Biological and Physical Controls on Coral Reefs

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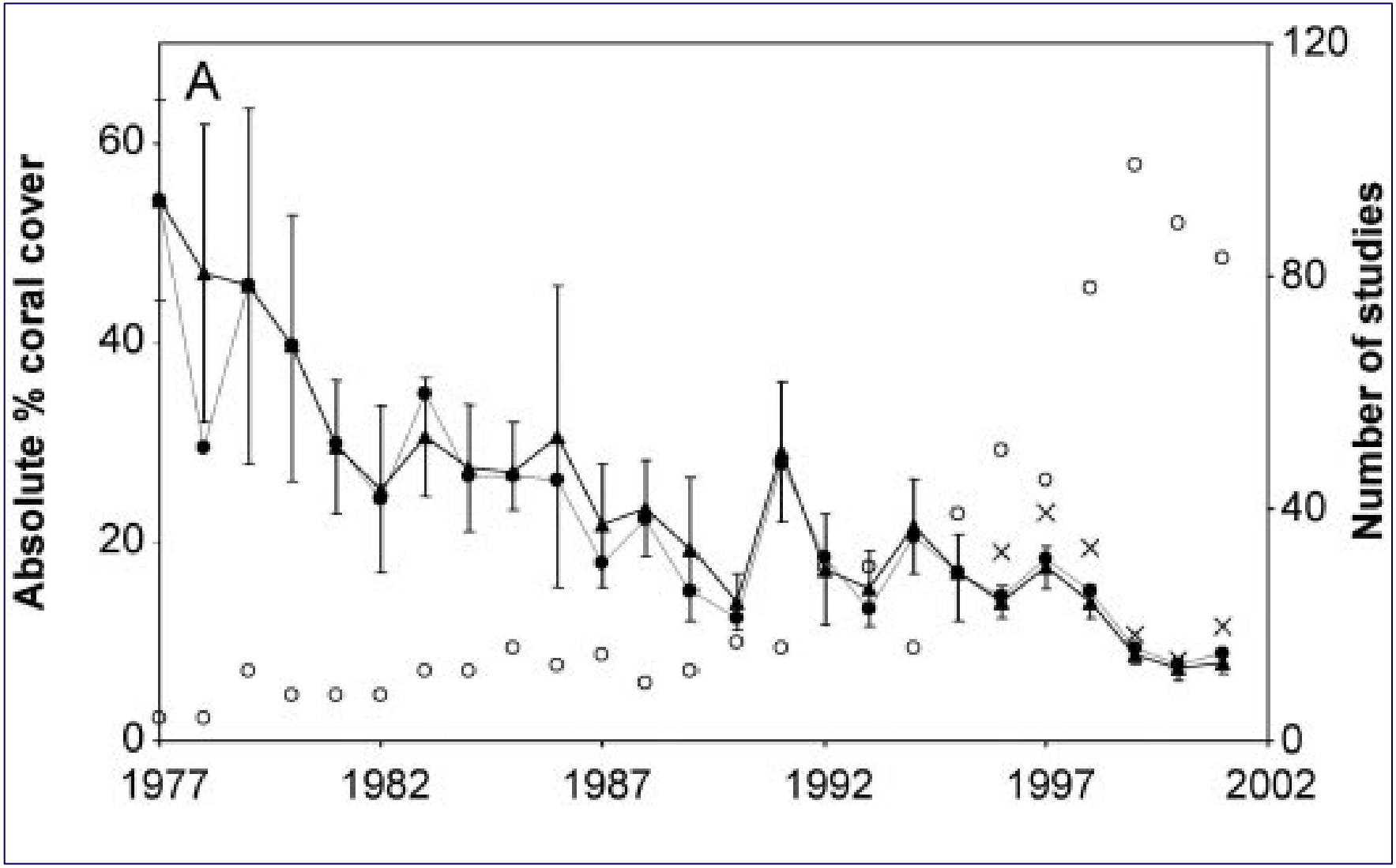
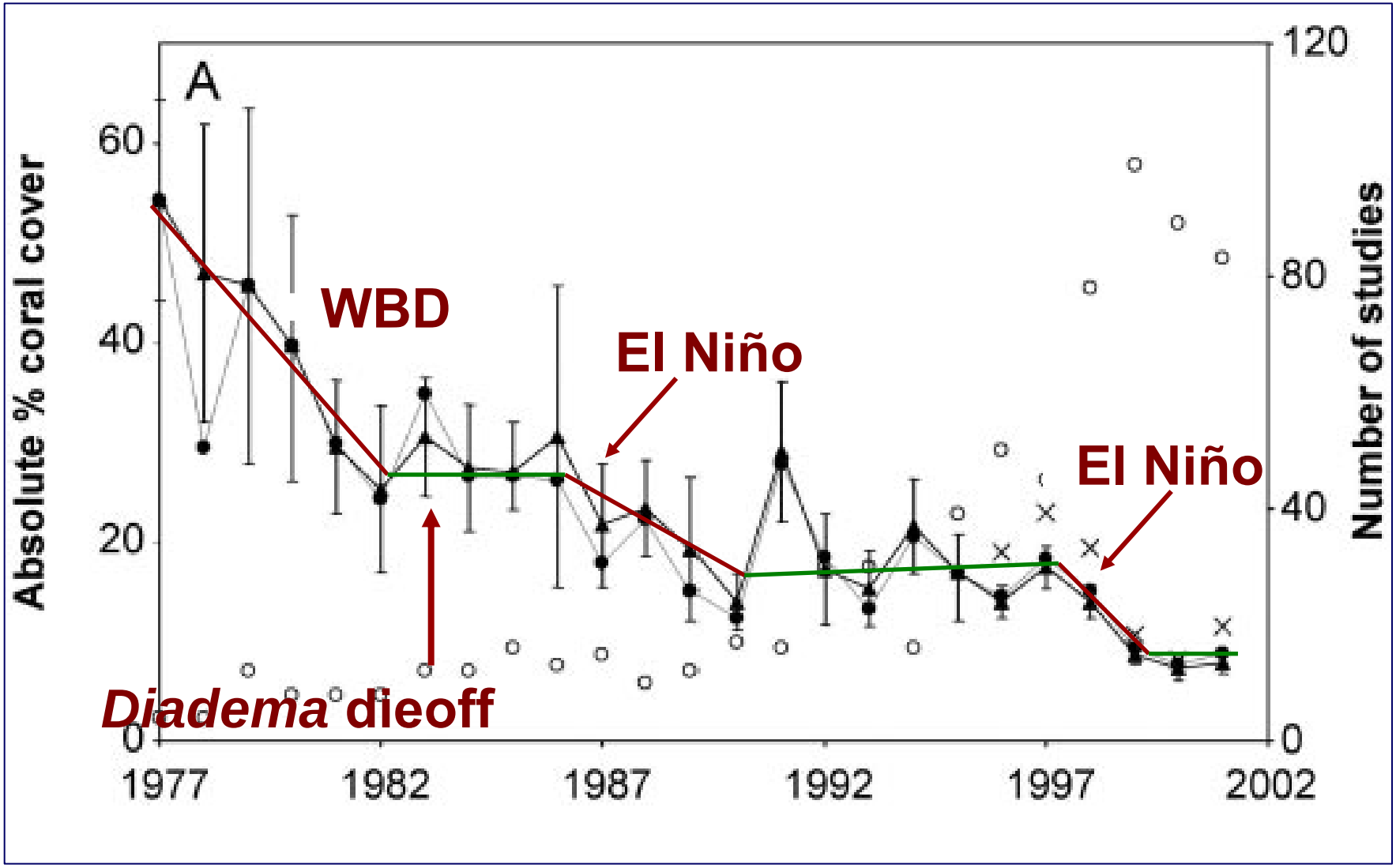
Challenges/Goals

