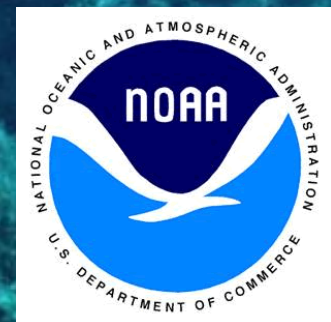


Florida's Coral Reefs in a Caribbean Context

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Florida Tech

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NOAA/FKNMS



Florida and the Wider Caribbean

- **Turnover on Caribbean reefs over the last 30 years**
 - **What we thought we knew: the story from Discovery Bay, Jamaica.**
 - **What we think we know now.**
- **How Florida's reefs fit (or don't fit) into Caribbean patterns.**

Acropora palmata



Acropora cervicornis
***Montastraea* spp.**





The narrative from Discovery Bay, Jamaica

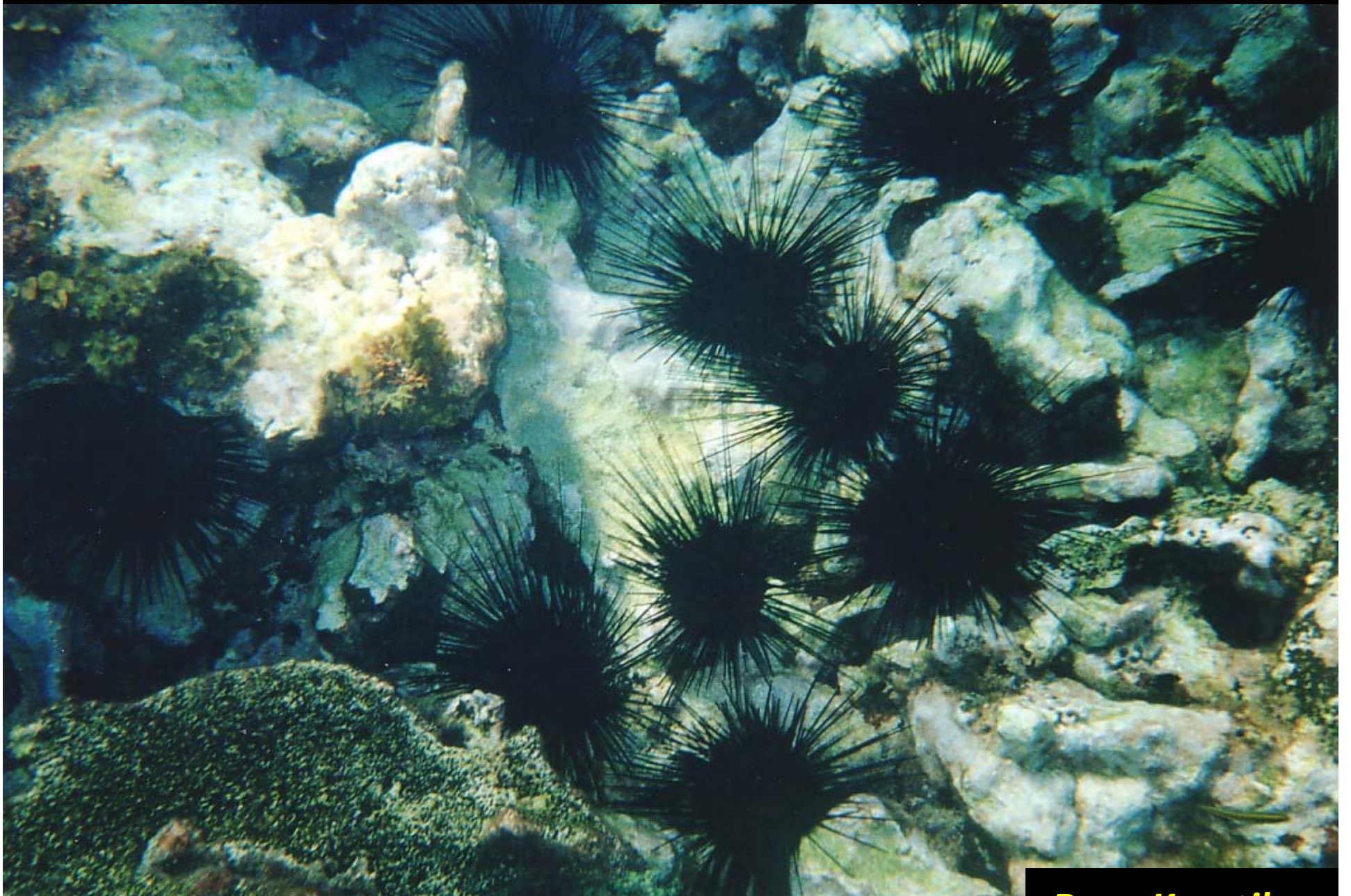
Fore Reef

DBML



Decades to centuries of overfishing





Ryan Kroutil

Hurricane Allen, September 1980

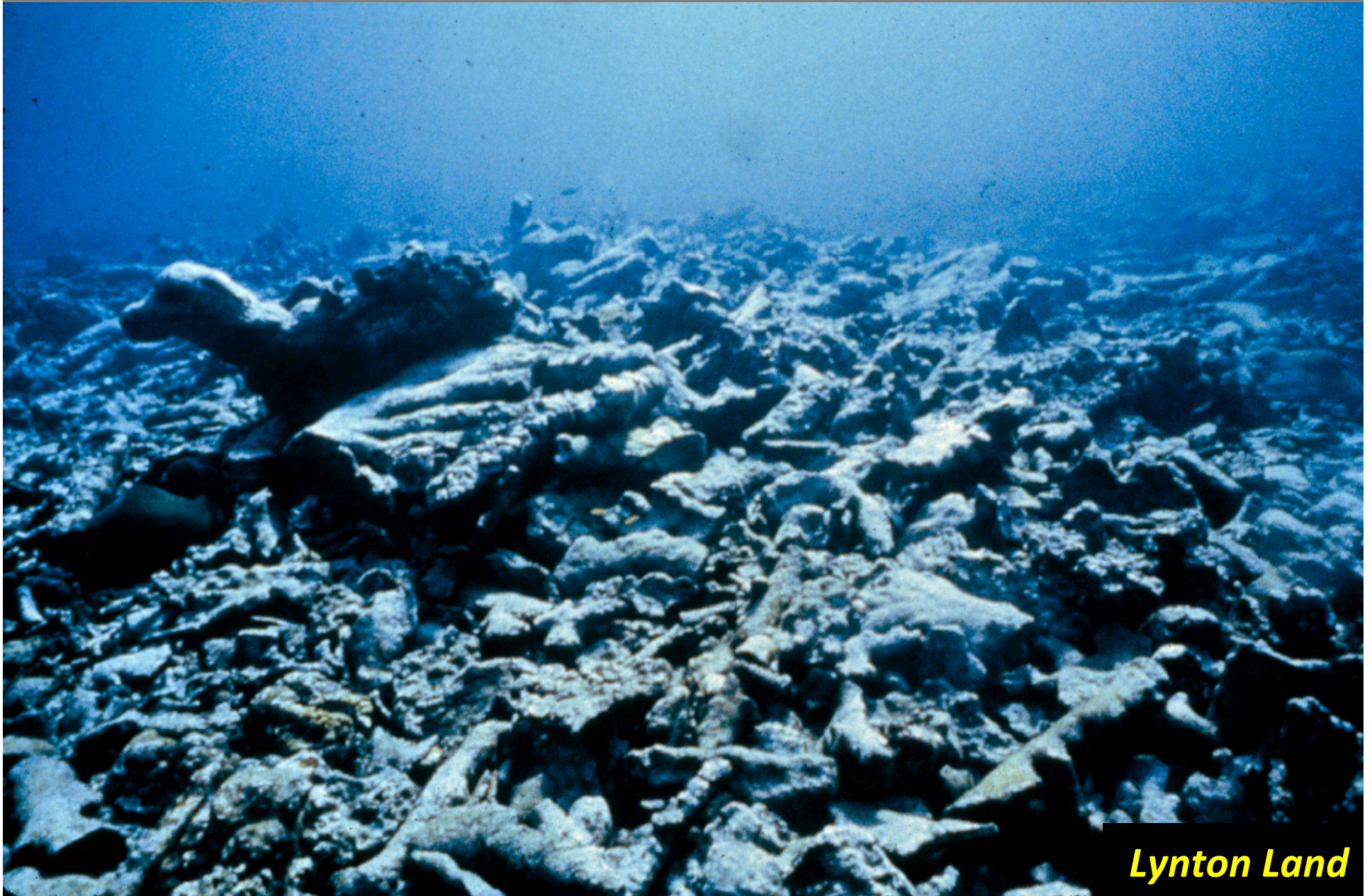


Charlie Wahle

Disco Bay fore reef: from this (1978)



...to this (the day after, 1980)...



