bleaching Expected

Mass Bleaching and Mortality

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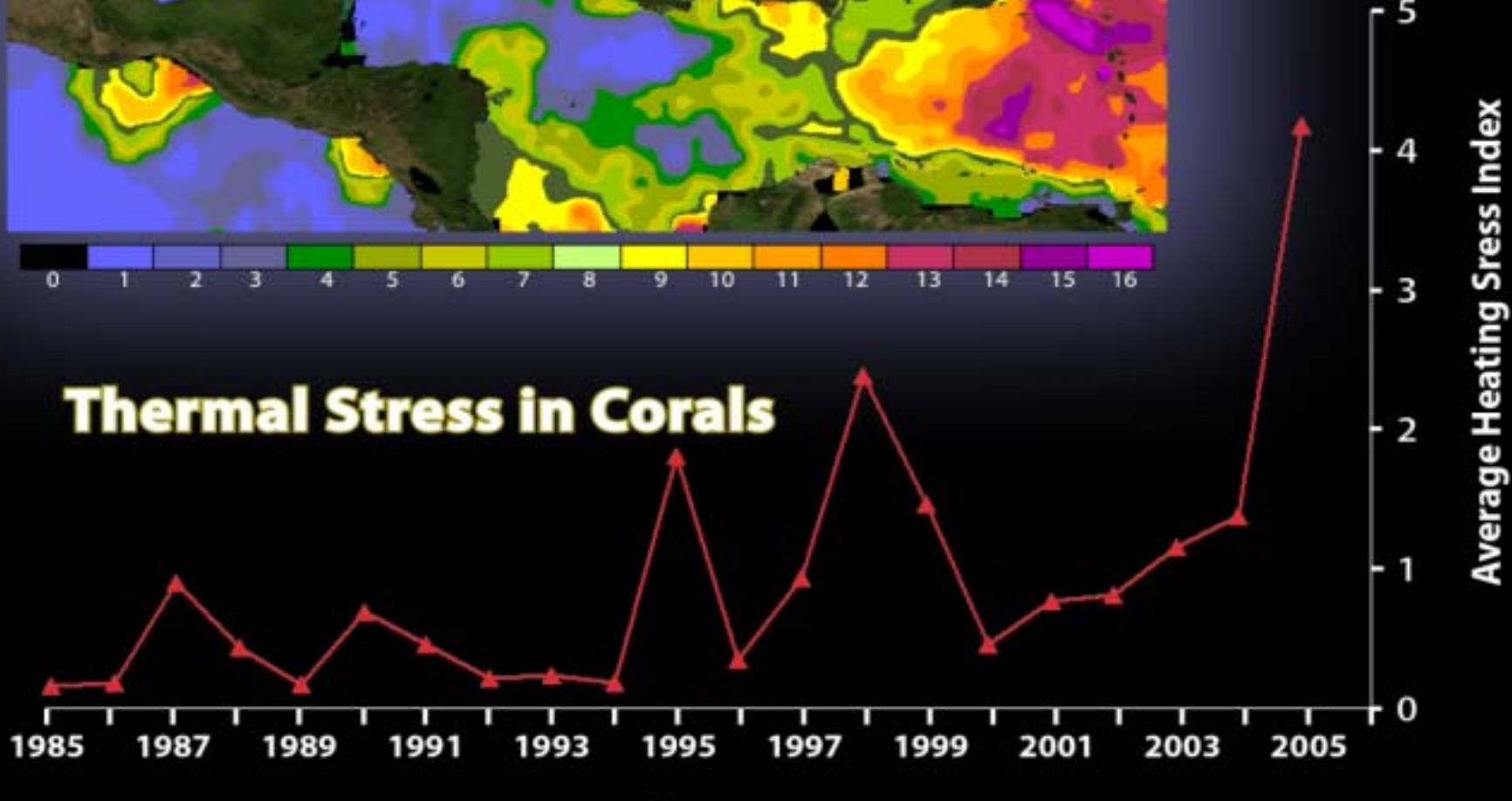
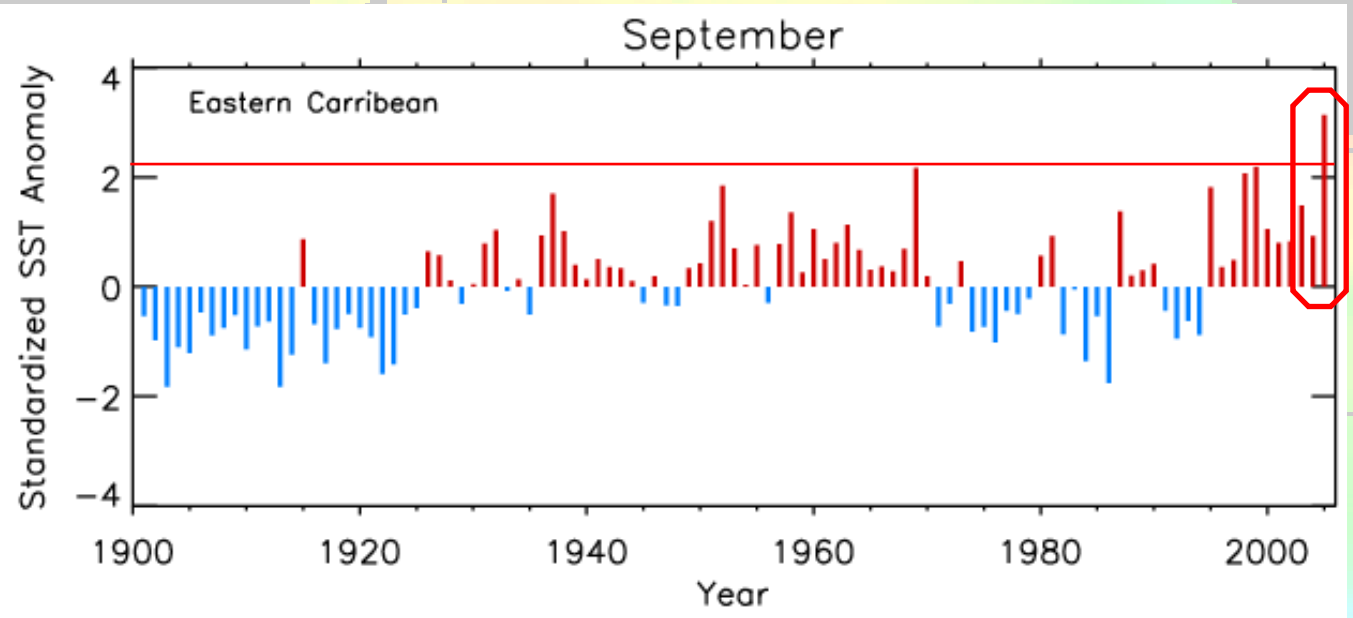


