Post-Hurricane Assessment of Sensitive Habitats of the Flower Garden Banks Vicinity

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NOAA

MMS

PBS&J
Ecological Sciences

Outline

- **Sensitive marine habitats in the vicinity of the Flower Garden Banks National Marine Sanctuary (FGBNMS)**
- **Hurricane Rita (September 2005)**
- **Post-hurricane assessment rationale and methodology**
- **Results and conclusions**

FGBNMS

- **Designated as a National Marine Sanctuary in 1992**
- **Located in the Gulf of Mexico (GoM), 110 miles south of the Texas/Louisiana border**
- **Consists of EFGB, WFGB, and Stetson Bank**
- **PBS&J currently holds annual monitoring contract, supported by the MMS and NOAA**

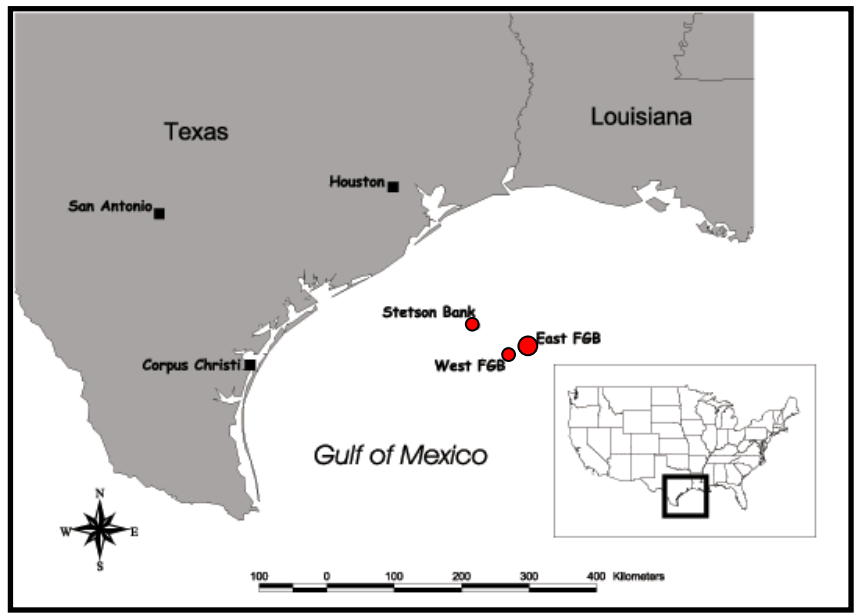


Image credit: Texas Parks and Wildlife Website

Sensitive Habitats in FGB Vicinity

- **In addition to the FGB, several sensitive marine habitats occur in the northwestern GoM**

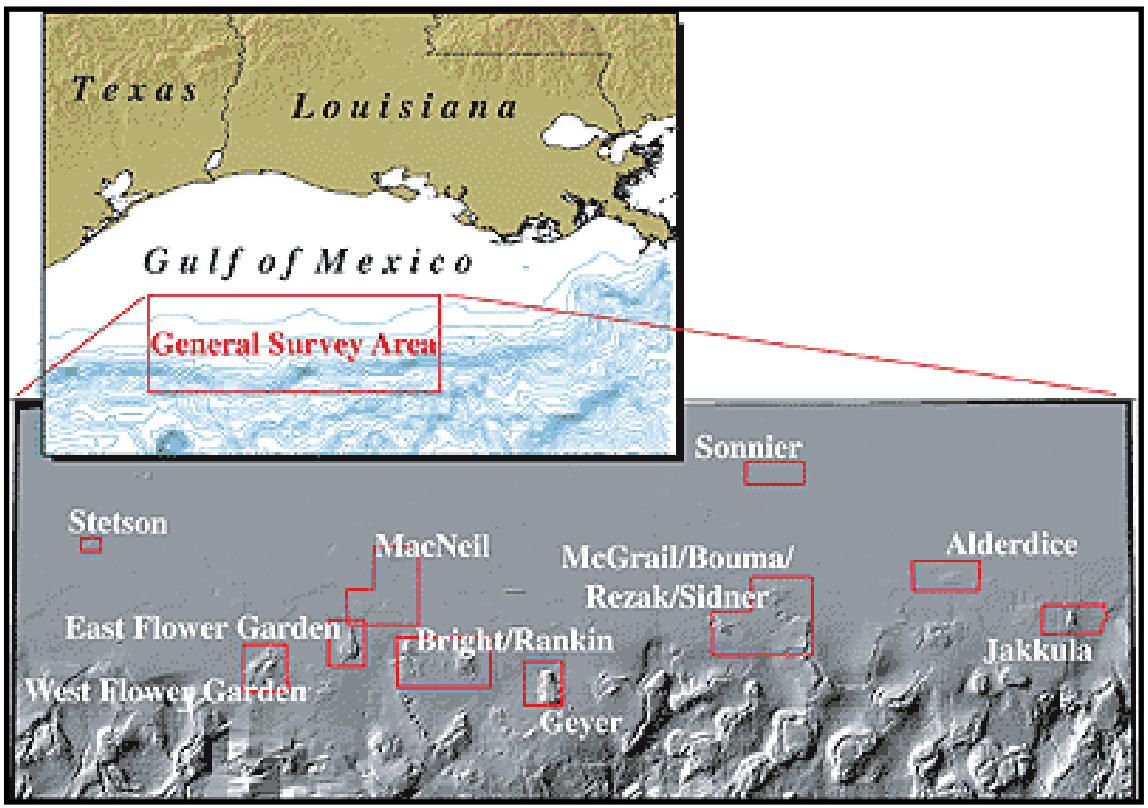
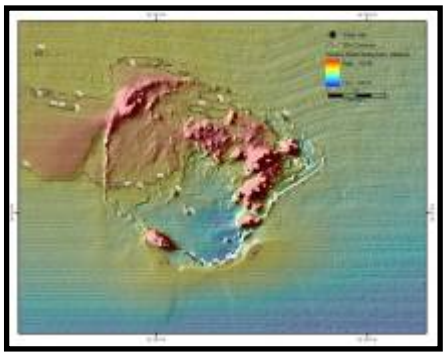


Image credit: U.S. Geological Survey

Including:

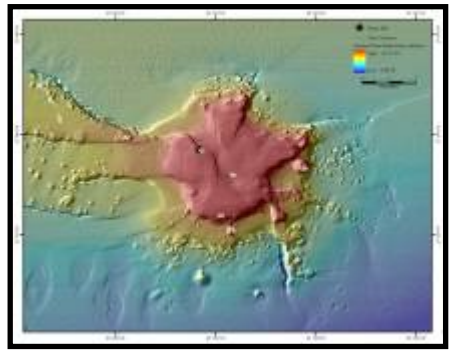
- **Sonnier Bank**
- **McGrail Bank**
- **Geyer Bank**
- **Bright Bank**

Study Sites



Sonnier Bank

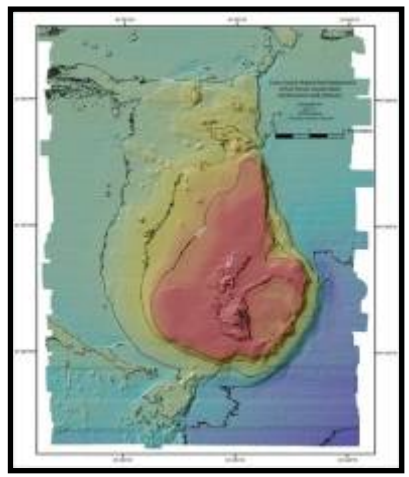
McGrail Bank



Bright Bank

Geyer Bank

- **All banks formed by salt diapir structures uplifting the seafloor into the photic zone**
- **Have not been studied in detail, with the exception of the FGB**



East Bank

Images courtesy of FGBNMS/D.C. Weaver

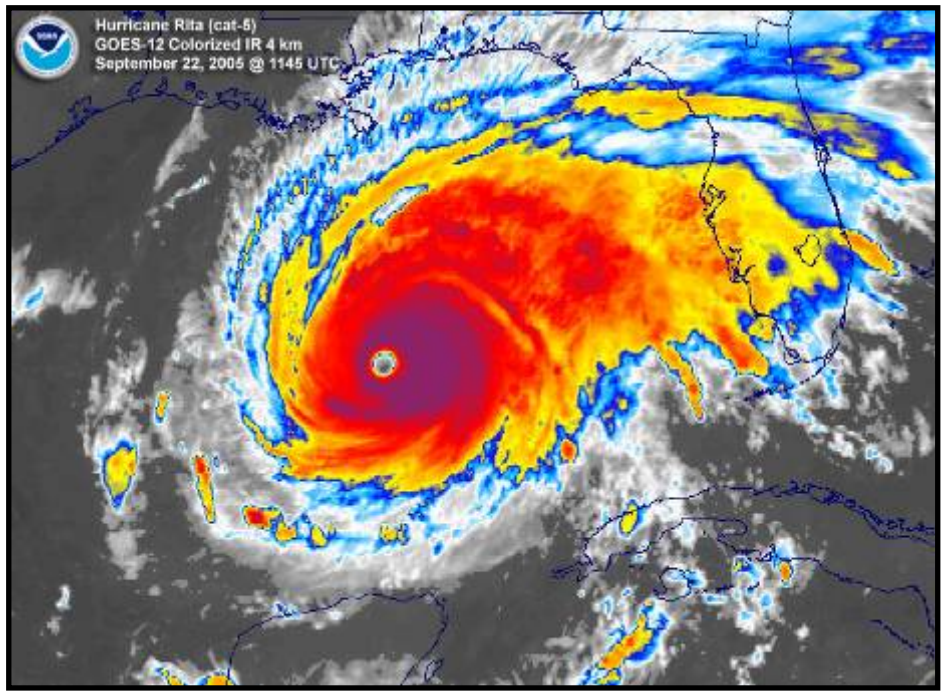
Biological Zones by Depth

	Coral Reef Zone			Coral Community Zone	Coralline Algae Zone
Bank	*Montastraea* habitat	*Madracis*	*Stephanocoenia*	*Millepora*/Sponge	Algal/Sponge
Sonnier	–	–	–	18-52	52-74
McGrail	–	–	45-47	–	45-82
Geyer	–	–	–	37-52	60-98
Bright	–	–	37	–	52-74
EFGB	15-36	28-44	36-52	–	45-90