- **Challenge for BRT: articulate the functional relationship between threats to coral reefs and threats to individual coral species.**
- **Goal of this talk: connect ecology to extinction threat for Caribbean species, which are the emphasis at this workshop.**

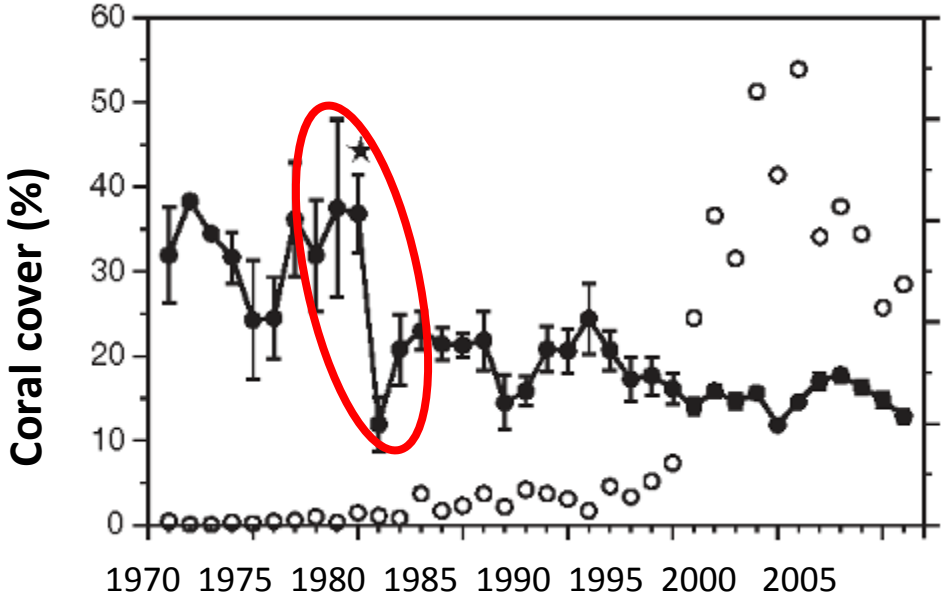


Gardner et al. 2003

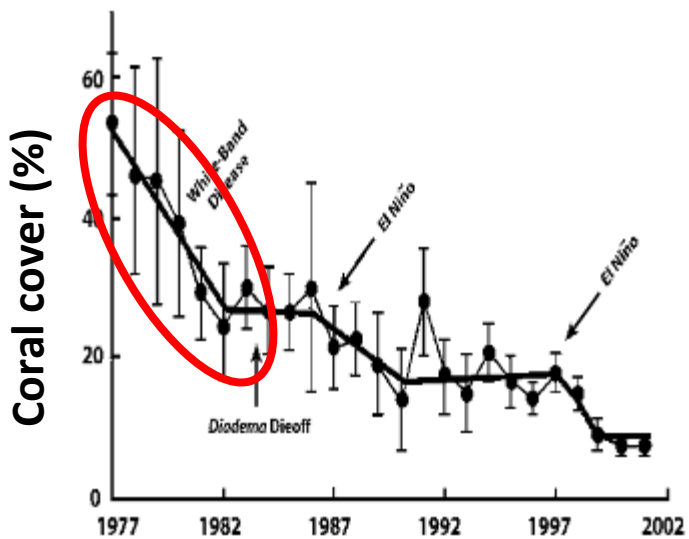


Aronson and Precht 2006

Two Meta-Analyses



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



Gardner et al., *Science*, 2003

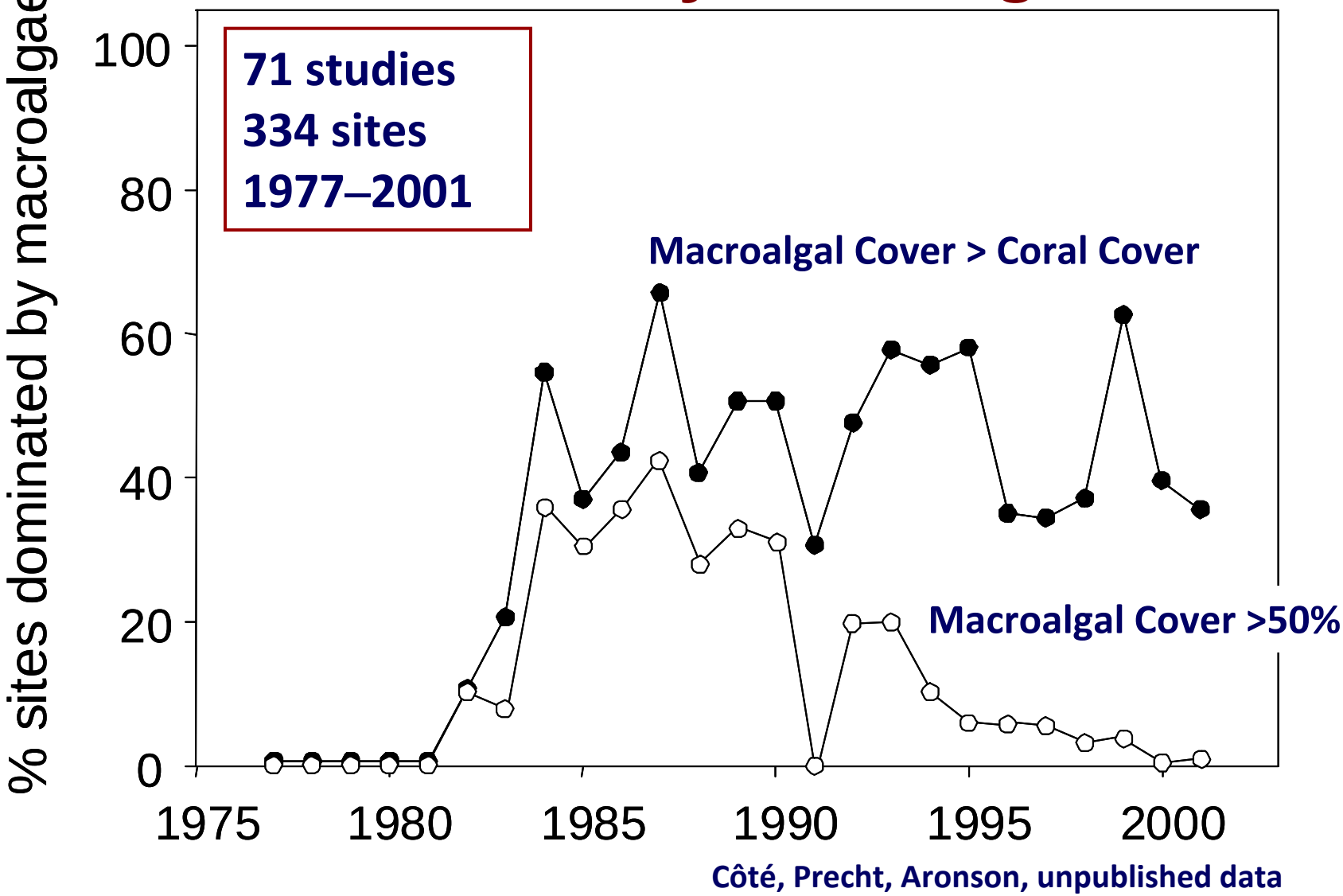
Subjects of Greatest Controversy in the Ecology of Caribbean Reefs

