

A 30-Year Historical Perspective of the
Coral Communities at Pulley Ridge Reef

Resilience of a Unique Mesophotic Reef in the Gulf of Mexico, USA:

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The Cooperative Institute for
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National Oceanic and
Atmospheric Administration
(NOAA)

Harbor Branch Oceanographic
Institute at Florida Atlantic
University



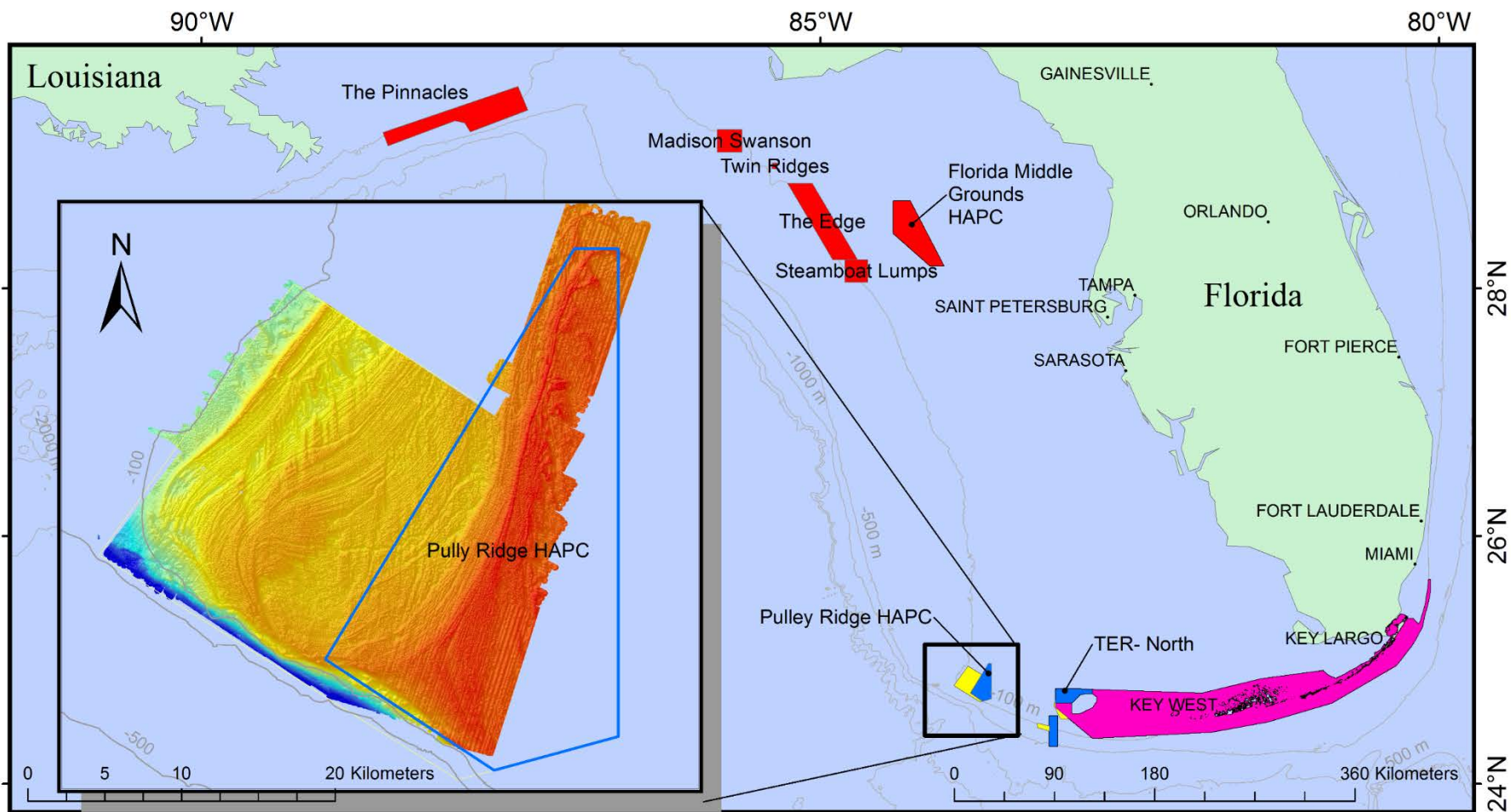
Community Structure Sub-Theme

Objectives

“Connectivity of the Pulley Ridge – South Florida Coral Reef Ecosystem”



- NOAA-NOS-NCCOS Grant
 - NOAA Center for Sponsored Coastal Ocean Research NA11NOS4780045
 - \$5 million grant- 5 years
- Synergistic Activity-35 Principal investigators:
 - Univ. Miami, CIOERT HBOI-FAU, UM-CIMAS, NOAA AOML, NOAA Fisheries, FSU
- Sub-Theme: Benthic Community Structure
 - J. Reed, S. Farrington, D. Hanisak



“Connectivity of the Pulley Ridge – South Florida Coral Reef Ecosystem”



- Sub-themes:
 - Community structure,
 - Coral genetics and connectivity,
 - Oceanographic currents and modeling
- Purpose:
 - Understand the coral ecosystem connectivity between mesophotic reefs
 - Pulley Ridge, Gulf of Mexico
 - & shallow water reefs
 - Florida Keys

Objectives of the Community Structure Sub-Theme



Agaricia sp. Lamarck, 1801

- Quantify and characterize: habitat and benthic community
 - Analyze percent cover and density of benthic community
 - Calculate coral size distribution
 - Determine health of coral and degree of coral morbidity
- Compare benthic communities among regions at PR
- Compare to historical data collected 35 years ago

Deep Refugia Hypothesis



Montastraea cavernosa (Linnaeus, 1767)

Puller Ridges (60-80 m)

- Suggests that MCEs may be less impacted from natural and human impacts
- Provide increased resilience for shallow water reef species through the export of fish and coral larvae.
- To prove this, we need to understand the long term stability and resilience of MCEs.

Glynn 1996, Bongaerts et al. 2011

Data Collection & Analysis

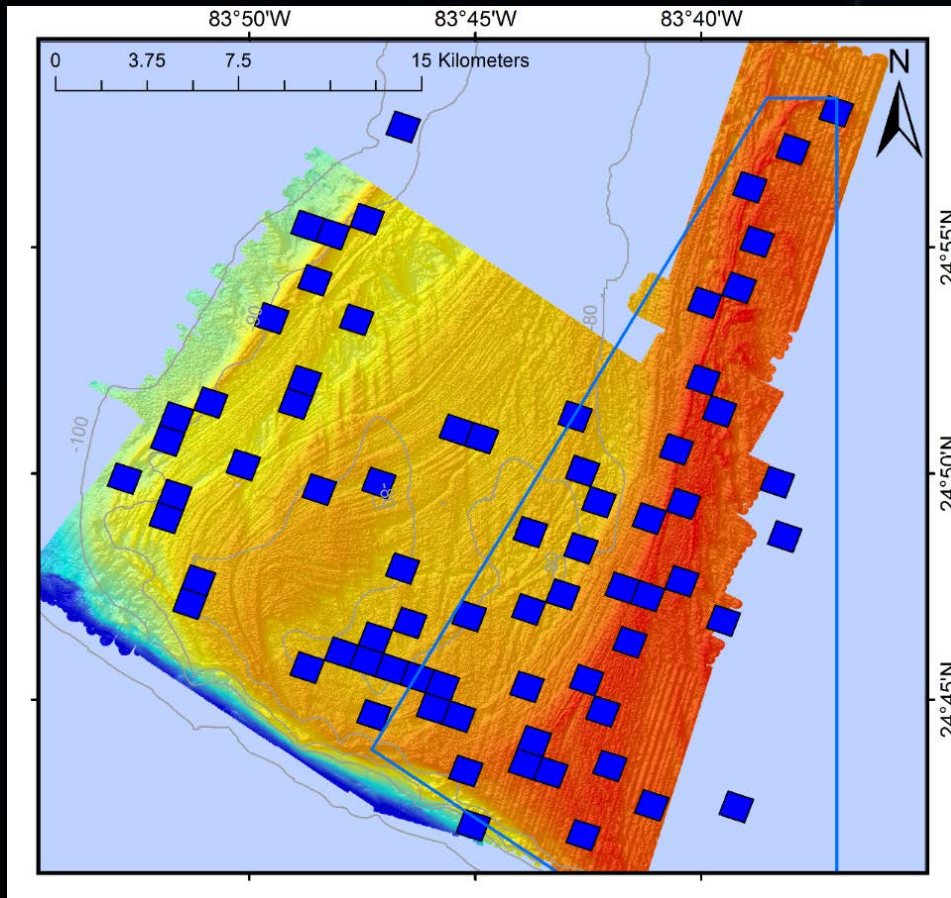
Methods

Methods



- *Mohawk* ROV- high definition video/photos w/ lasers
- Digital Still Images– to quantify benthic habitat, macrobiota
- ROV Collections- 5 function manipulator and collection skid

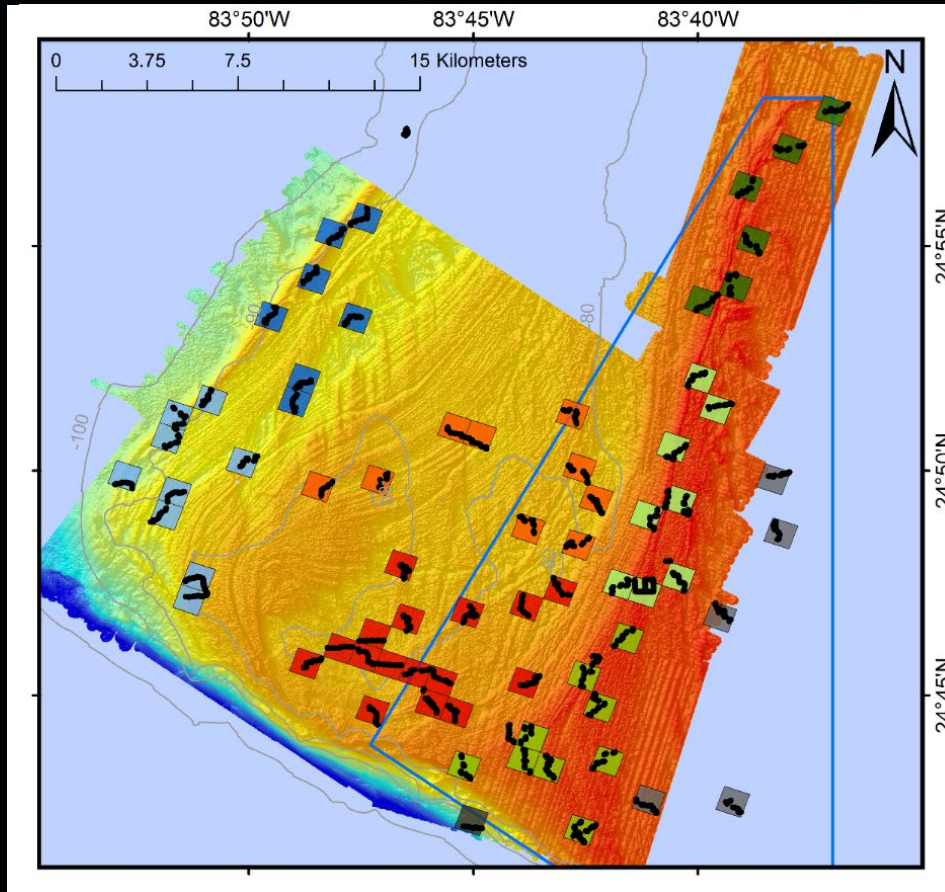
Methods



Site Selection

- Multibeam of Pulley Ridge and HAPC showing drowned paleo-shoreline from 15,000 ybp
 - (D. Naar,USF)
- 1 km² Fishnet layover
- Randomly selected 1 km² blocks