adapted from Rezak et al. 1985 and Hickerson et al. 2008

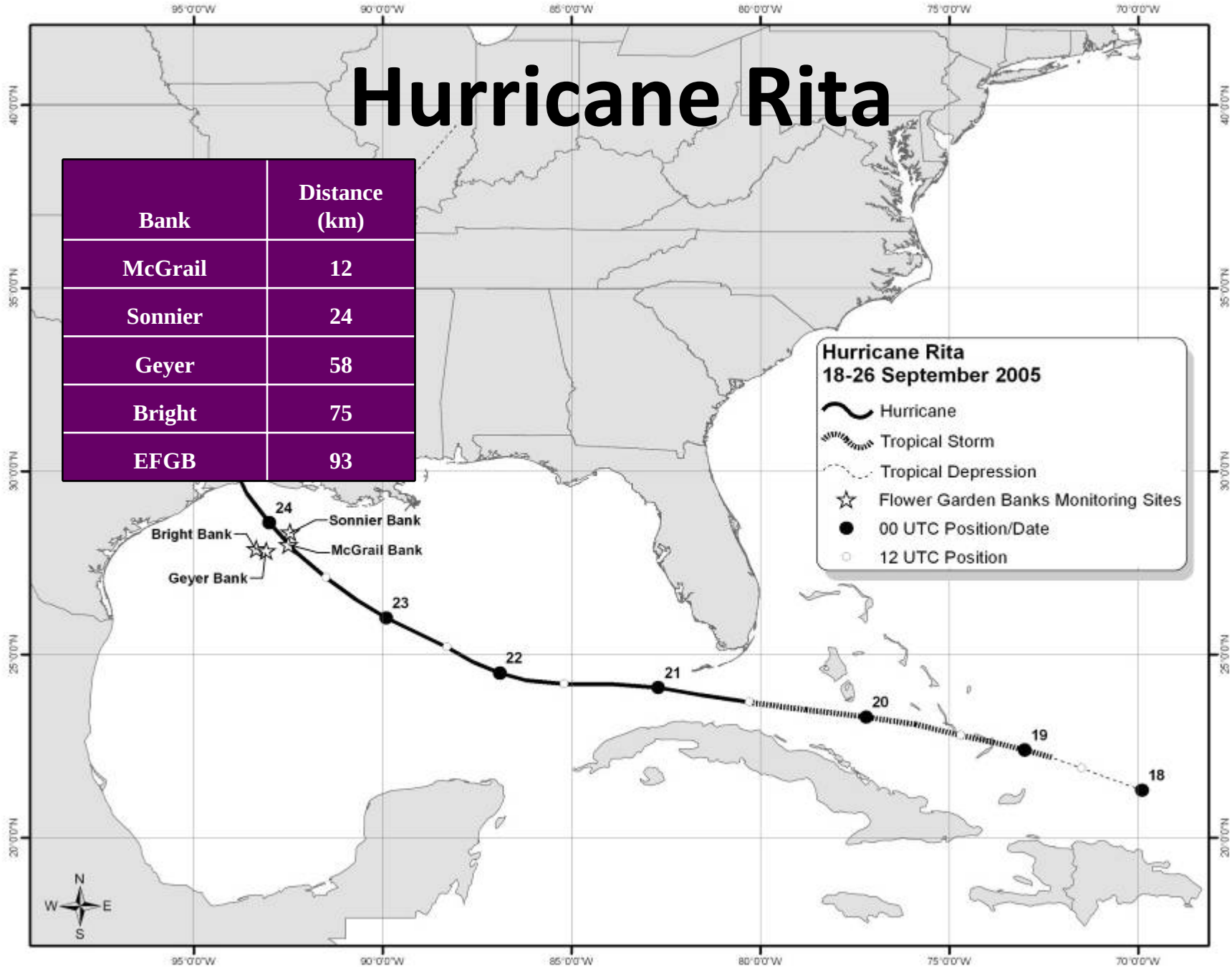
2005 Hurricane Season

- **Record high sea-surface temperatures in Atlantic and GoM**
- **2005 hurricane season most active on record**
- **Eleven tropical cyclones entered GoM in 2005**
- **Hurricane Rita passed near sensitive habitats in GoM**
- **Hindcast models estimated wave heights ranging from 13- to 26-m at these locations**



Hurricane Rita

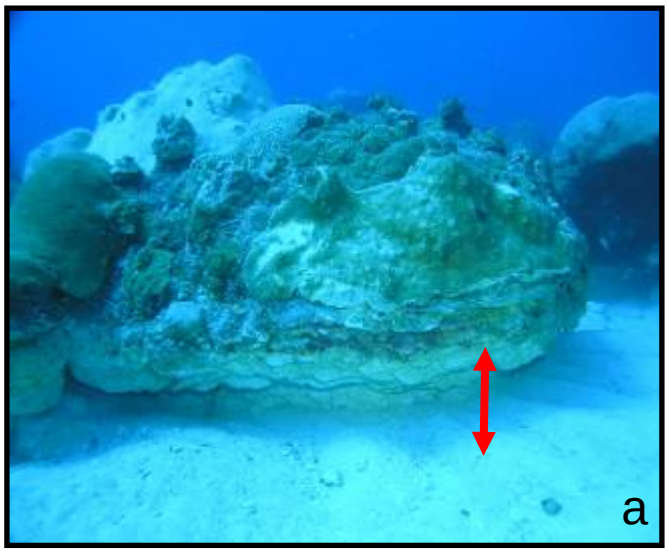
Bank	Distance (km)
McGrail	12
Sonnier	24
Geyer	58
Bright	75
EFGB	93

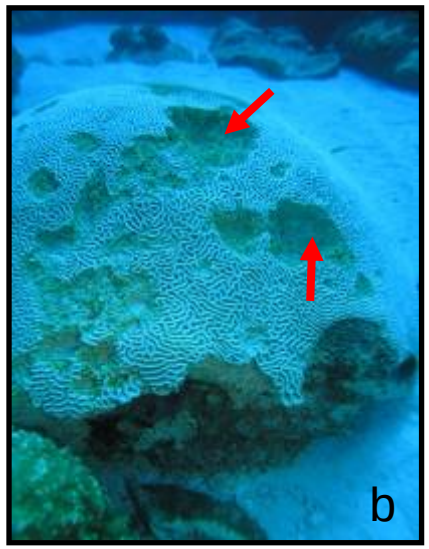


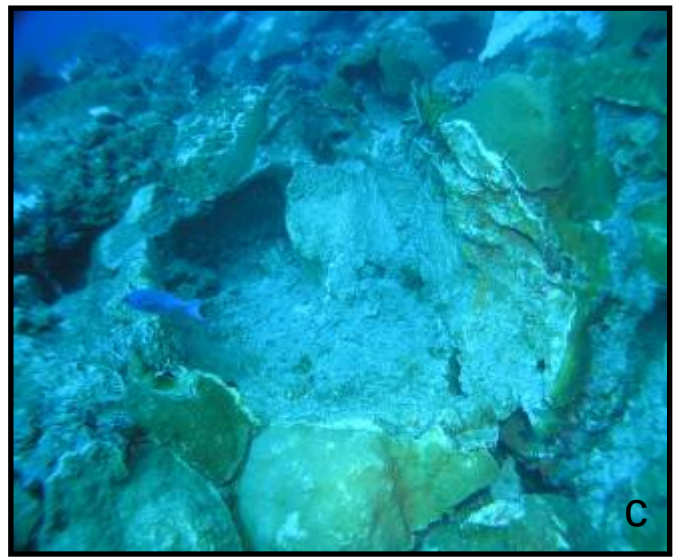
Source of hurricane track data: National Hurricane Center 2007

NOAA Preliminary Assessment

- **EFGB in October 2005**
- **Mechanical impacts observed:**
  - **a. Sediment scouring**
  - **b. Corals scarred by waterborne projectiles**
  - **c. Fractured and displaced corals**







