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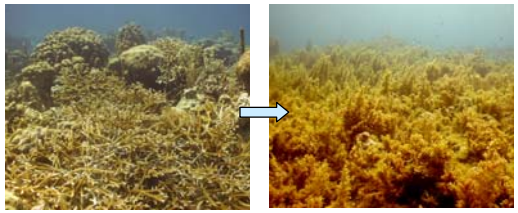
Environmental Stressors Driving the Global Decline of Coral Reefs: Identifying Context-Specific Effects

Introduction: Global Decline of Coral Reefs

The global decline of reef-building corals over the last twenty years is well documented, but the proximate causes are not well understood. The stressors typically implicated in reef degradation include sea surface temperature anomalies (SSTA) associated with global climate change and El Niño events, overfishing, nutrient enrichment, and sedimentation.

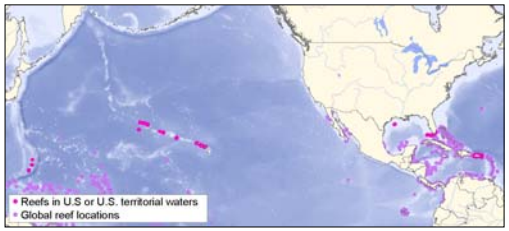
Coral reefs in the United States are no exception to these threats. Coral reefs throughout U.S waters are experiencing high rates of disease and bleaching as well as decreasing coral cover. Due to the wide geographic extent of U.S. coral reefs—the South Atlantic, Gulf of Mexico, Caribbean, and Pacific—only a global model will truly capture patterns of decline and identify likely causes. Without understanding the spatial patterns and context dependence of key stressors, resource managers will not be able to effectively manage protected areas in these disparate locations.

Decline of coral reef ecosystems



An example of the type of phase shift from coral- to algal-dominated systems increasingly seen across the wider Caribbean

The global distribution of U.S. coral reefs



Project

Goal: Quantify relationships between environmental stressors and coral reef health at multiple scales

This project will integrate spatial analyses and experimental approaches to document spatial patterns of stressor impact and infer causality between stressors and metrics of coral condition. Because disease is a major cause of coral mortality, the first phase will focus on how environmental stressors may affect disease dynamics.

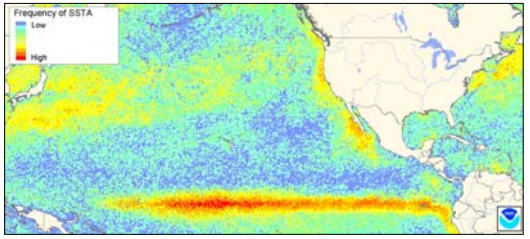
Stressors	Response	
Temperature Nutrient input	⇨ Coral disease prevalence and severity	Metrics of coral health
Nutrient input Overfishing Sedimentation	⇨ Macroalgal cover and live coral cover	
Temperature	⇨ Bleaching	

Phase One: Disease and Temperature

Yellow band disease

The first phase of the project will investigate the effects of temperature on yellow band disease dynamics. Yellow band disease infects the *Montastraea* sibling species complex, which is one of the primary builders of coral reefs in the Caribbean. The lethal nature of yellow band combined with *Montastraea*'s low recruitment suggest that the disease could have major impacts on the population viability of the species complex. This analysis will use coarse-scale temperature data and fine-scale mesocosm experiments to elucidate both pattern and mechanism.

Frequency of sea surface temperature anomalies, 1985-2003



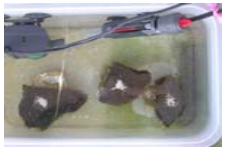
Spatial Analyses: Coarse-Scale

- Use remote sensing and GIS data to identify the spatial patterns of the stressor, temperature, and the response variable, disease
- Identify areas with high frequency and intensity of sea surface temperature anomalies
- Correlate the relationship between elevated temperature with *in situ* GIS data on yellow band disease prevalence and severity

Mesocosm Experiments: Fine-Scale

- Identify pathogen responsible for yellow band
- Determine effect of temperature on infection rate and spread across colony
- Investigate whether temperature effect is the result of increased disease virulence or host susceptibility

Inoculating corals



Significance

Coral reef ecosystems provide critical ecosystem services—fisheries, tourism, and shoreline protection—that are crucial to the economic and cultural health of coastal communities. Global estimates of these services total more than $375 billion annually. In South Florida alone, natural reefs support 44,500 jobs generating a total annual income of $1.2 billion. This project will help to explain the site-specific factors behind coral reef decline so that managers can more effectively protect our valuable marine resources.

Partners

National Oceanic and Atmospheric Administration and the Florida Keys National Marine Sanctuary

References: Gardner, T.A. et al. 2003. "Long-Term Region-Wide Declines in Caribbean Corals." *Science* 301(5635): 958-960; Hoegh-Guldberg, O. 1999. "Climate change, coral bleaching and the future of the world's coral reefs." *Marine and Freshwater Research* 50(8): 839-866; Pandolfi, J.M. et al. "Global trajectories of the long-term decline of coral reef ecosystems." *Science* 301(5635): 955-958; Szmant, A.M. 2002. "Nutrient enrichment on coral reefs: is it a major cause of coral reef decline." *Estuaries* 25(4b): 743-766; Nugues, M.M. and C.M. Roberts. 2003. "Coral mortality and interaction with algae in relation to sedimentation." *Coral Reefs* 22(4): 507-516.

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