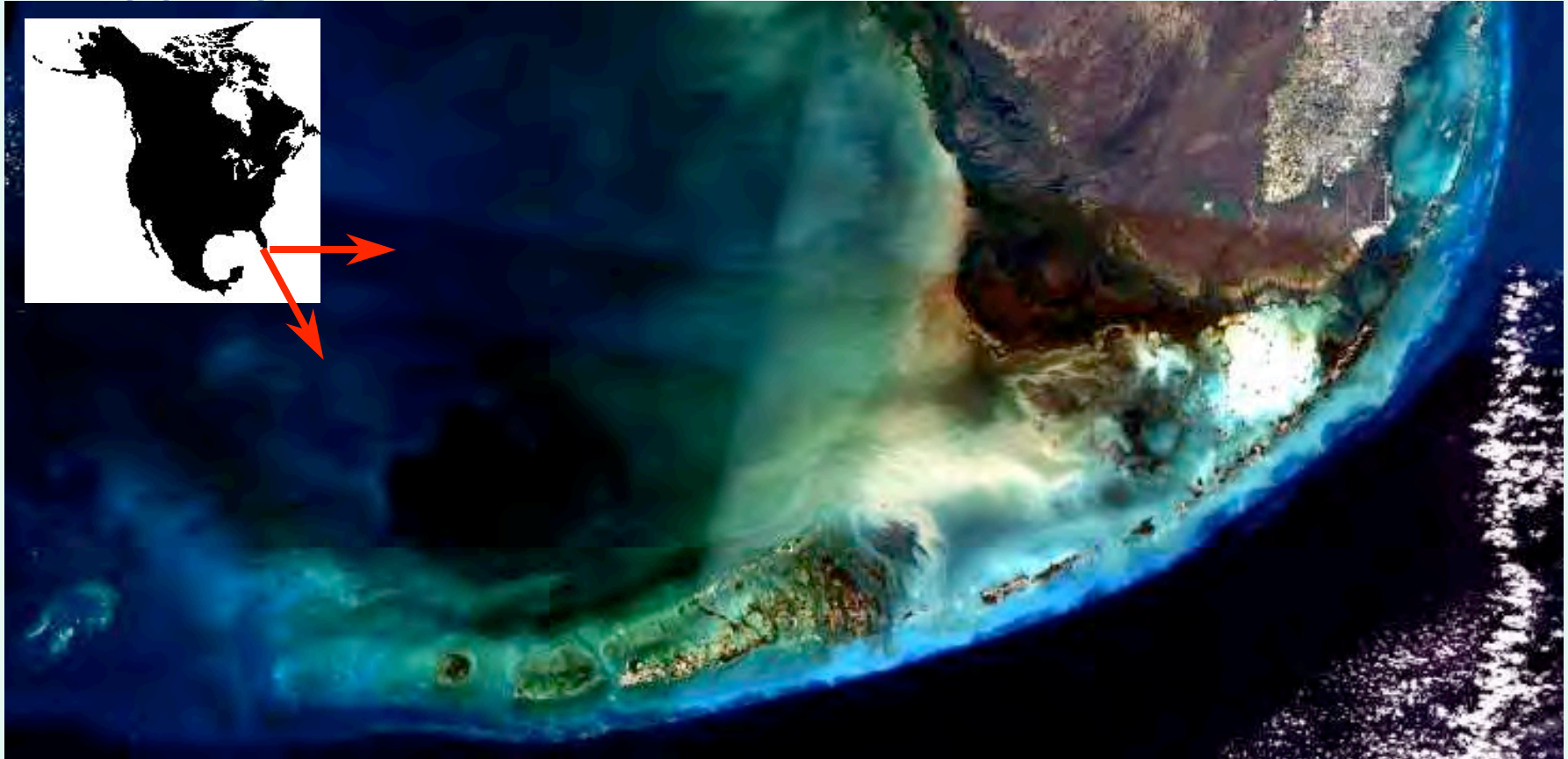


# Geomorphology of grouper and snapper spawning aggregation sites in the Upper Florida Keys, USA



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NOAA Fisheries



# South Florida: Society meets Nature

Population tripled 1960-2000:  
from 1.3 Million - 3.9 Million

Three National Parks

One National Preserve

One National Marine Sanctuary

Big Cypress NP

Broward  
1.6 M people

Miami-Dade  
2.2 M people

Everglades NP

Biscayne NP

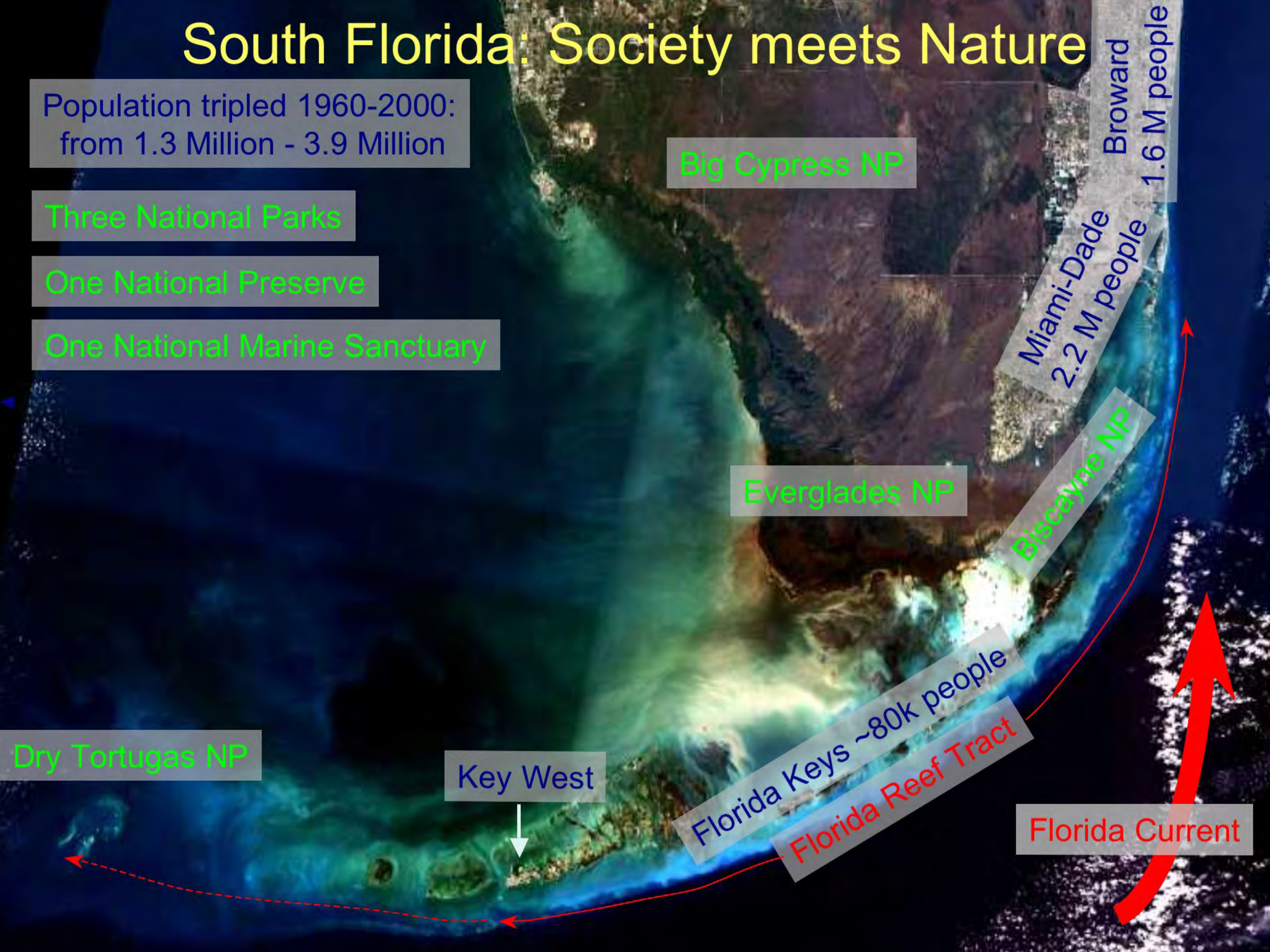
Florida Keys ~80k people