Images courtesy of FGBNMS/E. Hickerson

May 2007 Study Objectives

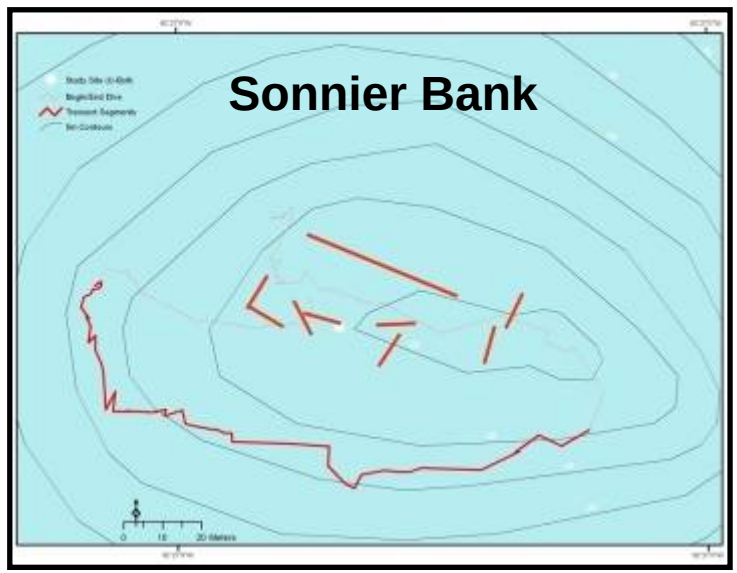
1) Establish baseline characterization of benthic communities at Sonnier, McGrail, Geyer, and Bright Banks
2) Assess possible hurricane damage at multiple depth ranges at these banks
3) Document possible recovery from Hurricane Rita

Methods – Sonnier, McGrail, Geyer, Bright Banks

Video Transects

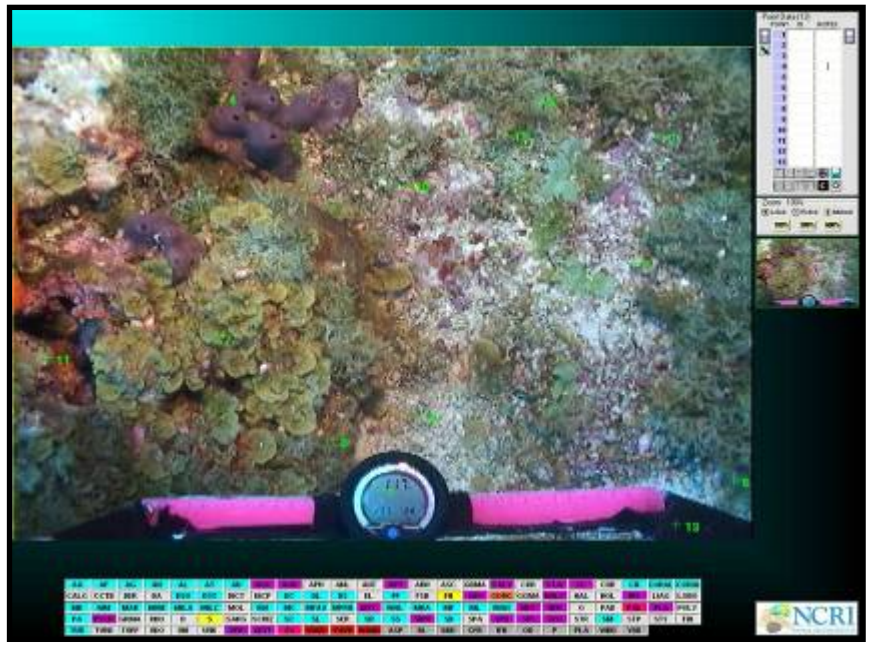
- **4 depth ranges collected by divers and ROV**

Depth (m)	Bank			
	Sonnier	McGrail	Geyer	Bright
22–27	X			
30–36.5	X		X	X
45–50 (ROV)	X	X	X	
55–60 (ROV)	X	X	X	



Methods – Sonnier, McGrail, Geyer, Bright Banks

- **Video was cut into non-overlapping still images**
- **Randomly placed dots were added to each image using Coral Point Count®, for a total of 500 dots per transect**
- **Each dot was classified at the lowest possible taxonomic level**



Methods – Sonnier, McGrail, Geyer, and Bright Banks

Roving Diver Surveys

- **Landscape-scale views of all banks**
- **Qualitatively analyzed for possible hurricane impacts**
- **Video footage from previous surveys assessed to estimate pre-hurricane conditions**

Methods
EFGB

Repetitive Quadrats

- **Assess reef community over time**
- **40 stations within study site**
- **9 deep stations**
- **Captured 8m^2 area at each station**
- **Photographs taken in November 2005 and June 2006**
- **Random dot analysis**
- **Planimetry analysis**

Methods
EFGB

Perimeter Video

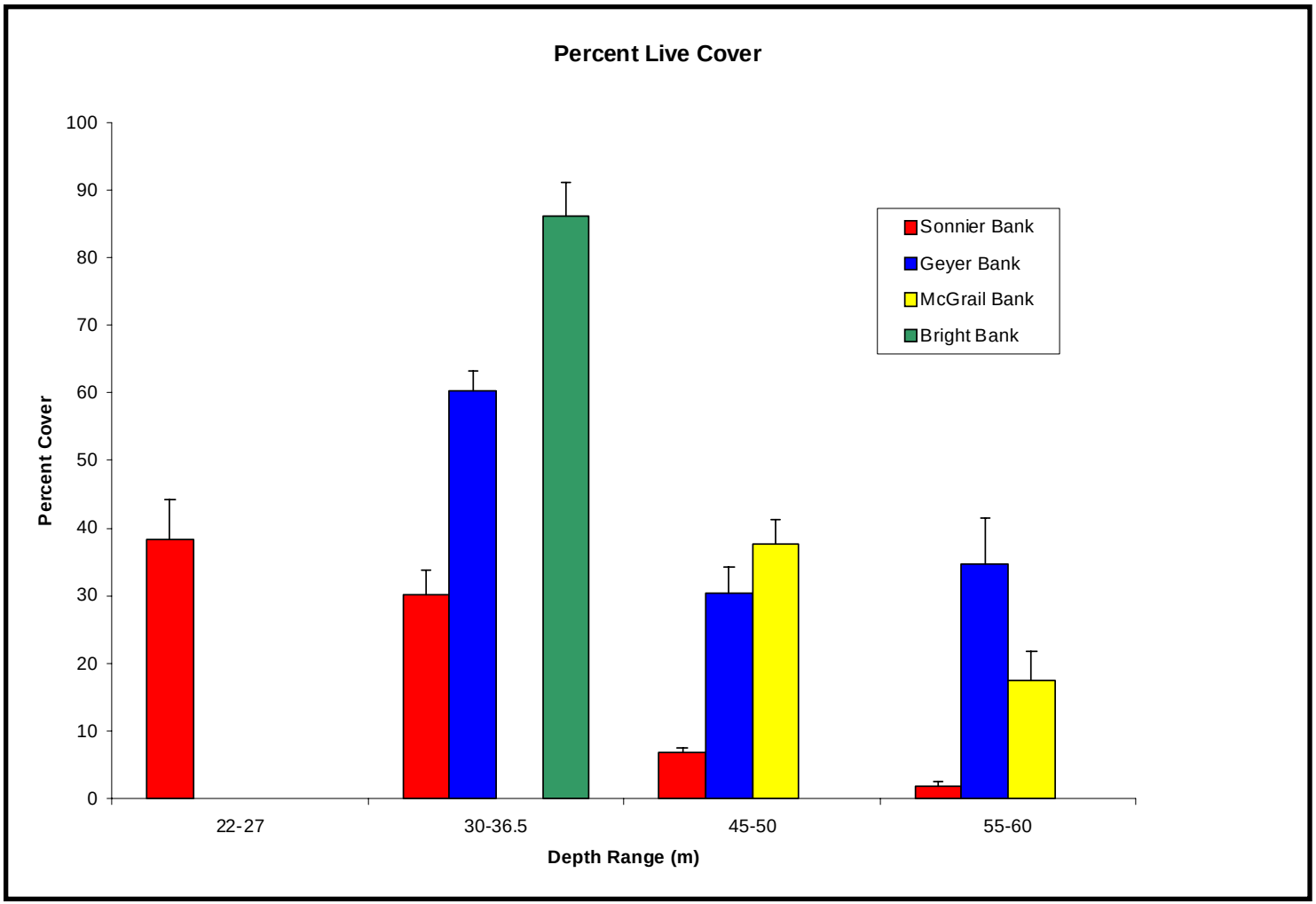
- **Videotaped north and east perimeter lines in November 2005 and June 2006**
- **Documented coral condition and fish populations**

Methods

Hydrological Model

- **Wave study using hindcast data provided by Oceanweather, Inc.**
- **Study consisted of 2 distinct analyses:**
  1. **Numerical modeling effort**
  2. **Analytical model (Chaplin 1999)**

Results

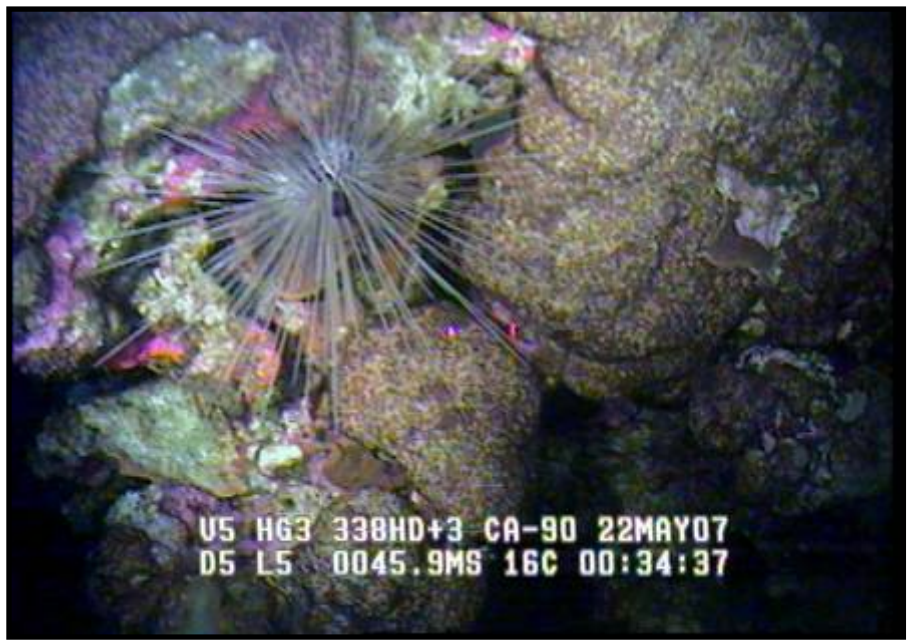

Percent Live Cover
Percent Cover
100
90
80
70
60
50
40
30
20
10
0
22-27
30-36.5
45-50
55-60
Depth Range (m)
Sonnier Bank
Geyer Bank
McGrail Bank
Bright Bank

