Long-Term Reef Monitoring at the Flower Garden Banks: Past, Present and Future

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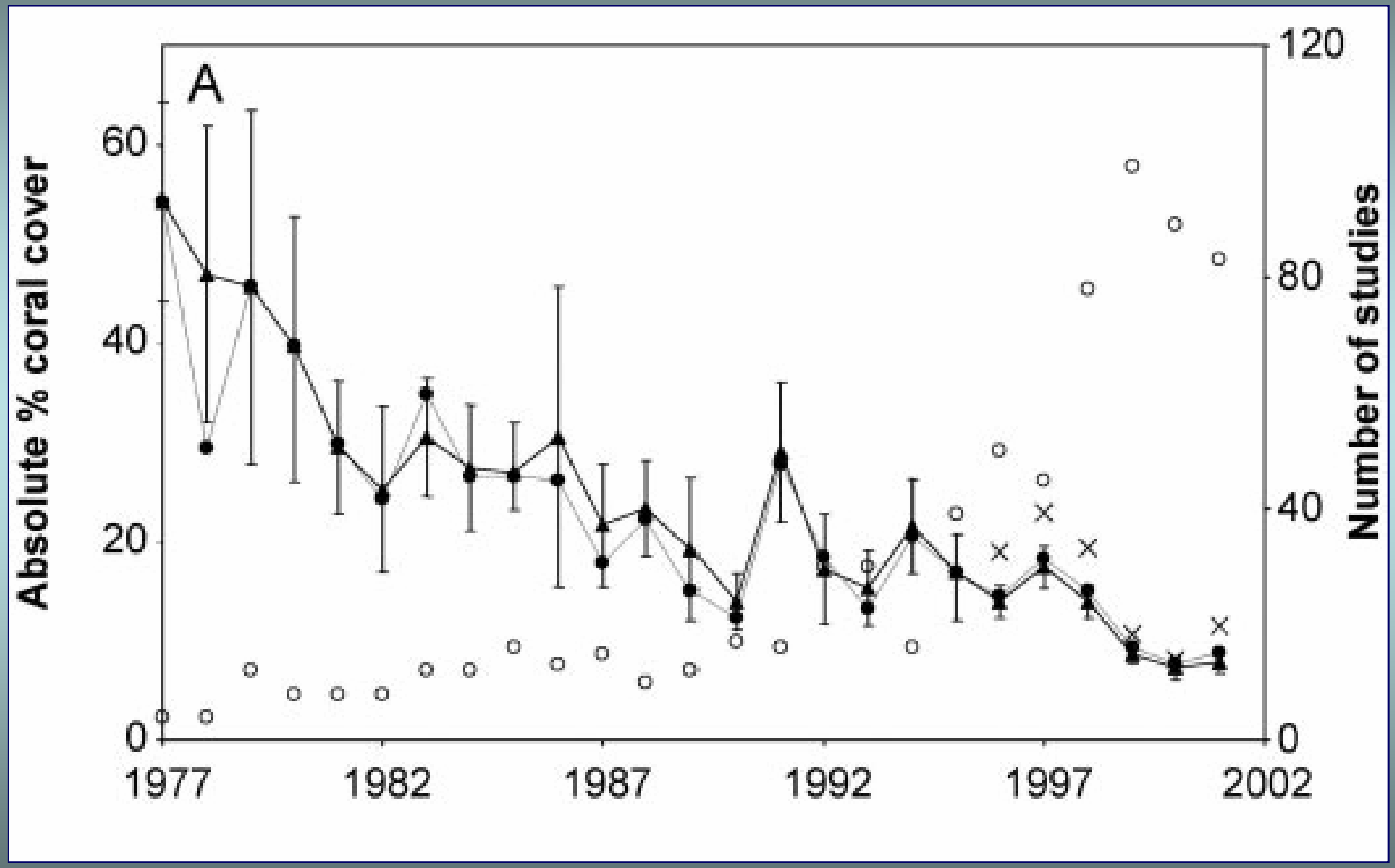
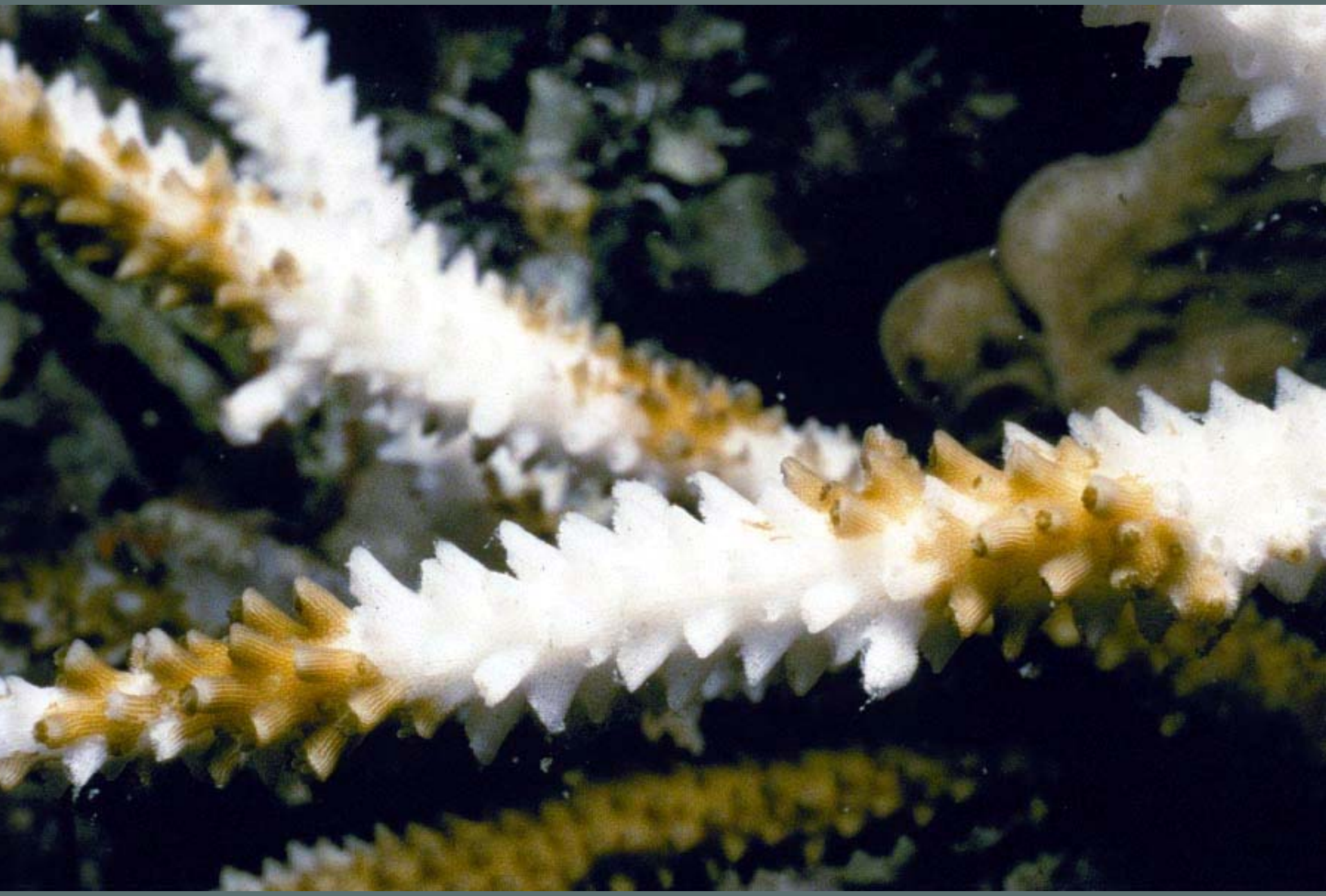
Decline of Coral Cover in the Caribbean

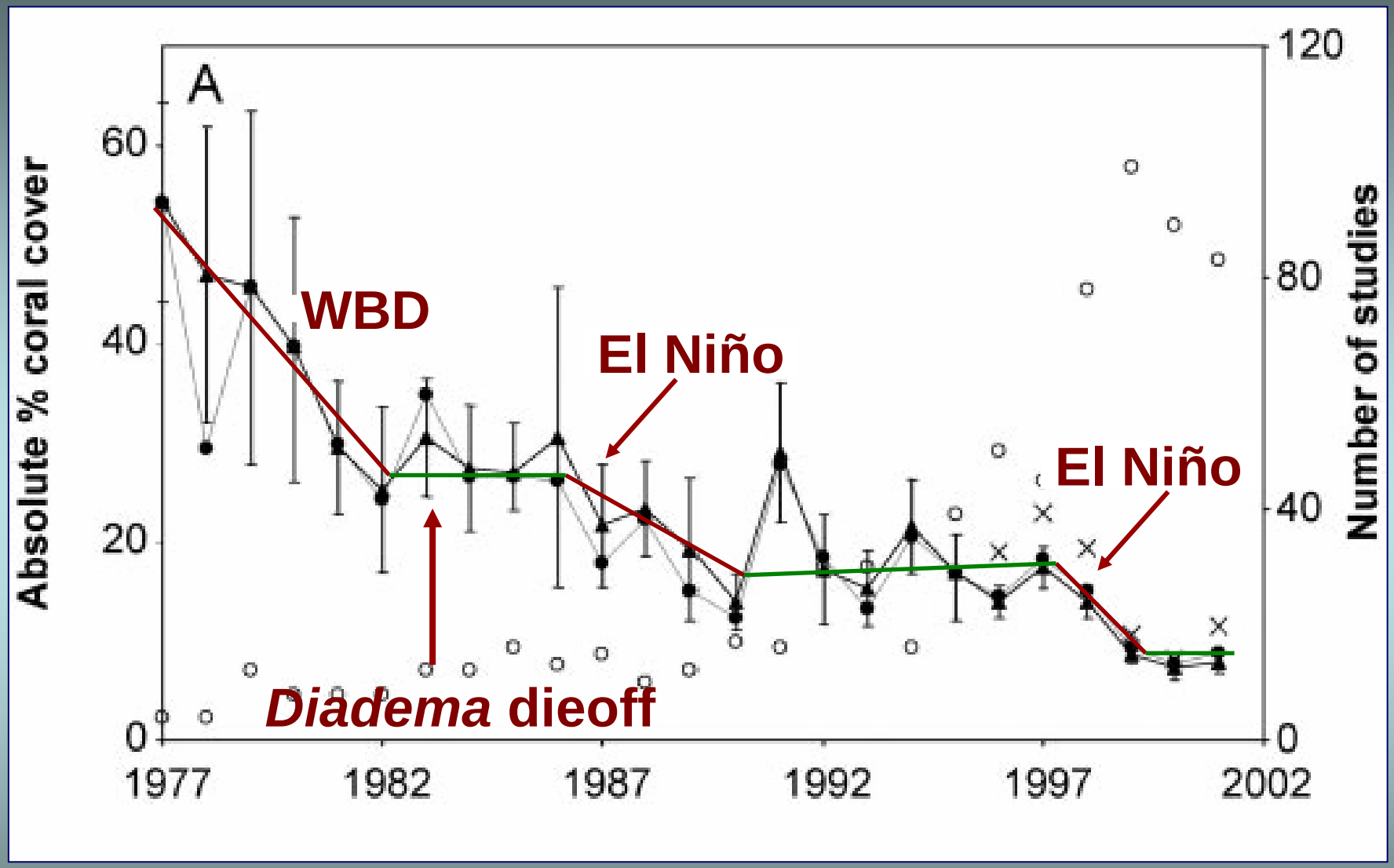


Gardner et al. 2003

Acropora palmata

Acropora cervicornis



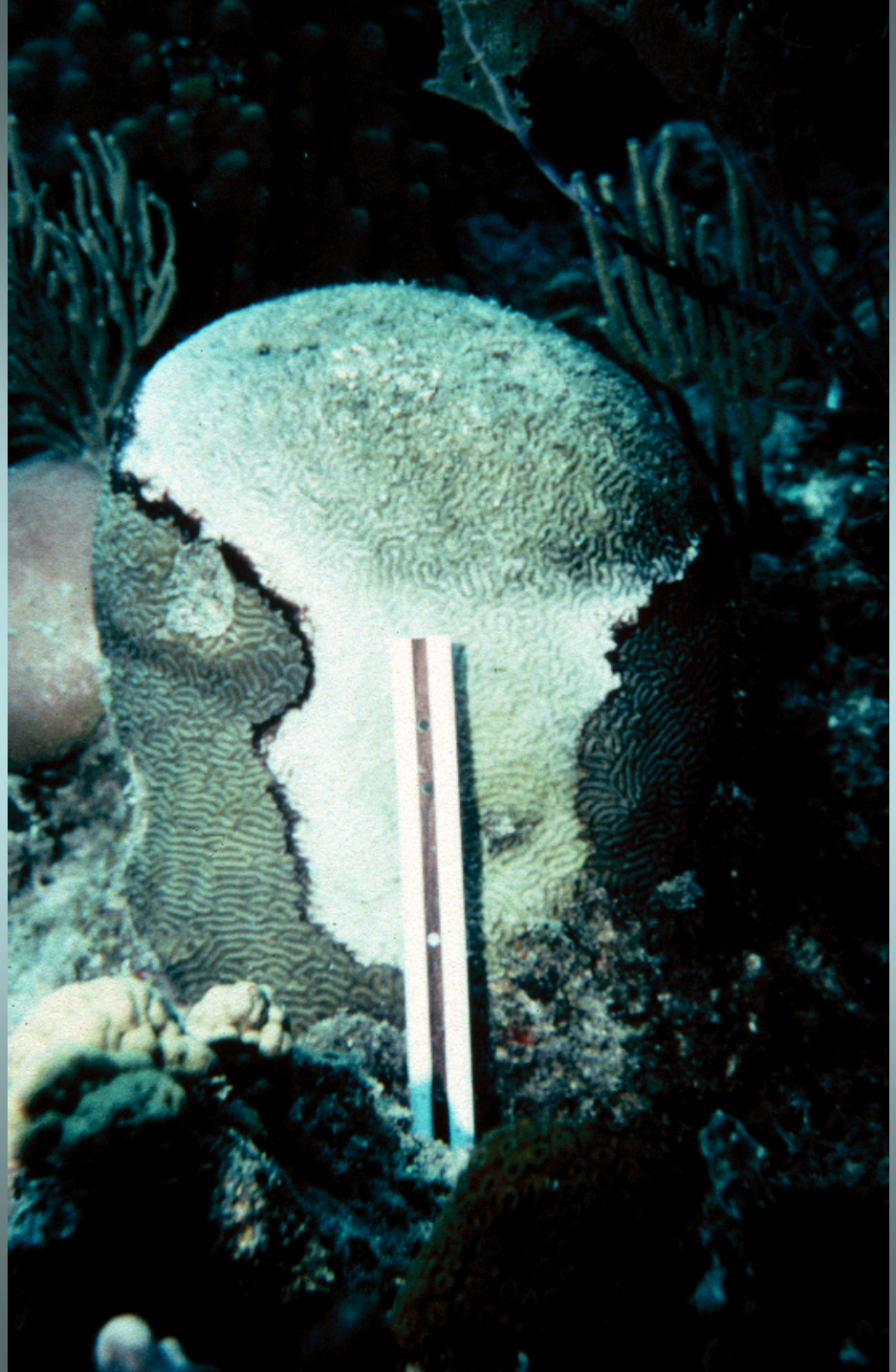


Gardner et al. 2003

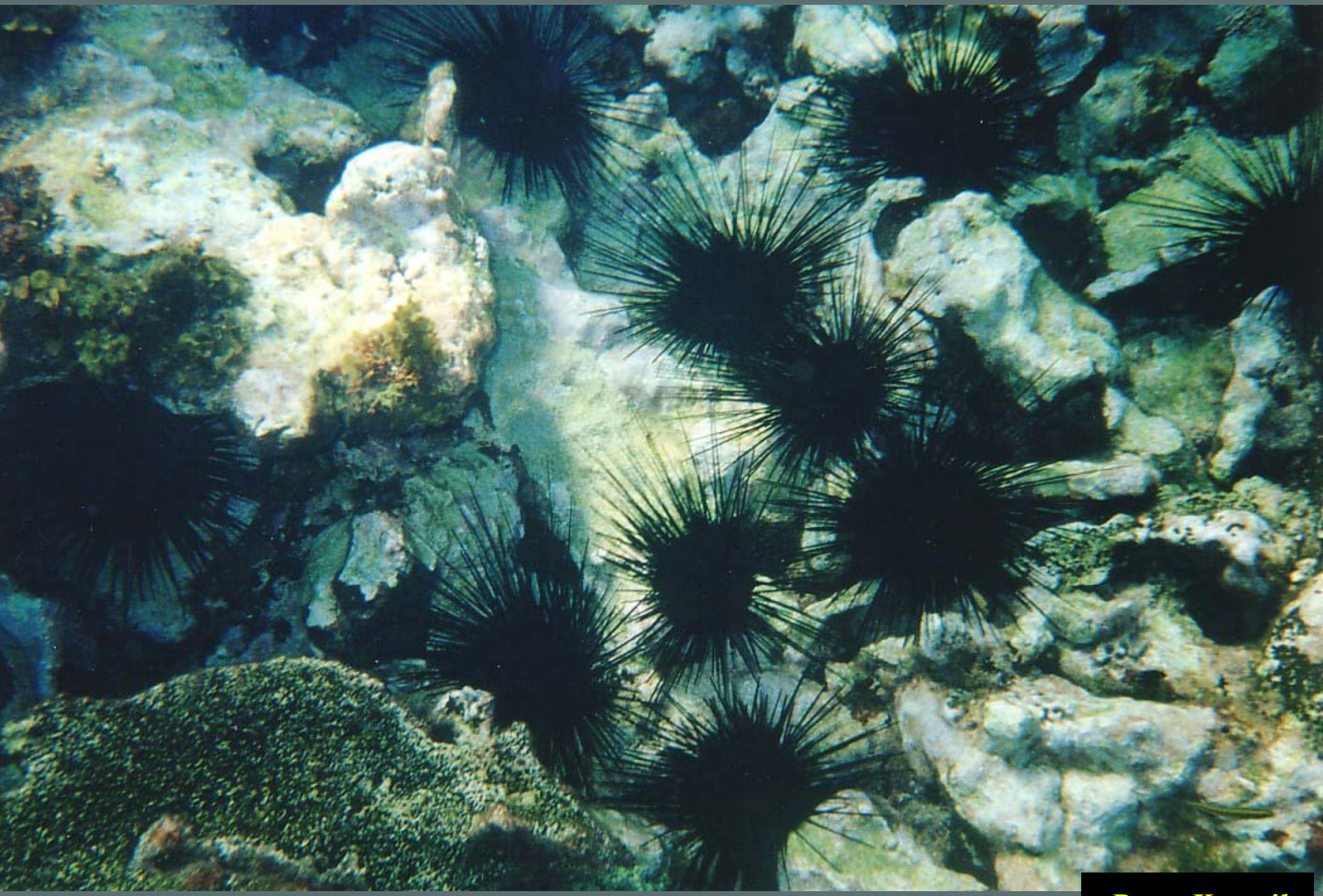
Bleached Montastraea faveolata: West End New Providence, Bahamas 1998. Bill Precht

Pear Tree Bottom, Jamaica, 1987

***Dichocoenia stokesi* with Plague II, Keyswide Cruise 1995**
Photo by Steven Miller



Role of Herbivory



Ryan Kroutil

Decades to Centuries of Overfishing

Diadema Mass Mortality: 1983–84

Algal dominance is the result.