- **Importance of macroalgal growth…**
  - **…in promoting coral mortality**
  - **…in preventing coral recovery**
- **Importance of herbivory…**
  - **…in preventing coral mortality**
  - **…in promoting coral recovery**
- **Whether the coral-to-macroalgal transition is a reversible *phase shift* or a shift between *alternative stable states*.**

What We Do Know

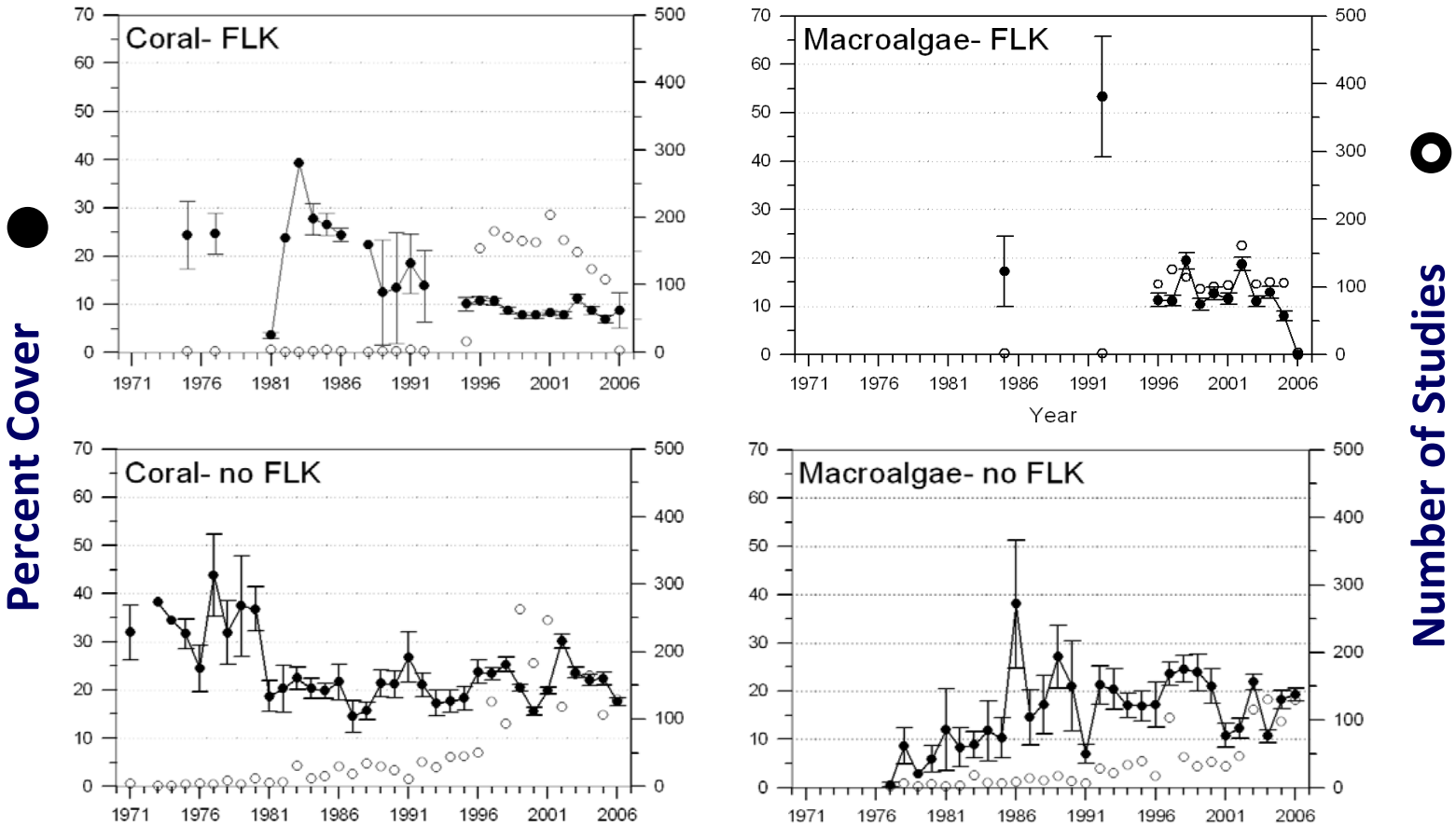
- Coral mortality has been widespread and catastrophic throughout the wider Caribbean.
- Macroalgae dominate some reefs, both fished and unfished…