Sonnier Bank

- **Lowest live cover of all banks studied (~2–38%)**
- **Dominated by macroalgae, sponges, and *Millepora alcicornis* in shallow areas**
- **TB and rubble dominant at depth**
- **Previous video surveys**

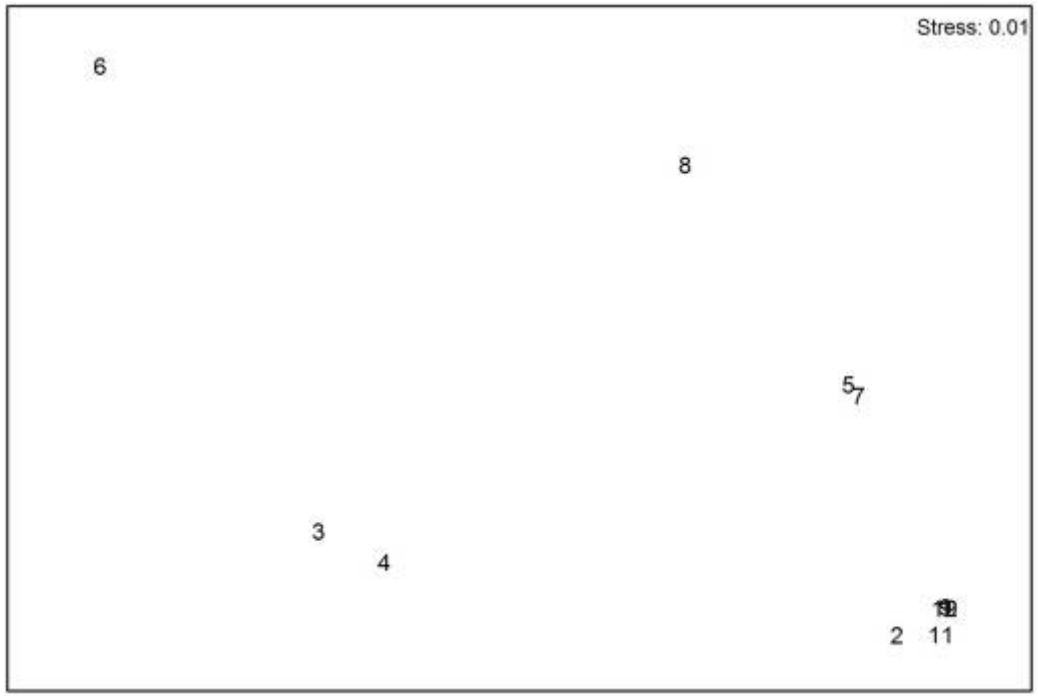
McGrail Bank

- **Deepest reef cap in this study (45m)**
- **Live cover ranged from 17–38%**
  - **45–50 m: dominated by macroalgae and coral**
  - **55–60 m: dominated by algal nodules and macroalgae**
- **Predominate coral was *Stephanocoenia intersepta***



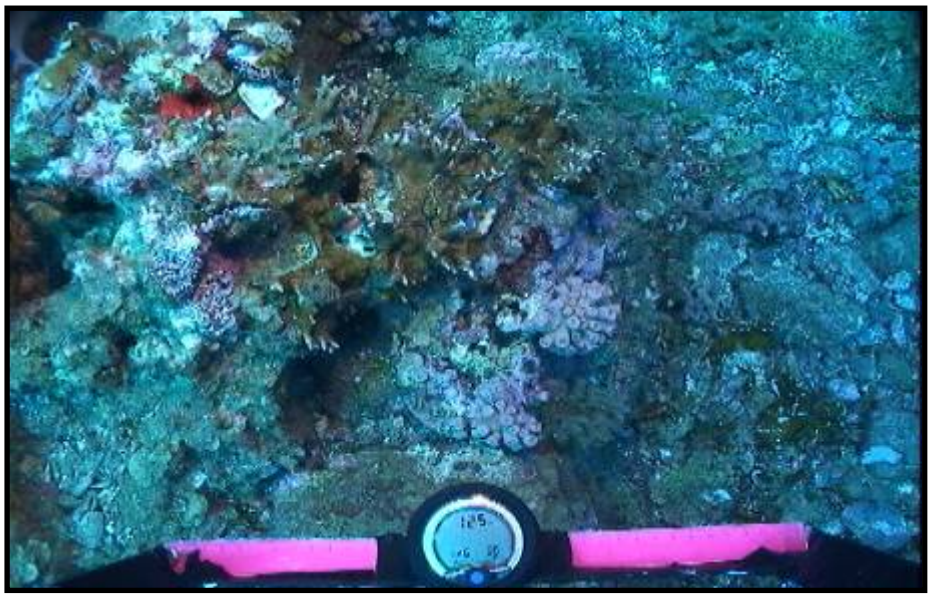
McGrail Bank

- **45-50 m: percent cover of *S. intersepta* was highly variable (0–32%).**
- **MDS analysis revealed high variability among transects**



Geyer Bank

- **Live cover ranged from 30–60%**
  - **Mostly brown macroalgae (specifically *Sargassum* sp.), sponges, and corals**
- **Only Bank with observed population of *Tubastraea coccinea***
- **Previous video survey**



Bright Bank

- **Highest live cover of any bank (86%)**
- **Dominated by macroalgae, turf algae, and corals**
- **Previous video survey**

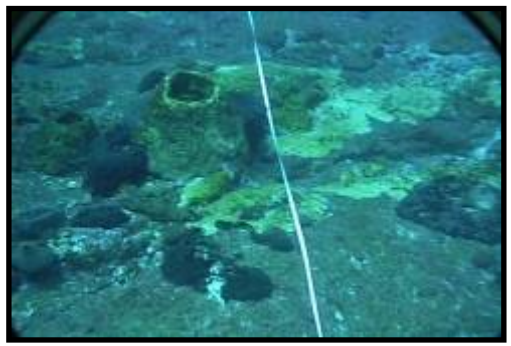
Shannon Weiner Diversity Index

	Bank				
Depth	**Sonnier**	**Geyer**	**McGrail**	**Bright**	**East**
22–27	2.86	–	–	–	2.43
30–36.5	1.55	1.65	–	1.81	2.27
45–50	0.23	2.13	2.08	–	–
55–60	0*	1.47	0.83	–	–
* only turf algae, rubble and sand					

- ***H'* was highest at Sonnier Bank from 22–27 m**
- **Diversity decreased with depth at all Banks except Geyer Bank**
- **Both Geyer and McGrail Banks exhibited highest diversity values in 45–50 m depth range**
- **Zero value at Sonnier Bank from 55–60 m**

Hurricane Impacts

Sonnier Bank 1996
Video courtesy of NOAA/E. Hickerson



Sonnier Bank 2002
Video courtesy of MMS/G. Boland

- **Sonnier Bank**
  - **Divers with experience at Sonnier noted that the surface appeared different from previous visits**
  - **Bare bedrock appeared in places where live cover previously occurred**
- **McGrail, Geyer, and Bright Banks: no obvious signs of hurricane damage**

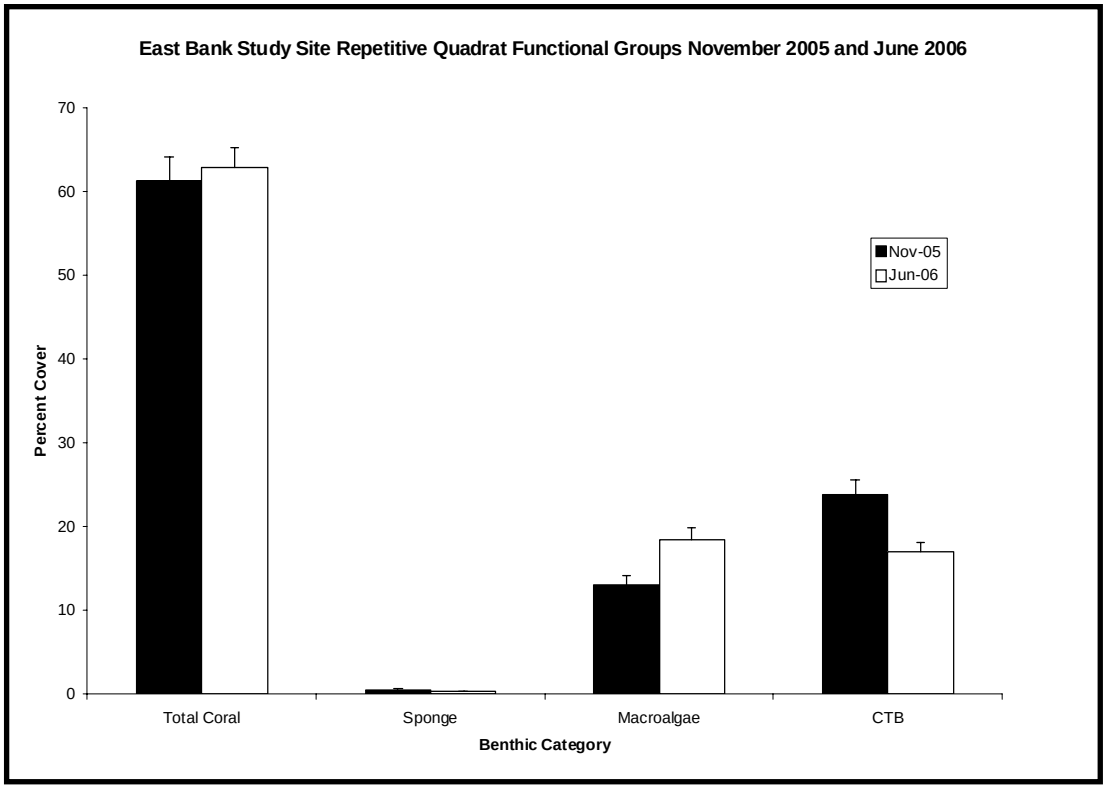
Sonnier Bank 2005
Video courtesy of NOAA/E. Hickerson

