



# Effective multi-agency collaboration improves spatial monitoring and planning in the Florida Keys

Jim Bohnsack  
Southeast Fisheries Science Center  
NOAA Fisheries Service  
Miami, FL

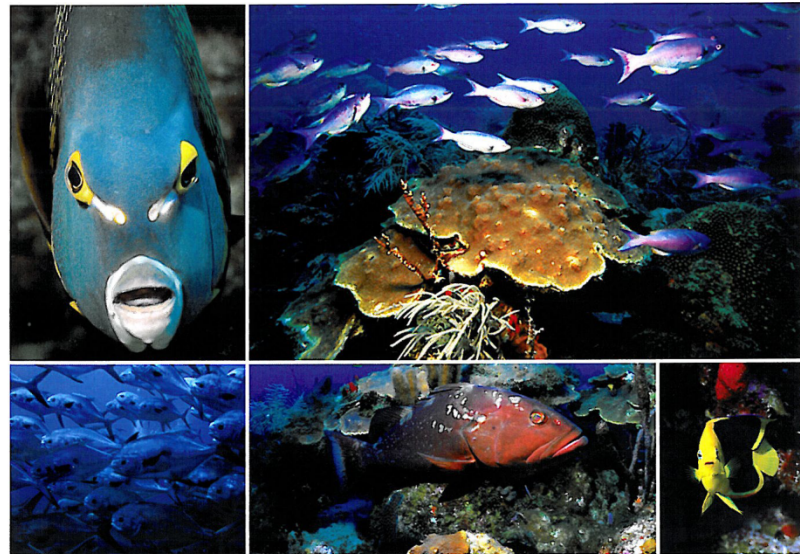
National Park Service  
U.S. Department of the Interior

Natural Resource Program Center

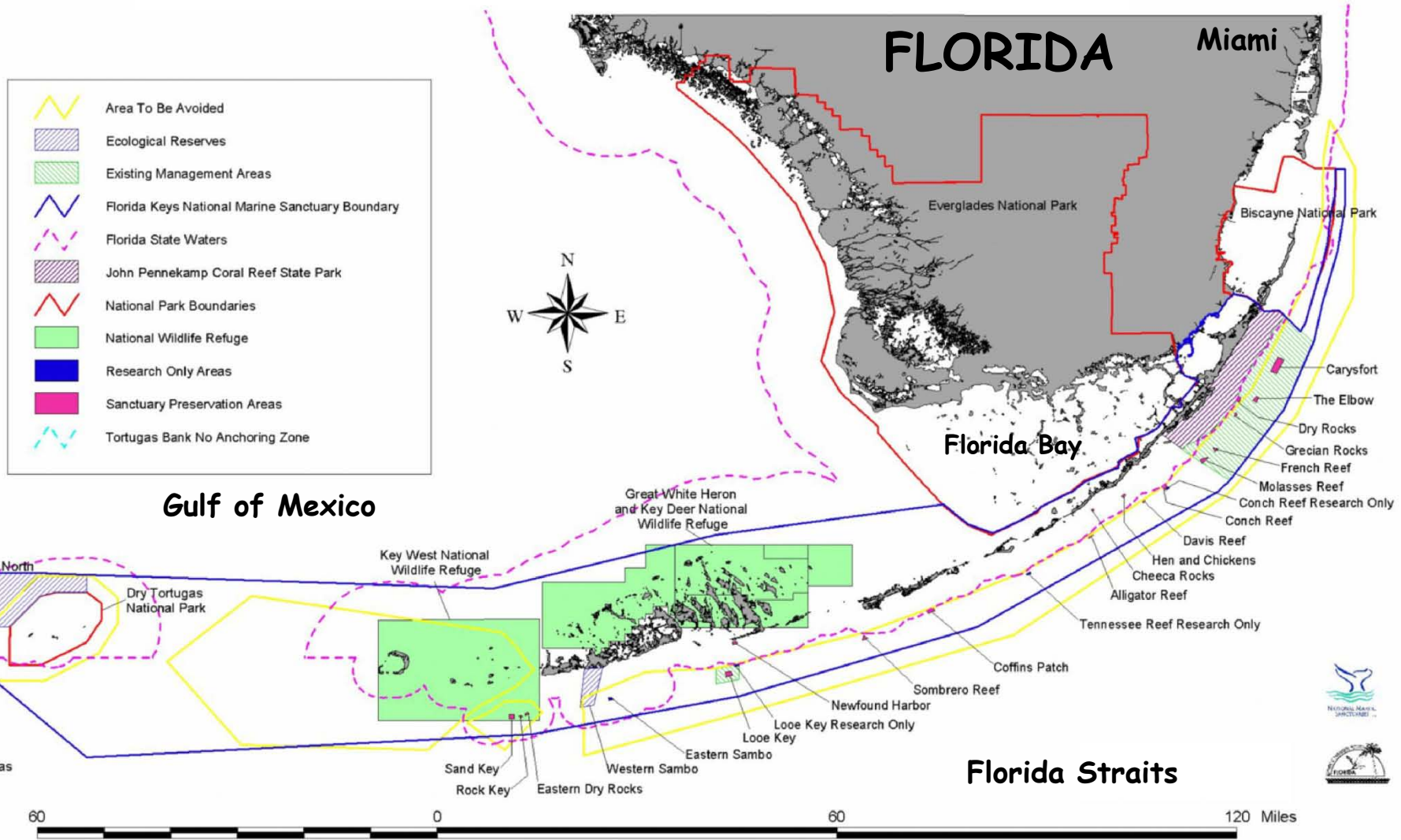


## A Cooperative Multi-agency Reef Fish Monitoring Protocol for the Florida Keys Coral Reef Ecosystem

Natural Resource Report NPS/SFCN/NRR—2009/150



# The Managed Florida Keys Coral Reef Ecosystem





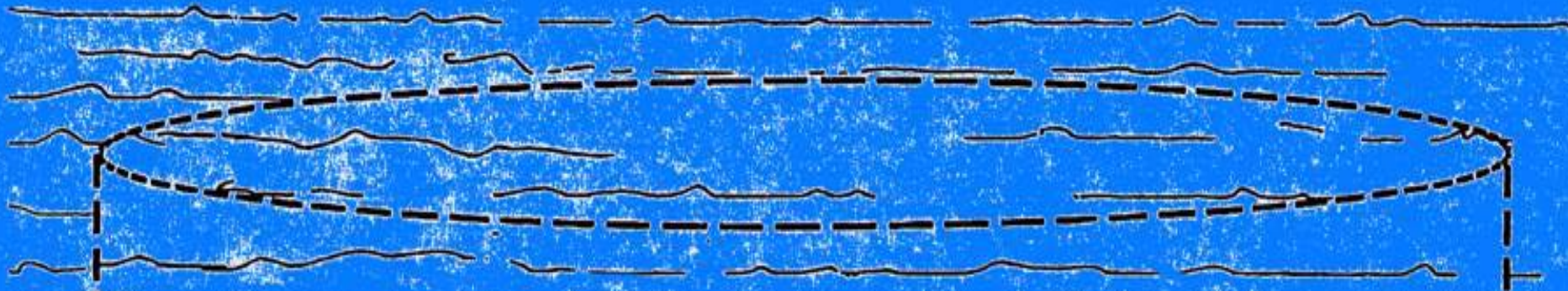
# Tortugas Cruises



Partnerships







← 15 Meters →



# Stratified Random Design

Heterogeneous Spatial Distribution

## Stratification Variables:

Cross-Shelf Habitat type

Habitat relief and patchiness

Depth

Geographical Subregion

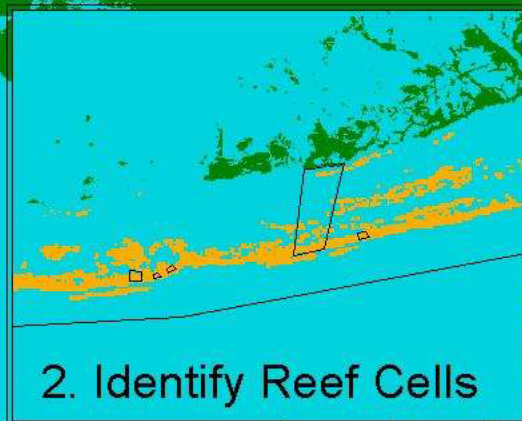
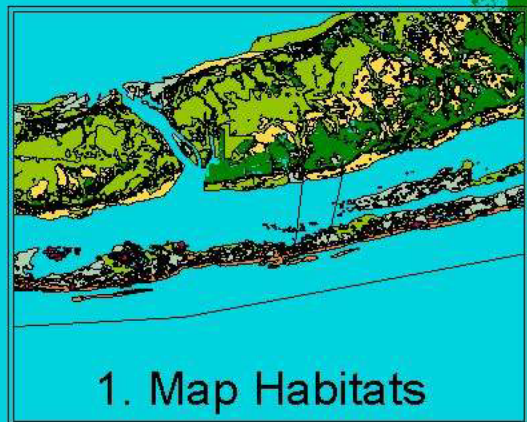
Spatial Management Zone

(e.g, no-take reserves, angling only)