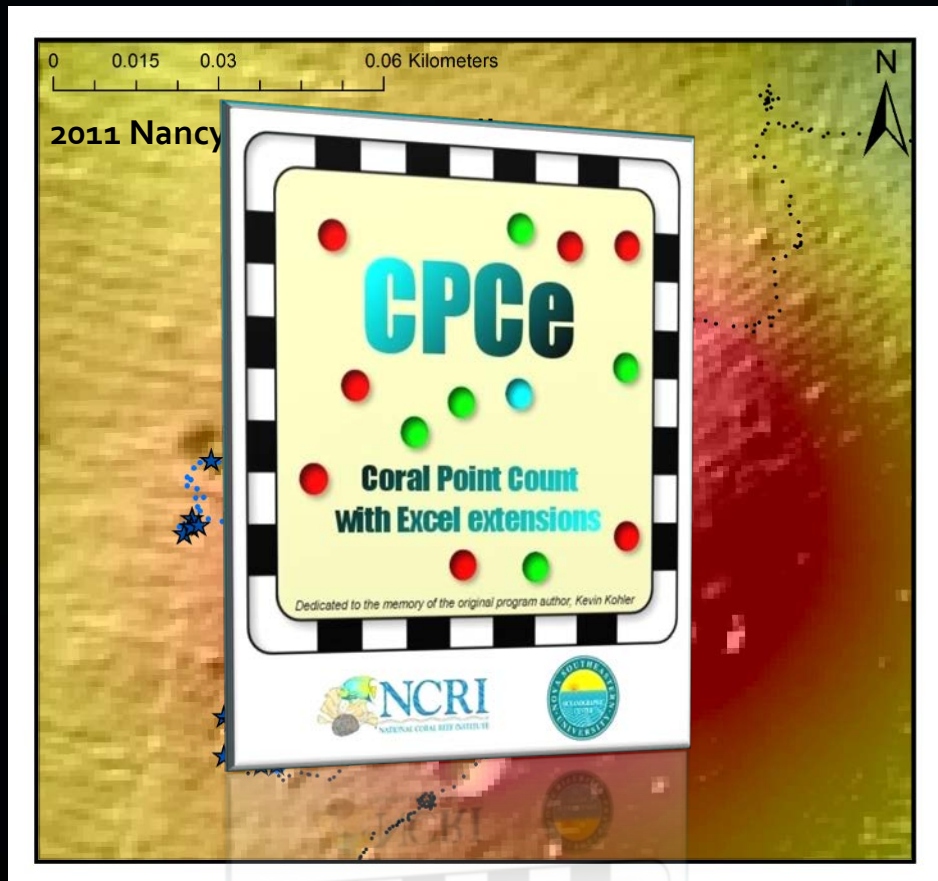
Methods



Over the 4 Cruises- Univ. Miami R/V Walton Smith, 2012- 2015:

- 9 Zones defined
- 69 1-km² blocks surveyed
- 237 hrs video for analysis of fish populations
 - All data (digital images, dive annotations etc.) georeferenced to ROV position for plotting in ArcGIS

Methods

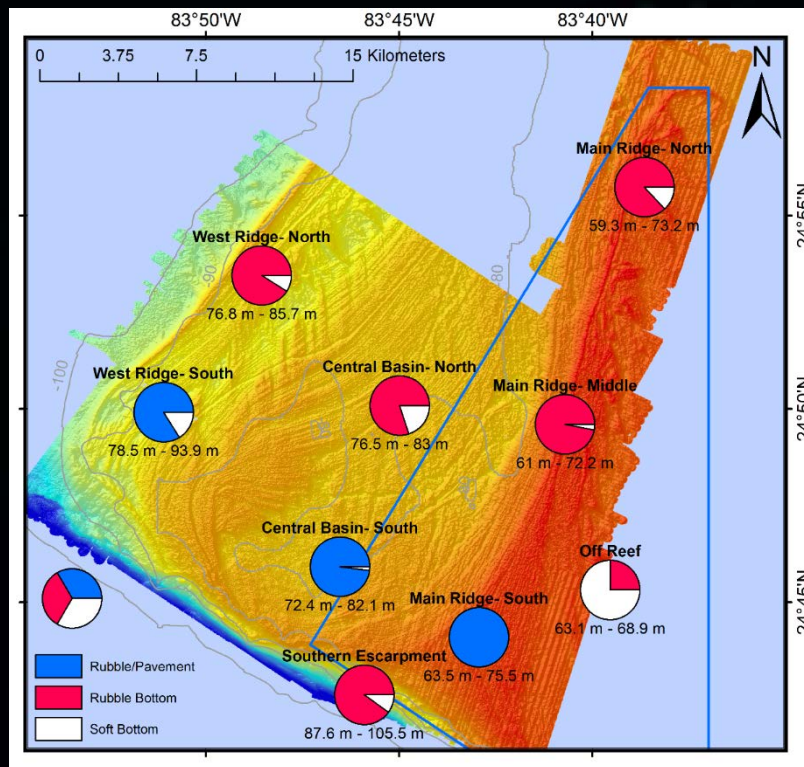


- Randomly conducted 5 - 1km transects in each block (at $\sim 1/4$ knot & 1-m altitude)
- At least 24 pictures per Transect
- Used CPCe to analyze each image for:
 - % cover
 - coral density, size & disease frequency
 - 8,280 photos used for quantitative analysis
 - 62,627! corals counted and measured

Overall Habitat Characterization from Percent Cover

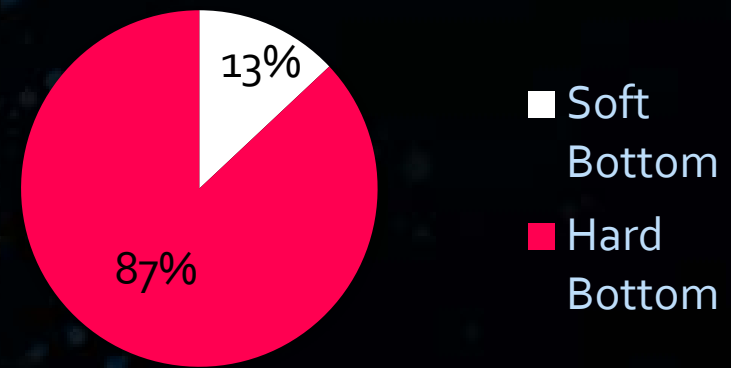
Results

Habitat Characterization by Zone

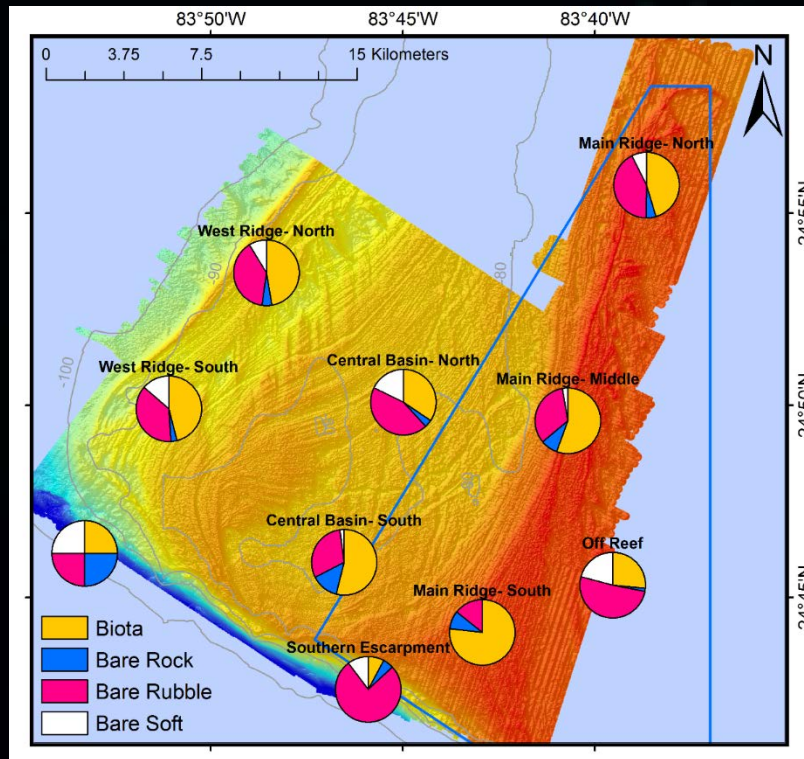


- Low Rugosity
- Low Relief (<1 m rise)
- Low Slope < 10°
- Depth Range: 60-105 m