Florida Reef Tract

Florida Current

Key West

Dry Tortugas NP

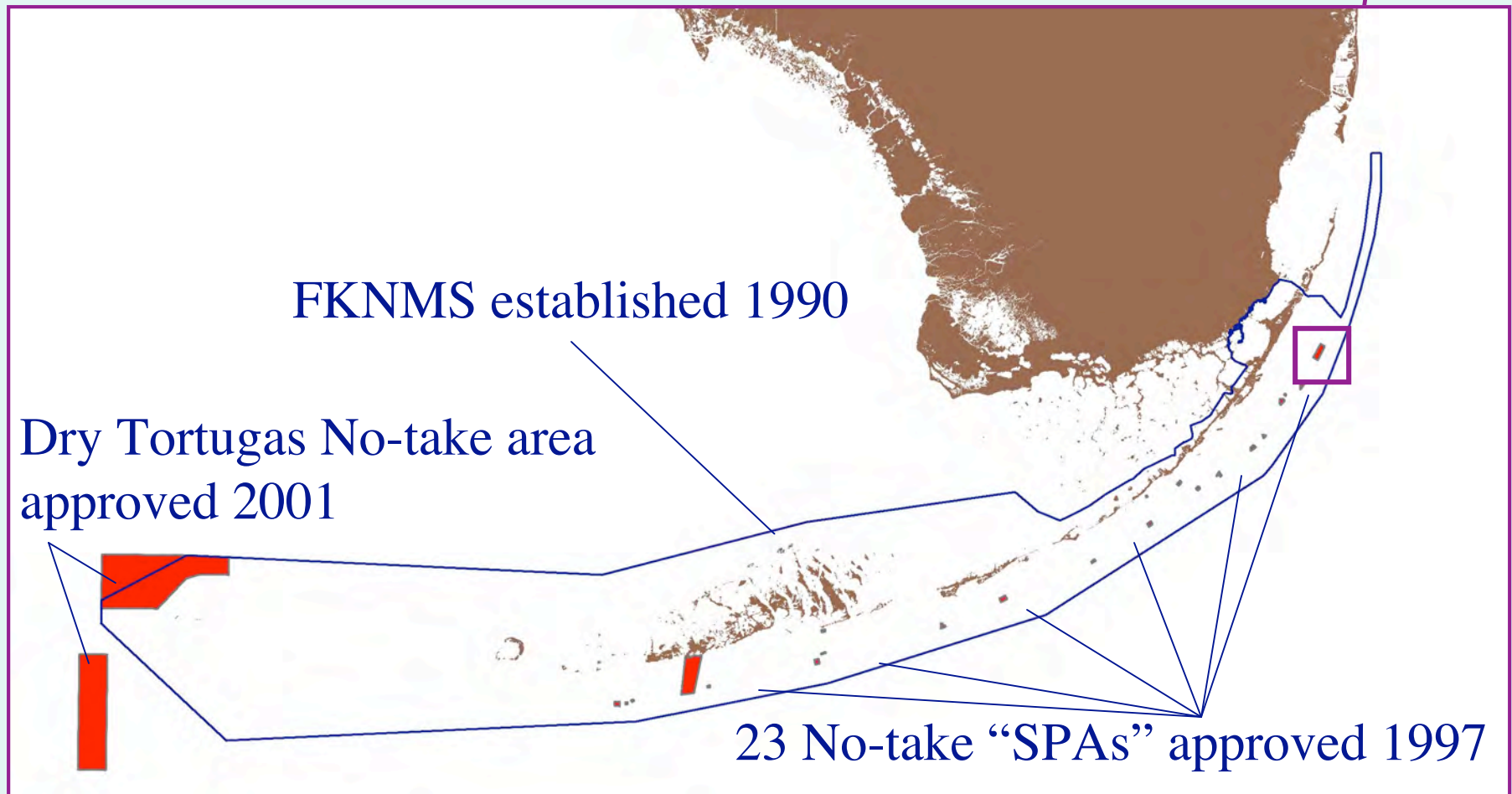




# Florida Keys National Marine Sanctuary (FKNMS)

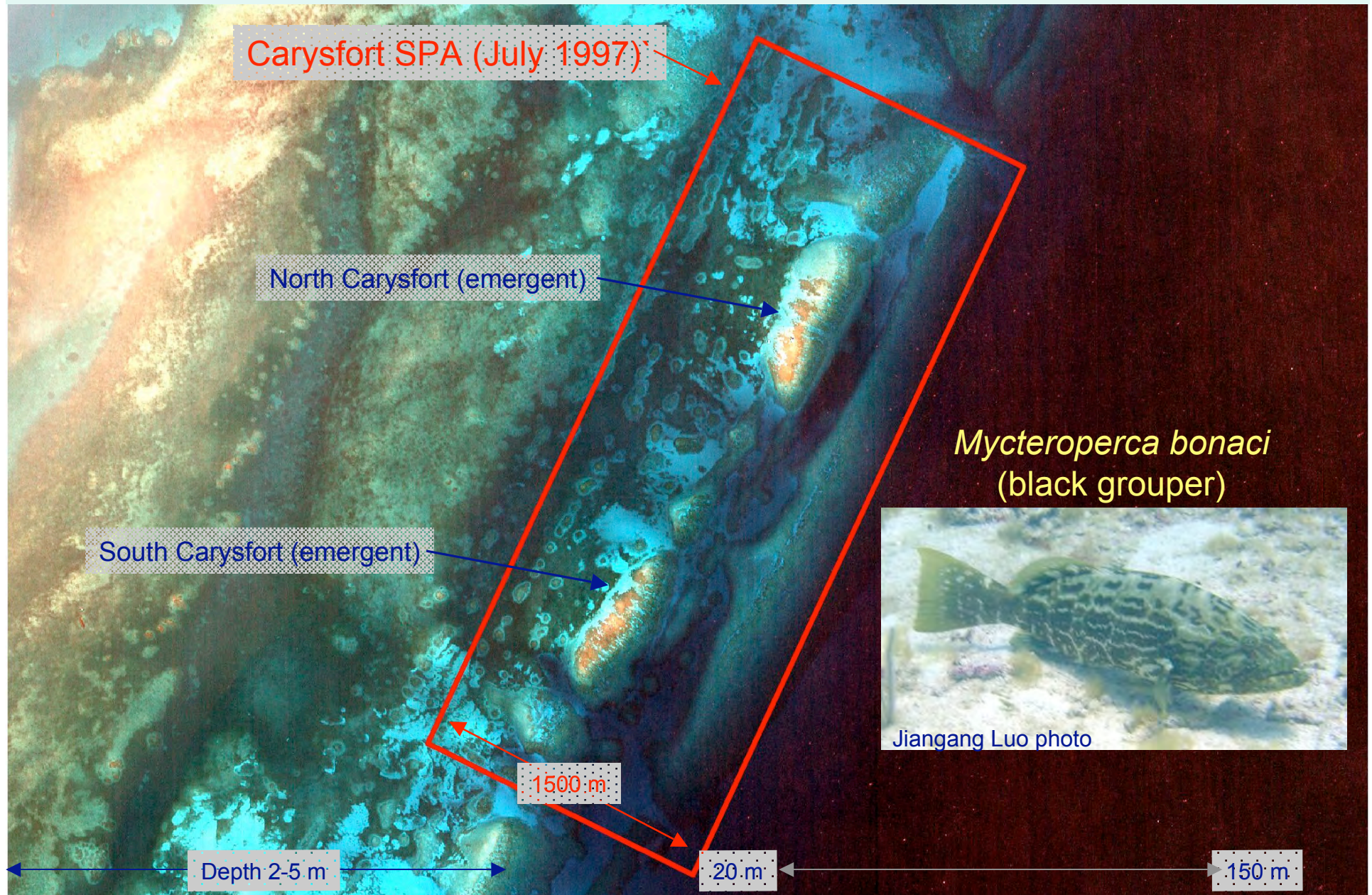


An innovative network of marine zoning  
includes 25 no-take areas





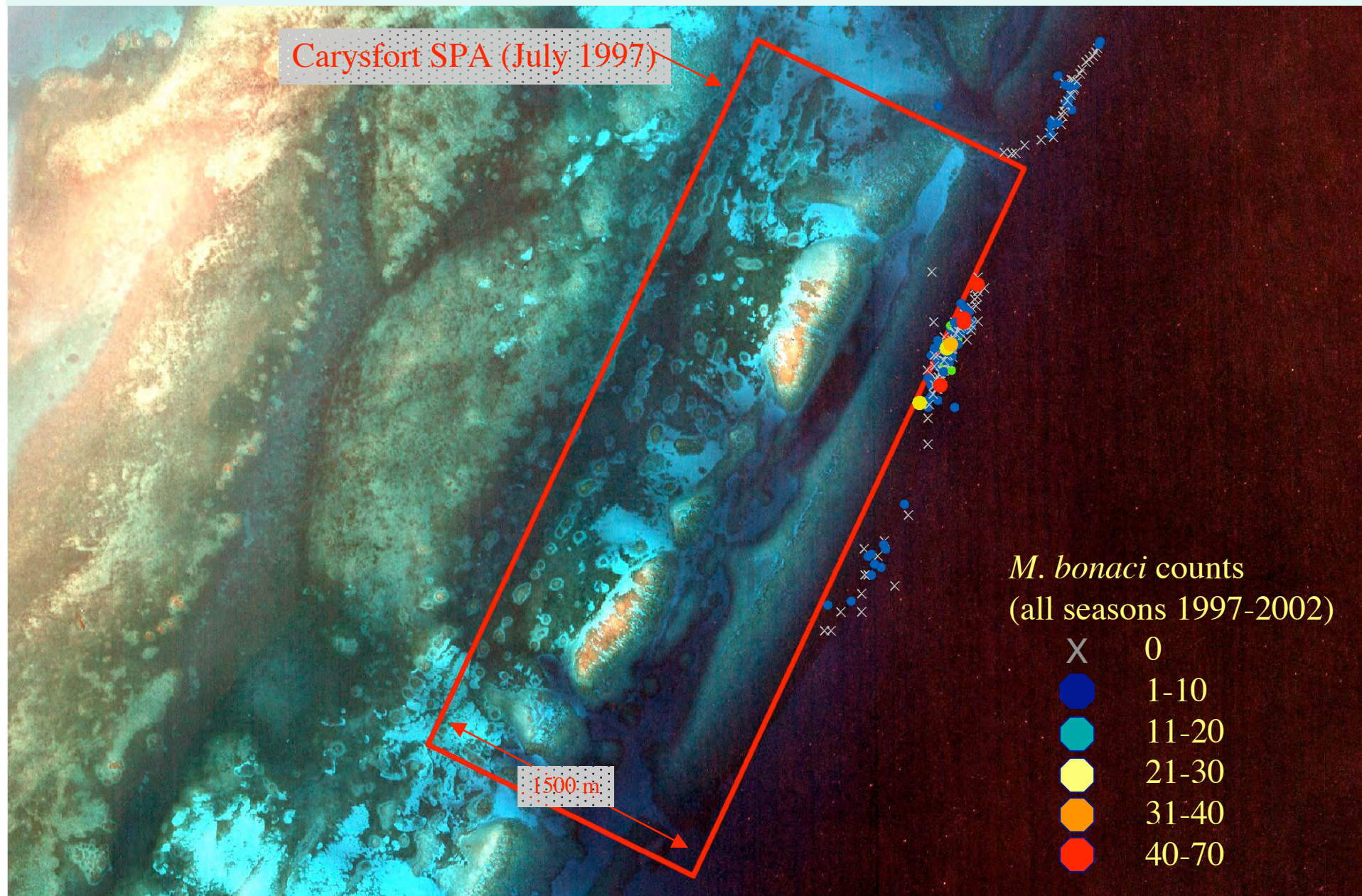
# Black Grouper Census at Carysfort Reef



Eklund et al. (2000)

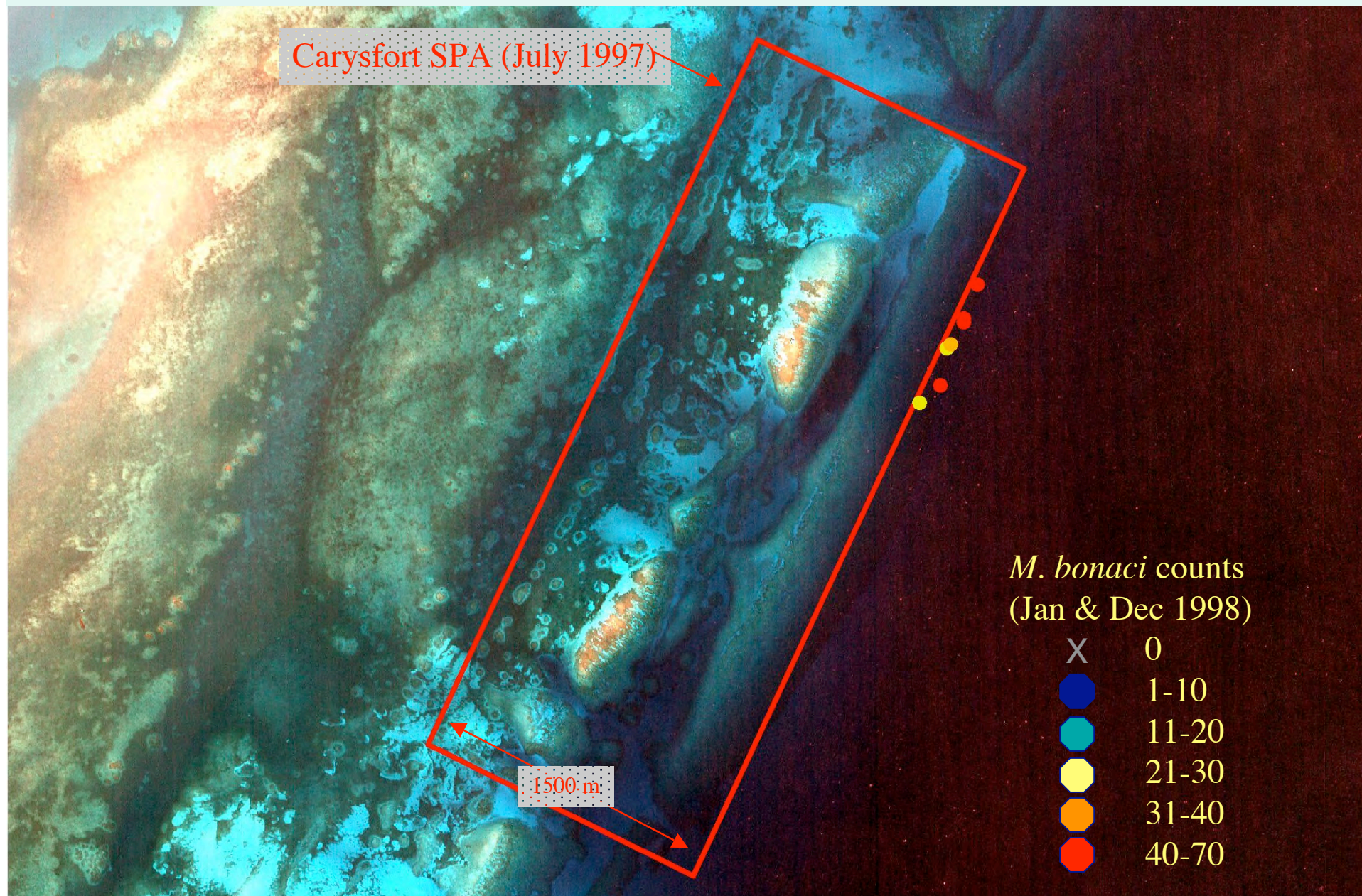


# Black Grouper Census at Carysfort Reef





# Black Grouper Census at Carysfort Reef





A Problem...