…but most Caribbean reefs are NOT dominated by macroalgae…



Côté, Precht, Aronson, unpublished data

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



3,668 surveys; 1,967 sites
1971–2006

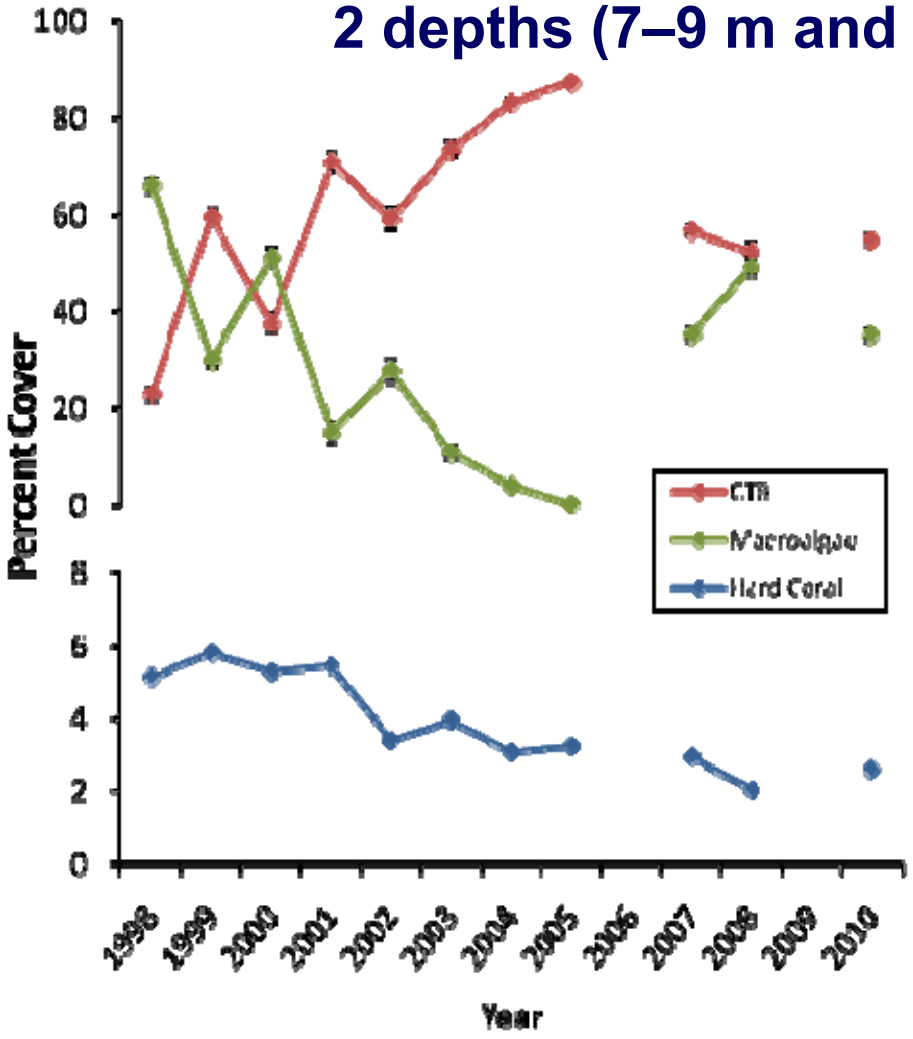
Schutte et al., *Mar. Ecol. Prog. Ser.*, 2010

What We Do Know

- **High herbivory and low macroalgal cover on many reefs, including reefs in the Florida Keys, do not promote coral recovery.**