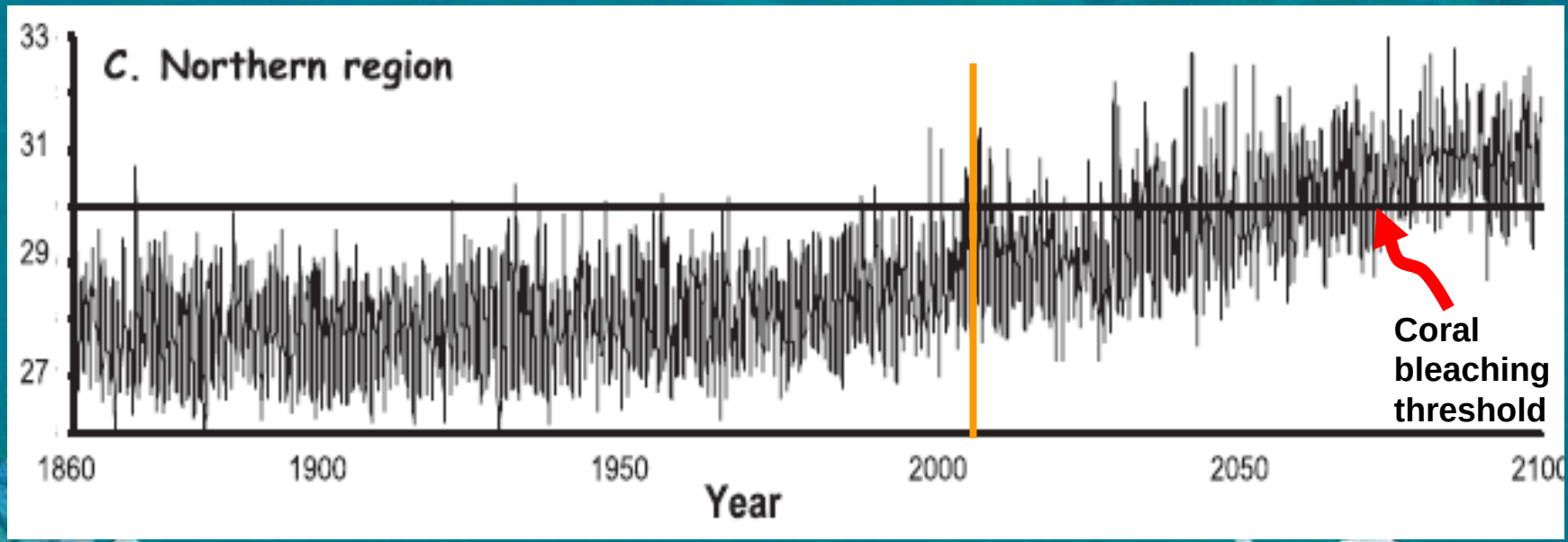
Warmest Caribbean in Over 100 Years



Warmest September in eastern Caribbean

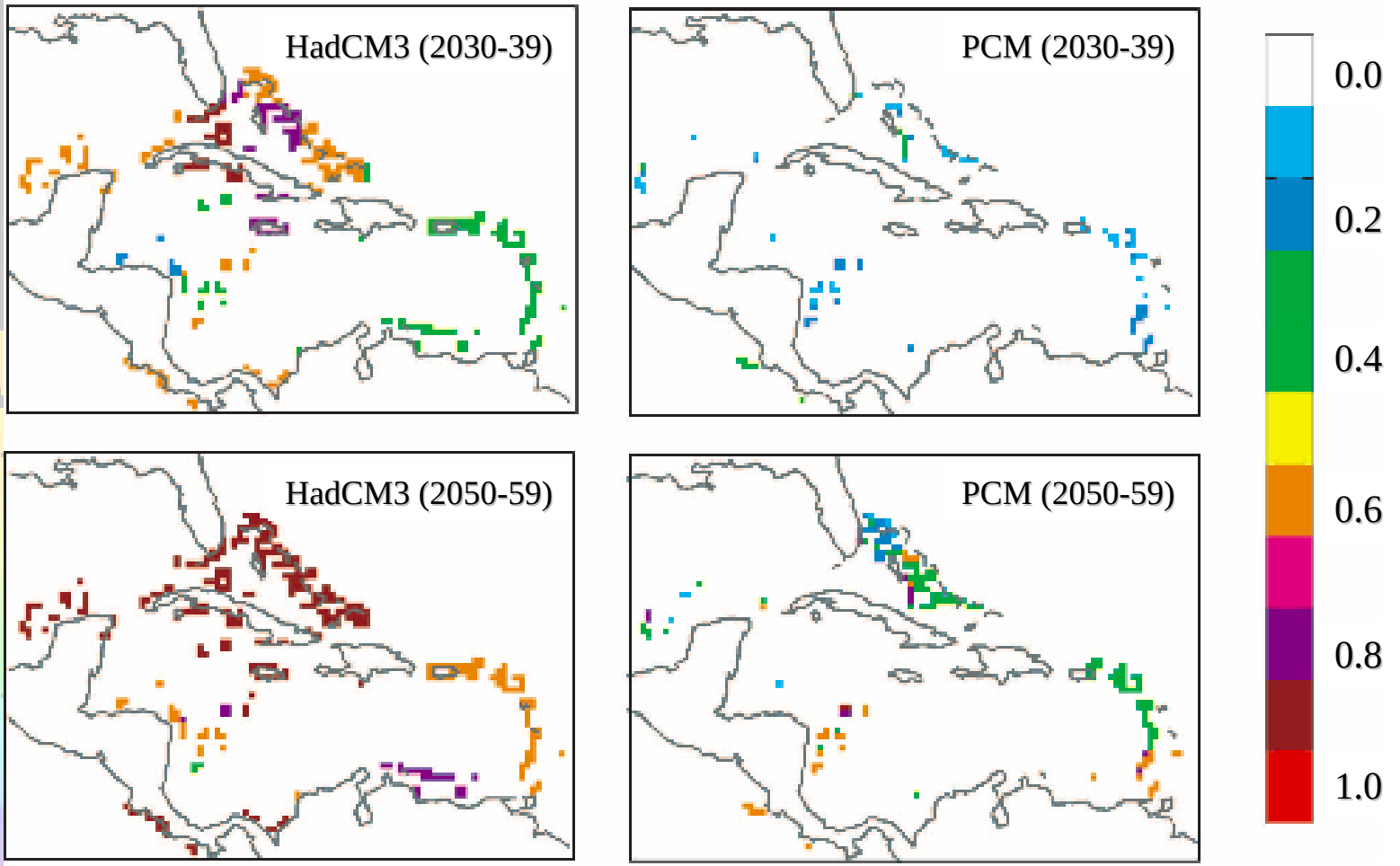
NOAA ERSST data (Smith and Reynolds 2004) plot courtesy NOAA CDC

Future change

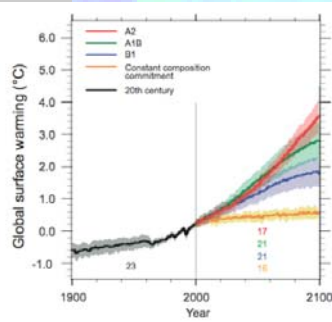


Doubling of CO_2 - Hoegh-Guldberg (1999)

Bleaching Under Future Climates?