**Recreational fishing boats line the corner of a Sanctuary Preservation Area in the Florida Keys National Marine Sanctuary**

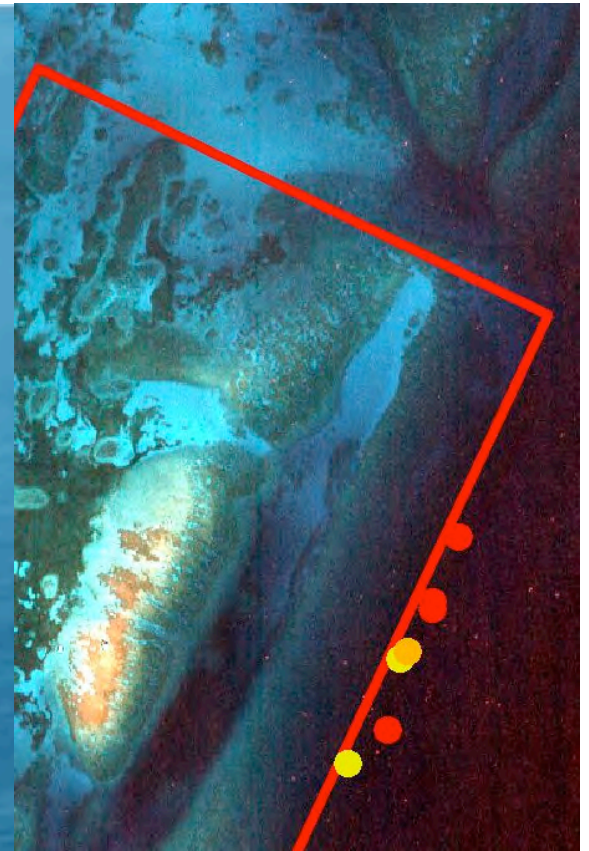
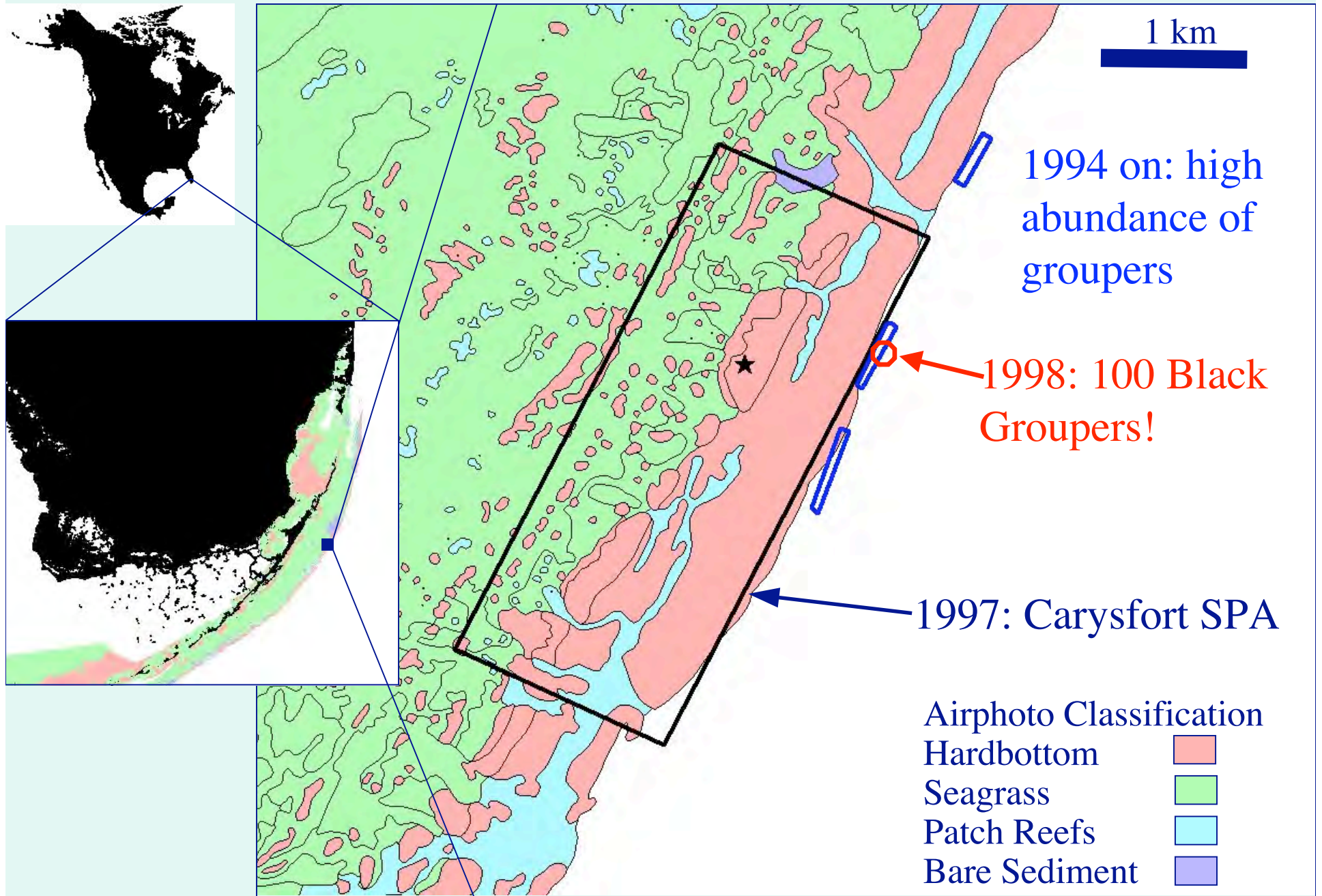


Photo by David McClellan, NMFS


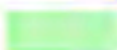




One reason for this: no habitat maps > 20 m.