Lynton Land

Diadema mass mortality: 1983–84



Haris Lessios

...to this (2003).



Restoring herbivory should reverse algal dominance and recover corals.



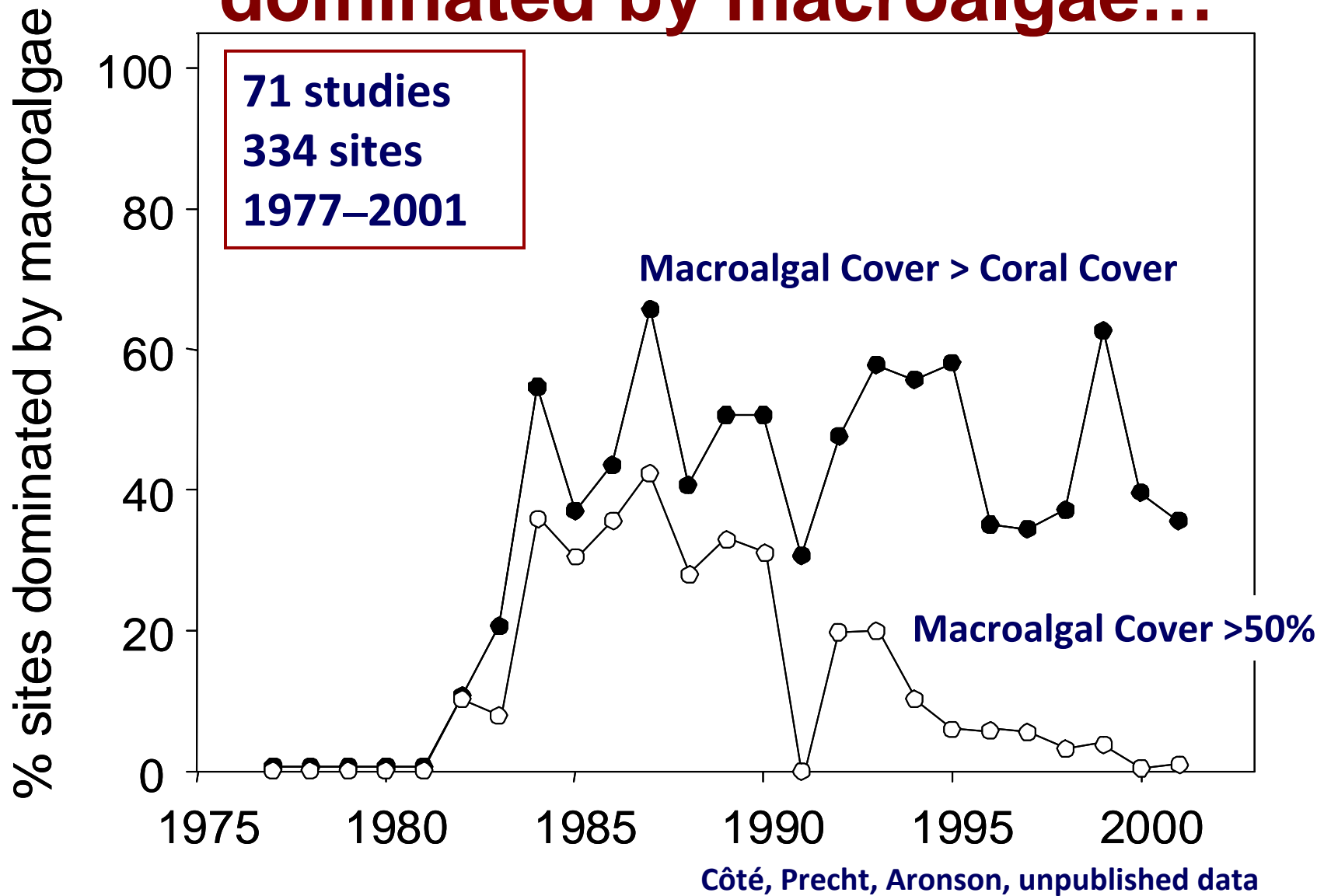
**Cayman Islands: fishing prohibited,
so...kill corals and herbivores
OR just kill enough corals.**



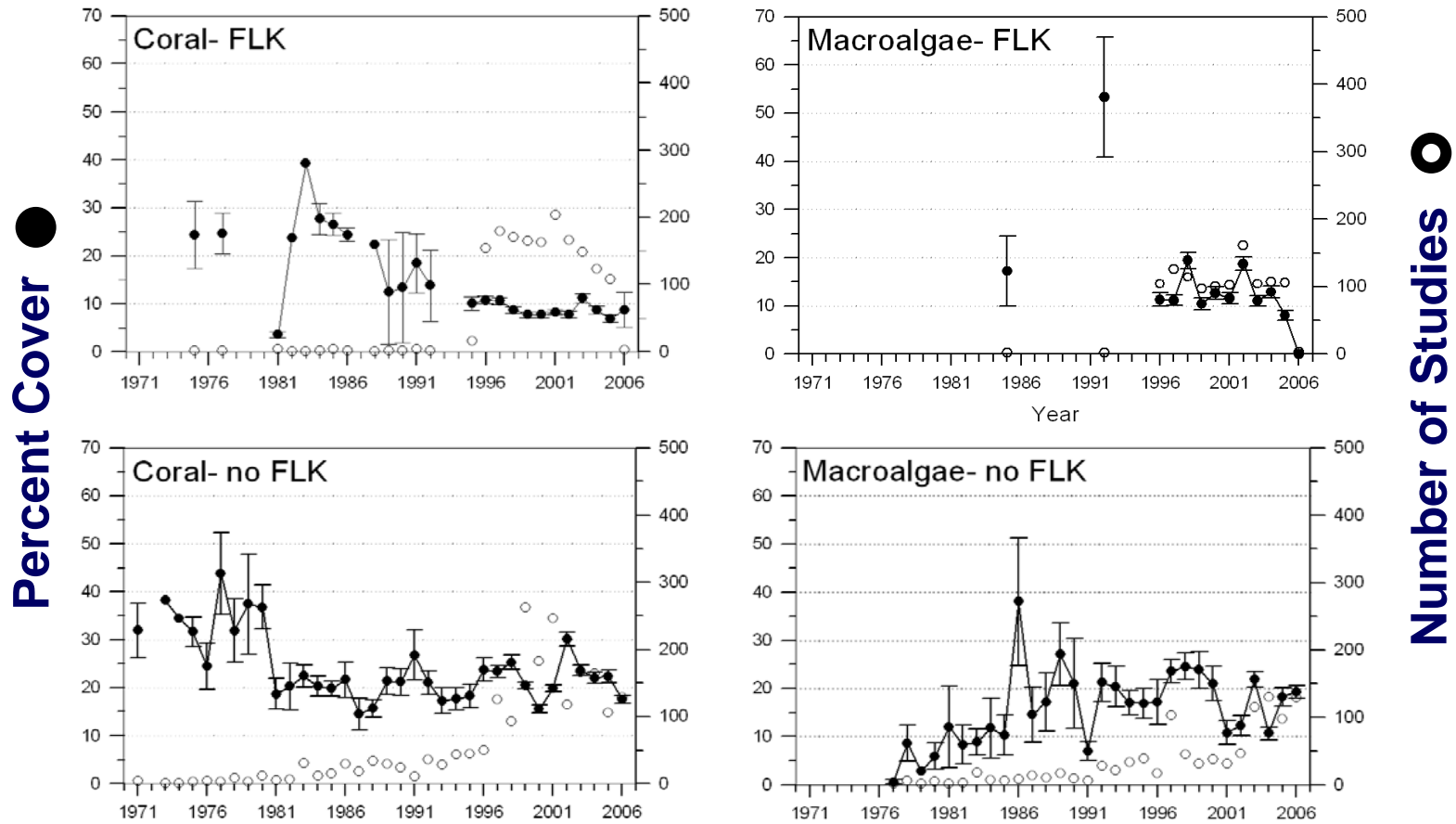
Recent Turnover on Caribbean Reefs

- **Coral mortality has been widespread and catastrophic throughout the wider Caribbean.**
- **Macroalgae dominate some reefs, both fished and unfished...**

...but most Caribbean reefs are NOT dominated by macroalgae...



