Programa de Monitoreo de Arrecifes de Coral de Puerto Rico: patrones, trayectorias y factores relevantes

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Presentation Overview

Description of sampling design, methodological approach and statistical data analyses

Time series trends on % live coral cover – degradation/recuperation variability

Time series analyses on coral species composition and community structure – phase shifts

Evaluation of driving forces influencing coral/benthic community changes

Temporal and spatial trends of reef fish community structure and abundance

Management perspectives

Coral Monitoring Program Sampling Design

Baseline characterizations on 78 reef stations from 14 Natural Reserves (1999 – 2016)

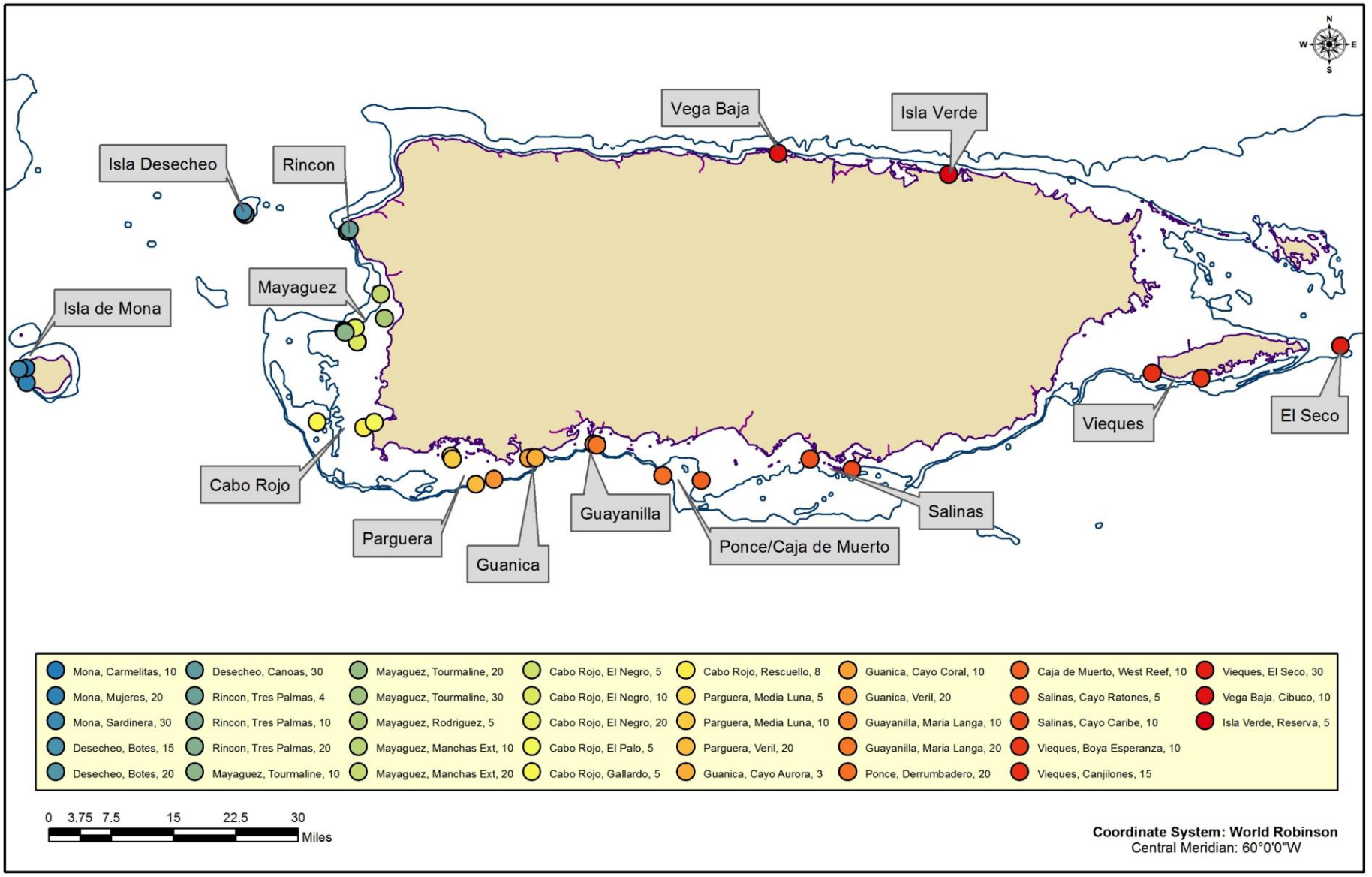
42 reef stations monitored on alternate years (21 reef stations annually)

Depth (5, 10, 20, 30 m), distance from shore and geographically (east-west) stratified, non-random sampling approach based on sets of 5 replicate (same z) 10 m long permanent transects per reef station established in reef zones of optimal coral growth

Data on % cover by sessile-benthic categories, benthic species, reef rugosity

10 m long x 3 m wide belt-transects for non-cryptic fish species and megabenthic invertebrates composition, density and size

Sampling Stations Layout - Puerto Rico Coral Reef Monitoring Program



Methodological Approach:
Continuous intercept method pros and cons…

Provides a cost-effective and robust statistical framework for time series analyses of benthic categories on permanent transects

Allows inferences of temporal variations at (benthic) community and population levels (dominant spp)

Chain overlay produce a minimum of 416 data points/transect; data points increase with reef topographic relief or rugosity

Produces an entire benthic community profile and a direct measurement of rugosity

Eliminate the 0's of coral cover that are common (and costly $$$) in random designs

Does not provide a representative measure of % live coral cover at any reef station

Time consuming – limits geographical coverage

Requires team work approach

Statistical Data Analyses

Time series of reef benthic % cover and fish abundance data sets analyzed by Repeated Measures ANOVA

Temporal and spatial variations of benthic and fish species composition and relative abundance analyzed with PRIMER multi-variate statistics, Anosim, Simper, Permanova

Non- metric, Multidimensional Scaling Plots (nMDS) based on Bray-Curtis similarities

Satellite –derived light attenuation coefficient Kd 490 as indicator of water turbidity

Coral Monitoring Program Major Findings: benthic community

Coral reef systems located at the outer shelf (Derrumbadero, La Boya - LP, Media Luna and Turrumote – LP), oceanic islands (Desecheo, Mona) and east coast islands (Cordillera de Fajardo, Vieques) presented the highest percent of live coral cover during the baseline surveys.

Live coral cover remained stable at most reefs during the monitoring program until 2006, when a variable decline of live coral was measured on the majority of the reef stations surveyed after a severe regional coral bleaching event affected reef systems of Puerto Rico and the U. S. Virgin Islands during late 2005.

The decline of (total) live coral cover was largely driven by mortality of Boulder Star Coral, *Orbicella annularis*, a highly dominant species in terms of reef substrate cover and the principal reef building species.