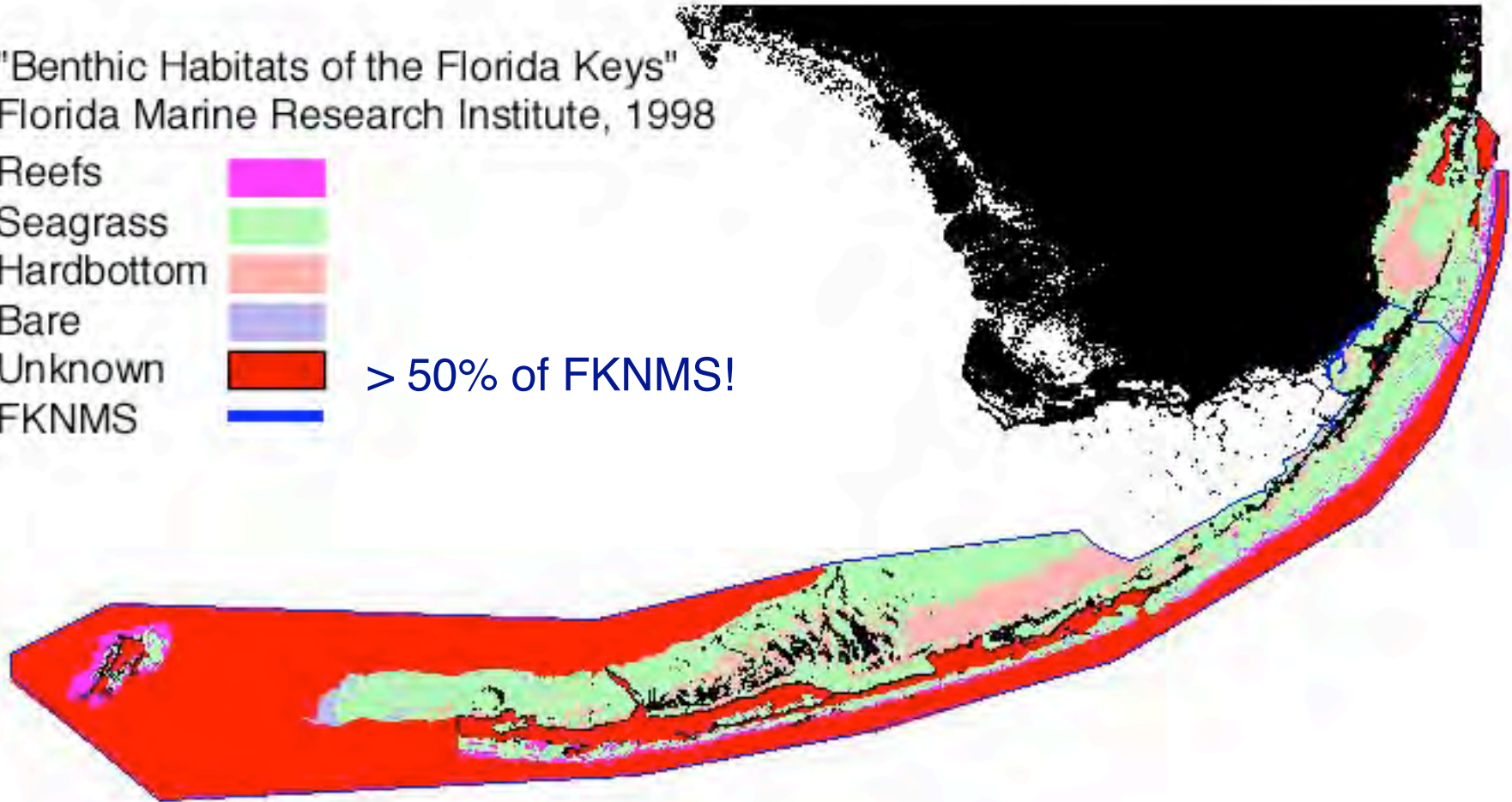


# Lack of habitat data for deep / turbid water

"Benthic Habitats of the Florida Keys"  
Florida Marine Research Institute, 1998

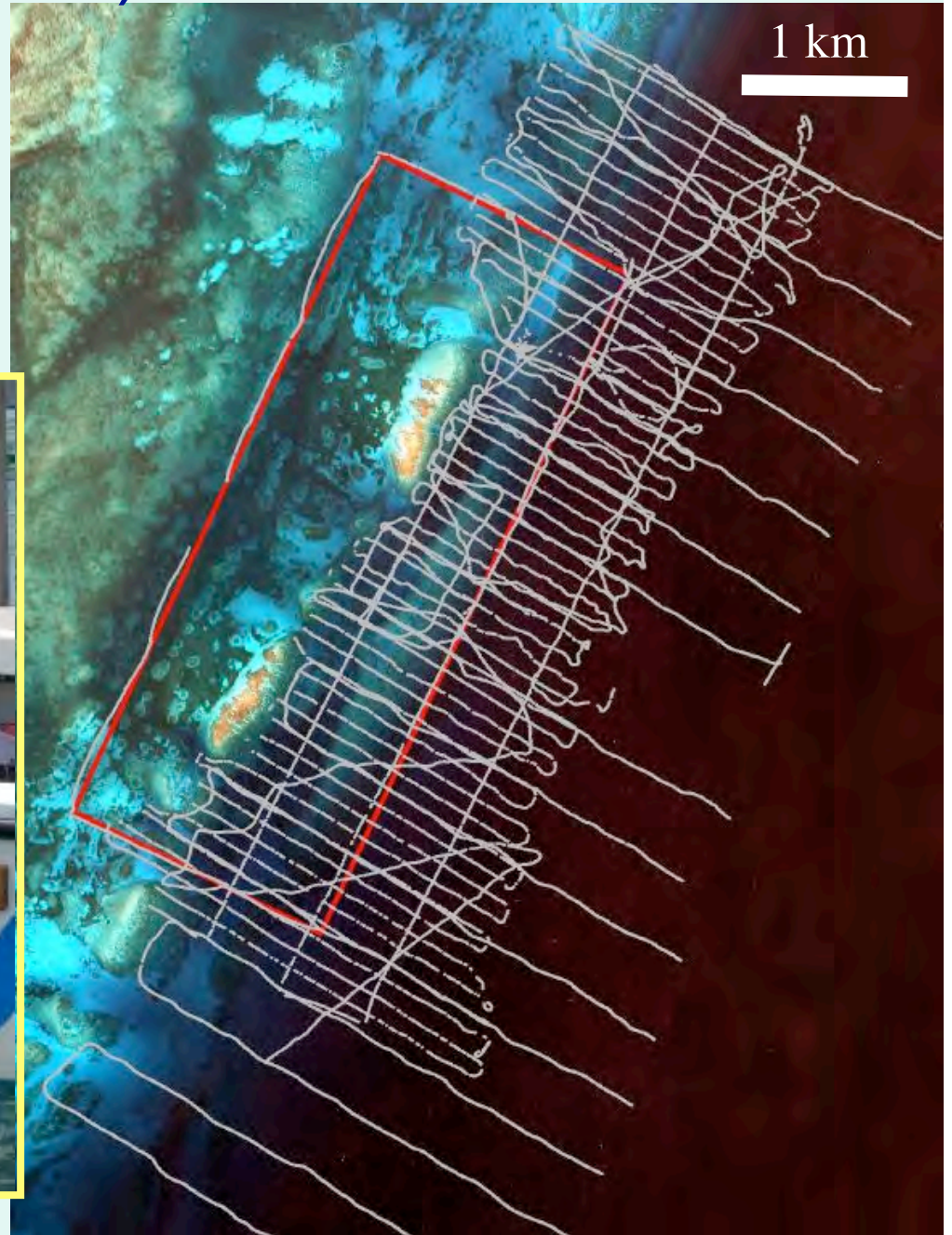
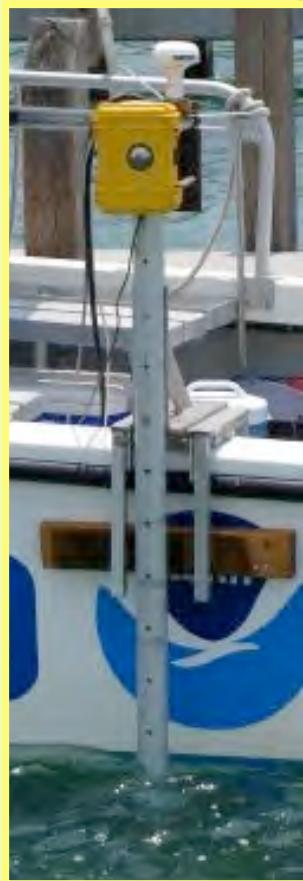
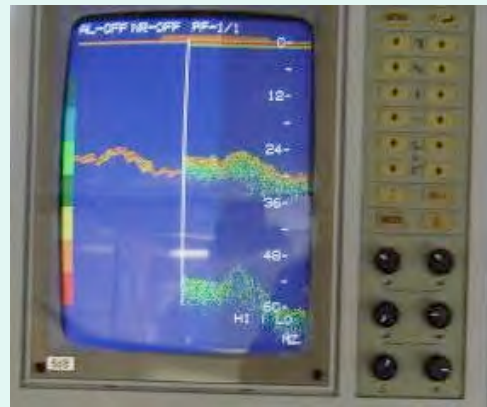
Reefs	
Seagrass	
Hardbottom	
Bare	
Unknown	
FKNMS	

> 50% of FKNMS!