...and Florida's reefs have low coral AND low macroalgal cover



**3,668 surveys; 1,967 sites
1971–2006**

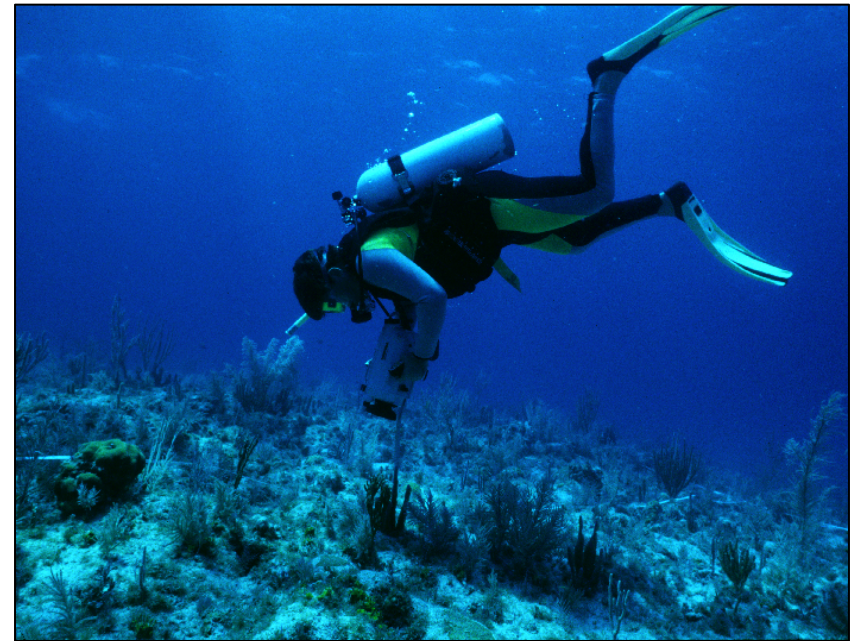
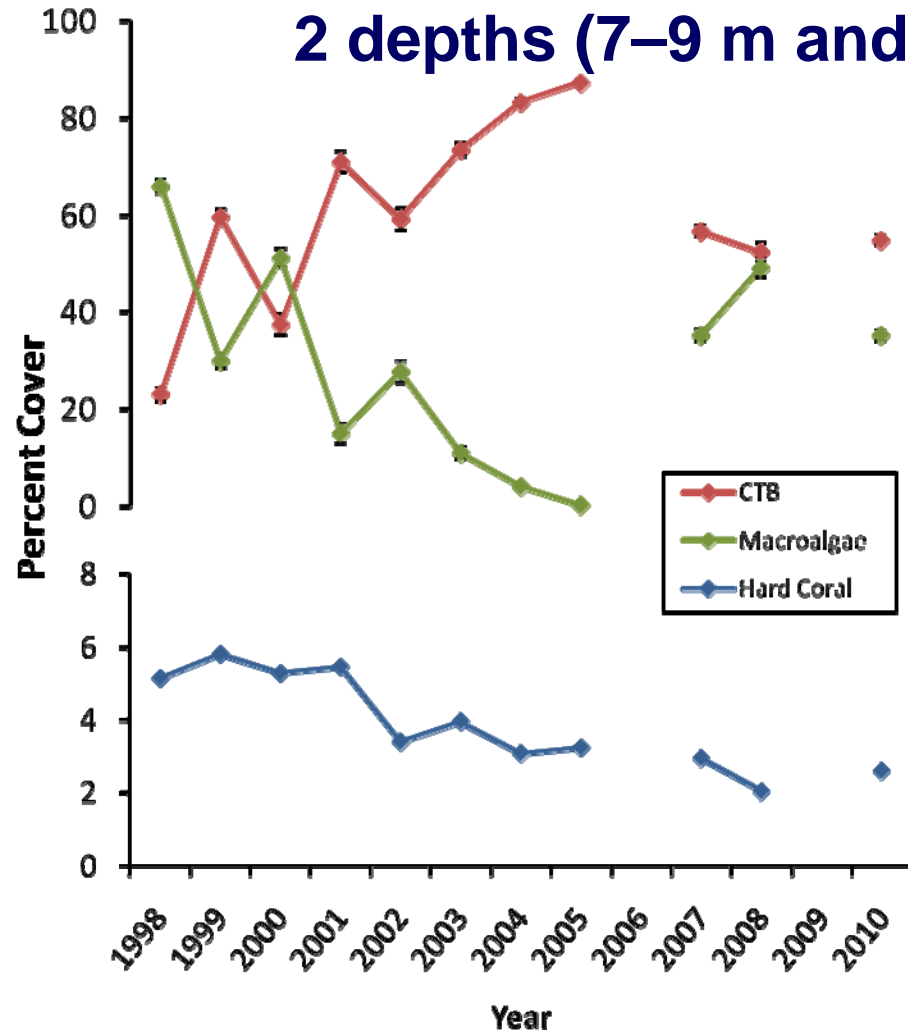
Schutte et al., *Mar. Ecol. Prog. Ser.*, 2010

Recent Turnover on Caribbean Reefs

- Coral mortality has been widespread and catastrophic throughout the wider Caribbean.
- Macroalgae dominate some reefs, both fished and unfished, but...
- ...high herbivory and low macroalgal cover on other reefs, **including many reefs of the Florida Keys**, have not been followed by coral recovery.

Mean Cover of Functional Groups

Pooled video-transect data
3 NTRs and 3 reference sites,
2 depths (7–9 m and 13–18 m), 13 years



Data courtesy Lauren Toth, Florida Tech

Recent Turnover on Caribbean Reefs

- **At present the trajectories of corals and algae are decoupled.**
- **Coral mortality and variations of coral cover around a low mean are independent of algal dynamics.**
- **Following coral mortality:**
 - **Low herbivory relative to available space: macroalgal dominance (some reefs).**
 - **High herbivory relative to available space: dominance by CTB, corals, sponges ascidians, and others (some other reefs).**

Recent Turnover on Caribbean Reefs

- Evidence is accumulating that macroalgae suppress coral recruitment and the recovery of coral populations.
- If that surmise is correct, then reduced macroalgal cover could promote coral recovery *if coral mortality could be controlled.*
- But again, is the Caribbean overrun by macroalgae?

Coral Morbidity and Mortality

- **Regional to Global Scales (some examples)**
 - Rising temperatures
 - Ocean acidification
 - Accelerating sea-level rise
 - Marine diseases
- **Local to Subregional Scales (some examples)**
 - Hurricanes
 - Nutrient loading and other forms of pollution
 - Loss of herbivores
 - **'Inimical waters' from Florida Bay (Florida Keys)**
 - hot and hypersaline in summer
 - cold and hyposaline in winter
 - **Cold sea temperatures (east coast of Florida)**

