Understanding Coral Ecosystem Connectivity in the Gulf of Mexico: Pulley Ridge to the Florida Keys

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Pulley Ridge Project

- **Funding**
  - NOAA National Centers for Coastal Ocean Science
  - NOAA Office of Ocean Exploration and Research
  - NOAA Office of Oceanic and Atmospheric Research
- **Managed through two NOAA Cooperative Institutes**
  - CIMAS – UM
  - CIOERT – FAU/HBOI
- 25+ PIs, 9 Institutions plus 2 NOAA labs
- **NOAA Program Manager**
  Kimberly Puglise

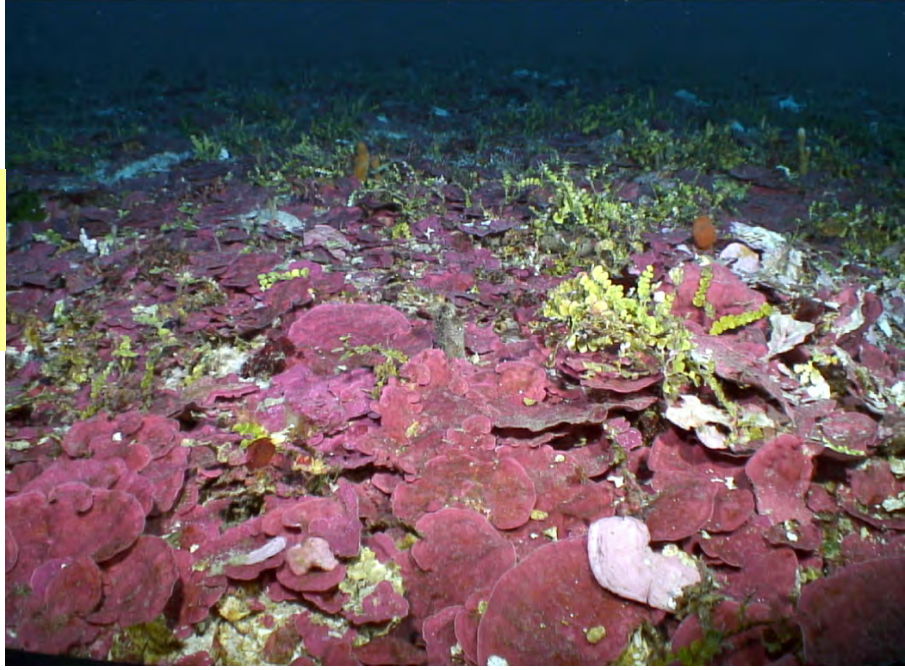
Talk Outline

- **Mesophotic Coral Ecosystems 101**
- **Pulley Ridge 101**
- **Results of Initial Project Objectives**
  - **Assessing Community Structure**
  - **Understanding Population Connectivity**

Mesophotic Coral Ecosystems (MCEs)

WHAT ARE THEY AND WHERE ARE THEY FOUND?

- Light-dependent coral ecosystems
- Depths: 30-40 m to over 100 m in the Atlantic, 150 m in Pacific Ocean
- Found in tropical and subtropical regions
- Dominant communities can be coral, algae, and sponge species



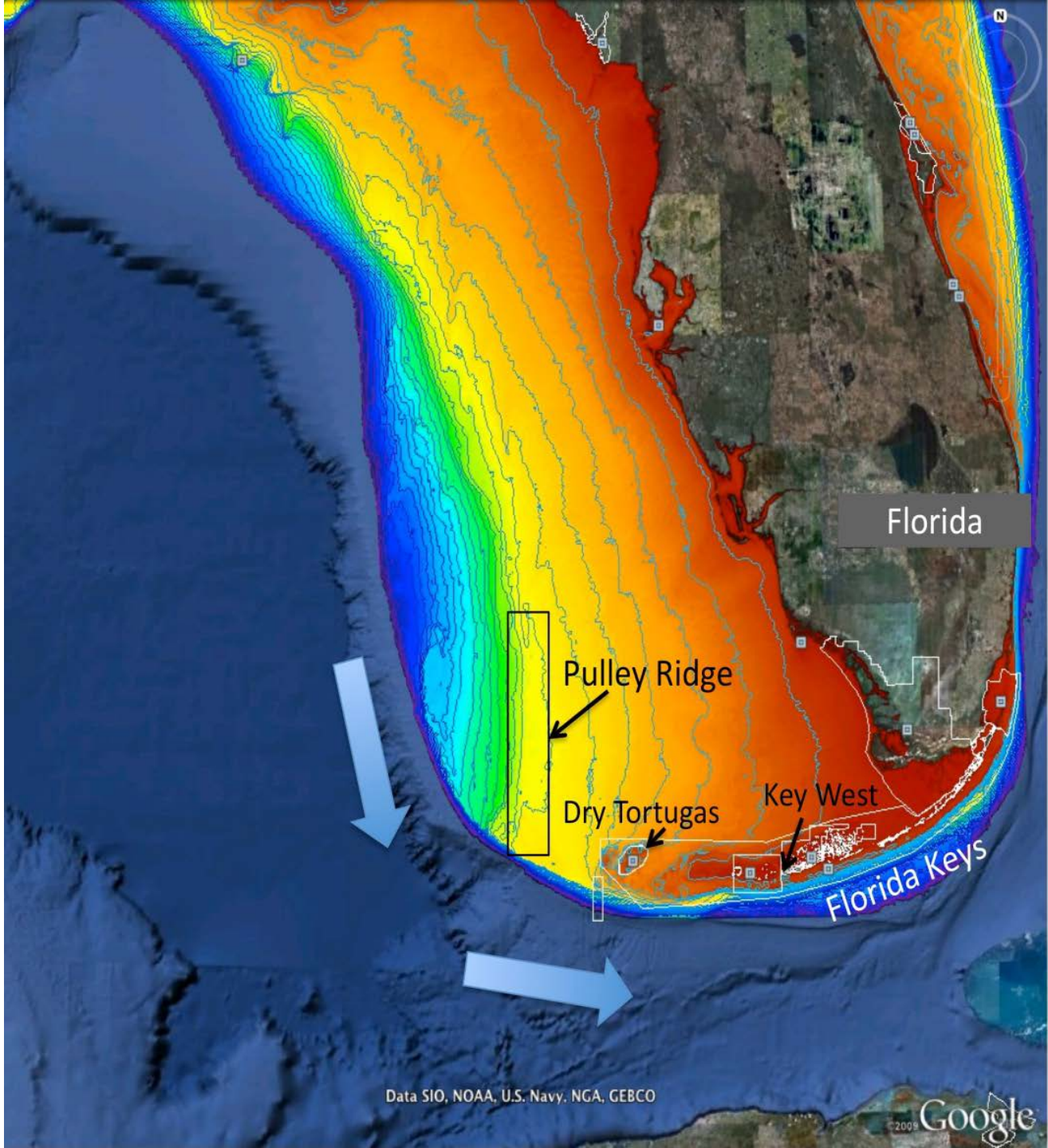
Mesophotic Coral Ecosystems (MCEs)

WHY ARE THEY IMPORTANT?

- In shallow waters of the Caribbean Region, documented coral decline of up to 80% over the last 30 years
- In some locations there is several times as much MCE habitat as there is shallow.
- They appear to be healthier than shallow water reefs.
- Habitat for commercially and ecologically important fishes and invertebrates.
- Possible source of coral & fish larvae for recruitment and potential recovery of downstream reef areas.

Pulley Ridge

- Located 250 km NW of Cape Sable, 50 km NW of the Dry Tortugas.
- The ridge is 300 km long by 15 km wide
- It's southern 30 km is the deepest known *mesophotic coral ecosystem* off the continental U.S.



Pulley Ridge: Discovery and Research History

- Since late 19thc well known to local fishermen
- 1950s - “Discovered” by scientists
- 1980s – SW Fla. Shelf Ecosystems Study (MMS) just 2 stations
- 1999-2003 – “Sustainable Seas” survey (USGS, NOAA, ONR)
- 2005 – Made Habitat Area of Particular Concern (HAPC)
- 2010 – NOAA CIOERT cruise to survey deep reefs that may be impacted by Deepwater Horizon
- 2011-2018 – Coral Ecosystem Connectivity Project
- 2018 – Gulf of Mexico Fishery Management Council voted to expand HAPC to incl. Central Basin and West Ridge

