CCRI - Coral Reef Long-Term Ecological Monitoring Program: A proposal and case studies from the eastern Puerto Rican shelf.

- **Edwin A. Hernandez**

- University of Puerto Rico
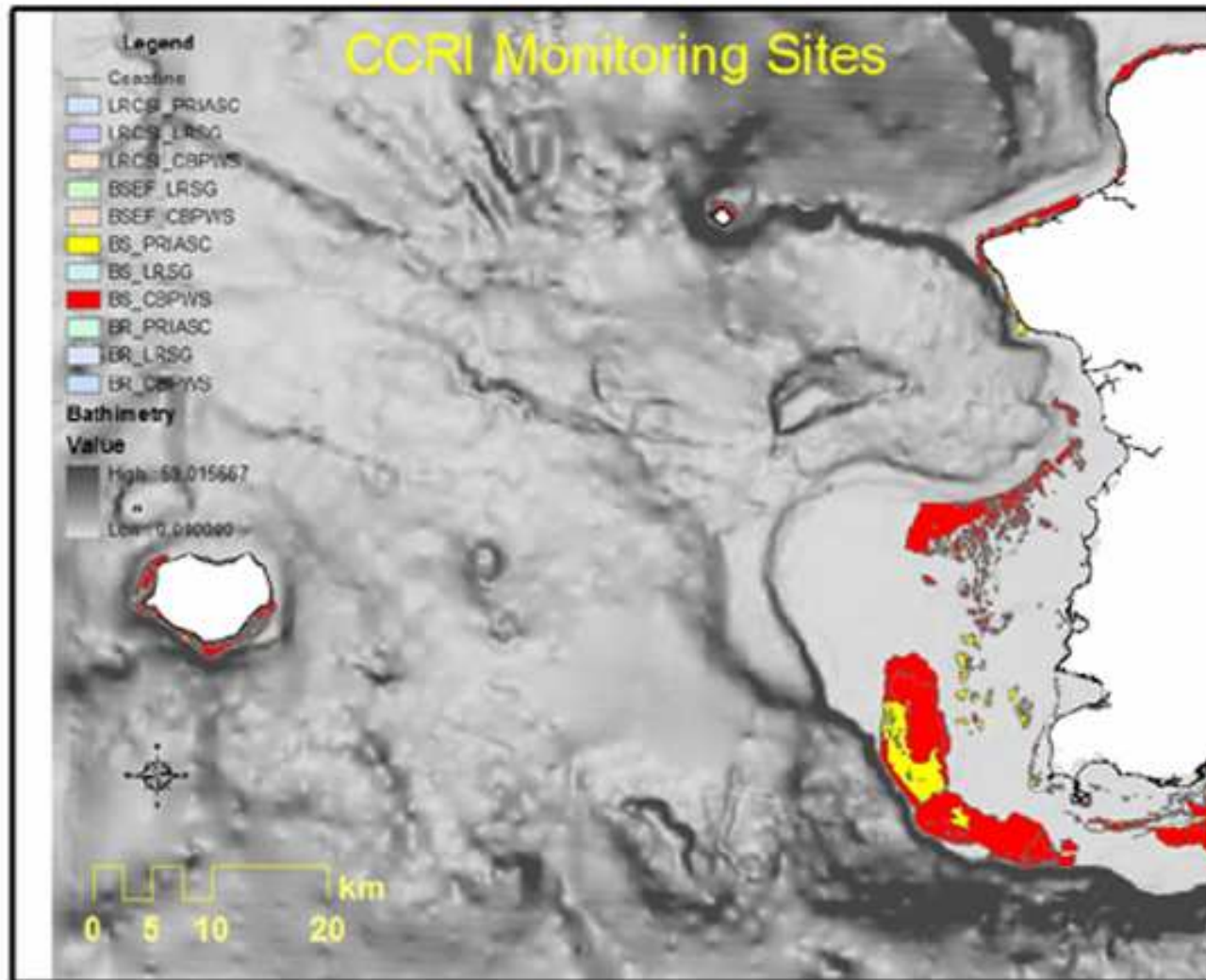- Department of Biology


Coral Reef Research Group

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Objectives

- Discuss the proposed sampling design for establishing the CCRI - Coral Reef Long-Term Ecological Monitoring Program (CRLTEMP).

- Present three case studies from the eastern PR shelf as examples of the type of analysis that will be carried out in the CRLTEMP.

Mayaguez (Tourmaline, Ron, Media Luna)
Boqueron (El Palo, Resuellos, Gallardo)
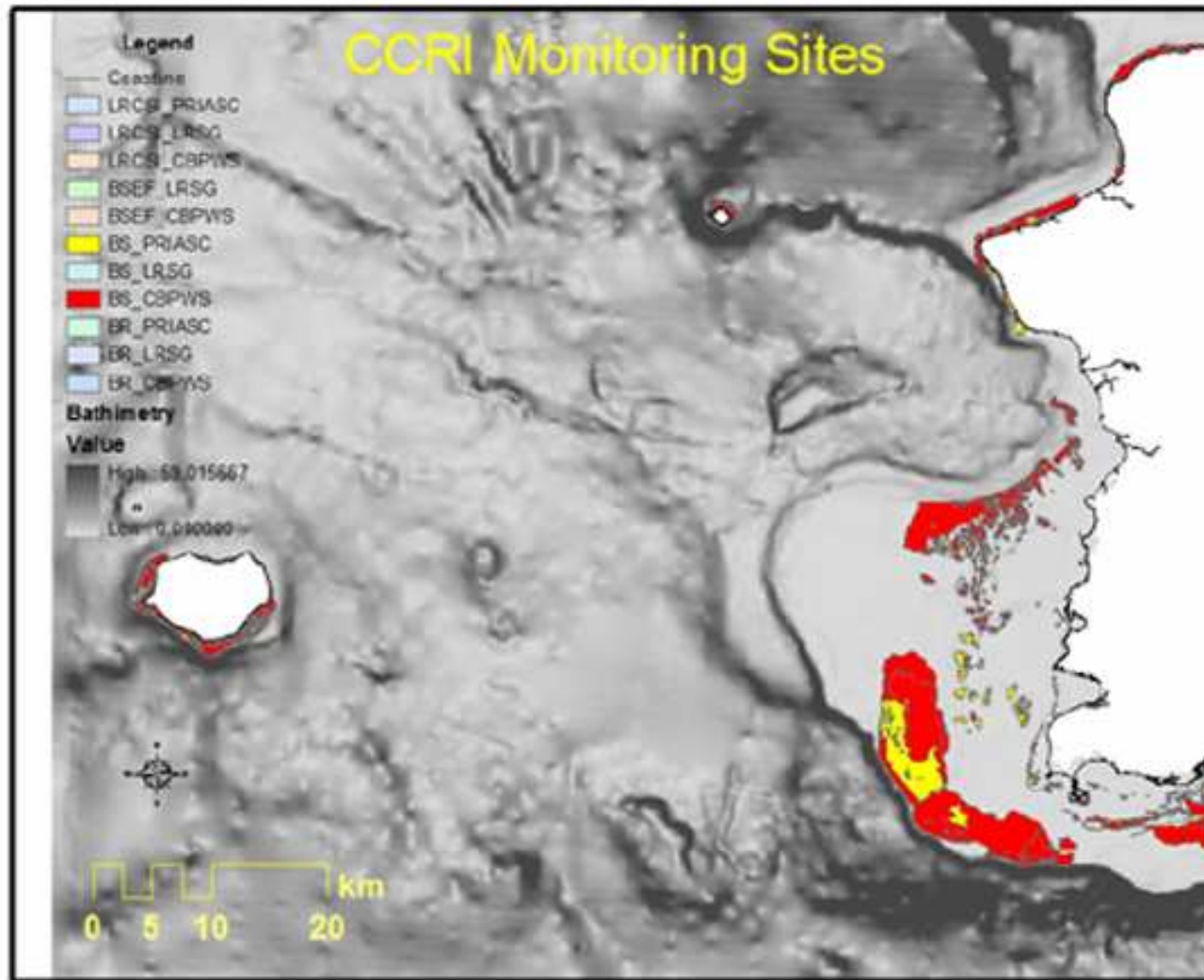
Mona (Pajaros, Mujeres, Carmelitas)
Desecheo (North, Botes, Canoas)

CCRI-CRLTEMP Research questions

- What are spatial and temporal variation patterns in the community structure of coral reef benthic and fish communities across the western PR shelf?

- Are coral reef benthic and fish communities in oceanic islands (Mona, Desecheo) in "better" ecological condition than those located in the western PR shelf (Boqueron, Mayaguez)?

Fish community assessment

- Belt transects (25 x 4 m).

- 4-way ANOVA
  - Location (shelf, oceanic)
  - Site (n=2)
  - Reef (n=3)
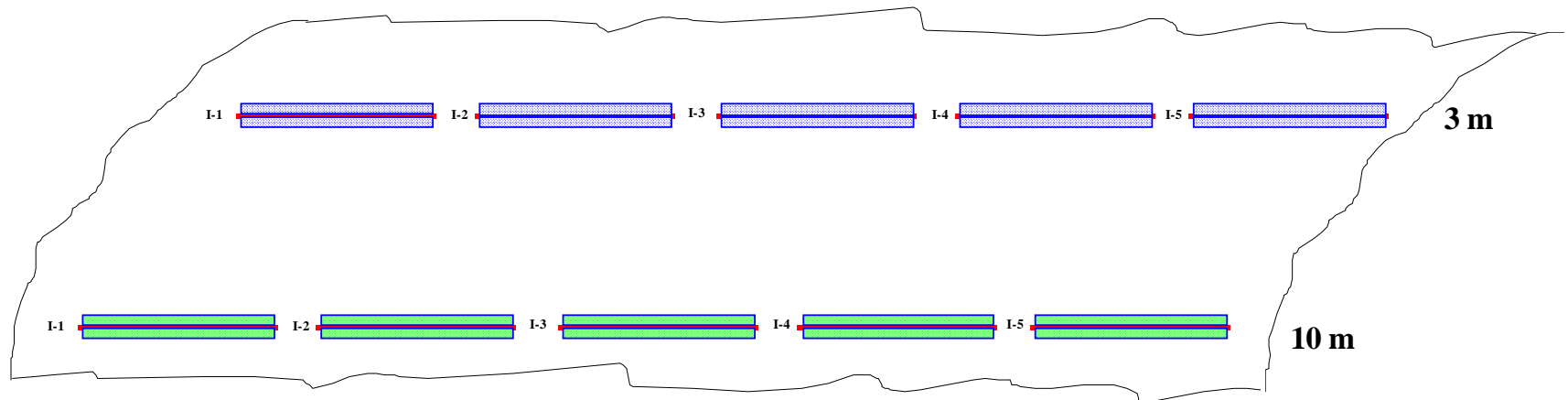 - Depth (3 m, 10 m)
  - Transect (n=6) – error term

Fish community data

- Species richness.
- H'n.
- J'n.
- Abundance.
  - Total.
  - Species.
  - Functional groups.
  - Fishery target species.

- Biomass.
  - Total.
  - Species.
  - Functional groups.
  - Fishery target species.
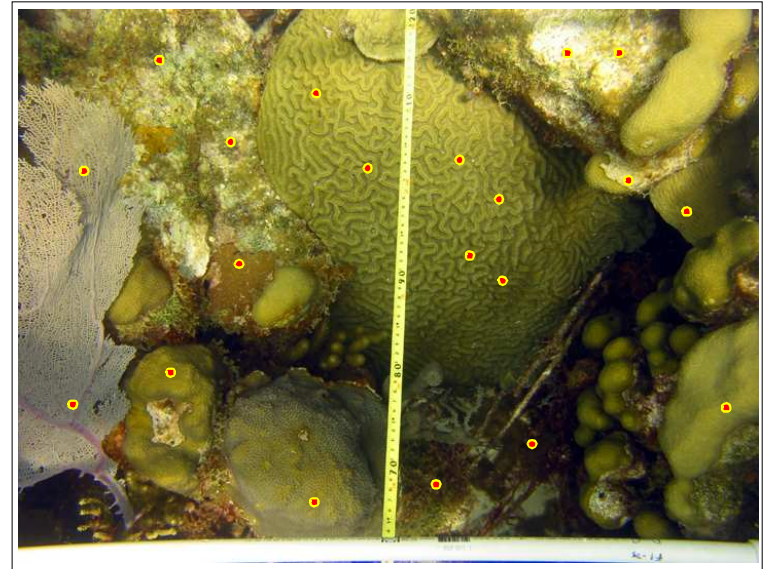
Benthic community assessment

- Belt transects (10 x 2 m).
- 3-way ANOVA
  - Location (n=2); Site (n=2); Reef (n=3);Depth (n=2)
  - Transect (n=5) – error term

Benthic community data collection

- High-resolution digital photography.
- Quadrats 1 m^2 (n=20/transect).
- 50 random dot grids (CPCE 3.0, NSU).