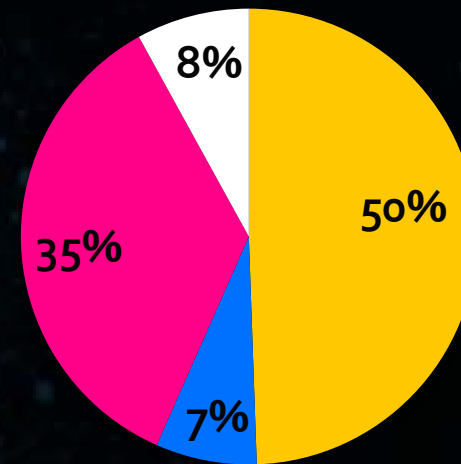
Overall Bottom Cover



Habitat Characterization by Zone

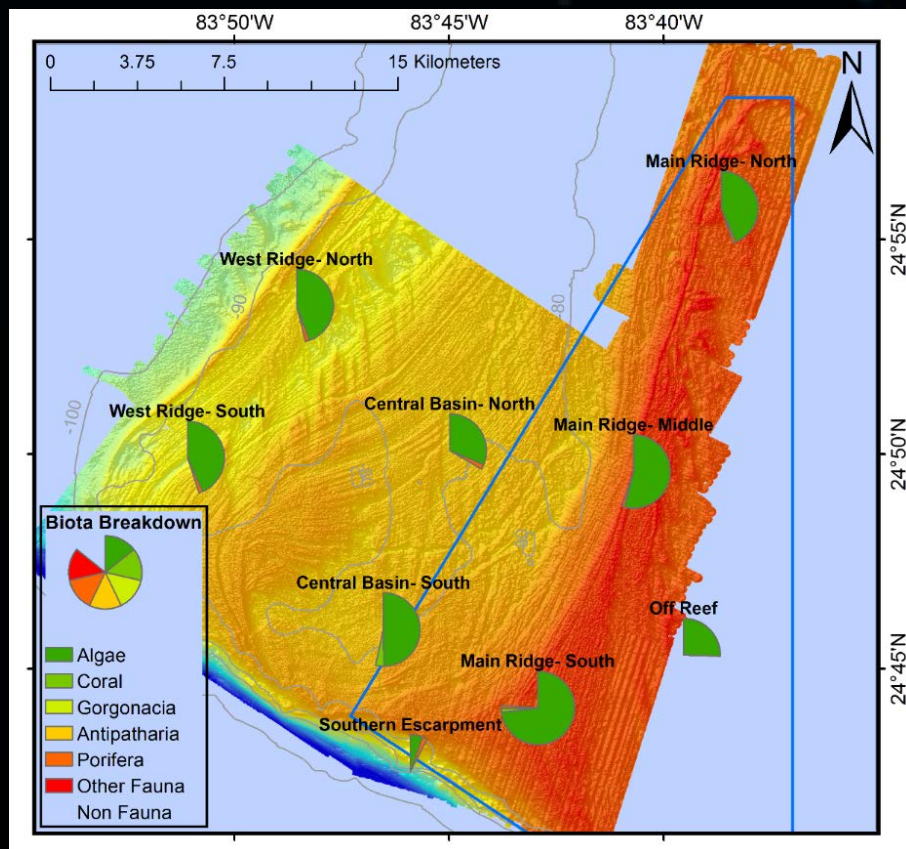


Overall Biota vs. Substrate Cover

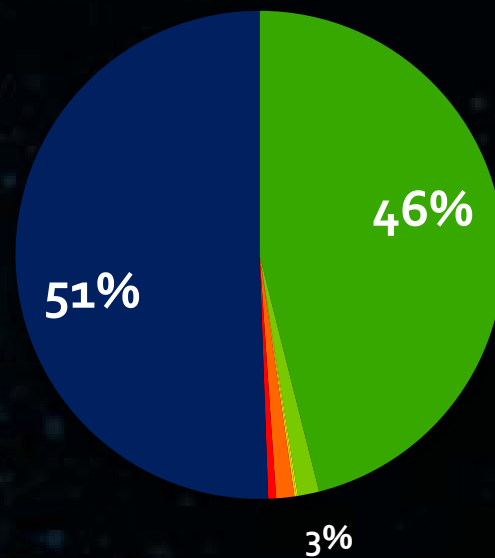


- Biota
- Bare Rock
- Bare Rubble
- Bare Soft

Habitat Characterization by Zone

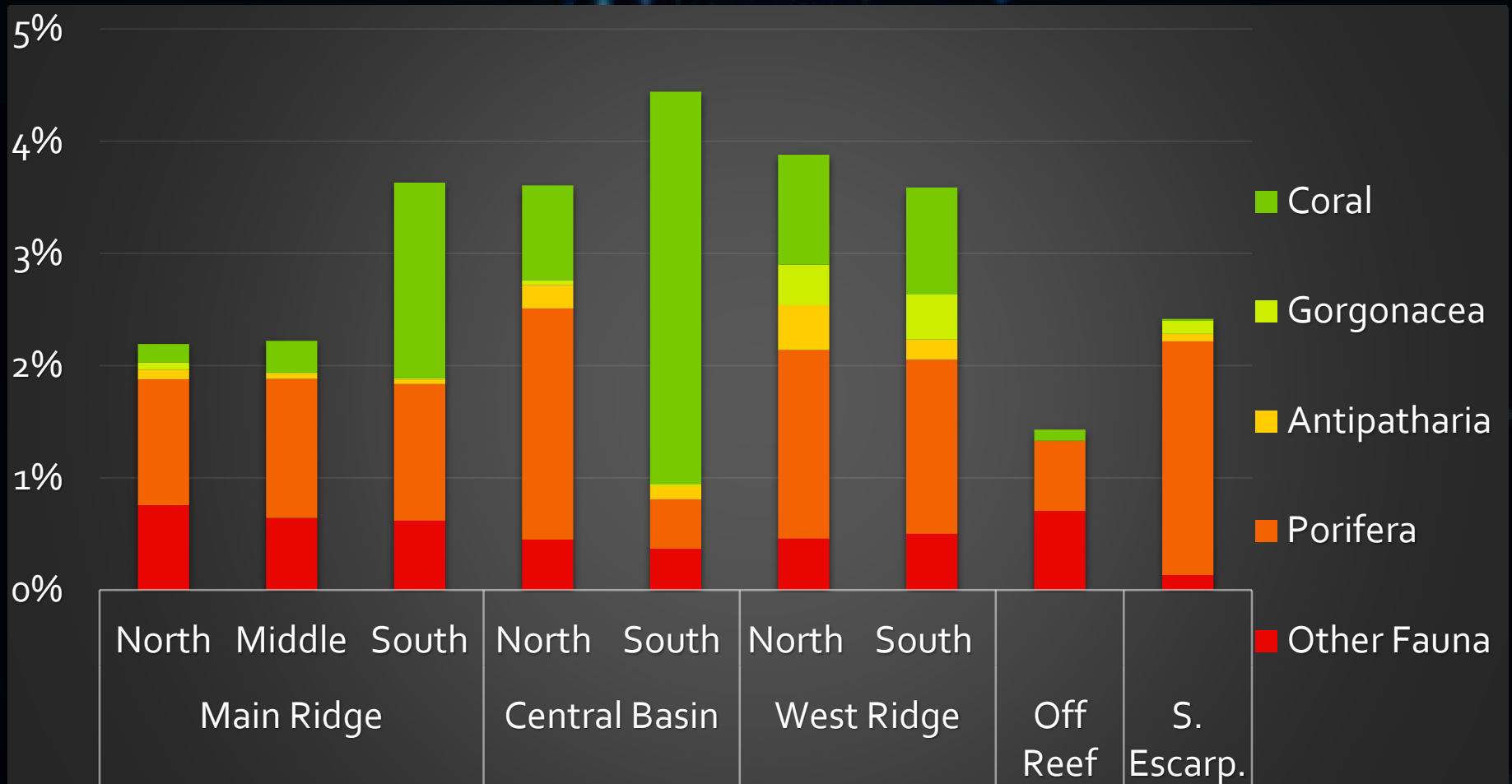


Overall Biota



- Algae
- Coral
- Gorgonacea
- Antipatharia
- Porifera
- Other Fauna
- Non-Fauna

Percent cover of fauna only (excl. algae)

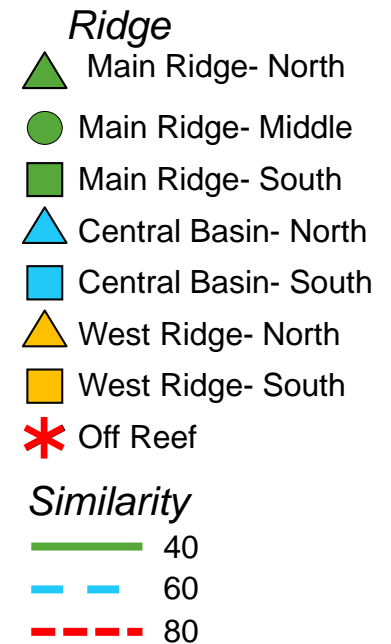
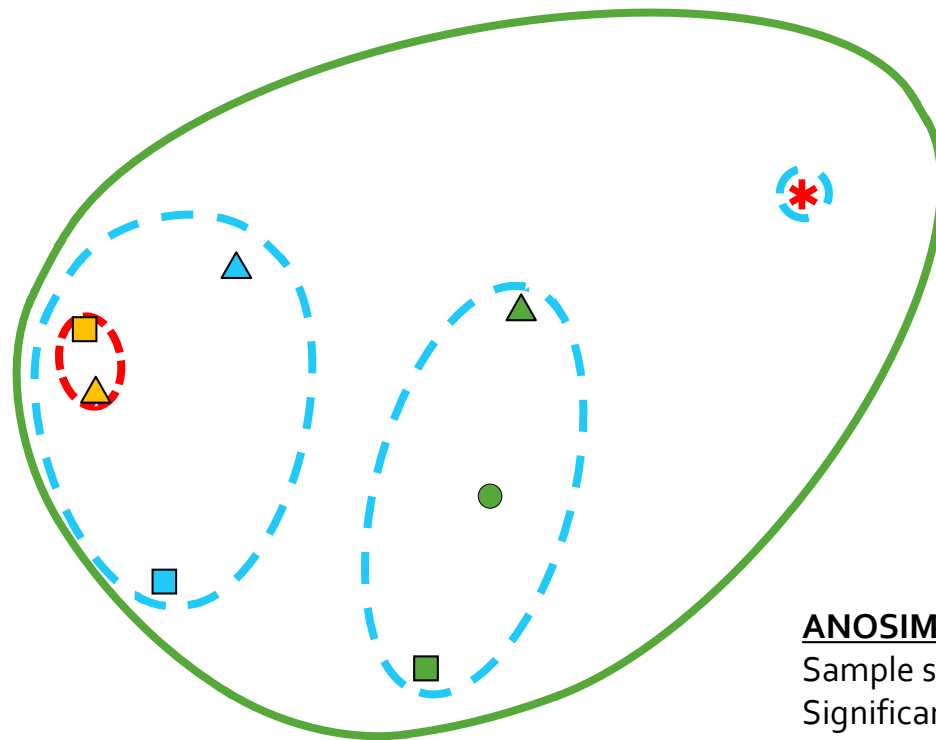


Multi-dimensional scaling (MDS)

2D Stress: 0.02

Transform: Square root

Resemblance: S17 Bray Curtis similarity

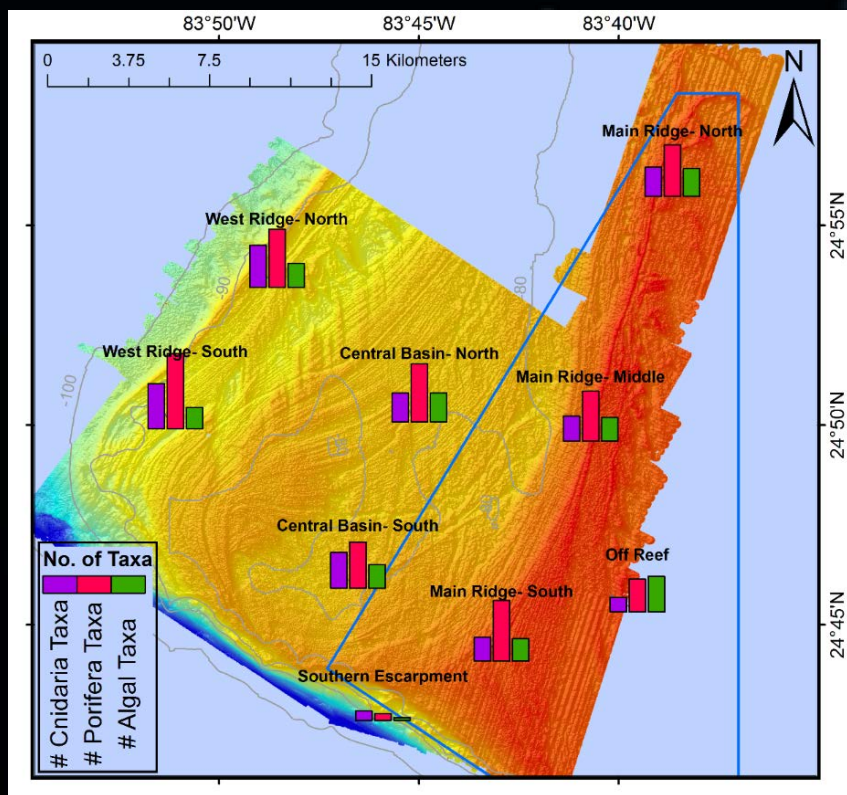


ANOSIM Global Test

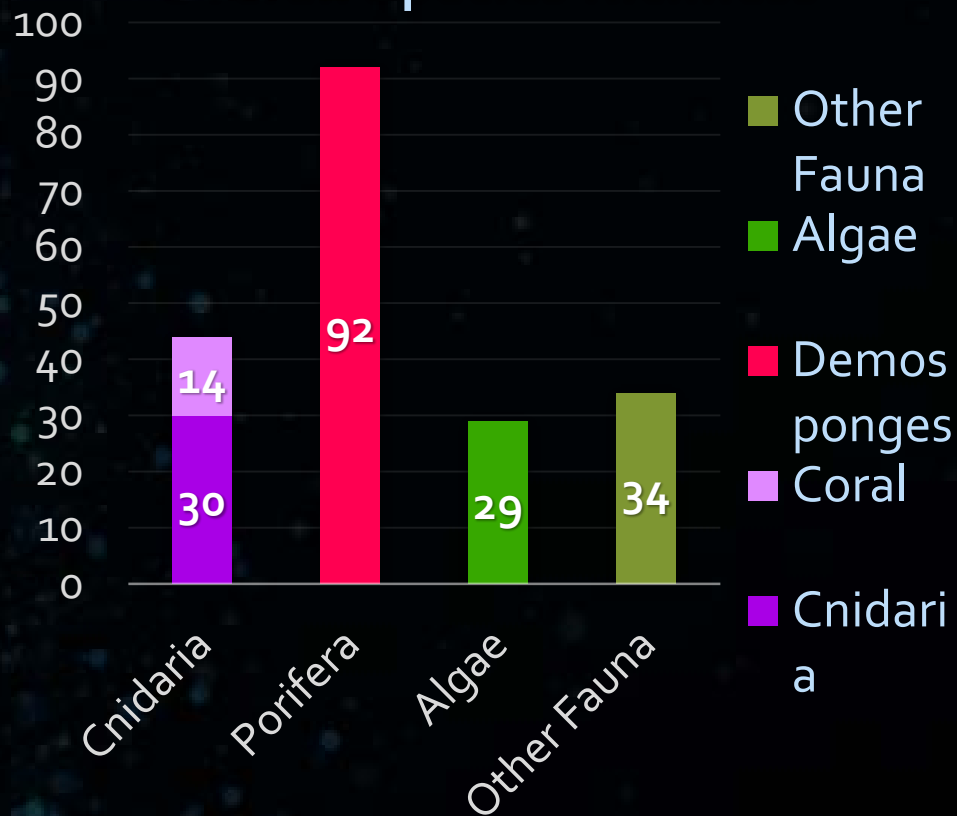
Sample statistic (Global R): 0.809

Significance level of sample statistic:
0.4%

Species Richness by Region



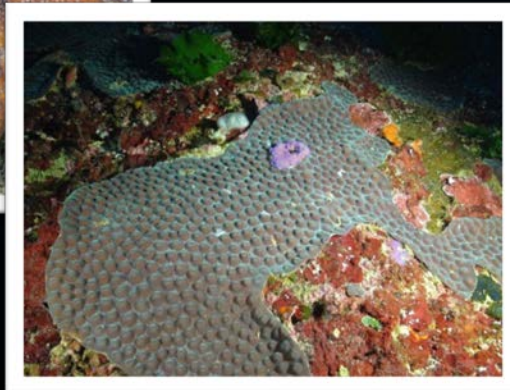
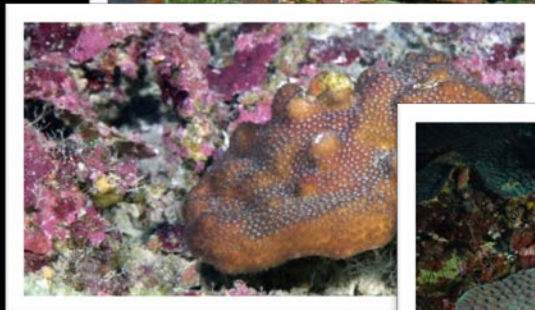
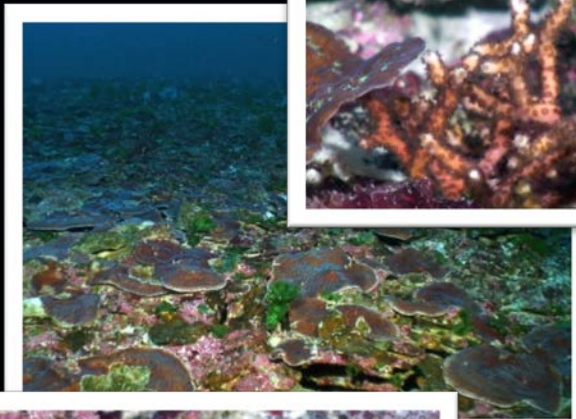
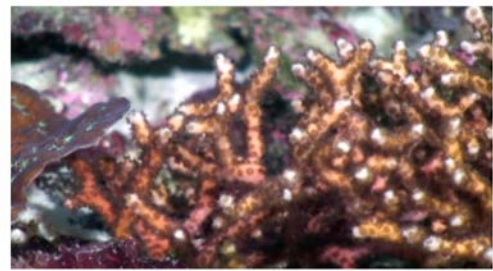
Overall Species Richness