Pulley Ridge

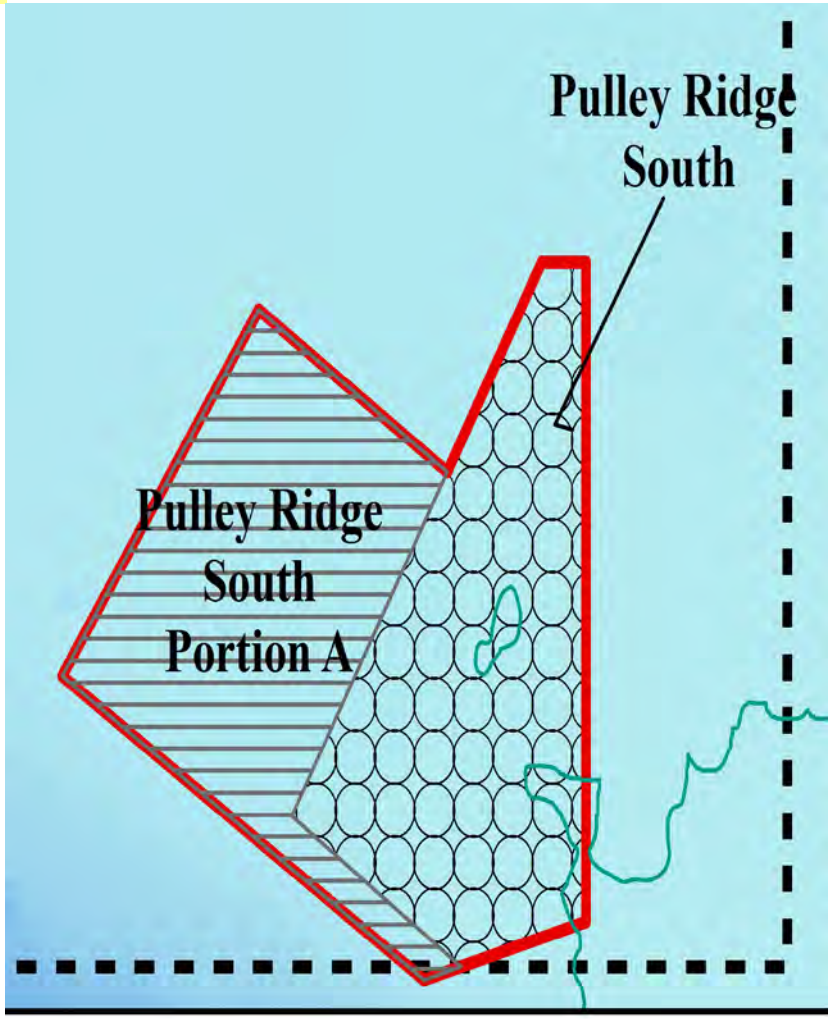
2018 HAPC Expansion

HAPC (South)– 2005

No bottom anchoring by fishing vessels, no bottom fishing gear (trawls, longlines, buoy gear, and traps/pots)

HAPC (South, Portion A)– 2018

Same except bottom longlining is allowed



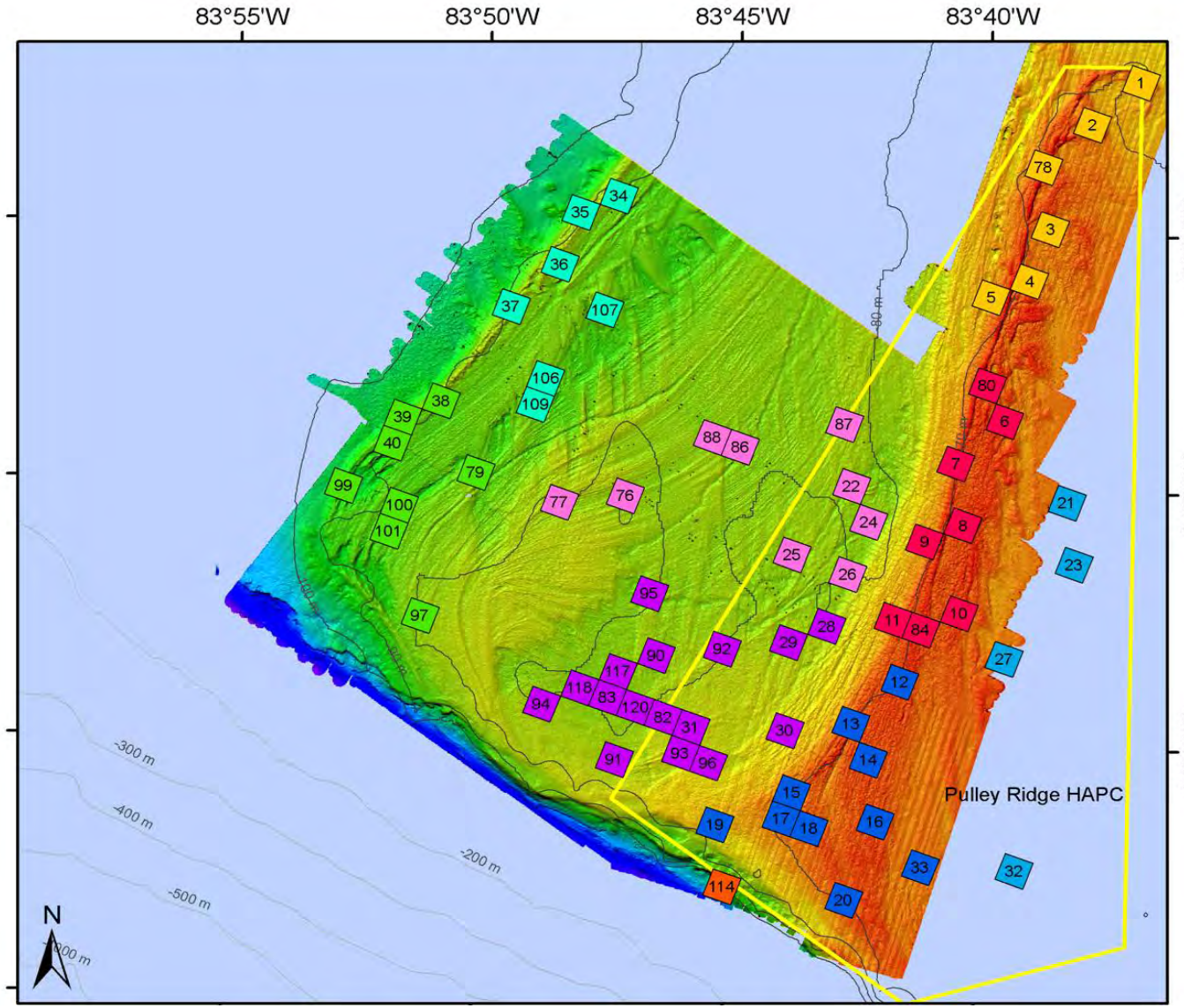
Coral Ecosystem Connectivity Project

Project Objectives

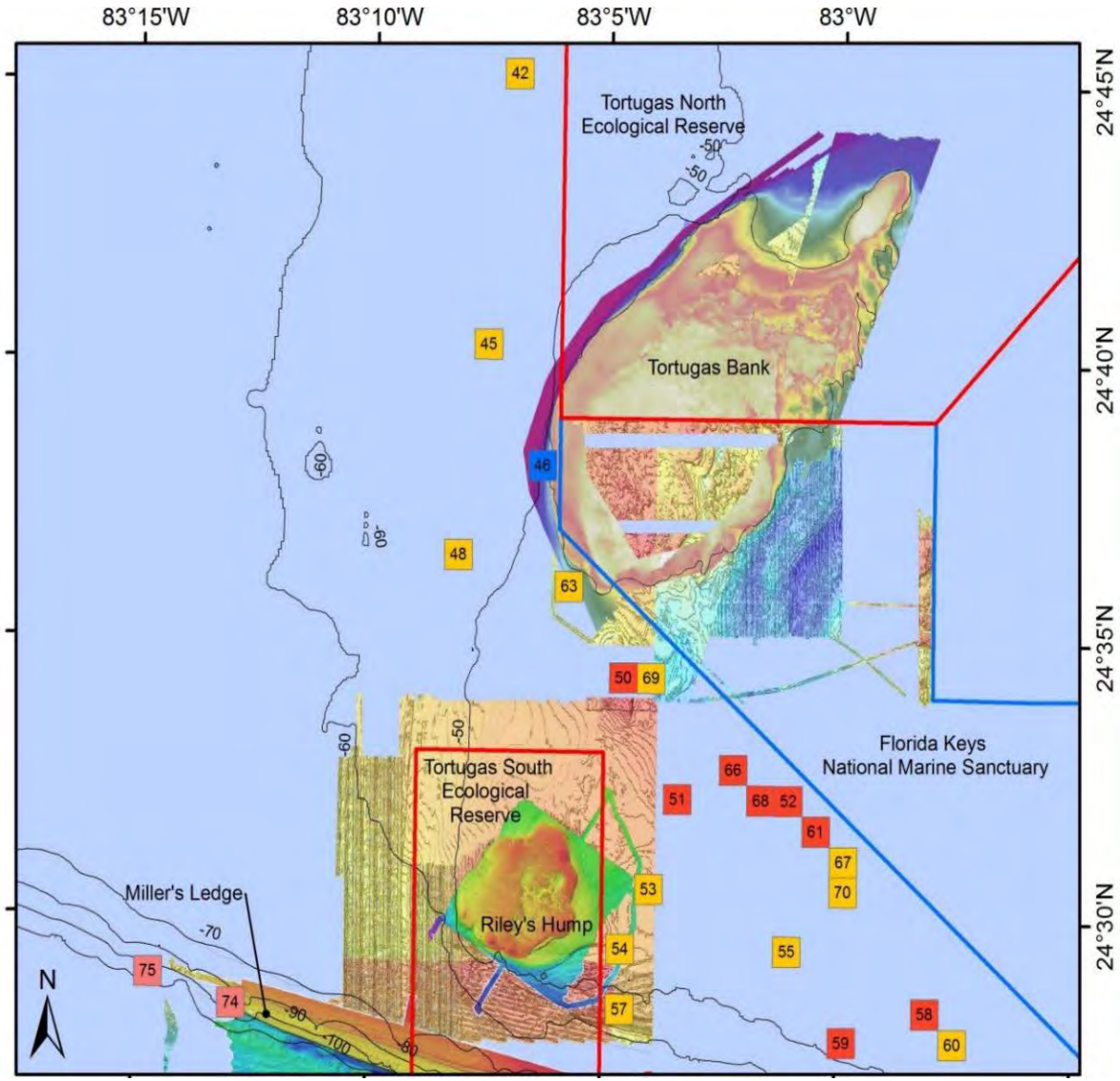
- **Assess Community Structure**
  - Benthos (algae, coral, sponges)
  - Fish populations
- **Understand Population Connectivity**
  - Spatial
  - Vertical (Deep ←→ Shallow)
- Estimate ecosystem value and cost/benefits of specific management alternatives
- Provide Tools for Resource Managers