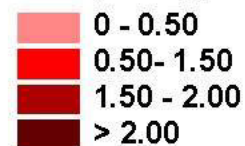
# Florida

Miami

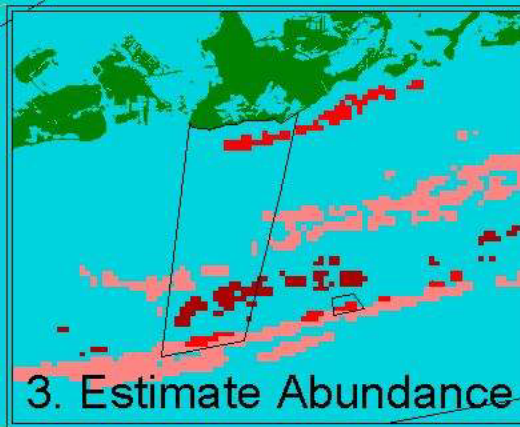


## Gulf of Mexico

Relative Abundance  
of Gray Snapper



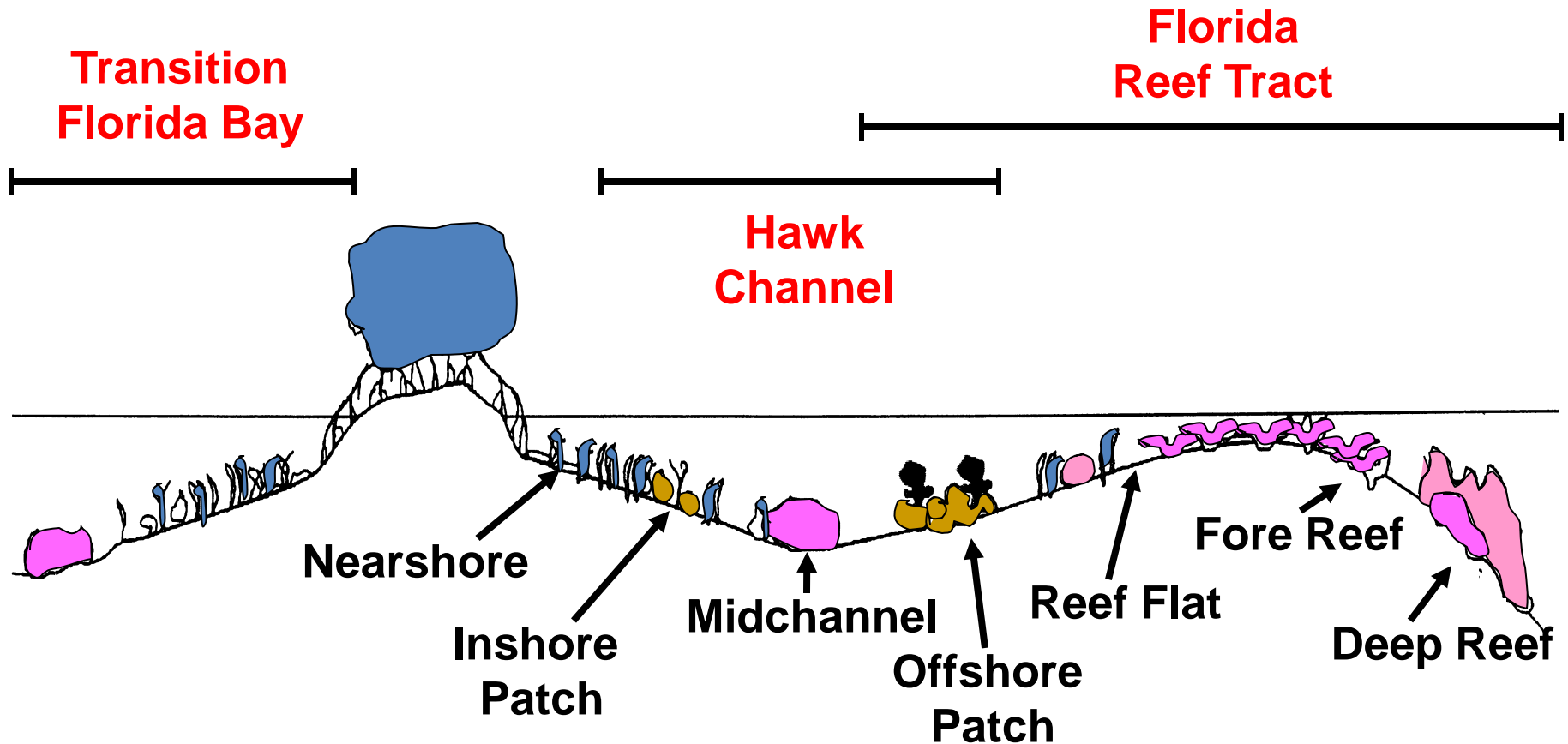
Key West



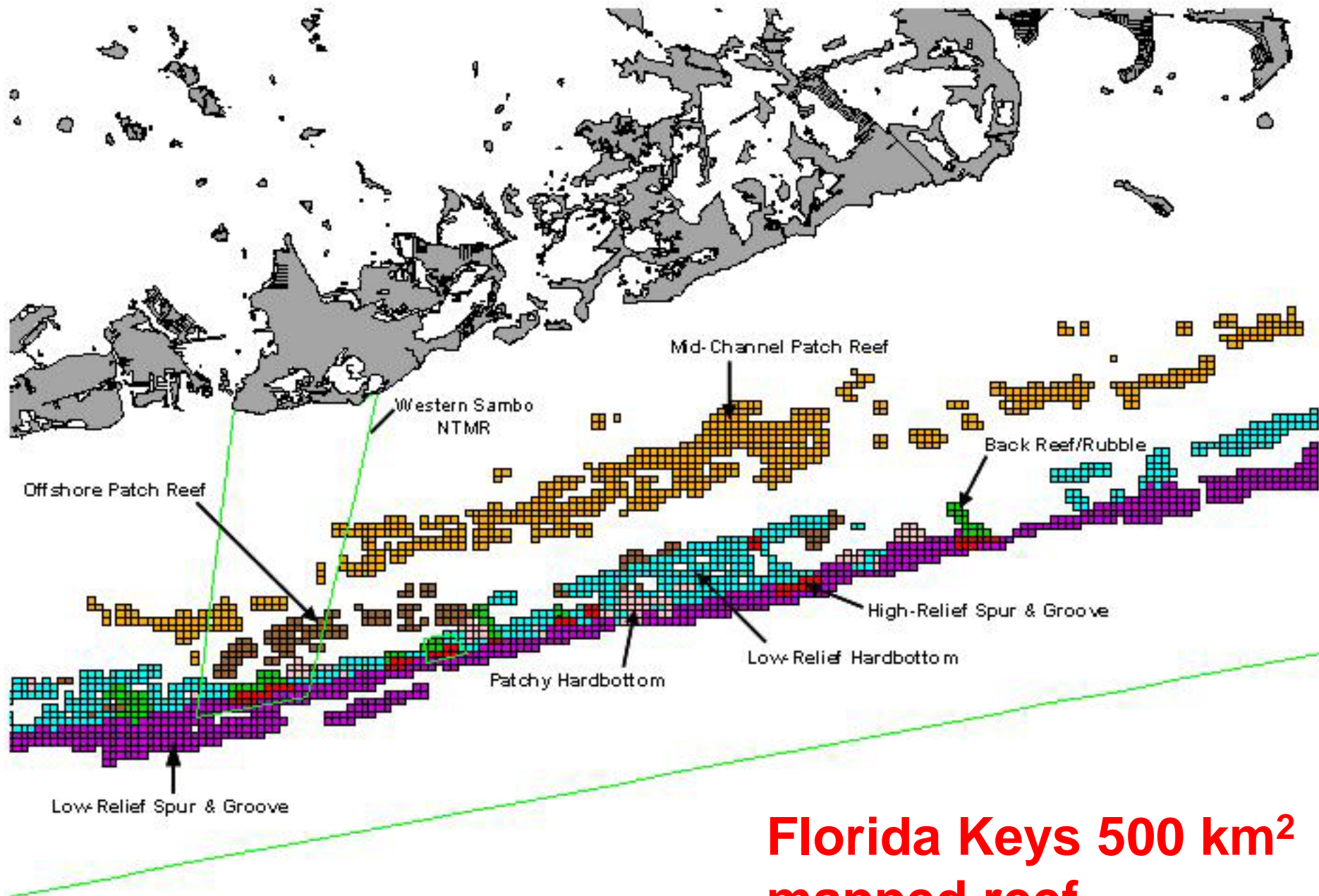
10 0 10 20 30 40 50 Kilometers