Coral Community

Results

Scleractinia Identified at Pulley Ridge (60-105 m)



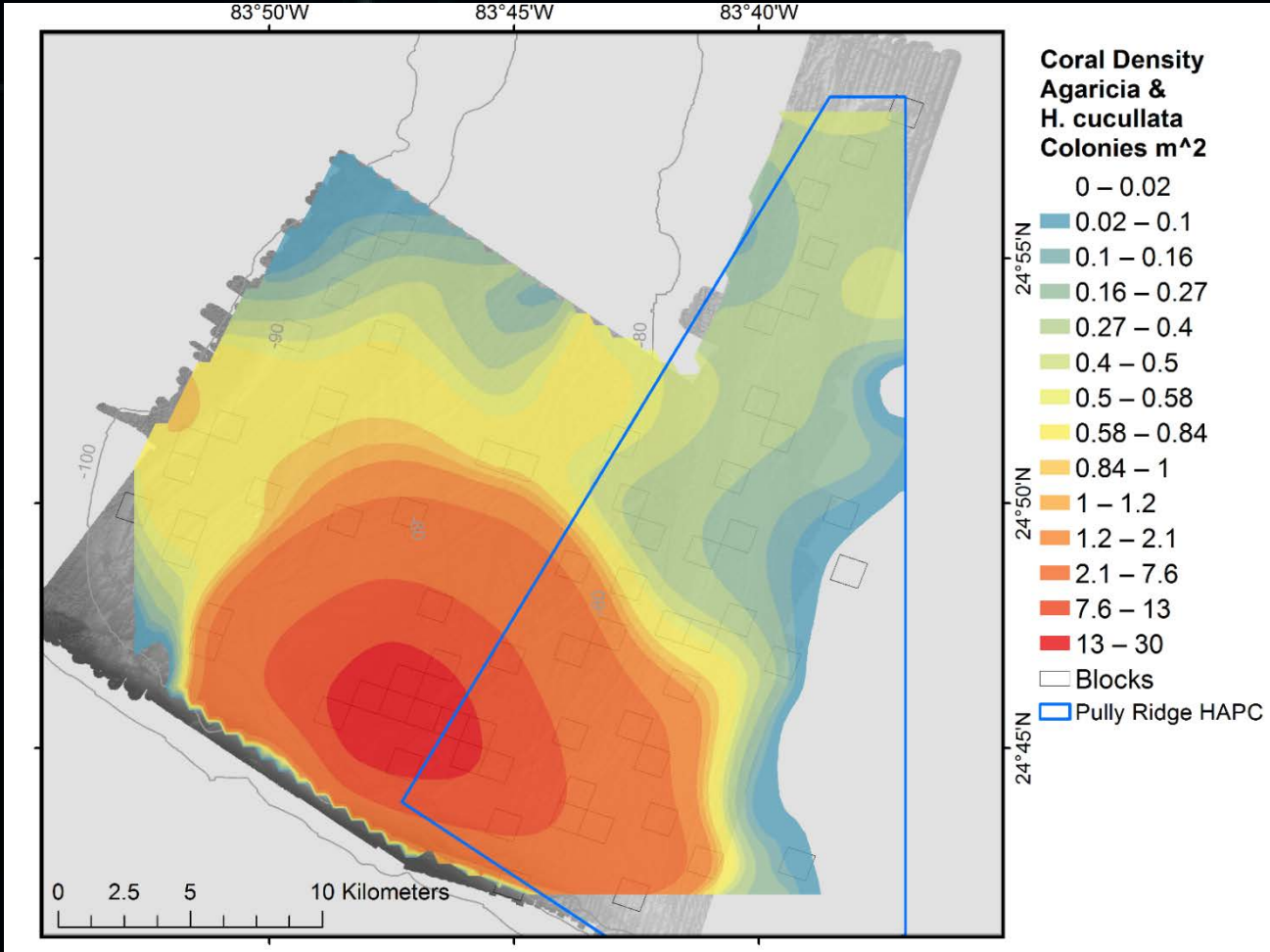
Class- Anthozoa

• Order- Scleractinia

- *Agaricia fragilis* Dana, 1848
- *Agaricia grahamae/ lamarcki* Wells, 1973
- *Agaricia undata* (Ellis & Solander, 1786)
- *Helioseris cucullata* (Ellis & Solander, 1786)
- *Madracis brueggemanni* (Ridley, 1881)
- *Madracis decactis* (Lyman, 1859)
- *Madracis formosa* Wells, 1973
- *Madracis myriaster* (Milne Edwards & Haime, 1850)
- *Madracis* sp. Milne Edwards & Haime, 1850
- *Montastraea cavernosa* (Linnaeus, 1767)
- *Oculina diffusa* Lamarck, 1816
- Scleractinia- unid colonial
- Scleractinia- unid solitary cup
- *Scolymia* sp. Haime, 1852

Kernel Smoothing Predication Model on Coral Density

Agaricia and *Helioseris* - 0-30 / m²
Central Basin South - Hot Spot

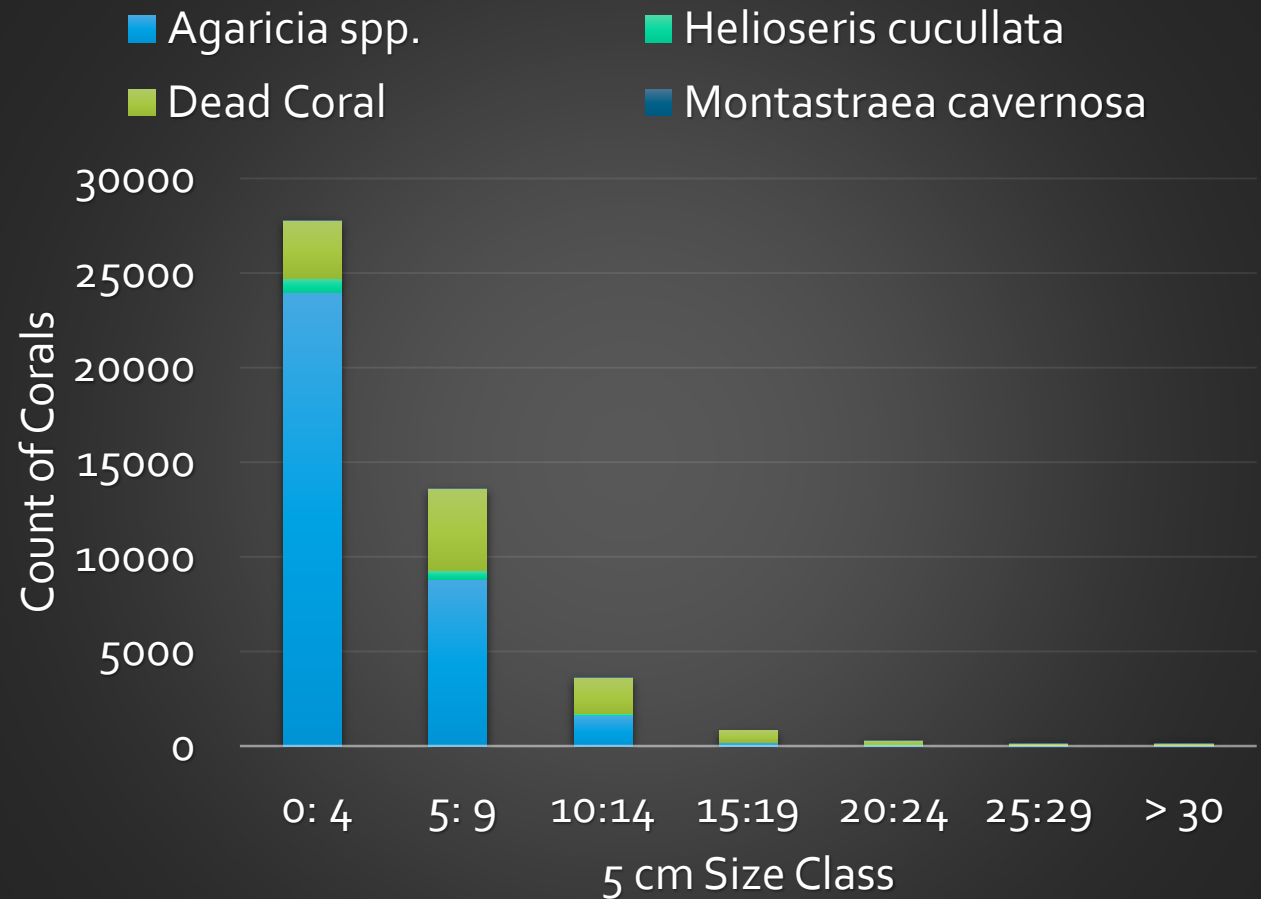


Distribution of corals by size

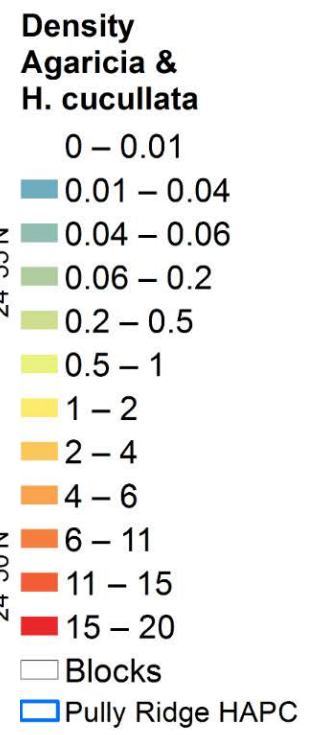
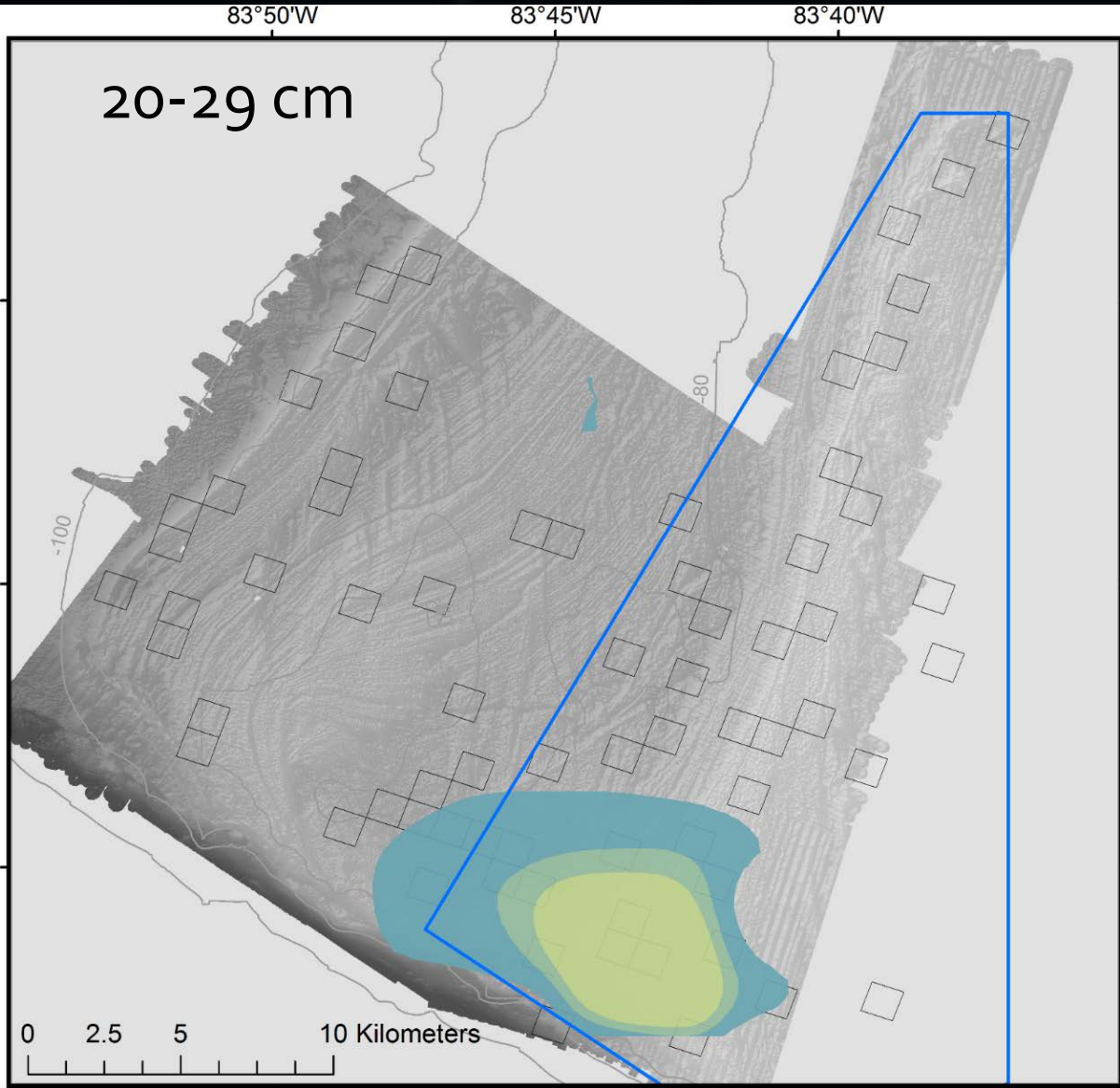
Coral Size

Distribution of Plate Corals by Size Class

- Distribution of plate corals by size class (5 cm increments)
- 68.7% <5 cm;
94.8% <10 cm diameter.