Sonnier Bank 2007

Statistical Results

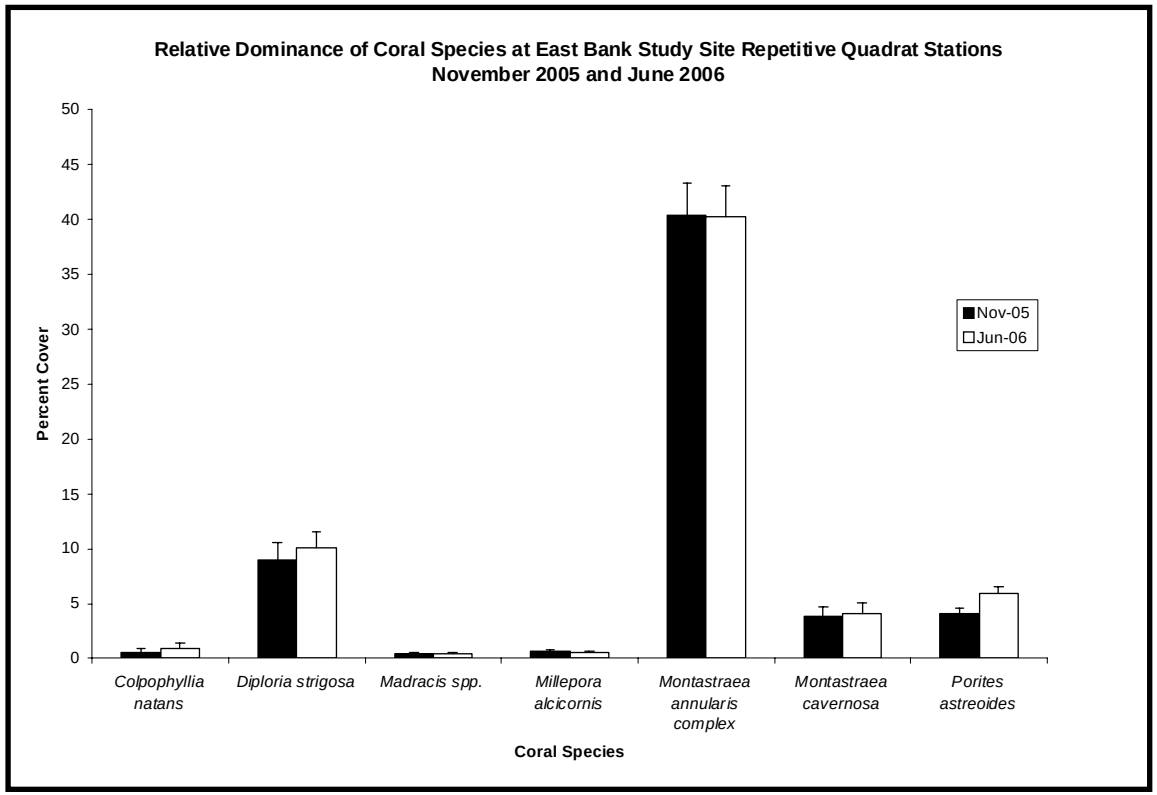
- **Statistical analyses performed using benthic cover data at Sonnier, McGrail, Geyer and Bright Banks**
- **ANOSIM (Analysis of Similarity): showed significant differences between Banks**
- **Pairwise ANOSIM: Bright Bank most different from Geyer and Sonnier Banks**
- **MDS highlighted the dissimilarities among banks, with depths within sites grouping more closely**

Repetitive Quadrats EFGB Study Site



- **Coral cover was stable (61.34% in November 2005 and 62.87% in June 2006)**
- **Macroalgal cover increased by ~5.4%, while CTB decreased ~6.9%**

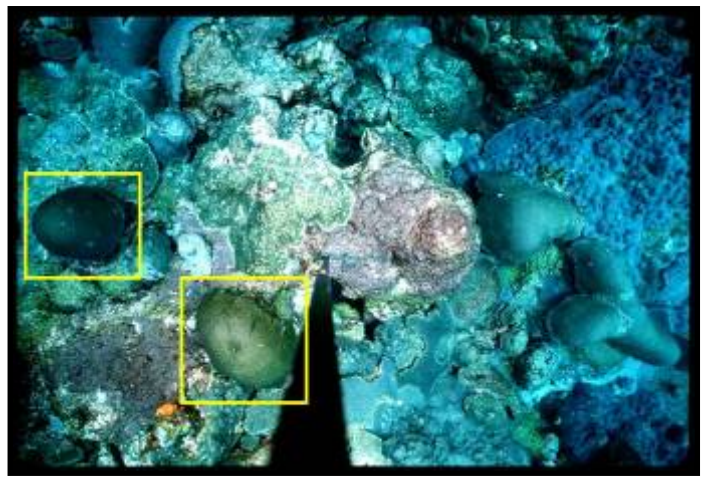
Repetitive Quadrats EFGB Study Site



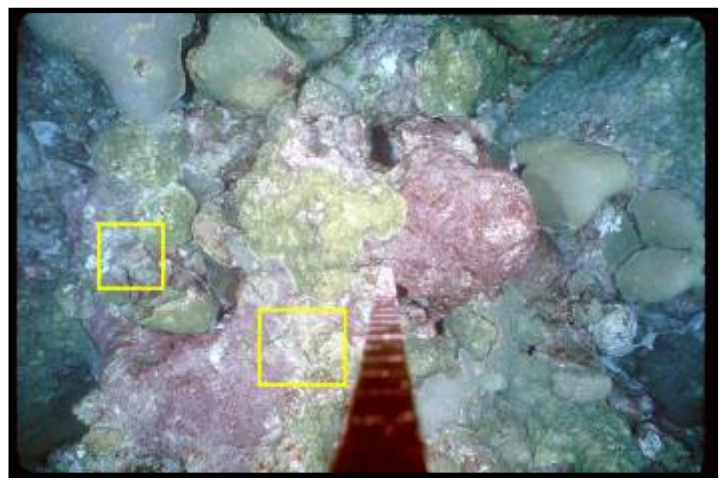
- **Species relative abundance showed stability**
- **Dominant species: *Montastraea annularis* spp. complex, *Diploria strigosa*, *Porites astreoides*, *M. cavernosa***

Repetitive Quadrats EFGB Study Site

- **~1.5% of coral colonies within repetitive quadrats were missing in November 2005 (~3m^2)**
- ***Diploria strigosa*, *Porites astreoides*, and *Montastraea annularis* spp. complex comprised the majority of missing coral colonies**