# Cross-Shelf Habitat Classification



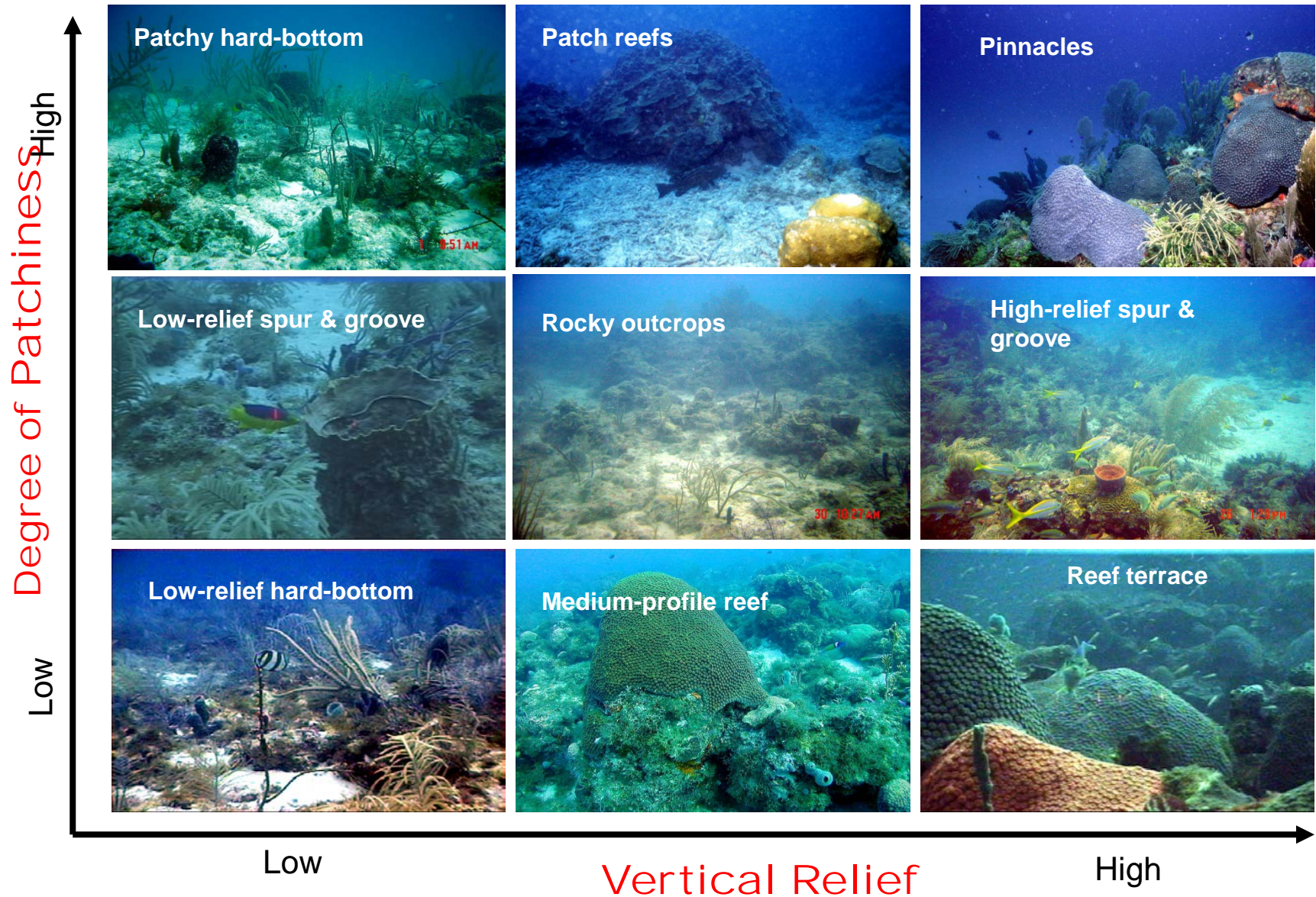
# Cross-shelf habitat classification



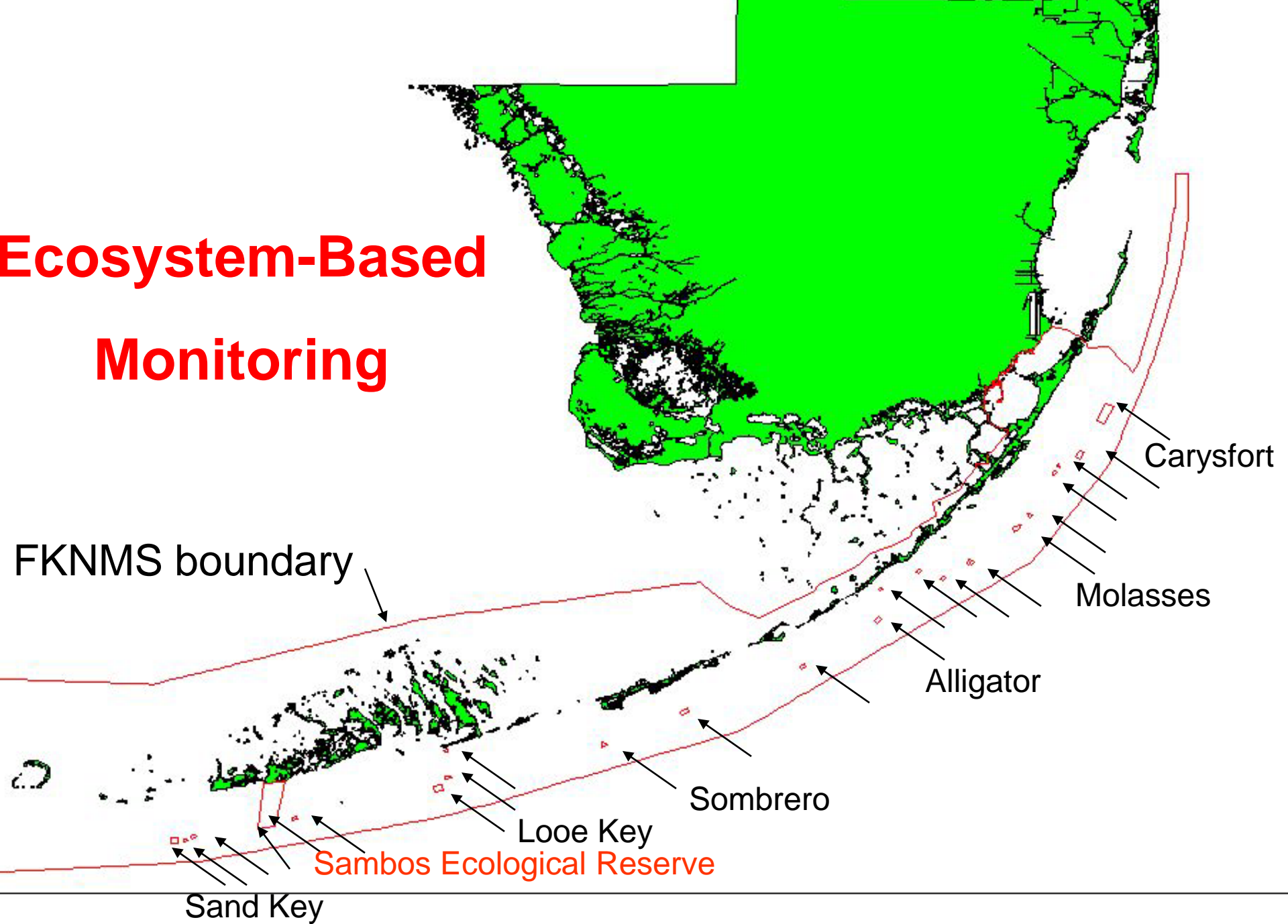
**Florida Keys 500 km<sup>2</sup>  
mapped reef**



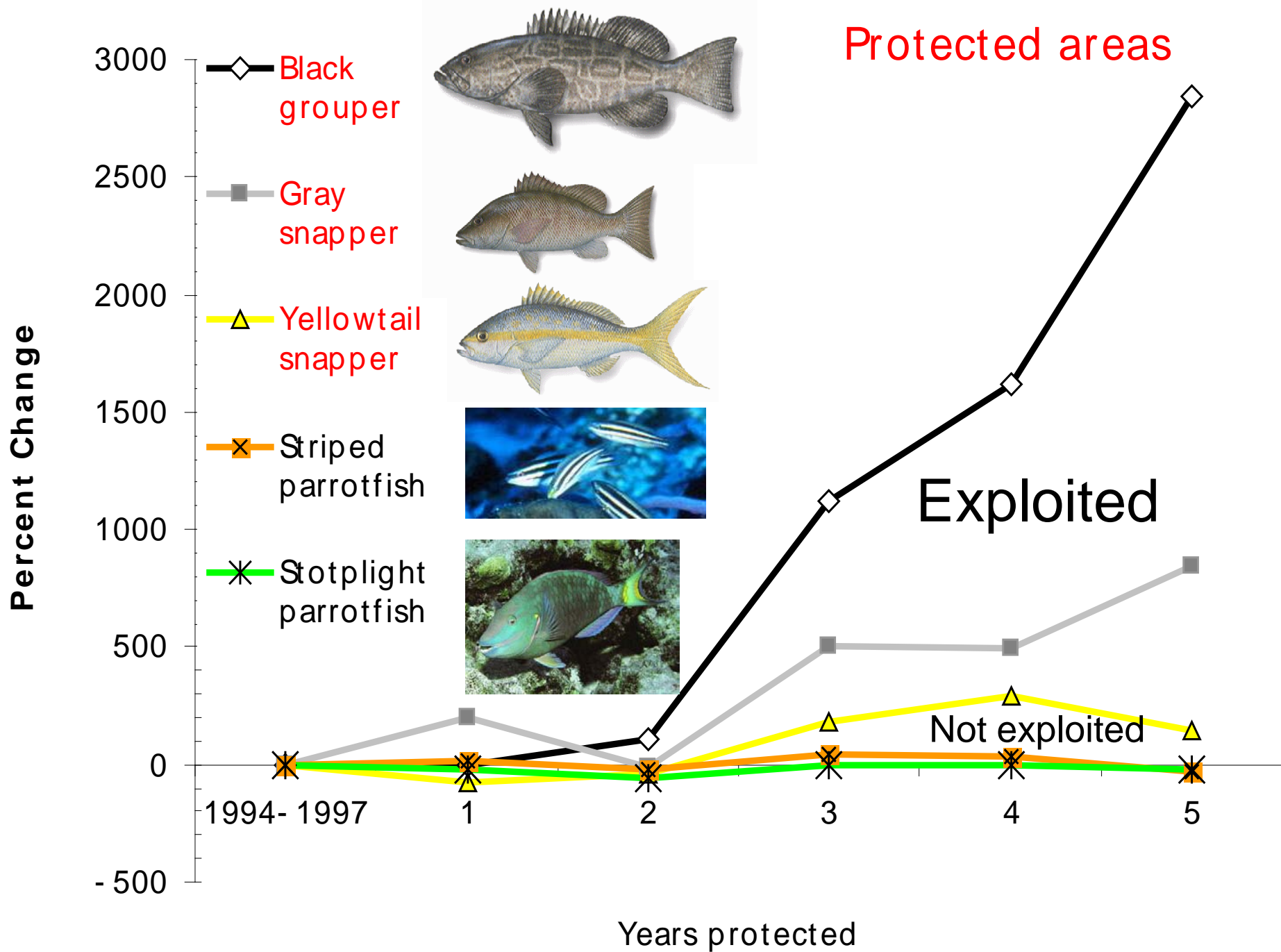
# Linking Reef Fish Spatial Abundance & Benthic Habitats