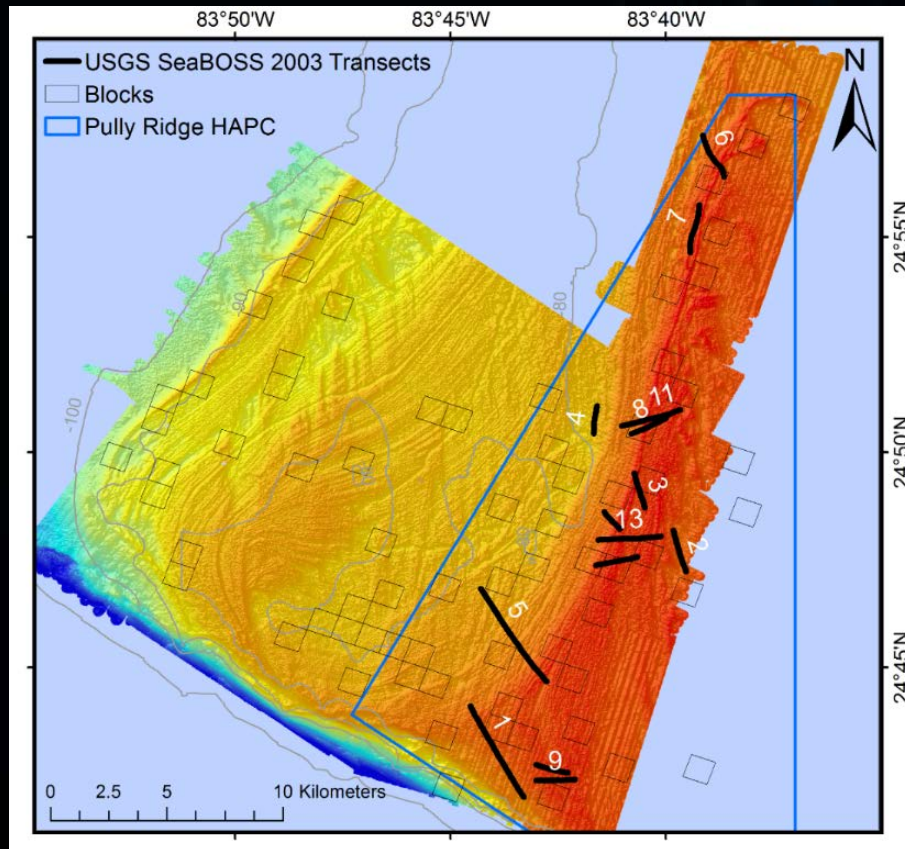
20-29 cm



Comparing Current Coral Cover to the Past

Changes Over Time

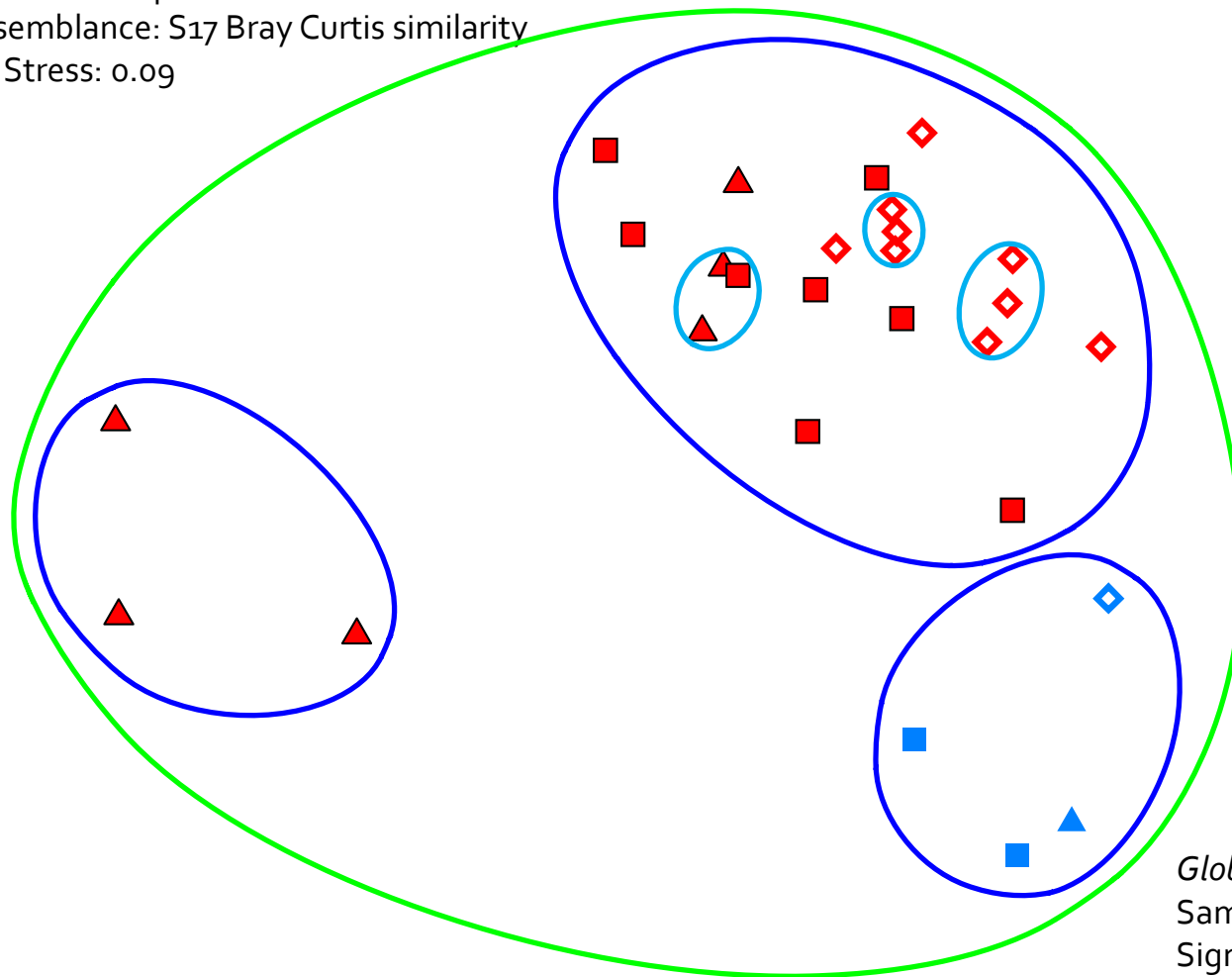
Long Term Stability, Changes & Resilience of Corals



- *1980's Bureau of Land Management*
- *2003 USGS Surveys*
- Same methodology as our surveys.
 - Using HBOI Code recoded 4 sites.
 - No lasers, so only % cover was completed



Transform: Square root
Resemblance: S17 Bray Curtis similarity
2D Stress: 0.09



Project Ridge

- ▲ HBOI MR-N
- HBOI MR-M
- ◆ HBOI MR-S
- ▲ USGS MR-N
- USGS MR-M
- ◆ USGS MR-S

Similarity

- 40
- 60
- 80

Global Test

Sample statistic (Global R): 0.583

Significance level of sample statistic: 0.4%

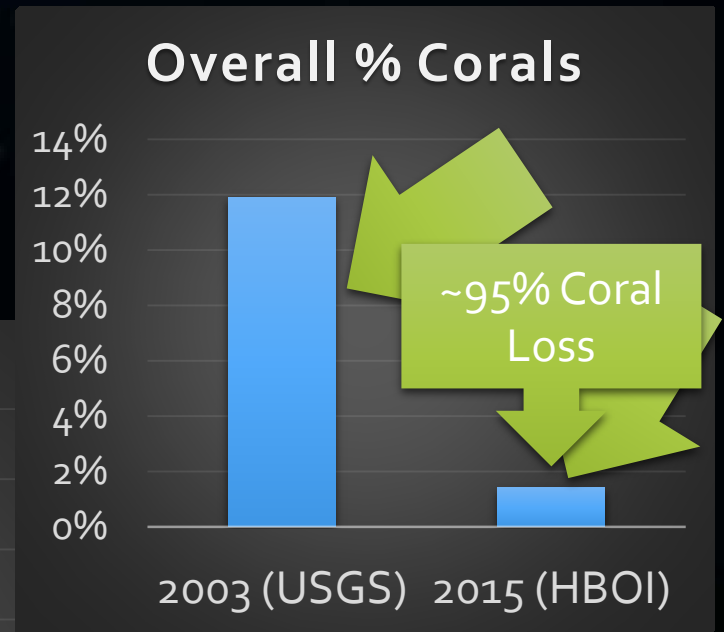
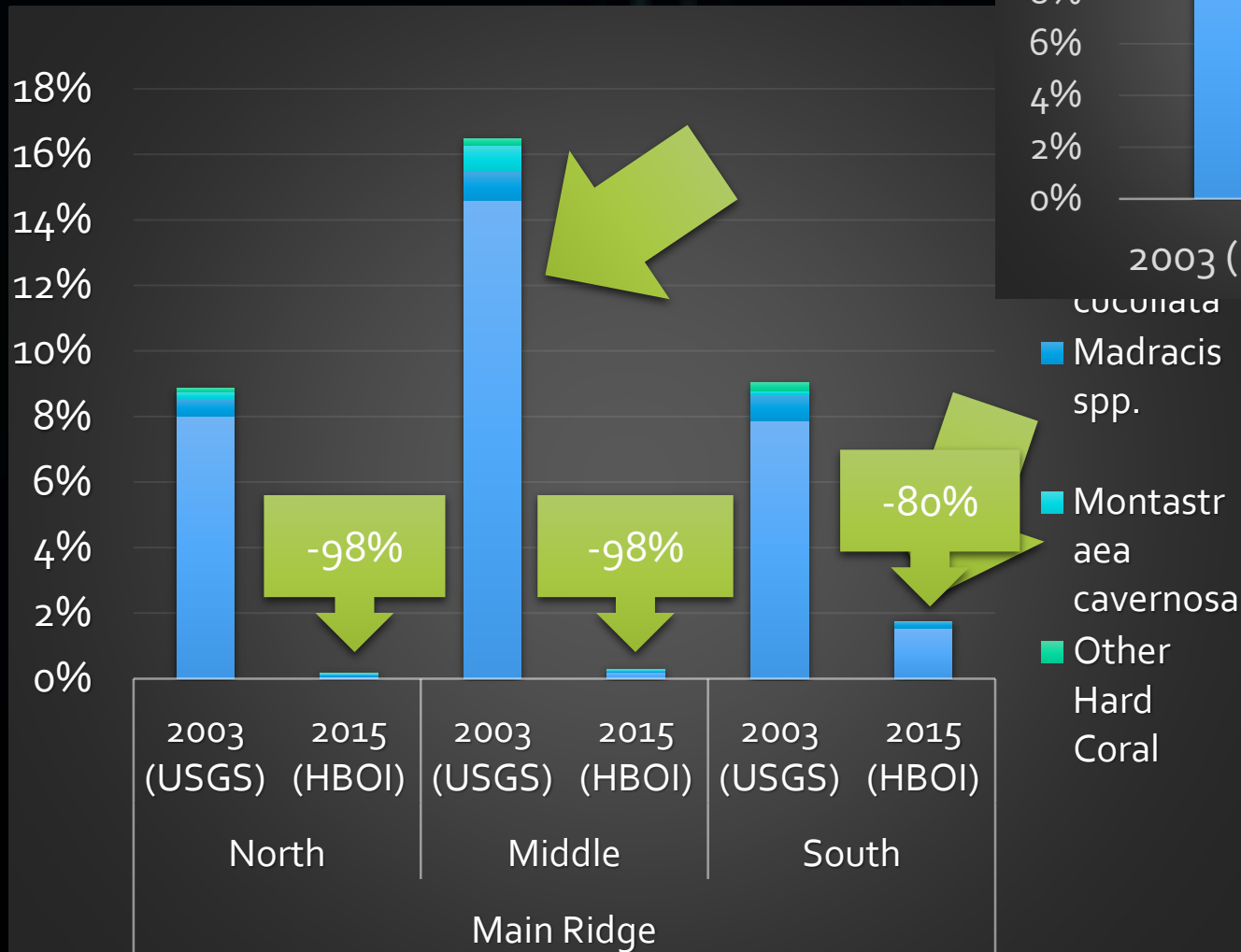
Species Differences 2003 to 2015

