Puerto Rico Coral Reef Monitoring Program: Progress Report to CCRI (June 6, 2005).

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UPR
Biology

Objectives

- Long-term goals of the project.
- Project’s progress.
- Sampling design.
- Proposed sampling schedule.

Long-term goals

- Set up a network of 12 representative coral reef permanent monitoring sites in the Puerto Rican archipelago.
- Apply uniform sampling design and statistical methods.

Long-term goals

- Identify what early warning signals indicate ecological change in coral reefs.

- Incorporate documentation of additional parameters:
  - Coral vitality (*sensu* Dustan).
  - Disease/syndrome prevalence.

Long-term goals

- Incorporate monthly monitoring of water quality parameters at selected locations.
- Apply multivariate statistical approaches to document spatial and temporal variation patterns in benthic and fish community structure.

Long-term goals

- Apply alternative statistical approaches (e.g. Effect Size Statistic) to document spatial and temporal uncertainty.
  - Important to separate natural uncertainty from any variable effect:
    - Water quality effects.
    - Management effects.

Long-term goals

- Theoretical and practical training of DNER personnel.
- Have DNER taking control of the Long-Term Monitoring Program within approximately 2 to 3 years.

Initial Research Question

- **Spatial patterns.**

- Are there any significant site or regional spatial variation patterns in the ecological status of coral reef communities?

Original sampling design

- **Unbalanced hierarchical design.**

- Region (East, South – Year 1)
  - Sites (East, n=2); (South, n=5)
    - Reefs/Site (n=3) [N=21]
      - Depth (3-10 m; 10-20 m)
        - » Transects (n=4)

Original sampling design

- **Unbalanced hierarchical design.**

- Region (Southwestern, West – Year 2)
  - Sites (Southwestern, n=3); (West, n=2)
    - Reefs/Site (n=3) [N=15]
      - Depth (3-10 m; 10-20 m)
        - » Transects (n=4)

Suggested sampling design

- **Balanced hierarchical design.**

- Region (East, South – Year 1)
  - Sites (n=3)
    - Reefs (n=3) [N=18]
      - Depth (3-10 m; 10-20 m)
        - » Transects (n=4)

Suggested sampling design

- **Balanced hierarchical design.**

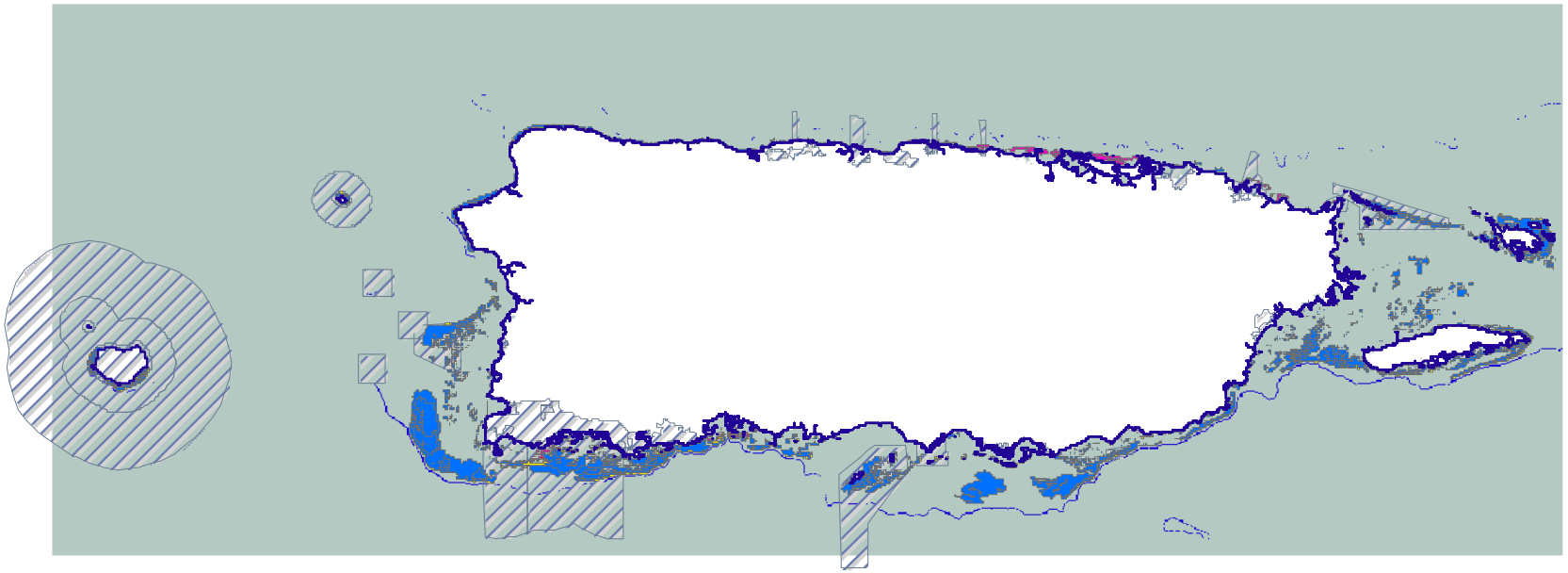
- Region (Southwestern, West – Year 2)
  - Sites (n=3)
    - Reefs (n=3) [N=18]
      - Depth (3-10 m; 10-20 m)
        - » Transects (n=4)