Objective: Assessing Community Structure

Pulley Ridge (59–105 m)



Dry Tortugas (23–55 m)



Pulley Ridge Images Video

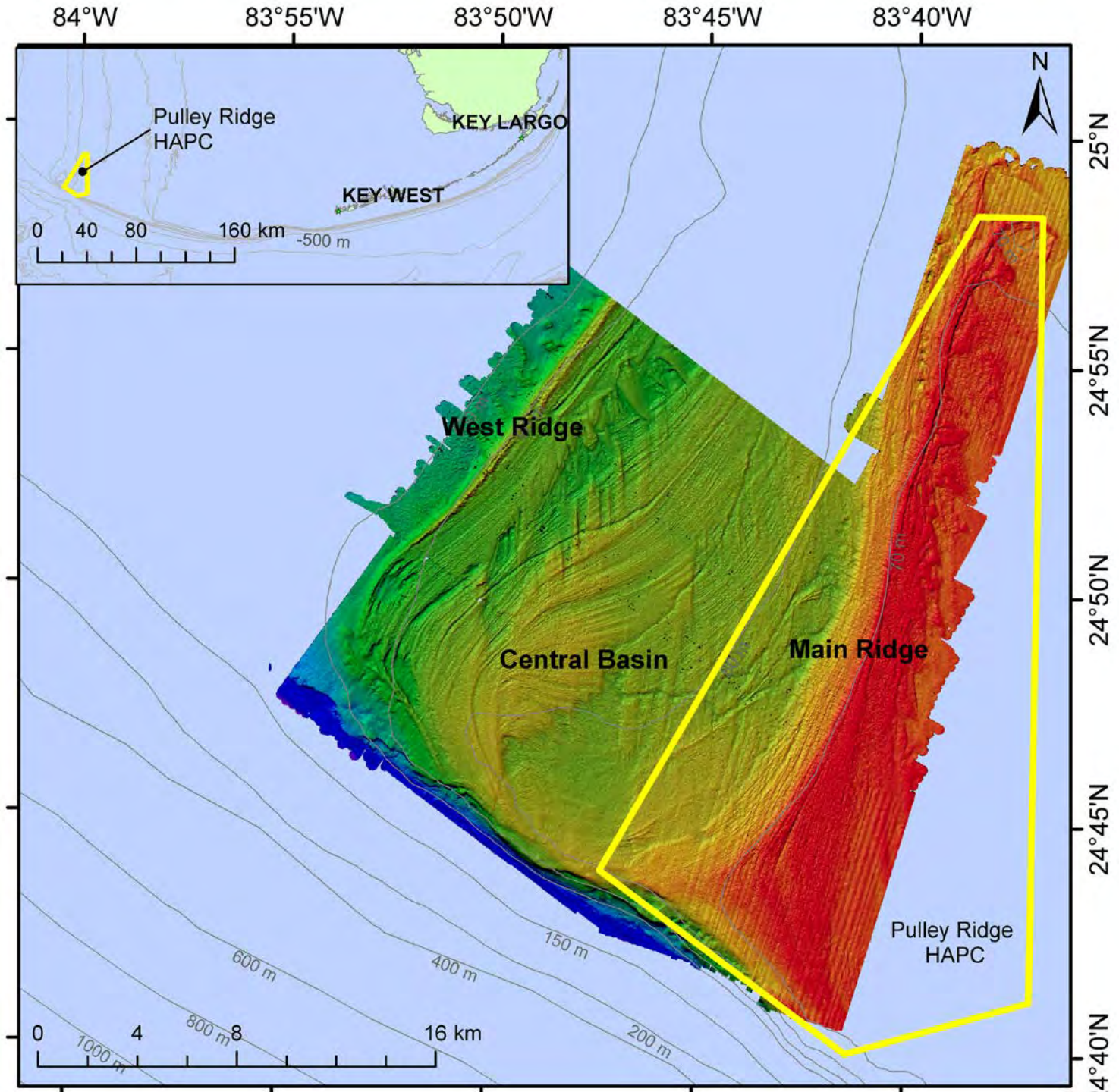
https://coastalscience.noaa.gov/news/final-report-released-floridas-mesophotic-coral-reefs-video/.

Pulley Ridge

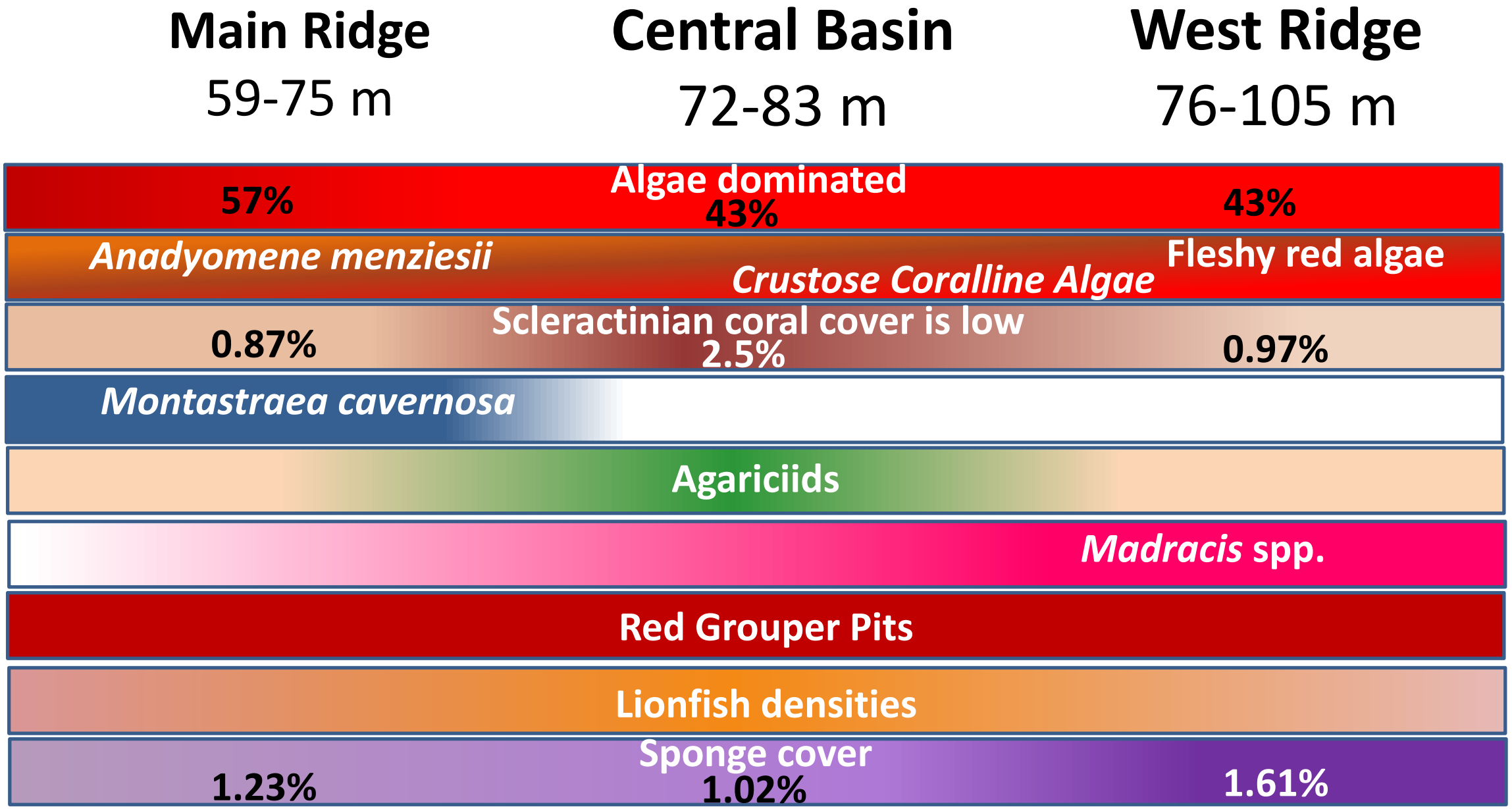
3 Locations

- Main Ridge (59-75 m)
- Central Basin (72-83 m)
- West Ridge (76-105 m)