Projected bleaching frequency of DHM >1 under SRES A2 (Donner et al. Global Change Biology 2005)

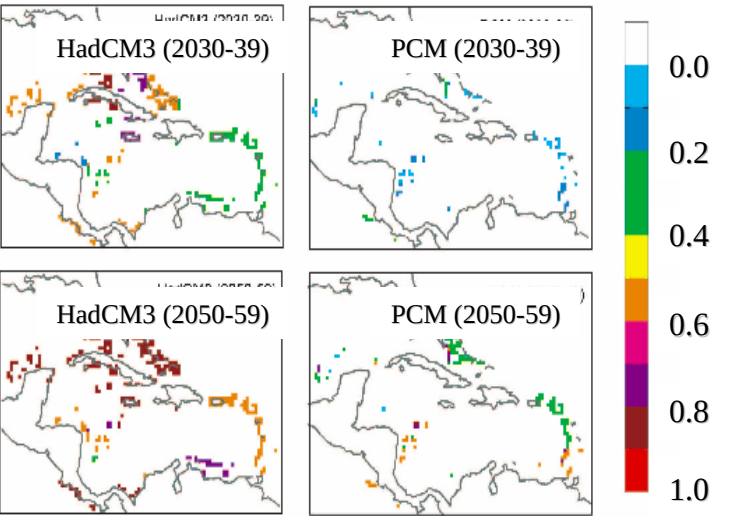


Corals must adapt to 0.2°C/decade temperature rise

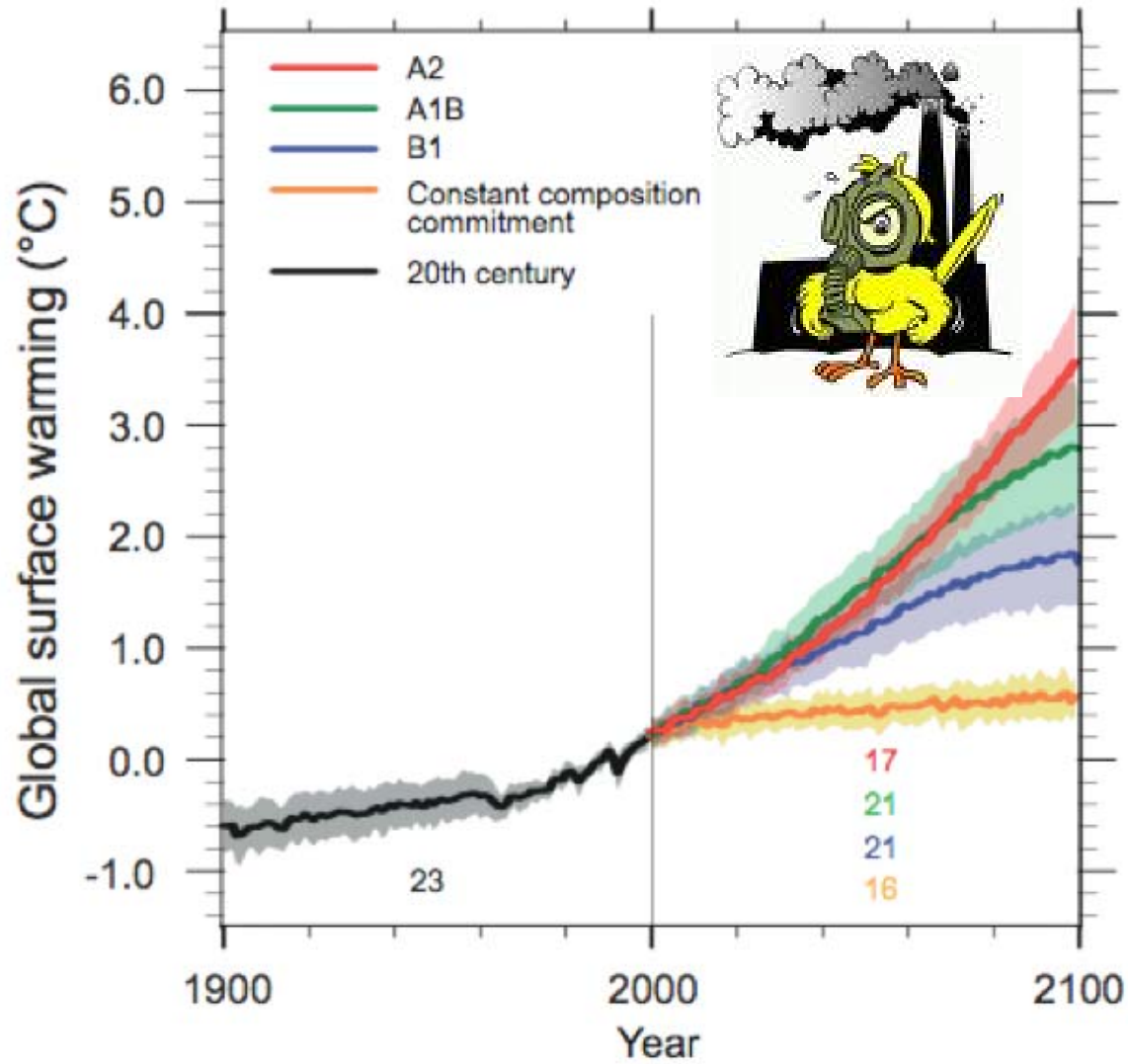
NOAA coral reef CONSERVATION PROGRAM

http://coralreefwatch

Bleaching Under Future Climates?