Benthic community data

- Coral species richness.
- Colony abundance.
- H'n
- J'n.
- % Coral.
  - Scleractinians.
  - Hydrocorals.
  - Encrusting octocorals.

- % Recent/Old mortality.

- % Algae (total).
  - Macroalgae.
  - Filamentous.
  - Halimeda.
  - Erect calcareous algae.
  - Encrusting algae.
- % Cyanobacteria.
- % Sponges.
- % Didemnid tunicates.
- % Others.

Benthic community data

- Gather baseline information regarding the incidence of coral diseases/syndromes.

- Follow Weil (2002).

- Belt transects (10 x 2 m).
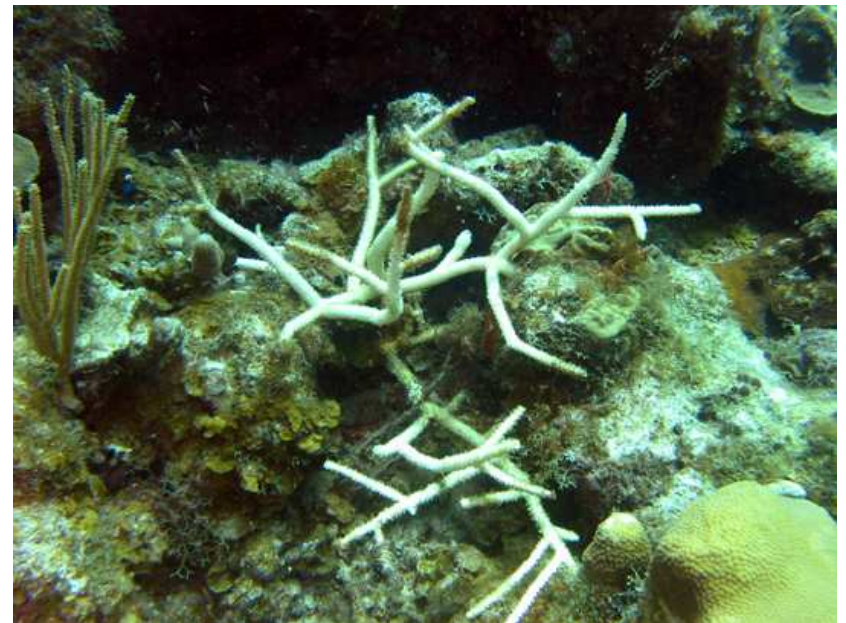
Benthic community data

- Assess benthic macroinvertebrate densities.

- Belt transects (10 x 2 m).

  - *D. antillarum.*
  - *C. abbreviata.*
  - *H. carunculata.*

Expected end-products

- Publish, of course!!!
- Produce useful data analysis and interpretation that can be readily available for.
  - Managers.
  - Decision-makers.
  - General public.
- Training of DNER personnel to apply the CCRI-CRLTEMP model to other locations.
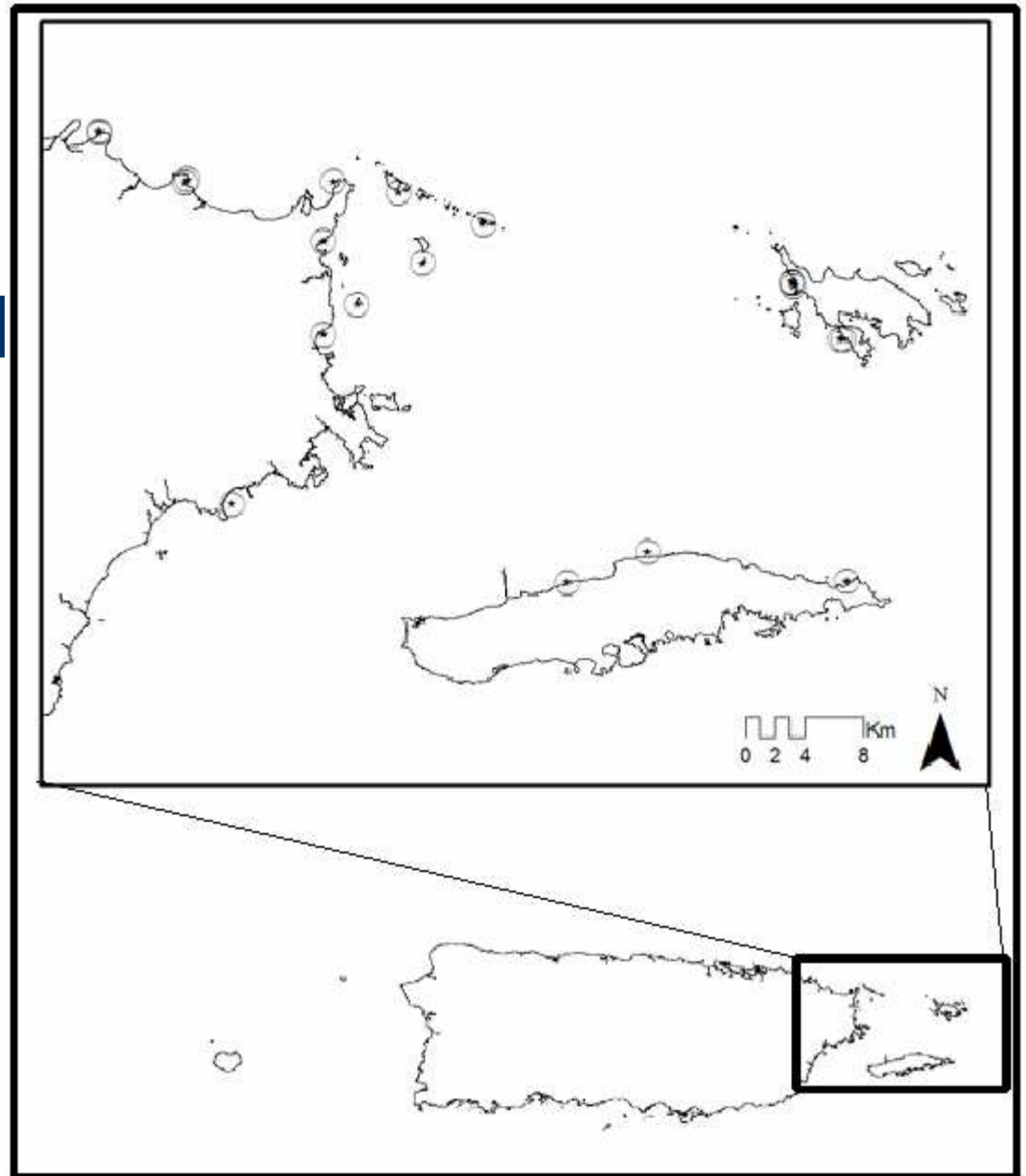
Case Study #1

- Spatial variation patterns in coral reef community structure in the eastern PR shelf.

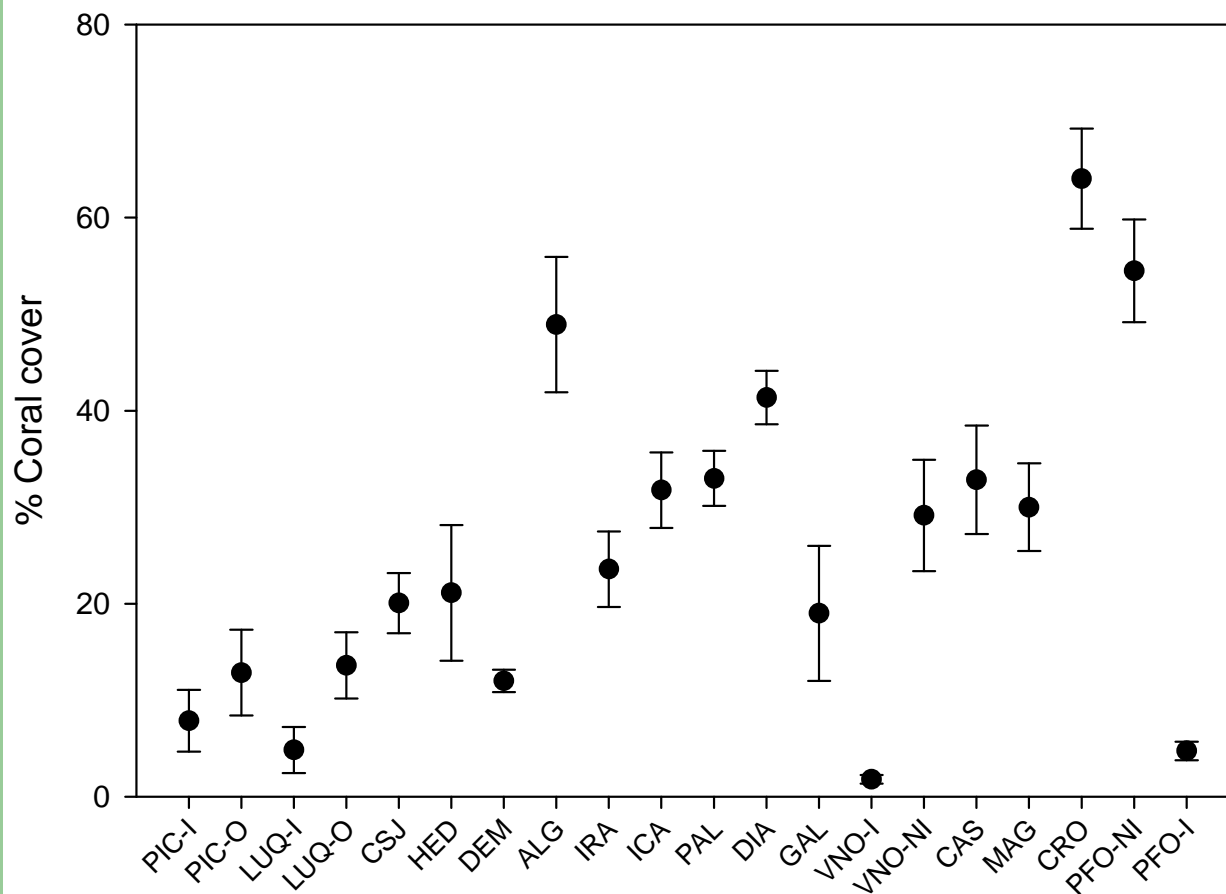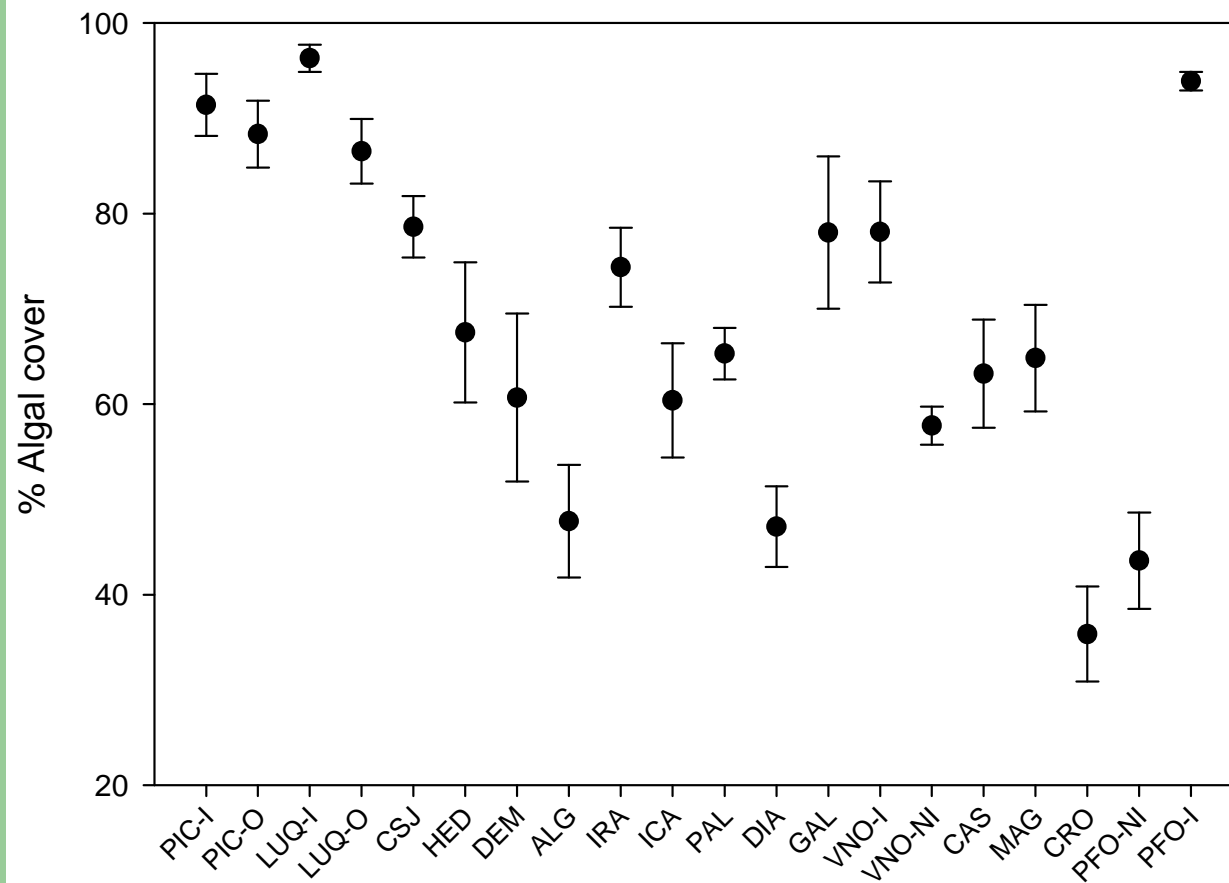# Design