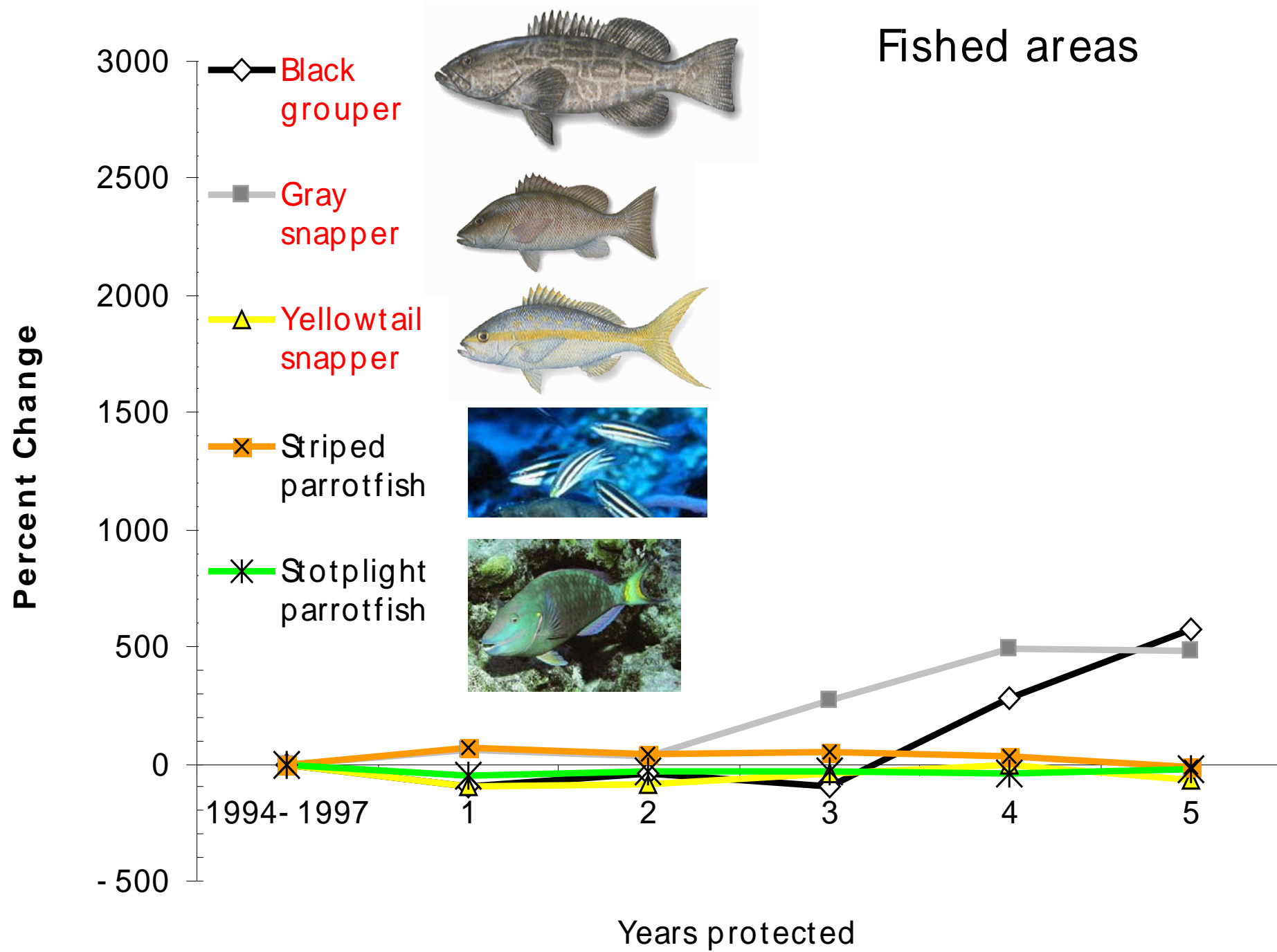
# Ecosystem-Based Monitoring





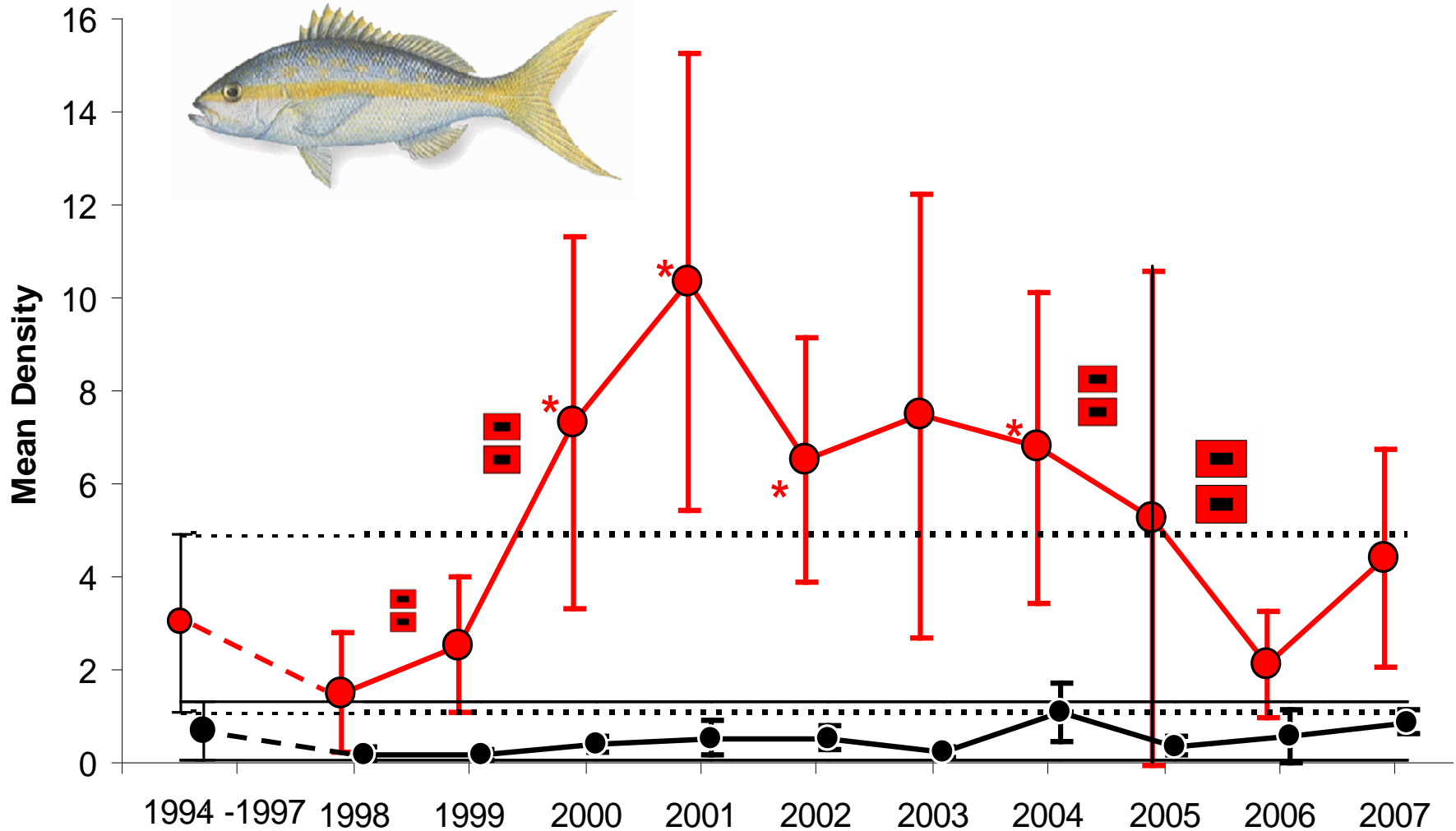
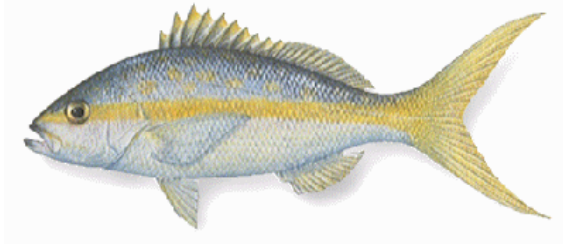