Benthic sampling

- **Balanced hierarchical design.**

- Time (every 2 years)
- Region
  - Sites (n=3)
    - Reefs (n=3) [N=18]
      - Depth (3-10 m; 10-20 m)
        - » Transects (n=4)

Sampling points



Legend

- PR_VI_Coastlines_2
- Bank reefs
- Bank Shelf
- BSEF
- Back reefs
- Linear Reefs
- Protected_Areas
- 0
- 1

0 15 30 60 Km

Challenging questions

- Monitoring frequency
  - Every 2 years: many sites, low temporal replication. Low resolution of short-term factors.
  - Every 1 year: fewer sites, higher temporal replication. Higher resolution of short-term factors.

Challenging questions

- Site selection

- Confounding effects:
- Structural coral reefs?
- Hard grounds?
- Highly degraded vs. “healthy”?

Challenging questions

- Management level

- Confounding effects:
- Natural Reserve?
- No-fishing reserve?
- Control?

Challenging questions

- Environmental gradient effects
- Confounding effects:
- Distance from pollution or stress sources?
- Fishing pressure?

Challenging questions

- Keep it as it is

- Trade offs:

- Does not respond any specific question.
- Unbalanced statistical design.
- Confounding temporal and spatial effects.

Challenging questions

- Are we having DNER collaboration?

- Personnel?
- Vessels?
- Water quality sampling equipment?

- If not:

- Limitation to sampling efforts.
- Not much to do regarding training DNER personnel.

Data collection

- Benthic sampling

- Fixed linear transects.

- 10 m-long.
- % cover.
- H’n.

- Digital images.

Data collection

- Benthic sampling

- Fixed belt transects.

- 10 x 2 m.
- Coral vitality.
- Disease/syndromes.
- Damselfish.
- *Diadema antillarum*.
- Lobsters.

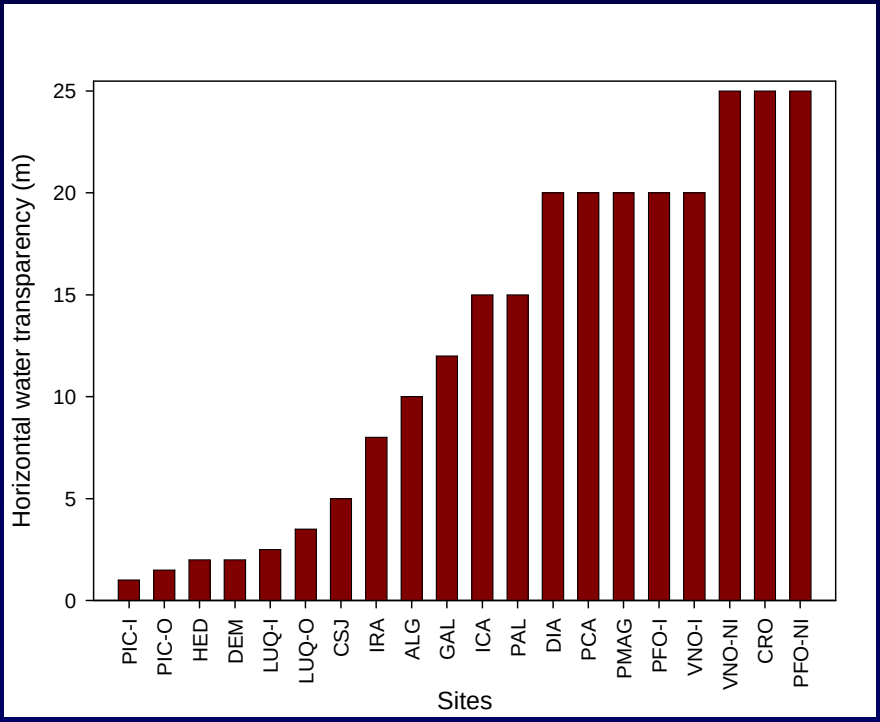
- Digital images.

Data collection

- Fish sampling

- Haphazard belt transects.
- 25 x 4 m.
- Whole fish community.
- Follow similar hierarchical design as benthic sampling.