20 Sites

Depth: 3-12 m

Replicates: 6-11
transects/site
(N=131 transects)

Low % Coral
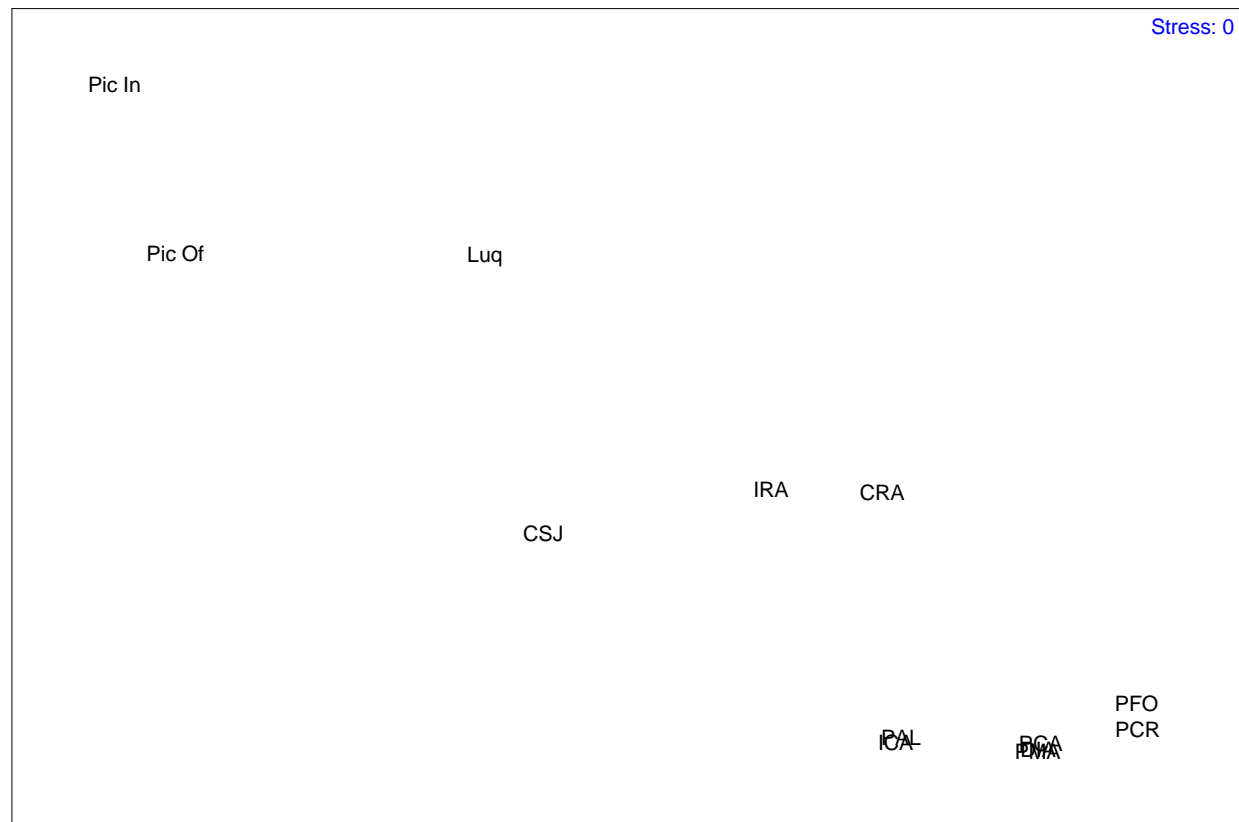## Chronic degradation and bombarded reefs

High % Algae
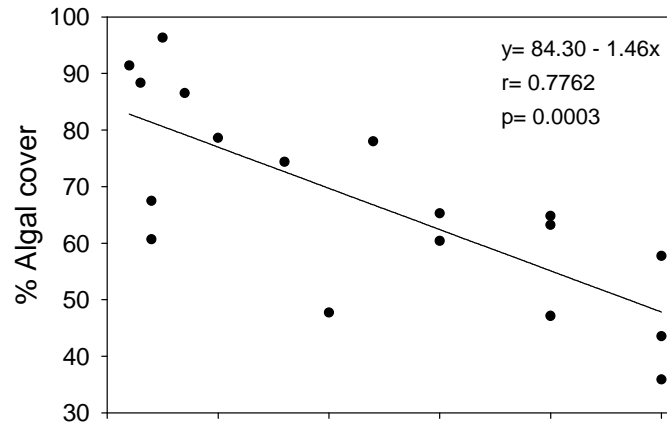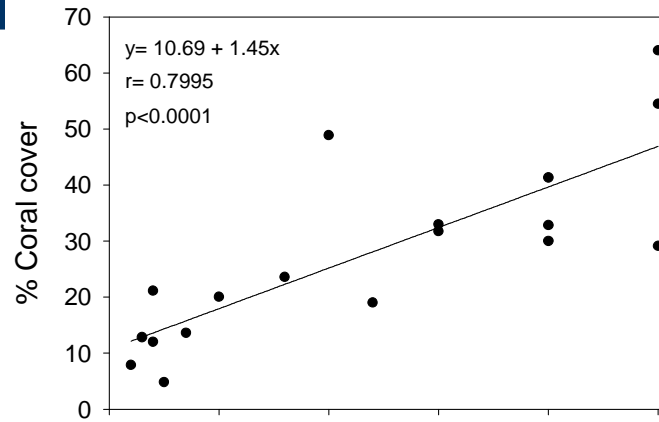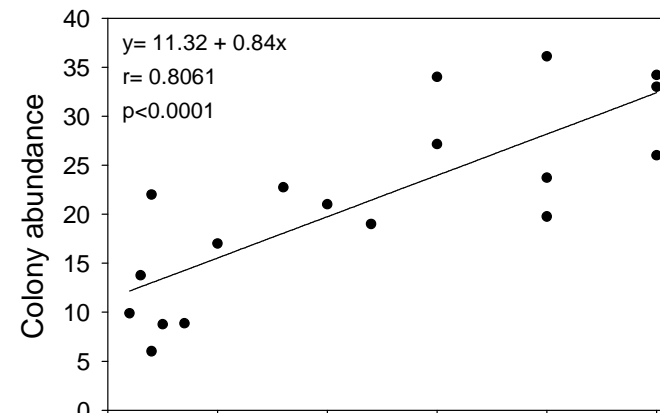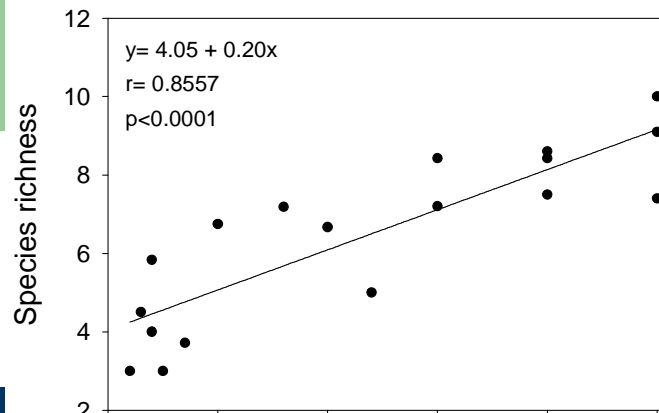## Chronic degradation and bombarded reefs

MDS Plot: Secchi readings

Stress: 0

Pic In

Pic Of   Luq

                                                    IRA   CRA
                              CSJ

                                                                            PFO
                                                                            PCR
                                          PAL   PCA
                                          PCA   PWA

Species richness
$y= 4.05 + 0.20x$
$r= 0.8557$
$p<0.0001$

Colony abundance
$y= 11.32 + 0.84x$
$r= 0.8061$
$p<0.0001$

% Coral cover
$y= 10.69 + 1.45x$
$r= 0.7995$
$p<0.0001$

% Algal cover
$y= 84.30 - 1.46x$
$r= 0.7762$
$p= 0.0003$

H'n
$y= 1.77(1-e^{-0.47x})$
$r= 0.7762$
$p=0.0002$

Horizontal water transparency (m)
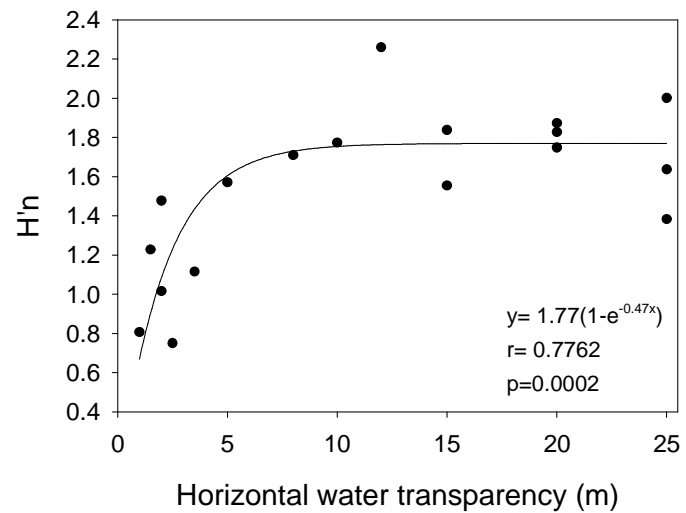
TABLE 1. One-way ANOVA testing the effects of different variables.