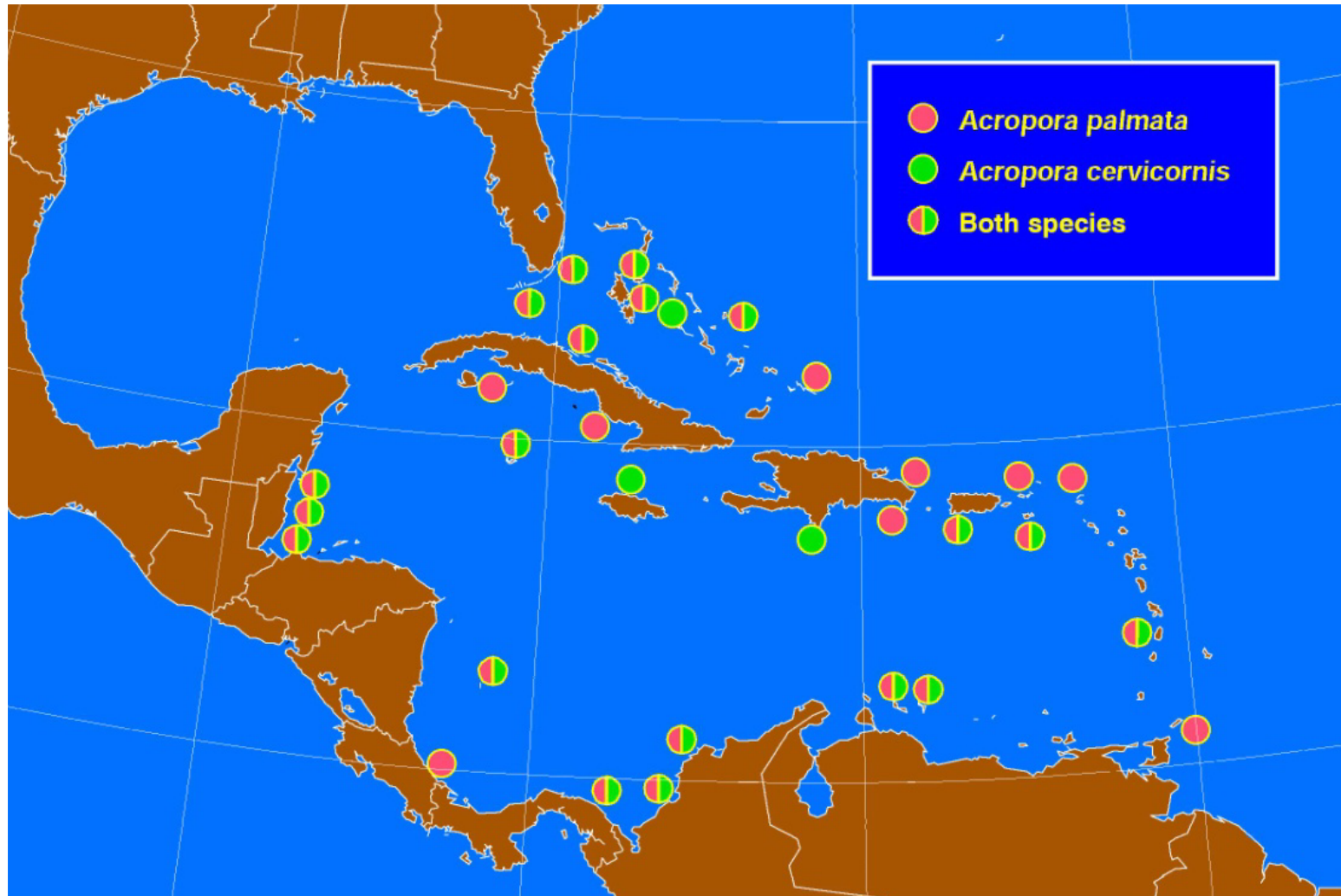
Hypothesis-Testing in Coral-Reef Ecology

[T]he object of investigation is [to ascertain] the proportion of observed variation that may be explained through the use of one or more predictors..., and the proportion that is... ascribed to “chance.”

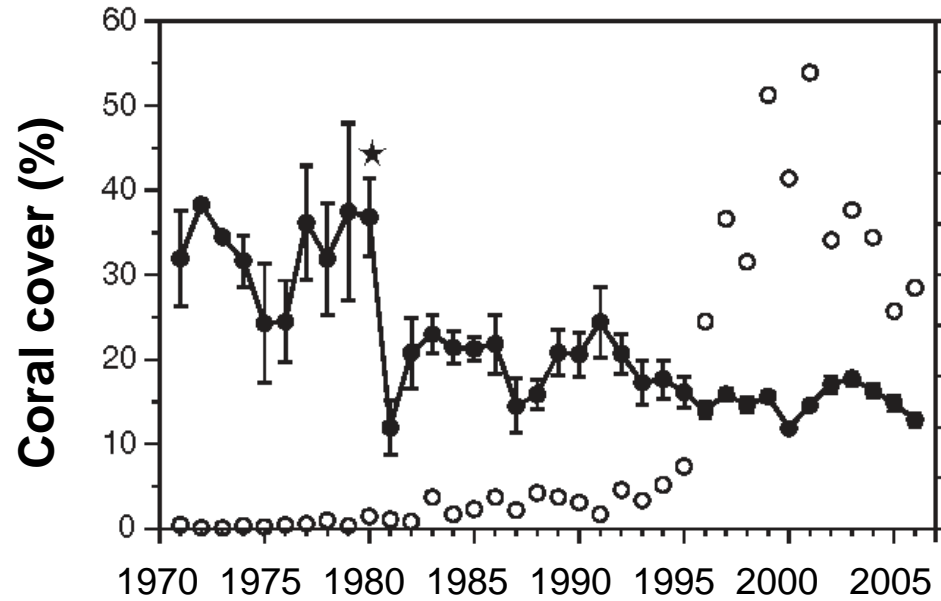
J. F. Quinn and A. E. Dunham (1983). On hypothesis testing in ecology and evolution. *American Naturalist* 122:602–617.