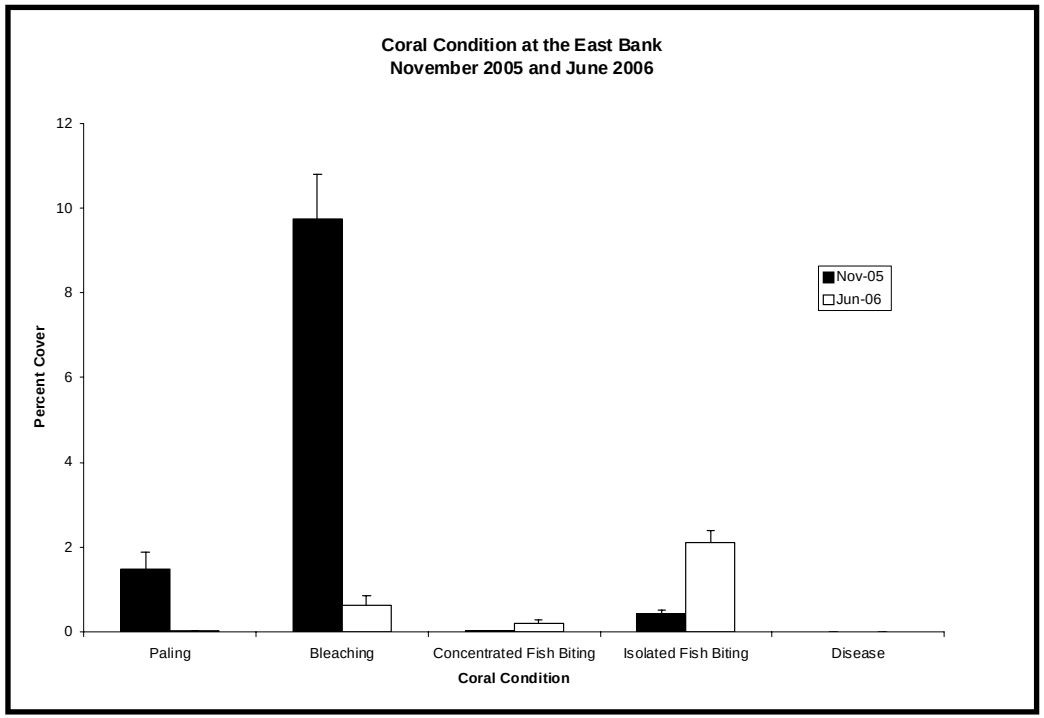


June 2005



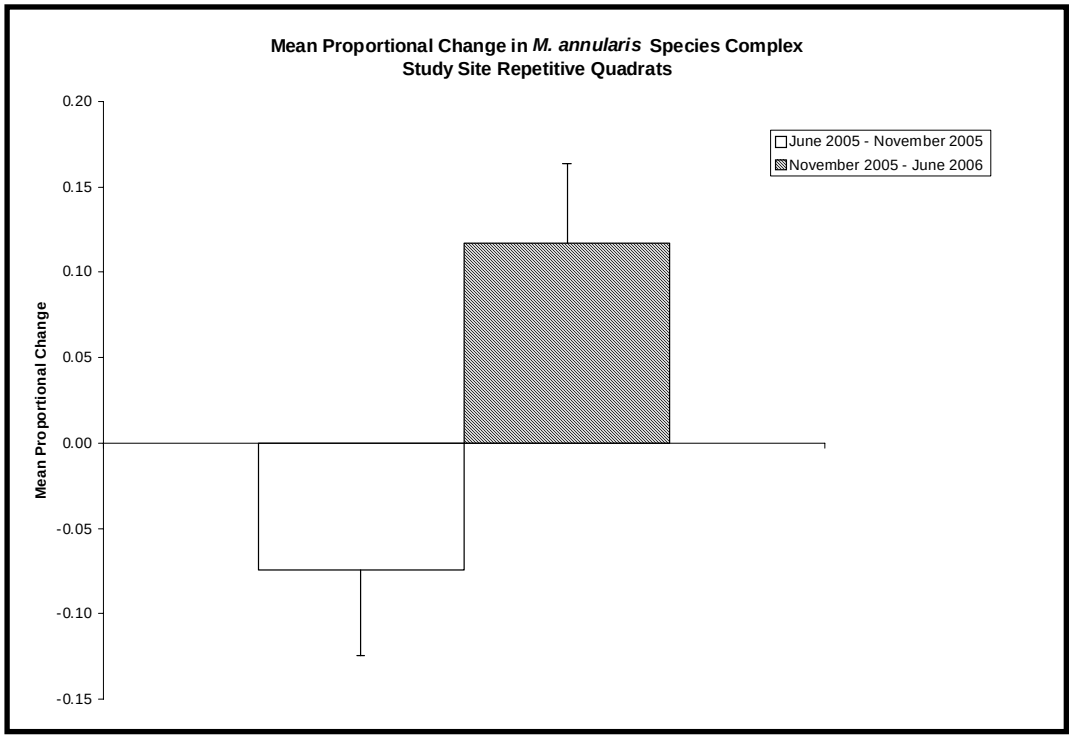
November 2005

Repetitive Quadrats EFGB Study Site



- **Bleaching most noticeable difference (9.74% in Nov. 2005)**
- **Bleaching was mostly on *Montastraea annularis* spp. complex, *M. cavernosa*, and *Millepora alcicornis***
- **Paling/fish biting low; disease not observed**

Repetitive Quadrats EFGB Study Site



- **Decrease in growth of *Montastraea annularis* spp. complex from June 2005–November 2005**
- **Increase from November 2005–June 2006**
- **Stability overall**

EFGB Perimeter Videography

- **High levels of coral cover**
- **Evidence of hurricane impacts in Nov. 2005**
- **Moderate levels of coral stress (paling and bleaching) documented in Nov. 2005**
- **Lower levels of paling and bleaching in June 2006**

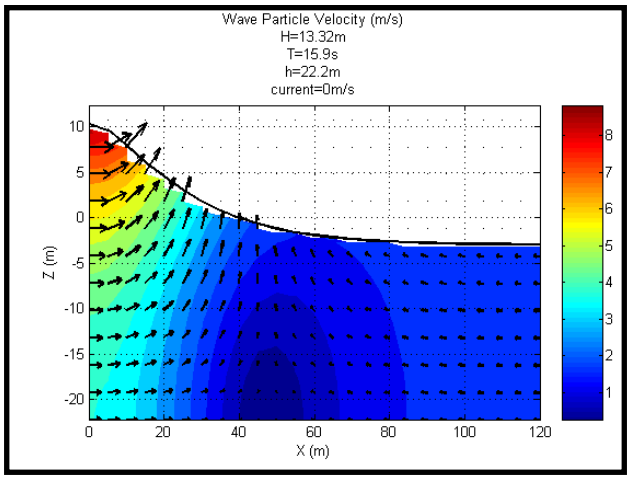
November 2005

June 2006

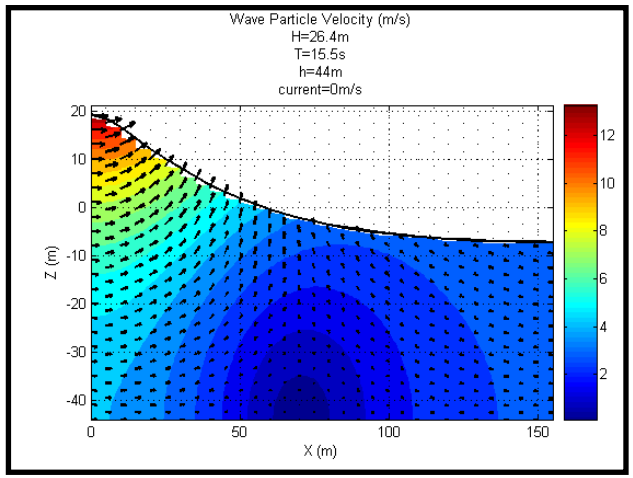
Hydrological Modeling Results

- **Wave heights increased dramatically in the vicinity of the Banks**
- **Wave height was highest directly over the peak of the Bank**
- **Per wave theory, the bottom velocity is highest at the summit of the Bank and decreases with depth**

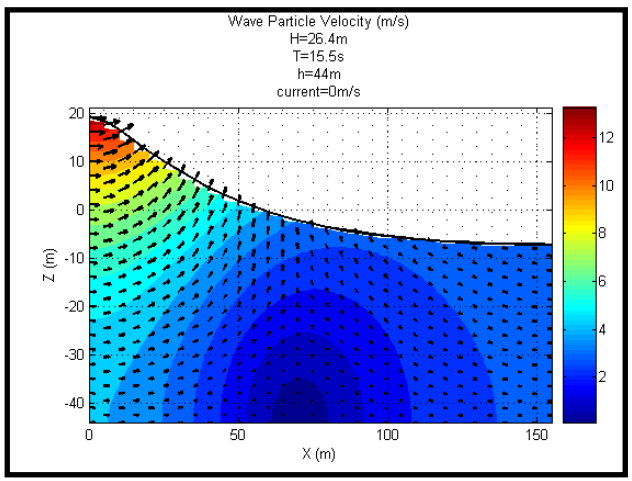
Wave Heights & Water Velocities



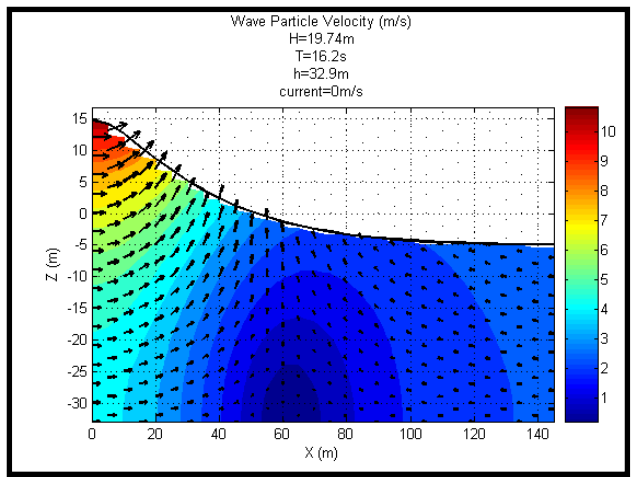
Sonnier Bank



McGrail Bank



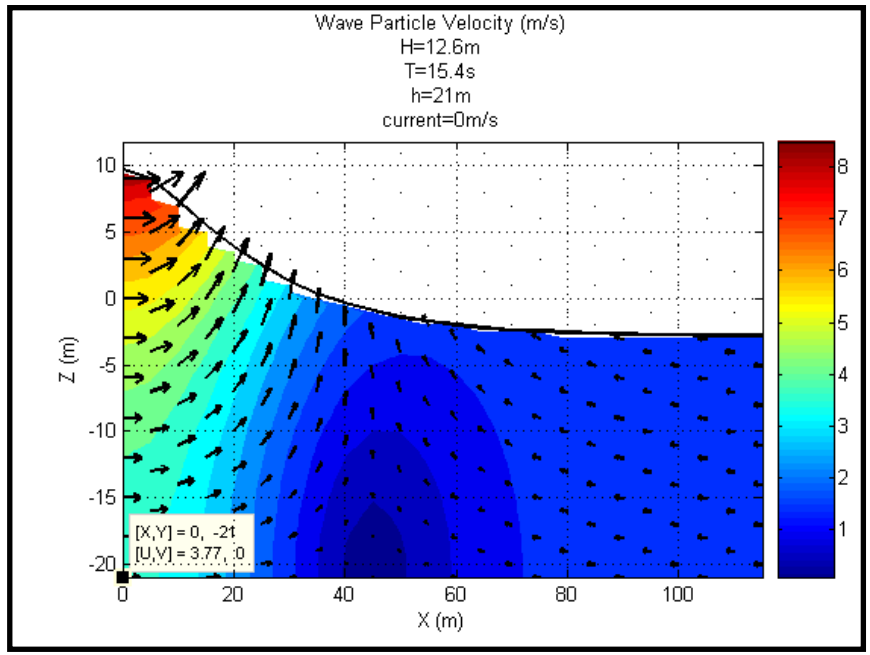
Geyer Bank



Bright Bank

EFGB Wave Height

- **The transformed significant wave height at the EFGB during Hurricane Rita was 12.6 m**