Factor	Site[a]	Treatment	Management Level	Reef category
Species richness	<0.0001	0.0324	0.2090 (NS)	0.1161 (NS)
Colony abundance	<0.0001	0.0200	0.0407	0.1174 (NS)
% Coral cover	<0.0001	0.0291	0.1022 (NS)	0.1271 (NS)
% Algal cover	<0.0001	0.0534 (NS)	0.3295 (NS)	0.1328 (NS)
% Sponge cover	<0.0001	0.8906 (NS)	0.1337 (NS)	0.4479 (NS)
% Zoanthid cover [c]	<0.0001	0.5329 (NS)	0.1399 (NS)	0.2211 (NS)
H'n	<0.0001	0.0182	0.7109 (NS)	0.1379 (NS)
J'n	<0.0001	0.3365 (NS)	0.7335 (NS)	0.0062
Water transparency	<0.0001	<0.0001	0.5876 (NS)	0.0132

[a]DF= degrees of freedom (between,within): site (19,112), treatment (3,18), management level (1,18), reef category (2,17).

TABLE 2. Significant differences in the coral reef community structure spatial patterns.

Factor	Global R statistic	Significance (p)
One-way ANOSIM test [a]		
Sites	0.649	<0.0001
Treatment [b]	0.329	0.0040
Management [c]	0.105	0.1060 (NS)
Reef category	0.515	<0.0001
Two-way crossed ANOSIM test [a]		
Sites x Treatment	0.497	<0.0001
Sites x Management	0.625	<0.0001
Sites x Reef category	0.534	<0.0001
Treatment x Management	0.630	0.0380
Treatment x Reef category	0.281	0.0660 (NS)
Management x Reef category	0.083	0.4000 (NS)

[a]ANOSIM tests based on 5,000 permutations. Data were square root-transformed. [b]Treatments (horizontal water transparency categories): I= <5 m, II= 5-15 m, III= >15 m, IV= Bombarded reefs.
[c]Management level: R=Natural Reserve sites, NR= Non-Natural Reserve control sites.
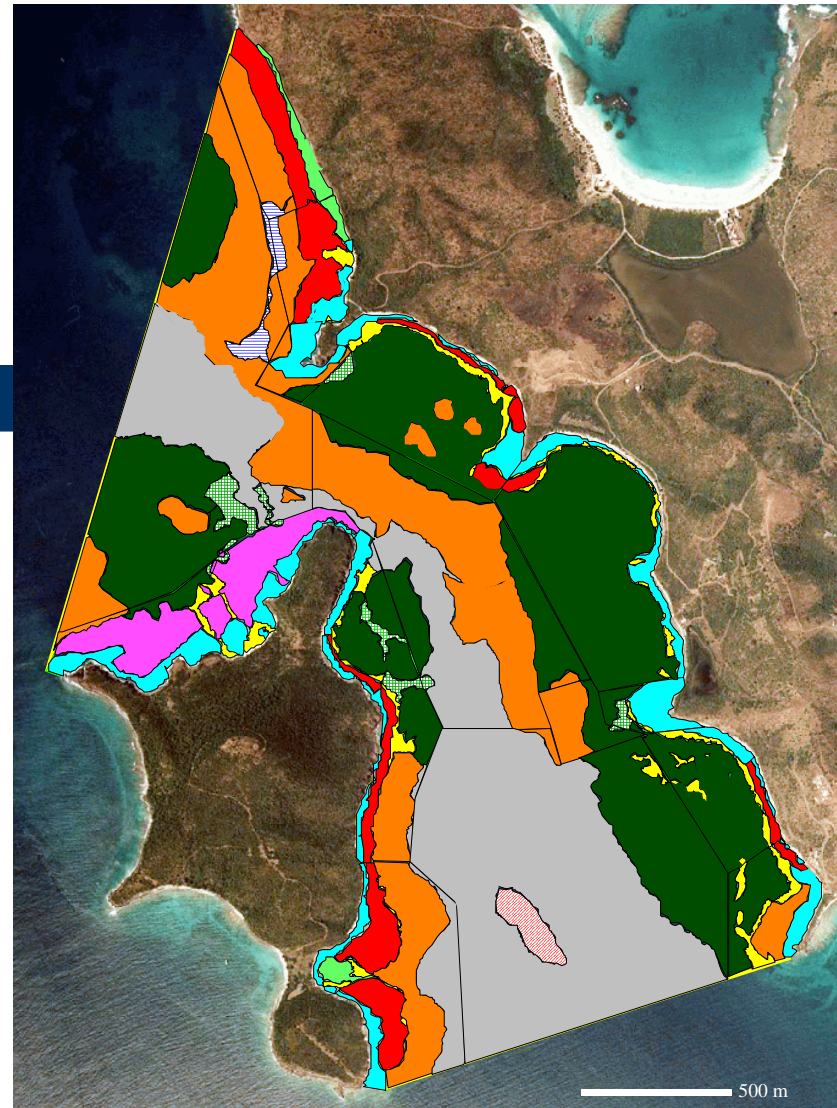
Case Study #2

- LPCNR Coral Reef Long-Term Ecological Monitoring Program.

Luis Pena Channel No-Take Natural Reserve, Culebra Island

June 11, 1999
Sept. 30, 1999 (no-take)

637 ha

Legend:

- Arrecife linear con algunos surcos y espolones
- Arrecife/Rocas colonizadas
- Arrecife/Pavimento colonizado
- Arrecife/Pavimento colonizado con canales
- Arrecife/Rocas y corales dispersos
- Arrecife de parcho (corales agregados
- Planicie de Macroalgas (10-50%)
- Hierbas marinas (Continuas)
- Hierbas marinas (70-90%)
- Hierbas marinas (30-50%)
- Arena

500 m

Bombs, bombs and more bombs!
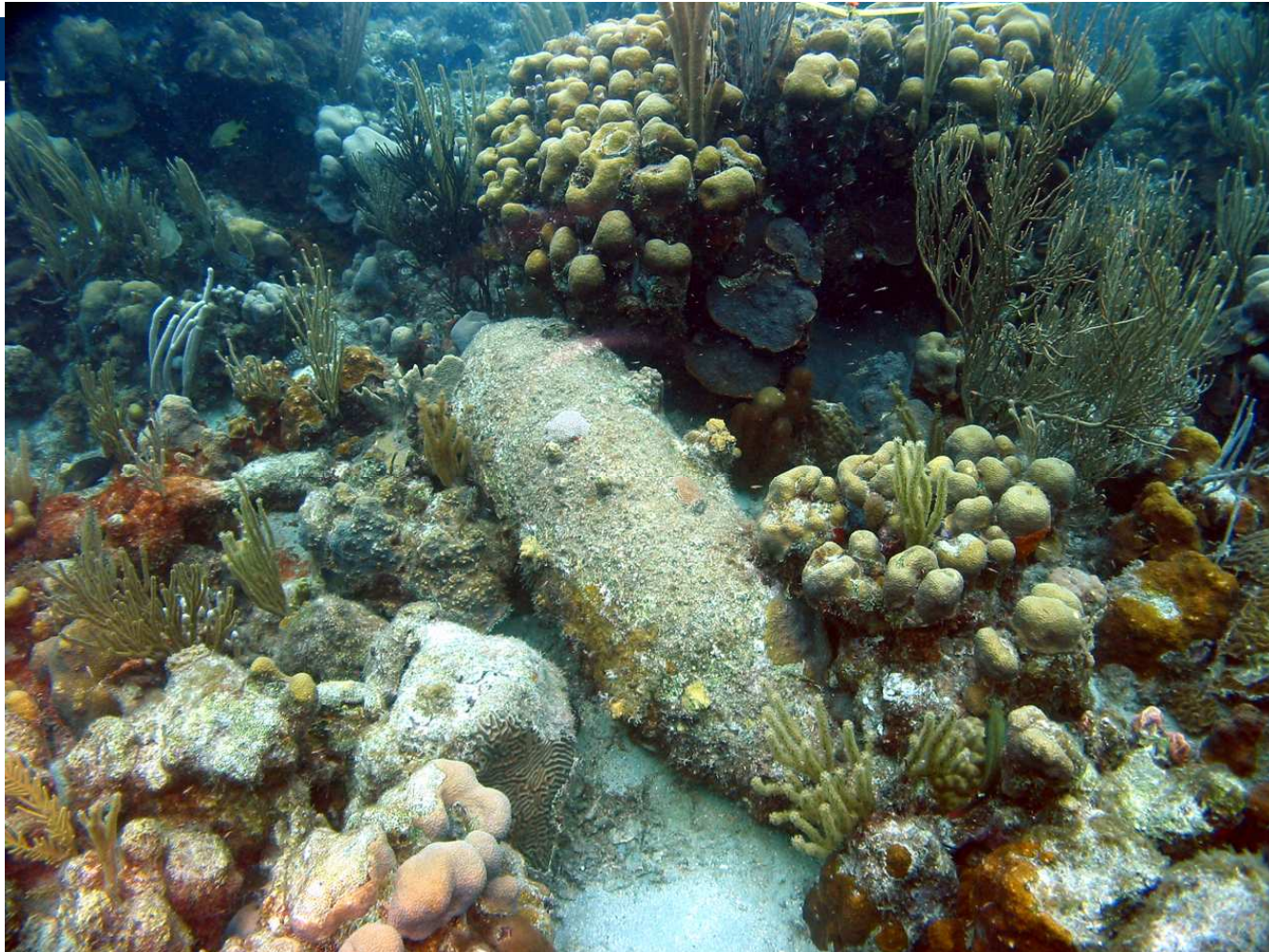
Methods
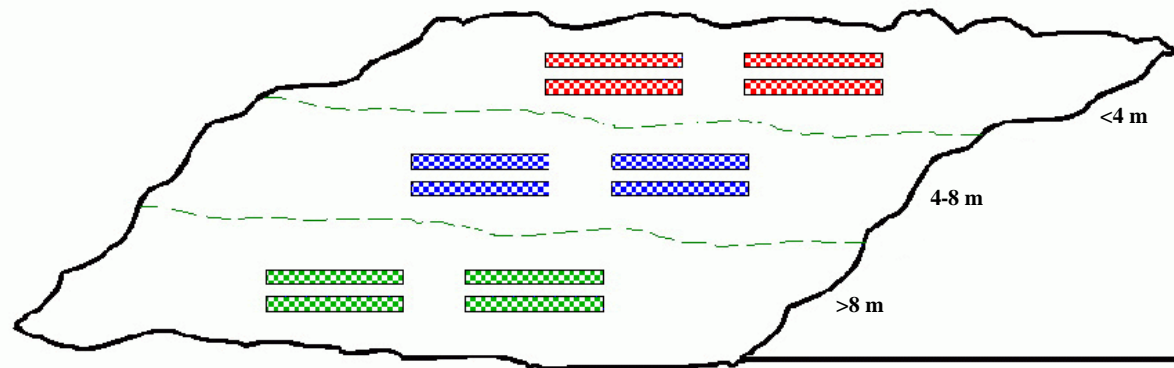
Line intercept transects + digital photography (10 m-long).
2-way Repeated Measures ANOVA
Years (1997, 1998, 1999, 2001, 2002, 2003)
Depth (<4m; 4-8 m; >8 m)
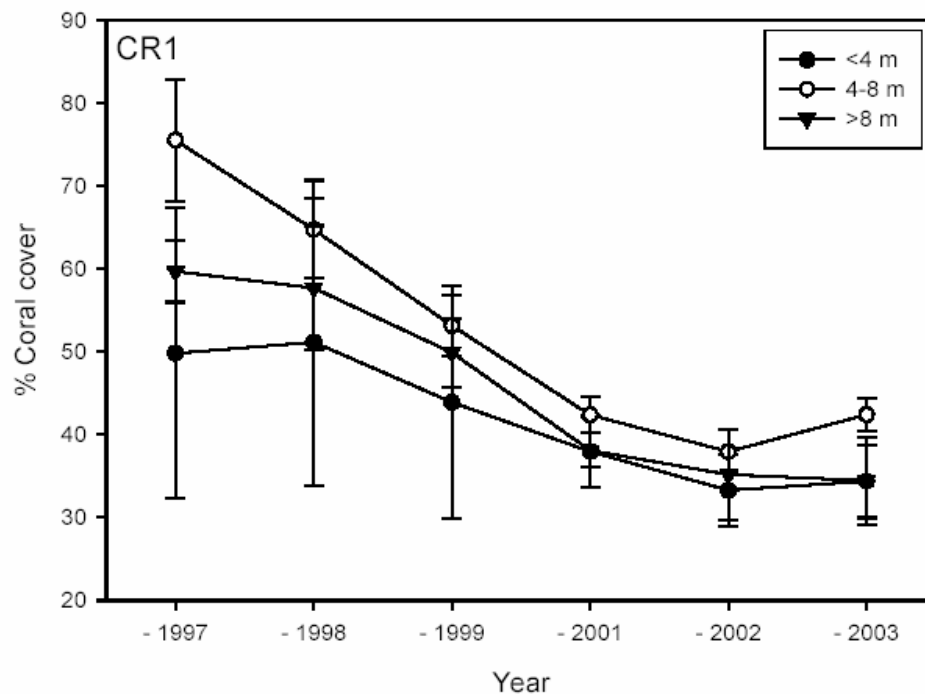
Reefs are rapidly declining!