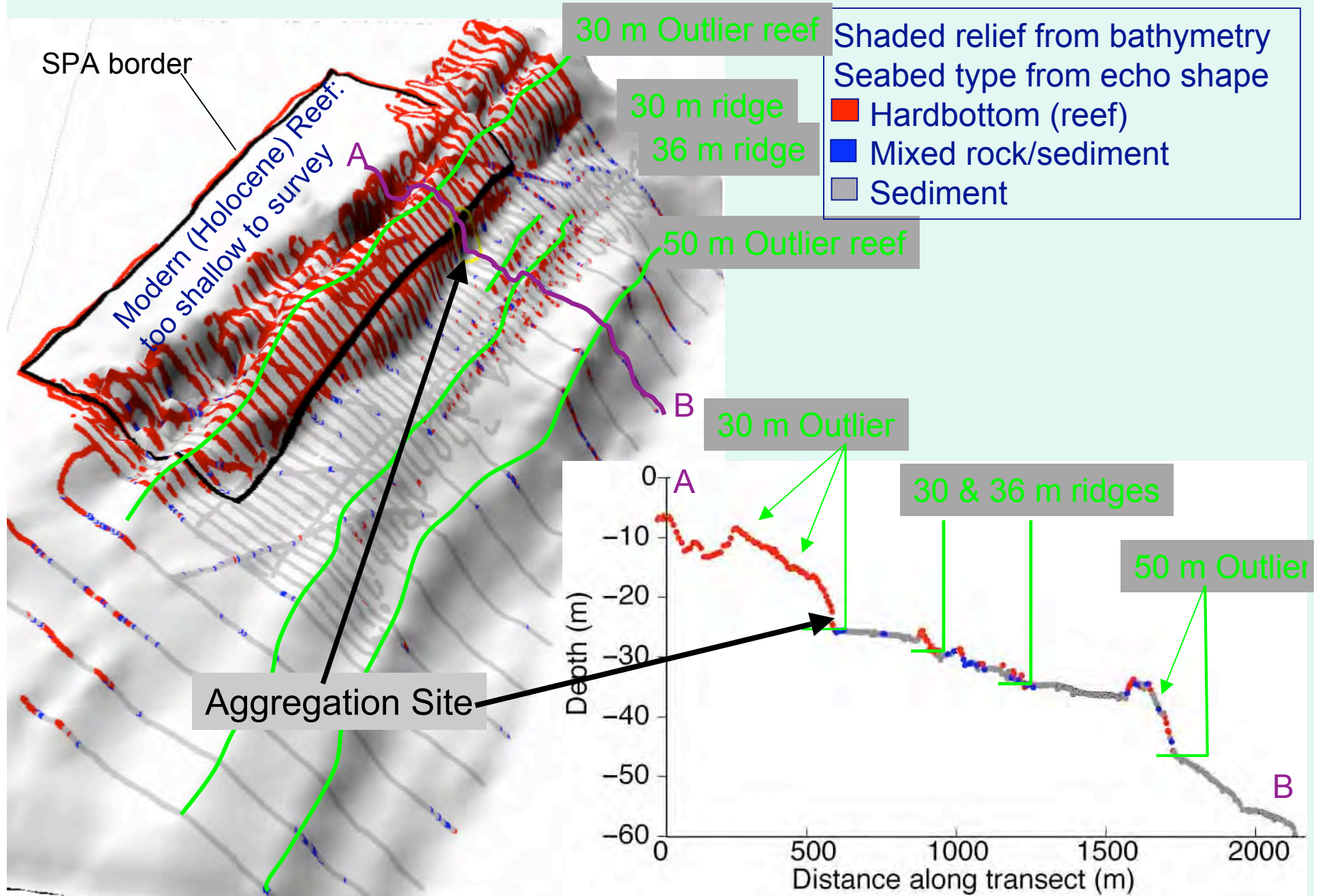


# Acoustic survey (2003) with QTC-View V



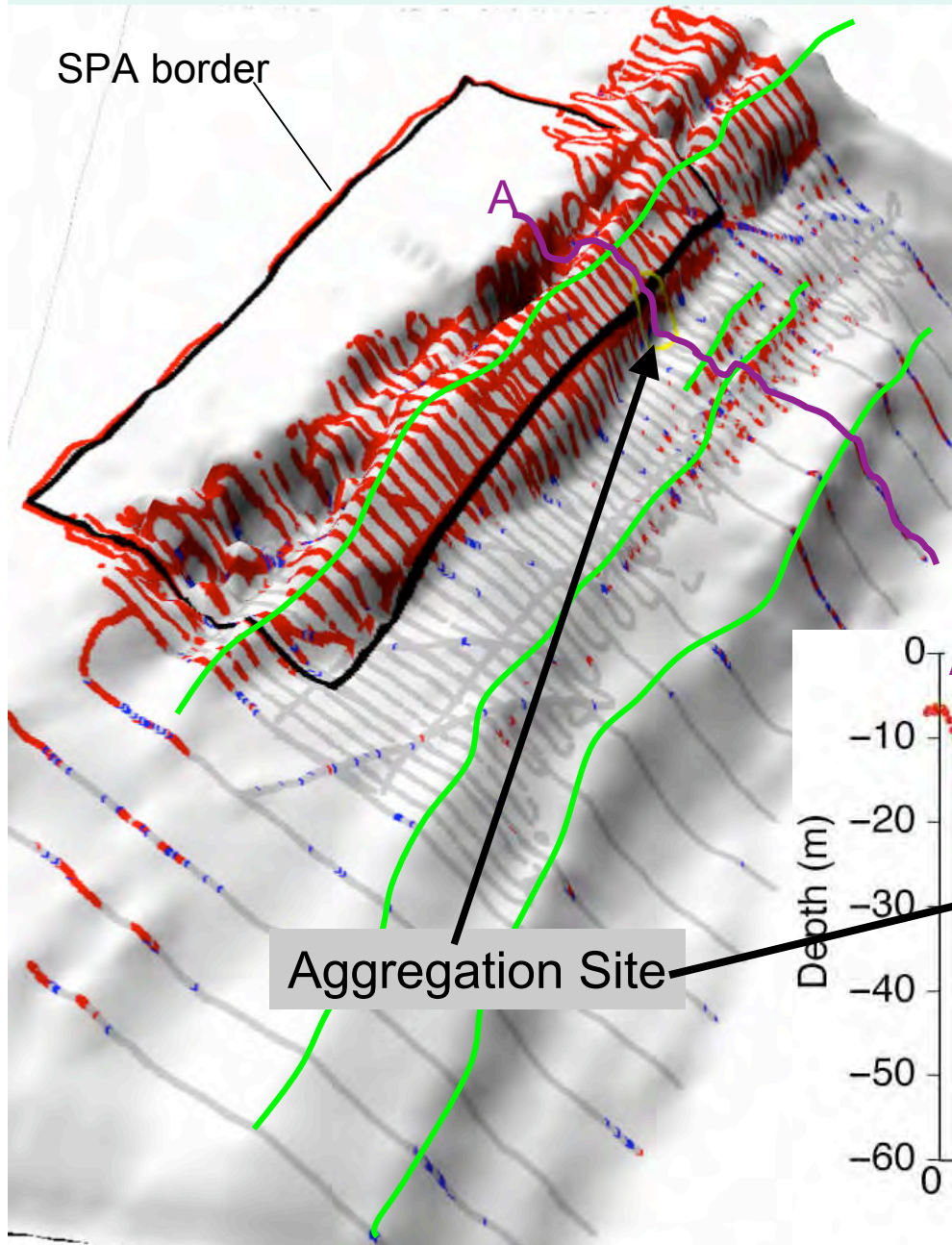


# Carysfort survey results





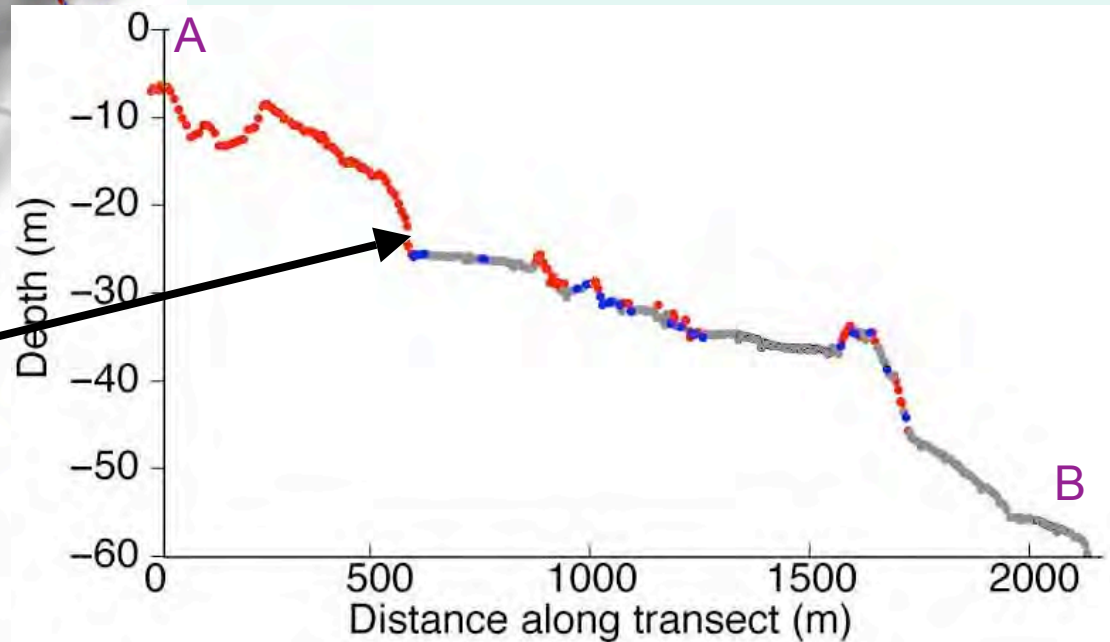
# Carysfort survey results



## **Black grouper aggregation site**

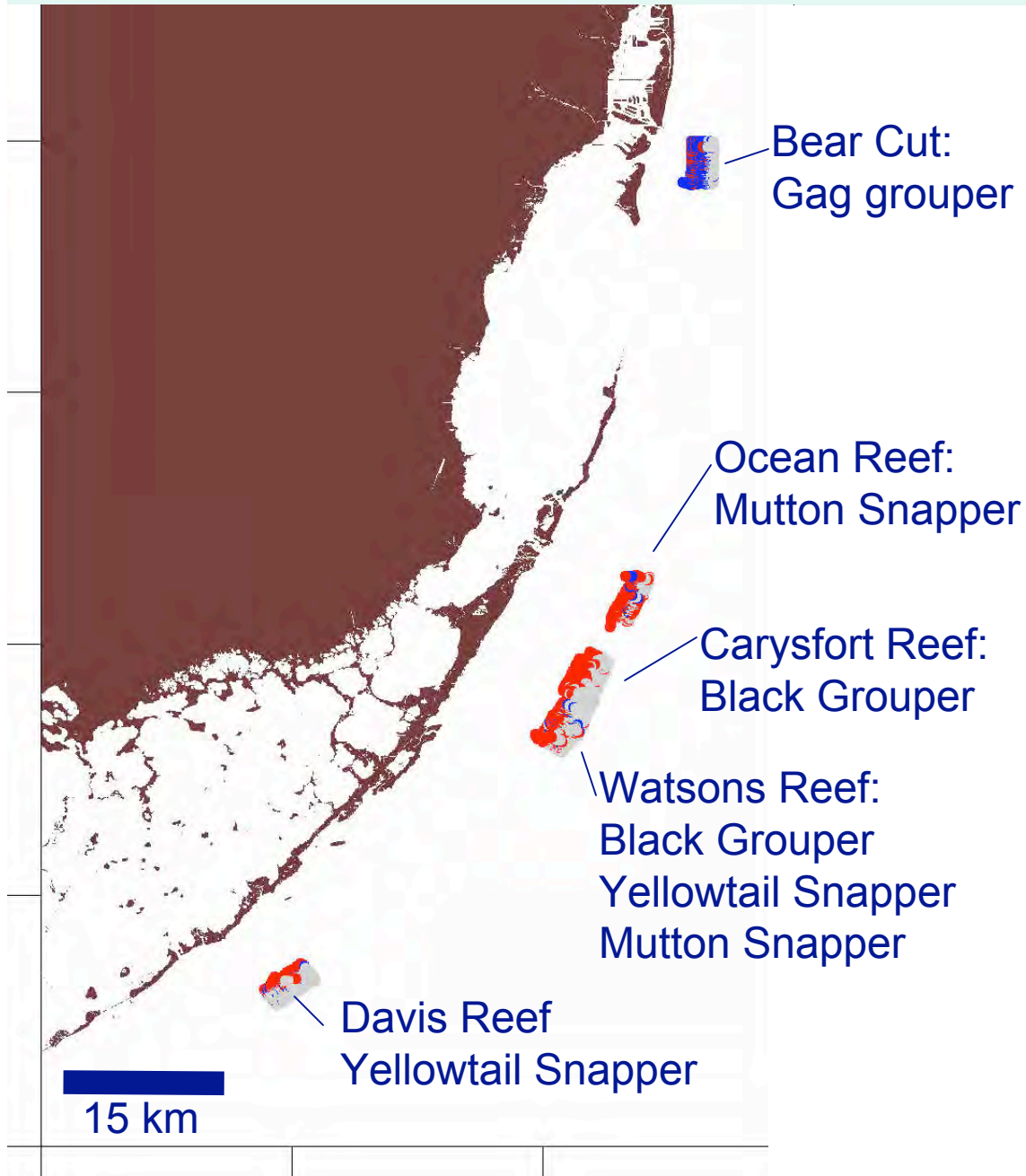
On steepest part of 30 m outlier  
Inshore exposed 30, 36 m ridges  
Inshore exposed 50 m outlier

**Does this pattern hold for other aggregation sites in the Keys?**





# Historical aggregation sites



*Lutjanus analis* (mutton snapper)



*Mycteroperca bonaci* (black grouper)



*Lutjanus chrysurus* (yellowtail snapper)







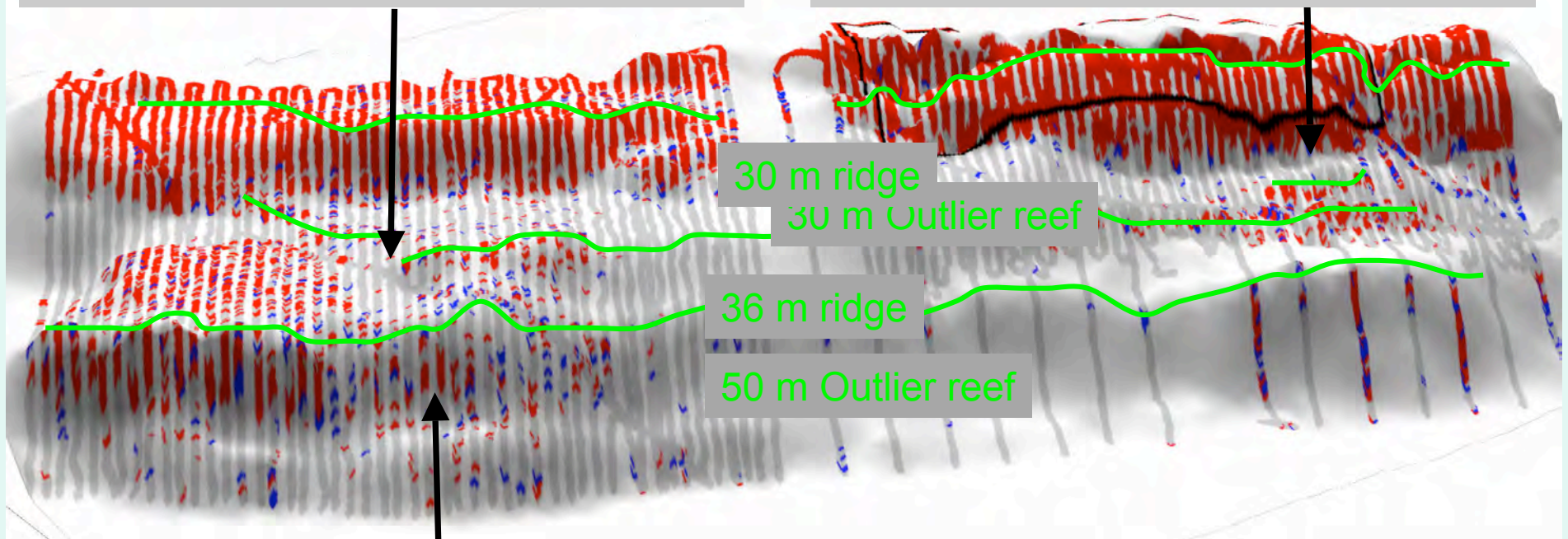
# Watsons & Carysfort viewed together

## Black grouper & Yellowtail snapper

Offshore steepest part of 30 m outlier  
Upstream of exposed 36 m ridge  
Downstream of patch reefs

## Black grouper (from earlier slide)

On steepest part of 30 m outlier  
Inshore exposed 30, 36 m ridges  
Inshore exposed 50 m outlier