# Fished areas



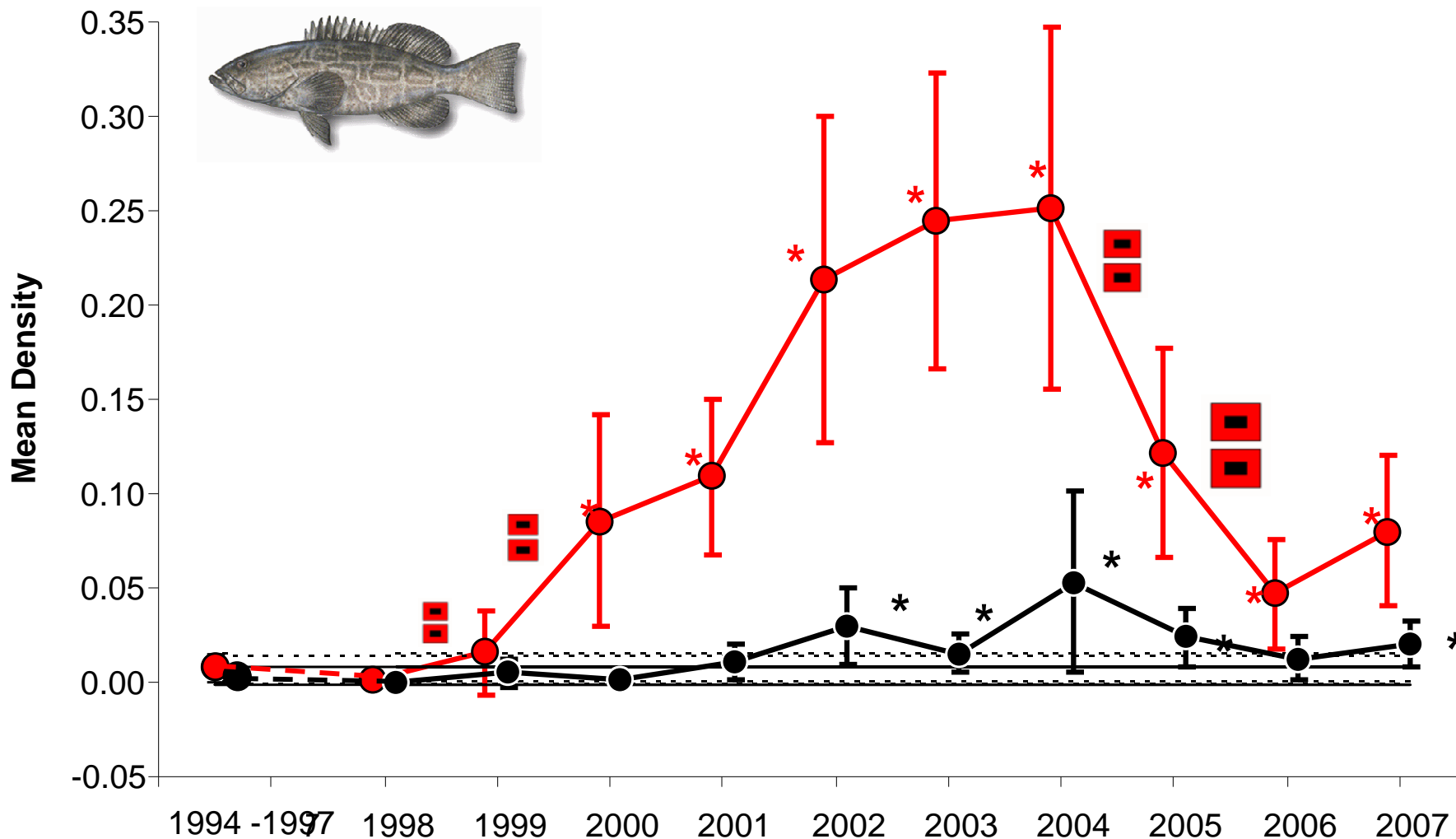


# Yellowtail Snapper, Exploited, Protected and Fished



Fishery Regulations: 1985 - 12" Minimum length, 1986 - max 10/day

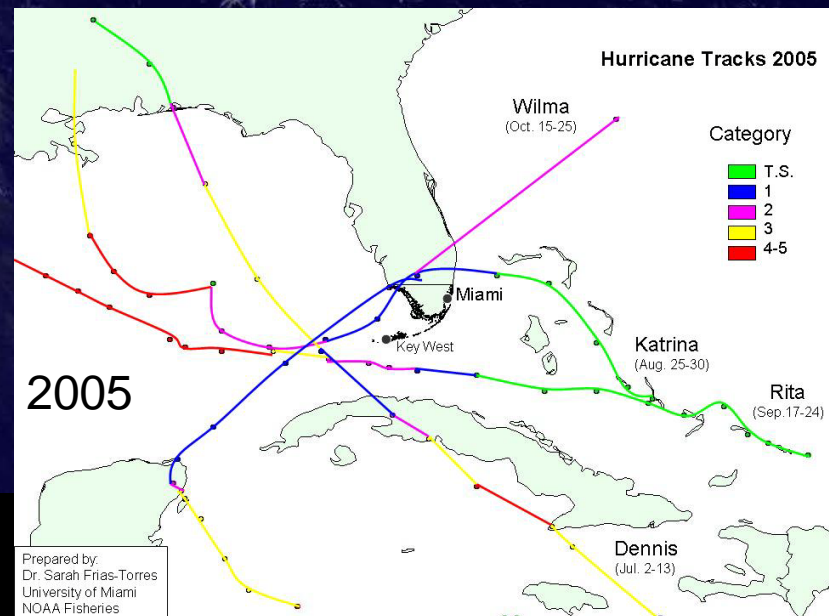
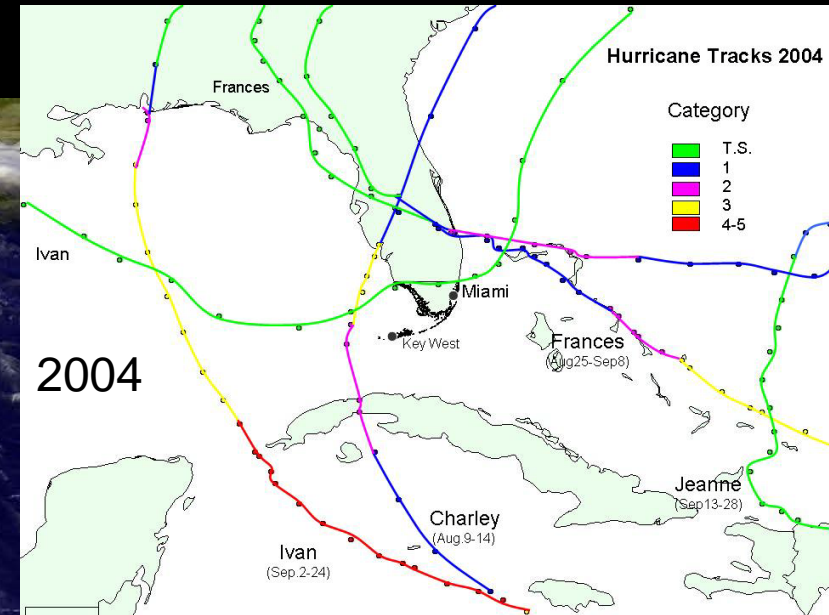
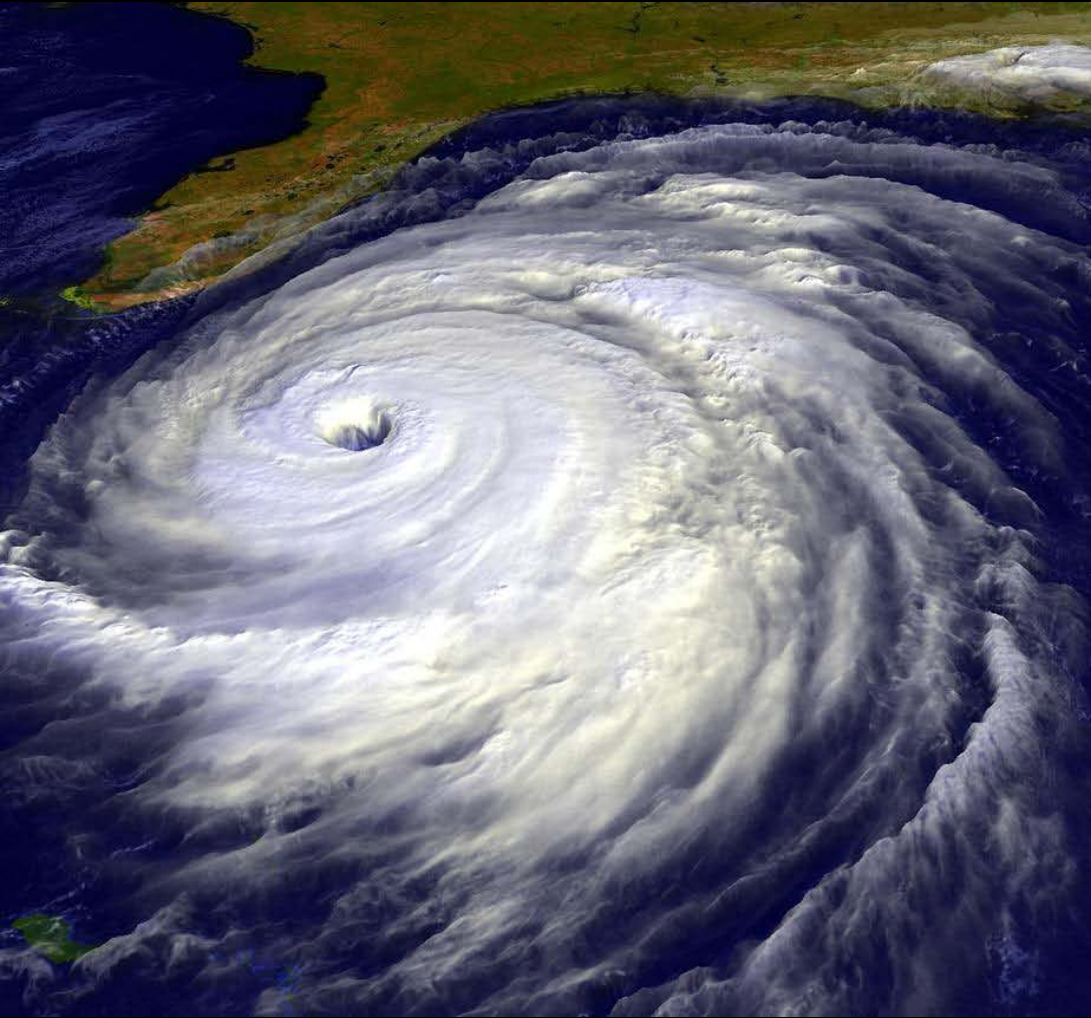
# Black Grouper, Exploited, Protected and Fished