Corals must adapt to 0.2°C/decade temperature rise (Donner et al. 2005)



Importance of Genetic Diversity in Coral Survival

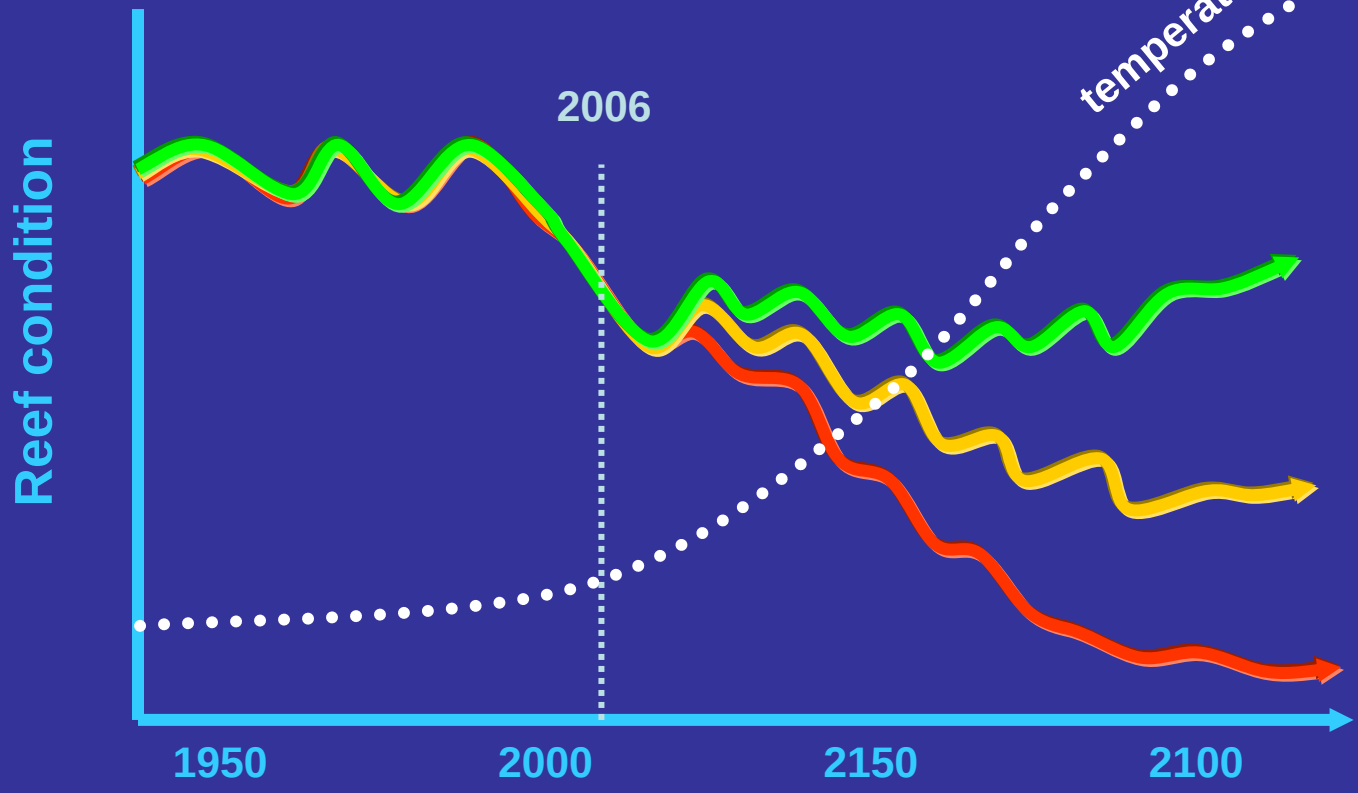
460 colonies monitored

First recorded bleaching of elkhorn corals in US Virgin Islands

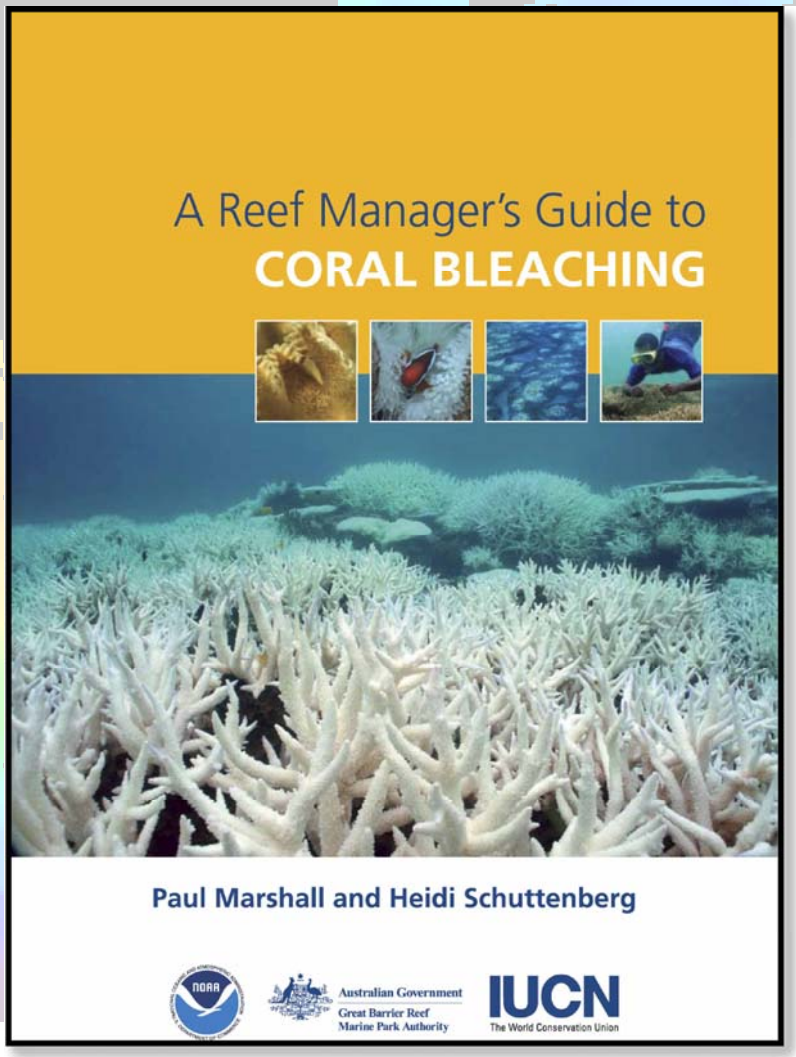
Multiple, Synergistic Stresses on both **Global & Local Scales**

NOAA coral reef CONSERVATION PROGRAM

Deciding the future for coral reefs



My Reef is Bleaching, What Can I do?