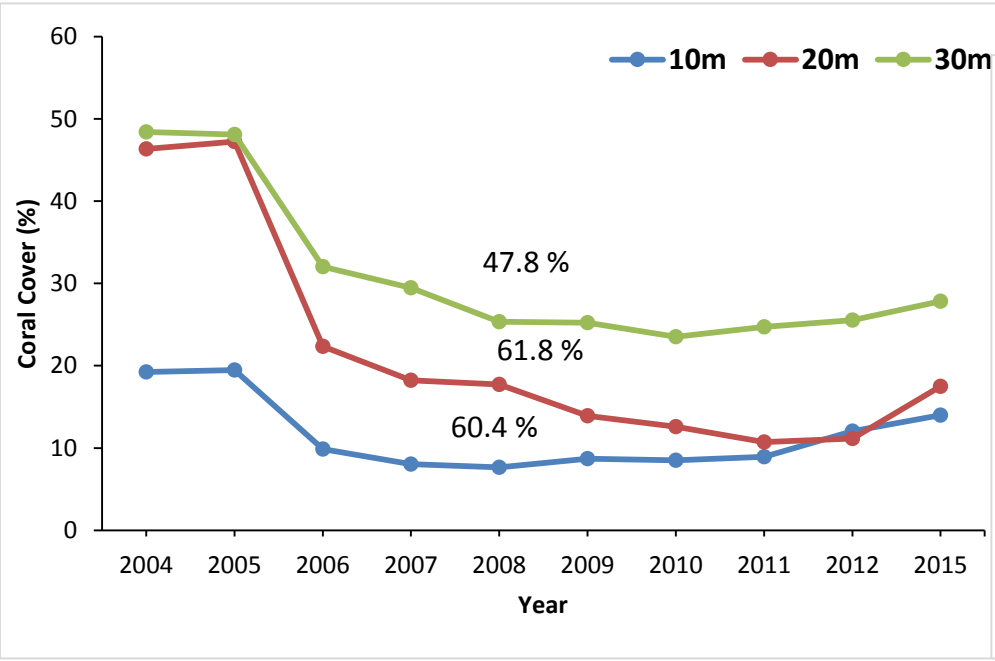
Live coral loss was highest amongst oceanic (Mona, Desecheo), shelf-edge (Derrumbadero) and east coast island reefs (Vieques). In general, coral mortality declined with increasing depth, towards the coast, and towards the west at similar depths. Reefs dominated by *Acropora palmata*, *Porites porites* and *Montastraea cavernosa* were the least affected.

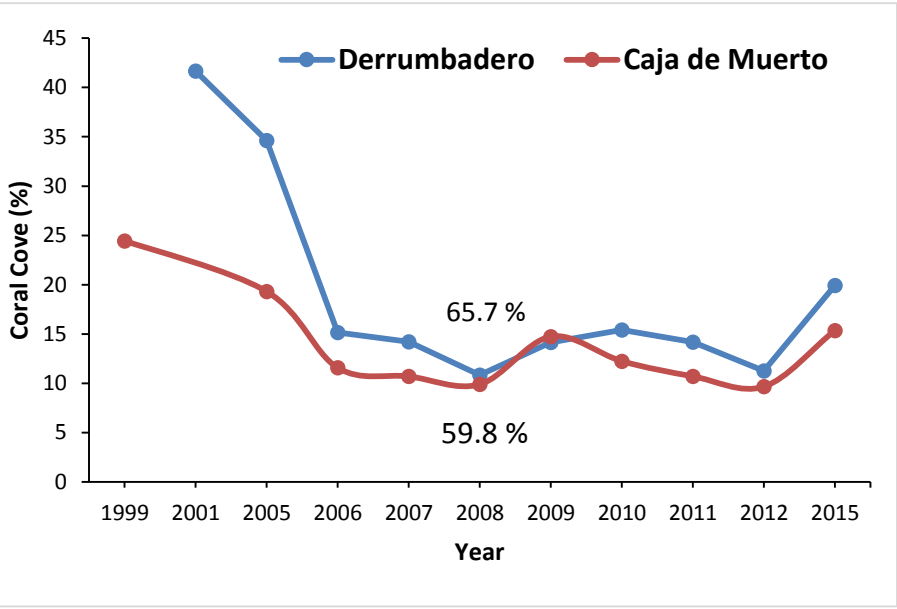
Mesophotic reef stations were not affected

Phase shifts of coral species dominance (% cover) and relative composition were observed on several of the most affected shelf-edge and oceanic island reefs.

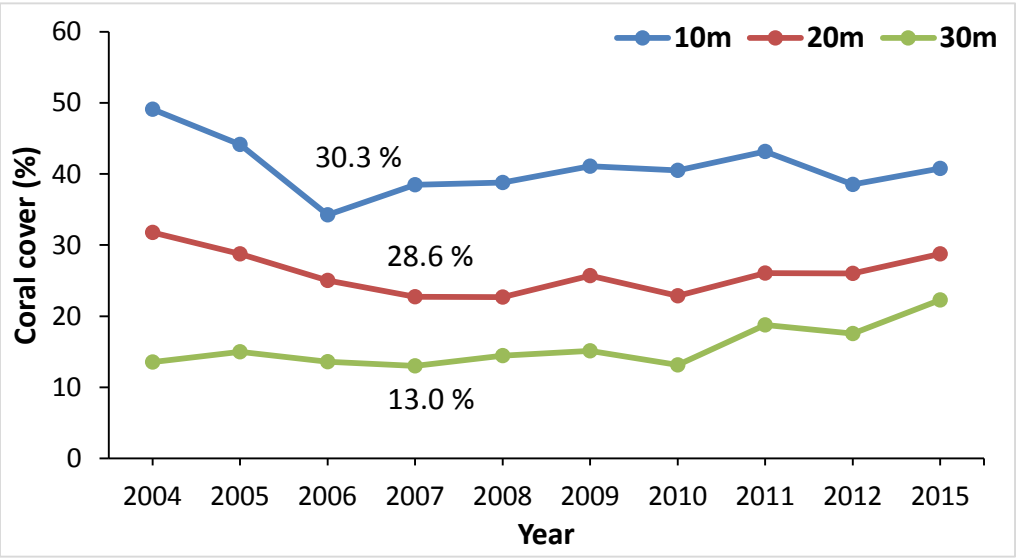
Recuperation of total live coral cover since 2006 to the present have been measured on coastal and estuarine influenced reefs, suggesting that water turbidity has played an important role in the protection and recuperation of shallow water (neritic) reefs of PR (sunblock effect)