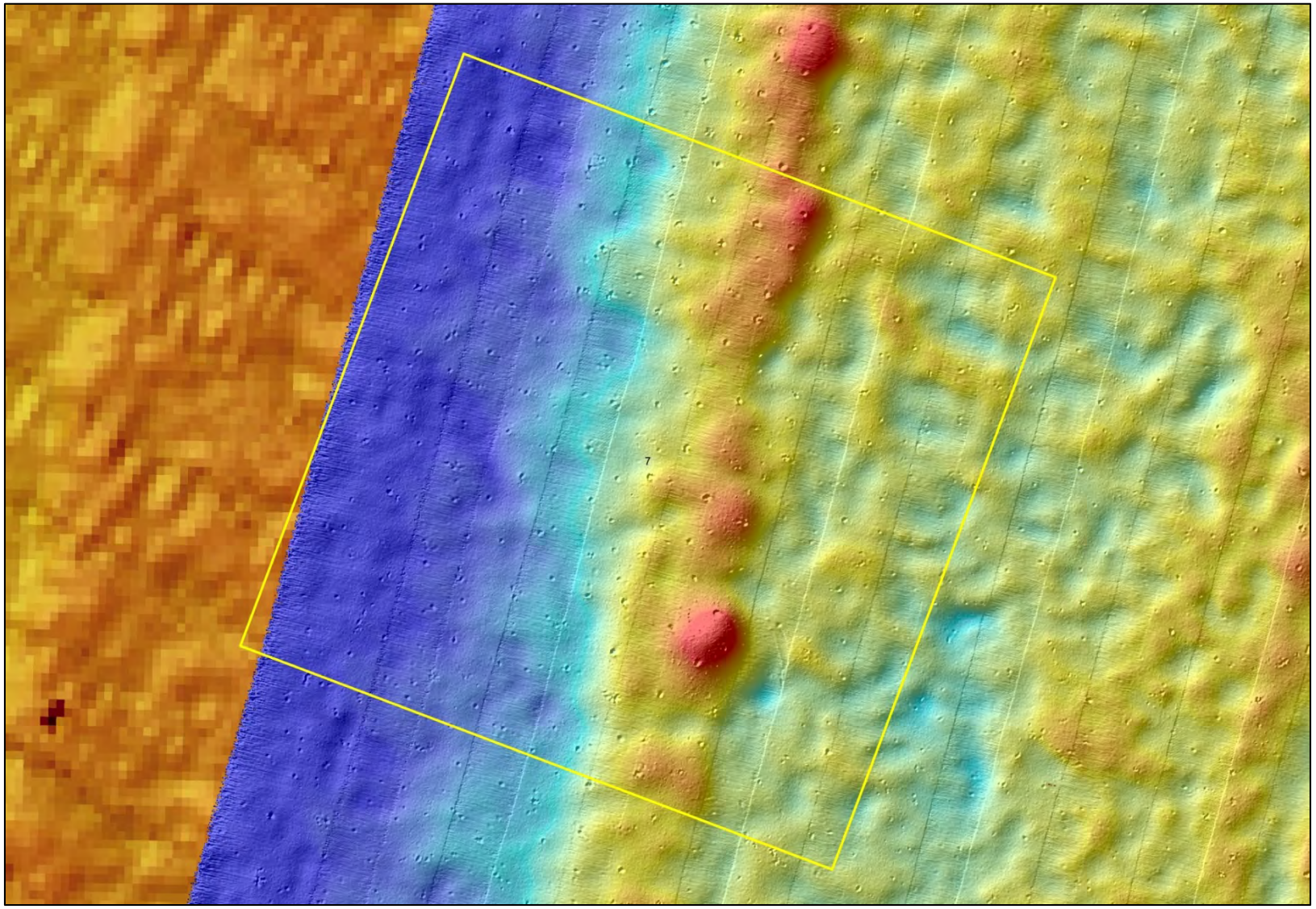
HAPC (2005)=yellow box



Pulley Ridge Community Summary

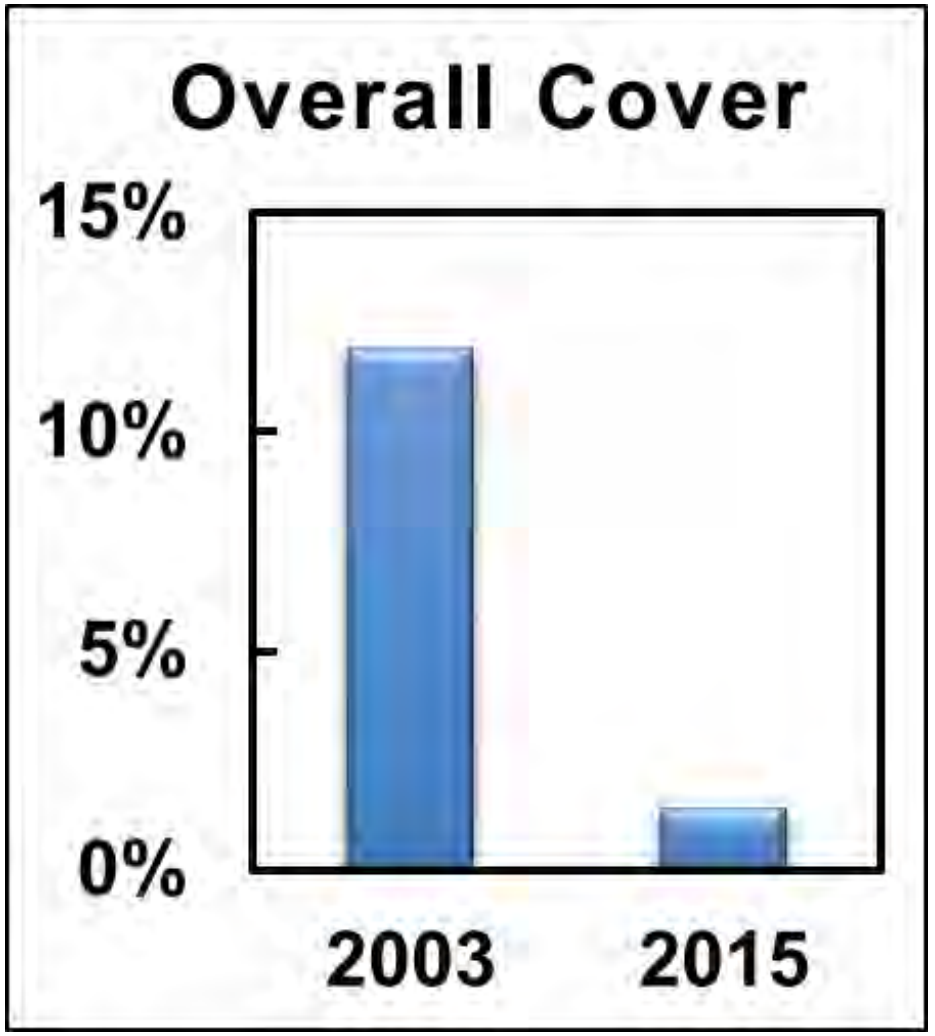


Multibeam Sonar Map Showing Red Grouper Burrows (10-m diameter) at Pulley Ridge HAPC



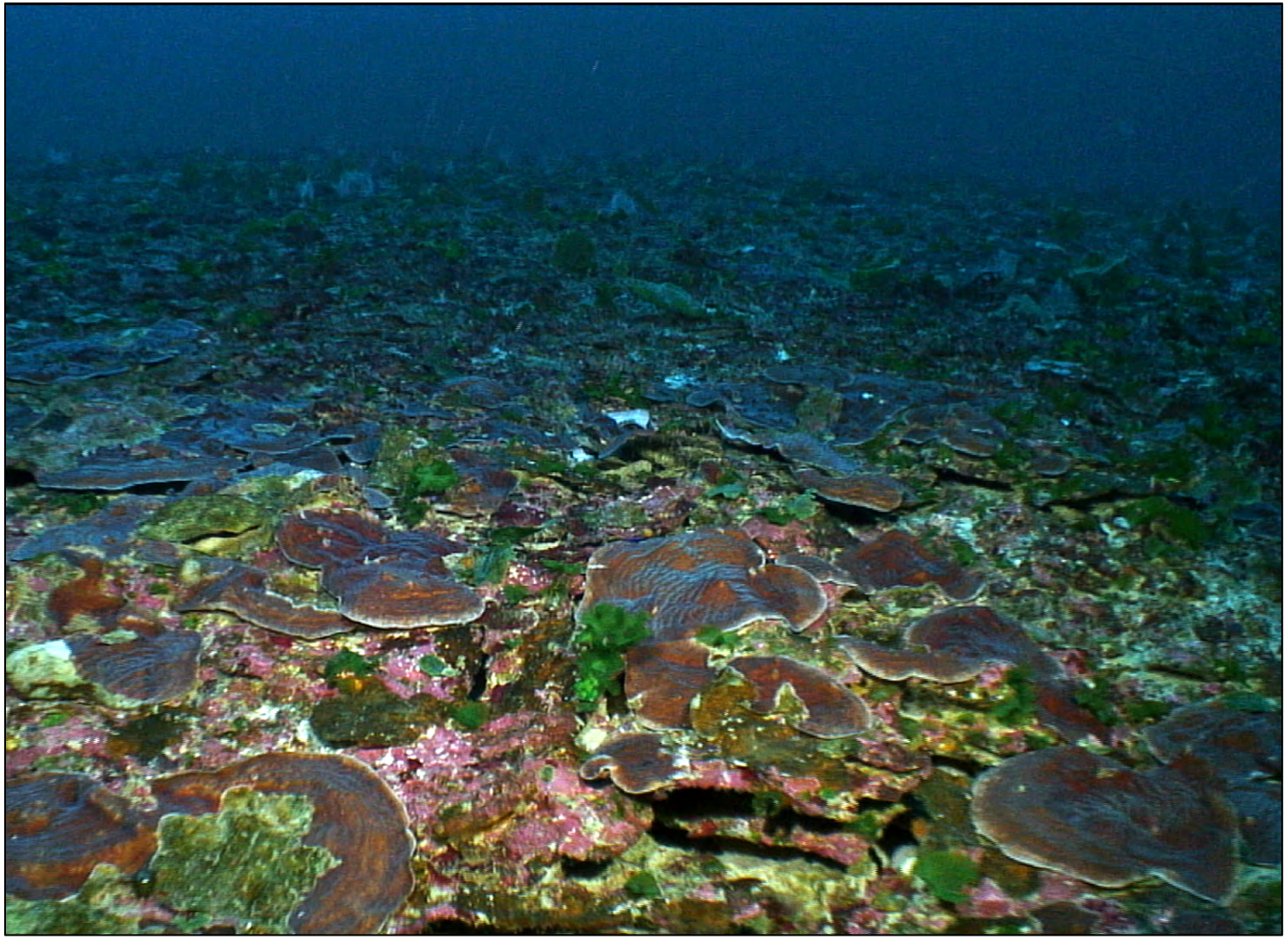
Estimated Number of Grouper Burrows = 155,490 w/in 2018 HAPC boundaries

Pulley Ridge Main Ridge



- 2003 - coral cover up to 60% in some areas of the Main Ridge, with an average of 12.8%.
- 2015 - 0.8% coral cover
- 93% decline in hard coral cover in 10 years
- **Why?...we really don't know**

But There was Good News in the Central Basin!