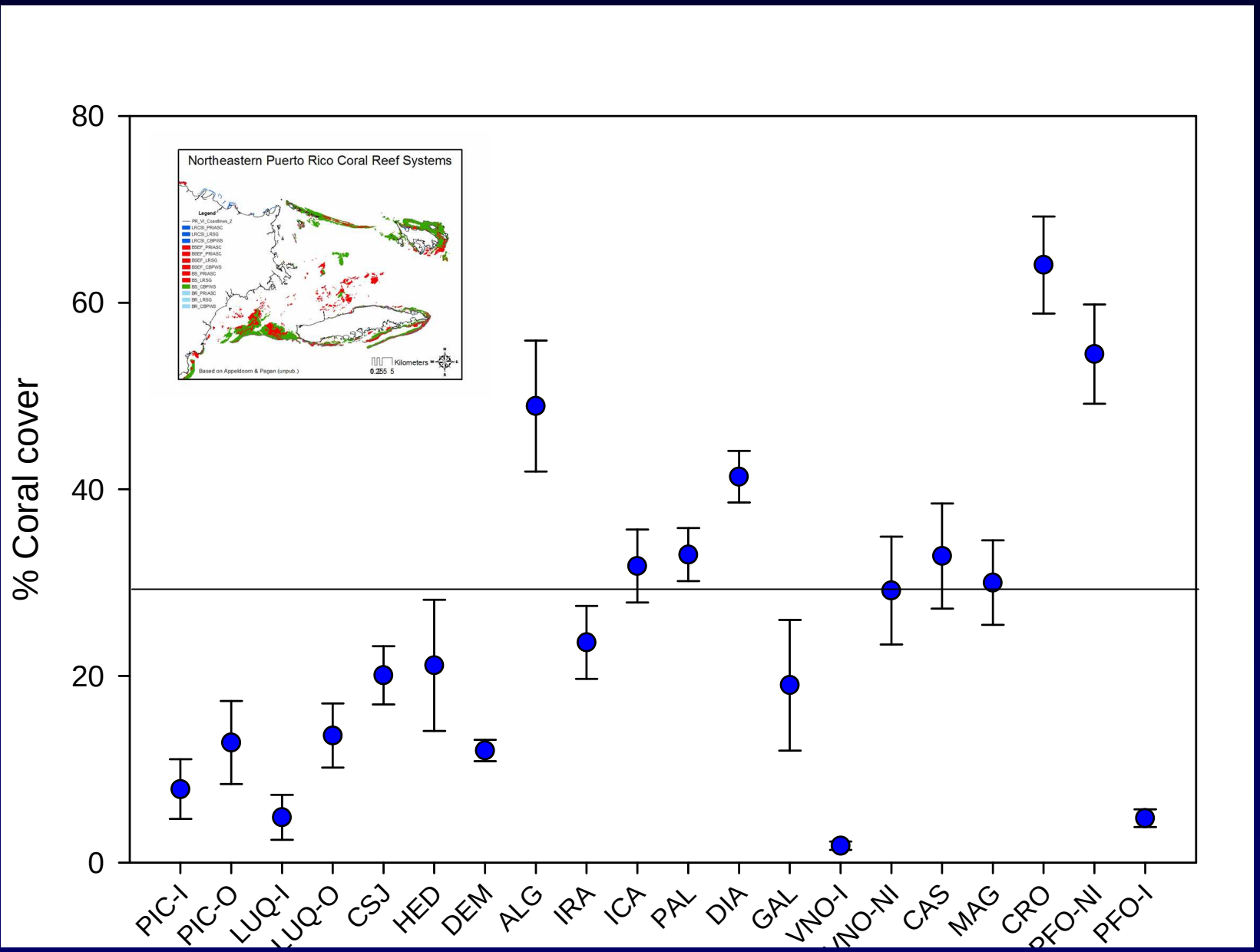
Water quality sampling at selected sites



- Water transparency.
- Turbidity.
- Dissolved oxygen.
- Chlorophyll.
- Nutrients.

- 3 replicates/reef/month at Culebra and Cordillera sites.

% Coral cover


% Coral cover
80
60
40
20
0
Northeastern Puerto Rico Coral Reef Systems
Kilometers
PIC-I
PIC-O
LUQ-I
LUQ-O
CSJ
HED
DEM
ALG
IRA
ICA
PAL
DIA
GAL
VNO-I
VNO-NI
CAS
MAG
CRO
PFO-NI
PFO-I