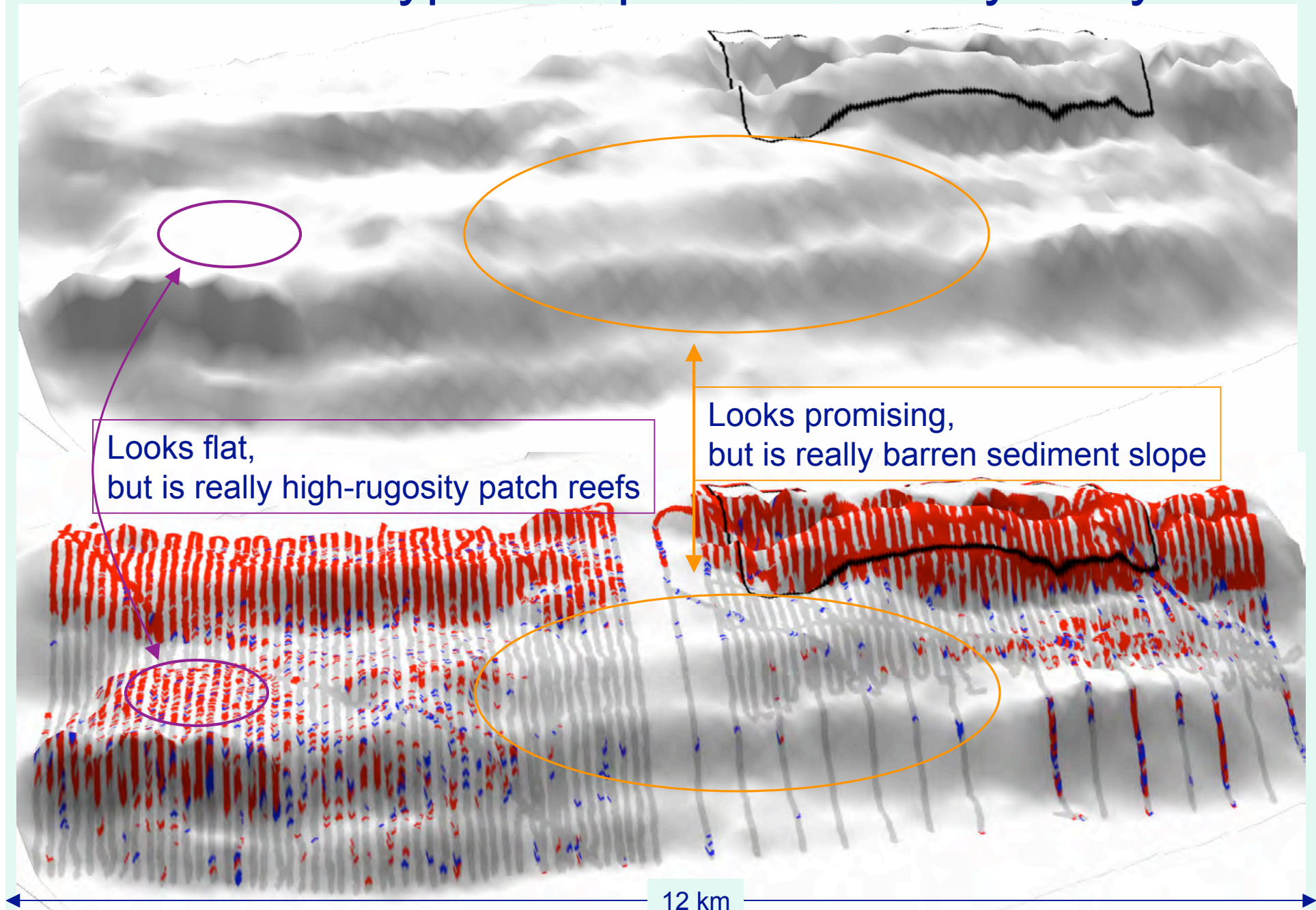


**Mutton Snapper:** Offshore steepest part of 30 m outlier  
On partially exposed face of 50 m outlier

12 km



# Seabed type complements bathymetry



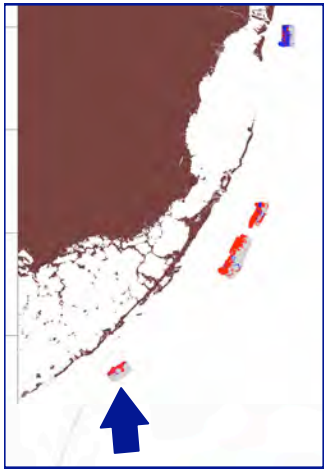


# Davis

## Yellowtail snapper

On steepest part of 30 m outlier

Inshore of unexposed 30 m ridge, 50 m outlier

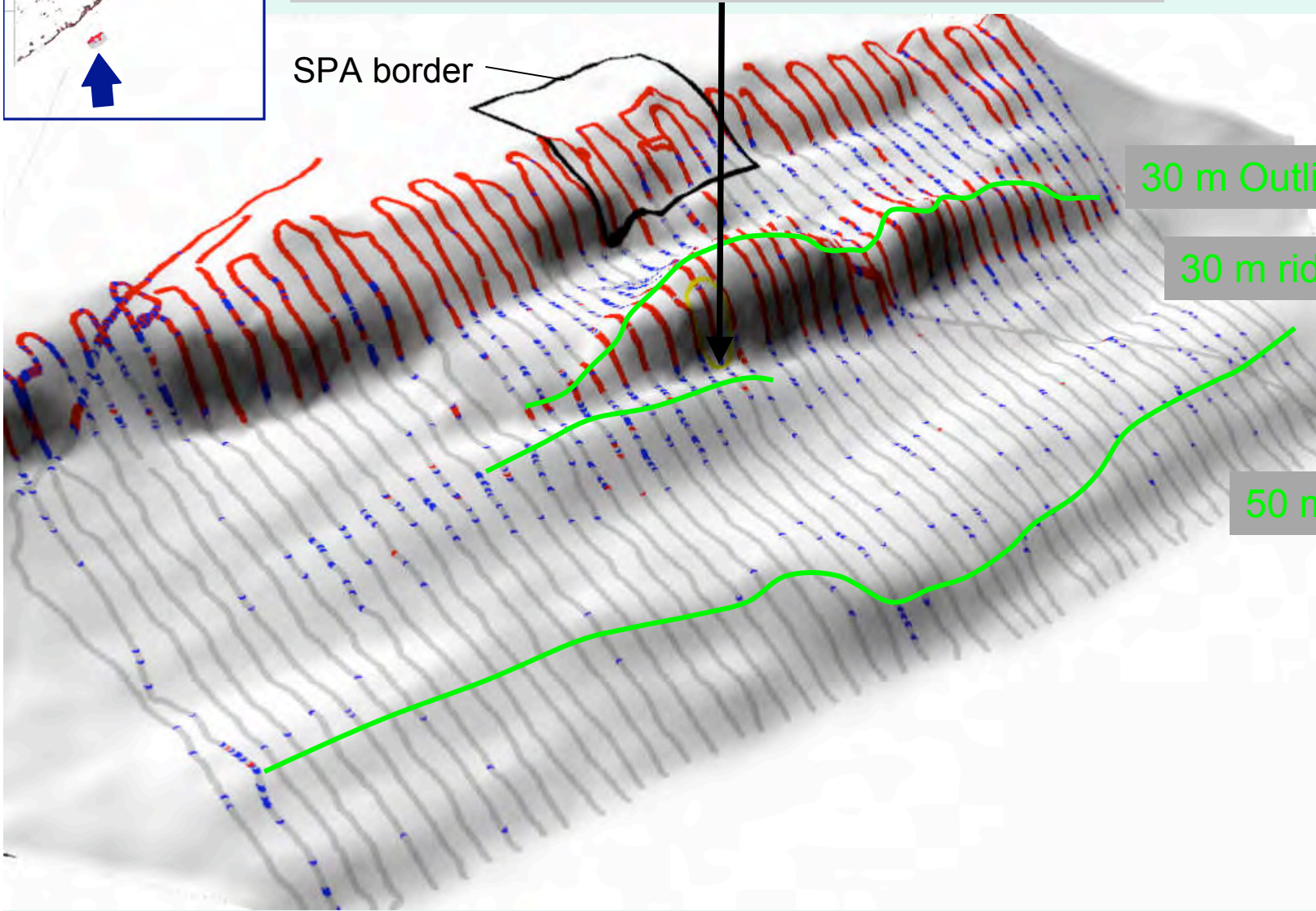


SPA border

30 m Outlier reef

30 m ridge

50 m Outlier reef







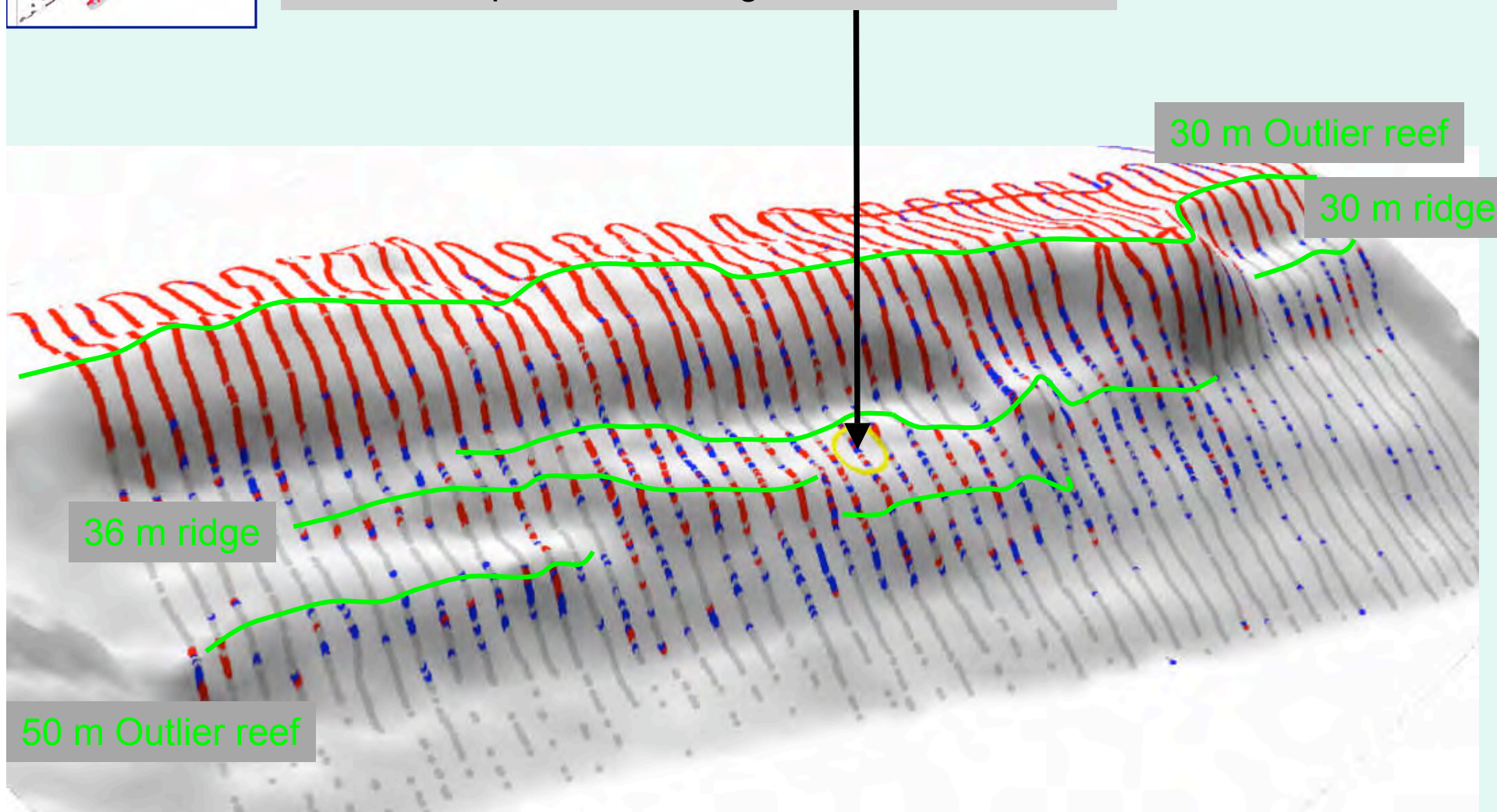
# Ocean Reef

## Mutton snapper

Offshore steepest part of 30 m outlier

On exposed 30 m ridge

Inshore exposed 36 m ridge, 50 m outlier



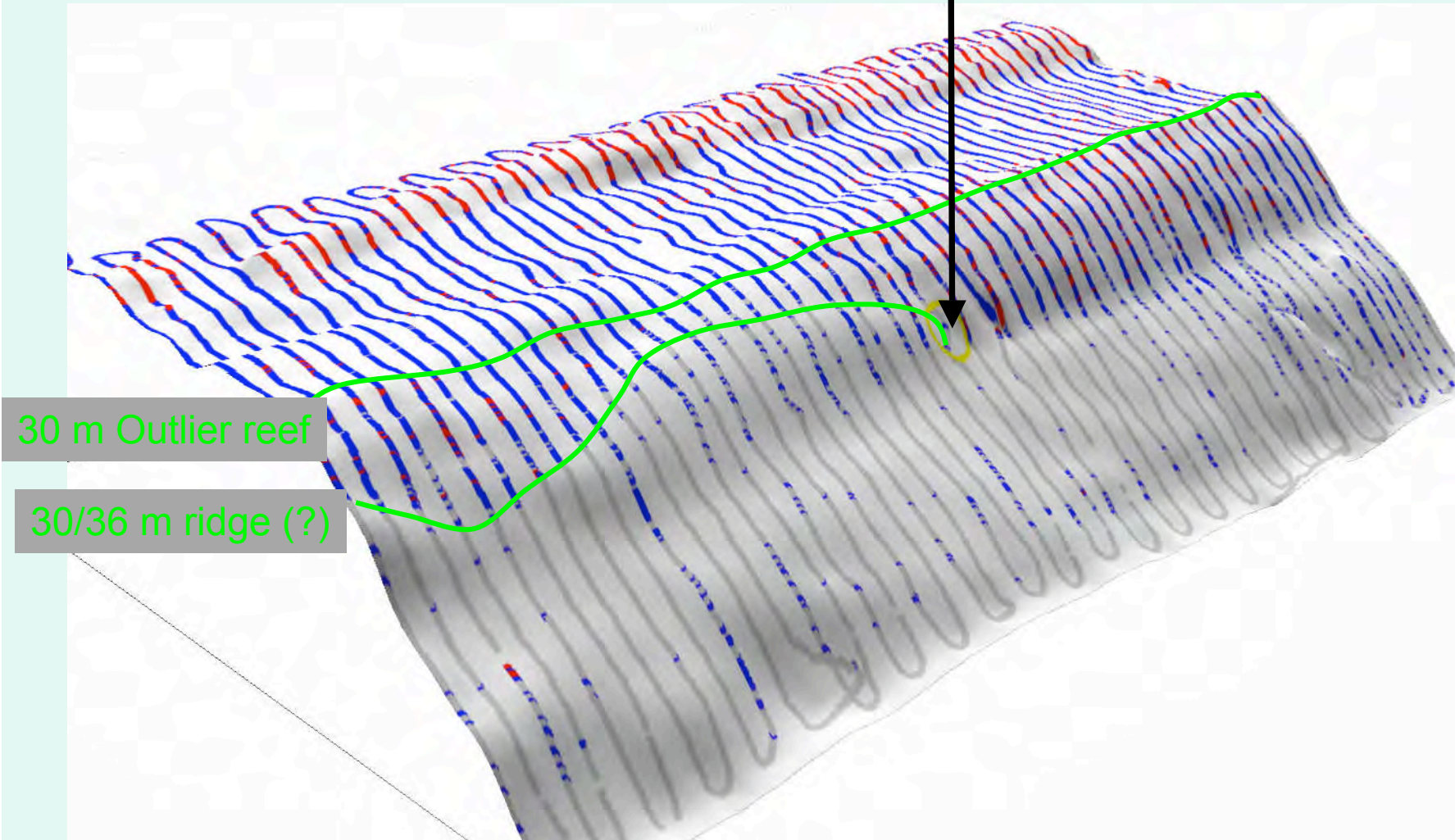
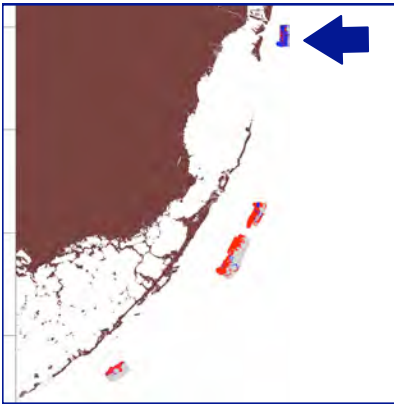


# Bear Cut

## Gag grouper

Offshore steep part of 30 m outlier