This scenario works for Jamaica, but …

Cayman Islands: fishing prohibited.

So … kill corals and herbivores

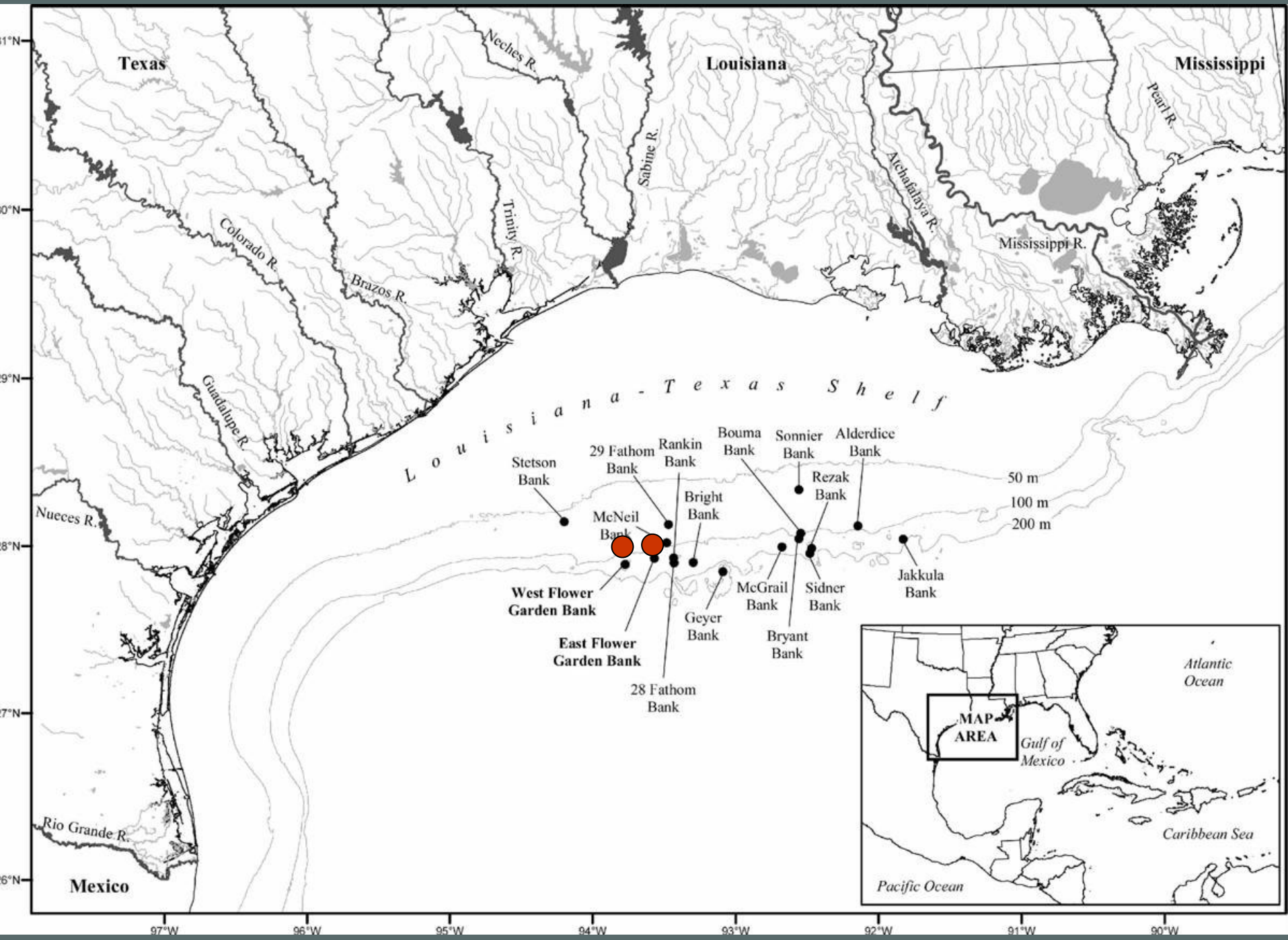
OR just kill enough corals.

Recent Turnover Events on Caribbean Reefs

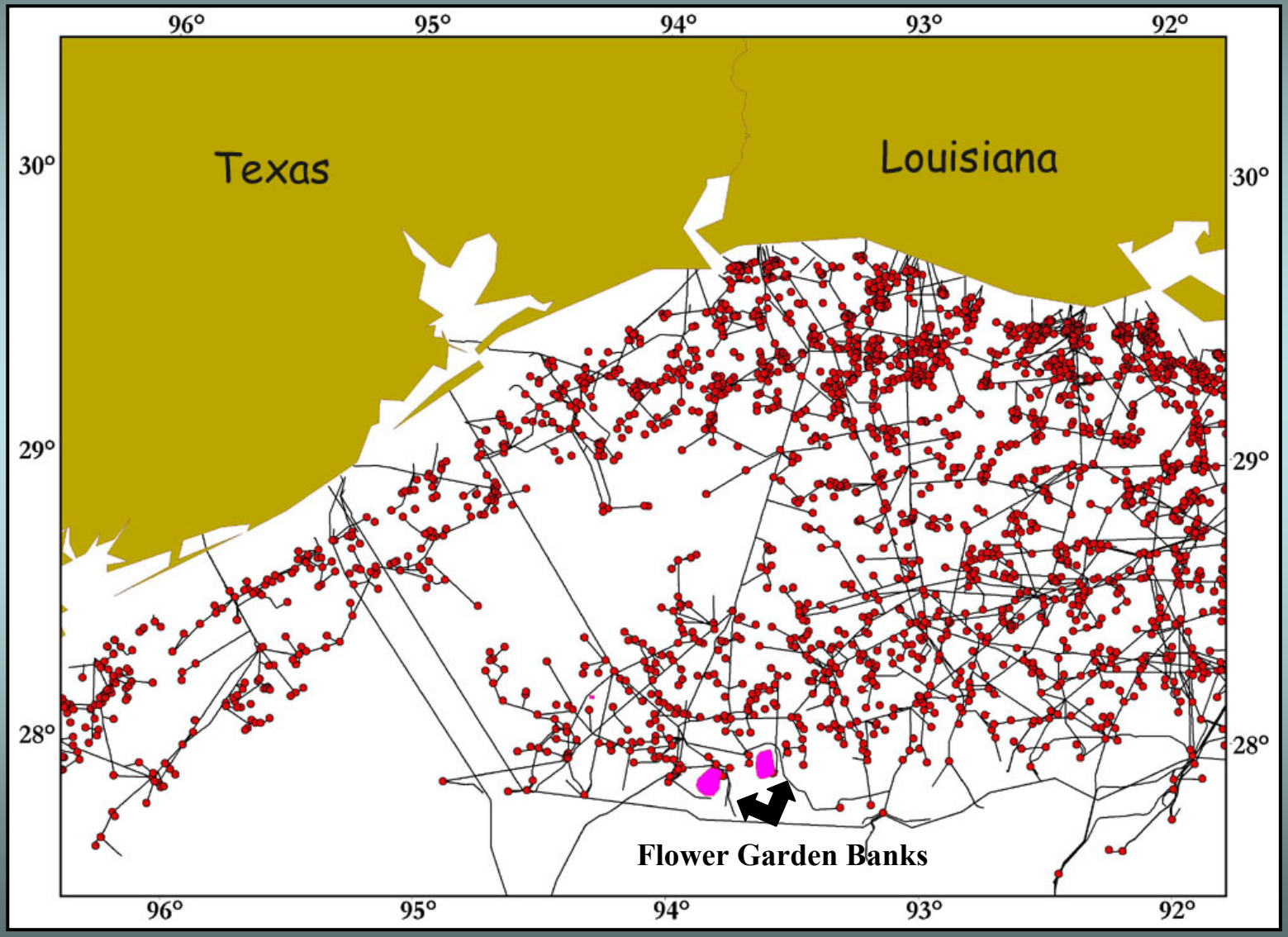
Following coral mortality:

- **Low herbivory relative to available space: macroalgal dominance (most reefs)**
- **High herbivory relative to available space: coral dominance (some reefs)**

Reefs of the Flower Garden Banks have not been significantly affected by these processes.

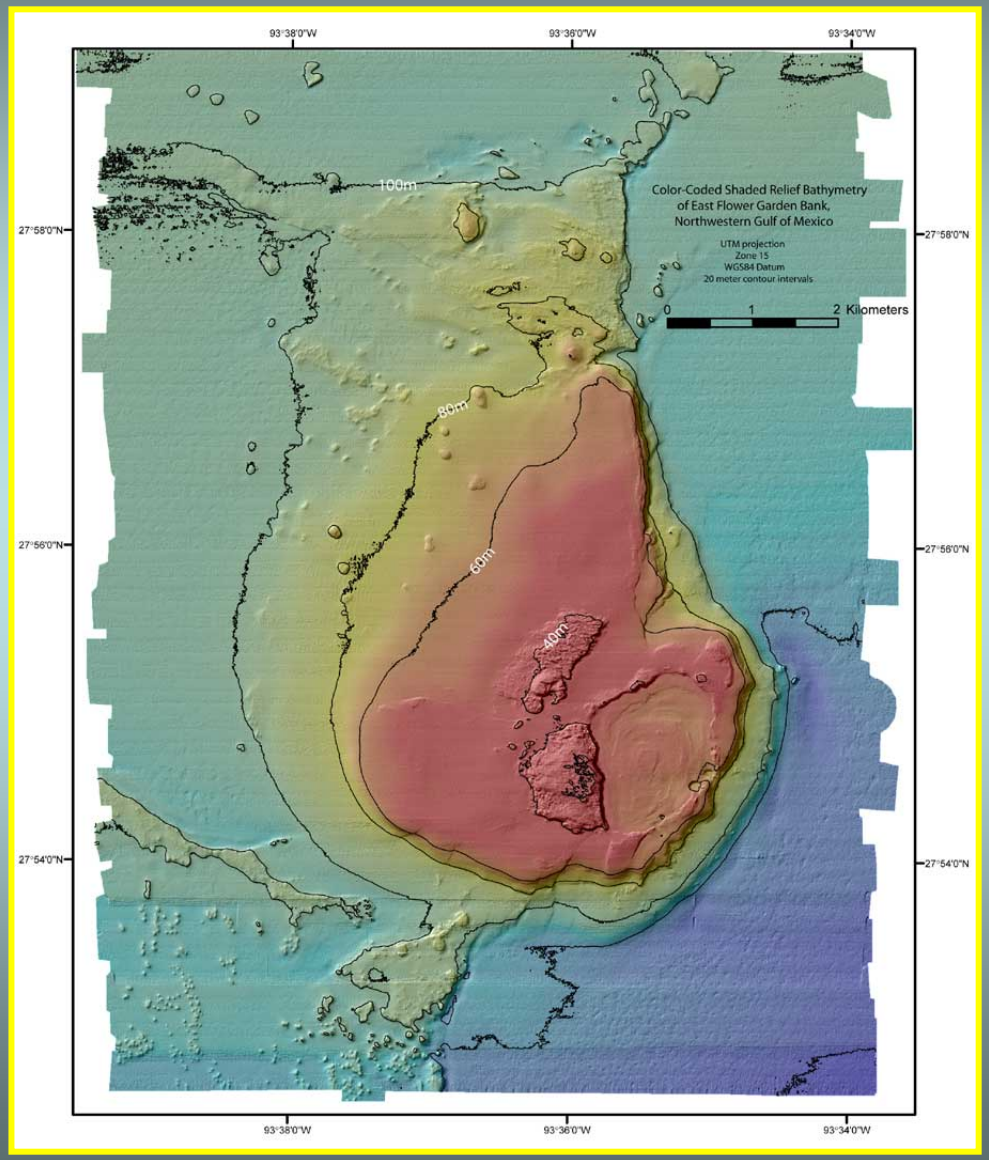

Texas
Louisiana
Mississippi
Mexico
Neches R.
Sabine R.
Pearl R.
Atchafalaya R.
Mississippi R.
Trinity R.
Colorado R.
Brazos R.
Guadalupe R.
Nueces R.
Rio Grande R.
Louisiana-Texas Shelf
Stetson Bank
29 Fathom Bank
Rankin Bank
Bouma Bank
Sonnier Bank
Alderdice Bank
Rezak Bank
Bright Bank
McNeil Bank
West Flower Garden Bank
East Flower Garden Bank
28 Fathom Bank
Geyer Bank
McGrail Bank
Bryant Bank
Sidner Bank
Jakkula Bank
50 m
100 m
200 m
MAP AREA
Gulf of Mexico
Atlantic Ocean
Caribbean Sea
Pacific Ocean
97°W
96°W
95°W
94°W
93°W
92°W
91°W
90°W

Oil and Gas Infrastructure



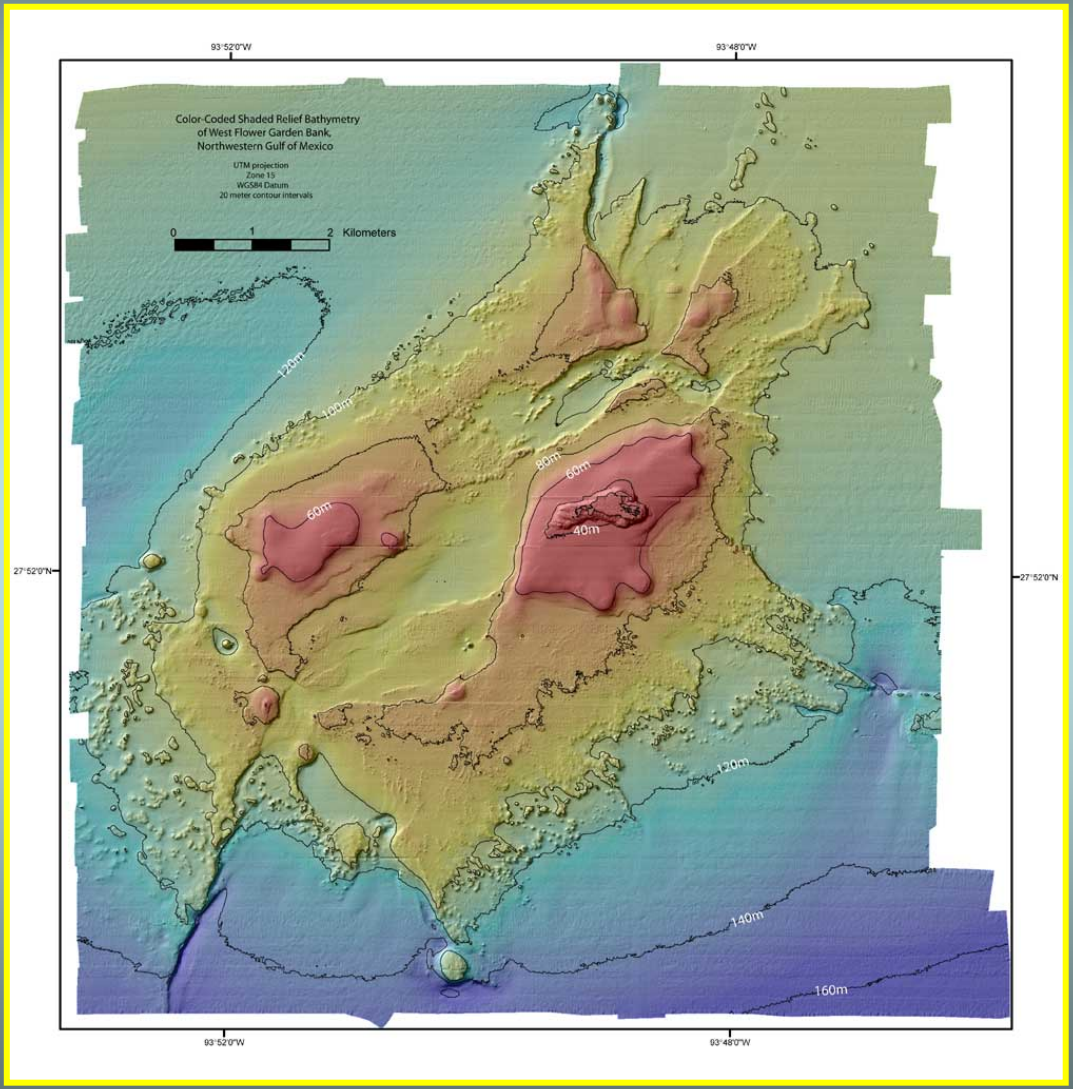
The Flower Garden Banks

- **East Bank**
  - **Total area is approximately 19.2 square miles**
  - **Reef crest is approximately 250 acres**
  - **Active brine seep forms an underwater salt lake about 100 feet in diameter and 10 inches deep**