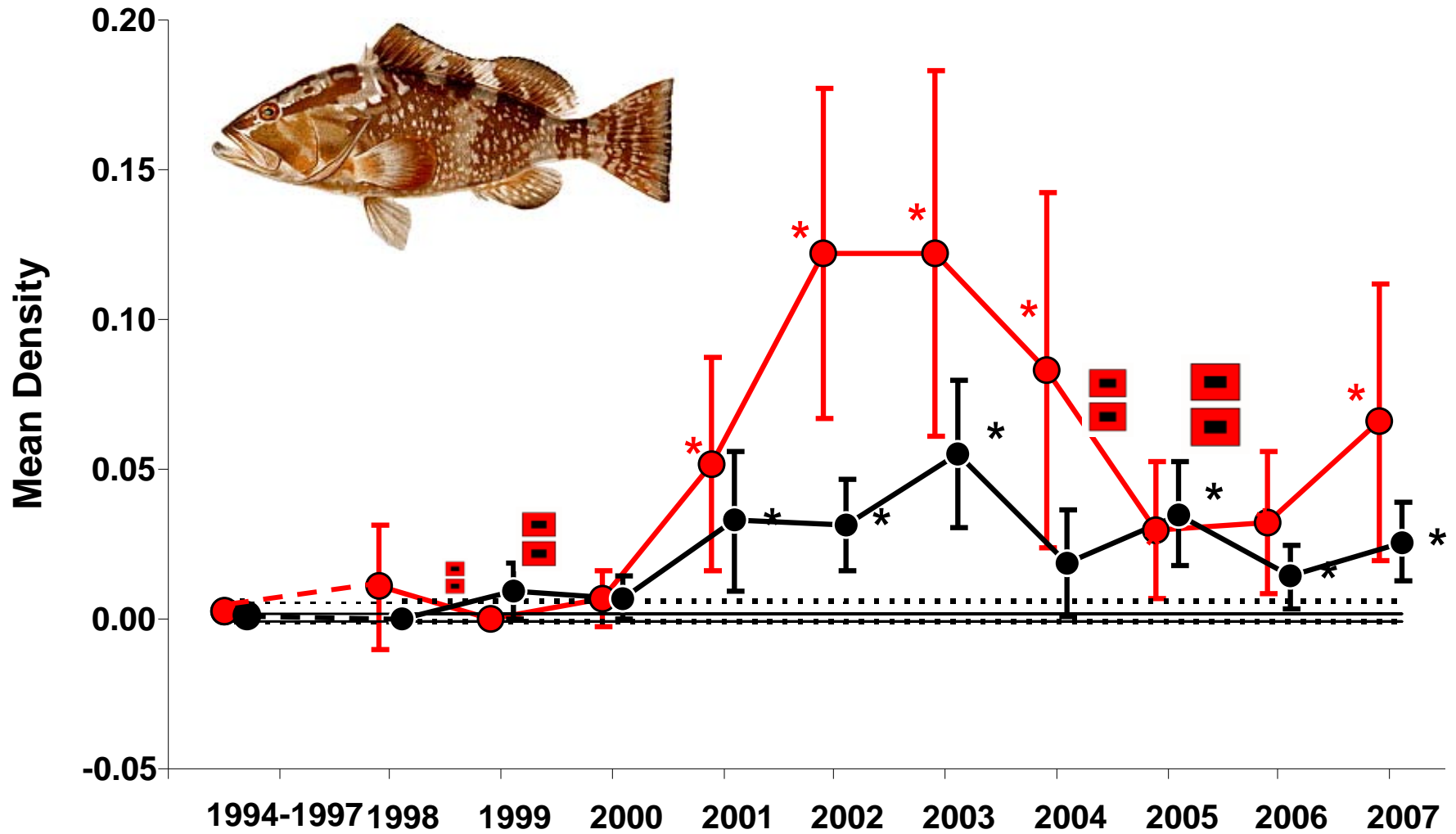
Fishery Regulations minimum length: 1985 - 18", Feb 1990 - 20", Dec 1998- 24",  
Jan 1 2001 - 22"; 1986 - 5/fisher/day



# Reef Fisheries, Coral Reef Ecosystems & Hurricanes?



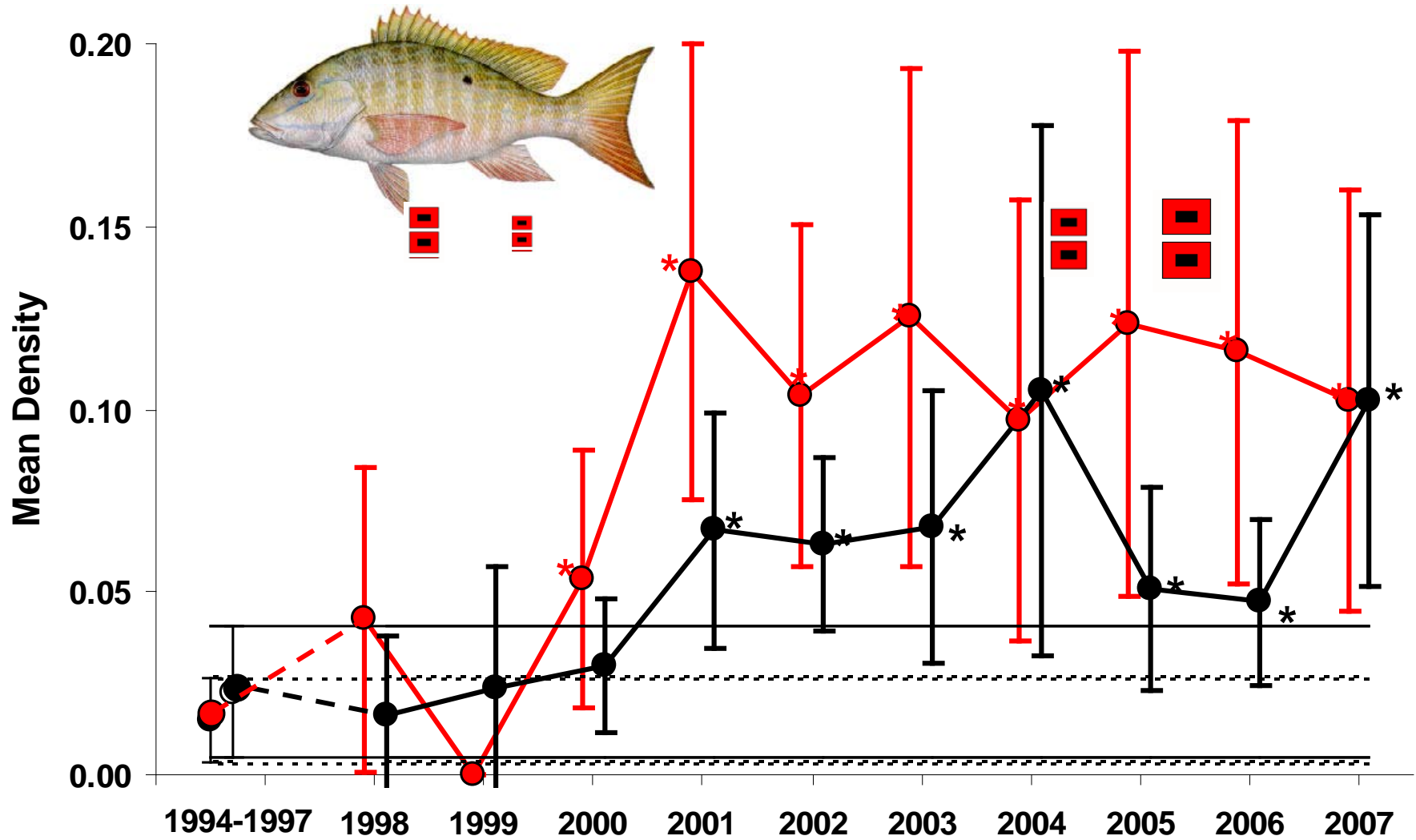
# Red Grouper, Exploited, Protected and Unprotected



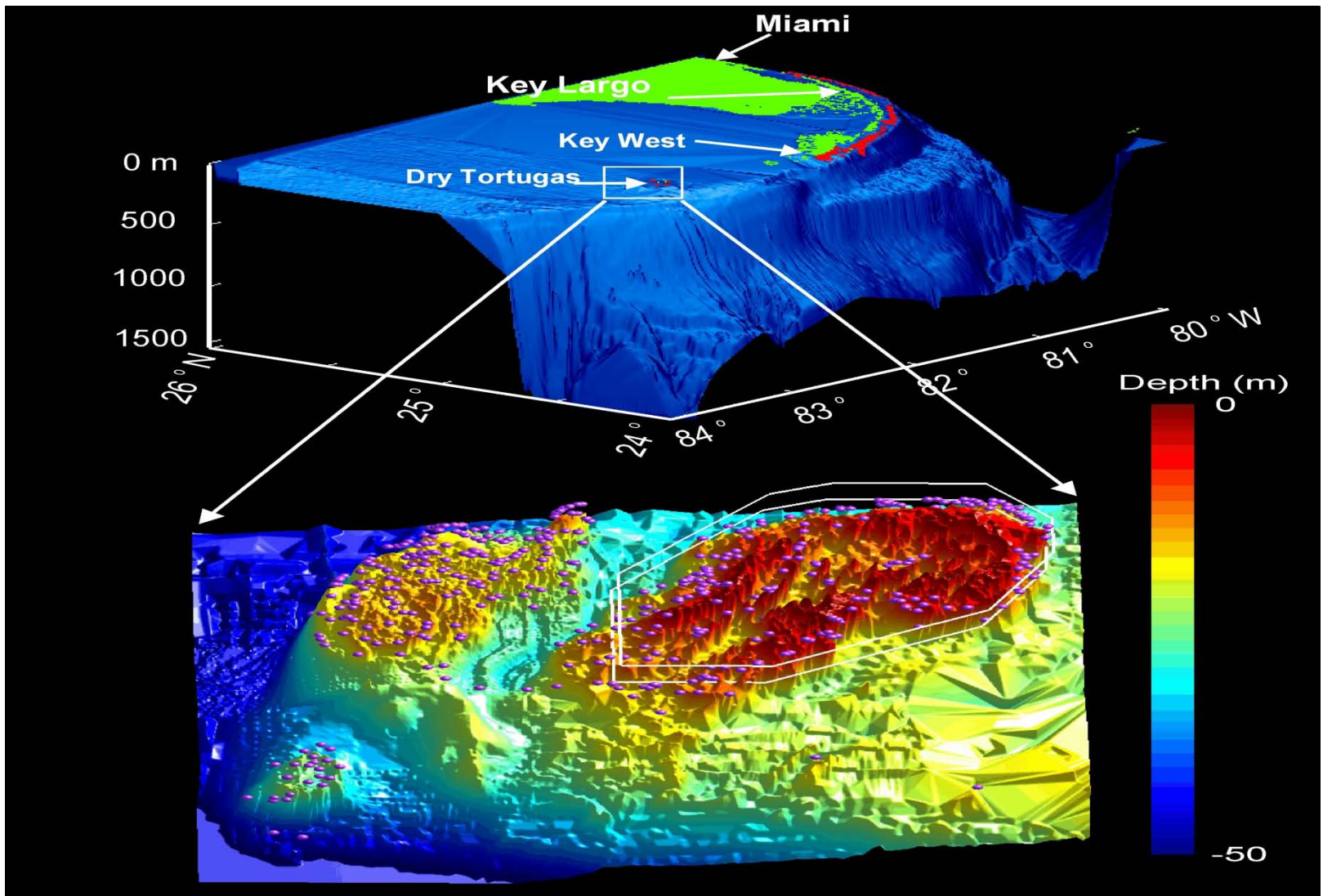
Fishery Regulations minimum length: 1985 - 18"; 1986 - 5/fisher/day