FIGURE 7. Change in the % of living coral cover at CR1 (mean±one standard error).

- 31-66% decline in % coral cover.

- 5-11% annual decline.

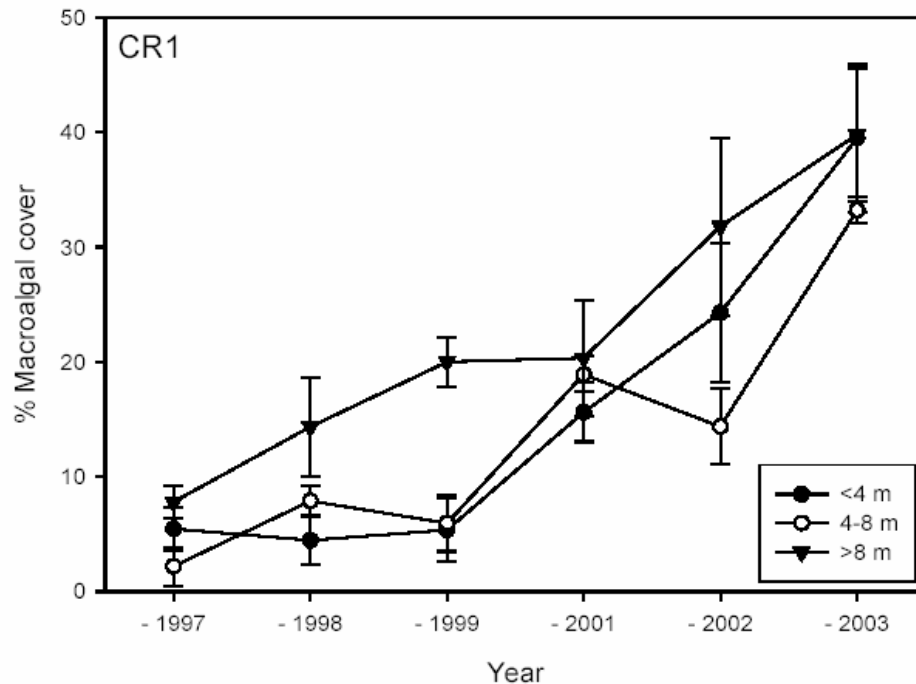# Algae are taking over reefs!

FIGURE 9. Change in the % of macroalgal cover at CR1 (mean±one standard error).

- 104 to 1,423% increase in % macroalgal cover.
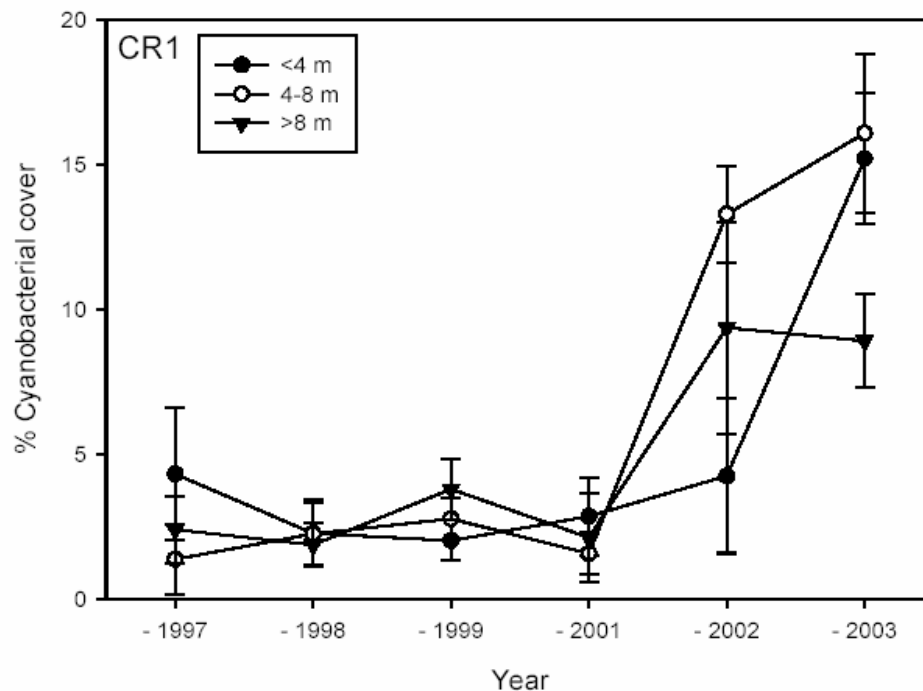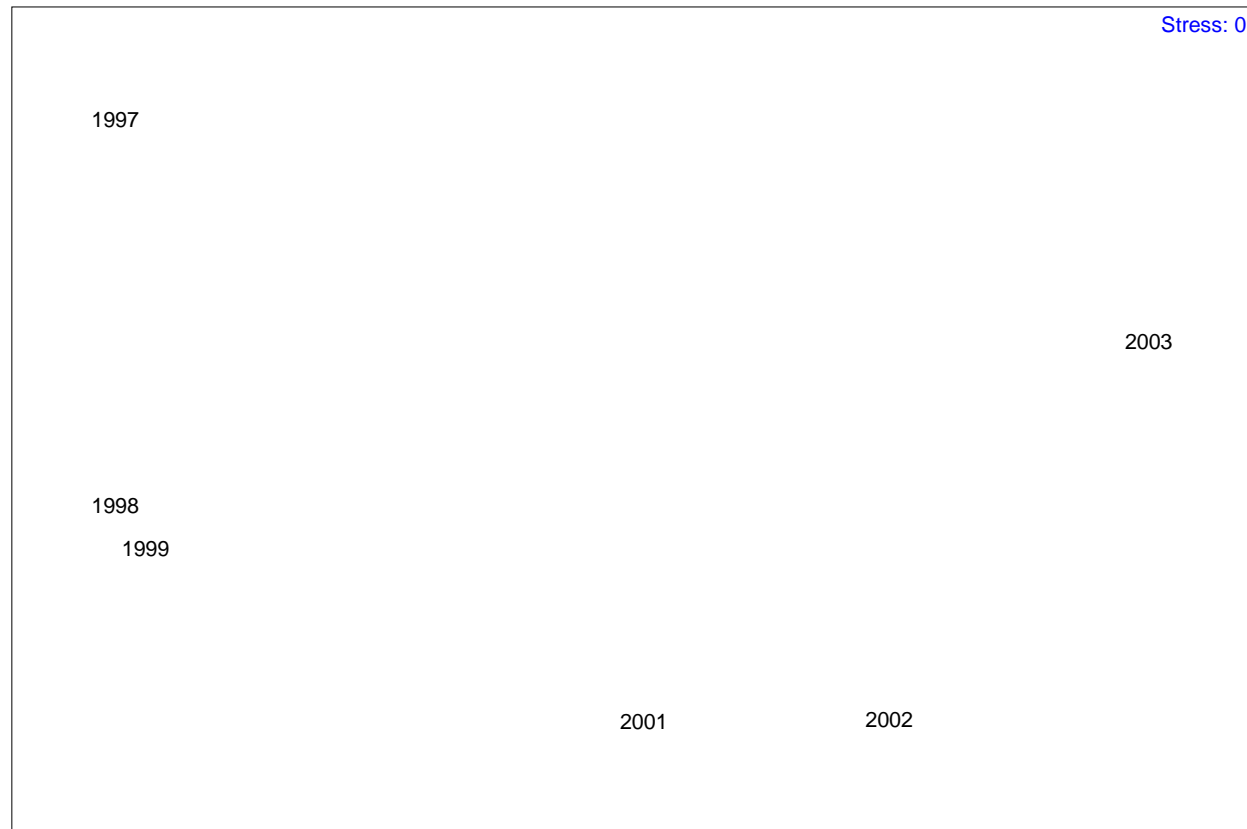
Cyanobacteria are blooming!

FIGURE 11. Change in the % of cyanobacterial cover at CR1 (mean±one standard error).

- 161 to 1,370% increase in % cyanobacterial cover.

Phase shift through time!

Stress: 0

1997

2003

1998

1999

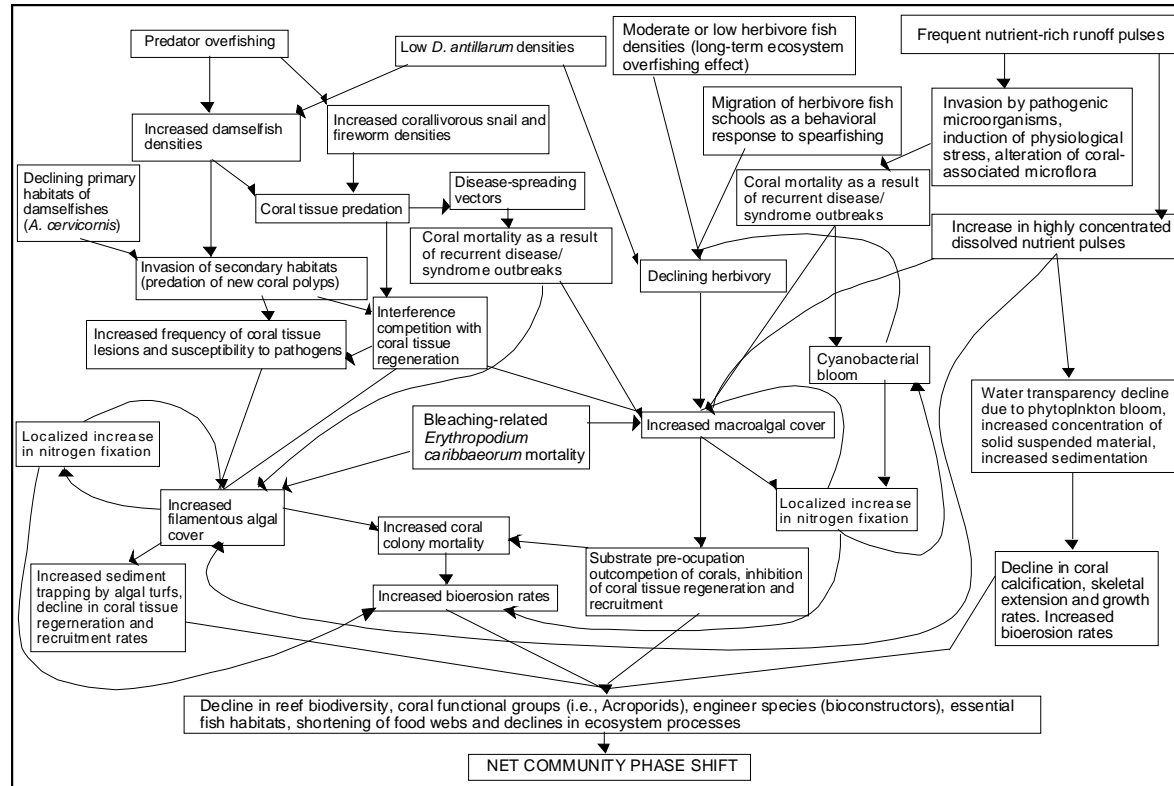2001   2002

A sort of "natural" mortality factors

Another bunch of human factors

- Water quality degradation associated to nutrient and sediment runoff pulses.