The Flower Garden Banks

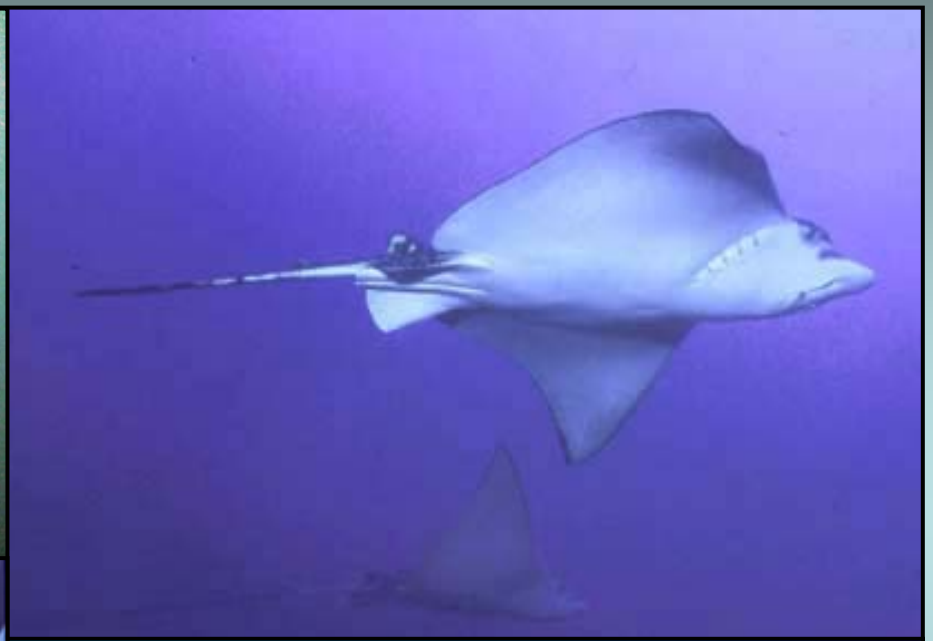
- **West Bank**
  - **Total area is approximately 22.5 square miles**
  - **Reef crest is approximately 100 acres**



The Flower Garden Banks

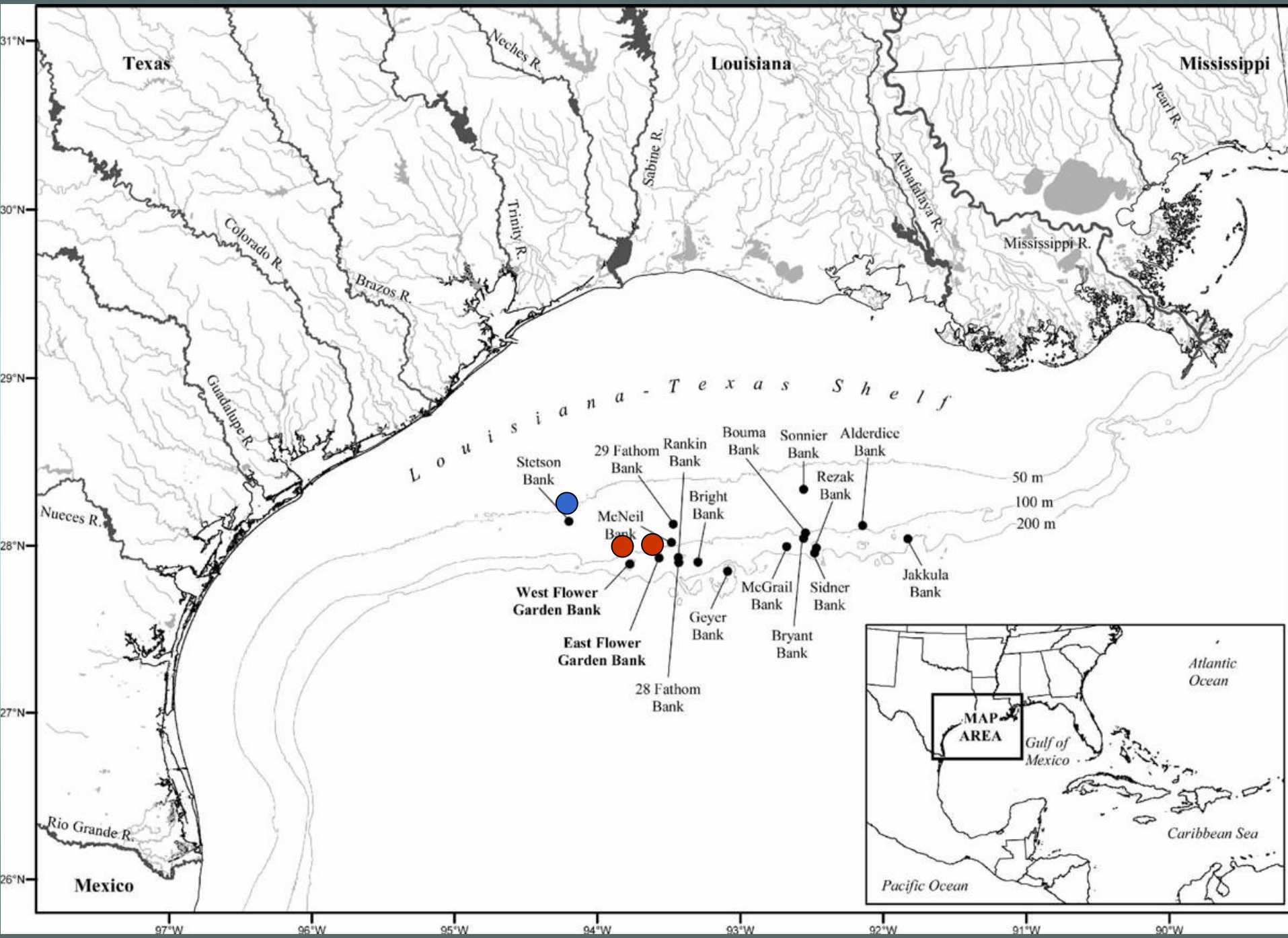
- Species diversity
  - 21 species of coral – few sea fans, or sea whips
  - 80+ species of Algae
  - 250+ species of invertebrates
  - 200+ species of fish (including sharks and rays)
  - Three marine turtle species documented – only loggerhead is resident
  - No resident marine mammals

Seasonal Aggregations of Sharks and Rays



The Flower Garden Banks

- Research efforts began in 1970s
- 1988: MMS began long-term monitoring program
- 1992: Flower Garden Banks designated a National Marine Sanctuary
- 1996: Congress expanded the sanctuary to include Stetson Bank


Texas
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Neches R.
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Nueces R.
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Bright Bank
McNeil Bank
West Flower Garden Bank
East Flower Garden Bank
28 Fathom Bank
Geyer Bank
McGrail Bank
Bryant Bank
Sidner Bank
Jakkula Bank
50 m
100 m
200 m
31°N
30°N
29°N
28°N
27°N
26°N
97°W
96°W
95°W
94°W
93°W
92°W
91°W
90°W
MAP AREA
Gulf of Mexico
Atlantic Ocean
Caribbean Sea
Pacific Ocean

Project Goals

Test the Null Hypothesis

Lease stipulations provide effective mitigation for impacts on the FGB

- **Monitor FGB coral reef ecosystems**
- **Monitor environmental conditions**
- **Understand natural variability**
- **Understand impacts from oil and gas operations**
- **Understand other anthropogenic impacts**

Provide information for resource management and regulatory decision-making

A Comprehensive, Long-Term Monitoring Effort

- **Water quality monitoring:** salinity, temperature, dissolved oxygen, turbidity, PAR

100 x 100 m study site at each bank; 17–26 m depth

- **Fish surveys:** Bohnsack-Bannerot stationary method (>20 surveys per bank per year)
- ***Diadema* and lobster surveys** (2 transects=400 m^2 per bank per year)
- **Random video transects** (10 x 0.4 m; *N*=16)
- **Repetitive photo-quadrats** (8 m^2; 40 each bank;$N \approx 90$)
- **Lateral growth stations:** repetitive photographs of margins of *Diploria strigosa* (262 cm^2; 60 each bank; $N \approx 100$)
- **Sclerochronology** of *Montastraea faveolata* (4 cores per bank every 2 years)
- **Videography of perimeter lines** of study sites
- **Deep repetitive photo-quadrats** (8 m^2; 32-40 m depth; *N*=9 at East Bank) **NEW in 2004!!**

Water Quality

- Persistently clear, oceanic water
- Periodic inputs of river water from the Mississippi and Atchafalaya Rivers, based on oceanography and fluorescent banding in corals.

Fish Surveys

Carnivores:

- High abundance of large carnivores compared to Caribbean reefs

Herbivores:

- High abundance of large parrotfish (Labridae)
- Large schools of surgeonfish (Acanthuridae)

Diadema and Lobsters

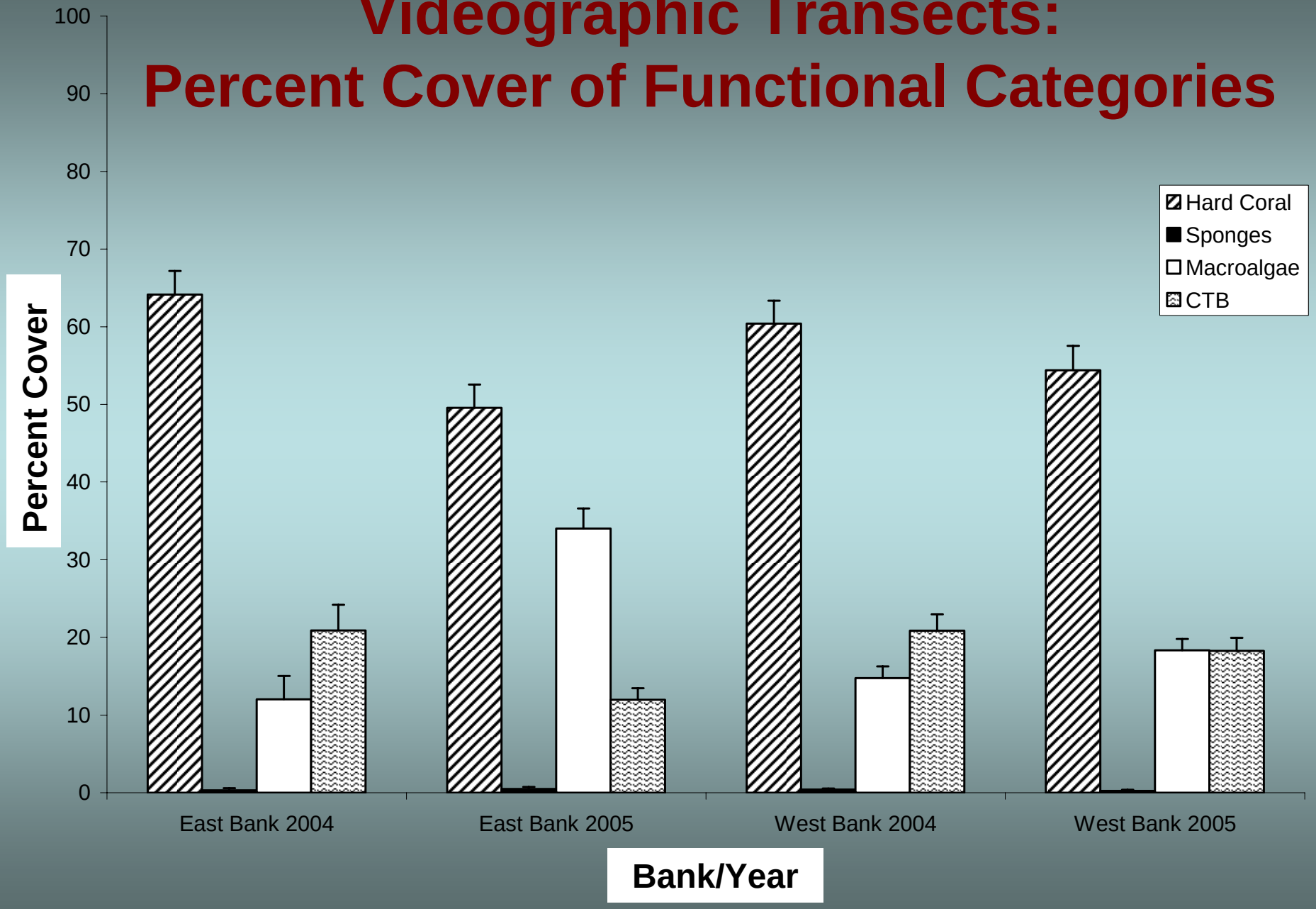
***Diadema*:**

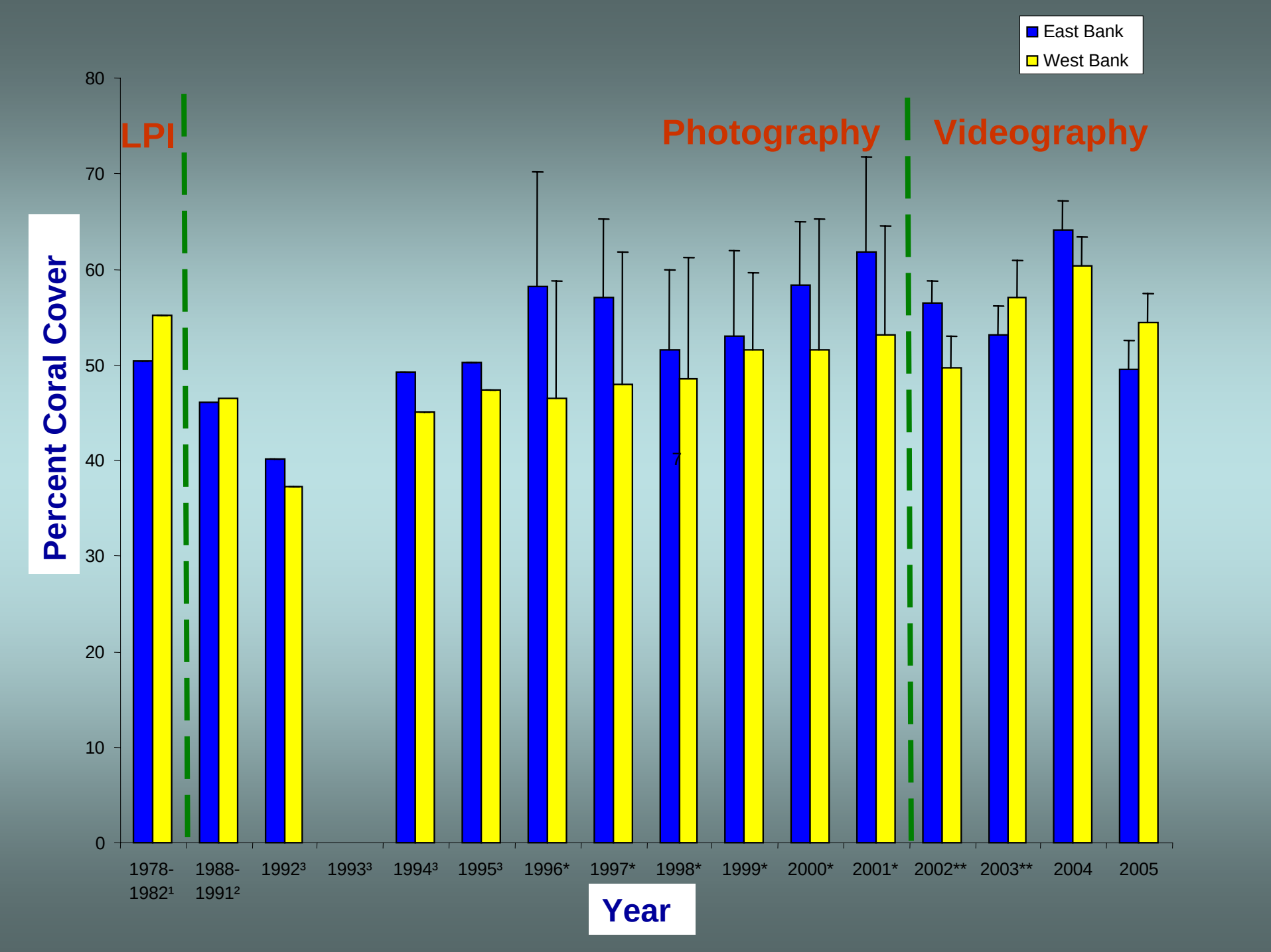
- **Rare**
- **1–2 per m^2 prior to dieoff in 1983–84**
- **Poor recruitment as elsewhere in the Caribbean**

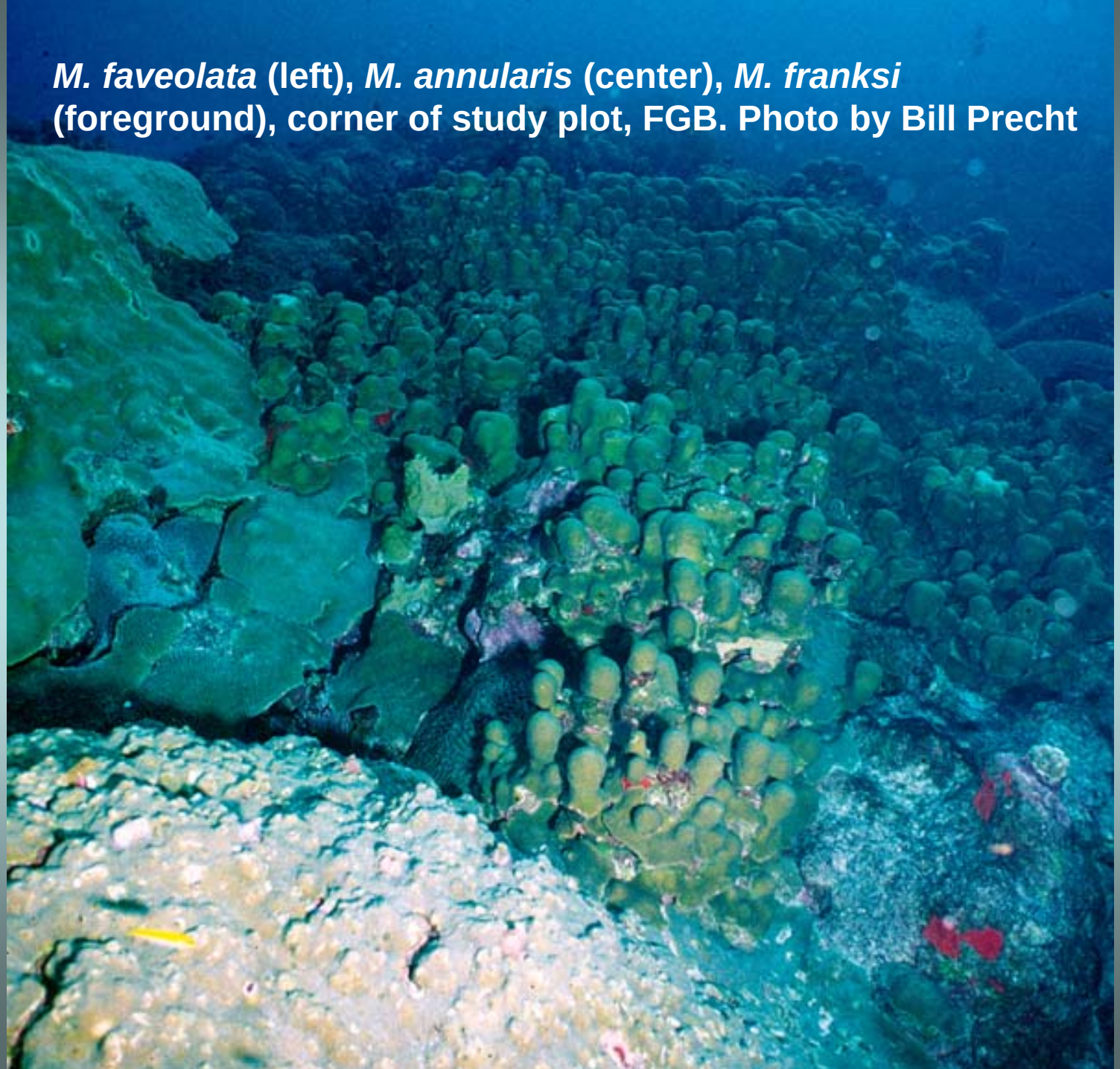
Lobsters:

- **Rare**
- **?High predation pressure**

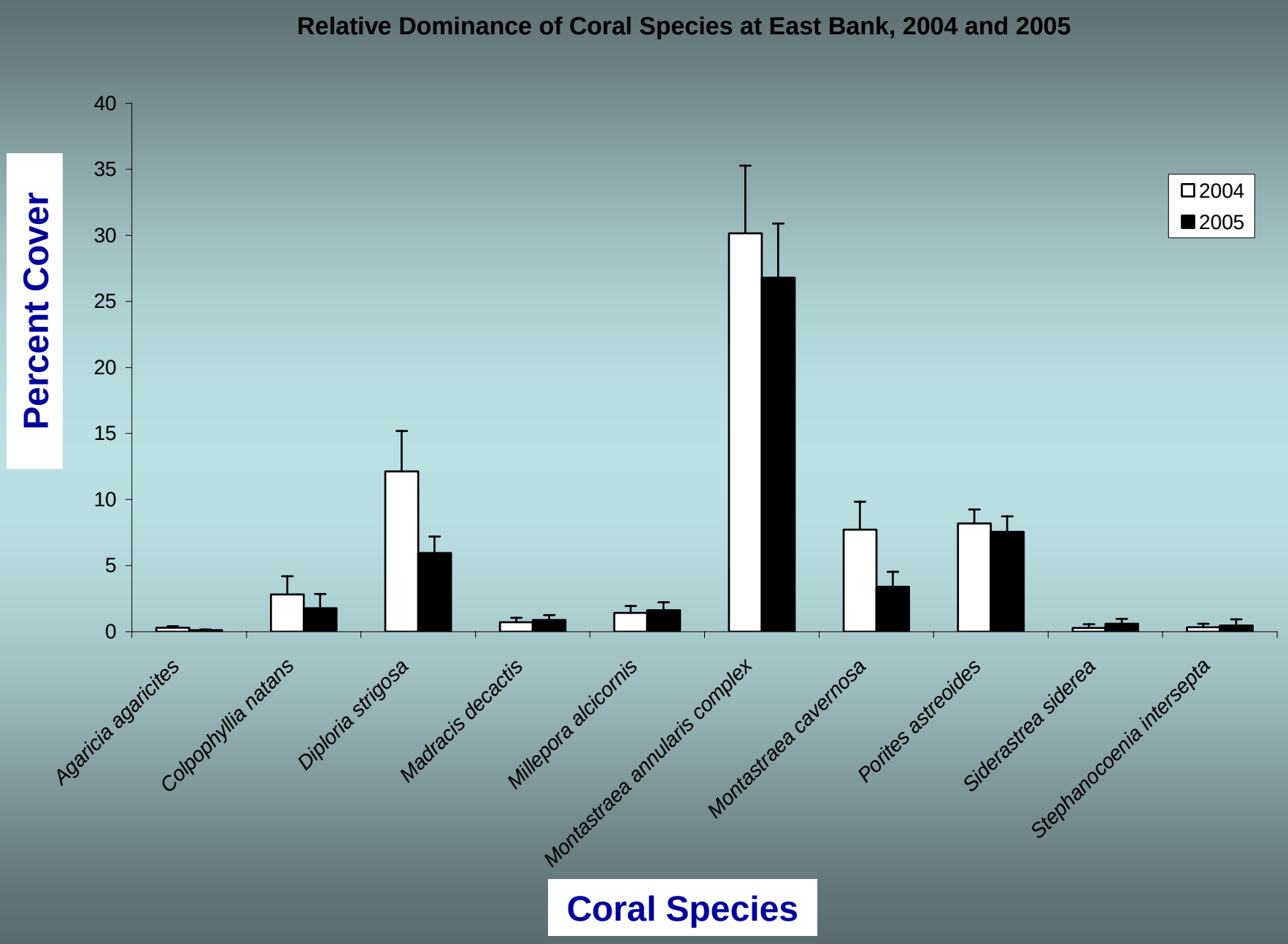
Videographic Transects: Percent Cover of Functional Categories

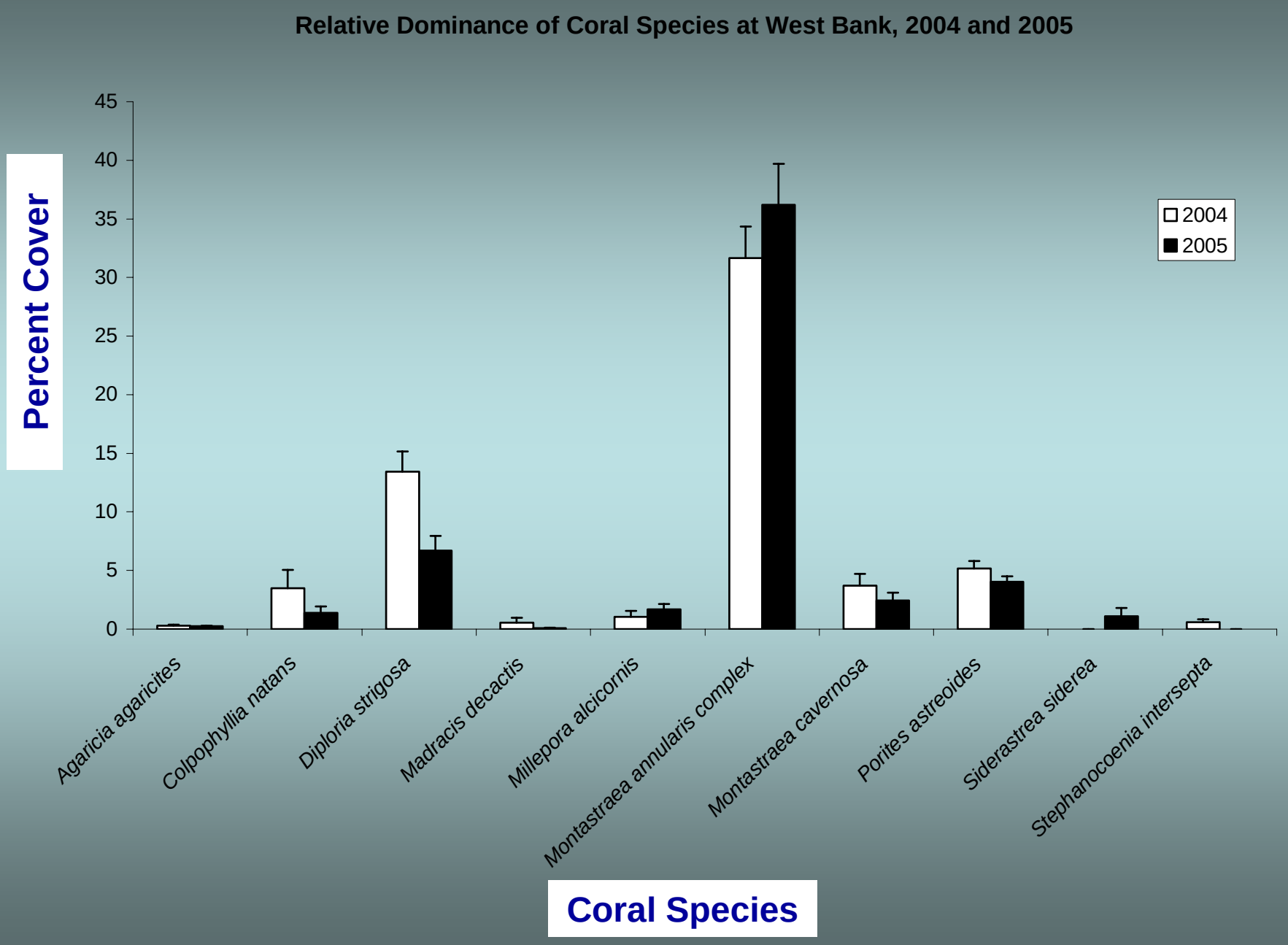



East Bank
West Bank
LPI
Photography
Videography
Percent Coral Cover
80
70
60
50
40
30
20
10
0
1978-1982¹
1988-1991²
1992³
1993³
1994³
1995³
1996*
1997*
1998*
1999*
2000*
2001*
2002**
2003**
2004
2005
Year

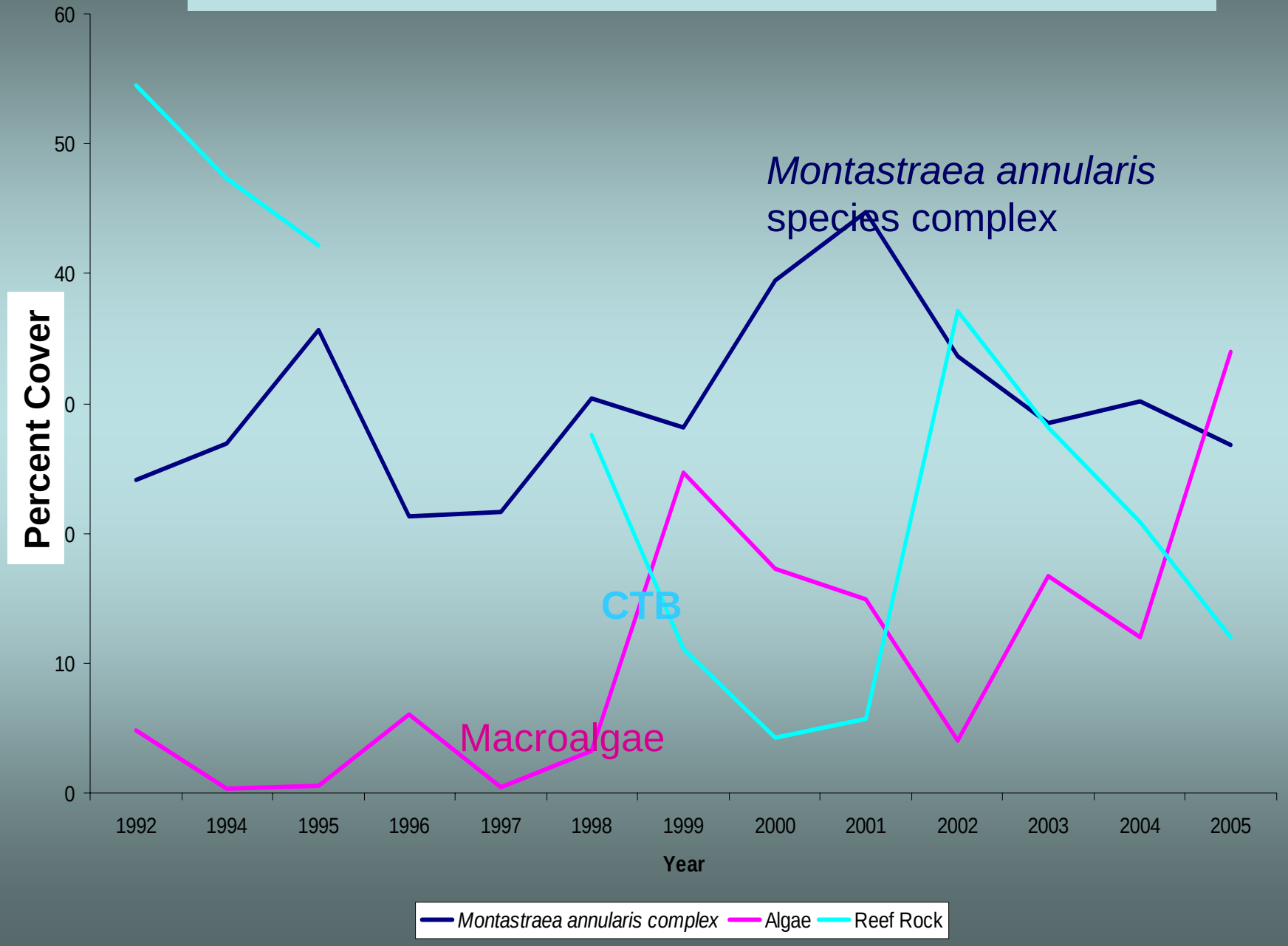


M. faveolata **(left),** ***M. annularis*** **(center),** ***M. franksi*** **(foreground), corner of study plot, FGB. Photo by Bill Precht**

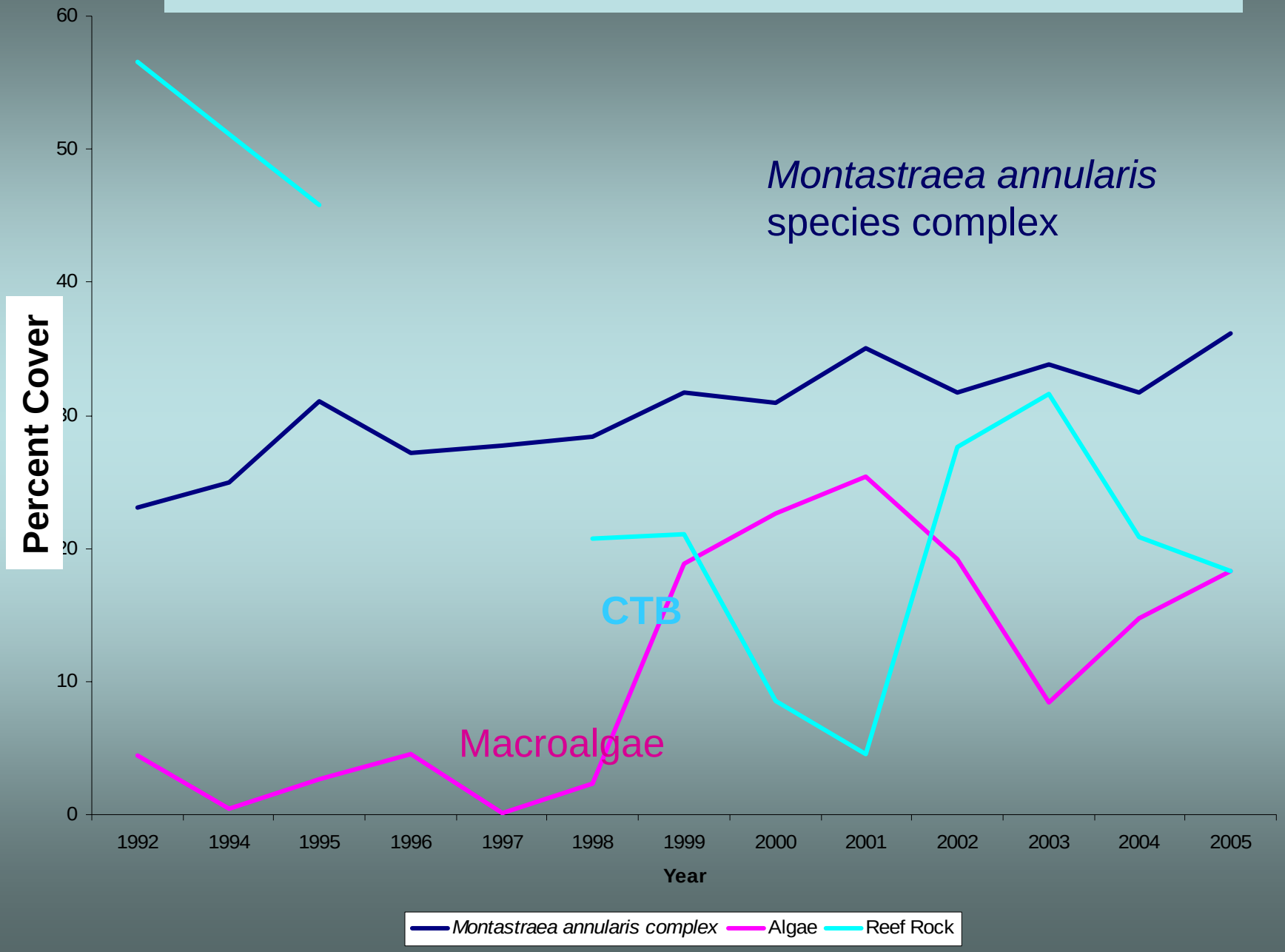

Relative Dominance of Coral Species at East Bank, 2004 and 2005
Percent Cover
40
35
30
25
20
15
10
5
0
2004
2005
Agaricia agaricites
Colpophyllia natans
Diploria strigosa
Madracis decactis
Millepora alcicornis
Montastraea annularis complex
Montastraea cavernosa
Porites astreoides
Siderastrea siderea
Stephanocoenia intersepta
Coral Species