# Mutton Snapper, Exploited, **Protected** and Fished



Fishery Regulations: minimum length 1985 - 12", 1994 - 16"; 1986 -10/fisher/day



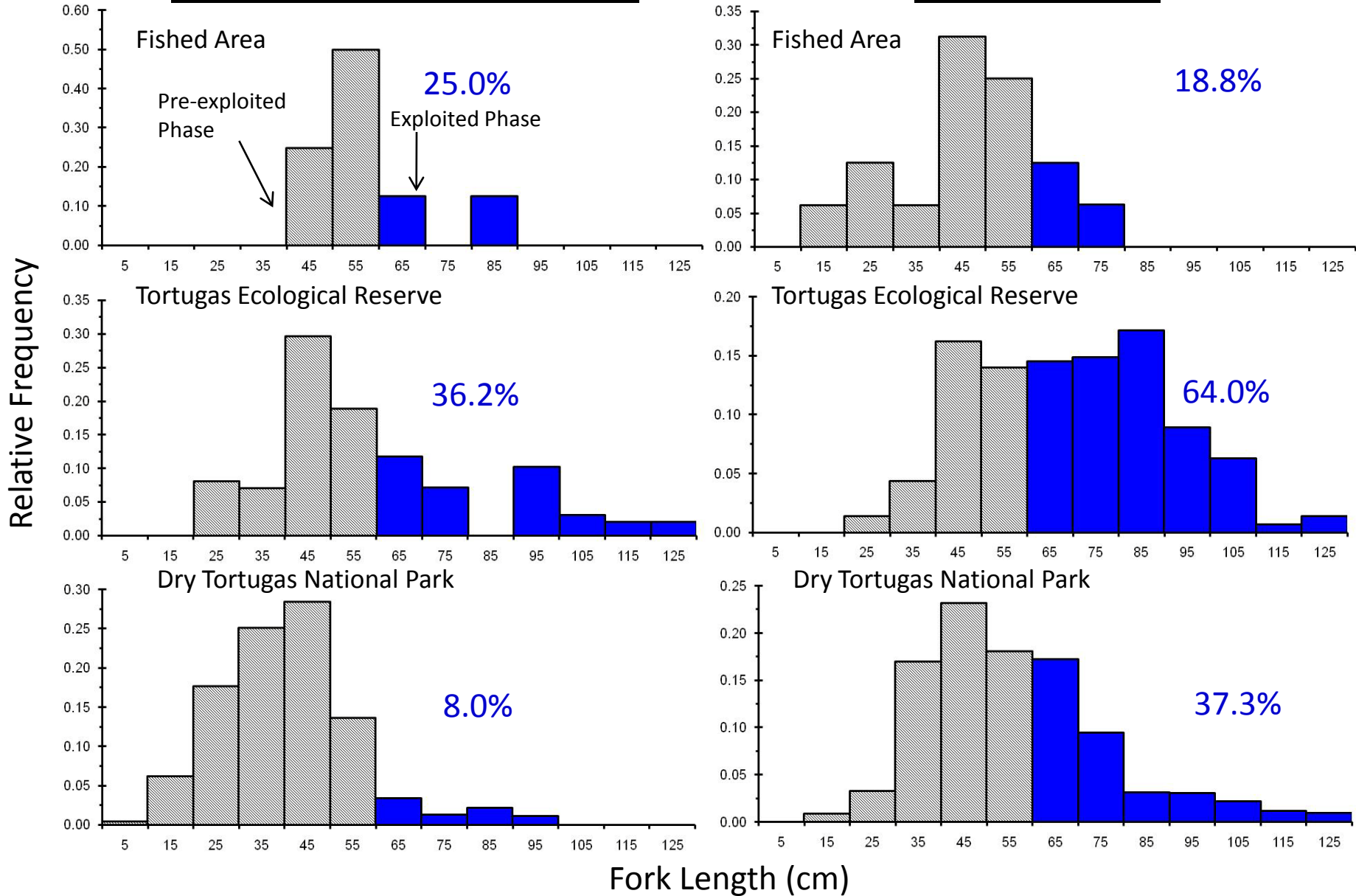
**Figure 1.1** - Three-dimensional maps of the Florida Keys coral reef ecosystem showing: (A) South Florida and the coral reef tract (red) from Key Biscayne to the Dry Tortugas; and (B) the bathymetry of the Tortugas region showing Dry Tortugas National Park, Tortugas Bank and Riley's Hump where the purple balls represent primary sampling units from the millennial RVC and reef habitat surveys.



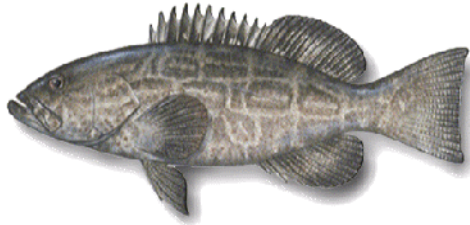
# Response of Tortugas MPAs to Protection

**Pre-Implementation: 1999-2000**

**2008 RVC Survey**



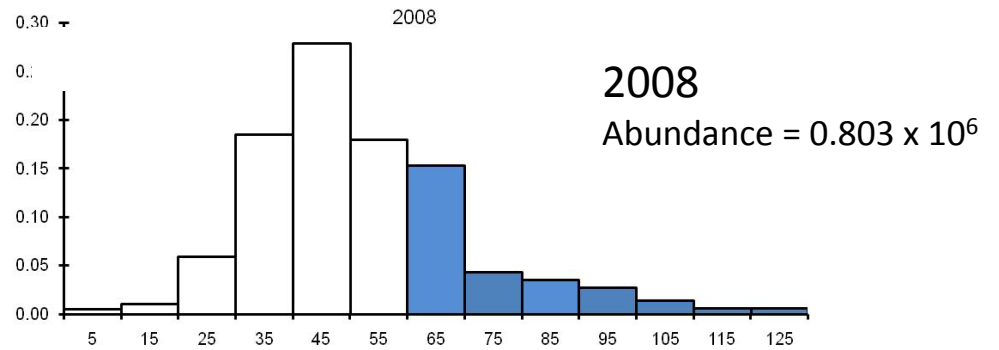
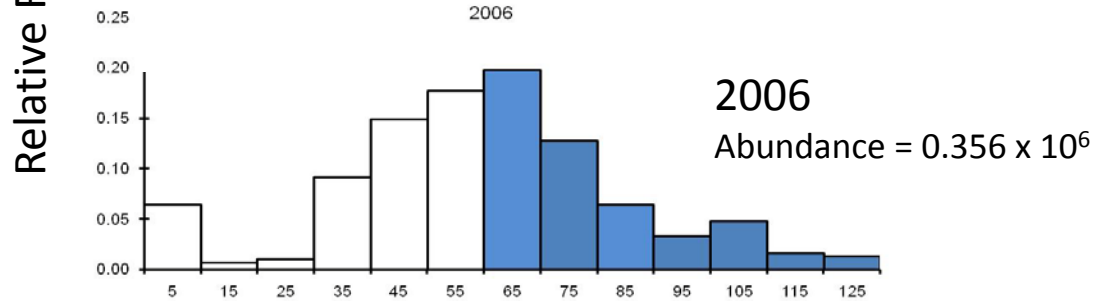
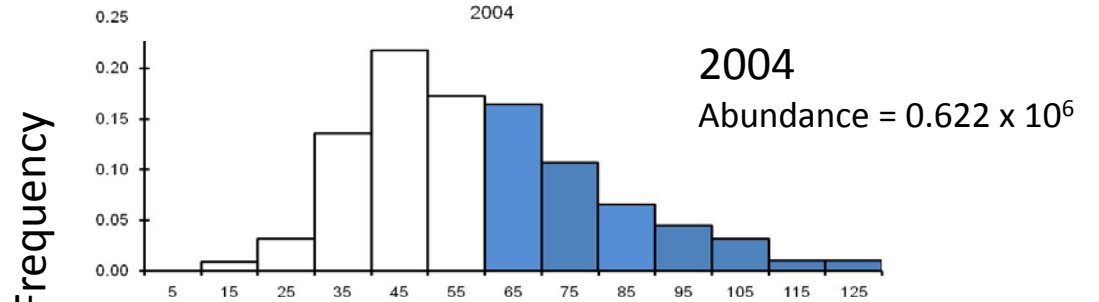
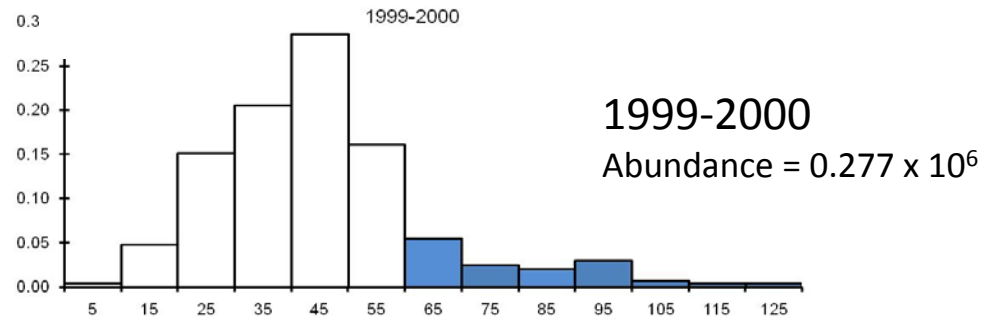
# DRY TORTUGAS REGION