- Increase in Algae Average Abundance

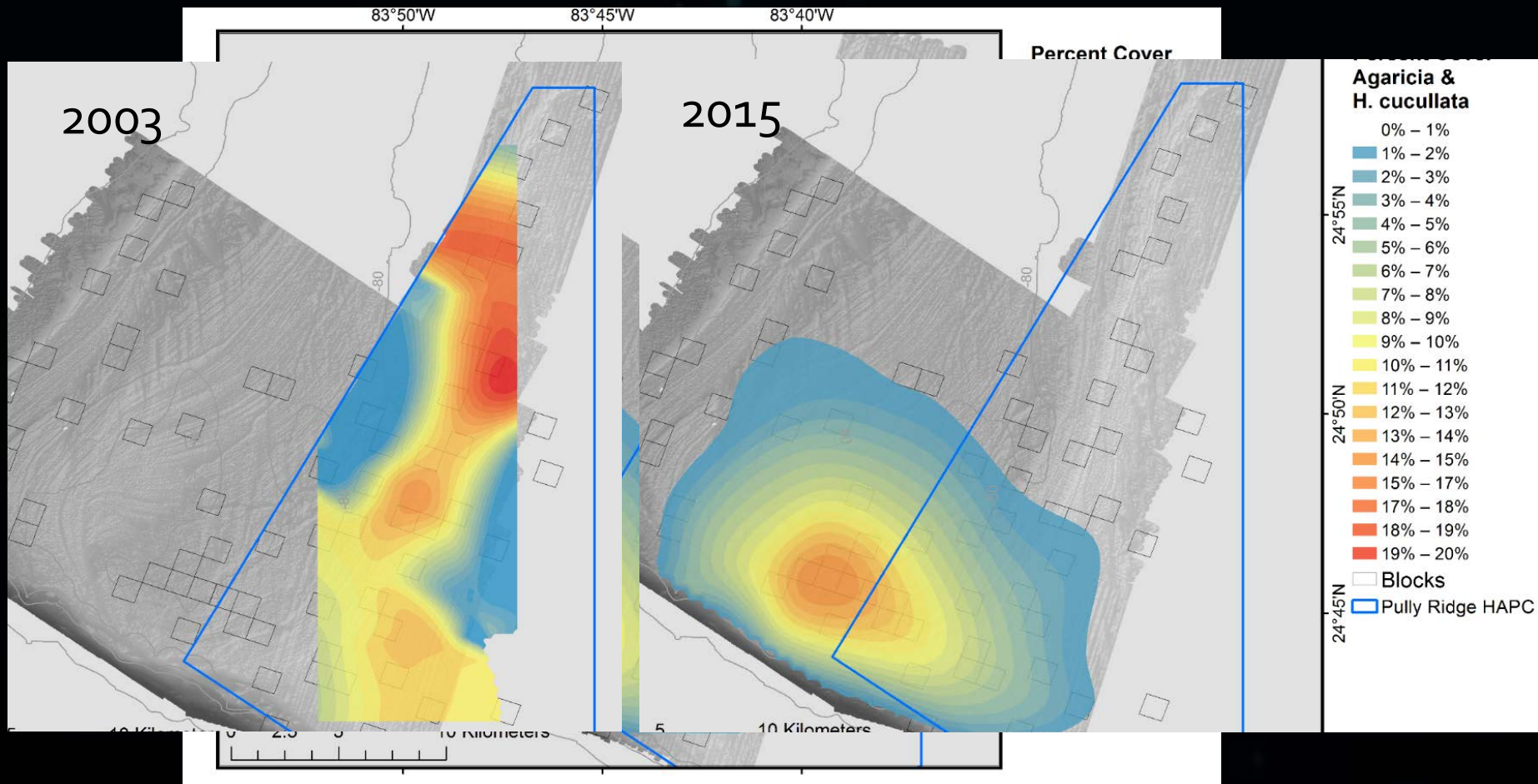
- Decrease in Corals Average Abundance



Percent Cover Coral



Coral % Cover Over Time

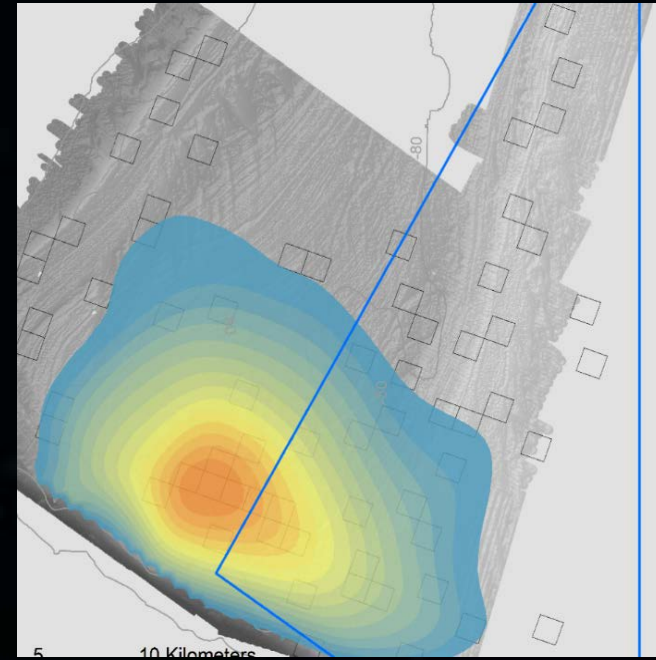
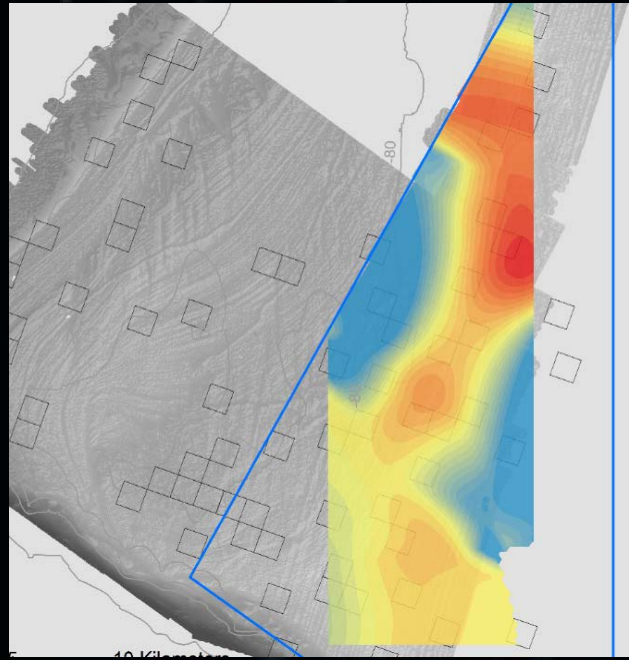


Potential Causes on Pulley Ridge in 30 Year Period

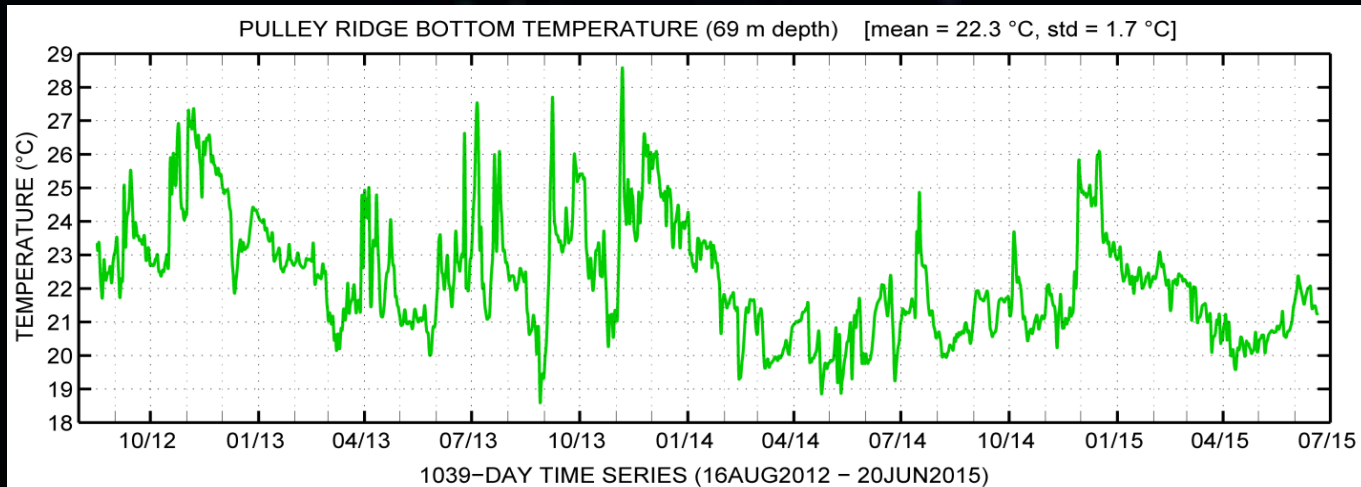
Coral Loss

Potential Causes of Coral Loss

- 95% Coral Loss from 2003 to today
- Central Basin has explosive new coral growth.

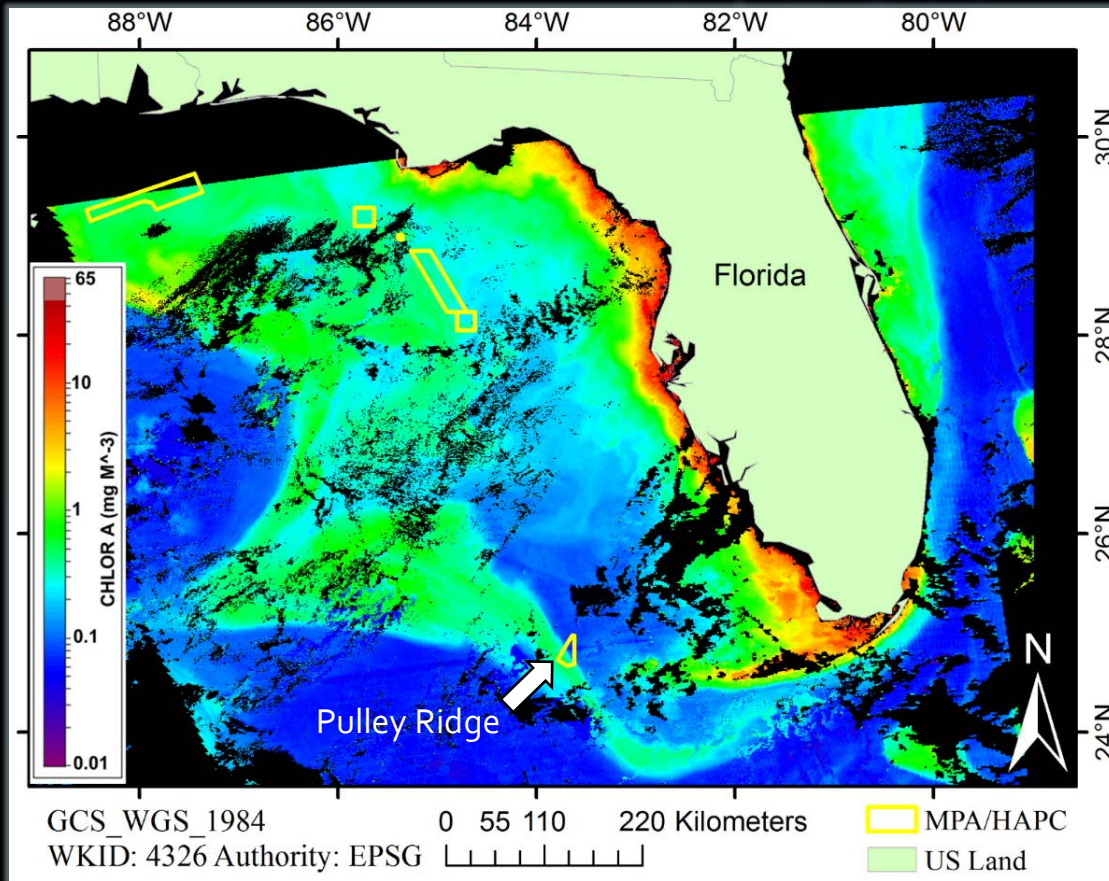


Climate Change and Bleaching Events



- 3 Yr CTD Record-
 - 18.47 (Aug) to 28.48°C (Nov.) and averaged 23°C (Ryan Smith, NOAA/AOML).
- Cold water upwelling events from Loop Current and nearby Florida shelf escarpment
- Florida Keys have had cold water events dropping shallow water reefs to 13°C causing coral death.