Effects of water transparency

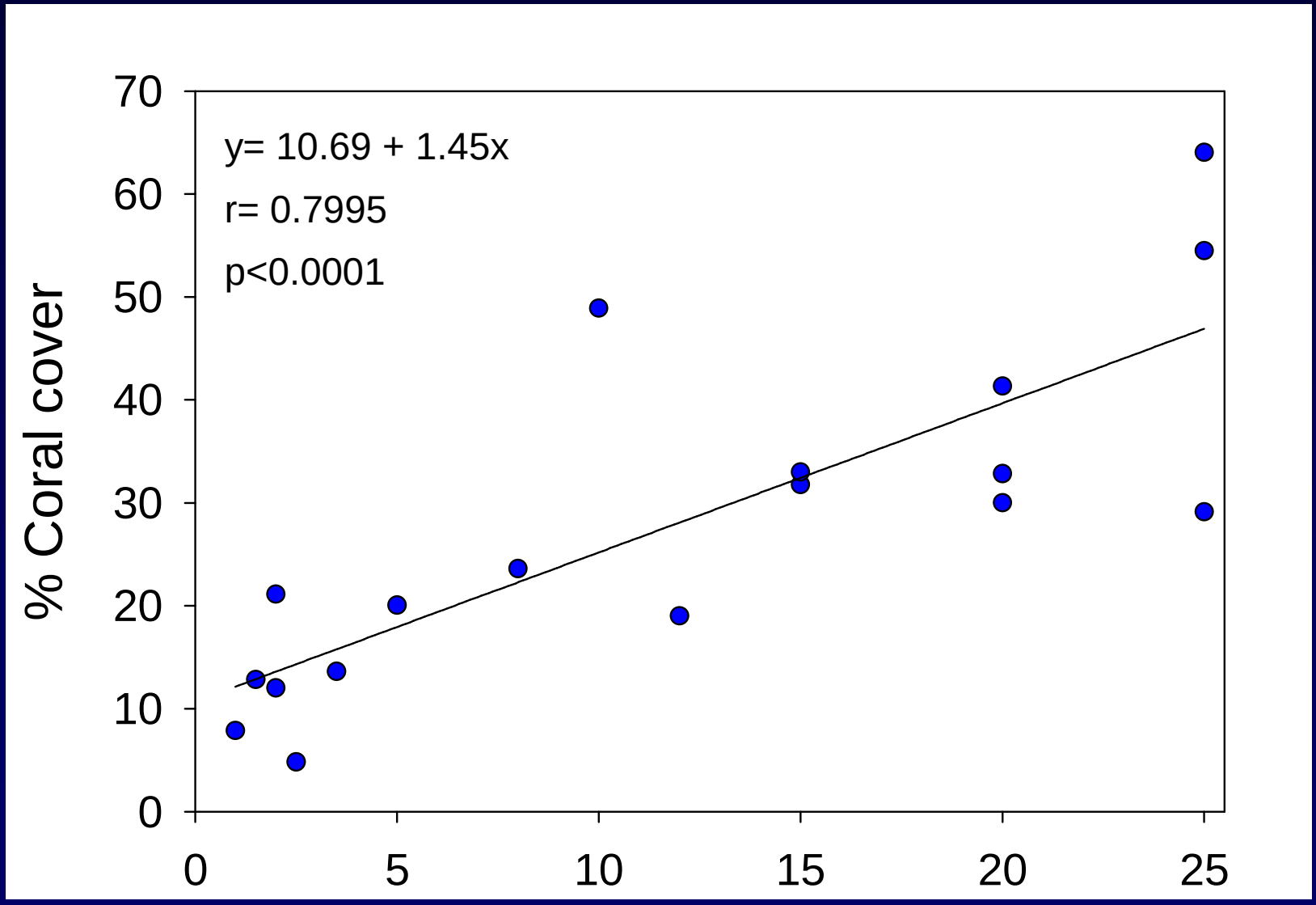


TABLA 2. Diferencias en los parámetros de la comunidad entre localidades (one-way ANOVA).

Factor	GL[a]	MS	F	p
Riqueza especies[b]	19,112	1.95	11.57	<0.0001
Abundancia colonias[b]	19,112	10.28	8.67	<0.0001
% Coral[c]	19,112	0.33	16.57	<0.0001
% Algas[c]	19,112	0.32	14.19	<0.0001
% Esponjas[c]	19,112	0.02	5.26	<0.0001
% Zoántidos[c]	19,112	0.09	15.45	<0.0001
H'n	19,112	1.45	11.33	<0.0001
J'n	19,112	0.20	6.52	<0.0001
H'c	17,109	1.23	8.83	<0.0001
J'c	17,109	0.04	4.88	<0.0001

[a] GL= grados de libertad (between,within).

[b] Datos transformados a la raíz cuadrada.

[c] Datos transformados al arcoseno-(raíz cuadrada).