- **Result of international workshop, research, and planning**

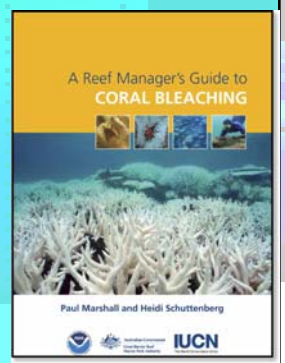
- **Australia: Great Barrier Reef Marine Park Authority**
- **US: NOAA and EPA**
- **IUCN**

Now Available at coralreef.noaa.gov

Short-term Opportunities for Coral Bleaching Management

Local managers can:

- Reduce bleaching
  - Reduce light stress
  - Cool reefs, increase mixing



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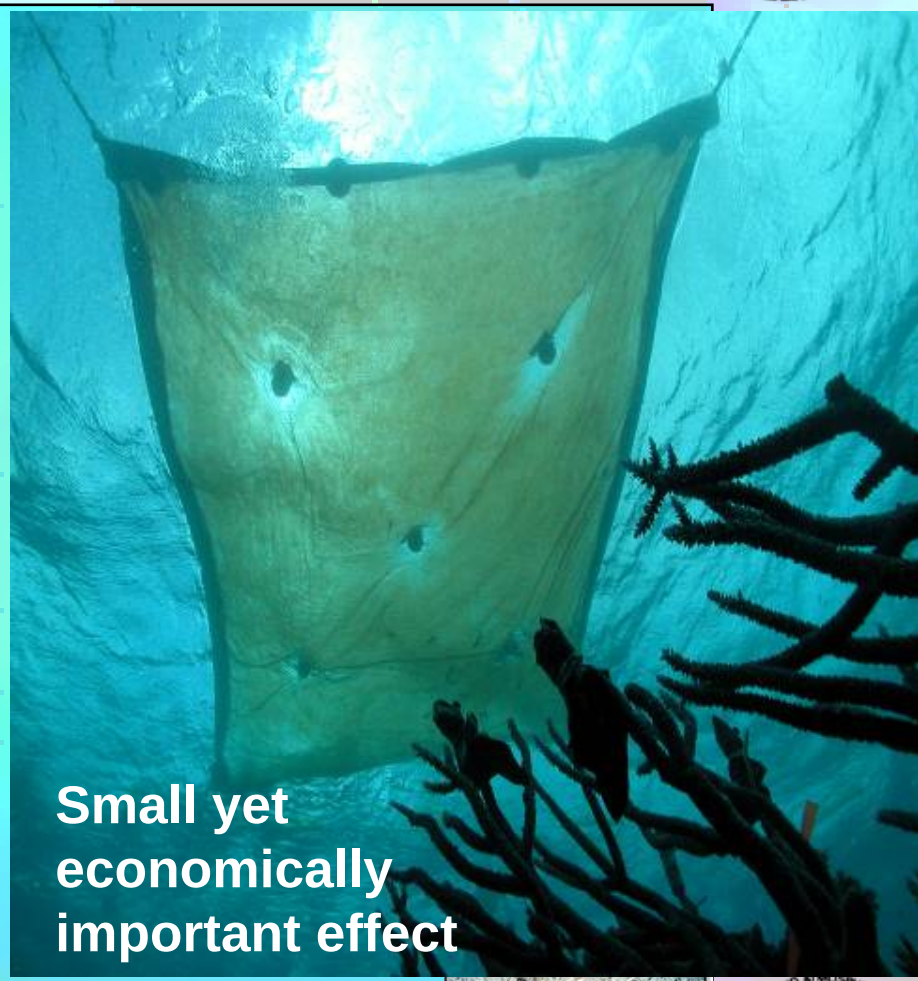
Quicksilver Connections