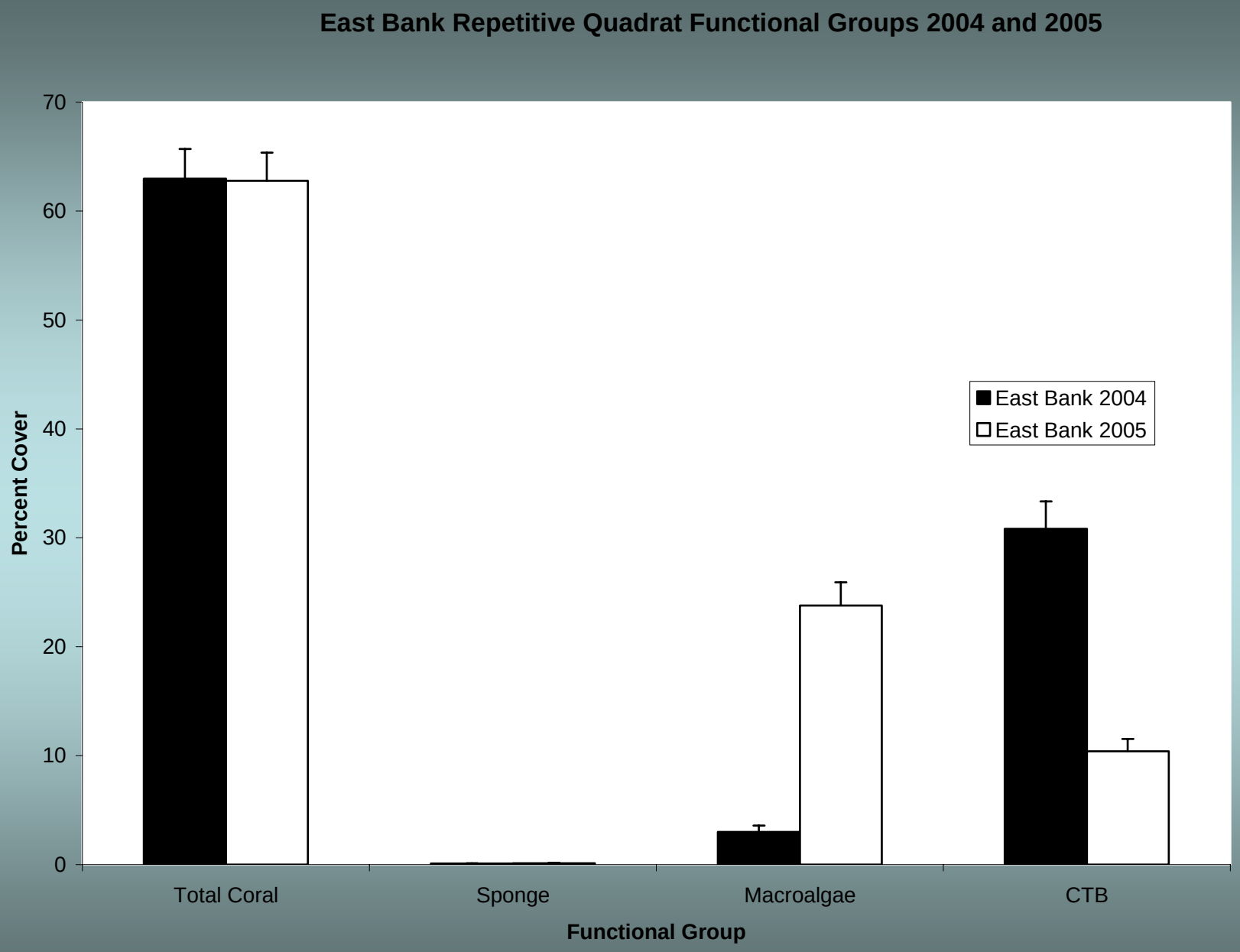

Relative Dominance of Coral Species at West Bank, 2004 and 2005
Percent Cover
45
40
35
30
25
20
15
10
5
0
2004
2005
Agaricia agaricites
Colpophyllia natans
Diploria strigosa
Madracis decactis
Millepora alcicornis
Montastraea annularis complex
Montastraea cavernosa
Porites astreoides
Siderastrea siderea
Stephanocoenia intersepta
Coral Species

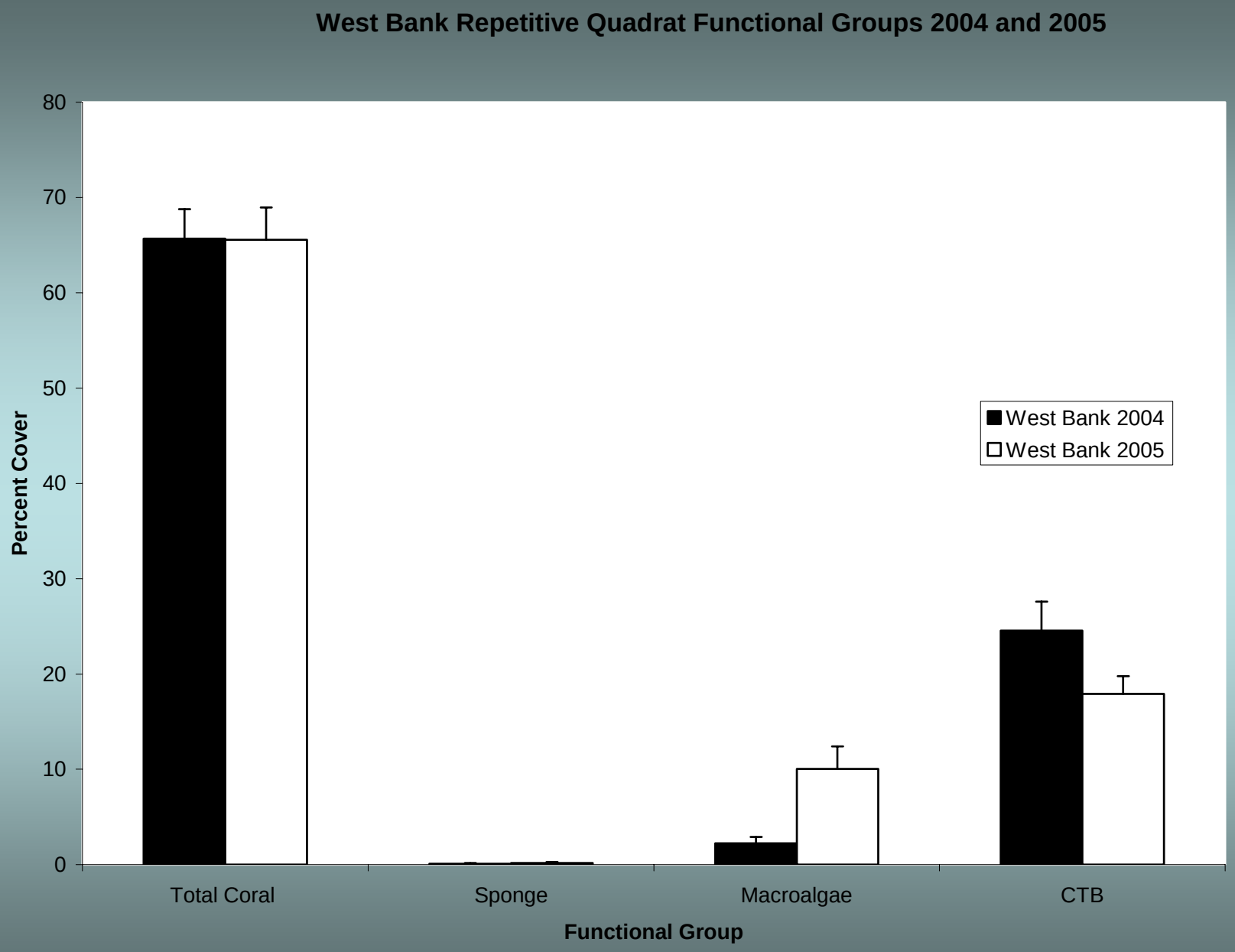
East Bank

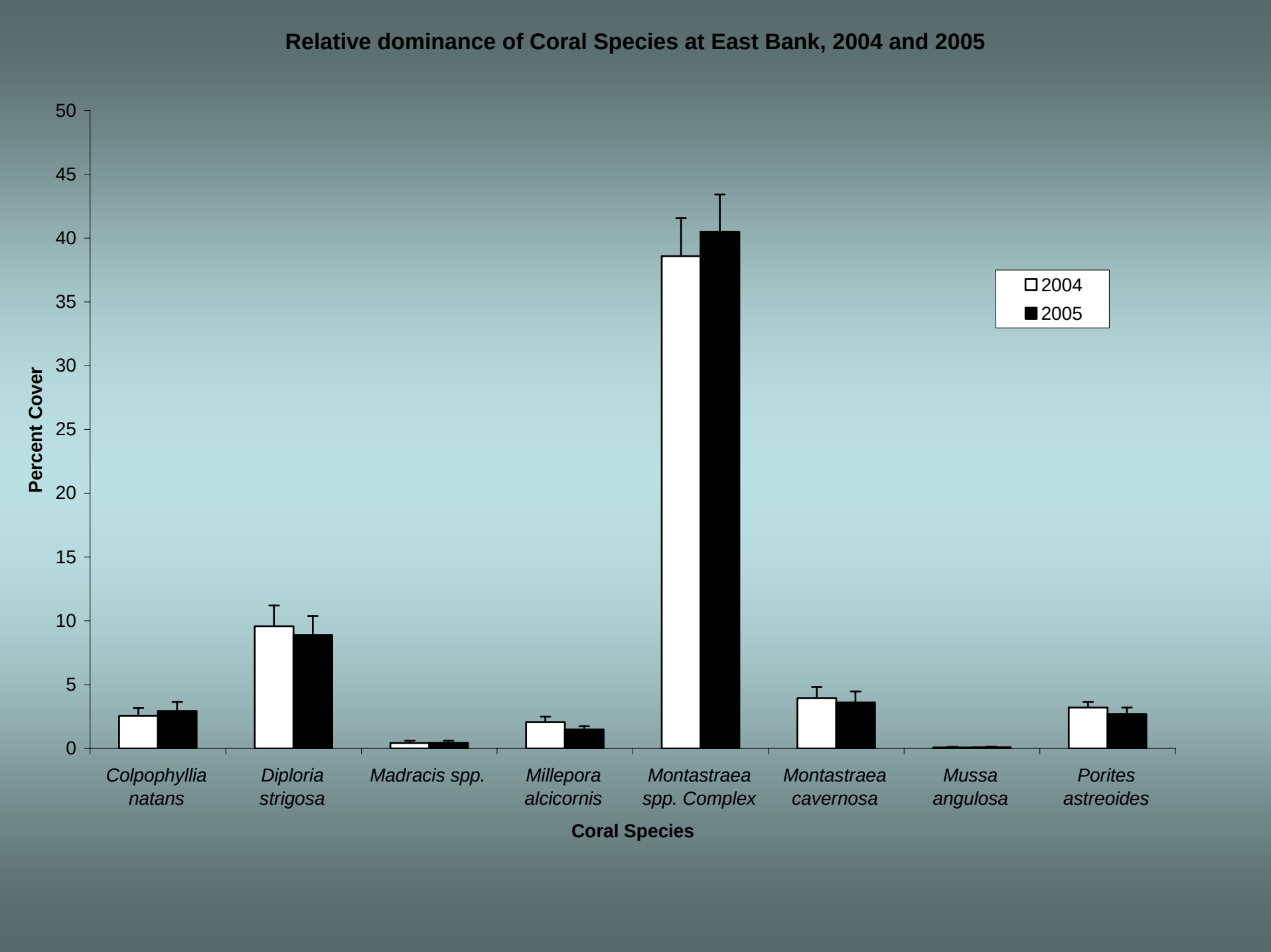

Percent Cover
60
50
40
0
0
10
0
1992
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
Montastraea annularis species complex
CTB
Macroalgae
Montastraea annularis complex
Algae
Reef Rock

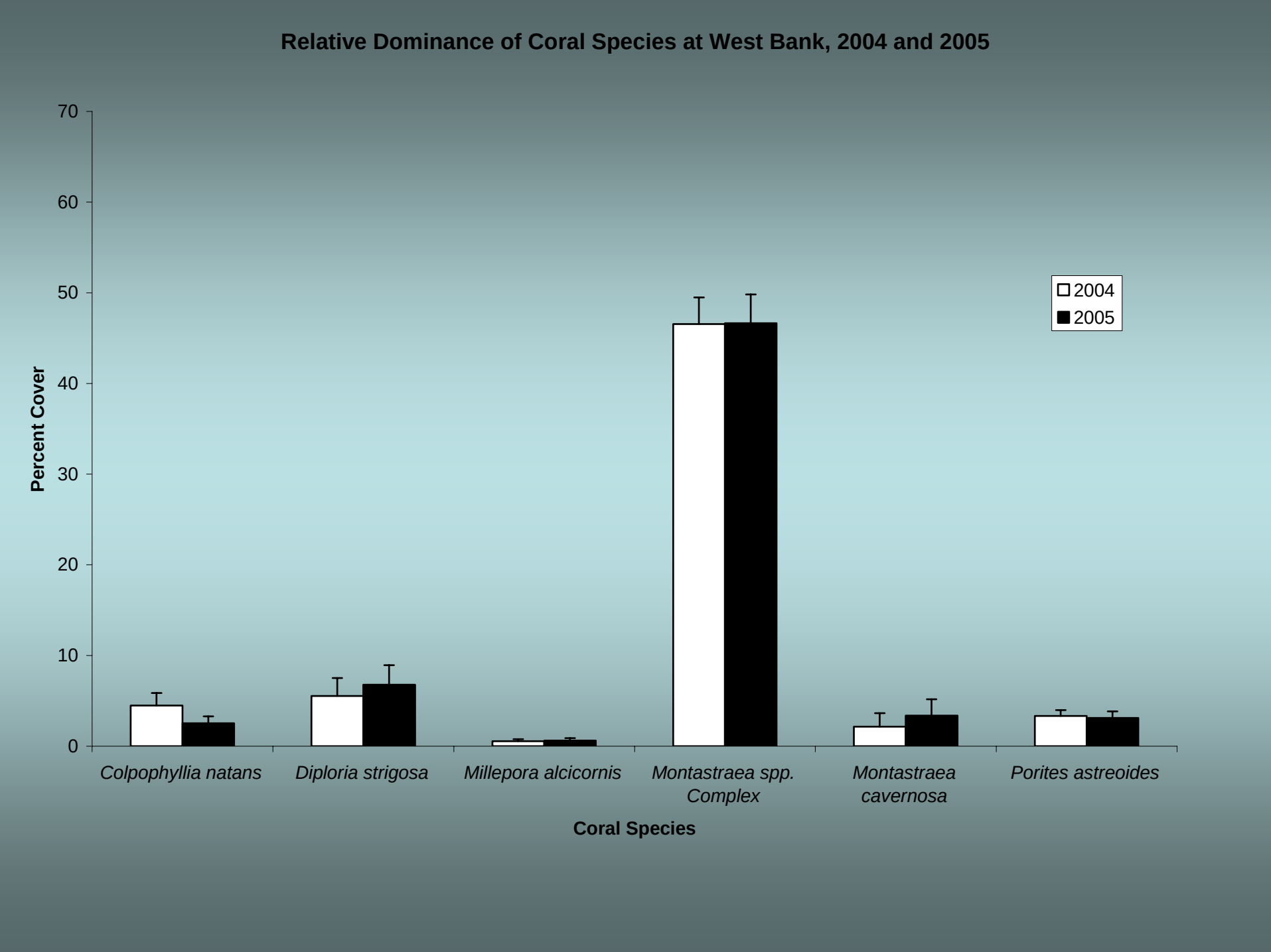
West Bank


Percent Cover
60
50
40
30
20
10
0
1992
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year
Montastraea annularis species complex
CTB
Macroalgae
Montastraea annularis complex
Algae
Reef Rock


East Bank Repetitive Quadrat Functional Groups 2004 and 2005
Percent Cover
70
60
50
40
30
20
10
0
East Bank 2004
East Bank 2005
Total Coral
Sponge
Macroalgae
CTB
Functional Group


West Bank Repetitive Quadrat Functional Groups 2004 and 2005
80
70
60
50
40
30
20
10
0
Percent Cover
West Bank 2004
West Bank 2005
Total Coral
Sponge
Macroalgae
CTB
Functional Group


Relative dominance of Coral Species at East Bank, 2004 and 2005
Percent Cover
50
45
40
35
30
25
20
15
10
5
0
2004
2005
Colpophyllia natans
Diploria strigosa
Madracis spp.
Millepora alcicornis
Montastraea spp. Complex
Montastraea cavernosa
Mussa angulosa
Porites astreoides
Coral Species