Black Grouper Abundance



2001 TER



Fork Length (cm)



# Optimal Design of Marine Reserves

## OBJECTIVE FUNCTION

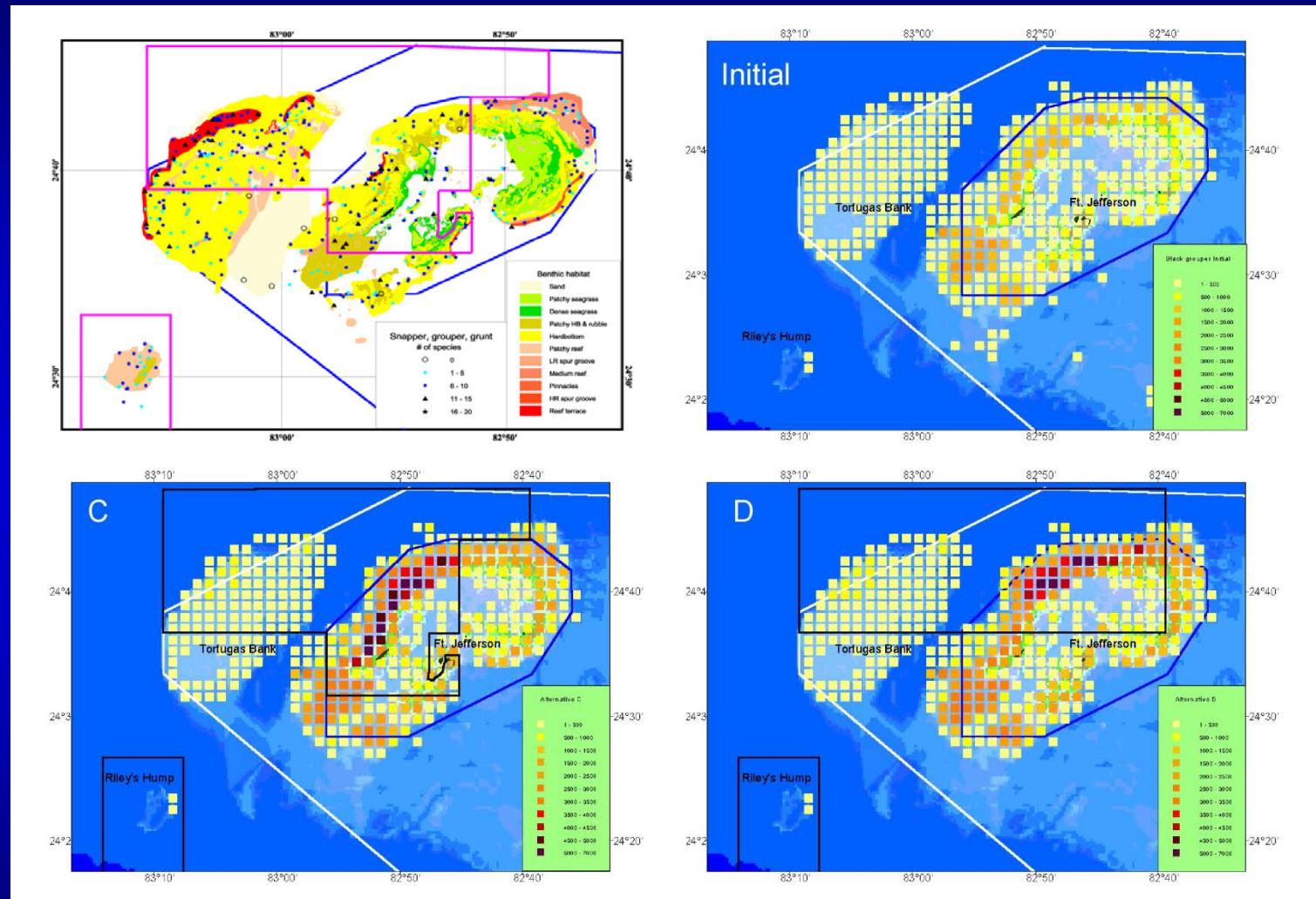
$$\text{Min} \left\{ \mu_q^+ q^+ + \sum_{s \in \mathcal{S}} (\mu_s^+ p_s^+ + \mu_s^- p_s^-) + (\mu_f^+ f^+ + \mu_f^- f^-) + (\mu_c^+ c^+ + \mu_c^- c^-) + (\mu_a^+ a^+ + \mu_a^- a^-) + \sum_{r \in \mathcal{R}} (\mu_{ar}^+ a_r^+ + \mu_{ar}^- a_r^-) \right\}$$

reserve	SPR over	fishing	Reef	Total	Regional
shape	all species	effort	area	Reserve	reserve
				area	area

## CONSTRAINTS -- SUBJECT TO:

- (C1) Reserves non-overlapping
- (C2) Prespecified number of reserves
- (C3) Fixed proportion of SPR protected
- (C4) Maximum number of fishing vessels displaced by reserves
- (C5) Target area of coral reef area protected
- (C6) Target total area protected
- (C7) Distribution of reserves among regions of ecosystem
- (C8) Each reserve contiguous, compact, and desirably shaped

# Designing Marine Reserves for Fishery Management



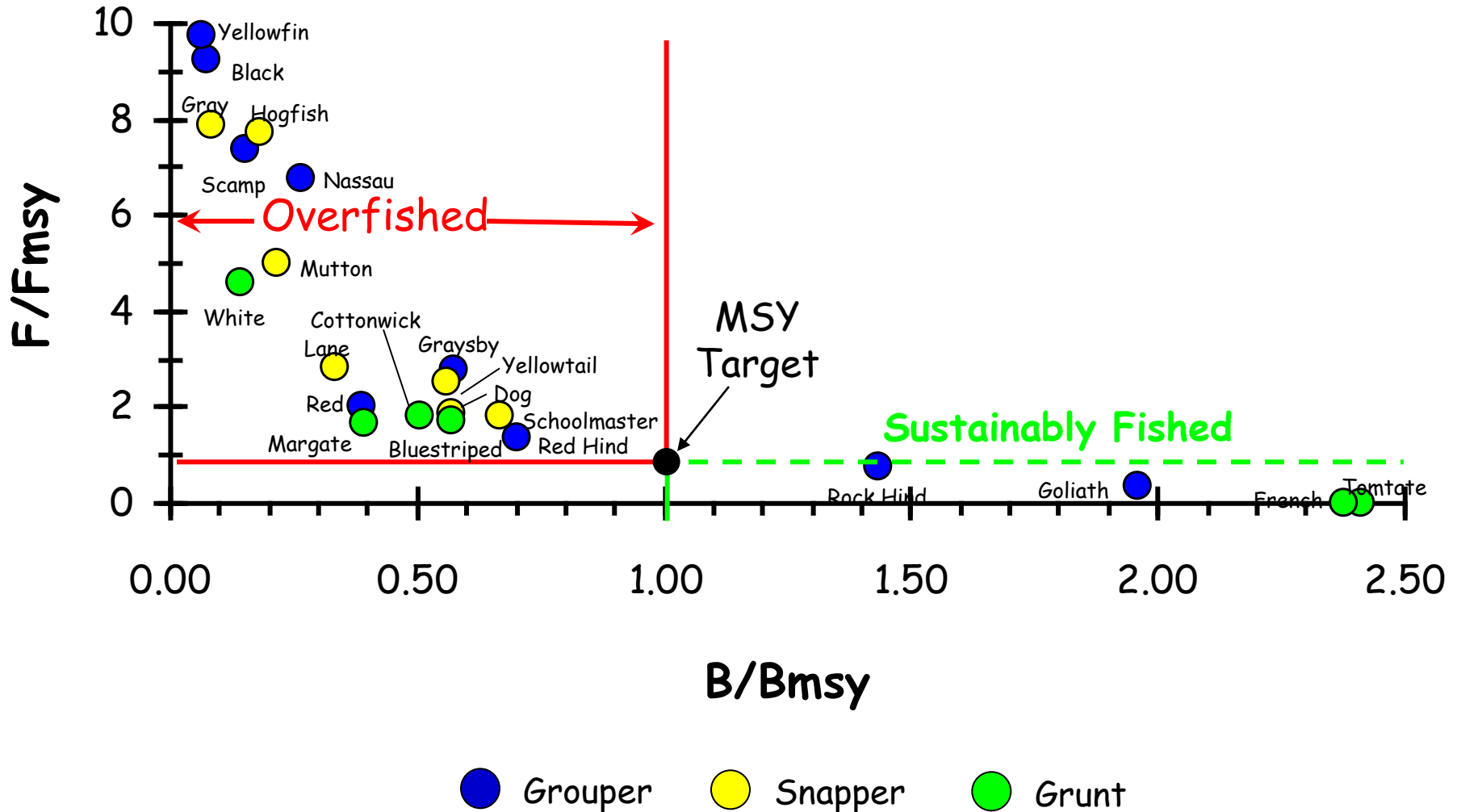
## Integrated methodologies:

**Integer Goal Program for network design; simulations to assess shape and size effects.**

Meester, Mehrotra, Ault and Baker. 2004. Management Science 50: 1031-1043



# Florida Keys Reef Fish Community Baseline



# Conclusions

- **Multiagency partnerships are important**
- **Standardization and effective monitoring strategies are essential for spatial planning**
- **Results support marine reserve predictions**
  - Mean abundance and size were proportional to level of protection
  - Initial population responses were rapid
- **Extreme physical events influence spatial patterns**