Isla Desecheo

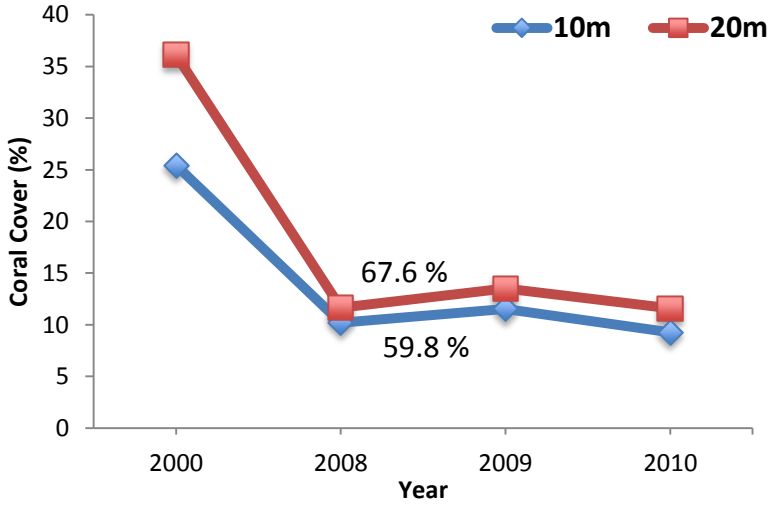




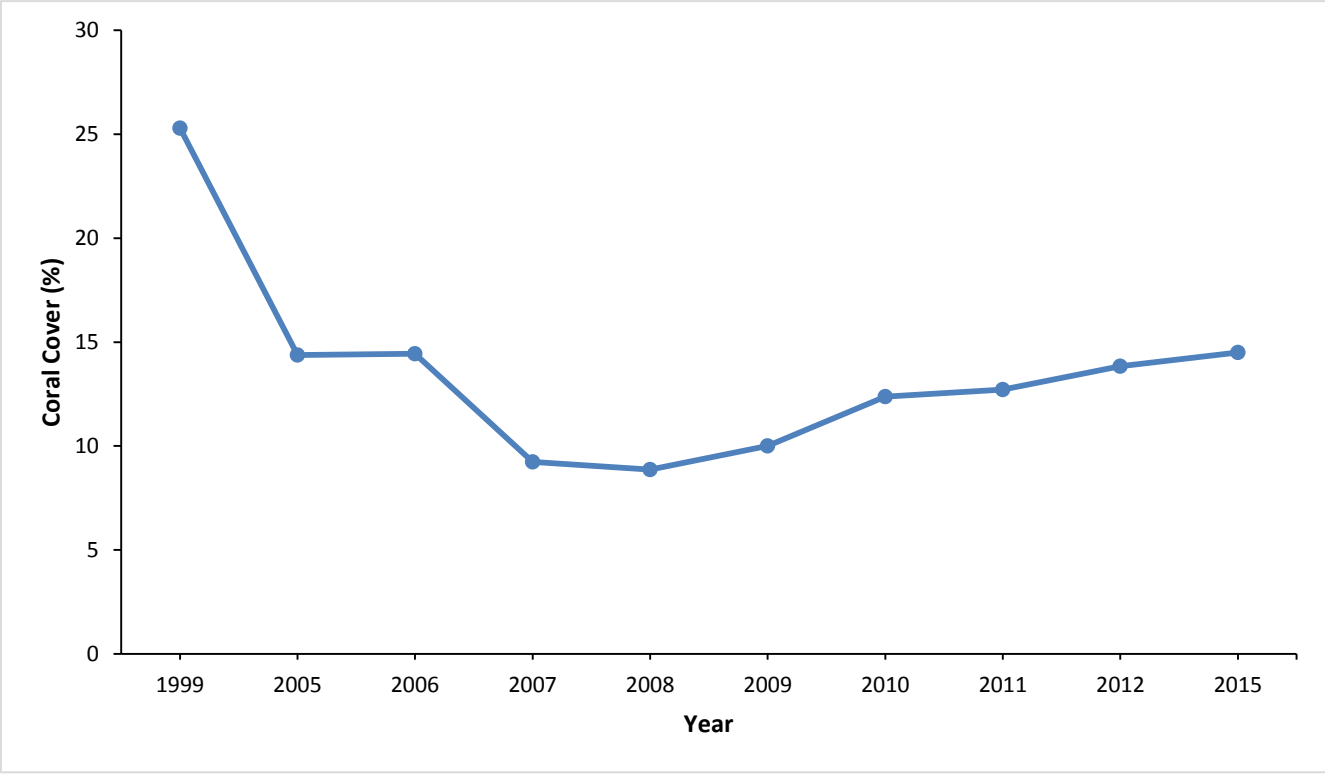
Tourmaline – Mayaguez Bay



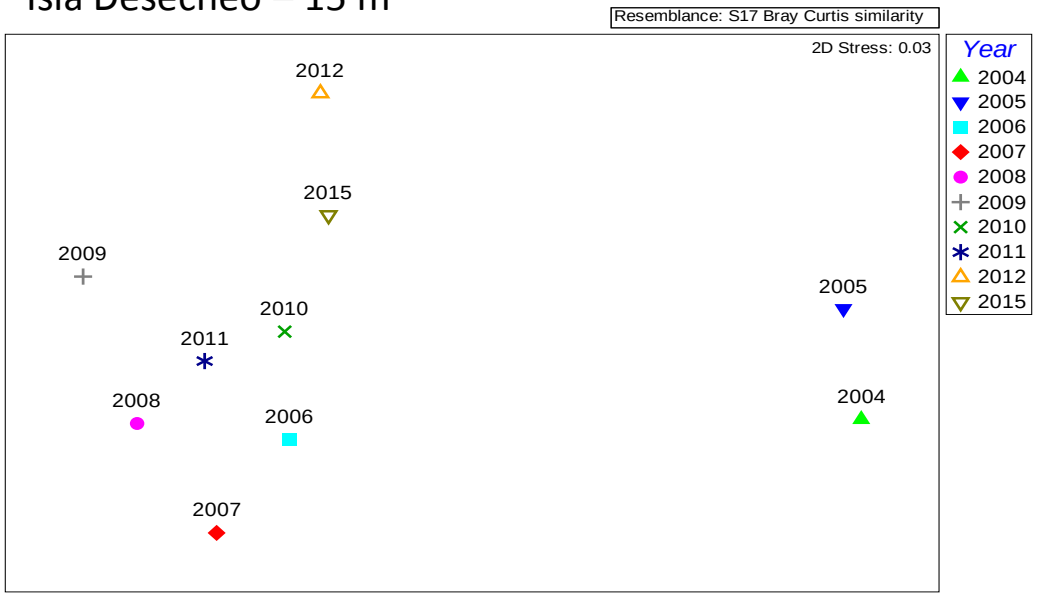
Isla Mona



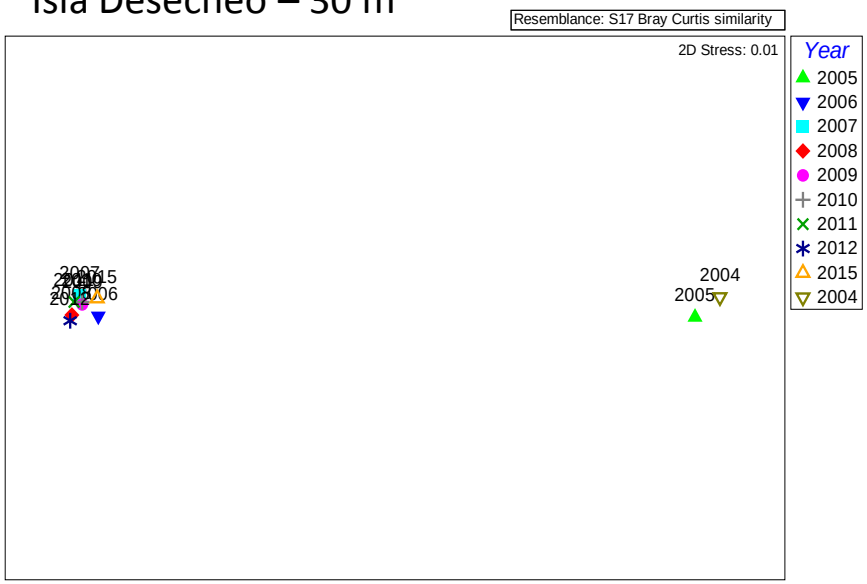
Cayo Coral - Guanica