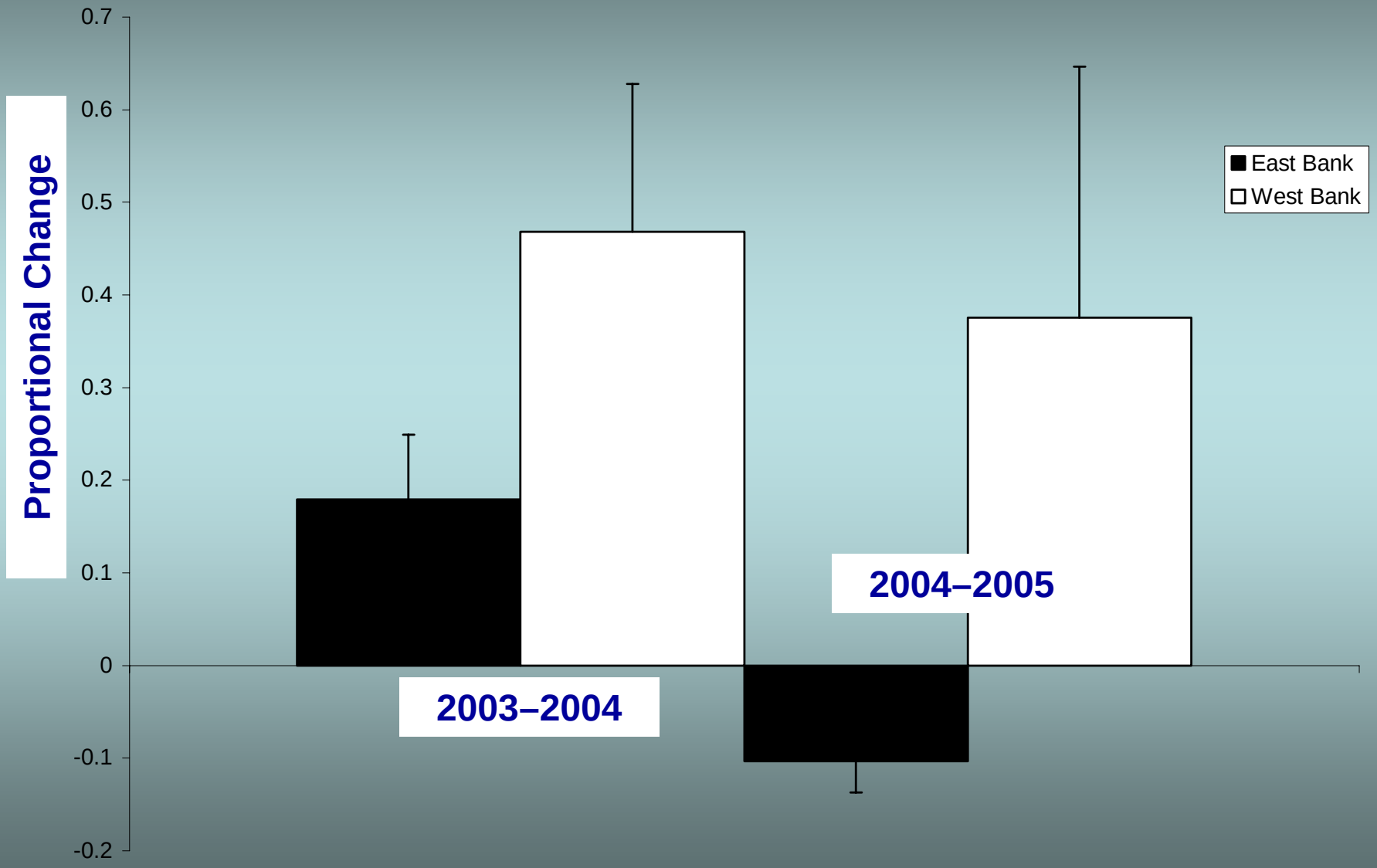

Relative Dominance of Coral Species at West Bank, 2004 and 2005
Percent Cover
70
60
50
40
30
20
10
0
2004
2005
Colpophyllia natans
Diploria strigosa
Millepora alcicornis
Montastraea spp. Complex
Montastraea cavernosa
Porites astreoides
Coral Species

Lateral Growth Stations: *Diploria strigosa*

Lateral Growth and Retraction of *Diploria*

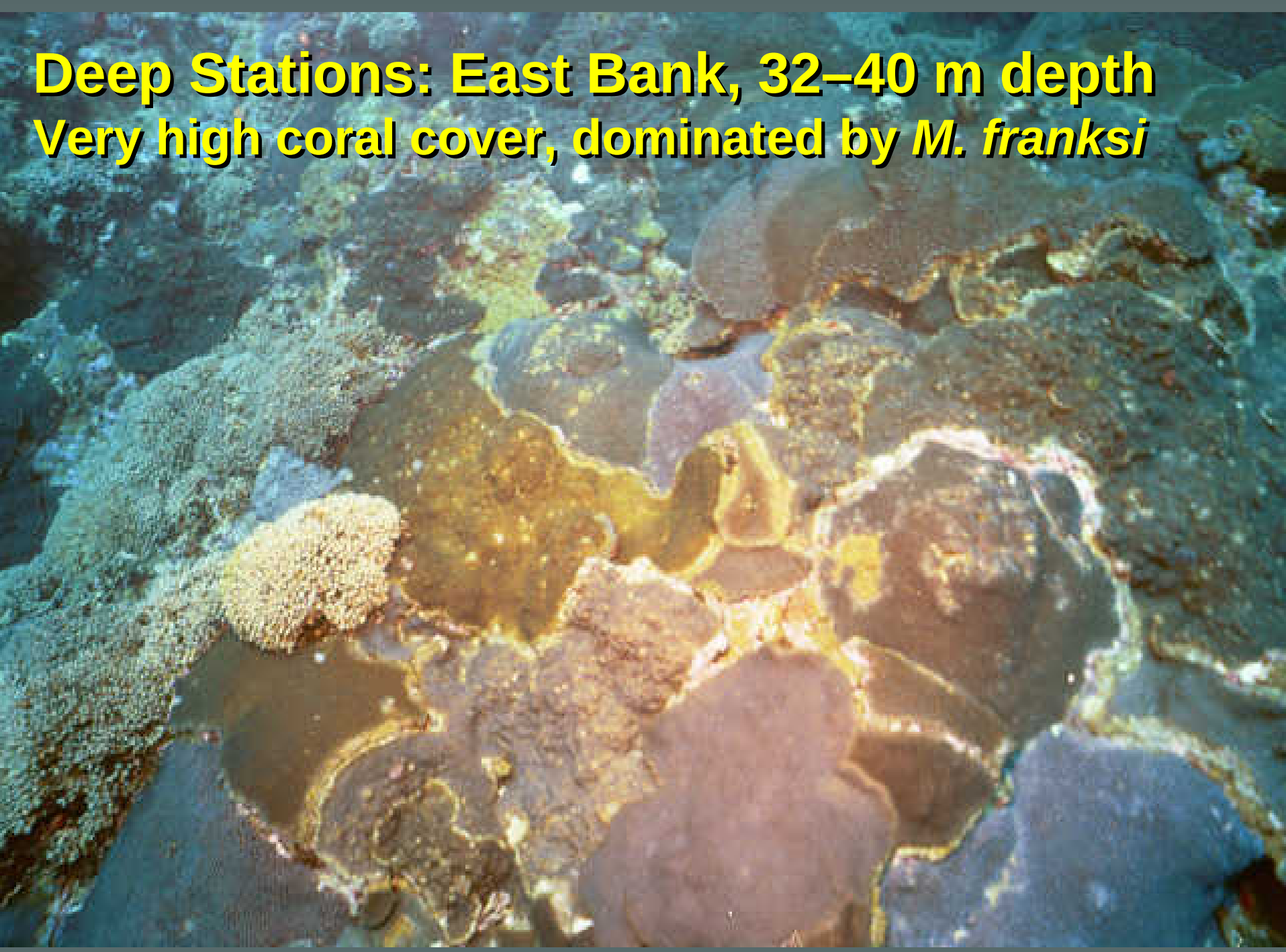
- Normal colony growth
- Interspecific competition
- Intraspecific competition
- Coral disease (insignificant in 2004–05)
- Coral bleaching (insignificant in 2004–05)
- Predation by parrotfish and damselfish??

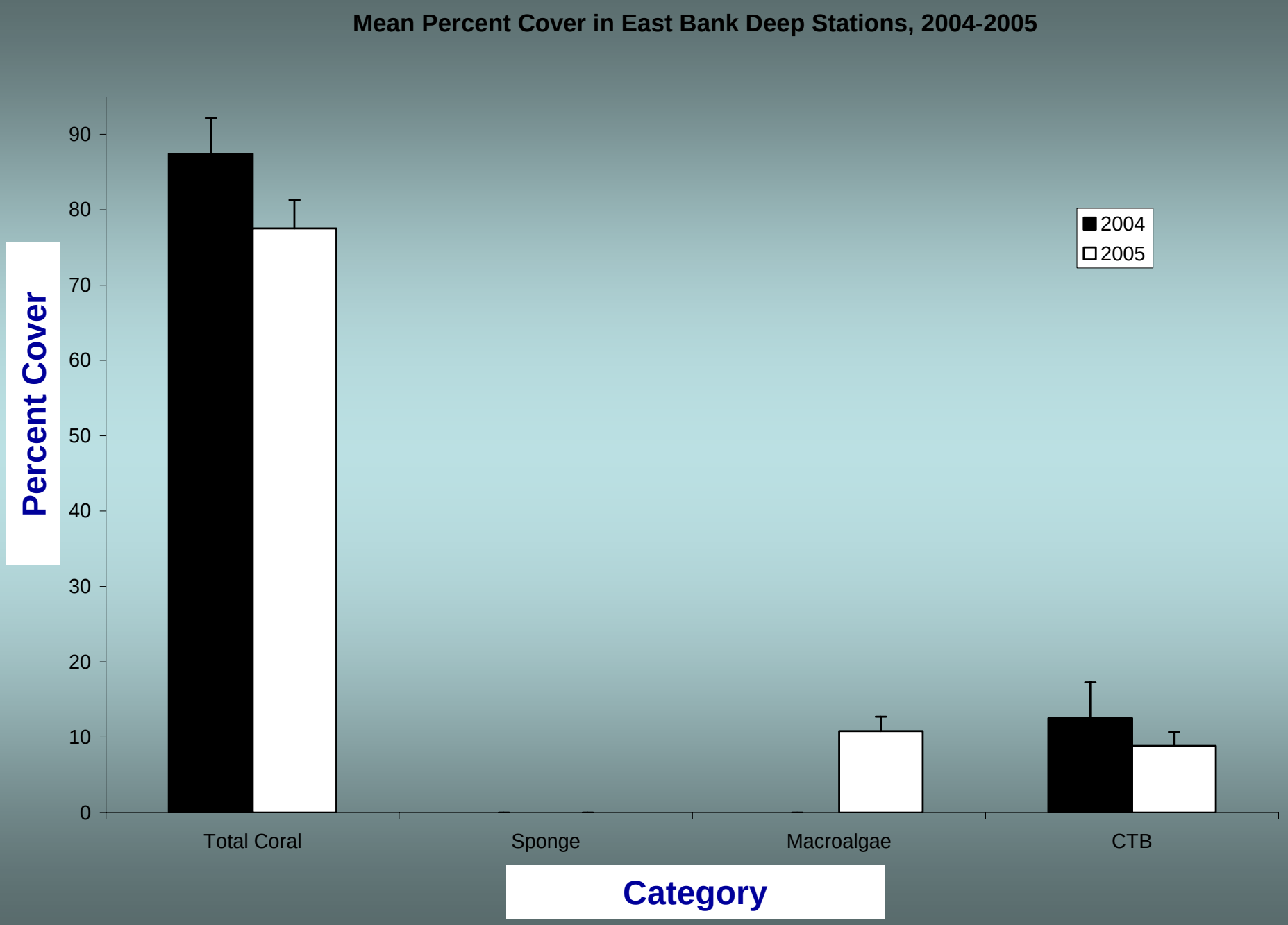
Mean proportional change in *Diploria strigosa* colonies at the East and West Banks 2003-2004 and 2004-2005.

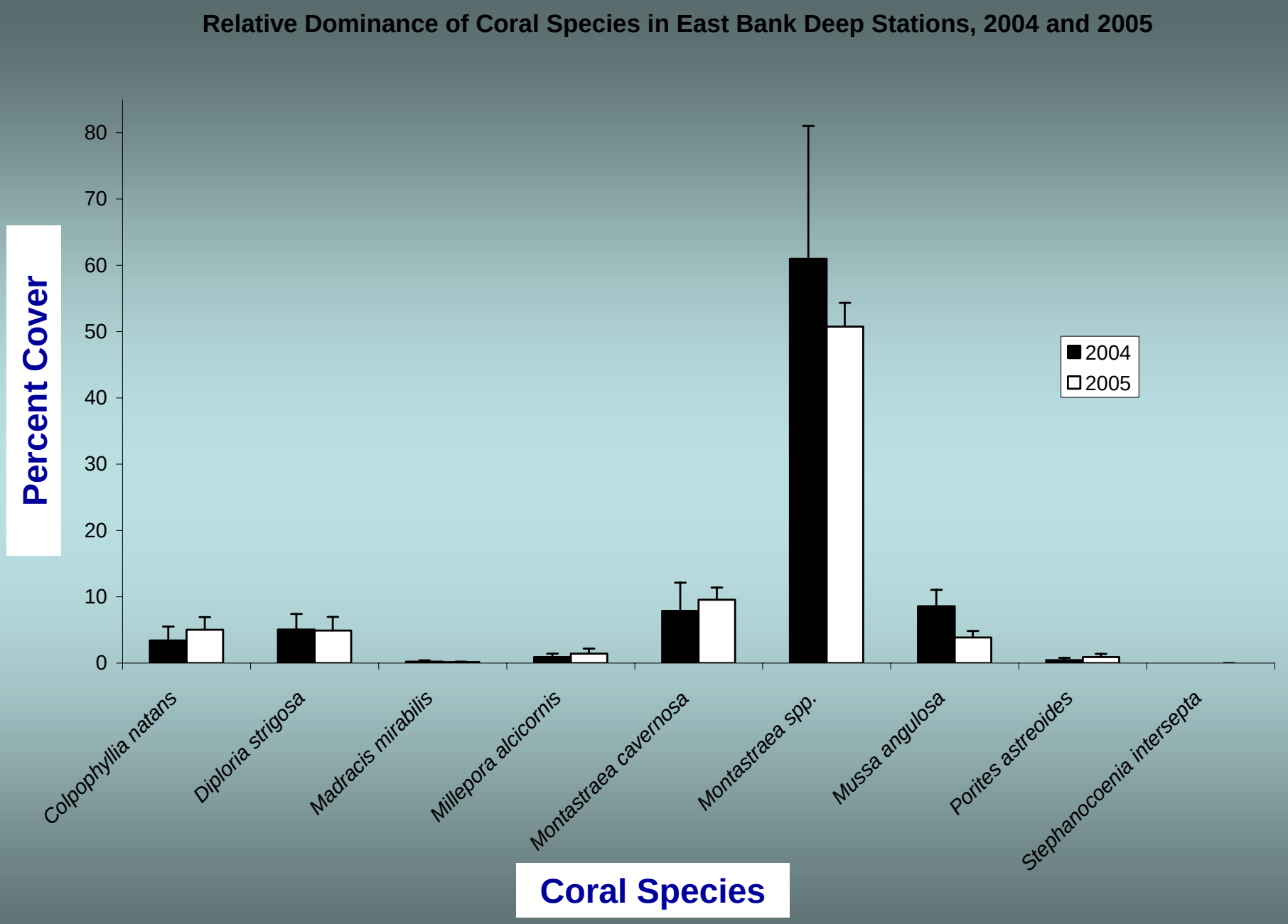


Deep Stations: East Bank, 32–40 m depth

Very high coral cover, dominated by *M. franksi*

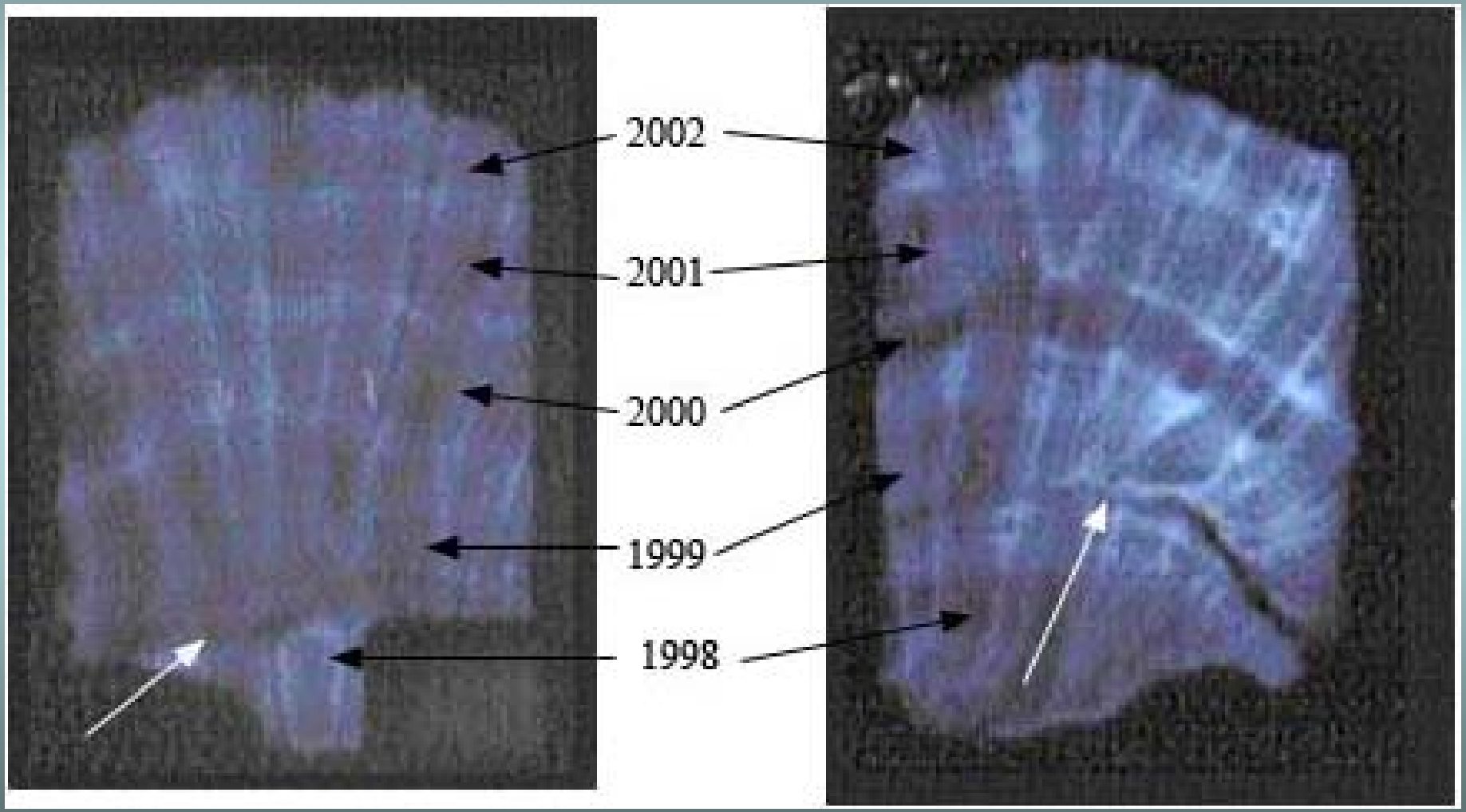



Mean Percent Cover in East Bank Deep Stations, 2004-2005
Percent Cover
90
80
70
60
50
40
30
20
10
0
2004
2005
Total Coral
Sponge
Macroalgae
CTB
Category