Spatial pattern analysis

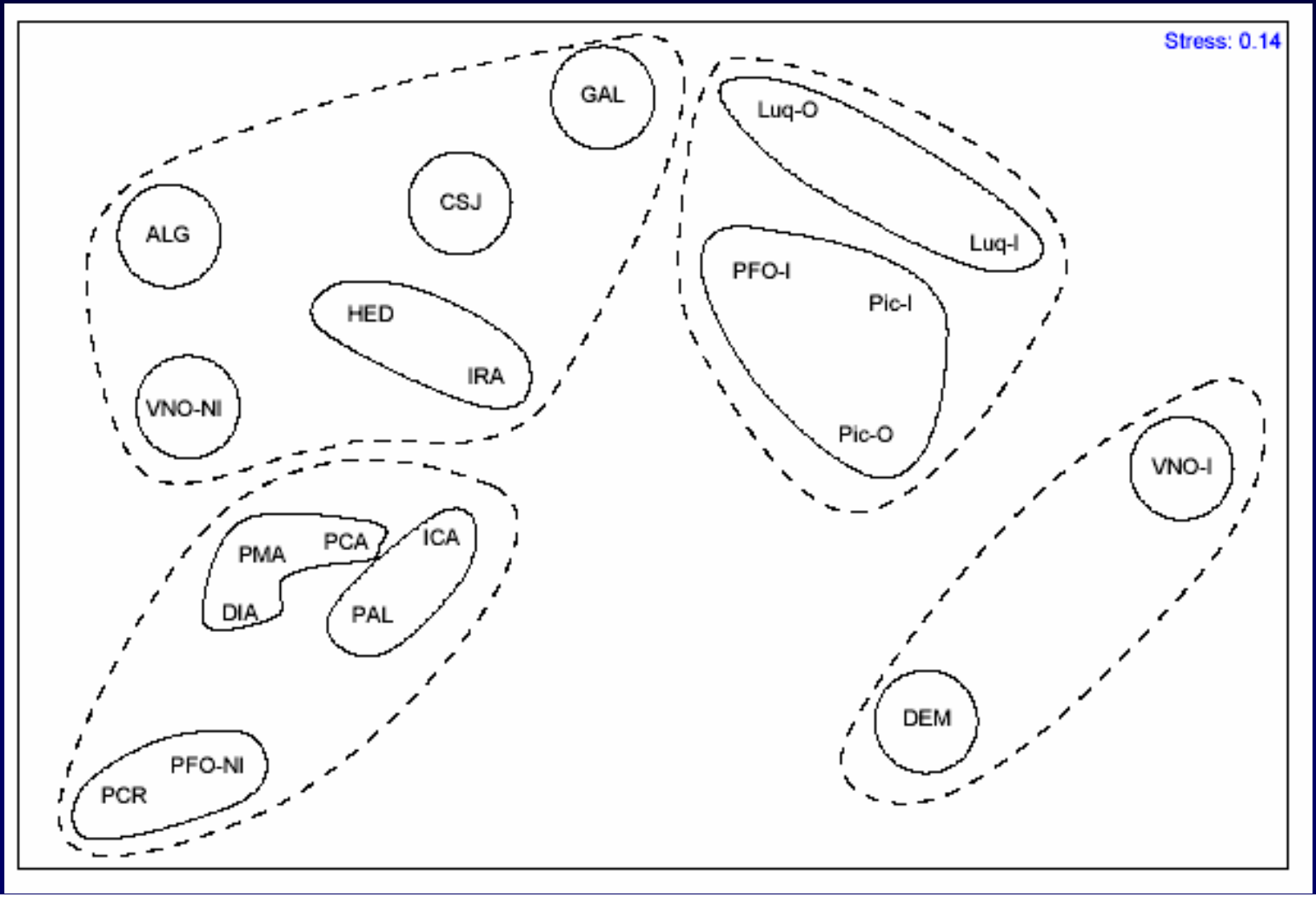


TABLA 5. Diferencias en los patrones espaciales de estructura de la comunidad arrecifal (ANOSIM)

Factor	Global R statistic	Significancia
Prueba Global [a]		
Tratamiento [b]	0.329	0.4%
Pueba de pares de Tratamiento		
I vs. II	0.026	38.6% (NS)
I vs. III	0.484	0.7%
I vs. Bombardeo	-0.116	66.7% (NS)
II vs. III	0.306	4.8%
II vs. Bombardeo	0.679	6.7% (NS)
III vs. Bombardeo	1.000	3.6%