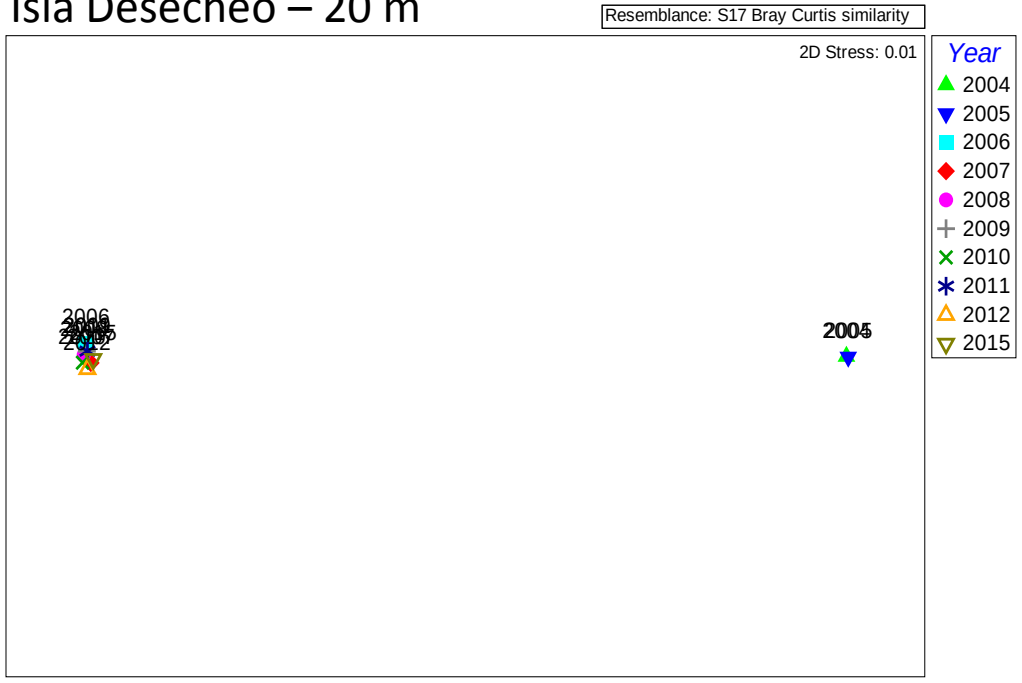
Isla Desecheo – 15 m



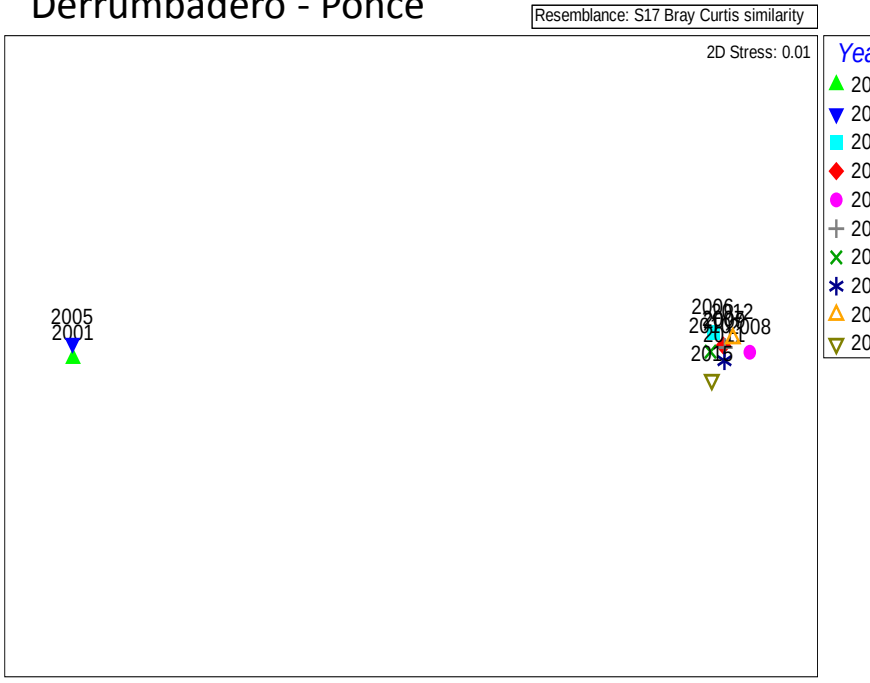
Isla Desecheo – 30 m

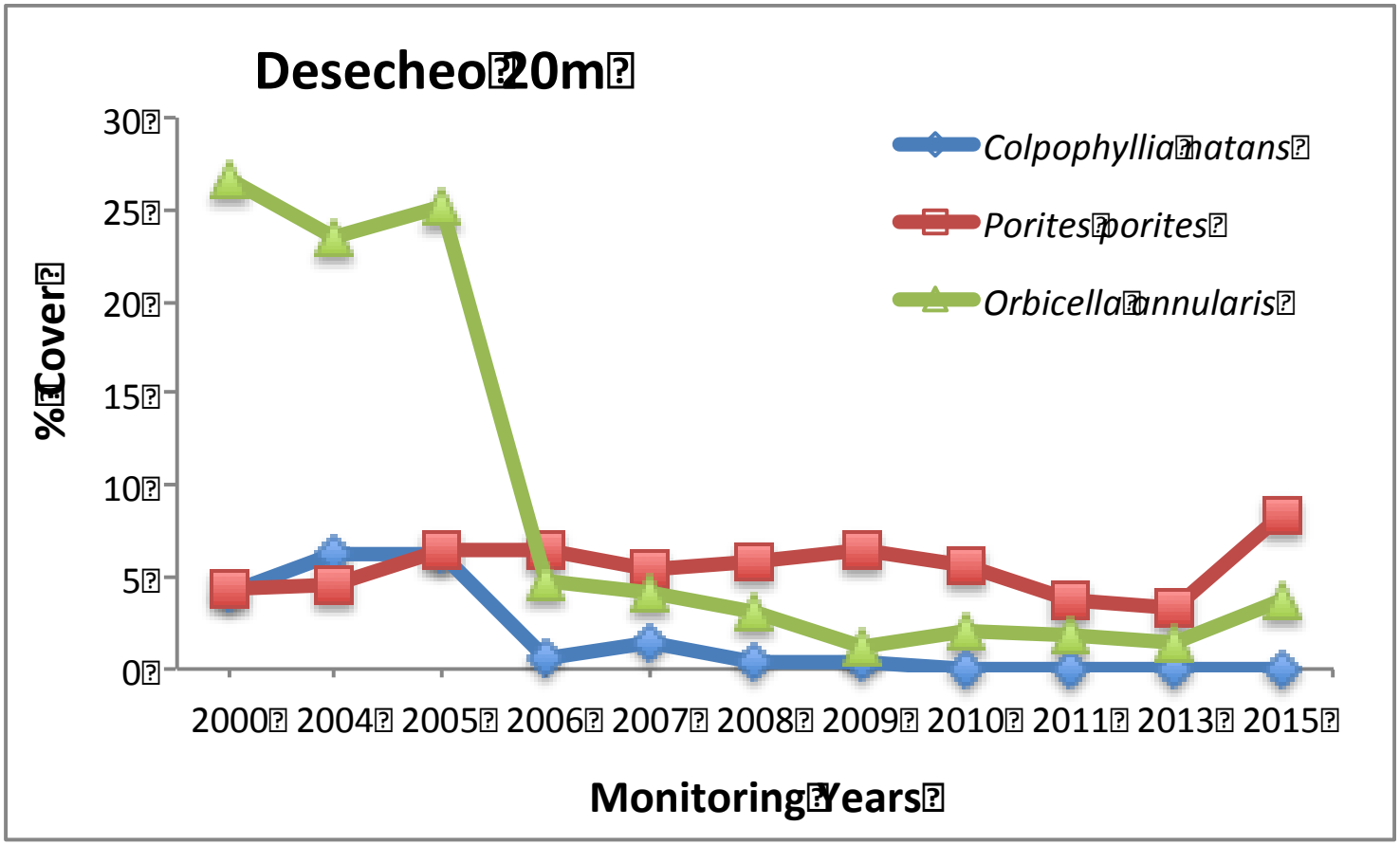


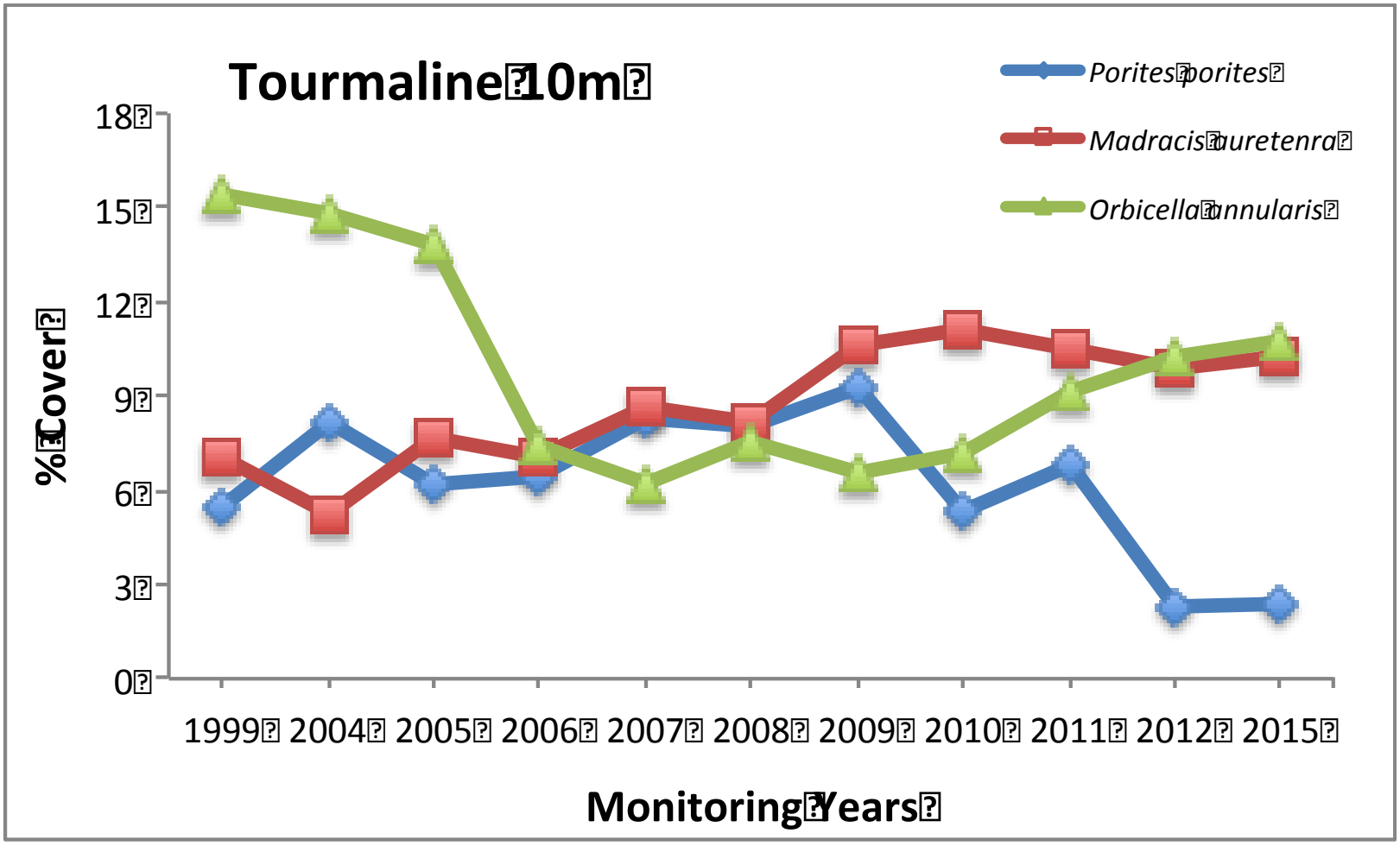
Isla Desecheo – 20 m