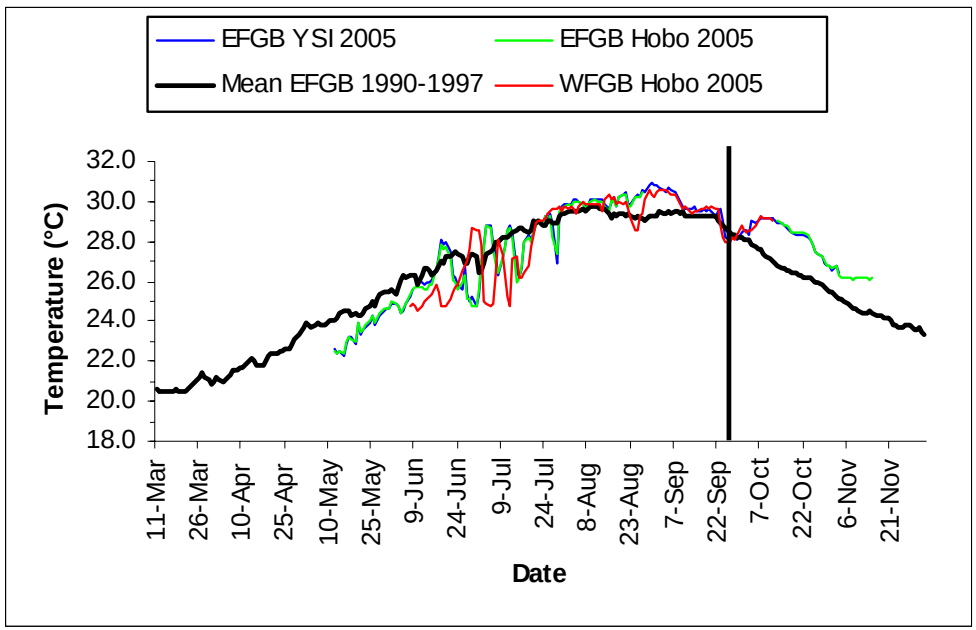


Hurricane Effects and Coral Reefs

- **Water depth provides some protection**
- **Bioeroded coral colonies susceptible to damage**
- **Nov. 2005 data showed that 62% of missing coral colonies were *Diploria strigosa***
  - ***D. strigosa* colonies experience intense bioerosion, forming mushroom-shaped colonies**

Beneficial Aspects of Hurricanes

- **Cooling water temperatures associated with hurricanes may relieve coral bleaching (Manzello et al. 2007)**
- **Hurricane Rita brought cooler water temps to the FGB in late September 2005**
  - **Sea temperatures abruptly decreased by 1.5° C**



Hurricanes and Non-Coral Dominated Banks

- **Hurricane impacts to algal and sponge dominated banks are harder to detect >1 year after the storm**

- **Vast areas of rubble may have represented hurricane effects. However, normal reef processes also create rubble zones (Rezak 1985).**

Hydrological Modeling Predictions

- **The REF/DIF model: predicts that larger wave heights may have occurred at banks with caps located in deeper water – study results do not support this**

- **Results do not support assumption that greatest damage would likely occur at banks located closest to the storm track**

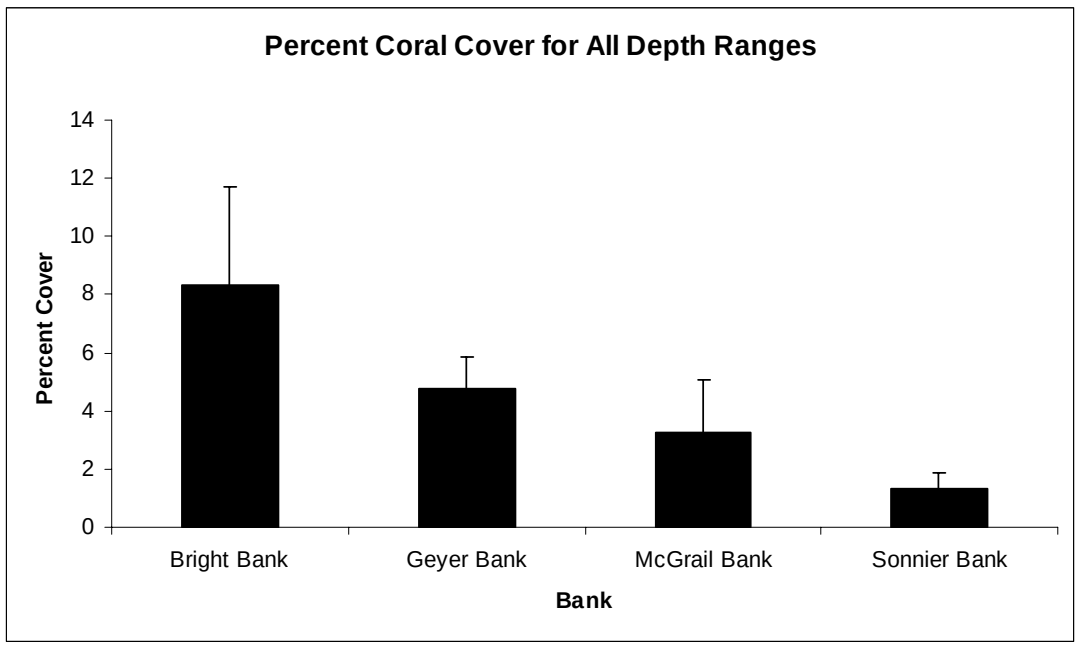
Conclusions

- **Variability within banks was lower than variability among banks**
- **Variability among transects within a depth range was lower than the variability among depth ranges, which was less than variability among banks**
- **These results suggest that variability of benthic communities is scale-dependent**
- **Dissimilarity may be related to oceanographic currents delivering propagules of benthic organisms (Lugo-Fernandez et al. 2001)**

Conclusions

Drift Studies

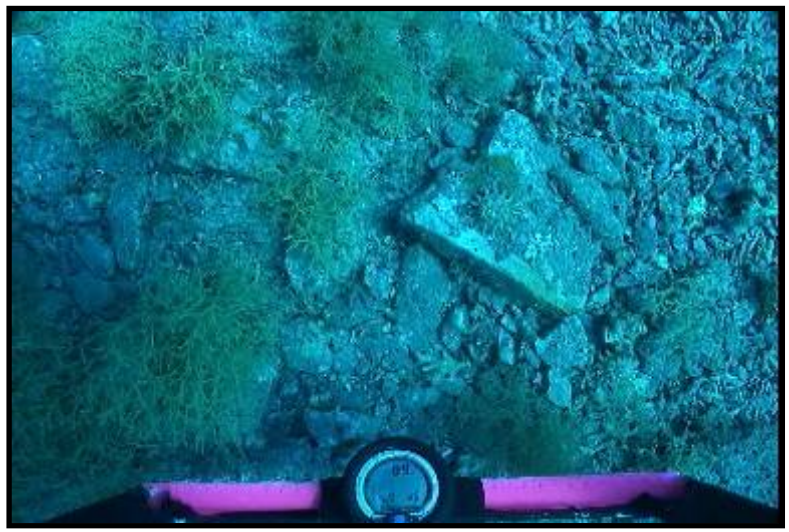
- **Lugo-Fernandez study**
- **Banks closest to the EFGB should have the highest coral cover**
- **This study: coral cover was highest at Bright Bank (located ~25 km east of the East Bank) and decreased in an eastward direction**



Conclusions: Sonnier Bank

- **Diver observations noted apparent benthic surface changes from previous visits**
- **Sonnier Bank likely sustained hurricane damage**
  - **4 m/s water velocities**
  - **Estimated wave heights**