Coral Reef Ecological Mess Model!
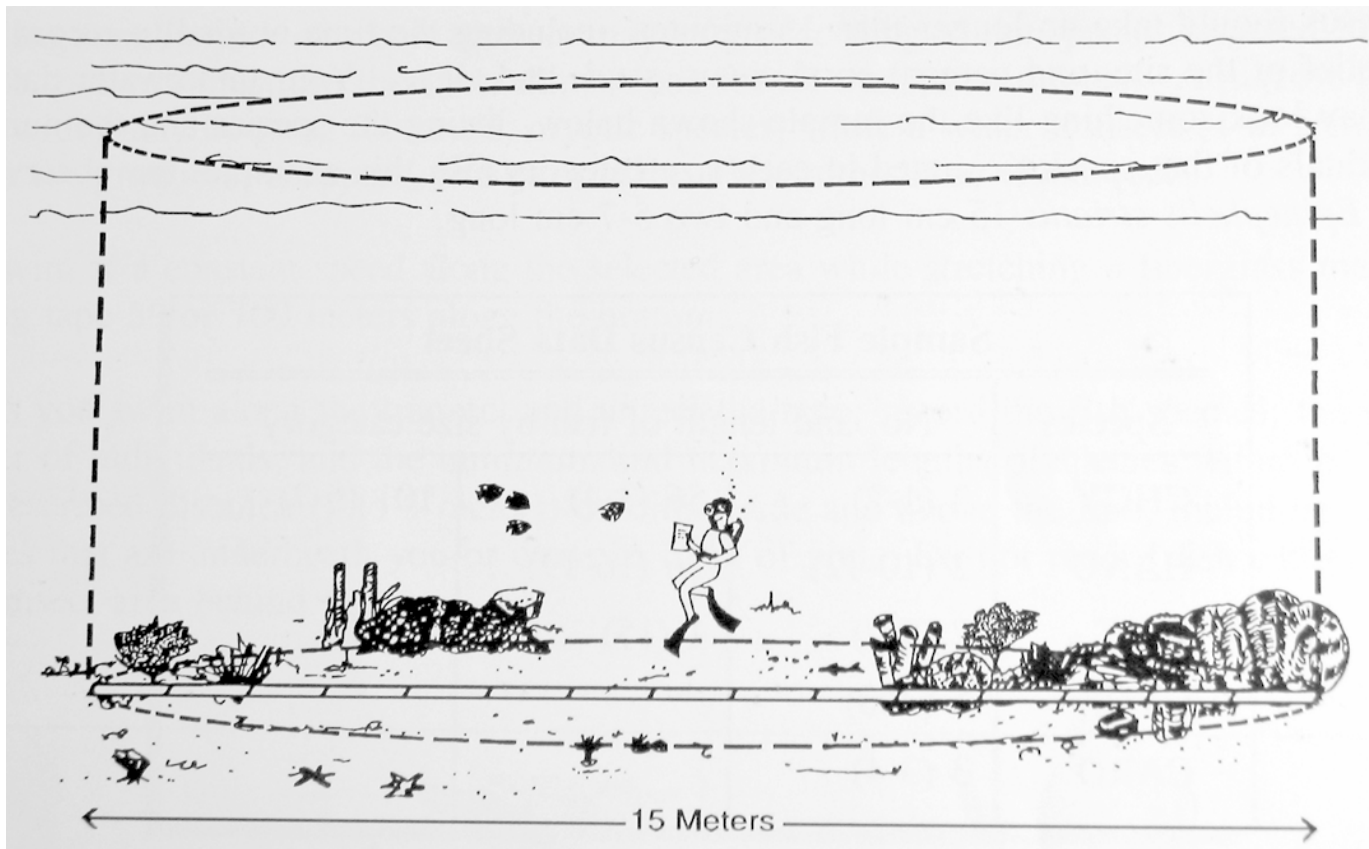

Oh, oh!!!!
What the heck!

Case Study #3

- Document spatial and temporal variation patterns in the structure of coral reef fish communities within the Luis Pena Channel No-Take Natural Reserve, Culebra, PR.
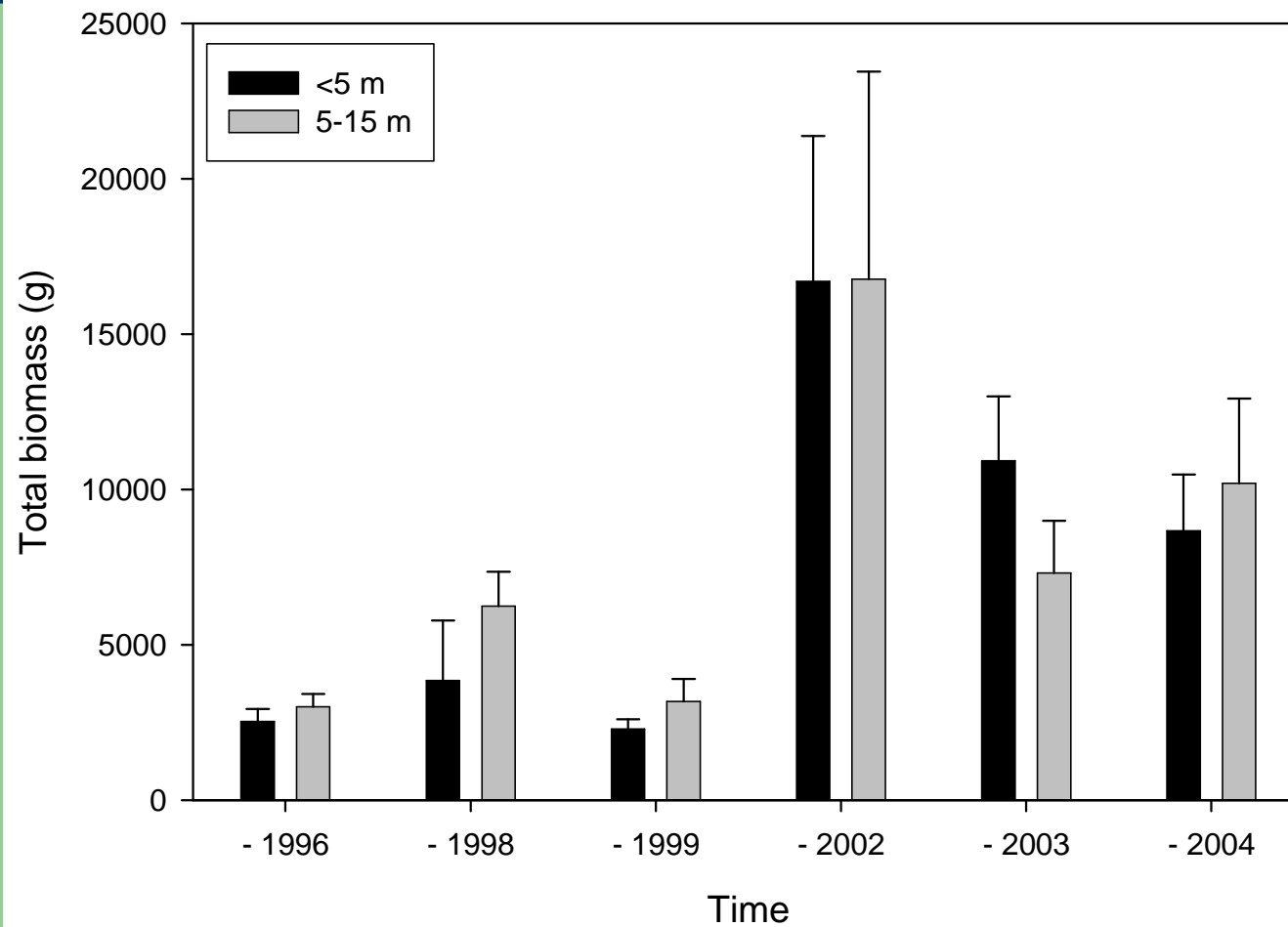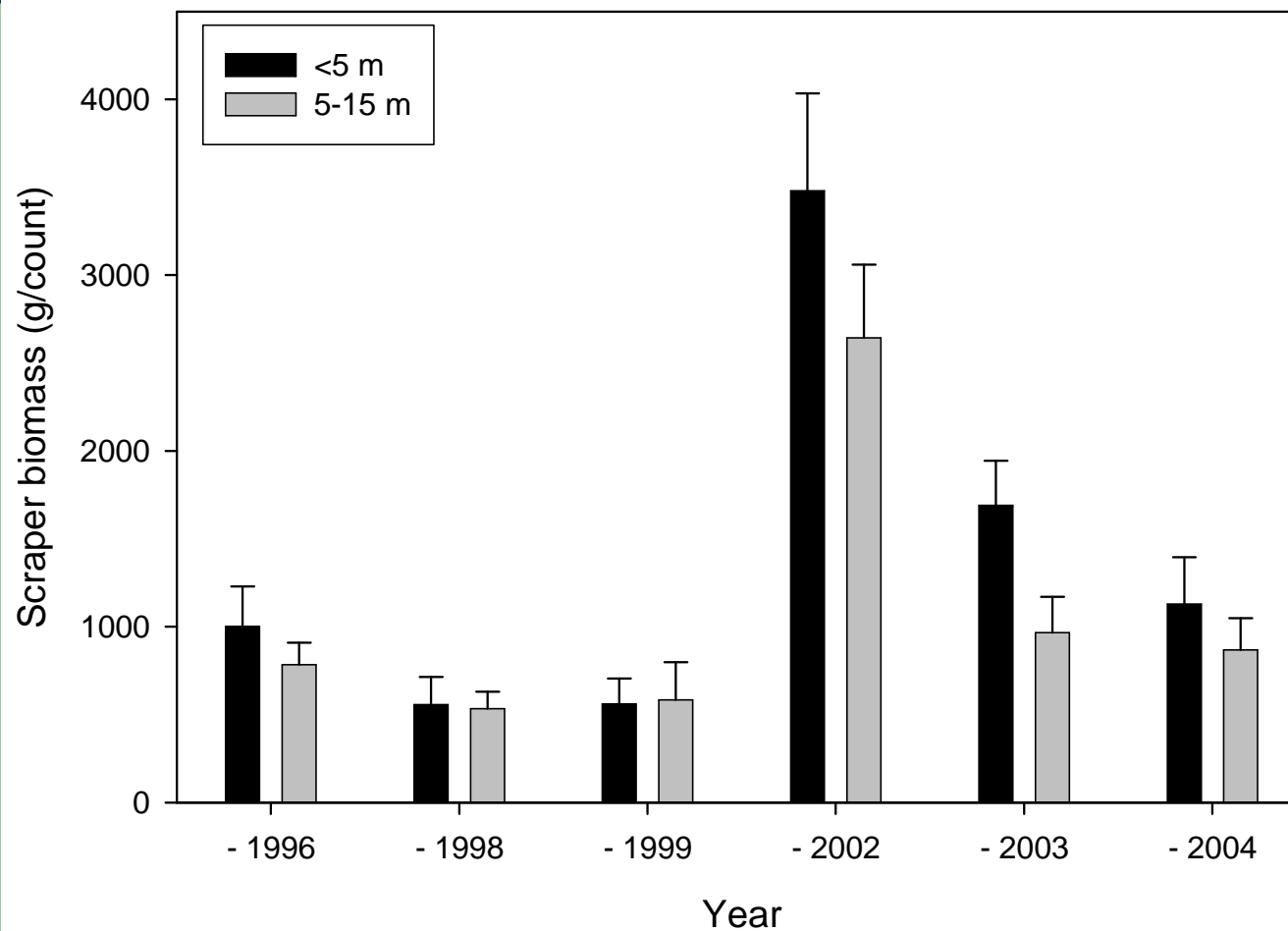
Stationary visual censuses