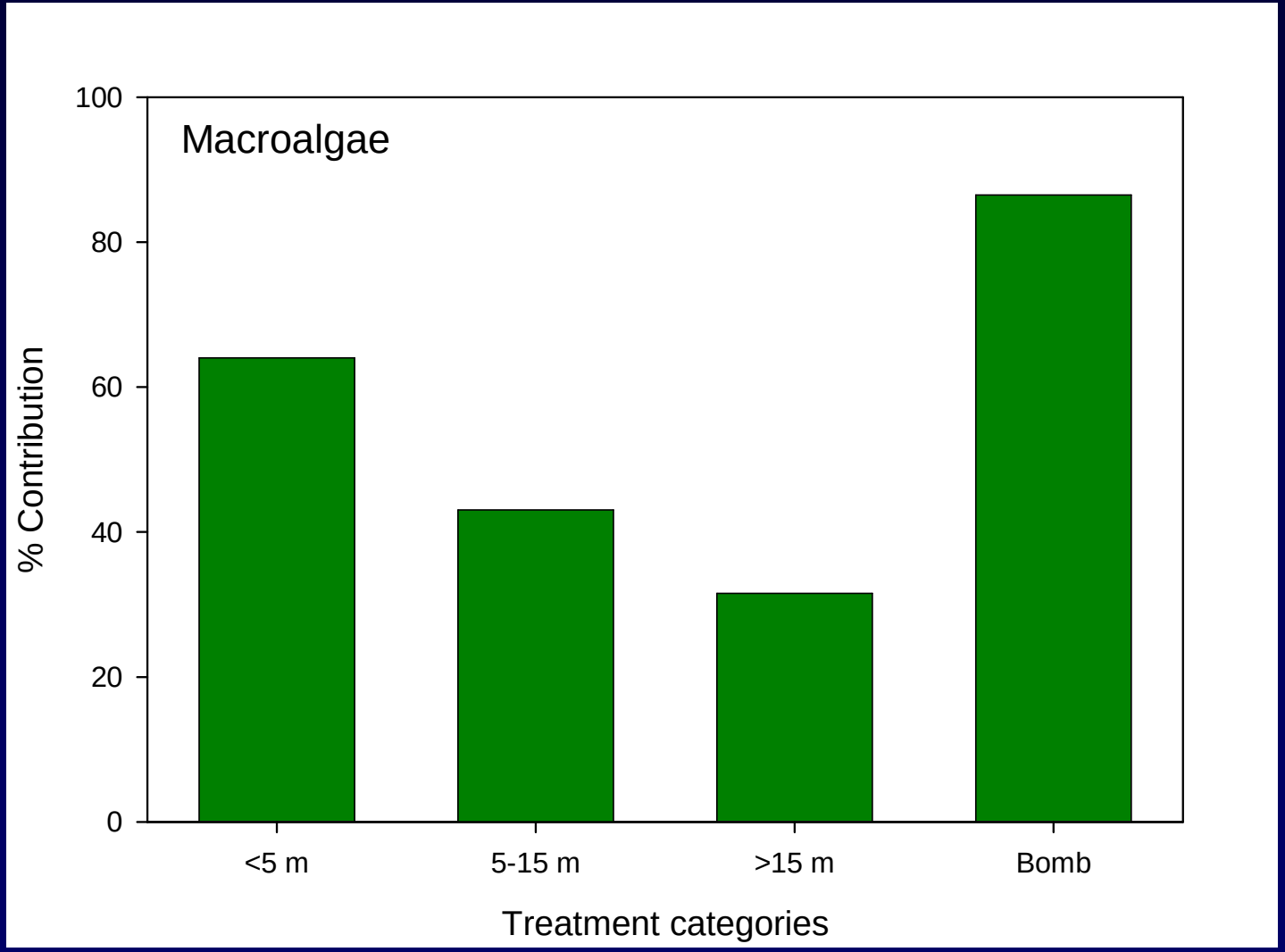
[a] Prueba ANOSIM basada en 5,000 permutaciones. Datos transformados a la raíz cuadrada.

[b] Tratamientos: I= <5 m, II= 5-15 m, III= >15 m, Bombardeo.

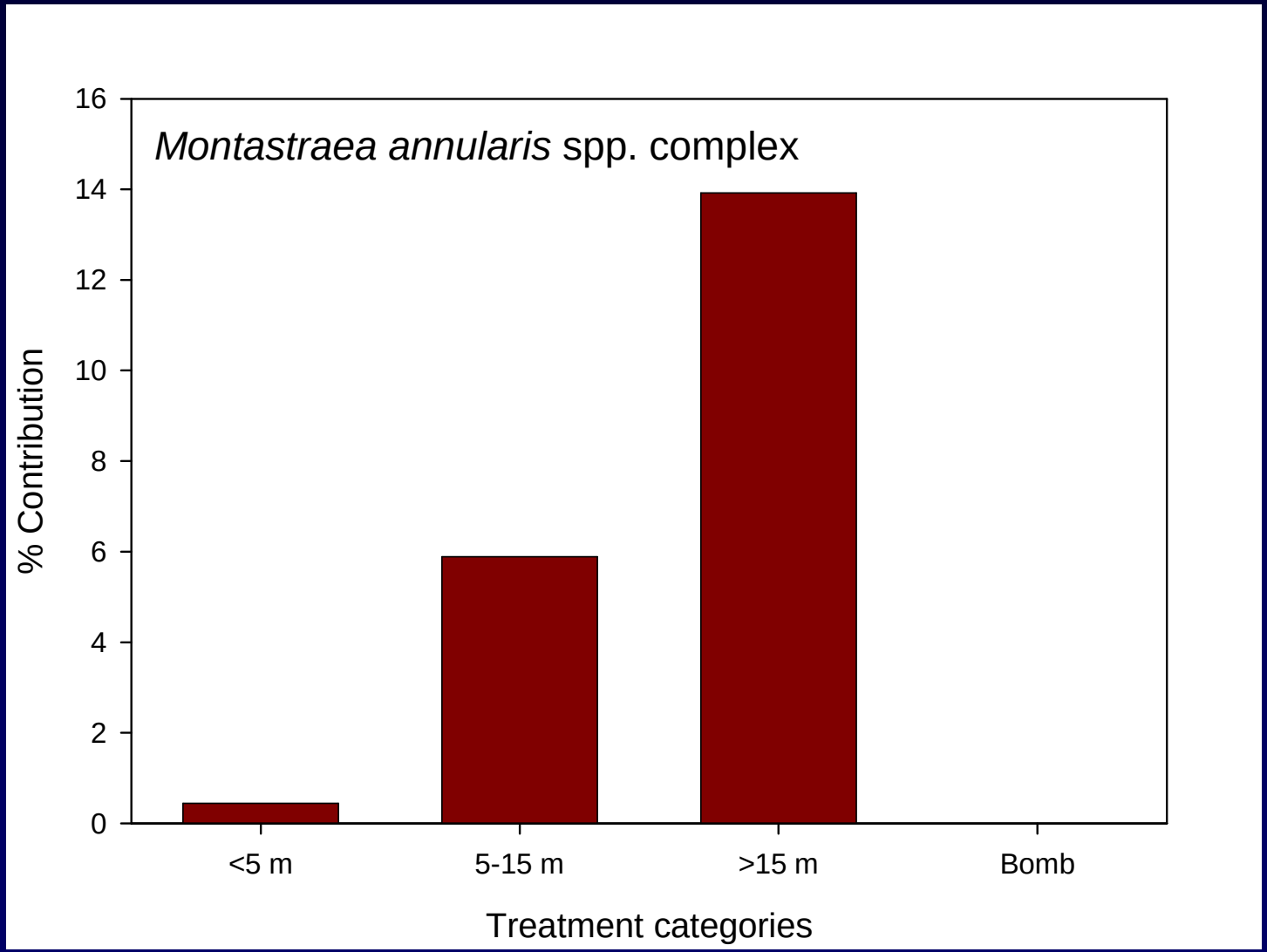
TABLA 6. Componentes dominantes en los arrecifes x tratamiento.