Relative Dominance of Coral Species in East Bank Deep Stations, 2004 and 2005
Percent Cover
80
70
60
50
40
30
20
10
0
2004
2005
Colpophyllia natans
Diploria strigosa
Madracis mirabilis
Millepora alcicornis
Montastraea cavernosa
Montastraea spp.
Mussa angulosa
Porites astreoides
Stephanocoenia intersepta
Coral Species

Sclerochronology of *Montastraea faveolata*:

Possible growth hiatuses after 1997–98 bleaching event



Flower Garden Banks

- Luxuriant coral growth
- Situated on shelf edge
  - Bathed by warm, oceanic currents
  - Coastal influences relatively weak
- Regional issues: No *Acropora* so none to die off and provide bare space for algal colonization

Montastraea franski, Flower Garden Banks. April 2003, 115 feet depth

Emerging Sources of Coral Mortality

- Coral Disease (February 2005)
- Bleaching (Fall 2005)
- Hurricane Damage (Rita, Fall 2005)

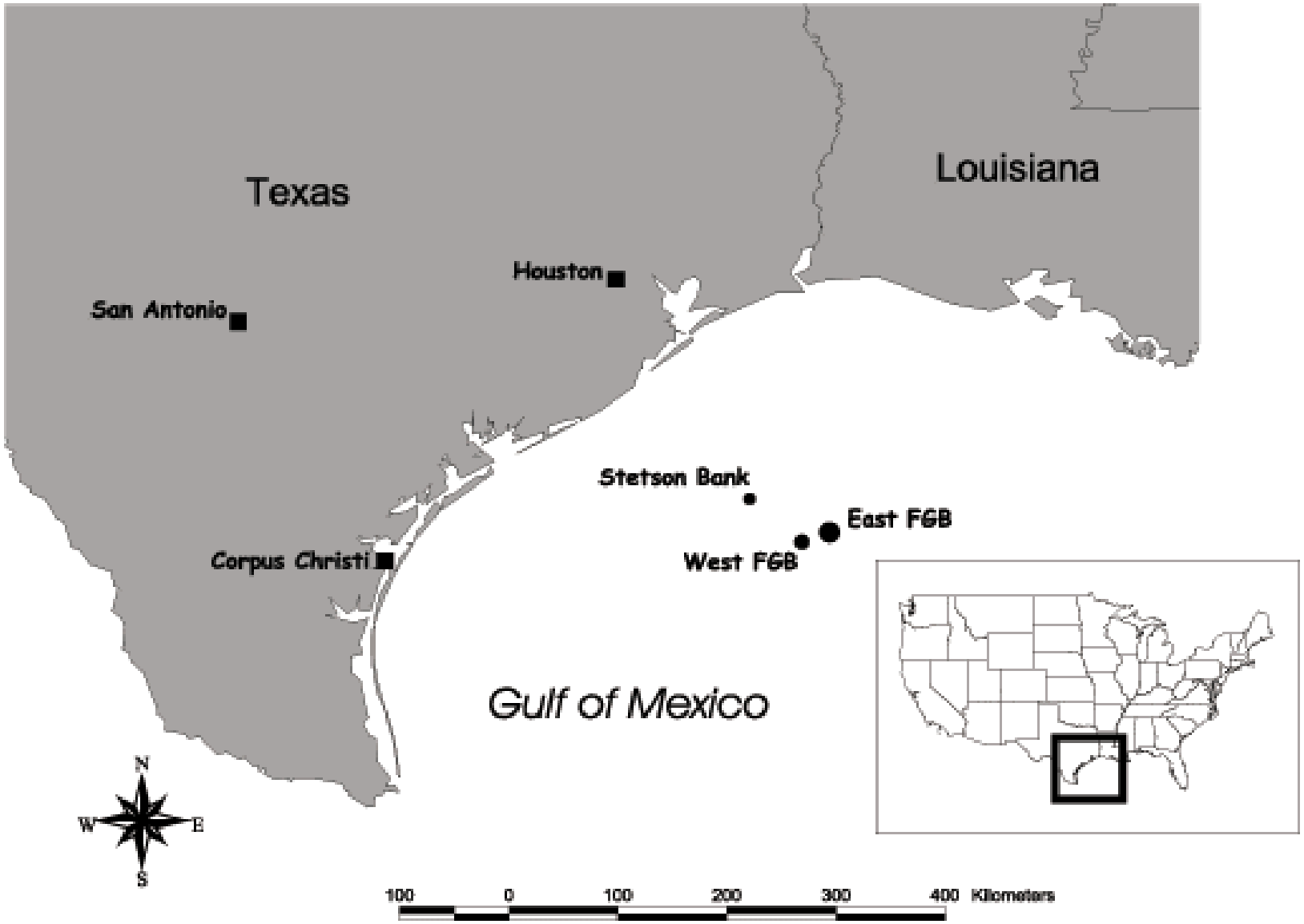
Montastraea franski, Flower Garden Banks. April 2003, 115 feet depth

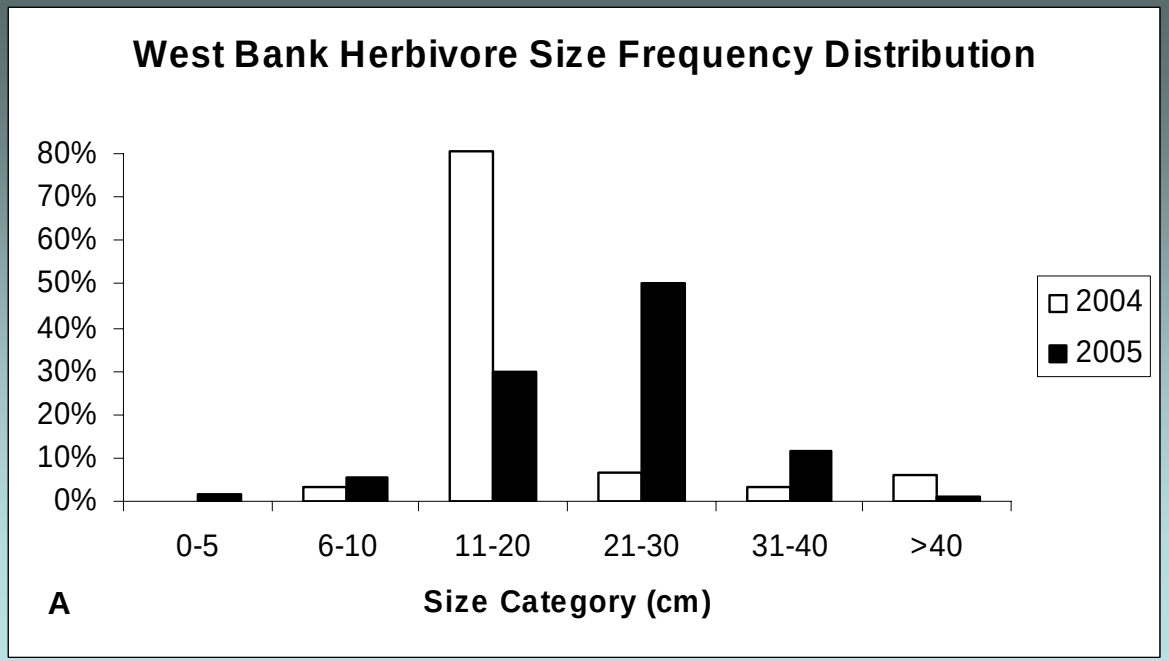
New Species Appearing at FGB

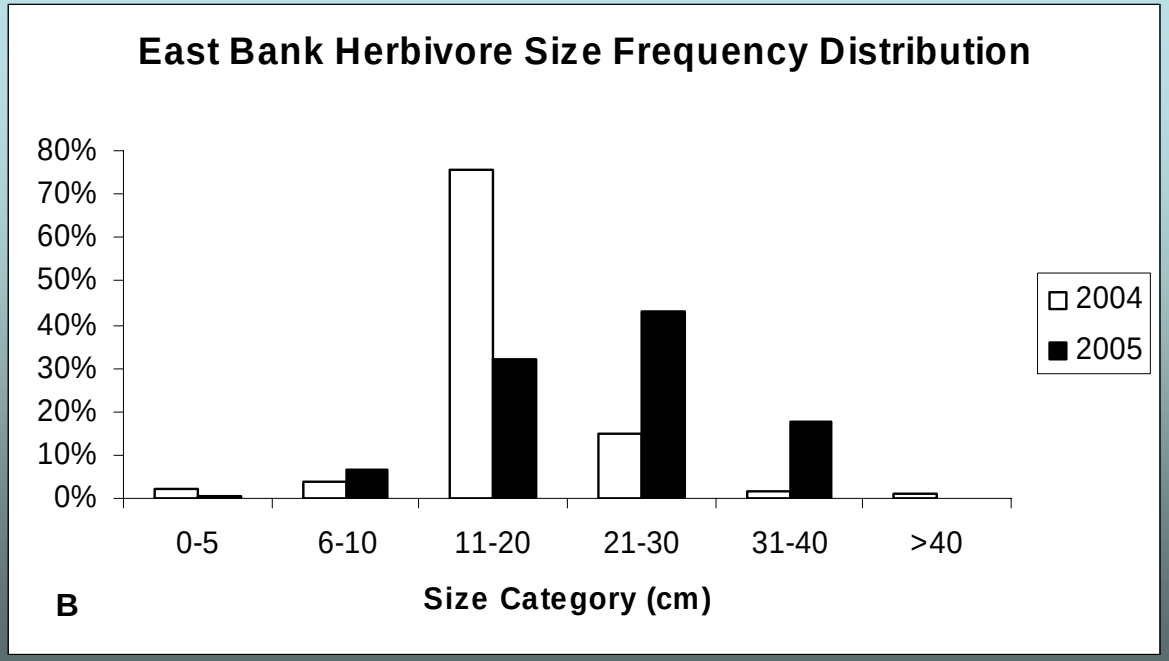
- *Tubastraea coccinea* (exotic, ahermatypic)
- *Acropora palmata* (elkhorn coral)
- *Dichocoenia stokesi* (East Bank, 2005–06; Emma Hickerson)
- *Epinephelus striatus* (Nassau grouper, 2006; Emma Hickerson)

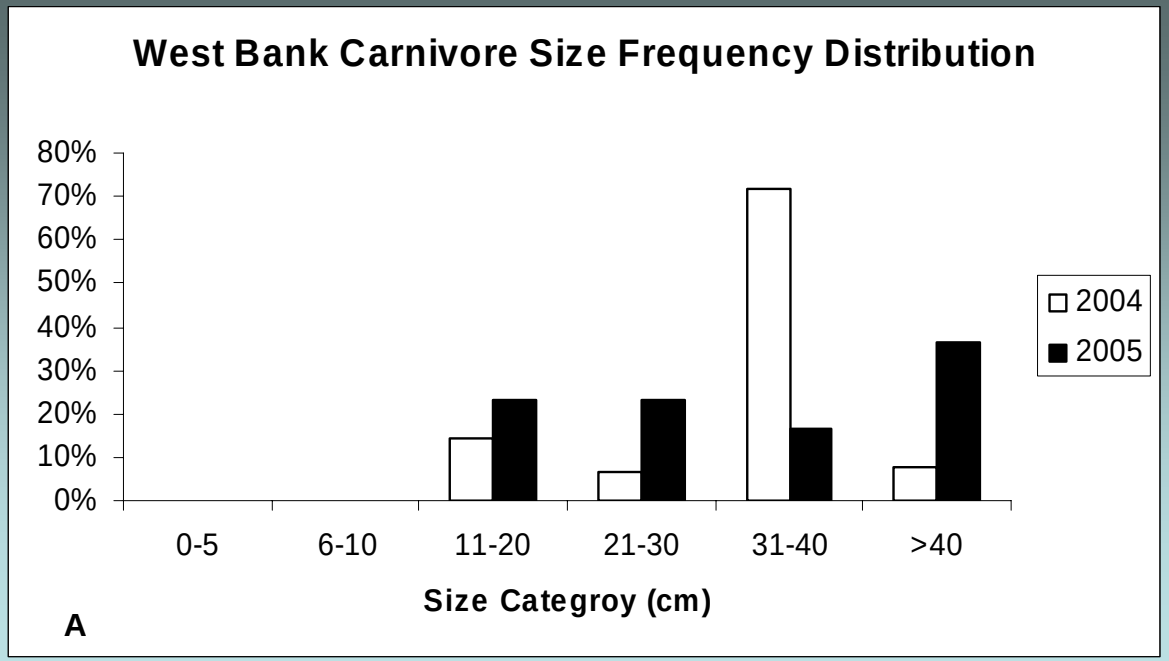
Montastraea franski, Flower Garden Banks. April 2003, 115 feet depth

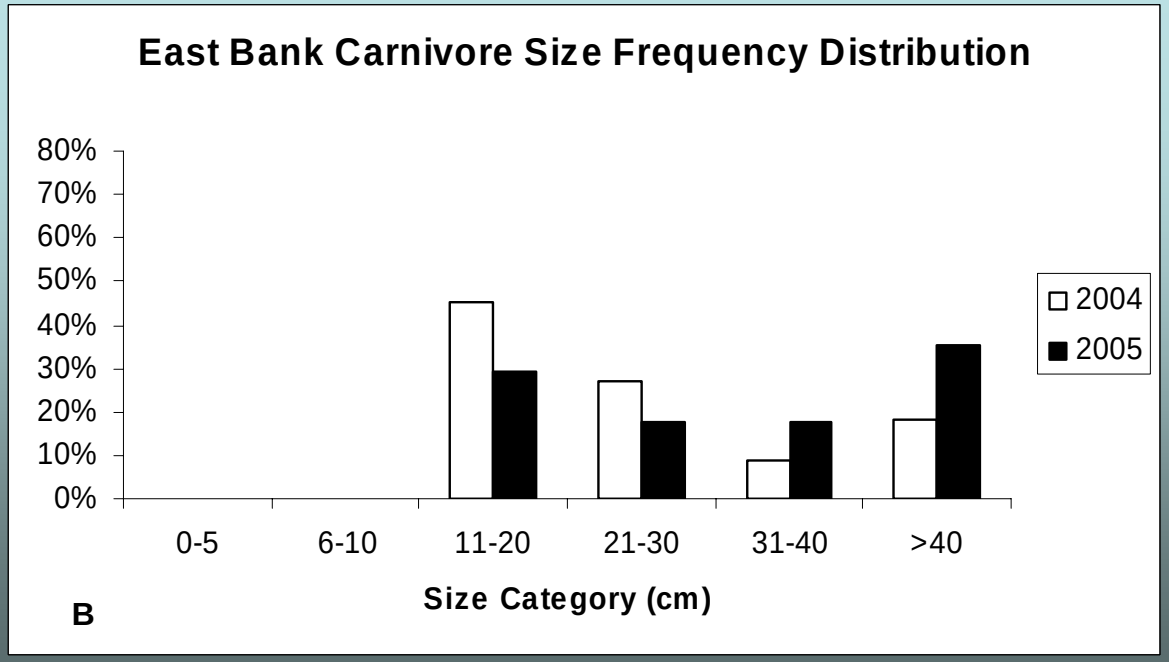
Flower Garden Banks National Marine Sanctuary