15 Meters

(Bohnsack & Bannerot, 1986)
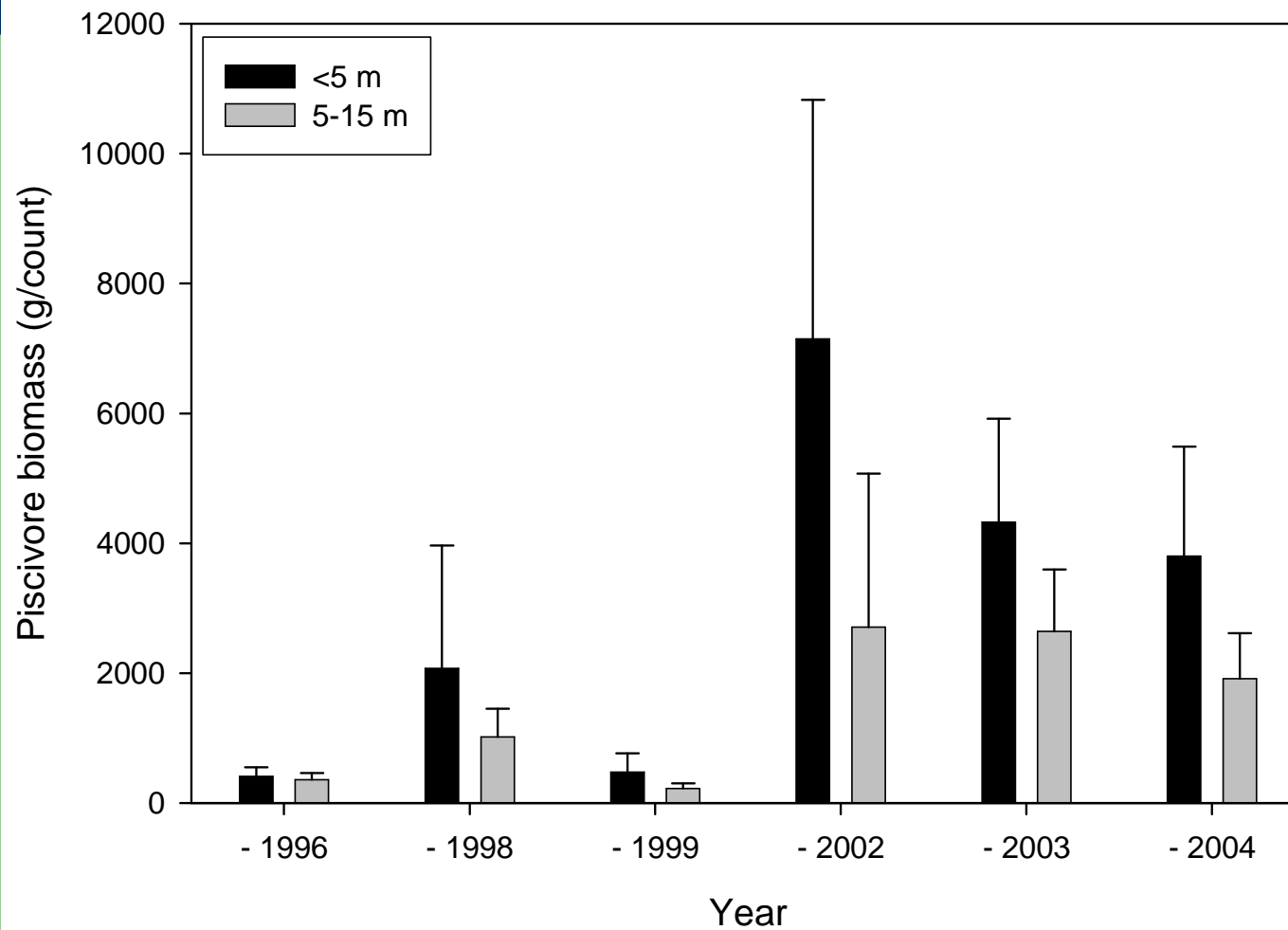
Core: Total biomass

Core: Scraper herbivore biomass
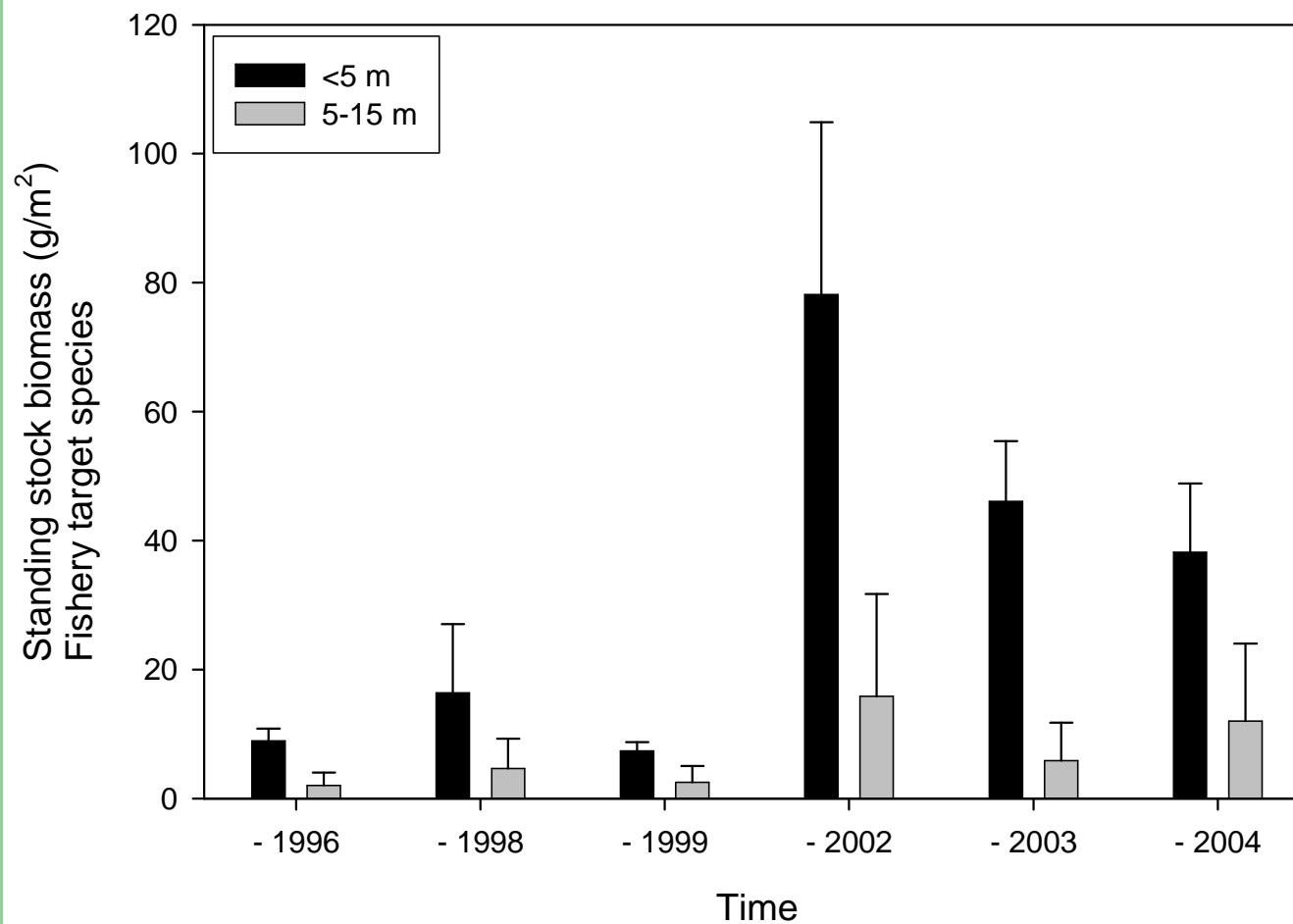
Core: Piscivore biomass

Core: Fishery target species SSB

ANOSIM core area (1996-2004)

Factors	Global R	Significance
Global test		
Year	0.600	0.2%
Depth	-0.013	42.9% NS
Year x Depth	0.065	0.2%

ANOSIM core area (1996-2004)

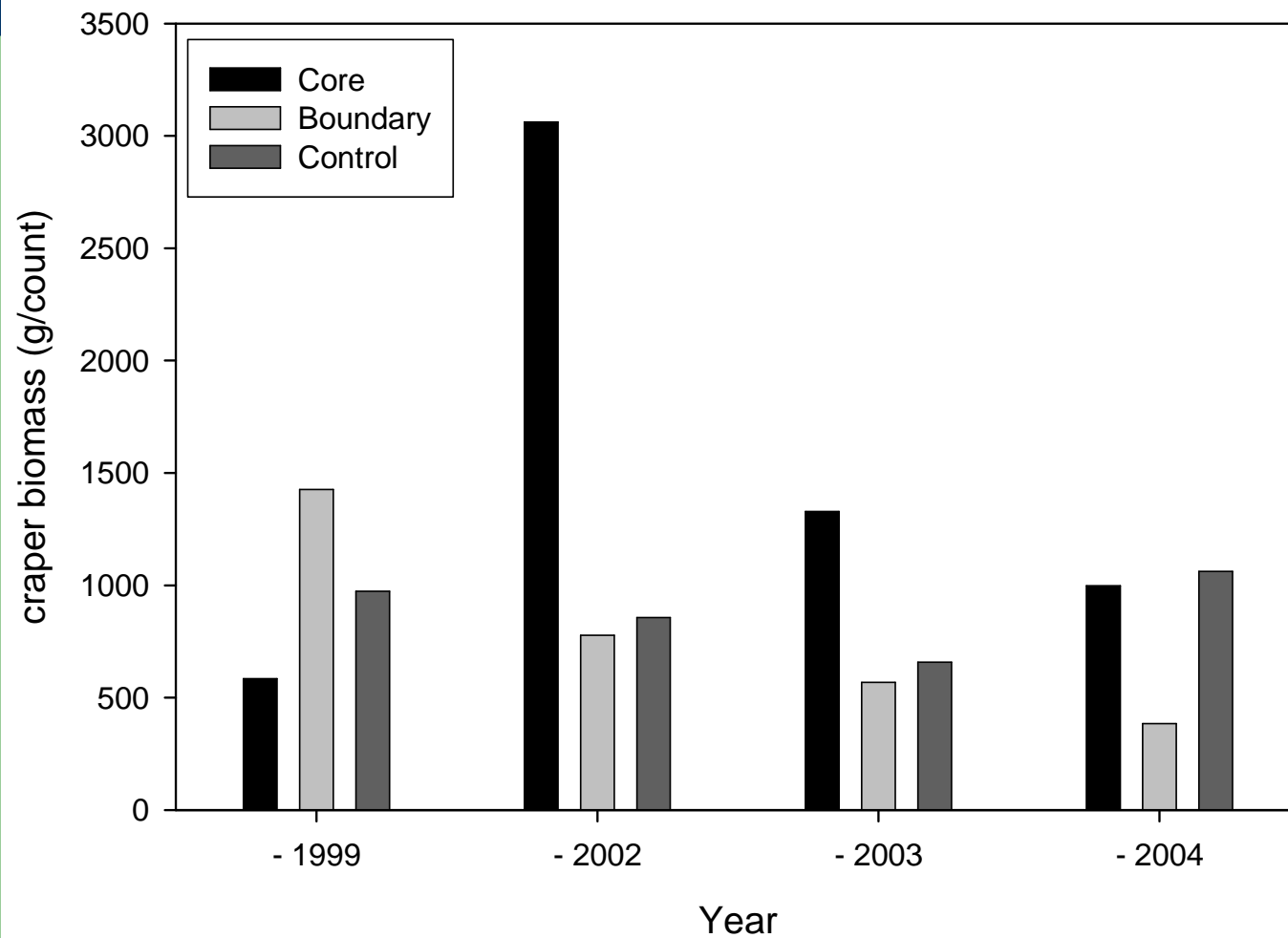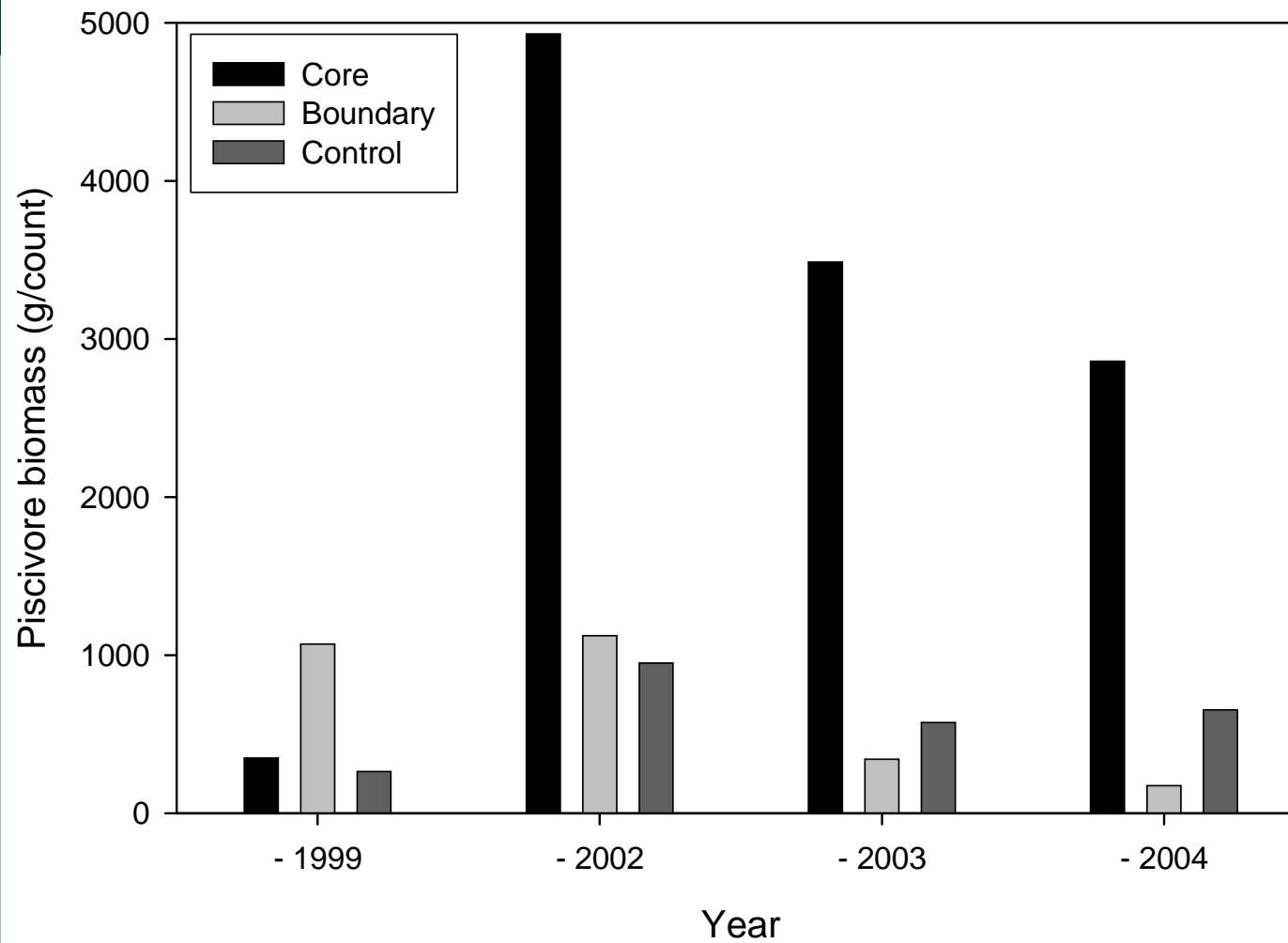| Factors	Global R	Significance
Pairwise test		
1996 vs. 1998	0.014	31.0% NS
1996 vs. 1999	0.056	15.8% NS
1996 vs. 2002	0.068	4.1%
1996 vs. 2003	0.122	1.6%
1996 vs. 2004	-0.001	46.8% NS
1999 vs. 2002	0.159	0.7%
1999 vs. 2003	0.221	0.1%
1999 vs. 2004	0.098	4.0%