In 2014 and 2015, we discovered vast fields of plate coral – outside of the 2005 Pulley Ridge protected area!

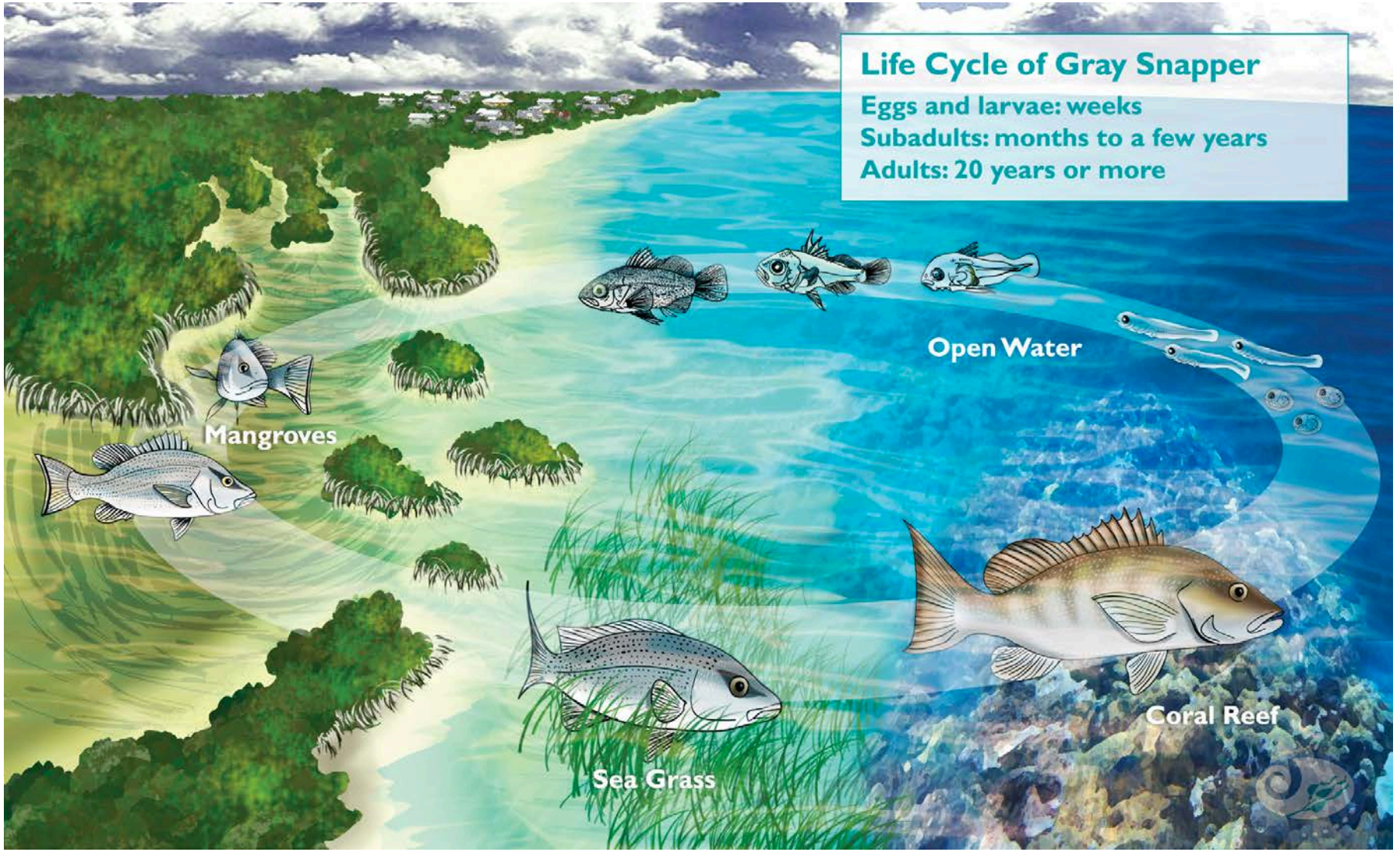
Agaricia **plate corals outside of the HAPC, majority are new recruits**
Coral densities averaged 16 colonies/m^2 (ranging from 3-77 colonies/m^2)

Number of Species

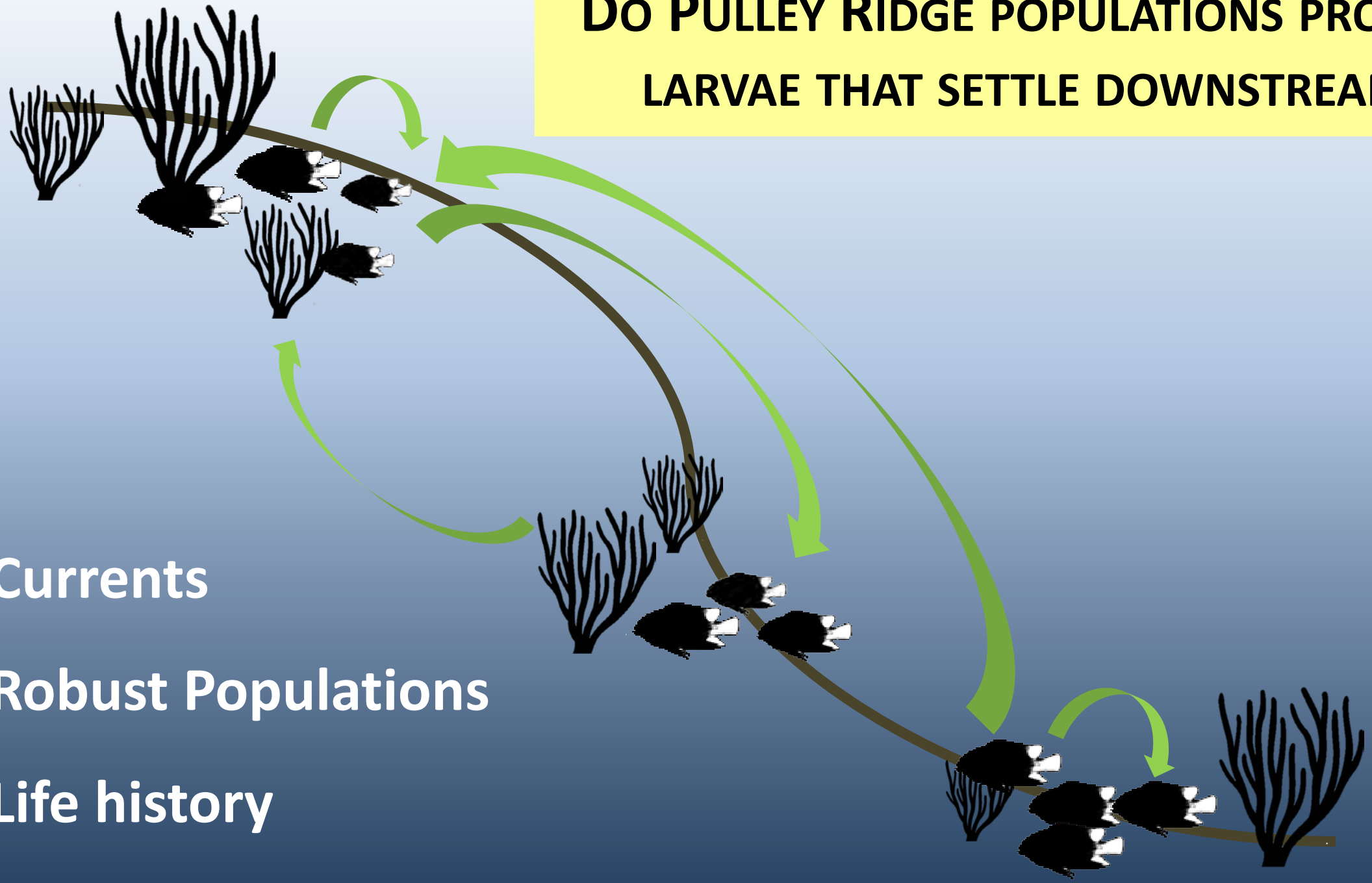
	Pulley Ridge	Dry Tortugas
Algae	95	32
Scleractinians	17	19
Antipatharians	9	0
Gorgonians	18	16
Sponges	92	57

OBJECTIVE: UNDERSTANDING POPULATION CONNECTIVITY

Most marine organisms have complex life histories



Do Pulley Ridge populations produce larvae that settle downstream?