Derrumbadero - Ponce

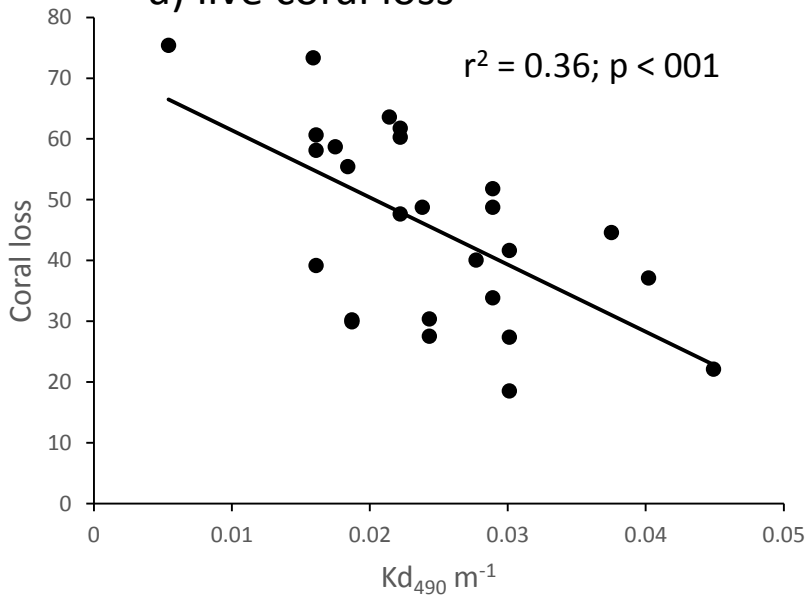



Desecheo 20m
30
25
20
15
10
5
0
% Cover
Colpophyllia natans
Porites porites
Orbicella annularis
2000 2004 2005 2006 2007 2008 2009 2010 2011 2013 2015
Monitoring Years