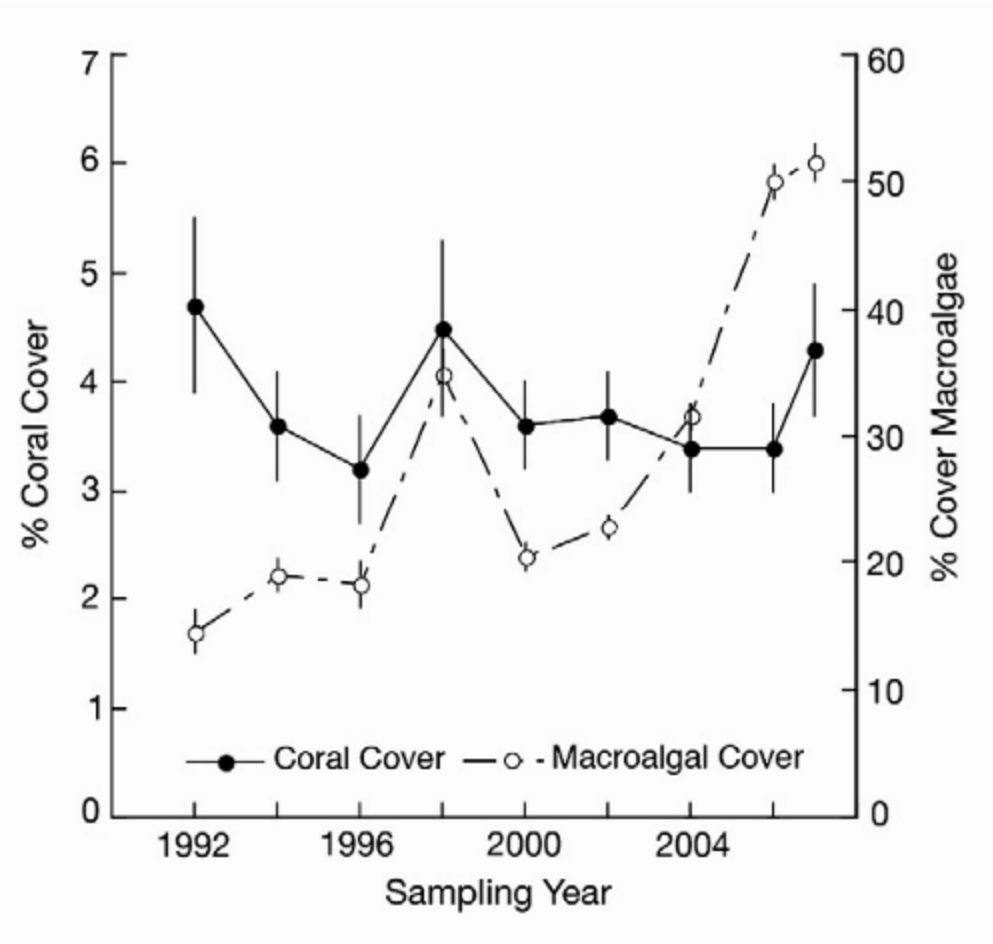
Mean Cover of Functional Groups: FKNMS

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



Coral and Macroalgal Cover: St. John

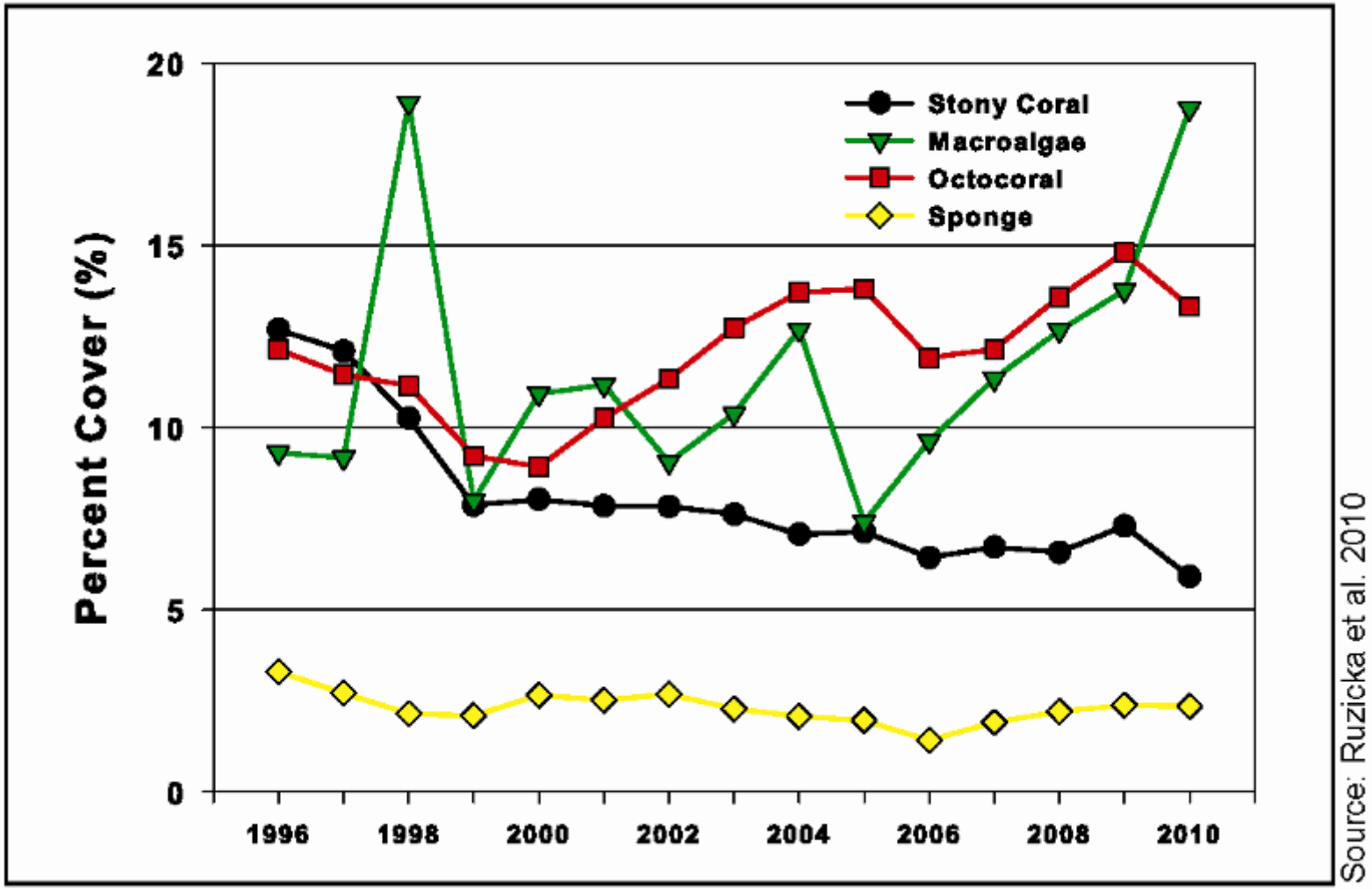
Pooled 0.25-m^2 photo-quadrat data
6 sites, 7–9 m depth
200 random dots per photo-quadrat
17 or more photo-quadrats per transect, 16 years