- Currents
- Robust Populations
- Life history

Physical Connectivity – Current Structure

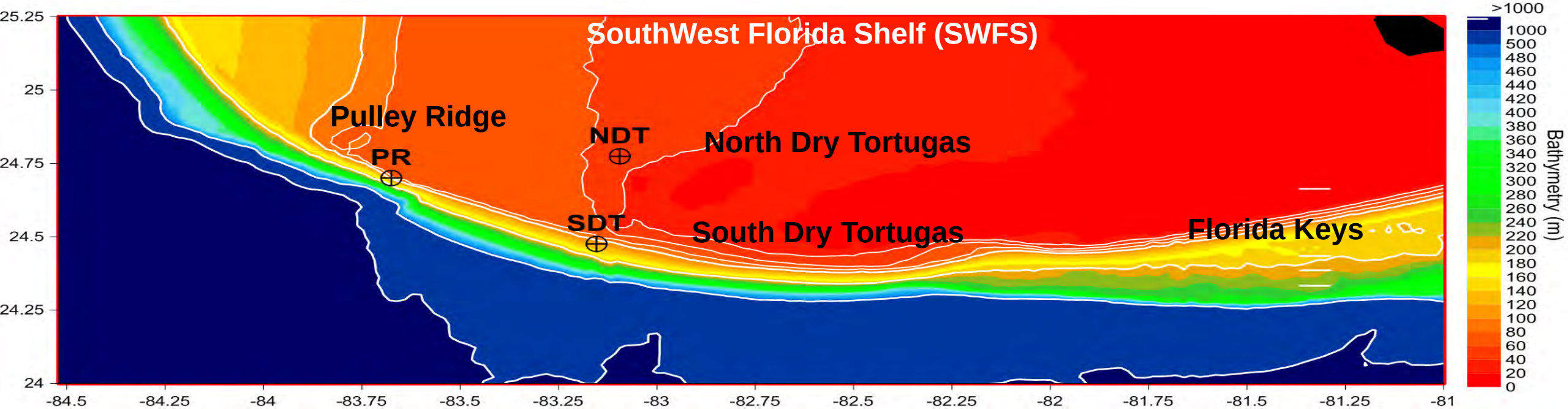
METHODOLOGIES USED

Field Observations

- Currents/Temperatures (3 Moorings ⊕)
- Altimetry/Sea surface temperature (Satellite)
- Deep/Surface Currents (Drifters)

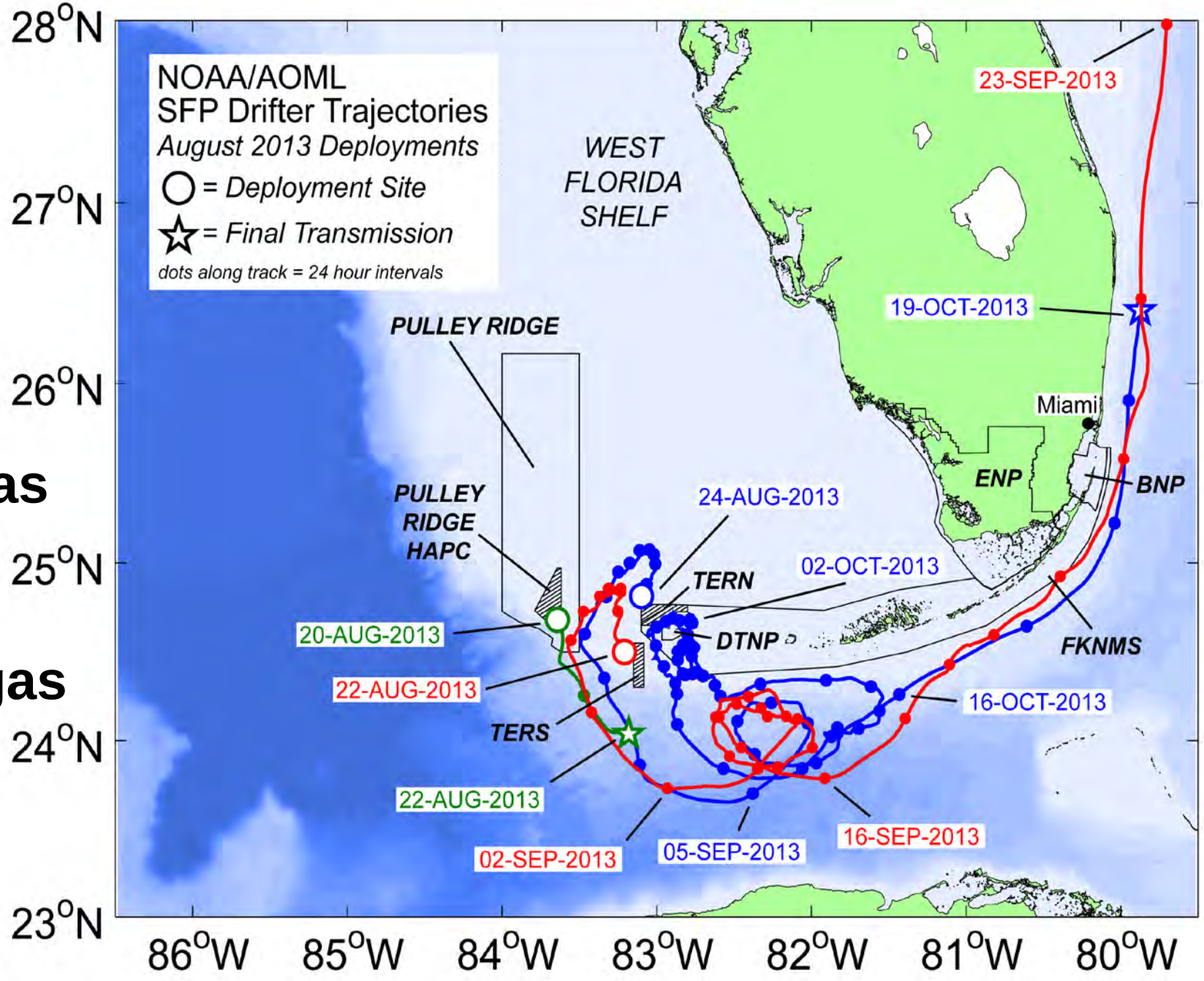
Models

- Gulf of Mexico HYCOM (1/50°, ~2 km)
- Florida Keys HYCOM (1/100°, ~1 km)



Field Observations: 2013 Drifters

- **Red= South Dry Tortugas** (22 Aug – 23 Sep)
- **Blue= North Dry Tortugas** (24 Aug –19 Oct)
- **Green= Pulley Ridge** (20–22 Aug)