The first wave: 1970s–1990s

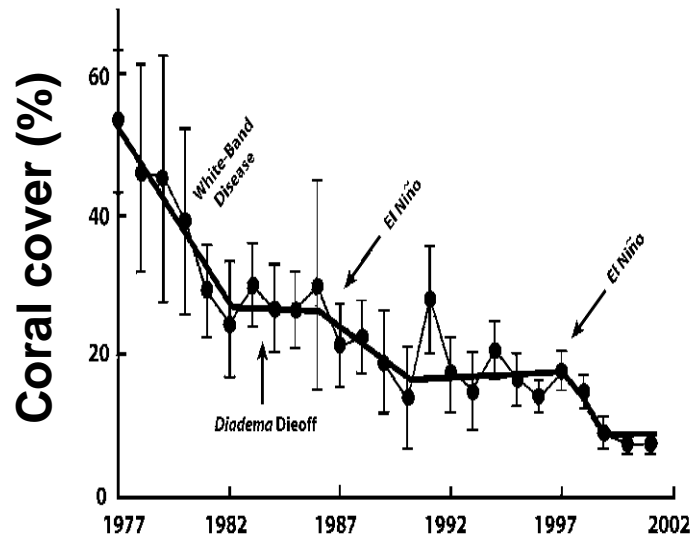
White-Band Disease



Two Meta-Analyses

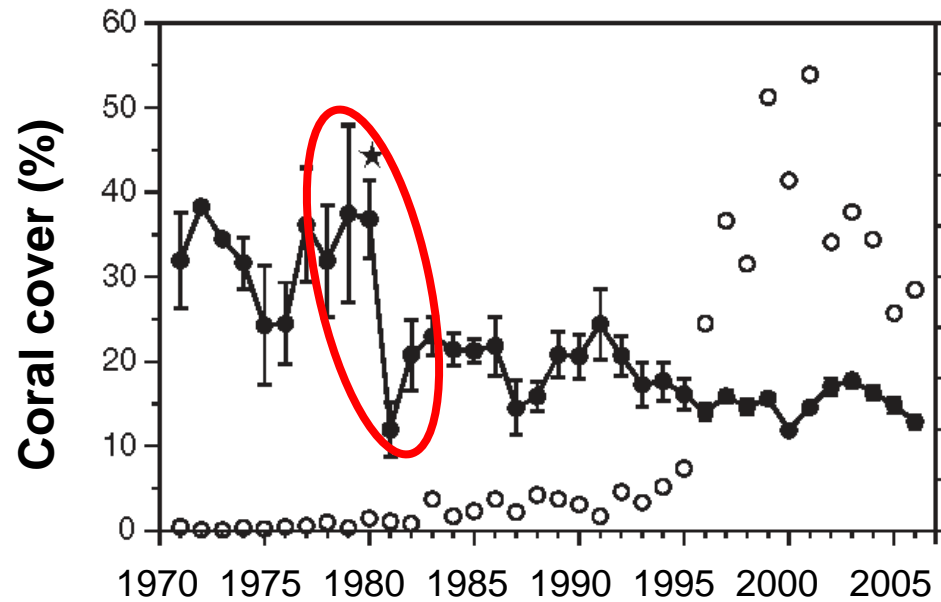


Schutte et al.,
Mar. Ecol. Prog. Ser., 2010

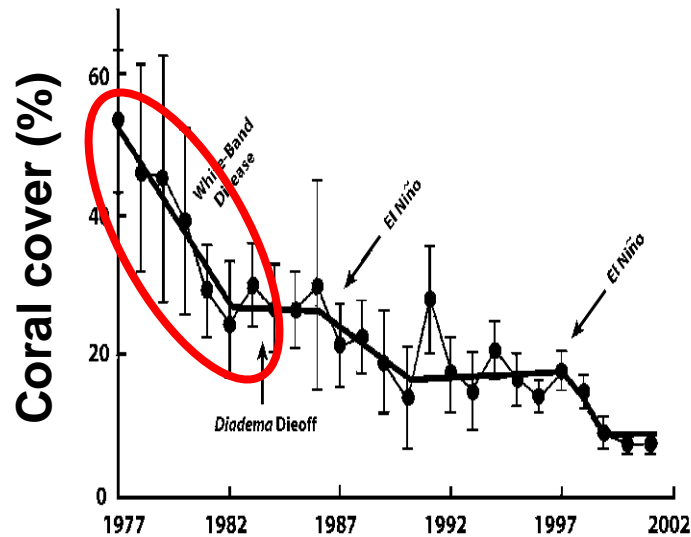


Gardner et al., *Science*, 2003
Aronson and Precht, *Coral Reefs*, 2006

Two Meta-Analyses

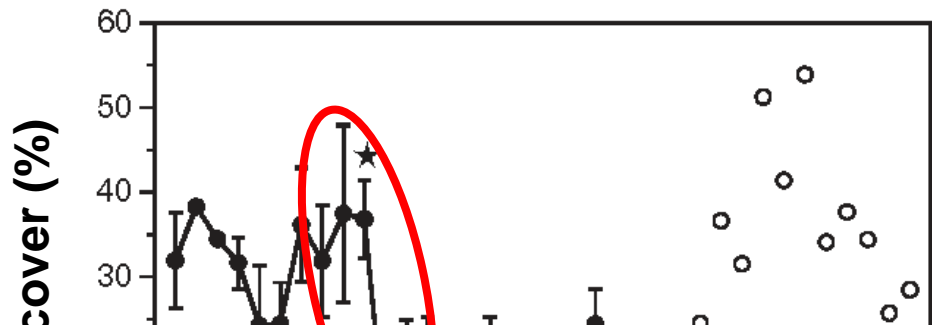


Schutte et al.,
Mar. Ecol. Prog. Ser., 2010



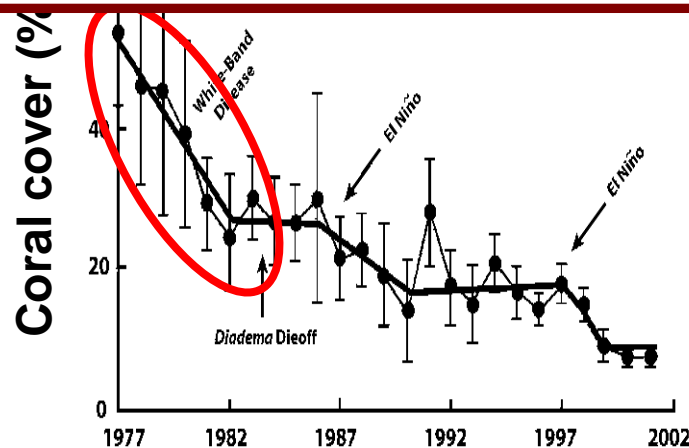
Gardner et al., *Science*, 2003
Aronson and Precht, *Coral Reefs*, 2006

Two Meta-Analyses



Schutte et al.,
Mar. Ecol. Prog. Ser., 2010

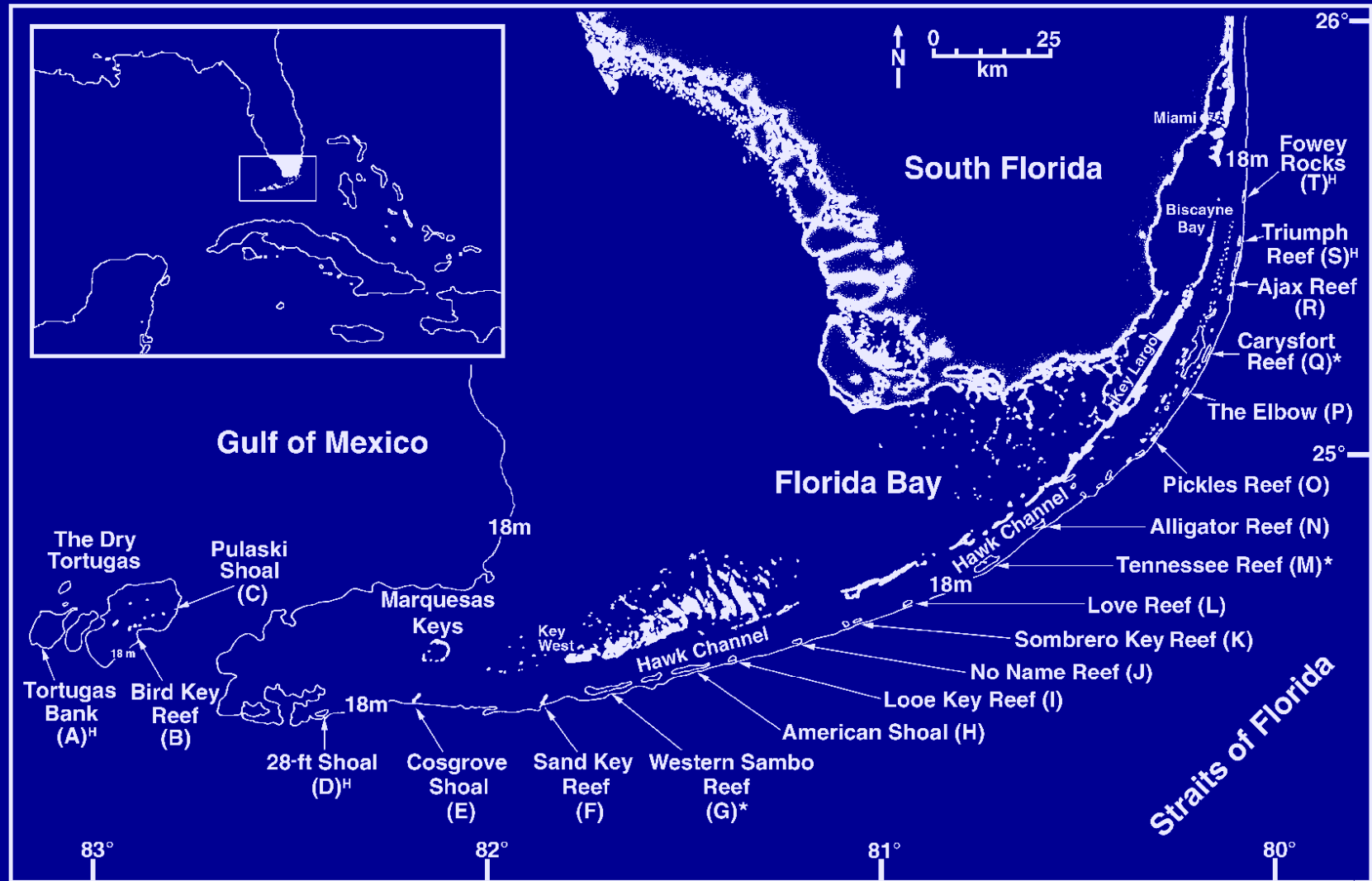
WBD, and to a lesser extent hurricanes, were the principal factors causing mortality of *Acropora* throughout the Caribbean, reducing coral cover substantially on most reefs.