Downstream unexposed 30 / 36 m ridge



30 m Outlier reef

30/36 m ridge (?)



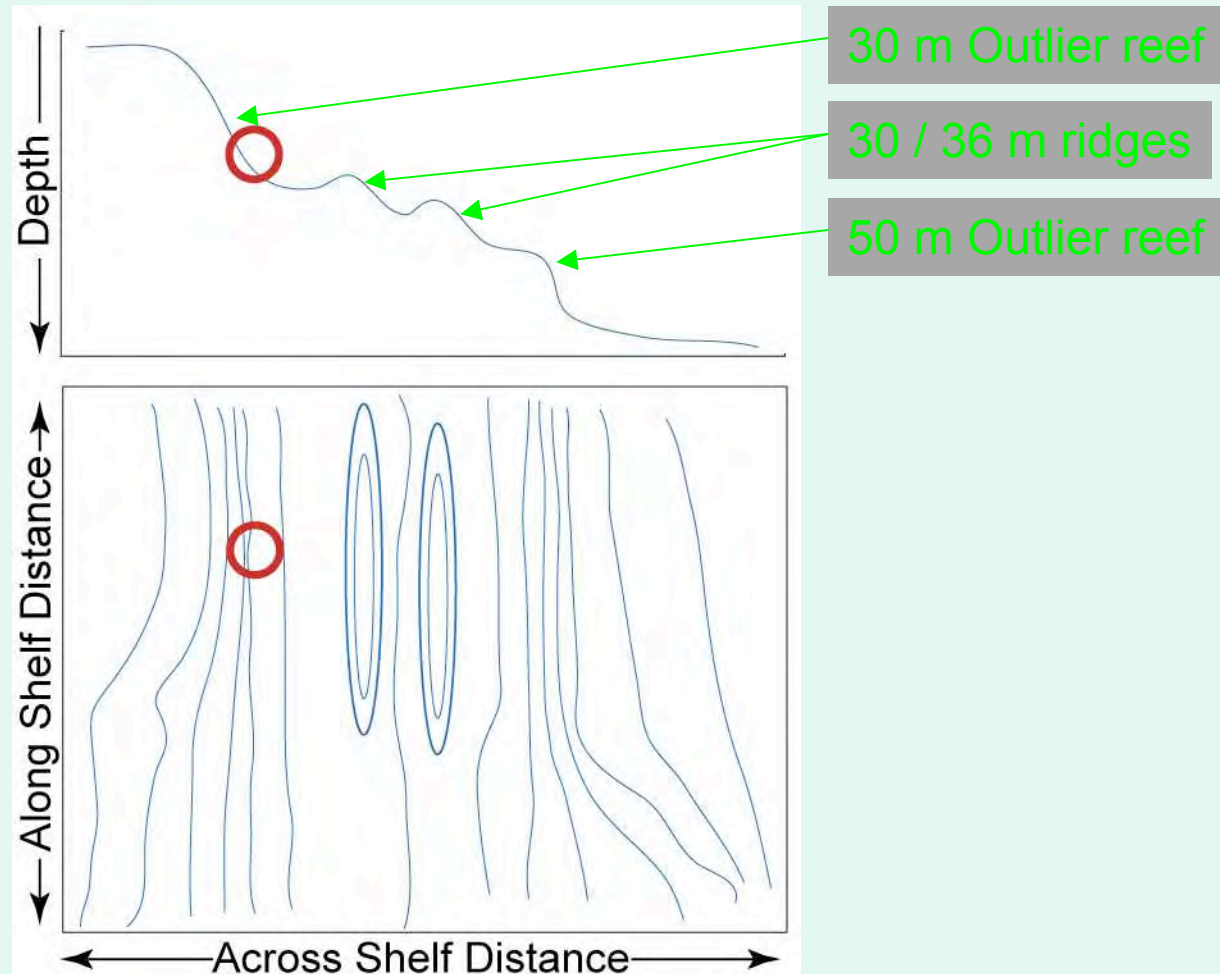
# Upper Keys Aggregation Sites Model

Original Hypothesis (Based on Carysfort)

**Aggregation sites expected at a point meeting three conditions :**

- 1) On steepest part of 30 m outlier
- 2) Inshore exposed 30, 36 m ridges
- 3) Inshore exposed 50 m outlier

Side view  
(depth profile)



Top view  
(depth contours)



# Upper Keys Aggregation Sites Model

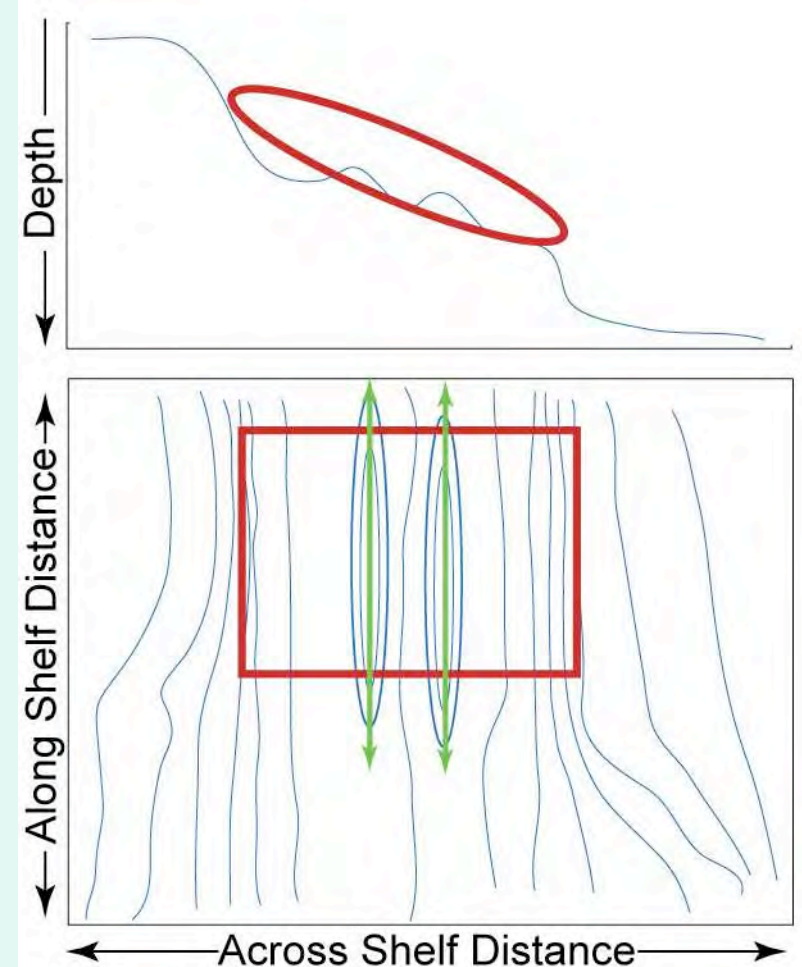
Revised Model (Based on observations at additional Upper Keys sites)

## Aggregation sites expected within a band meeting three conditions:

- 1) On face or offshore of steepest part of 30 m outlier
- 2) Within 100 m (along shore) of exposed 30 / 36 m ridge
- 3) On face of or inshore exposed 50 m outlier