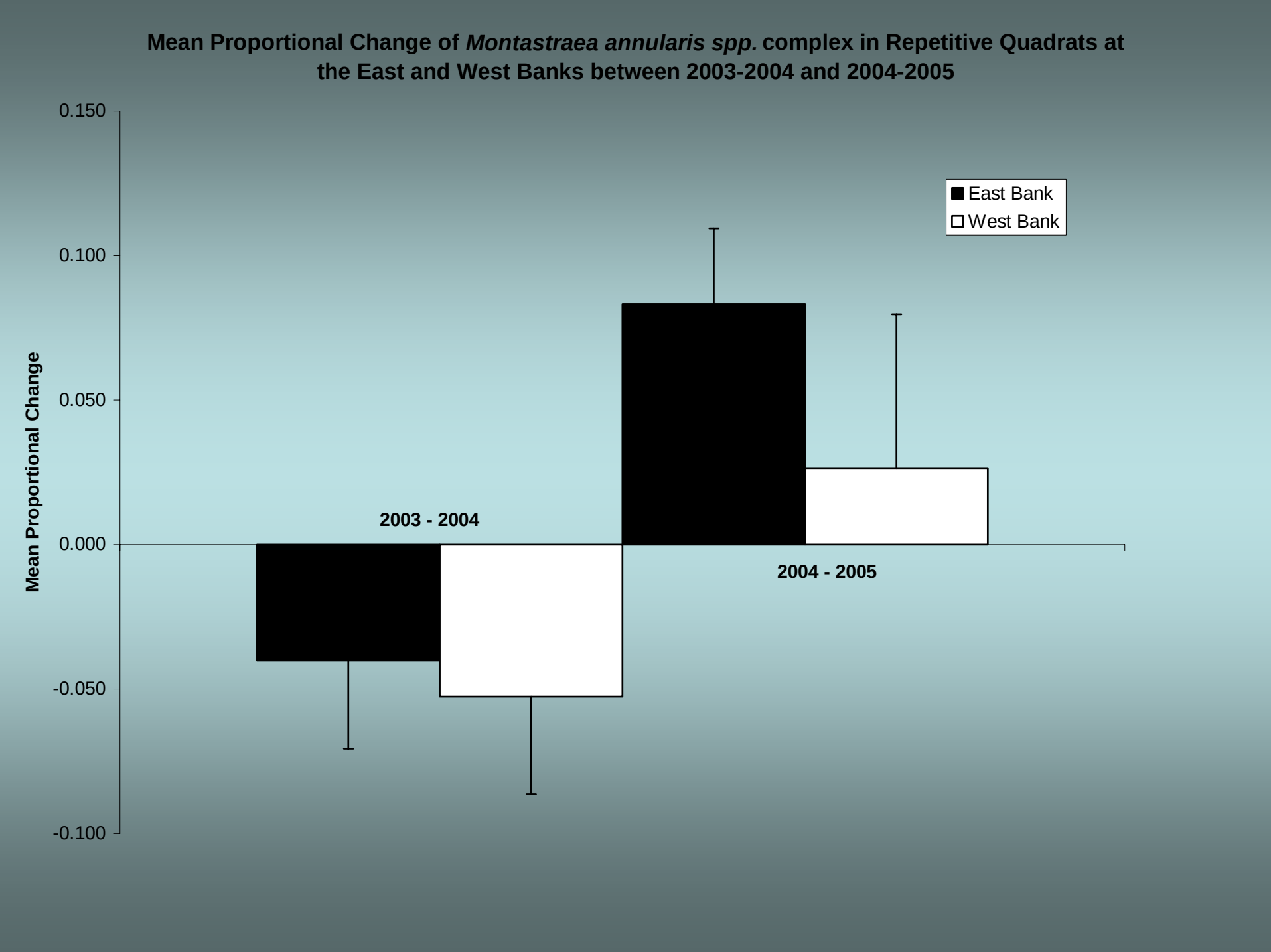


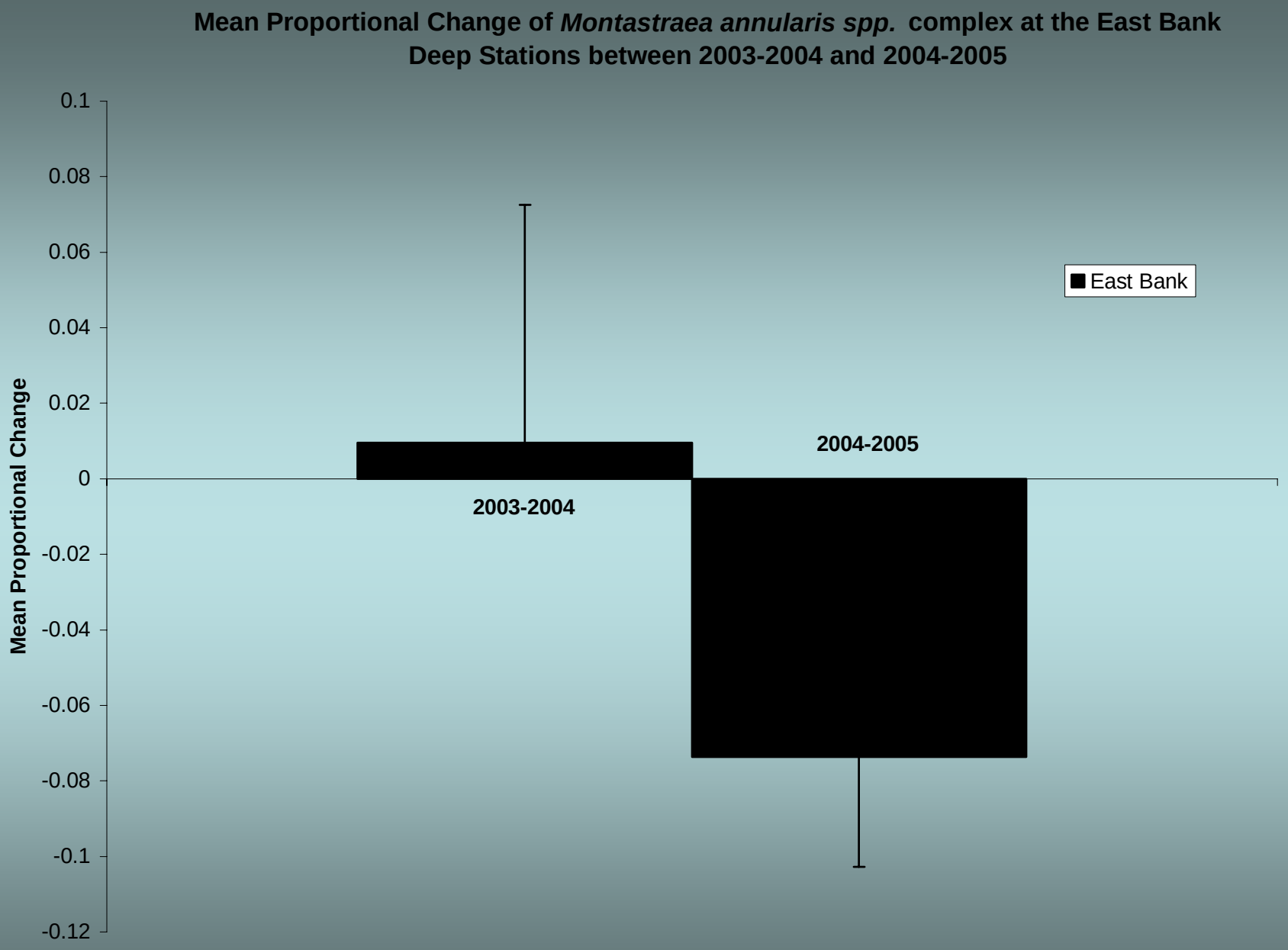

West Bank Herbivore Size Frequency Distribution
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-5
6-10
11-20
21-30
31-40
>40
2004
2005
A
Size Category (cm)


East Bank Herbivore Size Frequency Distribution
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-5
6-10
11-20
21-30
31-40
>40
2004
2005
B
Size Category (cm)

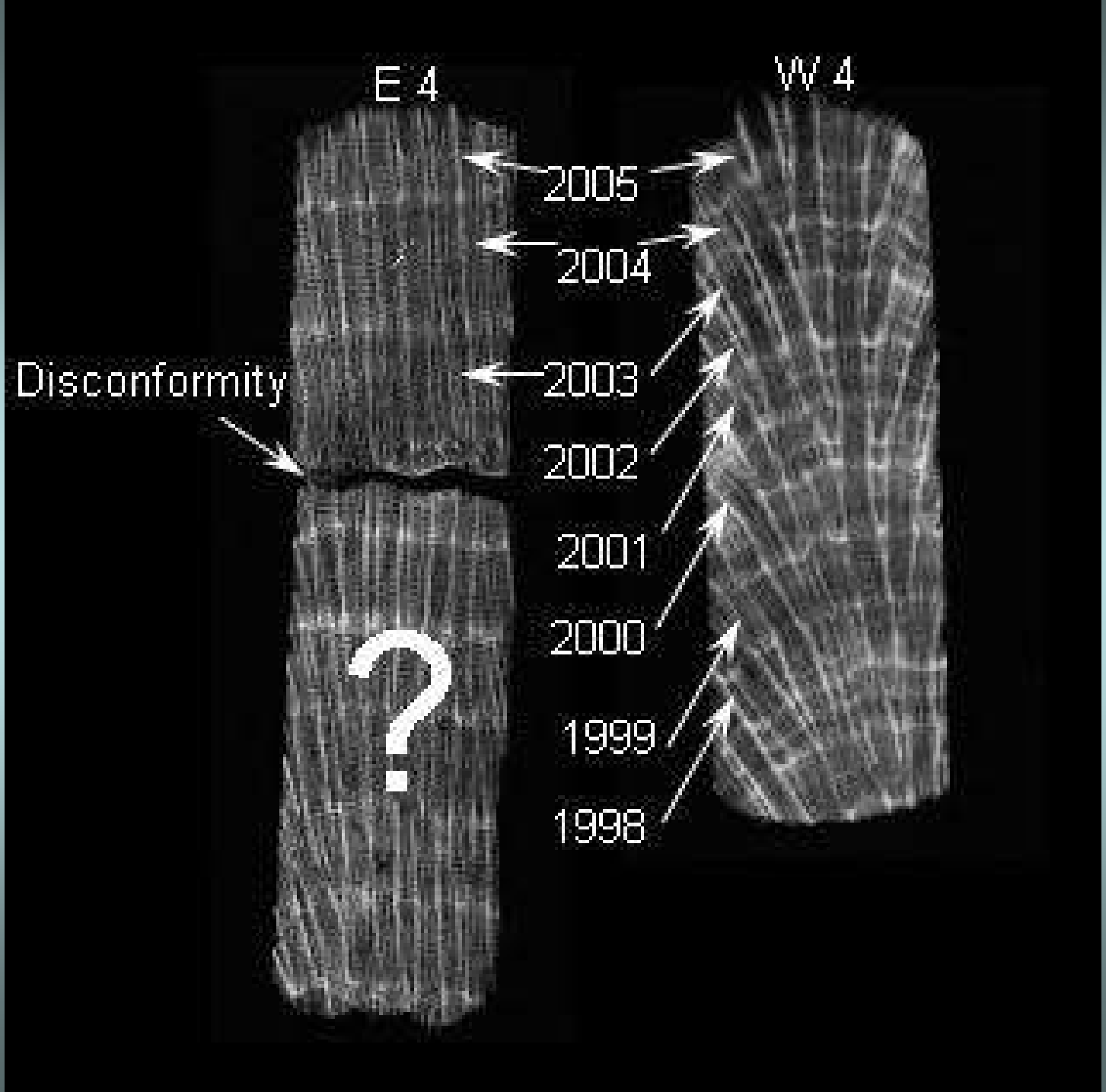

West Bank Carnivore Size Frequency Distribution
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-5
6-10
11-20
21-30
31-40
>40
Size Categroy (cm)
2004
2005
A


East Bank Carnivore Size Frequency Distribution
80%
70%
60%
50%
40%
30%
20%
10%
0%
0-5
6-10
11-20
21-30
31-40
>40
Size Category (cm)
2004
2005
B

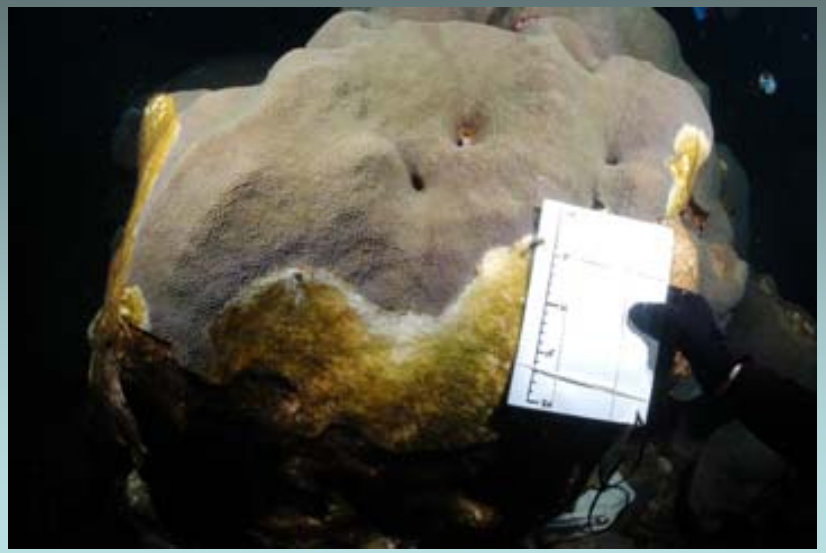

Mean Proportional Change of *Montastraea annularis spp.* complex in Repetitive Quadrats at the East and West Banks between 2003-2004 and 2004-2005
Mean Proportional Change
0.150
0.100
0.050
0.000
-0.050
-0.100
East Bank
West Bank
2003 - 2004
2004 - 2005


Mean Proportional Change of *Montastraea annularis spp.* complex at the East Bank Deep Stations between 2003-2004 and 2004-2005
Mean Proportional Change
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
East Bank
2003-2004
2004-2005

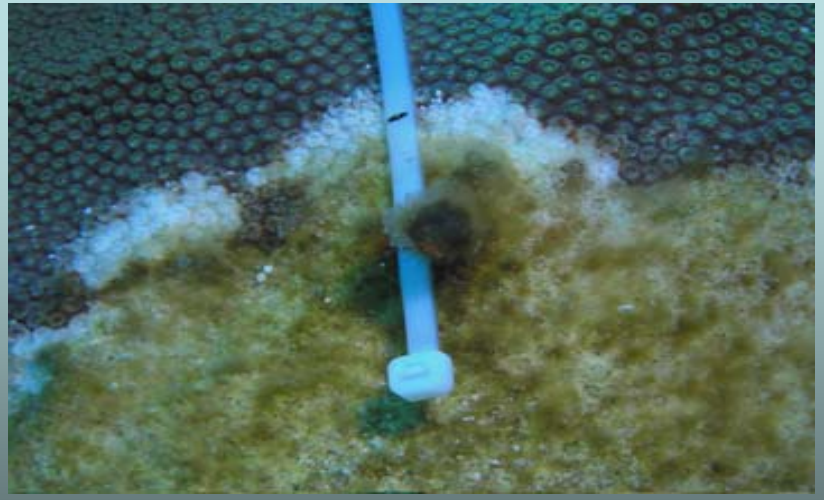
***Madracis mirabilis*, Flower Garden Banks. April 2003, 115 feet depth**


E 4
VV 4
2005
2004
2003
2002
2001
2000
1999
1998
Disconformity
?

Disease



A



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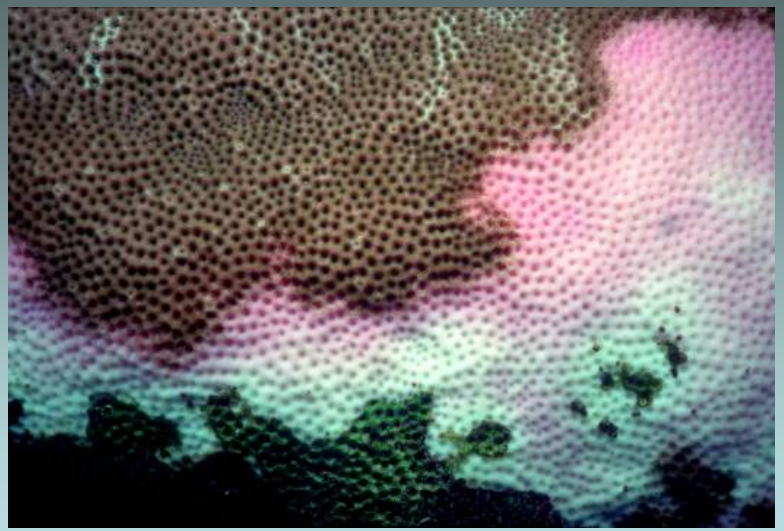
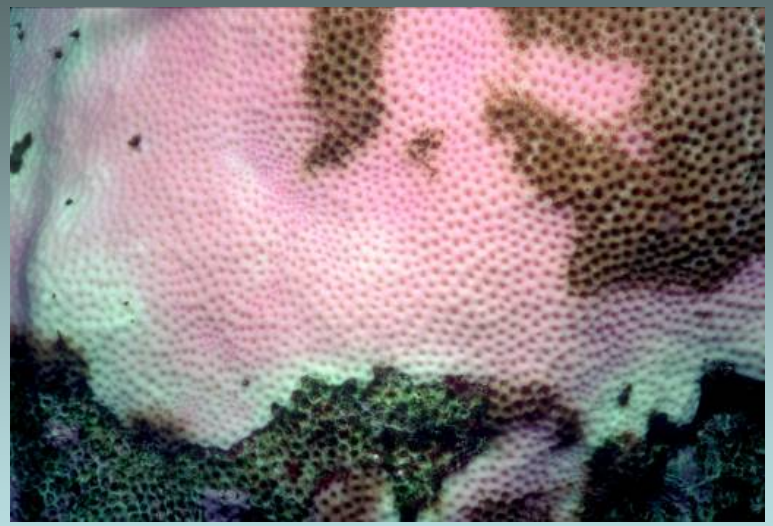


A



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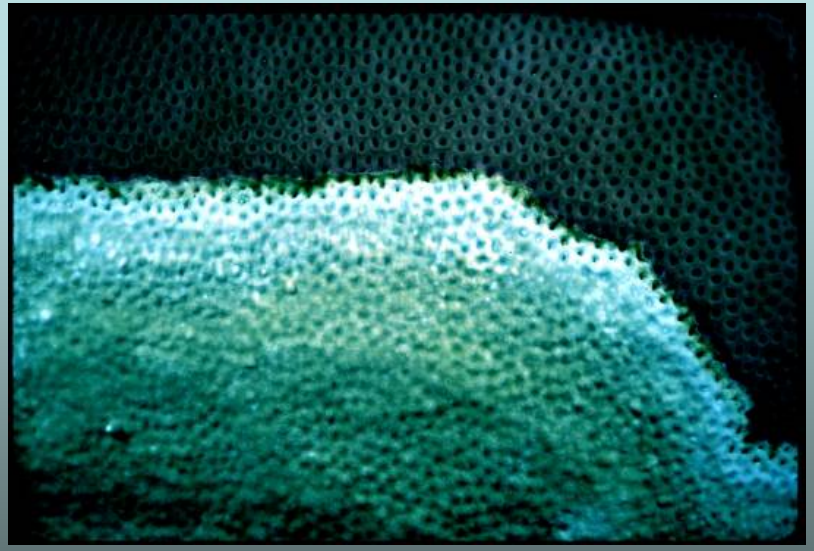

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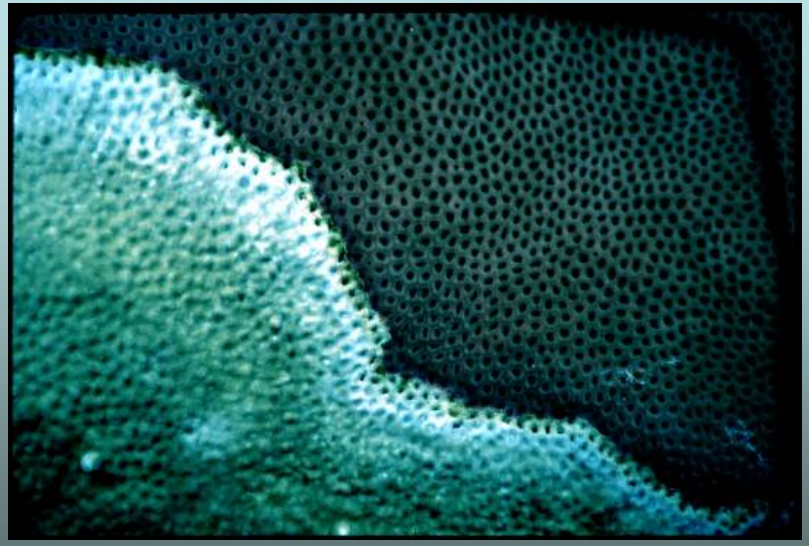

D

Acknowledgments

- MMS
- NOAA–FGBNMS

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Reference

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