Gardner et al., *Science*, 2003
Aronson and Precht, *Coral Reefs*, 2006

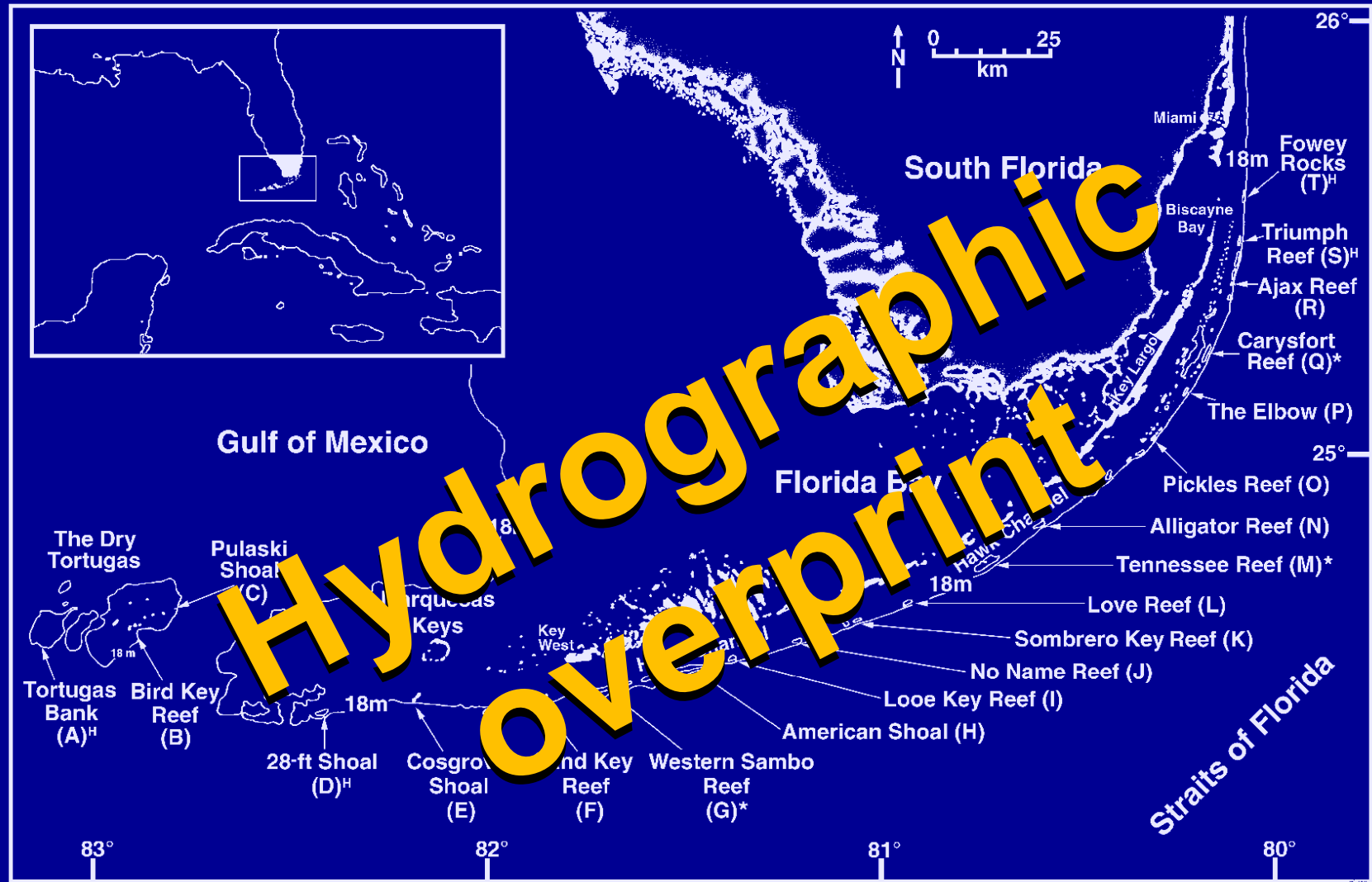
Contribution of White-Band Disease to the Observed Pattern

- Acroporid corals were primary framework builders and ecological dominants on most Caribbean reefs.
- WBD was the primary cause of *Acropora* mortality.
- Therefore, WBD was a leading cause (or the leading cause) of the decline of coral cover in the Caribbean.
- It was not the only cause: cold-water stress killed acroporids in the Florida Keys in January 1977.
- Subsequent perturbations killed *Montastraea* spp. and other corals.



Sectorial Classification

Shinn et al. 1989	Dry Tortugas ABC	—	Lower Keys DEFGHI	Middle Keys JKLMN	Upper Keys OPQRST
Klein and Orlando 1994	Dry Tortugas ABC	Marquesas Keys DEF	Lower Keys GHIJ	Middle Keys KLMN	Upper Keys OPQRST

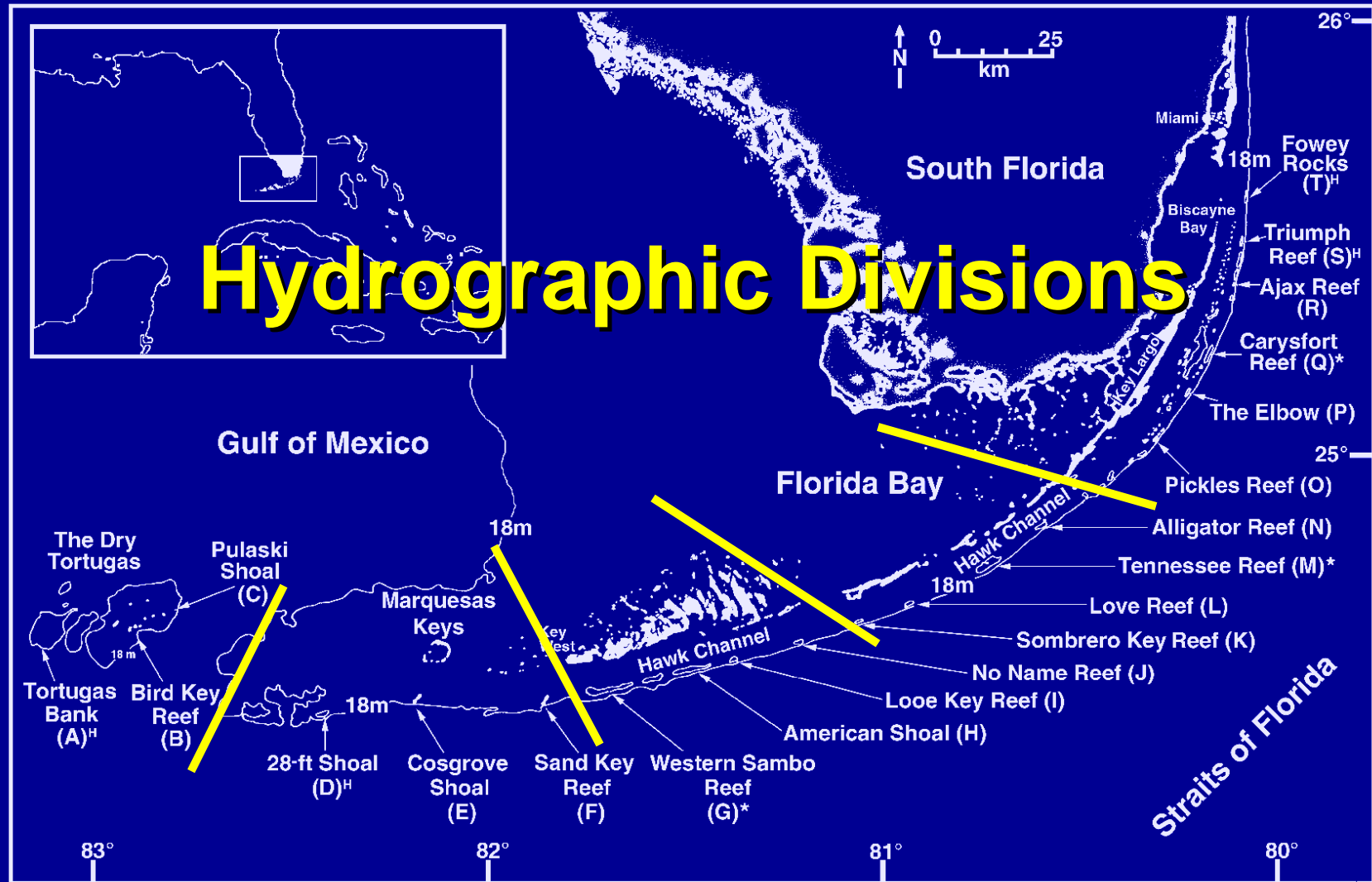


Hydrographic
overprint

Sectorial Classification

Shinn et al. 1989	Dry Tortugas ABC	—	Lower Keys DEFGHI	Middle Keys JKLMN	Upper Keys OPQRST
Klein and Orlando 1994	Dry Tortugas ABC	Marquesas Keys DEF	Lower Keys GHIJ	Middle Keys KLMN	Upper Keys OPQRST

Hydrographic Divisions



Sectorial Classification

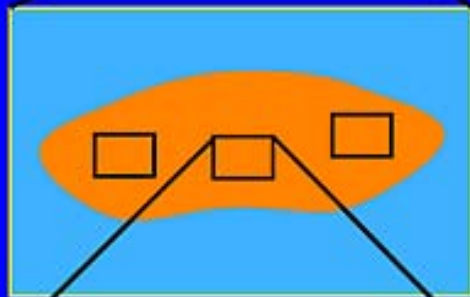
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Klein and Orlando 1994	Dry Tortugas ABC	Marquesas Keys DEF	Lower Keys GHIJ	Middle Keys KLMN	Upper Keys OPQRST