Colvard and Edmunds (2011), *JEMBE*

Mean Cover of Functional Groups: FKNMS

Pooled data from video-image analysis (CREMP data), 97 sites, multiple depths, 15 years



FKNMS Condition Report 2011. NOAA

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?**
- **It is not, yet corals are not recovering.**
- **Why not?**

An Important Conclusion

"The BRT considers ocean warming, disease, and ocean acidification to be the most influential threats in posing extinction risks to the 82 candidate coral species between now and the year 2100."

BRT Executive Summary

Threats to Corals and Reefs: BRT

I. Regional and Global Threats

- Ocean warming
- Disease (loss of corals and loss of herbivorous echinoids)
- Acidification

II. Local Threats that are Broadly Distributed

- Sedimentation
- Nutrient loading
- Fishing (including loss of herbivores)

III. Local Threats not Broadly Distributed

- Ship-groundings
- Hurricane damage
- Curio trade
- Outbreaks of predators
- Others

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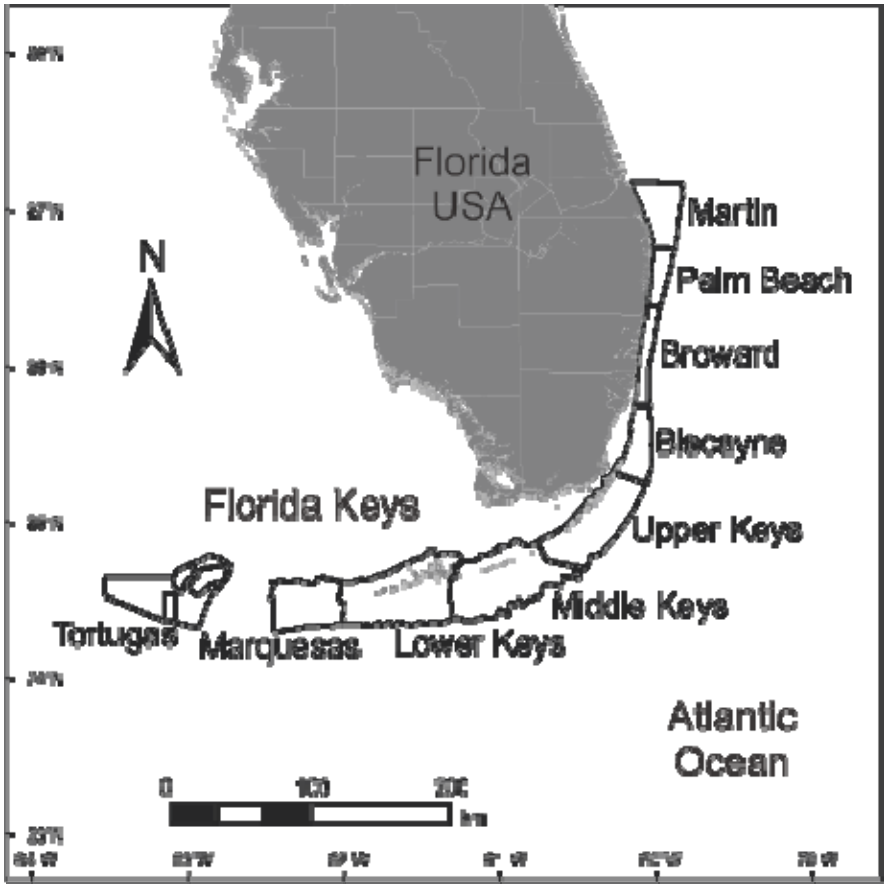
- Outbreaks of predators (move to category I or II)
- Others