What about spatial effects?
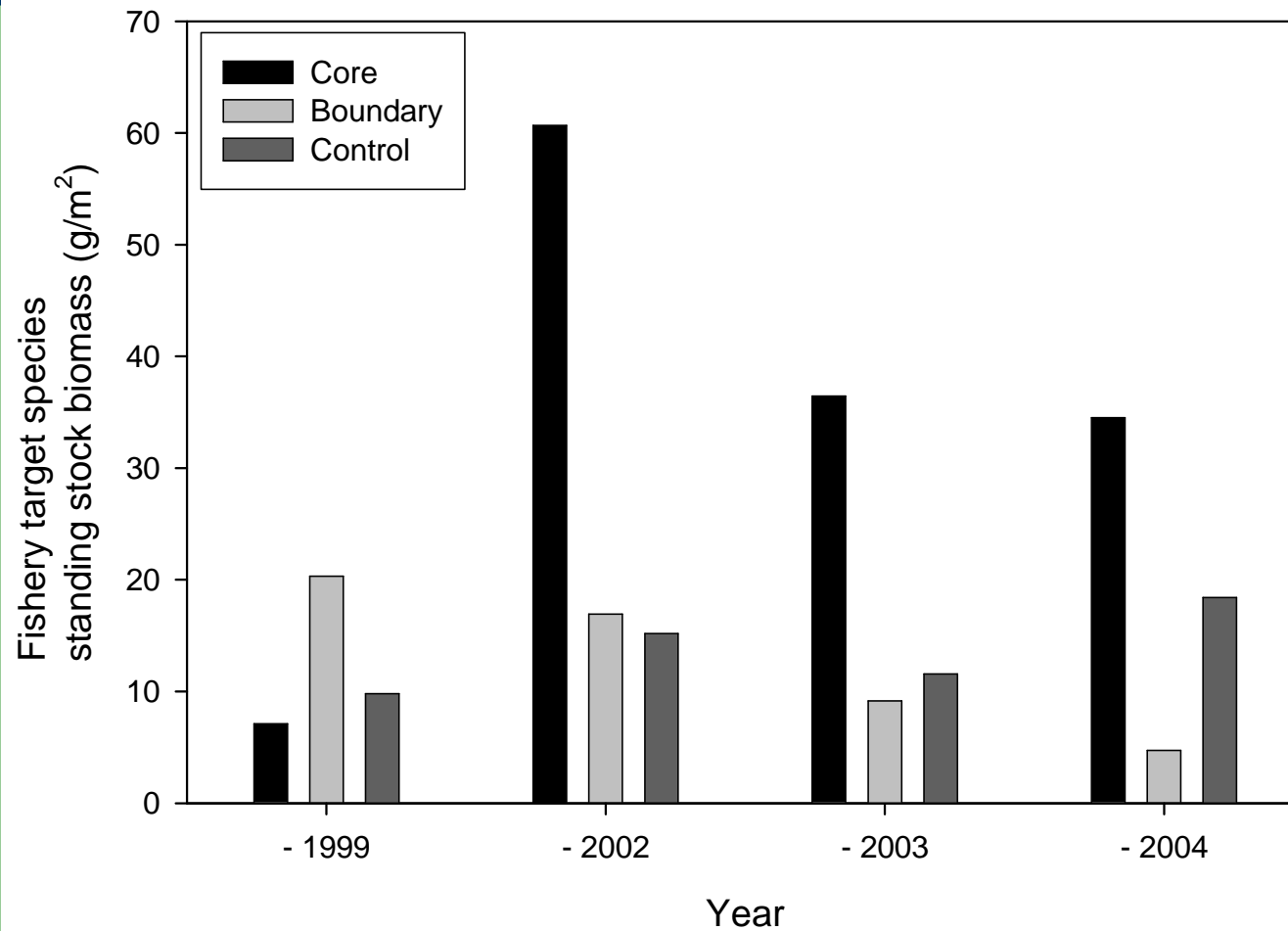
Total biomass
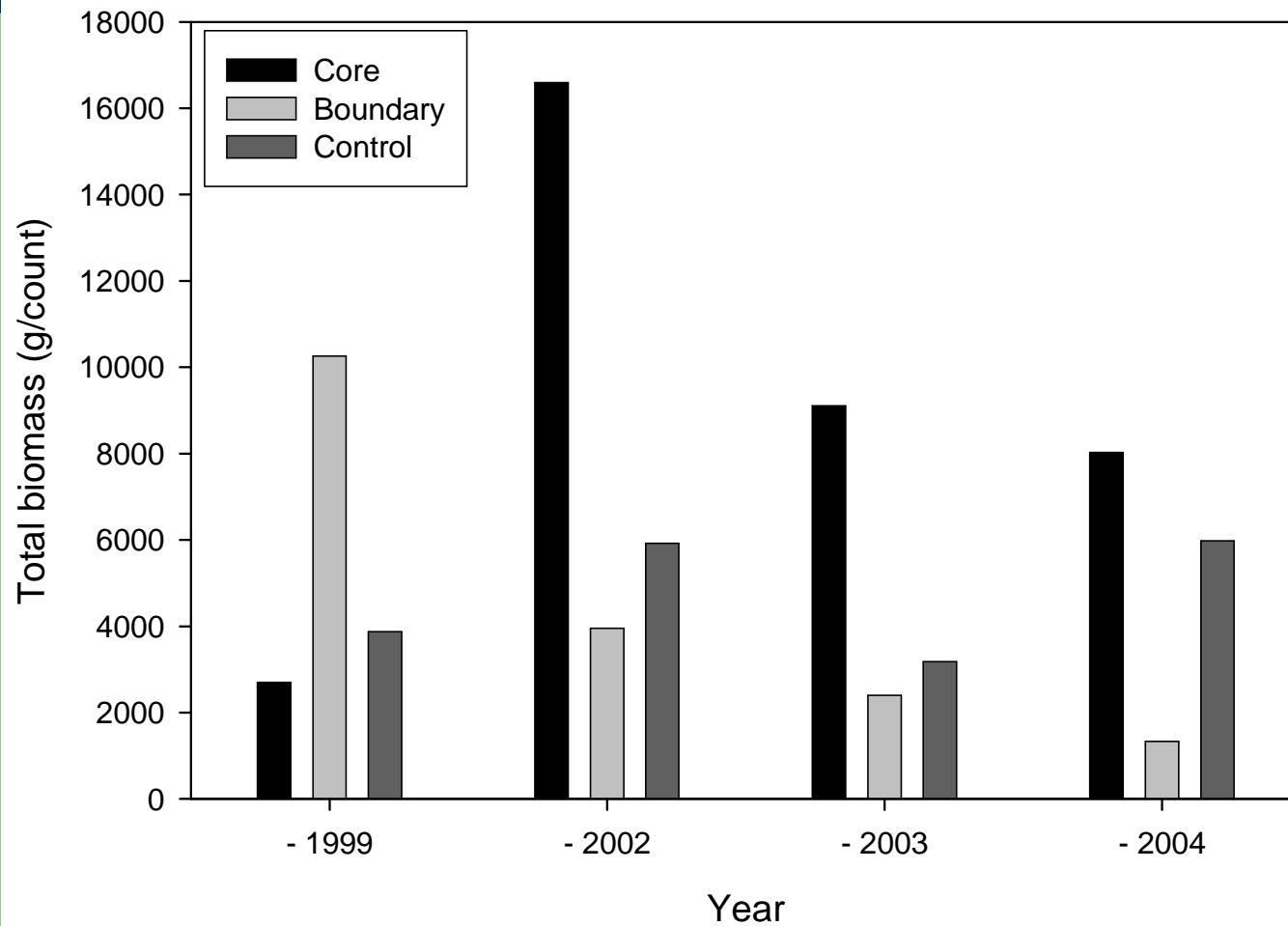
Scraper herbivore biomass

Piscivore biomass

Fishery target species SSB

ANOSIM Site x Year x Depth

Factors	Global R	Significance
Global test		
Site	0.402	0.0%
Year	0.079	11.9% NS
Depth	0.004	40.0% NS
Site x Year	0.403	0.9%
Site x Depth	0.382	0.0%
Year x Depth	-0.073	77.4% NS

Summary remarks

- CCRI-CRLTEMP aimed at measuring multiple coral reef benthic and fish community variables.

- Expand existing efforts to produce important baseline information regarding fish communities applicable to future model analysis.

Summary remarks

- Provide a useful data bank and recommendations to State and Federal managers and decision-makers.

- Sampling design can be applied to test different hypotheses.

- Have information accessible to the general public.

Thanks!

Any questions for Dad???