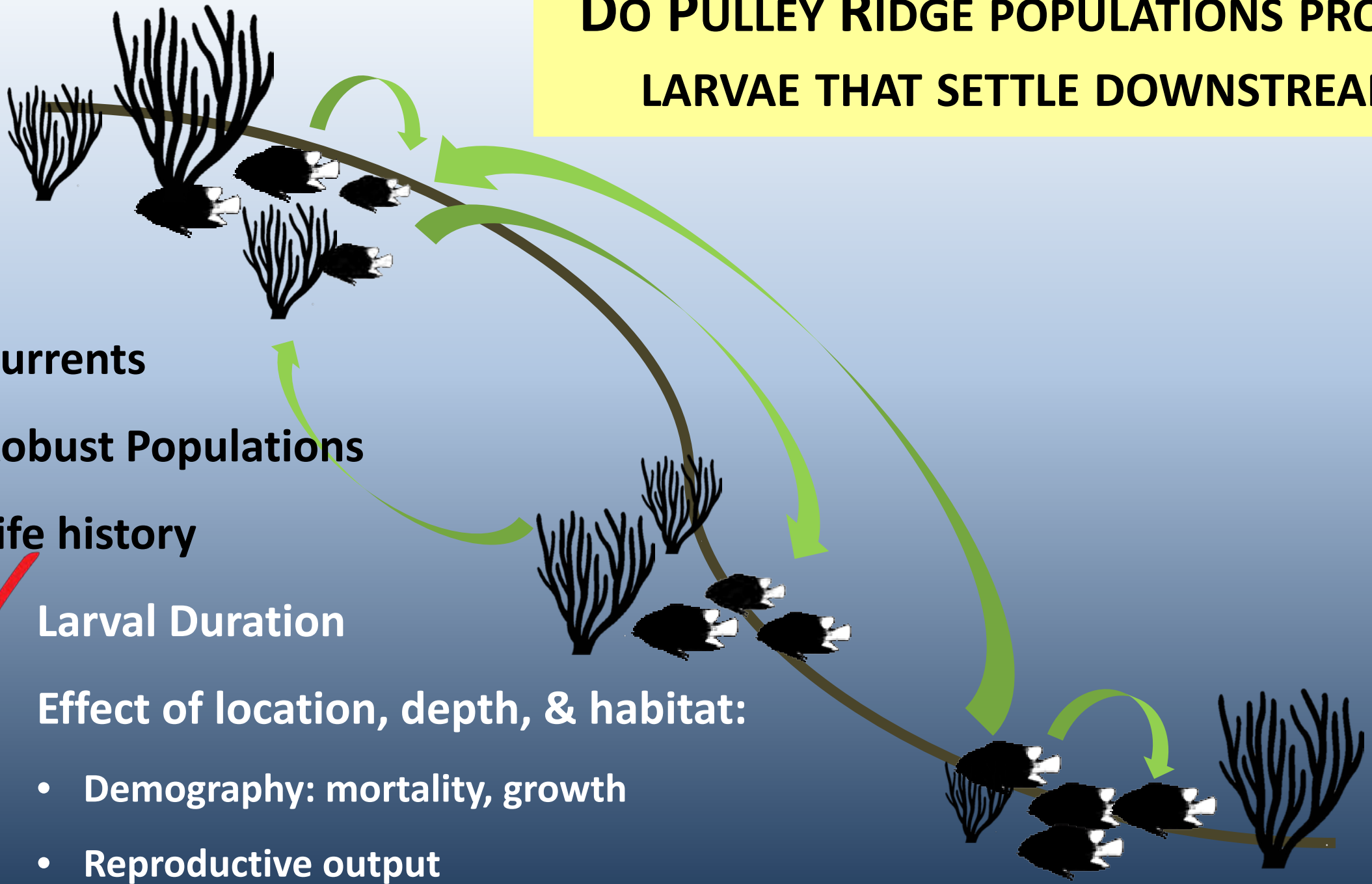


Physical Connectivity

FINDINGS

- The Loop Current does physically **connect** Pulley Ridge to the Dry Tortugas and Florida Keys.
- **Cyclonic Eddies** play an important role in the connectivity patterns and affect the duration of transport pathways.
- Model Studies incorporating simple biology suggest Pulley Ridge could serve as **a source (a refugia) for some species** and thus play a critical role in the **resilience of shallow reef communities** *(*i.e., Dry Tortugas and Florida Keys*).*

Do Pulley Ridge populations produce larvae that settle downstream?



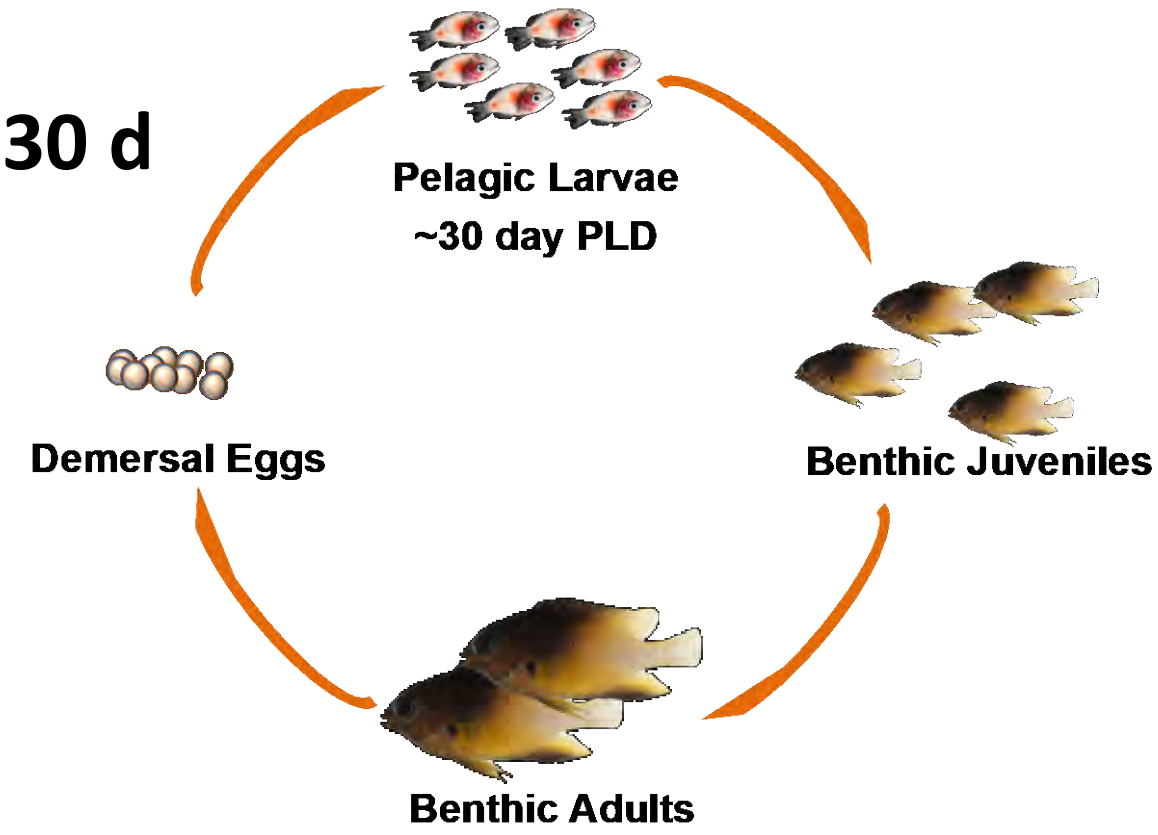
- ✓ Currents
- ✓ Robust Populations
- Life history
  - ✓ Larval Duration
  - Effect of location, depth, & habitat:
    - Demography: mortality, growth
    - Reproductive output

Bicolor damselfish—*Stegastes partitus*

- Bipartite life cycle

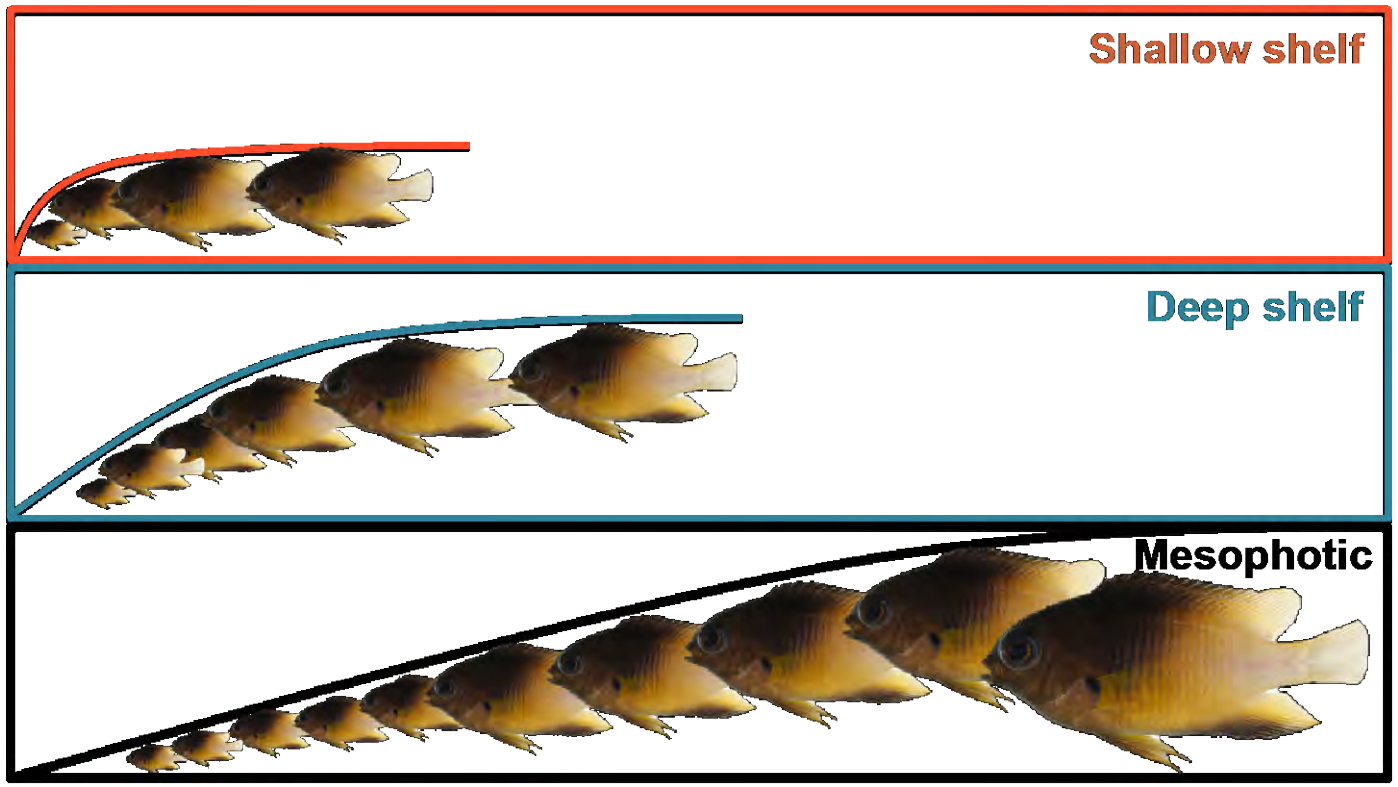
  Pelagic larval duration = ~30 d

- Common reef fish
- Planktivorous
- Territorial
- Easy to observe & collect
- **Broad depth range (0-150m)**



Population Dynamics – Findings

1



At Pulley Ridge, fish:

- grow more slowly
- live longer
- attain larger body sizes
- have higher reproductive investment