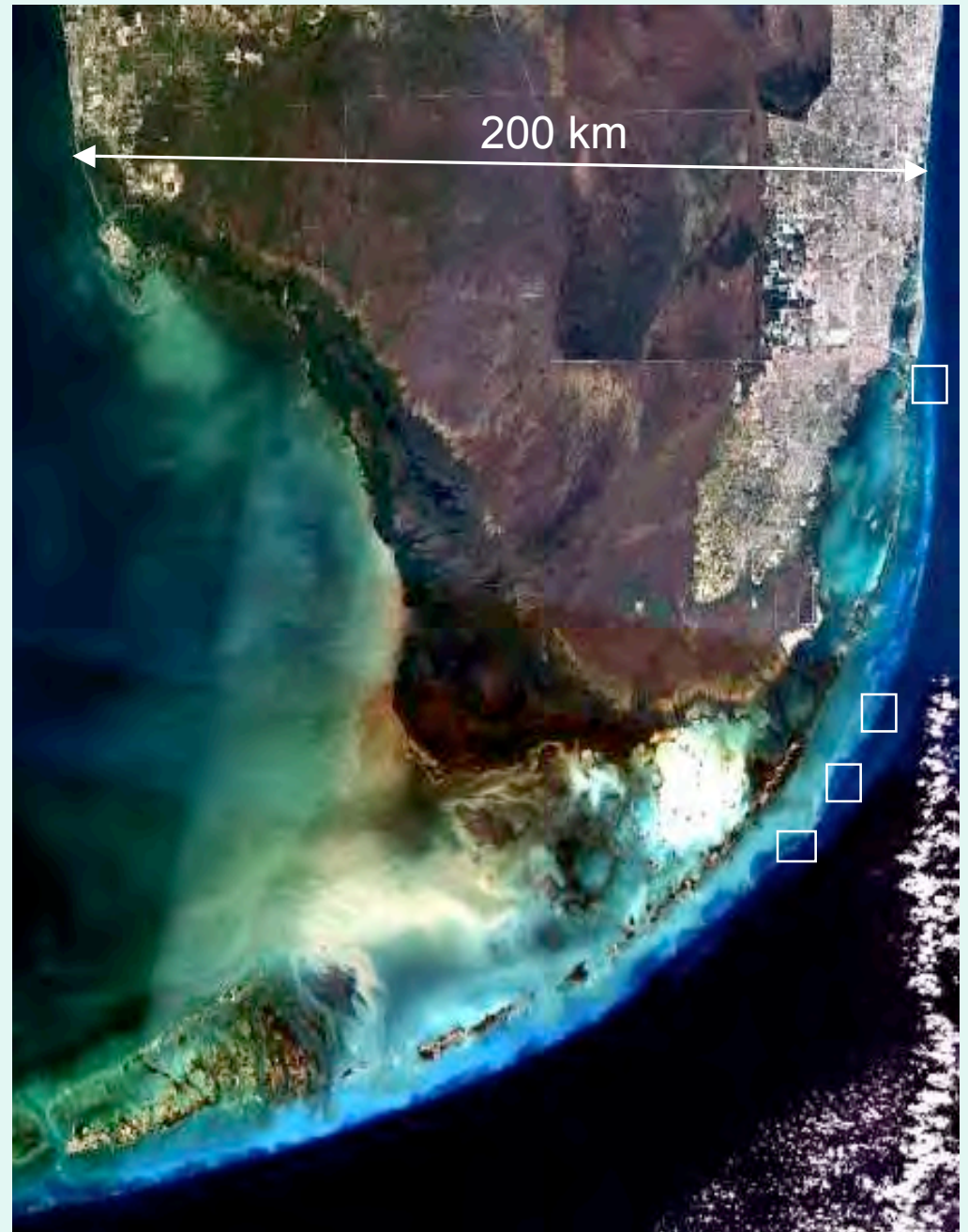
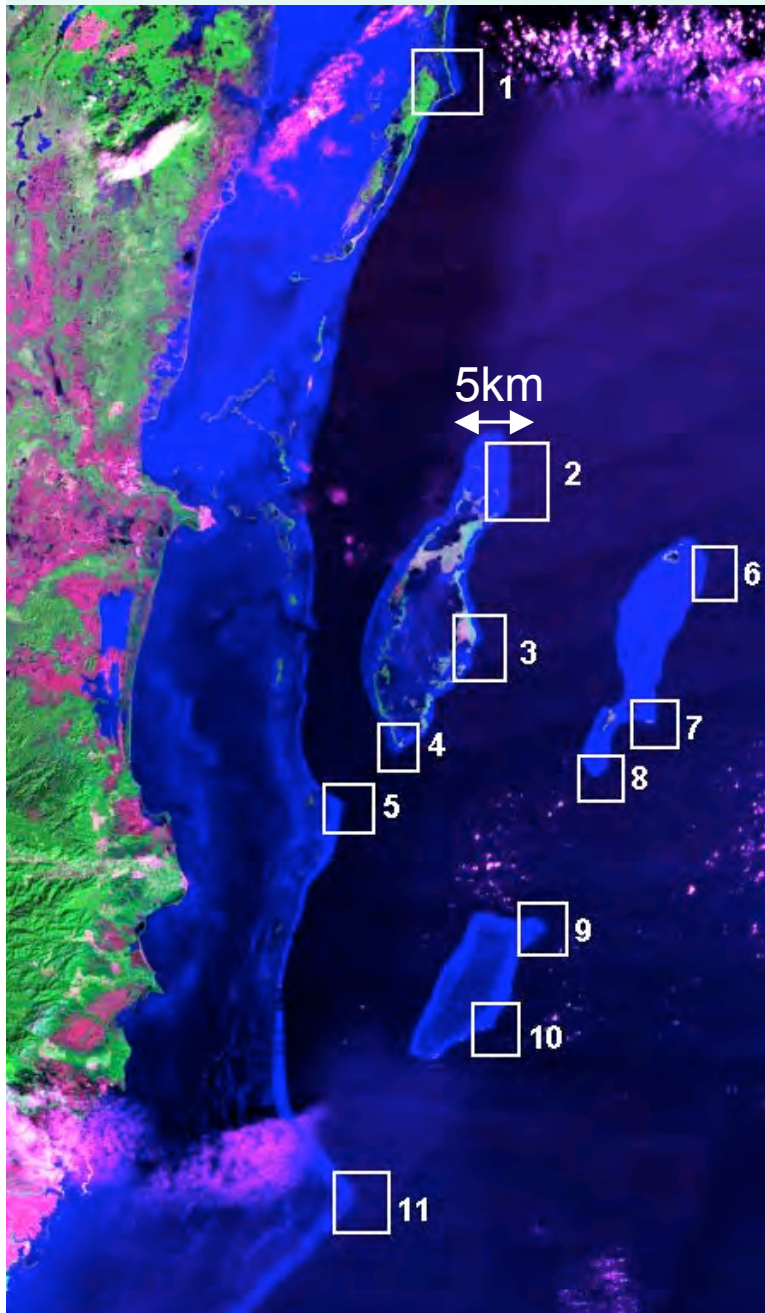
How well do sites fit the revised model?

Site	1	2	3
Carysfort (Black)	Y	Y	Y
Watsons (Black and Yellowtail)	Y	Y	Partial
Davis (Yellowtail)	Y	N	N
Watsons (Mutton)	Y	Y	Partial
Ocean Reef (Mutton)	Y	Y	Y
Bear Cut (Gag)	Y	Maybe	N





# Relevance to Caribbean

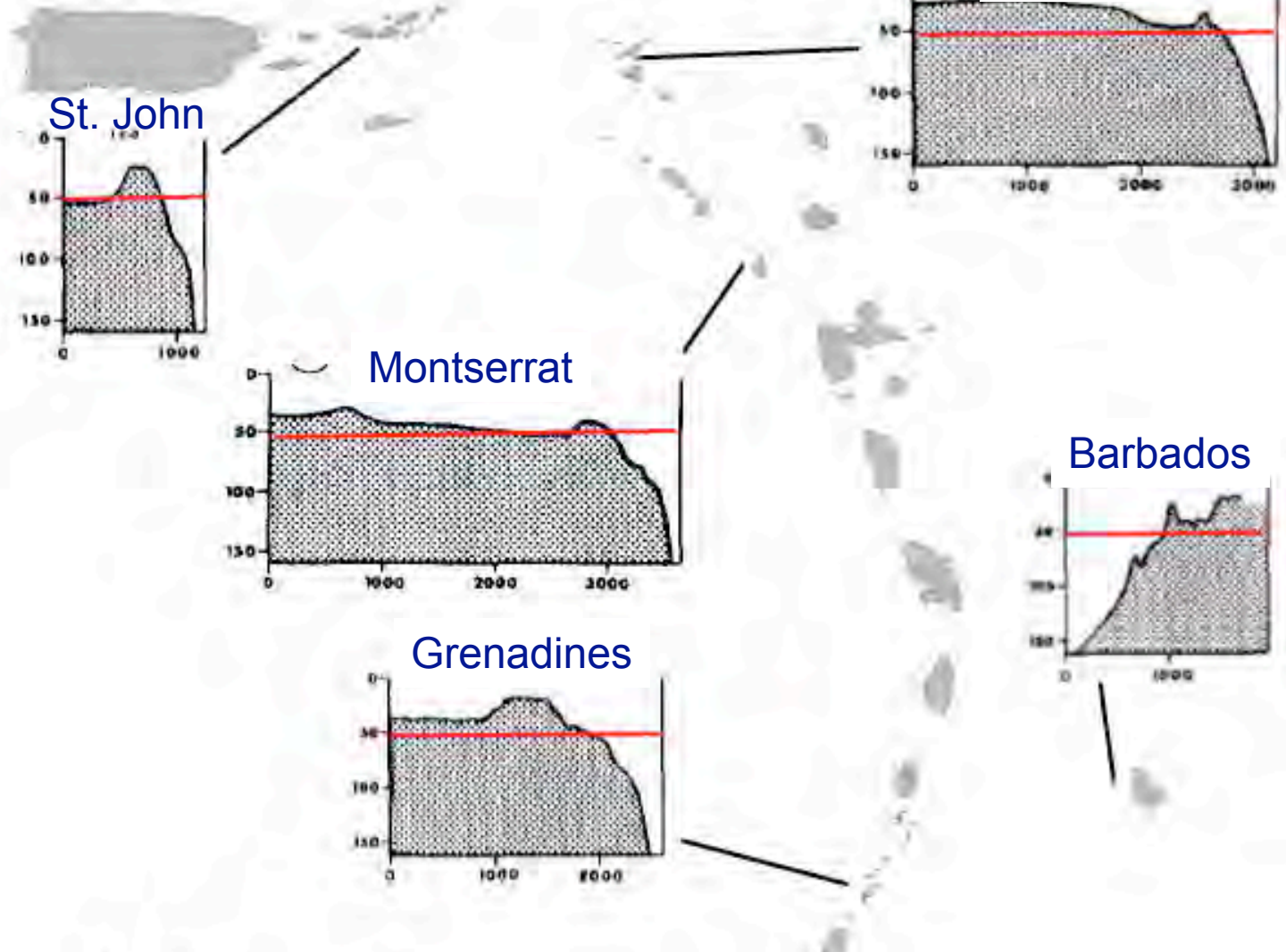




# Macintyre 1972: Shelf edge reefs on 40m terrace



## Eastern Caribbean Islands



On all plots: a) both axes in meters (vertical exaggeration = 10x)  
b) red line marks 50 m depth



# Summary

## **Outlier reefs are:**

- critical habitat in the Upper FI Keys
- critical habitat elsewhere (probably)
- too deep to survey with imagery
- possible to survey with acoustics (or lidar maybe)

**“Deep water” survey needed when considering MPA boundaries: We don’t want another Carysfort.**

## **Benefits of single beam**

- Inexpensive
- Retrieves substrate type, not just bathymetry



# Acknowledgements

- Funding from NOAA CRCP and ONR
- SPAG local knowledge from Roberto Torres
- Diving and boat ops support: Dave McClellan, Mark Miller, Jack Javech, Leah Harman, Sean Cimulluca, Doug Harper, Joe Contillo, Heather Balchowsky, Jen Schull, Neil Baertlein
- Anne-Marie Eklund initiated this project