Homogenization of Coral Assemblages

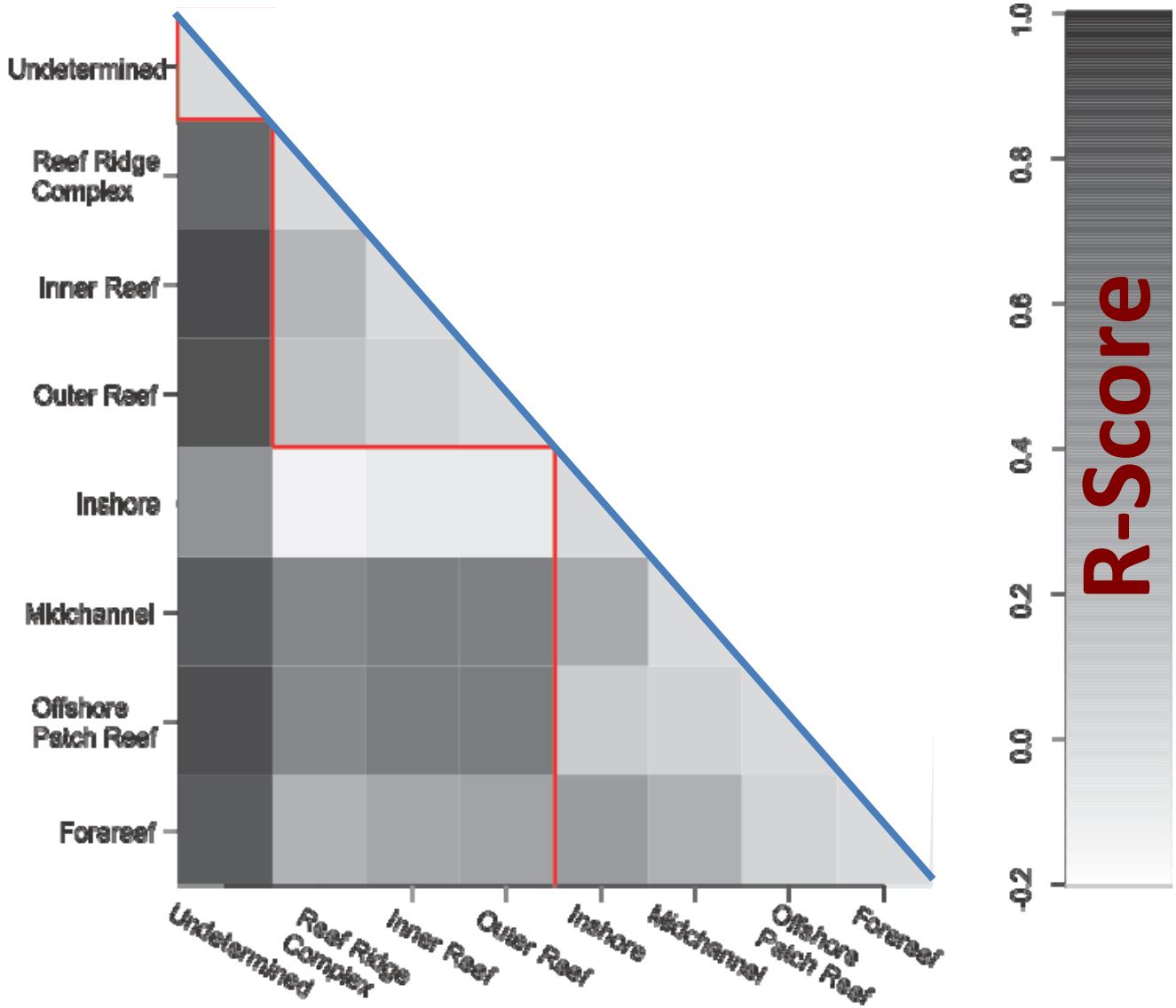
Florida Reef Resilience Program (FRRP)
Funded by The Nature Conservancy

2 randomly located transects in each of 1157 sites
3 depths
8 reef zones
9 subregions
9 monitoring intervals
(2005–2010)
ANOSIM: pairwise R-scores



Burman, Aronson, van Woesik (In review)

Reef Zones



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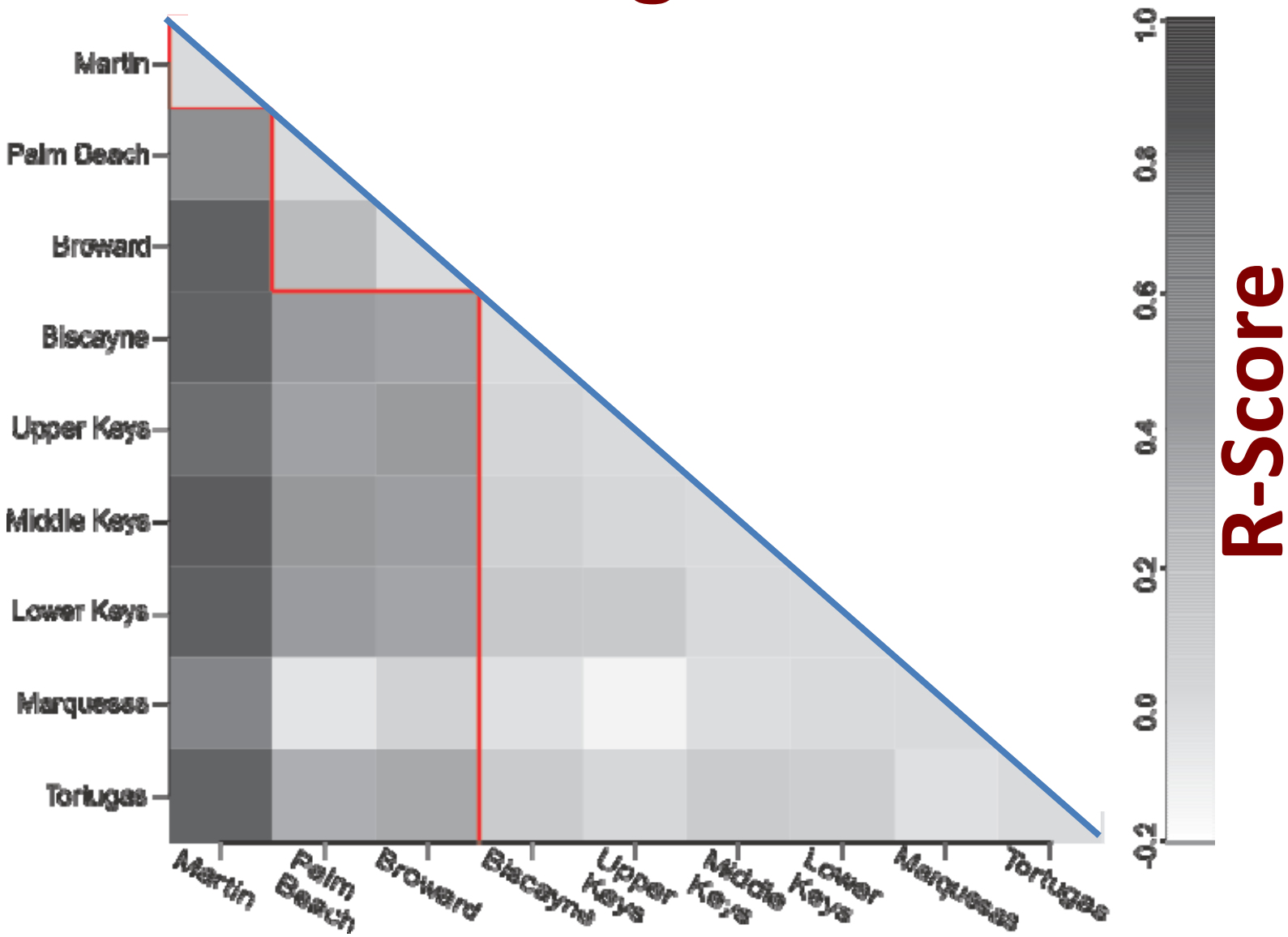
Subregions