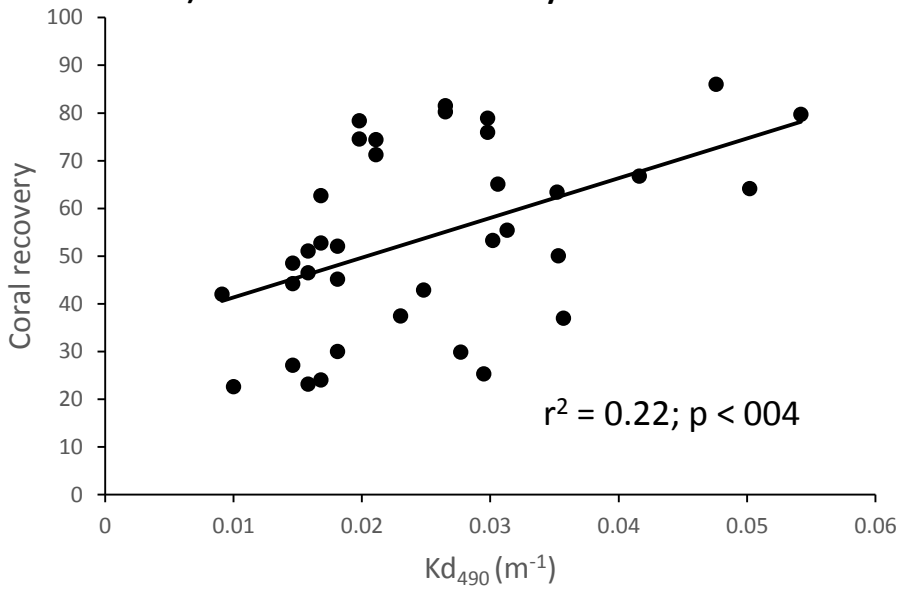

Tourmaline 10m
Porites porites
Madracis auretenra
Orbicella annularis
18
15
12
9
6
3
0
% Cover
1999 2004 2005 2006 2007 2008 2009 2010 2011 2012 2015
Monitoring Years

Relationships between light attenuation coefficient (Kd 490) and:

a) live coral loss



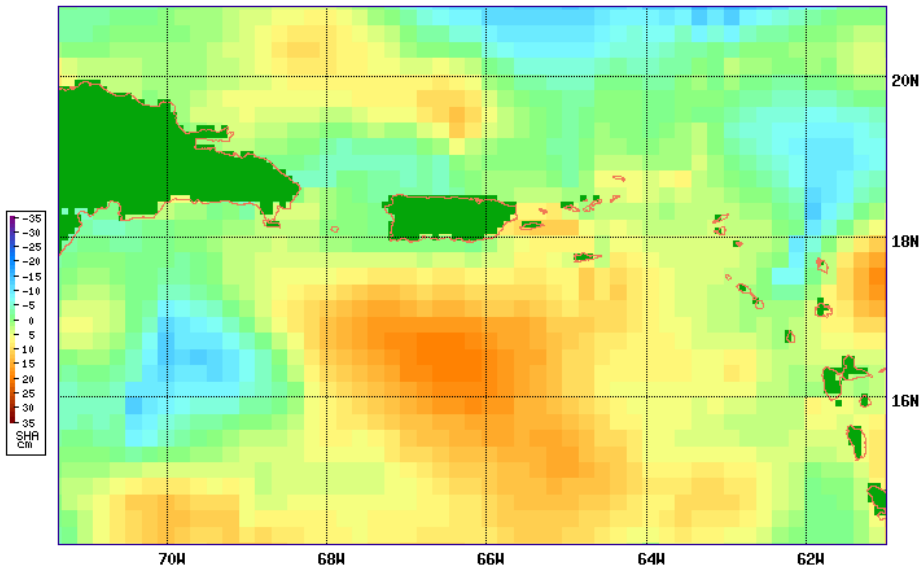
b) live coral recovery

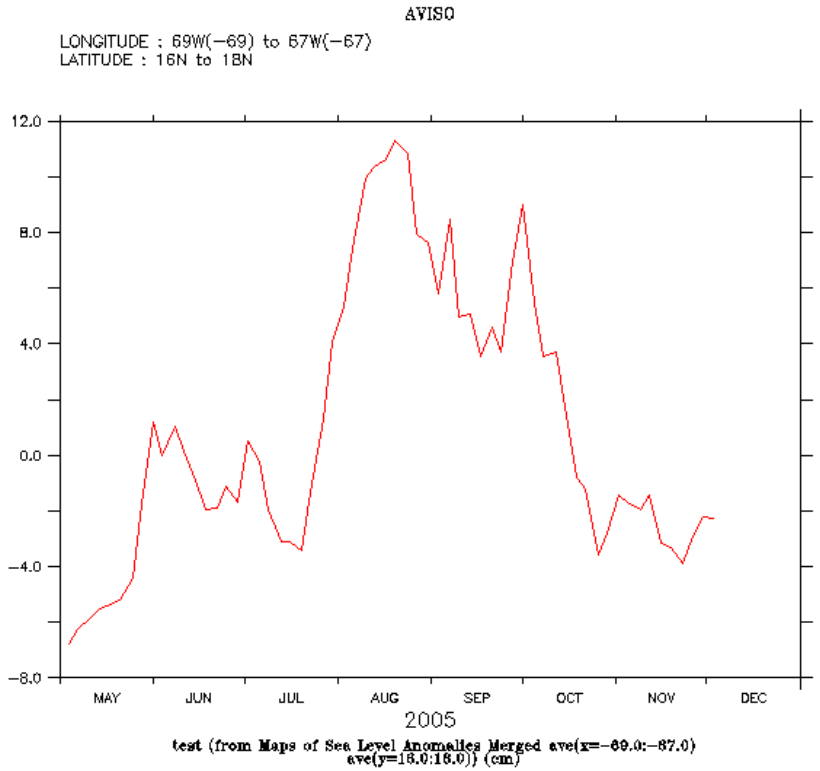


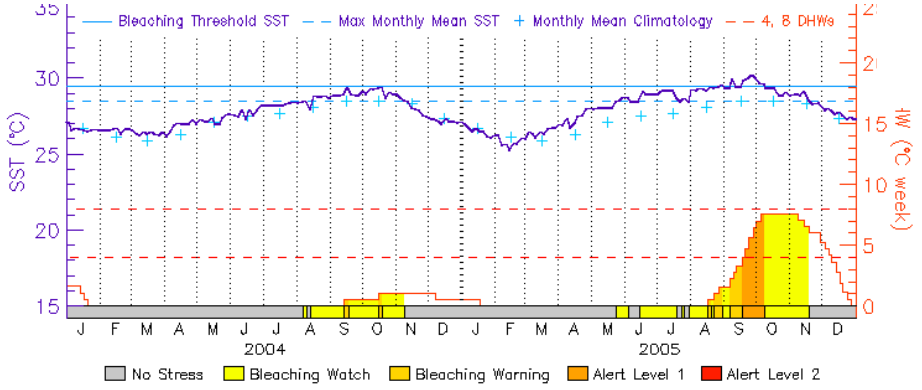
CORAL BLEACHING:

Passage of an anti-cyclonic eddy coincident with the 2005 coral bleaching event.