Sedimentation and River Runoff



- Satellite imagery from NOAA VIIRS chlorophyll A sensor
- Satellite imagery shows the clear influence of the Mississippi River plumes, over 375 miles away over Pulley Ridge

(Hine et al. 2008; CoastWatch, 2015).

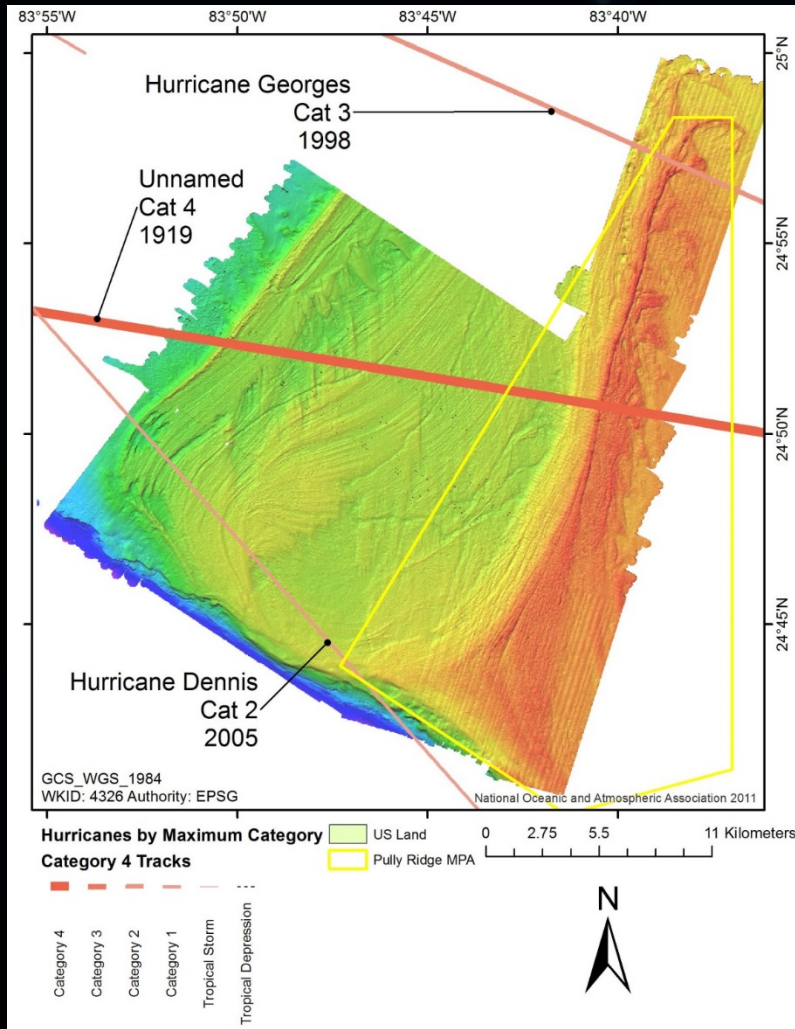
Deepwater Horizon Oil Spill



- In 2010, HBOI-CIOERT conducted *Johnson-Sea-Link II* (JSL) submersible dives to survey the mesophotic reefs all along the west Florida shelf
- We saw no visible evidence of oil on any of the MCEs along the west Florida shelf or Pulley Ridge, 340 nmi away from the wellhead.

Reed & Rogers 2011

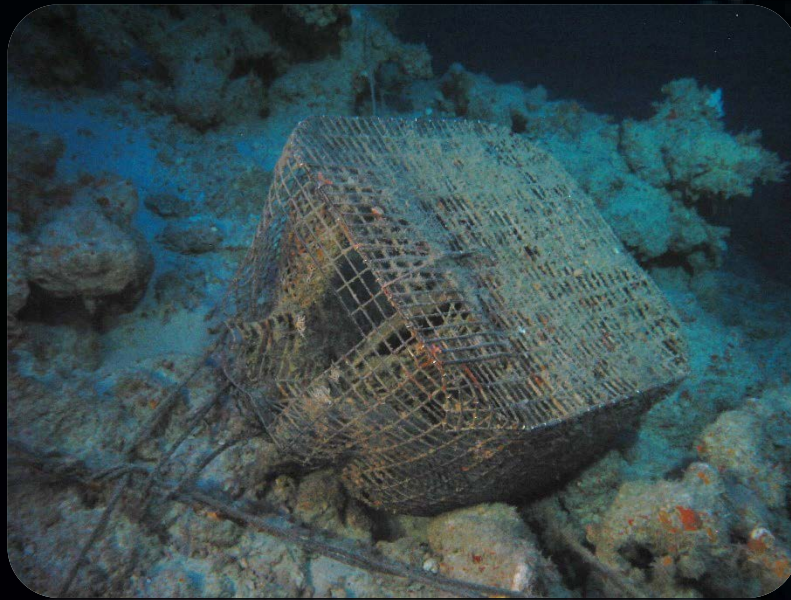
Hurricanes



- 339 hurricanes passed through eastern GOM since 1900
- Major Hurricanes to cross Pulley Ridge
 - 1998- Cat 3
 - 2005 (after USGS survey)- Cat 2
- In 2012 Hurricane Isaac (Cat 1) crossed directly over Pulley Ridge
 - No visible damage
 - Bottom ADCP current records never exceeded 50 cm/s.

(Bongaerts et al. 2013. NOAA 2016)

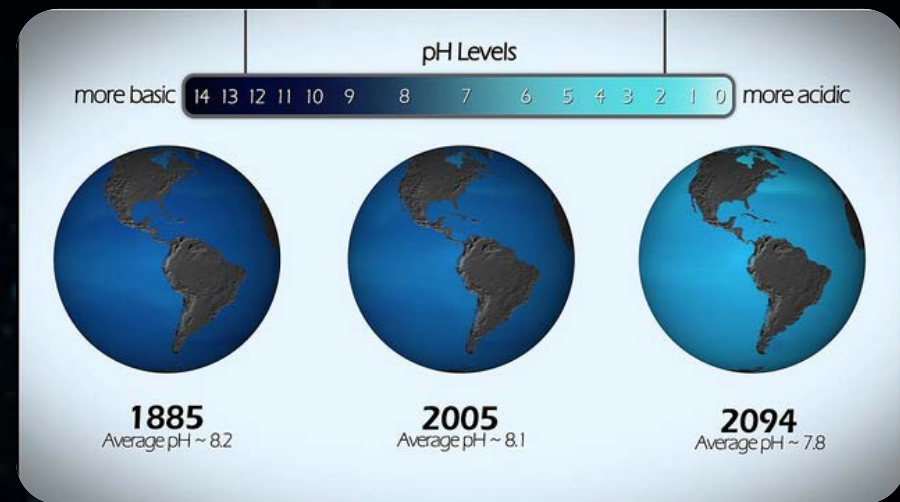
Fisheries



- MCEs are just as prone as shallow water reefs to damage from overfishing
- With GPS even these deep and far offshore mesophotic reefs can be easily targeted
- There is documentation that Trawling has destroyed MCEs

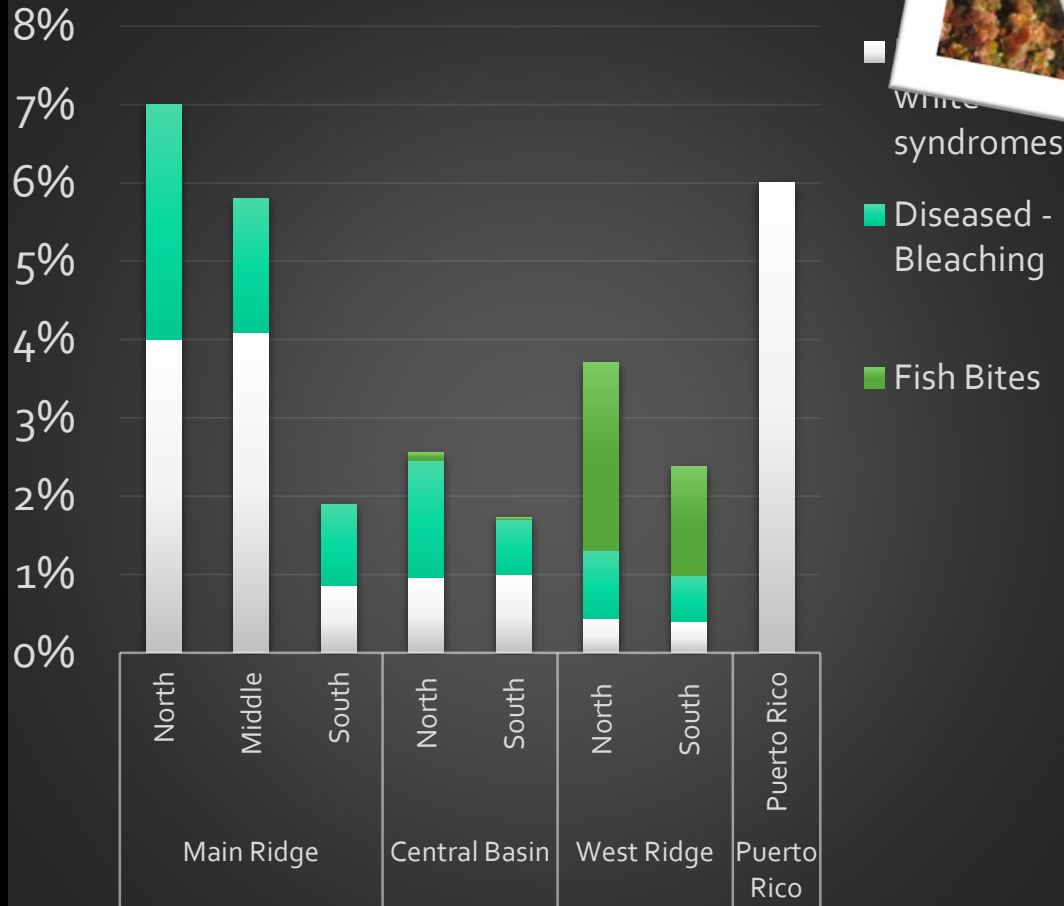
Ocean Acidification

- The impact of ocean acidification on carbonate reef building species is well known
- Acidification is expected to impact MCEs worldwide



<http://c-can.msi.ucsb.edu/>

Disease



- Recent surveys indicate that mesophotic coral communities are indeed susceptible to biotic diseases.
- Only 1.76% of the corals showed signs of bleaching or disease (primarily some white syndrome).
- Main Ridge North had the highest % of White Syndrome and bleaching



- Lionfish are now prevalent throughout the Pulley Ridge HAPC and in particular associated with red grouper burrows– depopulating the small and juvenile reef fish?