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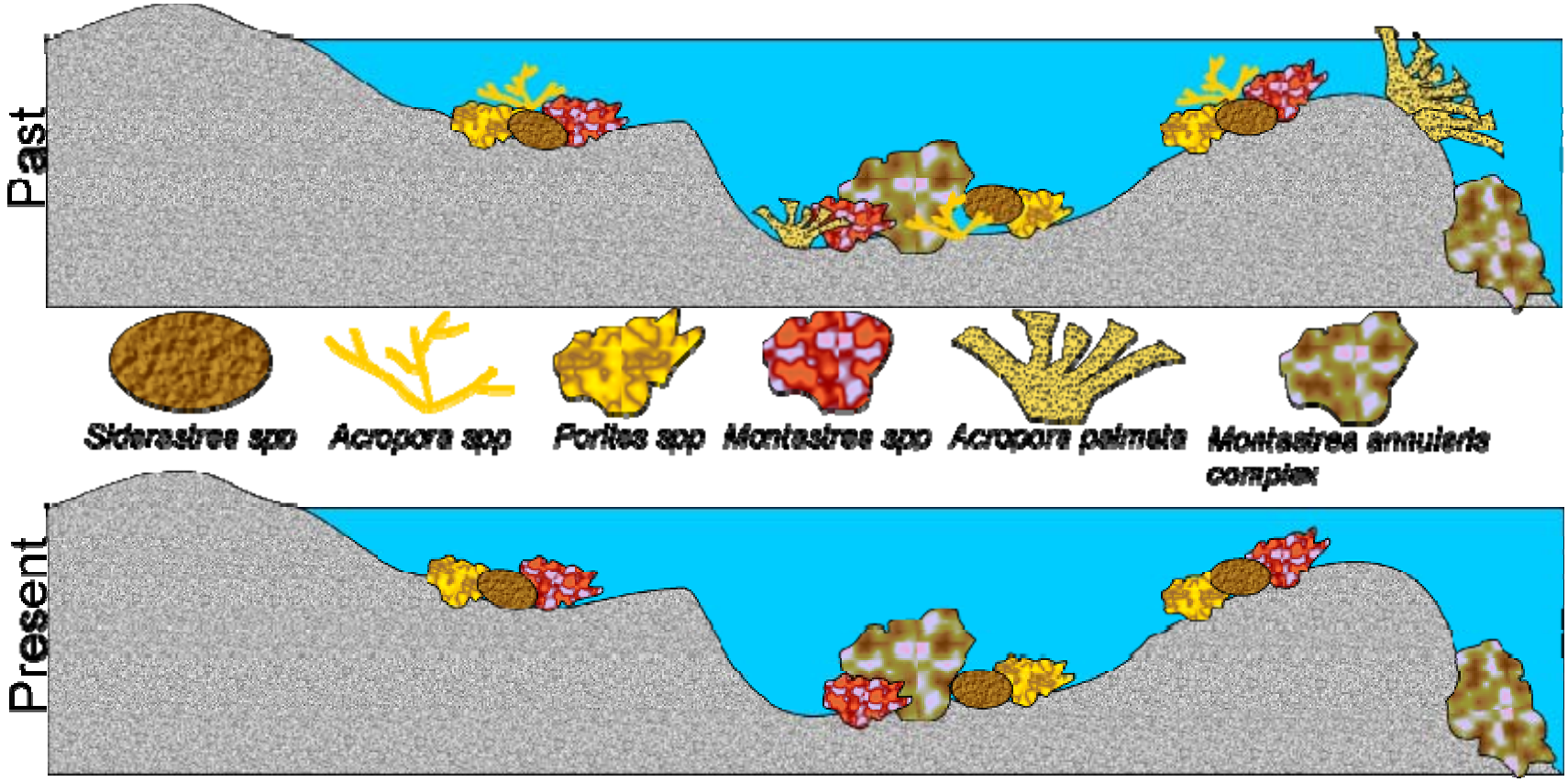

Declines of *Acropora palmata* and *Acropora cervicornis* have homogenized reef zones. Declines of other species will further homogenize zones and subregions.

Implications for Subjects of Greatest Controversy

- Macroalgal cover, macroalgal growth rates, and rates of herbivory are moot, because larger-scale threats exert an overriding influence.
- Herbivory could be important to future recovery.
- The physical environment is changing so rapidly that alternative stable states, if they exist, are unknowable.

Primacy of the Physical

- It is trivially true that at large enough scales physical processes trump biological processes.

Primacy of the Physical

- Because corals live a long time, physical processes drive coral populations at roughly ecological scales.
- The controlling influences and greatest extinction threats are physical: oceanic warming, disease (abetted by warming), and perhaps acidification.
- It could be all over from rising sea temperatures before acidification exerts a strong influence.

From Ecology to Extinction Threat

- If temperature effects—direct and collateral via disease—will exert the greatest influence on coral populations in the coming decades…
- …can we quantitatively evaluate resilience to temperature extremes and resistance to extinction using biological traits of the coral species?
- Stay tuned for Rob van Woesik's talk.