Increased heat content and UV radiation associated with anti-cyclonic eddies can exacerbate coral bleaching







Coral Monitoring Program Major Findings: Fish community

- Statistically significant temporal variations of fish abundance and species richness at any given reef have resulted from fluctuations in abundance of dominant schooling species and associated with wave action and surge effects, w/o evidencing any particular pattern or trend though time and probably driven by density-independent factors, such as recruitment dynamics

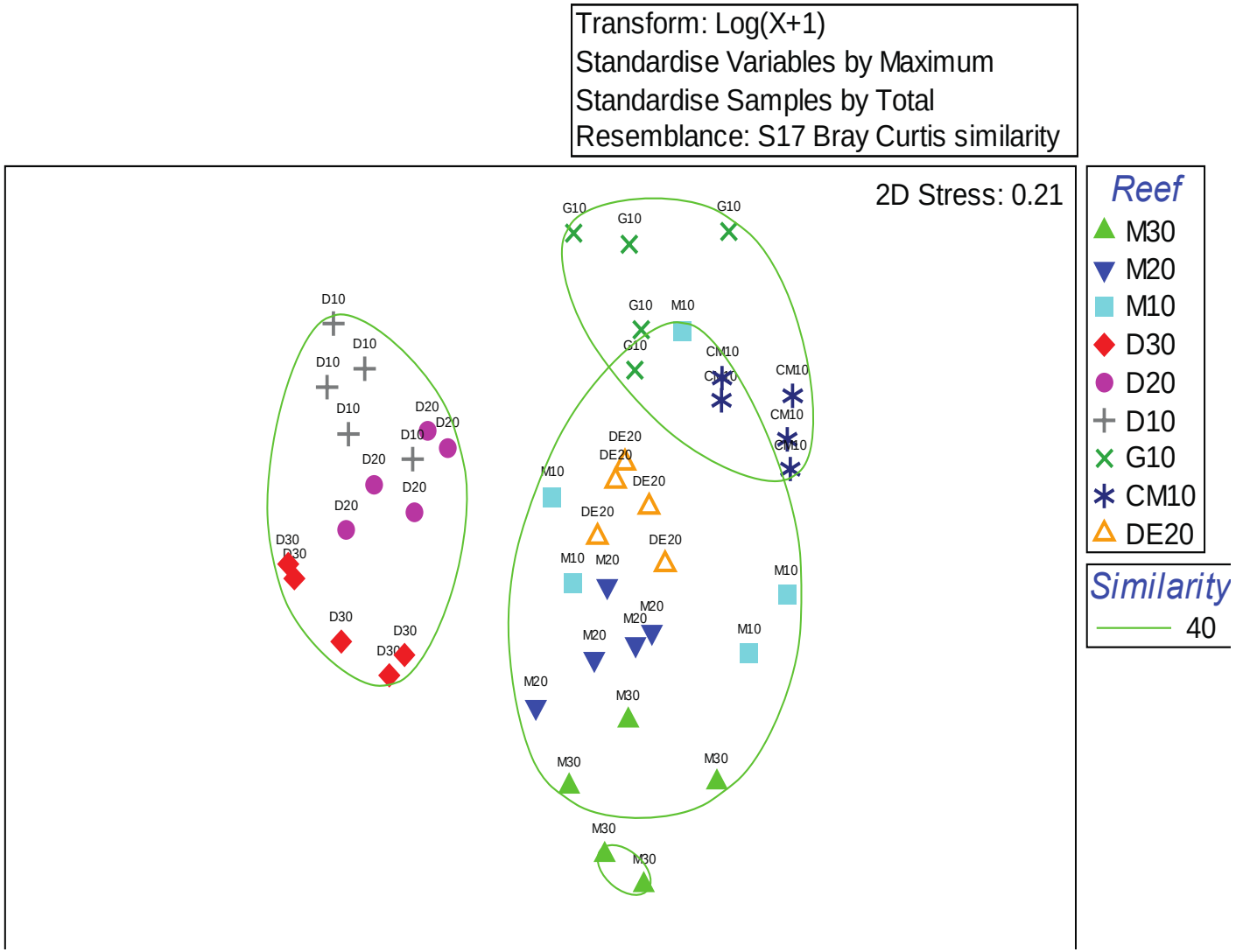
- Differences of fish community structure (spp. composition and relative abundance) influenced by factors such as distance from shore, depth and rugosity and reflect rank order dissimilarities by trophic (functional) groups (e.g. herbivores, planktivores, top carnivores)

- Live coral cover explained a minor fraction of the variability associated with fish abundance and species richness

- Marked losses of live coral cover associated to the regional coral bleaching event of 2005 may be below a threshold potentially regulating phase shifts of reef fish community structure, and/or there is also a time threshold required for coral structural loss that has not been surpassed

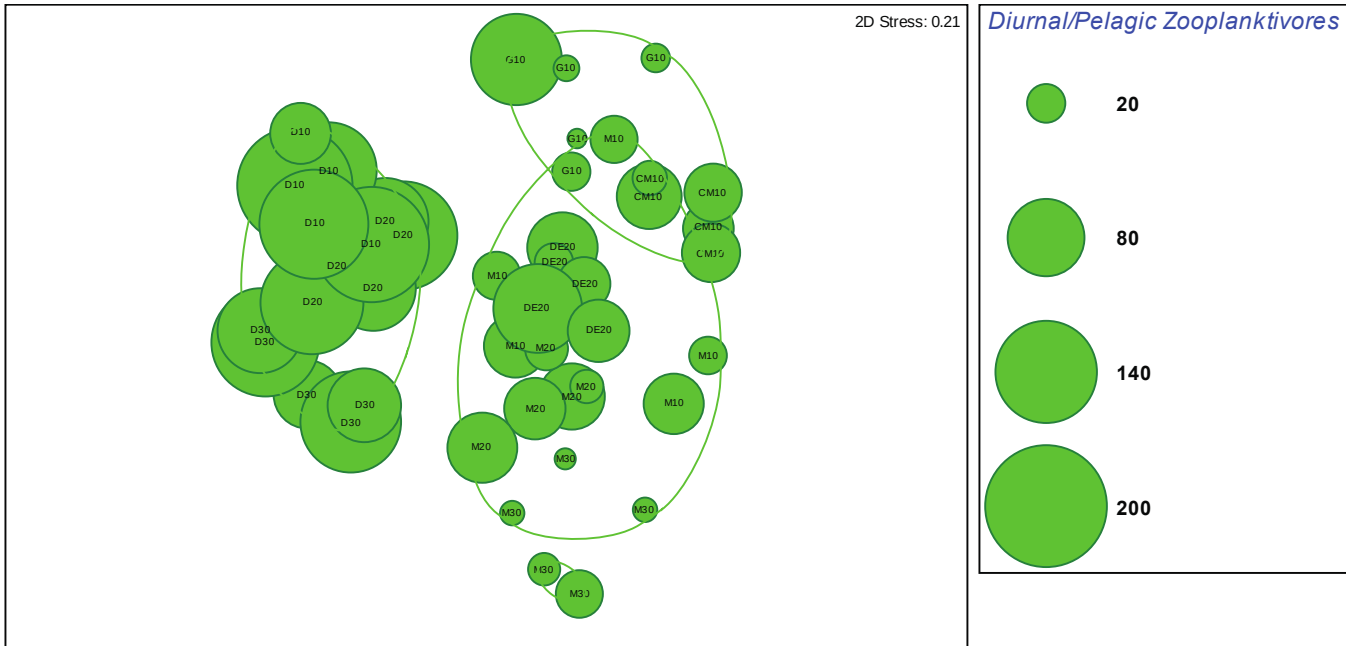
- Lionfish invasion had no measurable or permanent impact on reef fish populations