100-km scale:
Sectors within the reef tract



10-km scale:
Reefs within sectors

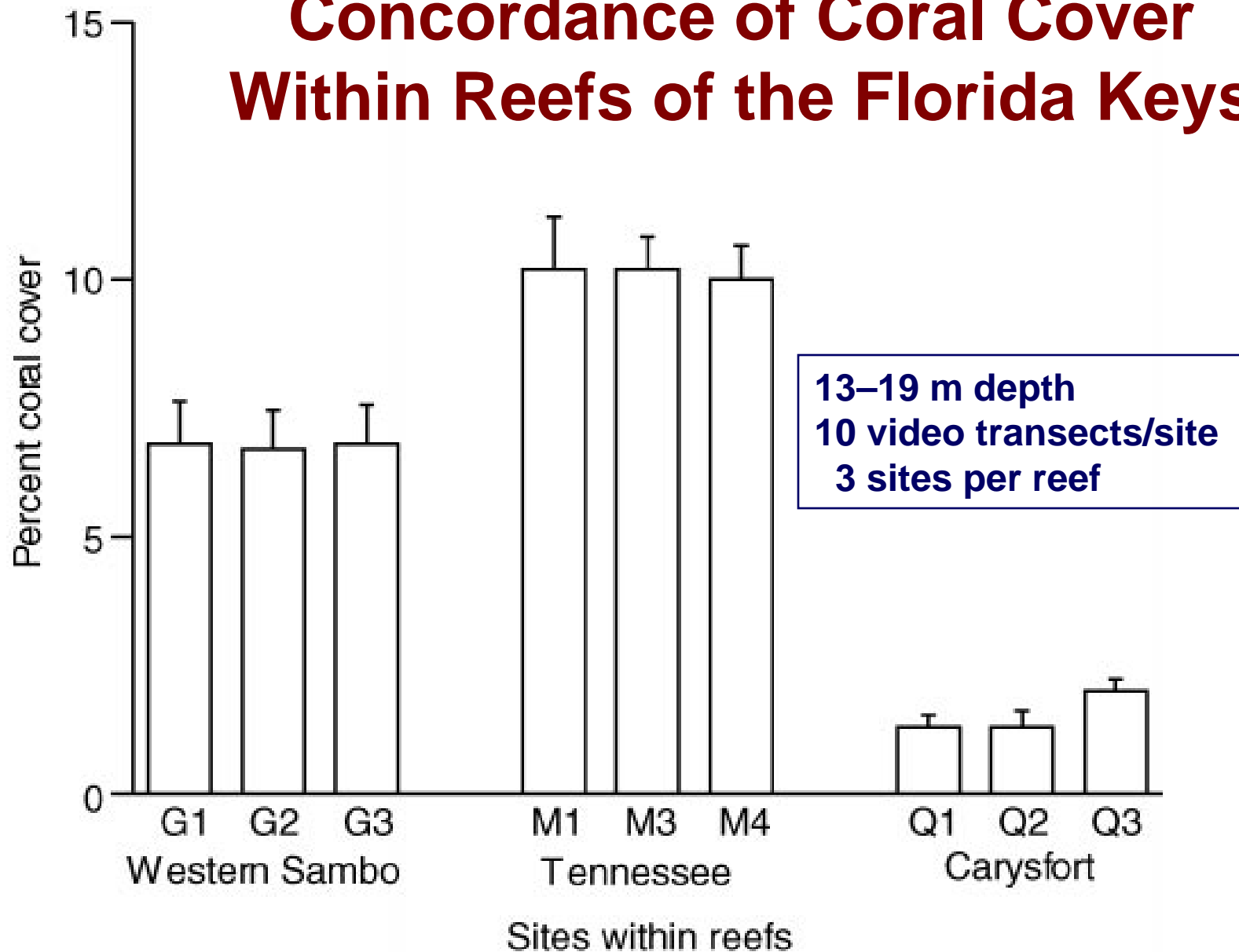


1-km scale:
Sites within reefs



0.1-km scale:
Transects within sites

Concordance of Coral Cover Within Reefs of the Florida Keys

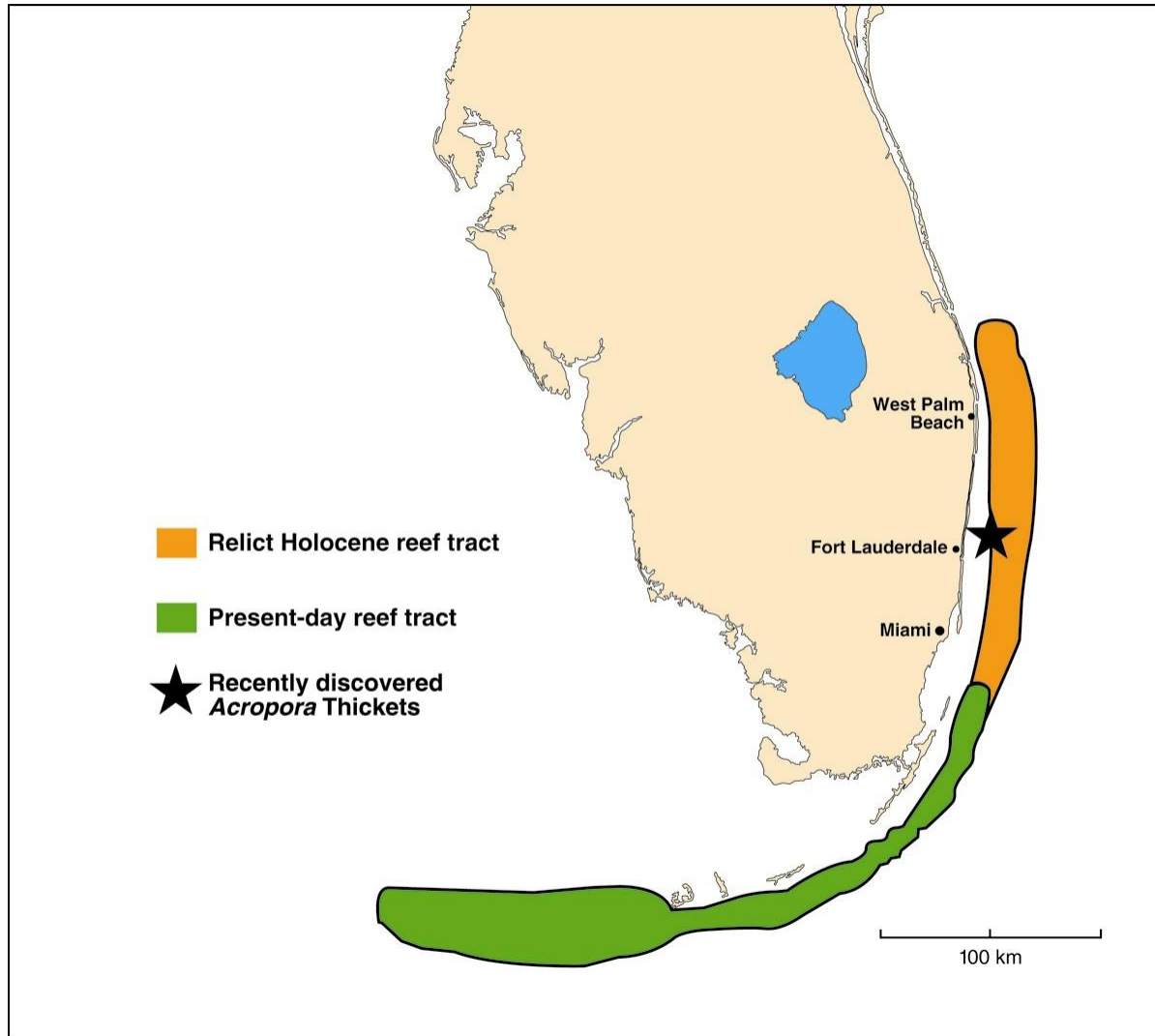


Murdoch and Aronson, *Coral Reefs*, 1999

Variance in Coral Assemblages in the Florida Keys

- low among sites within reefs
sites are relatively uniform.
- high among reefs within sectors
hydrographic differences cause variation from reef to reef.
- low among sectors
any differences are swamped by smaller-scale hydrography.