Small yet economically important effect

Short-term Opportunities for Coral Bleaching Management

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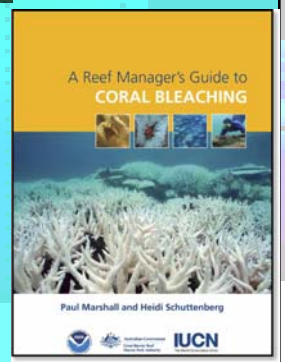
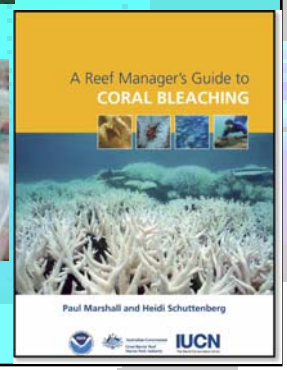
  - Cool reefs, increase mixing
- Increase survival
  - Improve water quality
  - Reduce disease prevalence



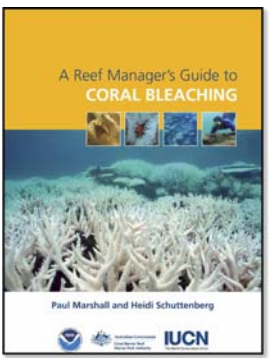
Short-term Opportunities for Coral Bleaching Management

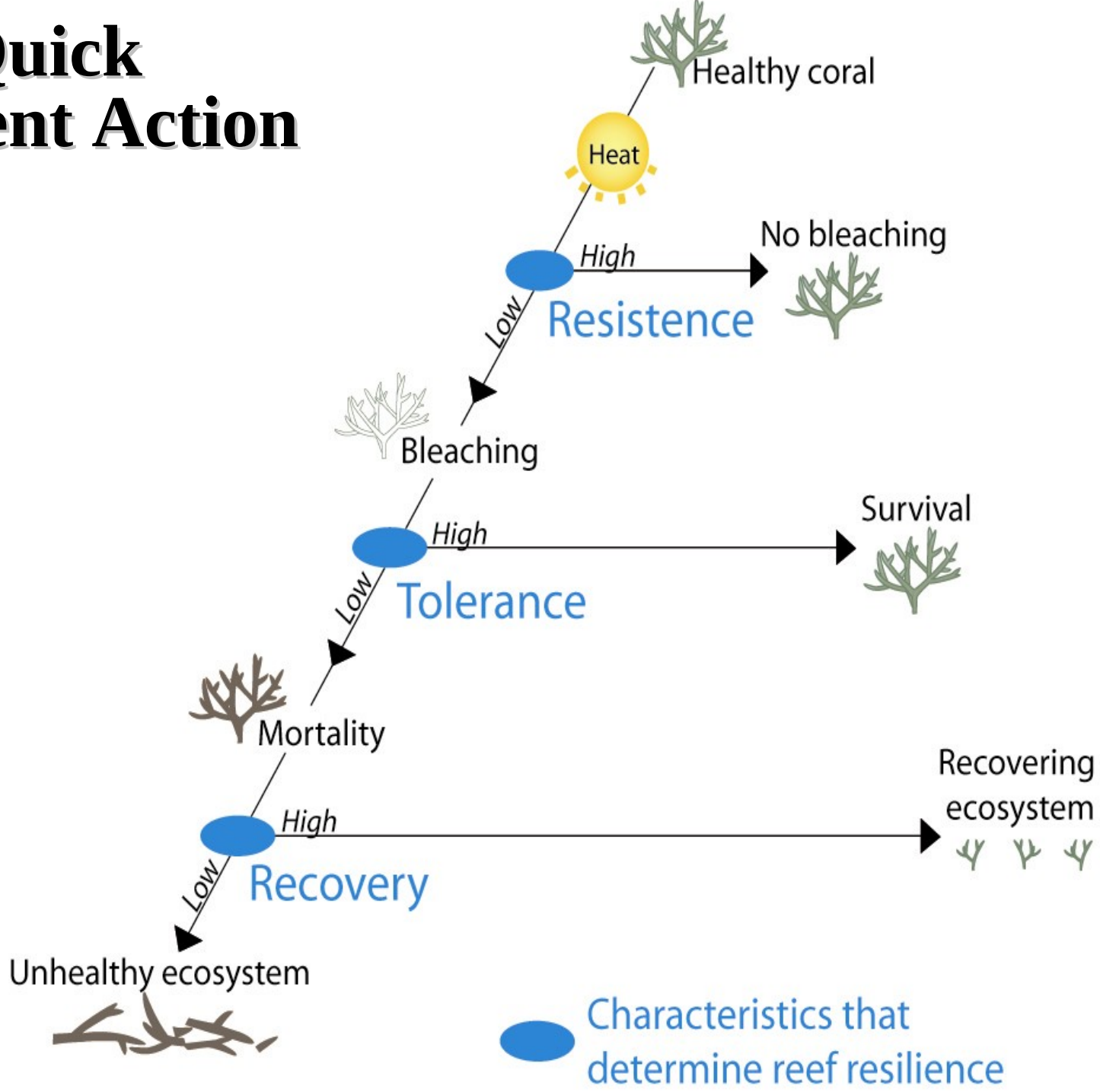
Local managers can:

- Reduce bleaching
  - Reduce light stress
  - Cool reefs, increase mixing
- Increase survival
  - Improve water quality
  - Reduce disease prevalence
- Aid recovery
  - Coral fragmentation
  - Encourage recruitment
  - Protect ecosystem functions (herbivory)



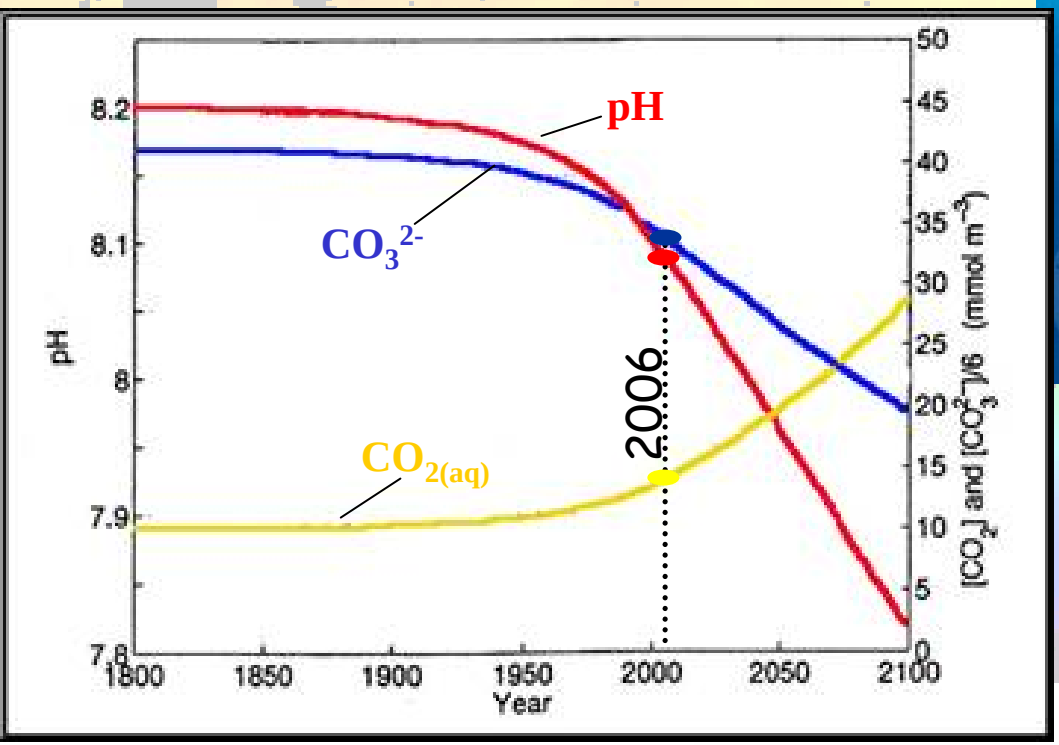
Need for Quick Management Action





Ocean Acidification

The Elephant in the Room:



After Wolf-Gladrow et al., 1999

http://coralreefwatch.noaa.gov

We don’t want to lose all of our canaries

Conclusions

- Threats to coral reefs continue to increase
- As oceans warm, bleaching will continue
- Necessary Change: Slow or reverse emissions
- Buy Time: Increase ecosystem resilience

- Can improved management save reefs from ecological disaster?