- There is an evident lack of large reef demersal predators

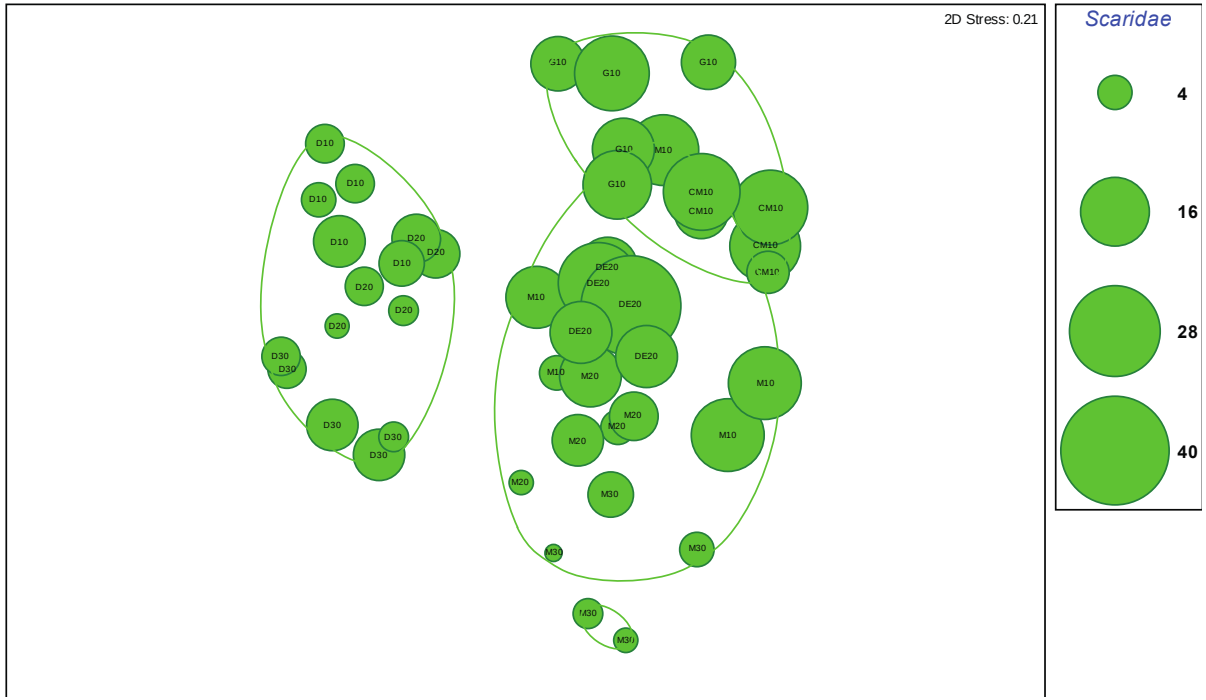


Non-metric, multidimensional scaling (MDS) plot of Bray-Curtis similarities based on the rank order abundances of reef fishes from sets of five replicate belt-transects surveyed at nine reef stations encompassing a 10-30 m depth gradient of the west and south coast of Puerto Rico.

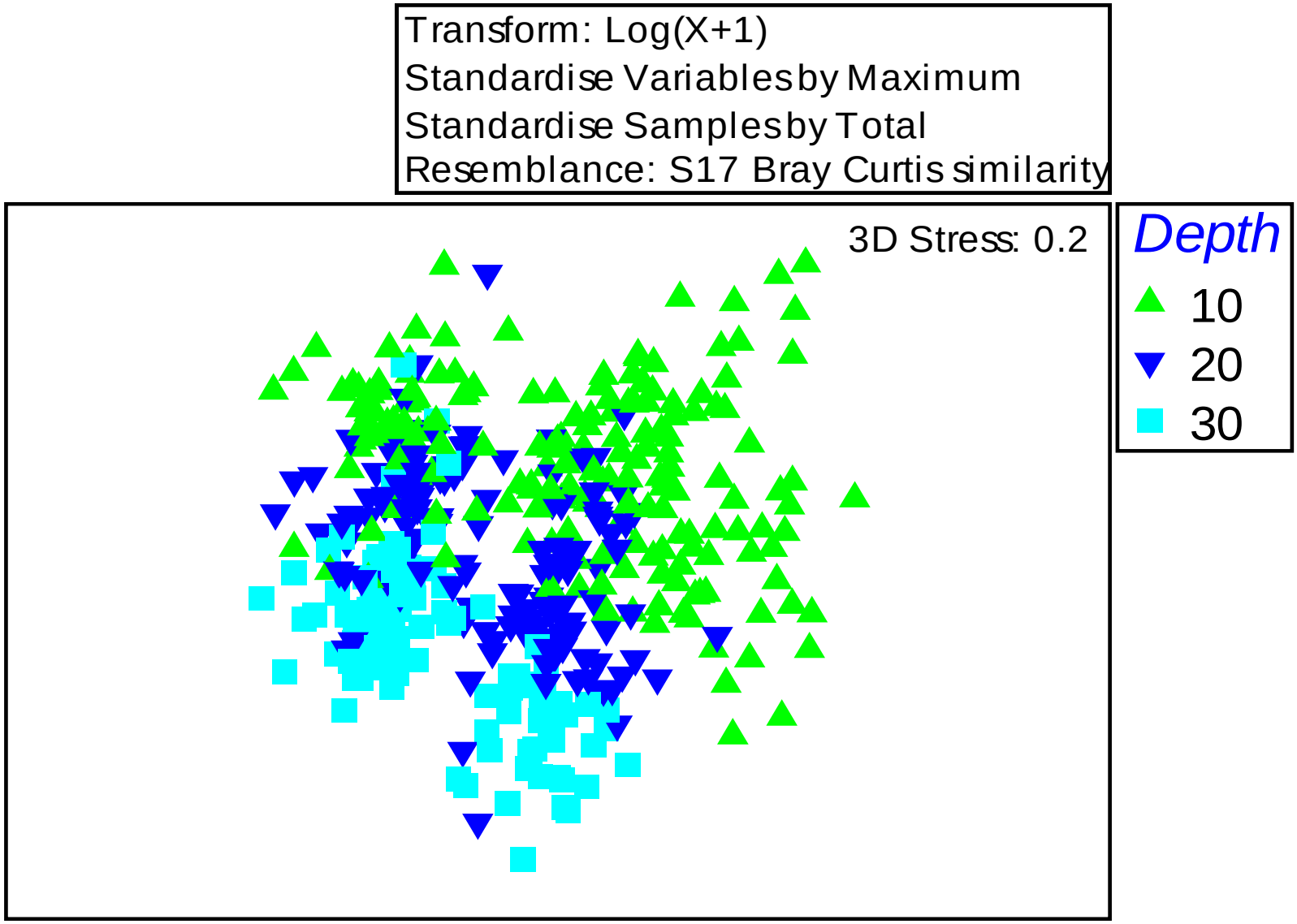
Diurnal pelagic zooplanktivore fish species



Herbivores : Scaridae (Parrotfishes)



MDS Plot of fish composition Bray-Curtis similarities at different depths (10, 20 30 m)



Management Perspectives

The main factor driving measurable changes of live coral cover appears to be associated with climatological/oceanographic phenomena that has been virtually ignored by the scientific community and its predictability in time and space remains adrift

There are clear signs of partial to full recuperation of live coral cover after the 2005 bleaching event, particularly in coastal reefs which have received the most management attention

The present coral monitoring program has shown to be capable of identifying ecologically significant changes of live coral cover and species composition and now provides a framework for detection of localized vs regional factors potentially driving coral degradation

There is an evident lack of ecological integrity associated with absence of large demersal fish predators that can be and should be managed by protection of seasonal spawning aggregations for these large demersal predators