2

Population Distribution

32% Shallow shelf

46% Mid-shelf

8% Deep shelf

14% Mesophotic

3 Factoring in spatially explicit population densities & area of suitable habitat:

At least 9% of total regional egg production is from Pulley Ridge

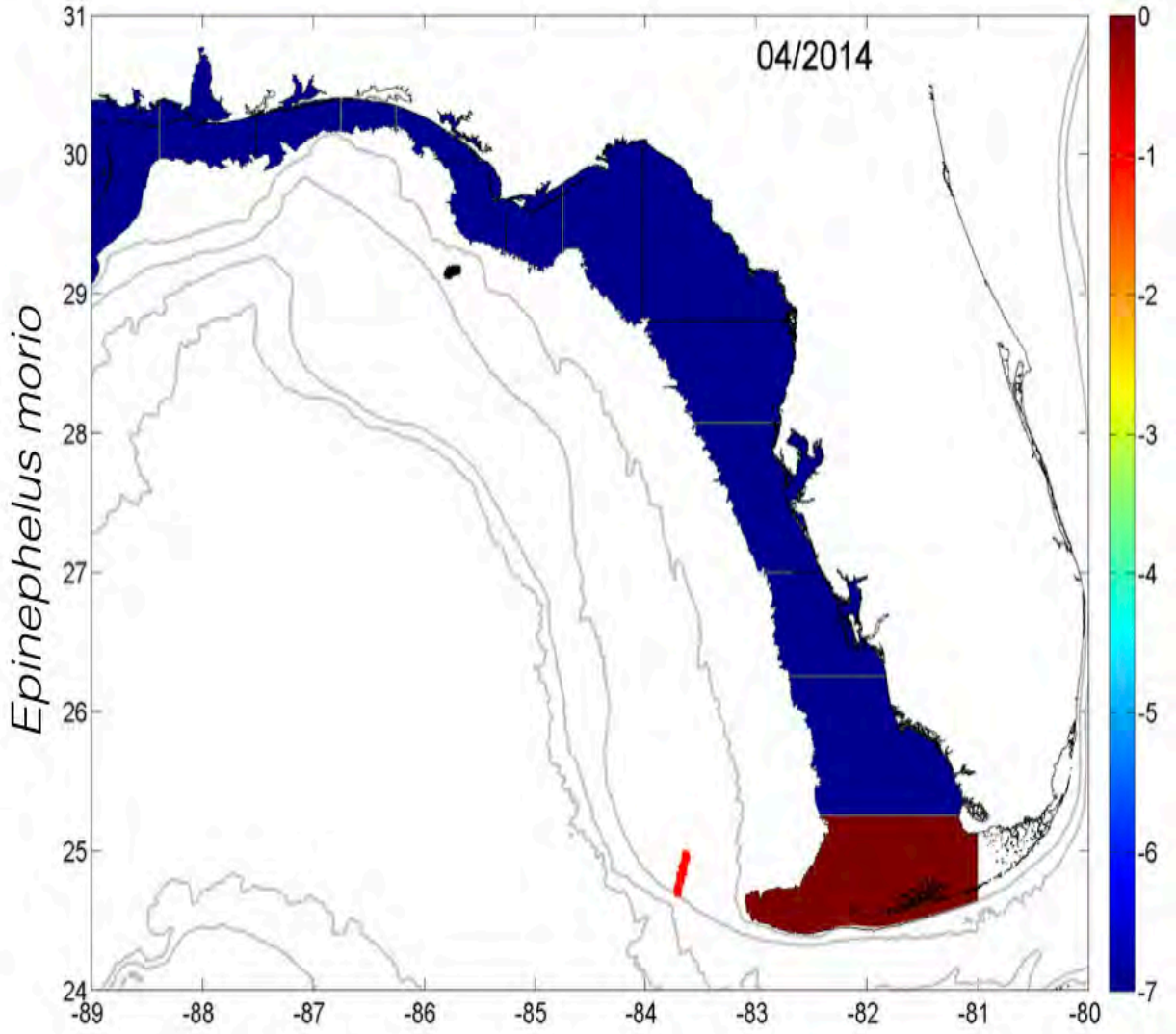
RED GROUPER: BIOPHYSICAL MODELING

Objective

Determined the probability of connections between Pulley Ridge and juvenile settlement grounds

Finding

The only area predicted to receive recruits from Pulley Ridge is the Dry Tortugas/Florida Keys



Blue = 0 Maroon = 100%

Genetics Connectivity Results

Bicolor Damselfish
Stegastes partitus

Red grouper
Epinephelus morio

Lionfish
Pterois spp.

Findings

Samples from Gulf of Mexico, Florida Keys and Western Atlantic

Found no significant population structure

Individuals at all sites are well connected, forming a single demographic population

Genetics Results For Sessile Species

Great star coral

Montastraea cavernosa

Giant Barrel Sponge

Xestospongia muta

Findings for *M. cavernosa*

- Pulley Ridge is connected to deeper populations (> 15 m) *M. cavernosa* populations in the Lower Florida Keys, but not the Dry Tortugas.
- Flower Gardens and the Fkeys (< 10 m) belong to the same populations.

Findings for *X. muta*

- Dry Tortugas and Pulley Ridge populations are the same.
- The populations at Flower Gardens, Marquesas, Key Largo, Palm Beach and Dry Tortugas/Pulley Ridge are all different.

Summary of Genetics Results

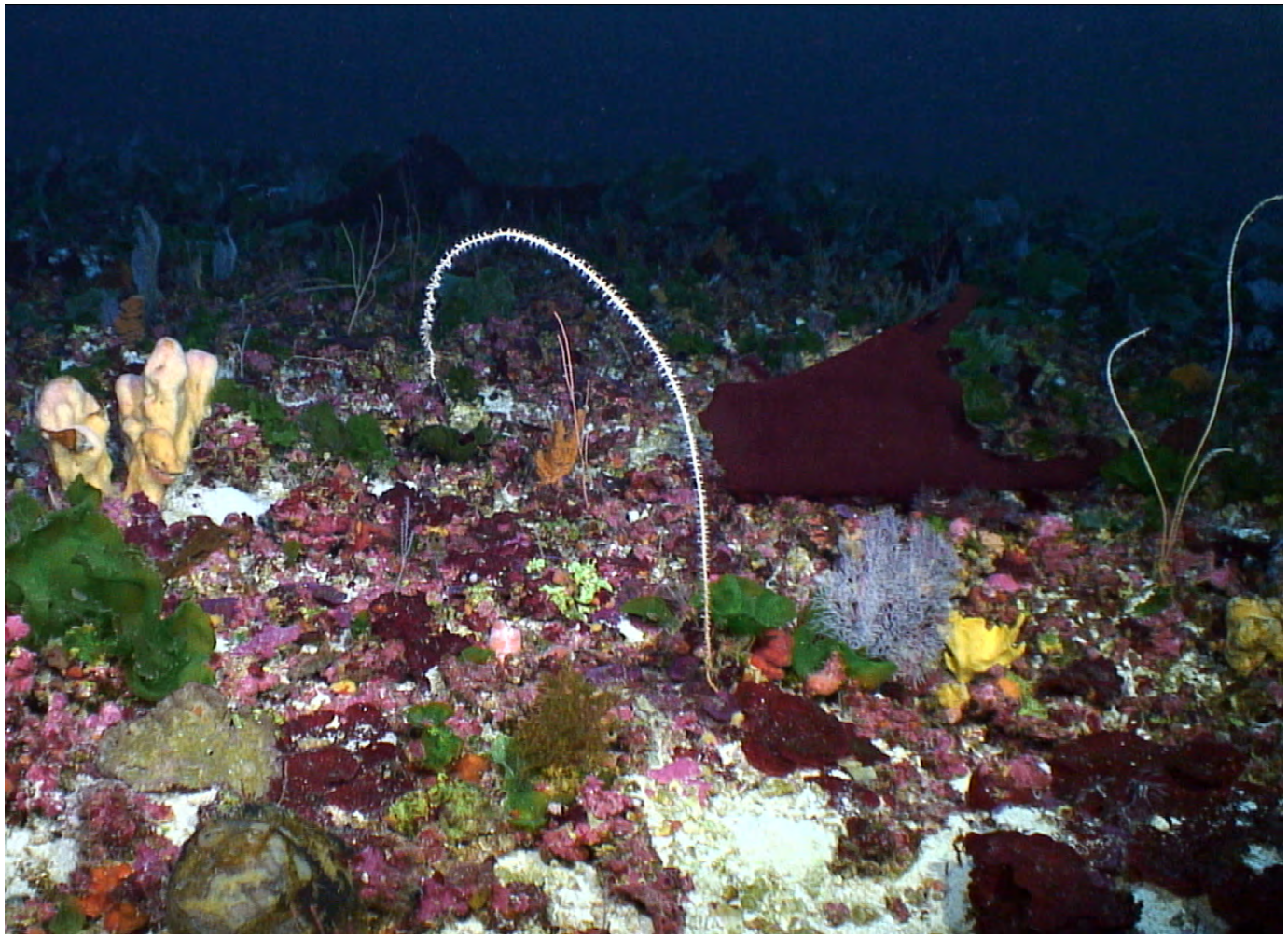
Mobile species (fishes):

- Long planktonic larval stages (3-7 weeks)
- High connectivity among sites and depths between Pulley Ridge and the Florida Keys

Sessile species (corals, sponges):

- Shorter planktonic phases (days to a week or so)
- Connectivity to Pulley Ridge and Florida Keys/Dry Tortugas is species (life history/ duration) dependent

SUMMARY



Pulley Ridge is:

- Unique with sensitive habitats and diverse robust populations
- Physically connected to the Florida Keys via the Loop Current
- Ecologically connected to the Florida Keys for fish species and for *Montastrea cavernosa*
- Ecologically connected to Dry Tortugas for *X. muta*
- **PR Increases the resilience of Florida Keys reefs by providing an upstream source of larvae**

THANK YOU

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NOAA Oceanic and Atmospheric Research

Data and Publications can be accessed via the NCCOS website at:
https://coastalscience.noaa.gov/project/coral-ecosystem-connectivity-gulf-florida-keys/