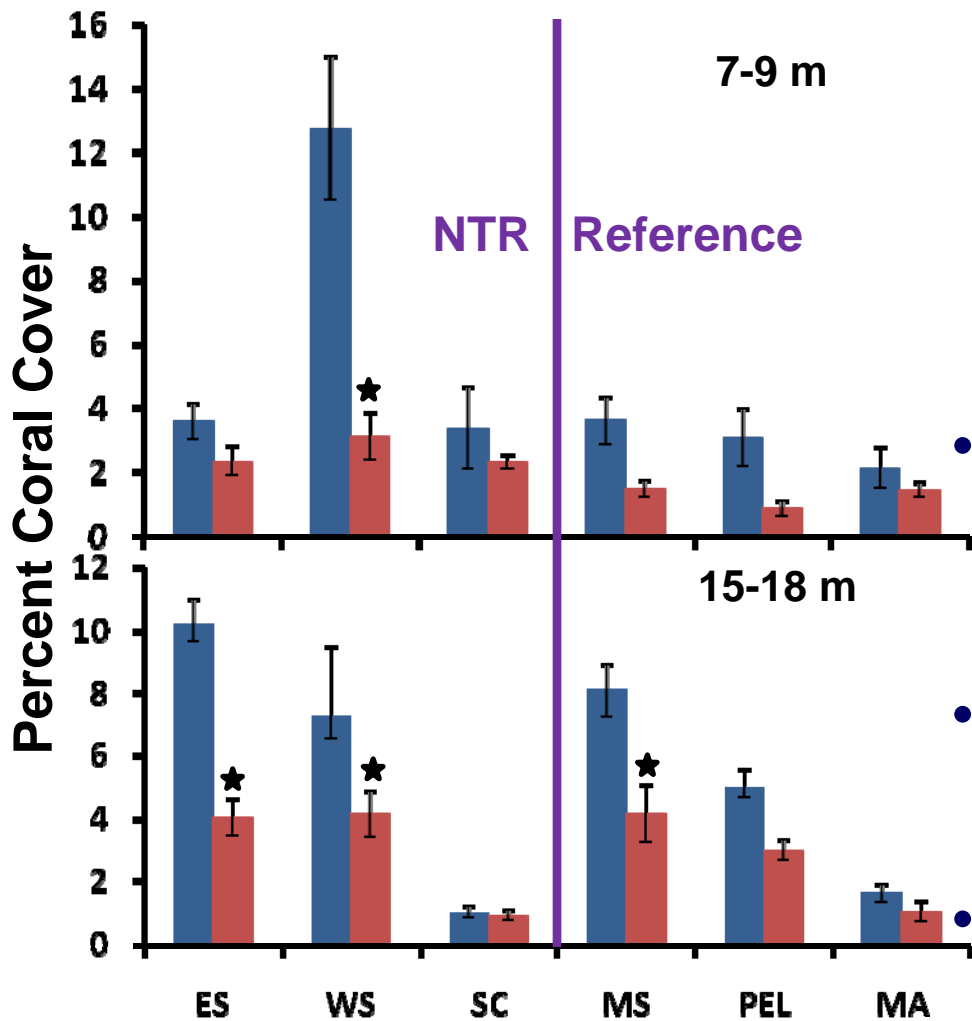
Overprint of cold-water events on the east coast of Florida



Controls on Floridian Reefs

- Reef assemblages along the Florida Keys are strongly influenced by hydrography (inimical waters flowing through passes increasing variability of coral cover), which overprints Caribbean-wide patterns (loss of *Acropora*; generally low coral cover).
- *Acropora* populations along the east coast of Florida are controlled by their (in)tolerance of cold sea temperatures, which overprints Caribbean-wide patterns.

Effect of No-Take Restrictions on Coral Cover within the FKNMS



- Significant declines in coral cover were more common in protected than non-protected sites
- Sites with higher coral cover in 1998 experienced greater coral loss
- Decline in coral cover was unrelated to protection

Data courtesy Lauren Toth, Florida Tech

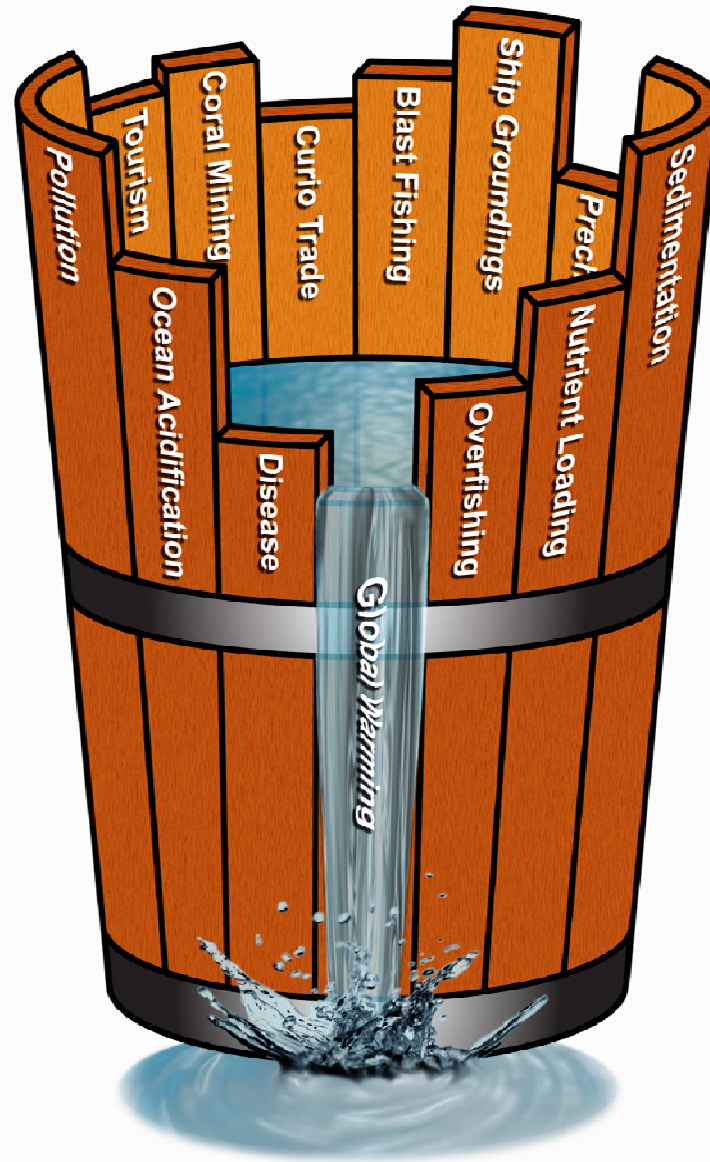
Efficacy of MPAs in the Florida Keys

- **Overprint #1: regional, global**
 - coral disease
 - climate change
 - ocean acidification, etc.
- **Overprint #2: hydrographic, latitudinal**
 - Florida Bay water to the Keys
 - Winter temperatures on the east coast

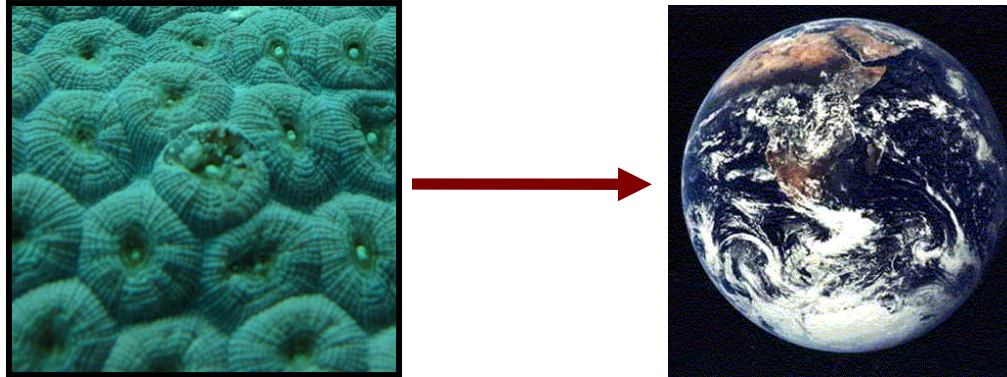
Efficacy of MPAs in the Florida Keys

- **So should we just give up on MPAs, MPA networks, and other management and restoration actions?**
- **Of course we should not give up, because...**

Liebig's Law of the Minimum



From the Polyp to the Planet



- Of course we should not give up...
- ...but the rationale cannot be to work on local problems just because they are the tractable ones; that is rear-guard action—the prelude to surrender.
- Local action must be explicitly promoted as a *component* of management integrated across scales and hierarchical levels.