    ~ 13 m

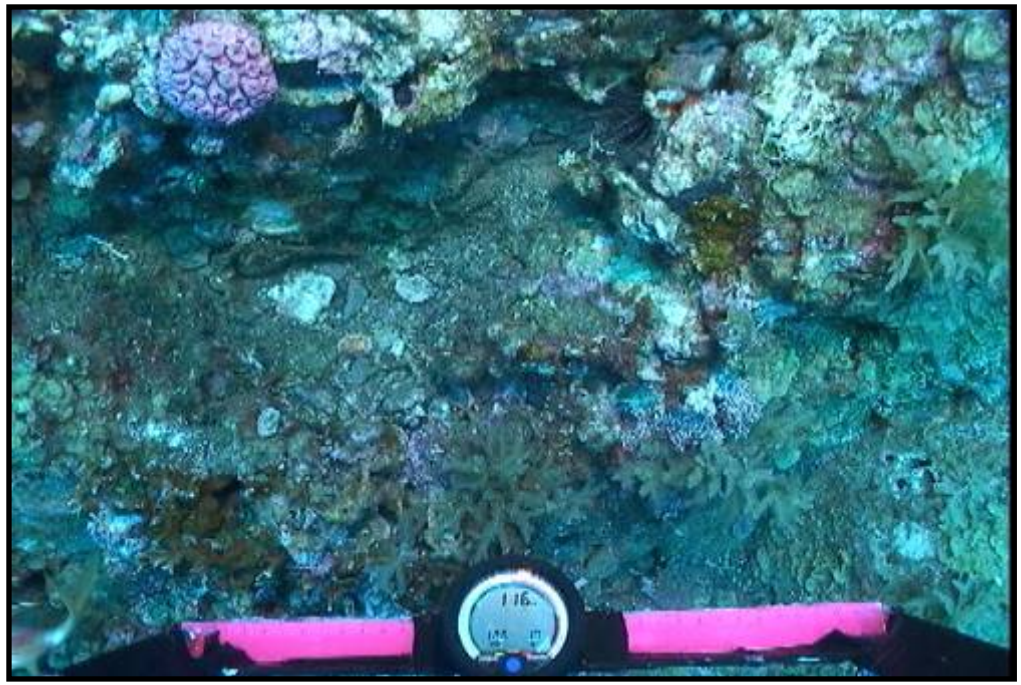


- **Lowest live cover of all banks**
- **More live cover in previous years**
- **Disappearance of *Xestospongia muta***

Conclusions: McGrail Bank

- **~12 km from Hurricane Rita**
- **Large *Stephanocoenia intersepta* colonies & vast areas of algal nodules**
- **Bank depth (45 m) may have provided protection**
- **Storm likely affected the top of the bank; however**
  - **ROV footage collected at night and landscape-scale views were not possible**
  - **Observed colonies appeared undamaged; however high variability of coral cover could be consequence of hurricane or reflect patchiness of benthic biota**

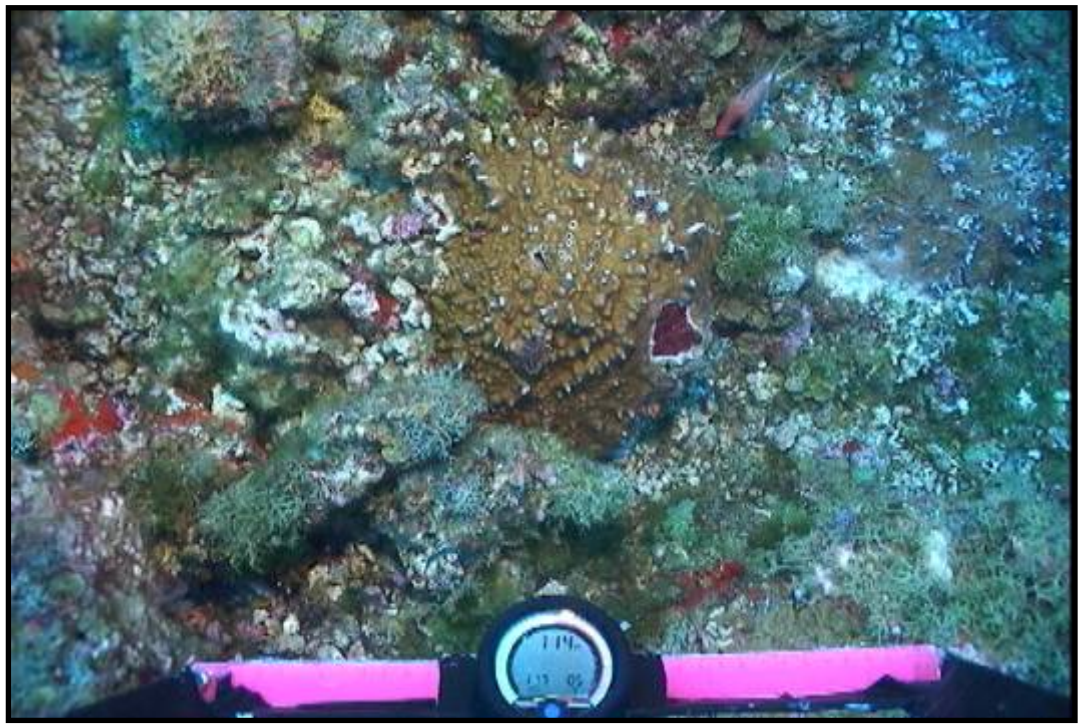
Conclusions: Geyer Bank



- **Only bank with observed population of *Tubastraea coccinea***
- **Previous video survey at Geyer:**
  - **Dominance of macroalgae and hydrocorals**
  - **Variety of sponges**
- **No obvious signs of hurricane damage**

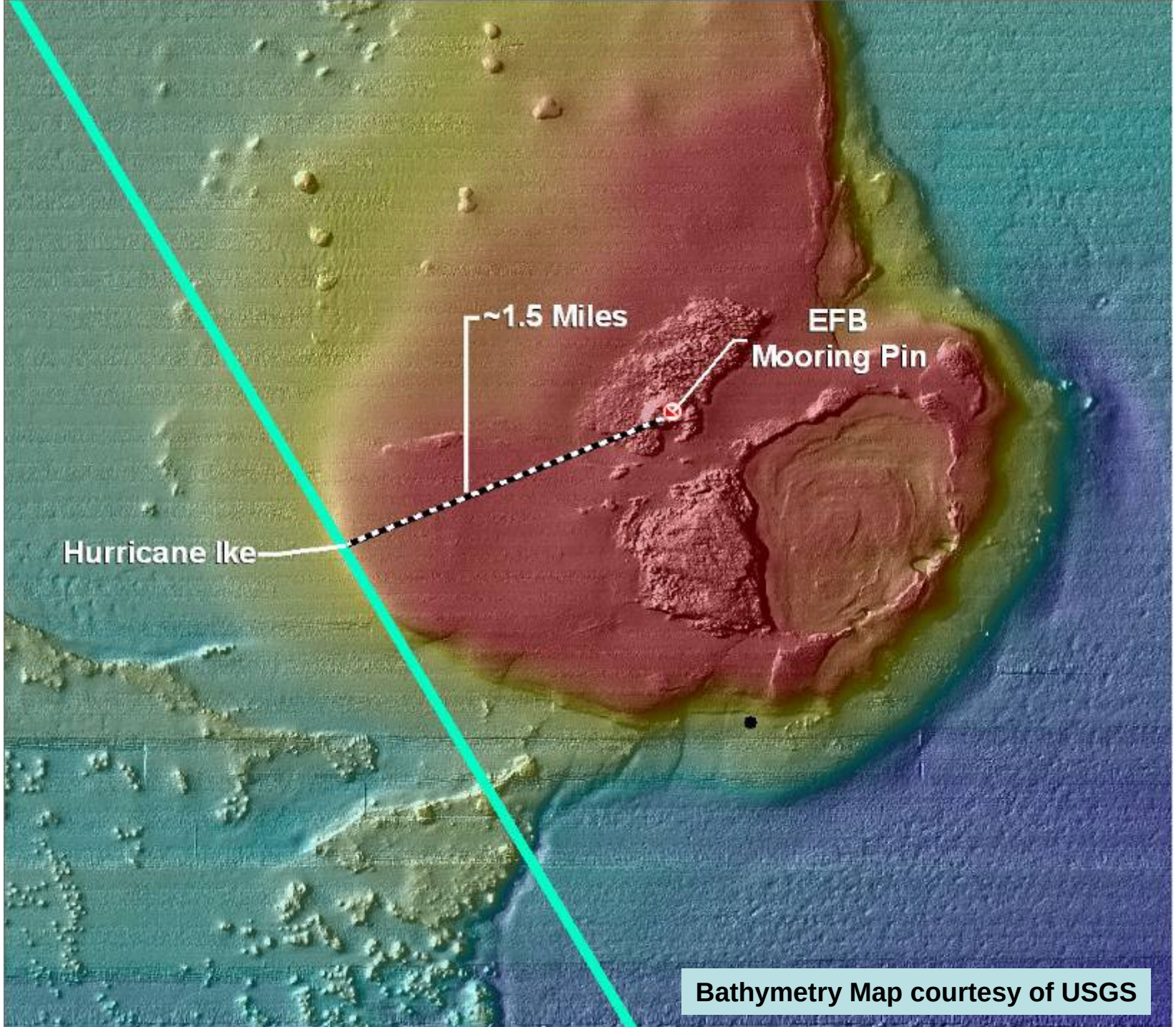
Conclusions: Bright Bank

- **Highest live cover of all Banks (86%)**
- **Dominated by macroalgae, turf algae, and corals**
- **Previous video survey at Bright Bank:**
  - **Mostly bare substrate, low macroalgal cover, and few coral colonies**



Conclusions: EFGB

- **Substantial mechanical damage**
- **Coral cover and species relative abundance was stable**
- **1.5% of coral colonies missing at repetitive quadrat stations (~60% *Diploria strigosa*)**
- **Bleaching most noticeable difference between Nov. 2005 and June 2006**


~1.5 Miles
EFB
Mooring Pin
Hurricane Ike
Bathymetry Map courtesy of USGS

Recommendations

- **Conduct dispersal or drift studies**
- **Study fish populations at these Banks**
- **Detailed surveys should be conducted at McGrail Bank (including sclerochronology of *Stephanocoenia intersepta* colonies)**
- **GIS mapping initiative**

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