Invasive Lionfish

- Lionfish on Pulley Ridge
- 53 Lionfish
- 1 Grouper



Trophic Cascade and Lionfish

Lionfish

Small Herbivorous Fish

Algal Cover

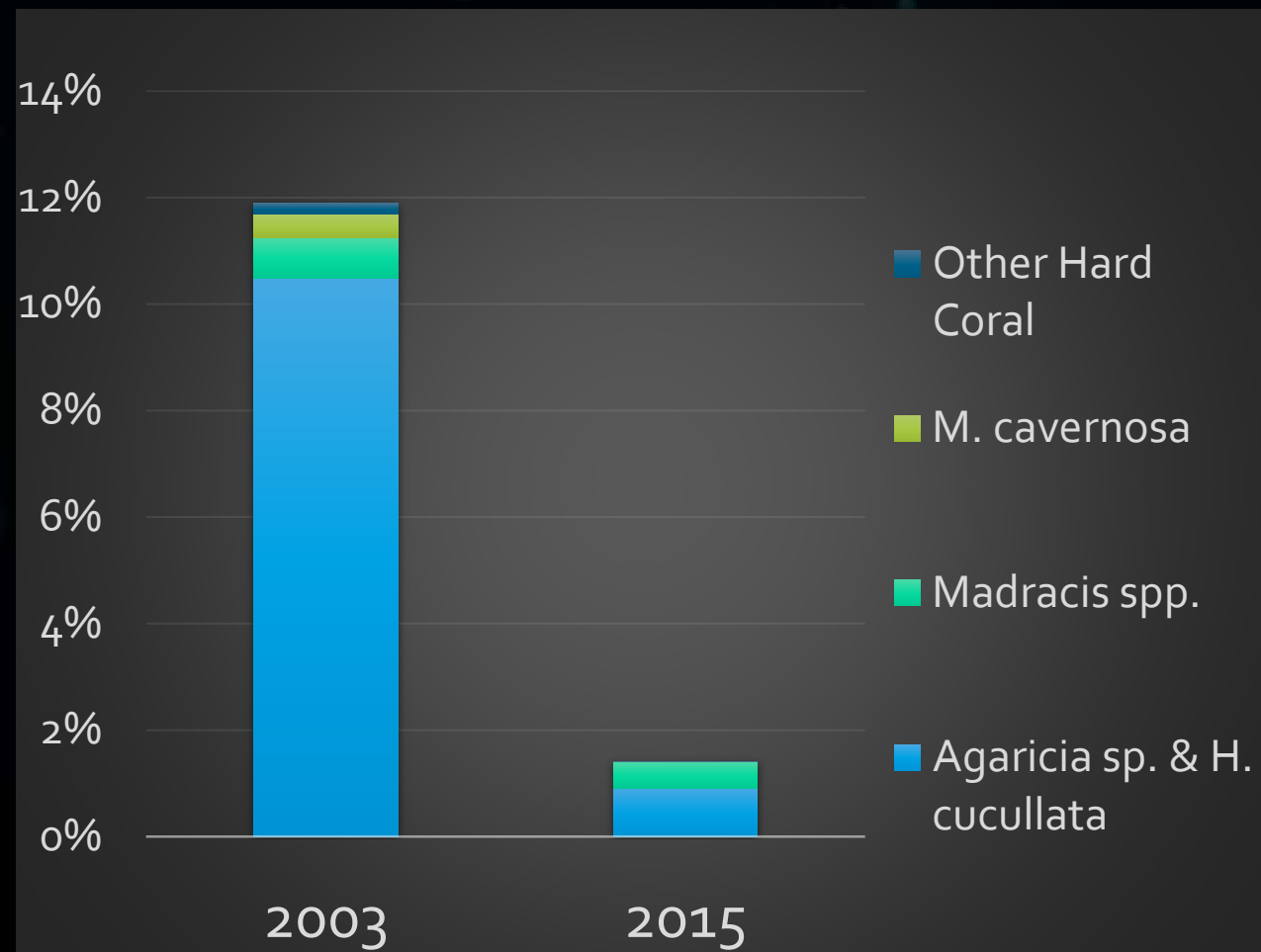
Corals



Smoking Guns?

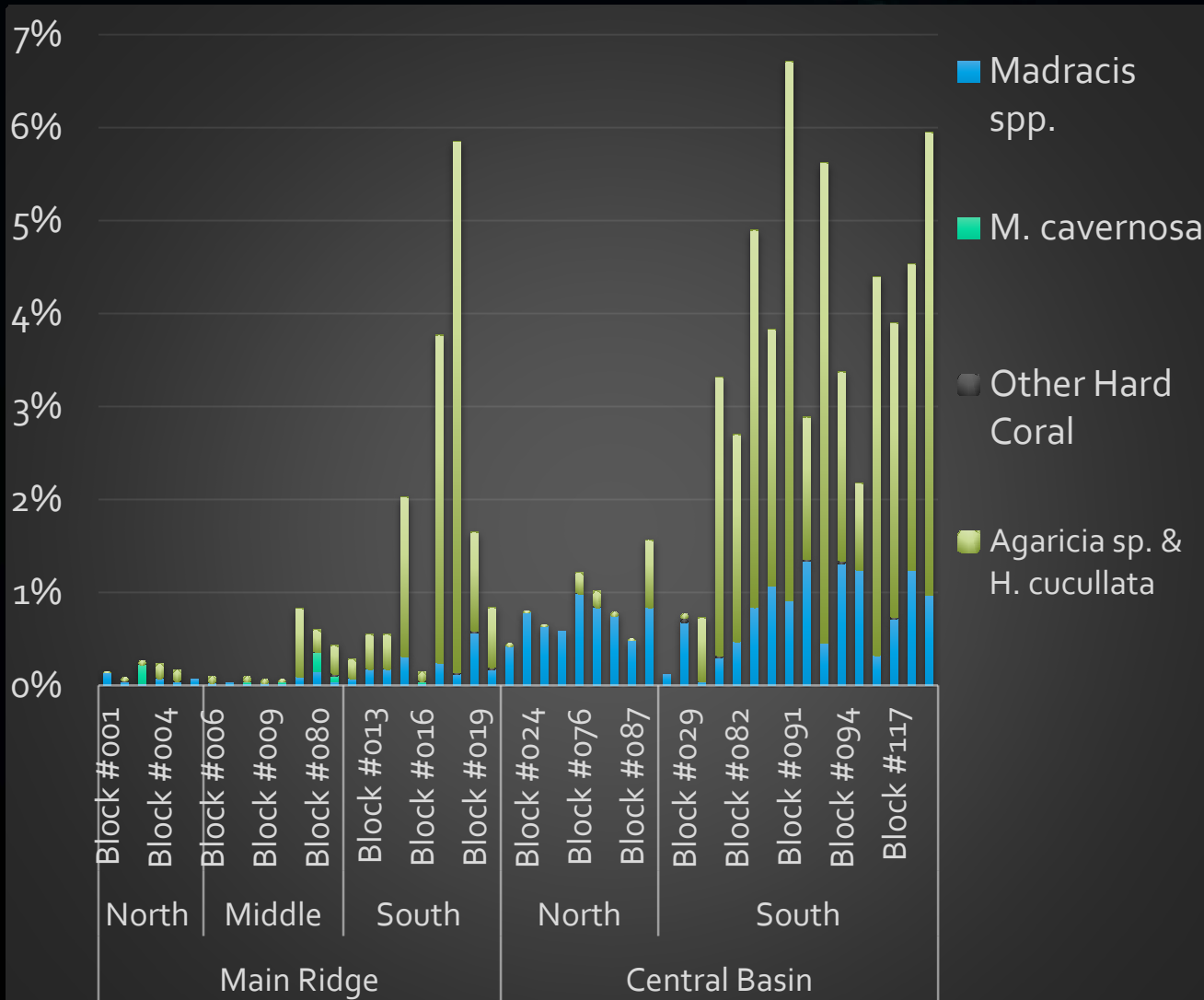
Conclusions

Conclusions



- Comparing the 2003 year USGS data with our data of 2012-2015:
 - ~95% loss of coral cover!
- There is no smoking gun:
 - could have been disease outbreak, cold water upwelling event, or hurricane loss or lionfish caused trophic cascades?

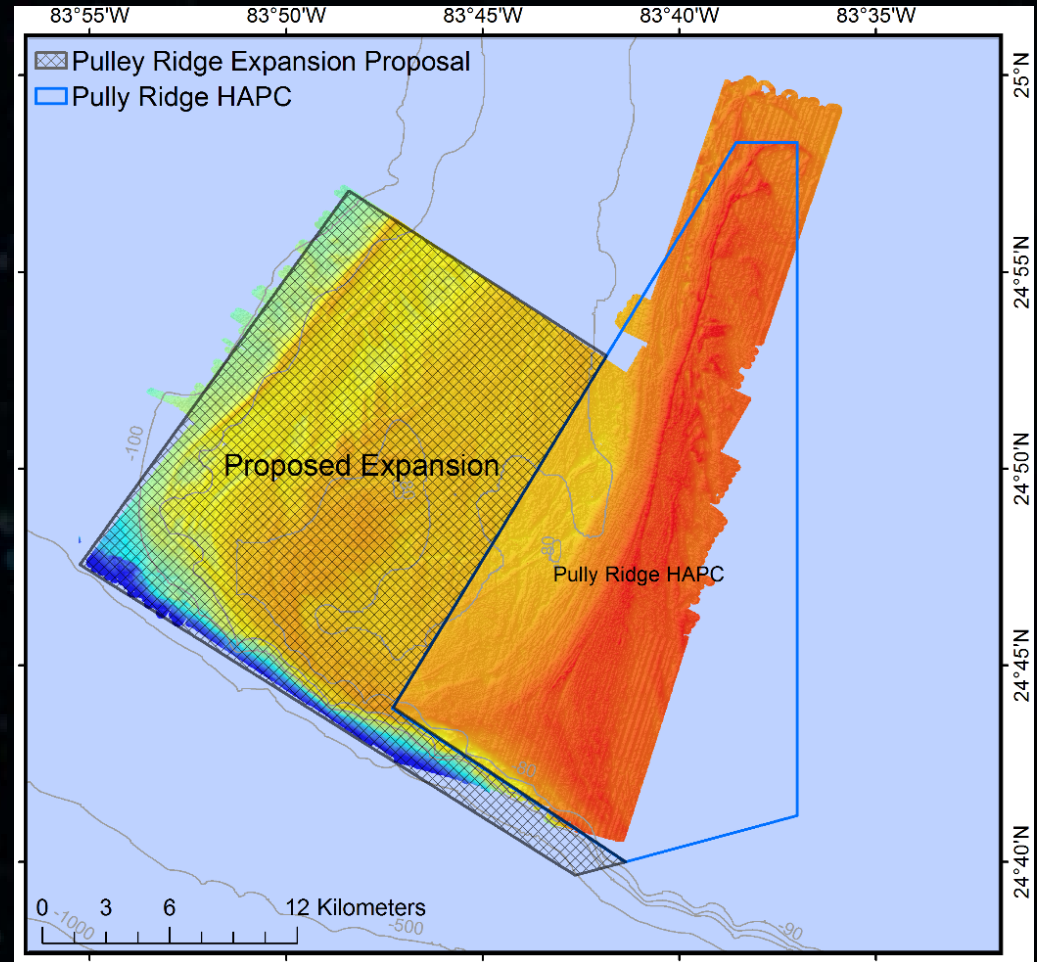
Resilience of the Coral Community at PR MCE



- Resilience- A clear shift in the epicenter of the major coral density also occurred in that 10 year period.
- Coral cover is now greatest in Central Basin South (average 3.5% cover, maximum 6.71% by block).
- 94.8% of the coral at this new epicenter are <10 cm diameter (68.7% <5 cm). Clearly a new coral settlement within the past 10-15 years.

Proposal for New MPA at Pulley Ridge and Florida Keys National Marine Sanctuary

Reed, J. and S. Farrington. 2014. Proposed HAPCs/MPAs for mesophotic and deepwater coral/sponge habitat and essential fish habitat in the eastern Gulf of Mexico. A proposal to the Gulf of Mexico Fishery Management Council. GOMFMC Webinar, September 22, 2014. 38 pp. Harbor Branch Oceanographic Technical Report Number 152.



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- The following Taxonomists have helped species verifications: Cnidaria- S. Cairns, P. Etnoyer, C. Messing, J. Voss, M. Nuttall, D. Opresko, C. Moura, J. Reed, R. Turner, J. Thoma, J. Lang; Porifera- S. Pomponi, C. Diaz, P. Cardenas.
- The NOAA Cooperative Institute for Ocean Exploration, Research and Technology (CIOERT) at Harbor Branch Oceanographic Institute, Florida Atlantic University (FAU)
- Crew of the University of Miami Ship *R/V Walton Smith*
- UNCW Underwater Vehicles Program, ROV pilots: Lance Horne and Jason White
- Cruises were conducted in collaboration with: the University of Miami (Drs. Robert Cowen, Peter Ortner), HBOI-CIOERT, NOAA Fisheries (Andy David, Stacey Harter), Florida State University Coastal and Marine Laboratory (Drs. Felicia Coleman and Chris Koenig), The University of North Carolina at Wilmington, The Florida Keys National Marine Sanctuary, The Gulf of Mexico Fisheries Management Council, and The Flower Gardens National Marine Sanctuary.



Any Questions?

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