Componente	Abundancia	% Contribución
I (<5 m)		
Algas	0.79	64.01
Porites astreoides	0.02	6.83
Siderastrea radians	0.01	4.09
II (5-15 m)		
Algas	0.67	43.05
Erythropodium caribbaorum	0.04	10.34
Siderastrea siderea	0.04	6.23
III (>15 m)		
Algas	0.54	31.54
Montastraea annularis	0.21	13.92
Porites astreoides	0.04	7.97
Bombardeo		
Algas	0.86	86.46
Siderastrea radians	0.01	8.19
Esponjas	0.01	2.82

Spatial patterns (Dominance x Treatment)



Spatial patterns (Dominance x Treatment)



Spatial patterns (Dominance x Treatment)

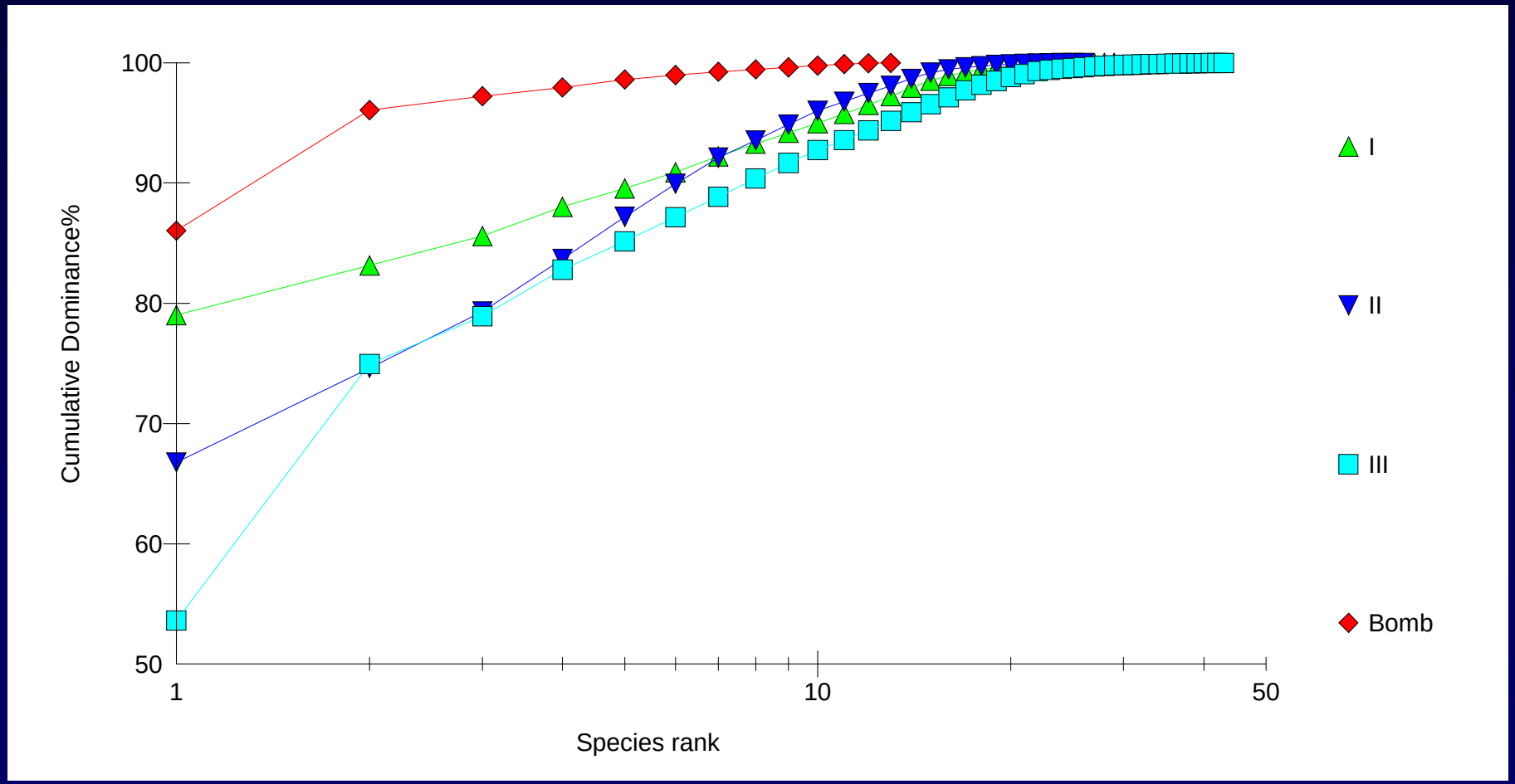
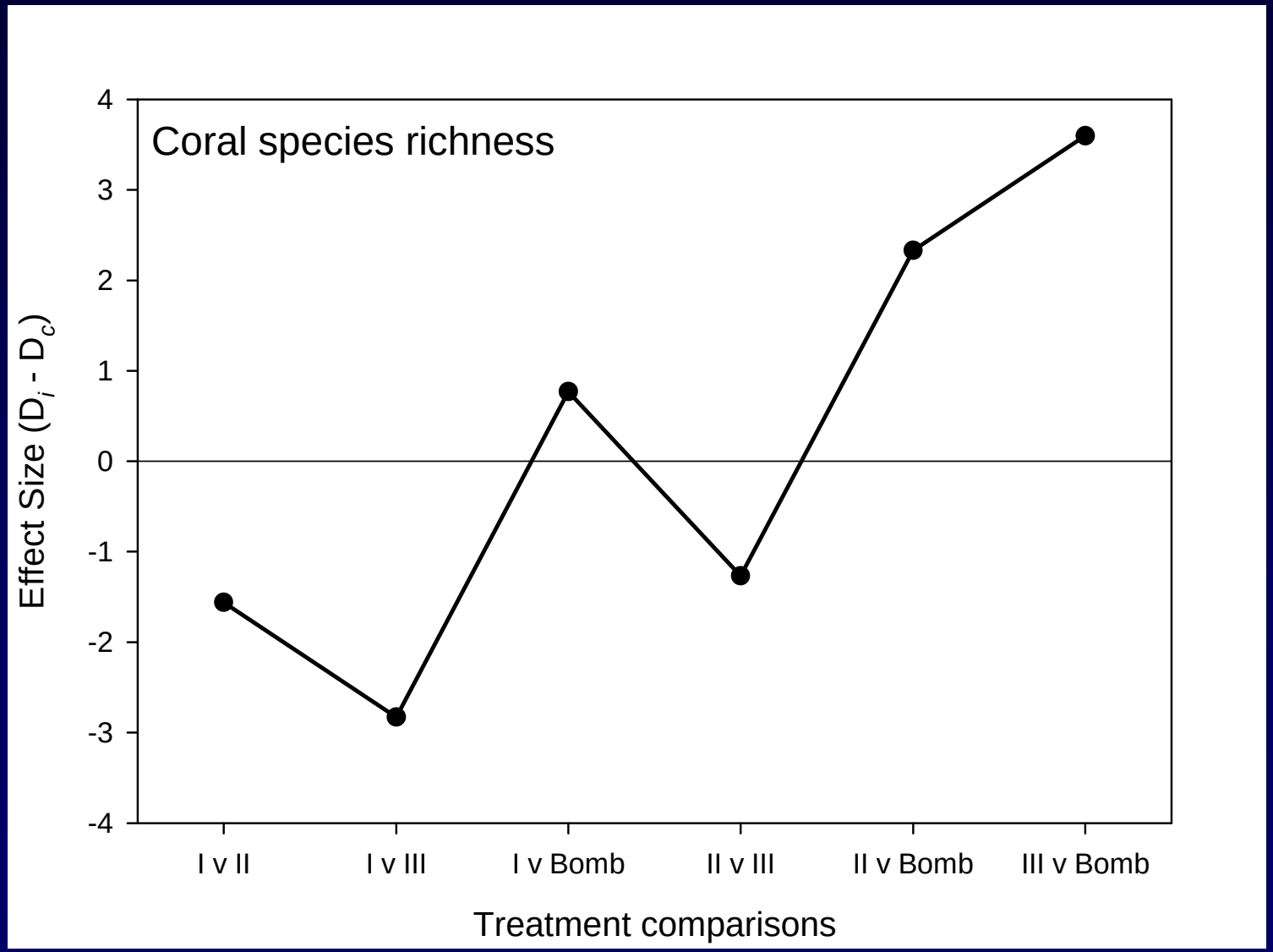


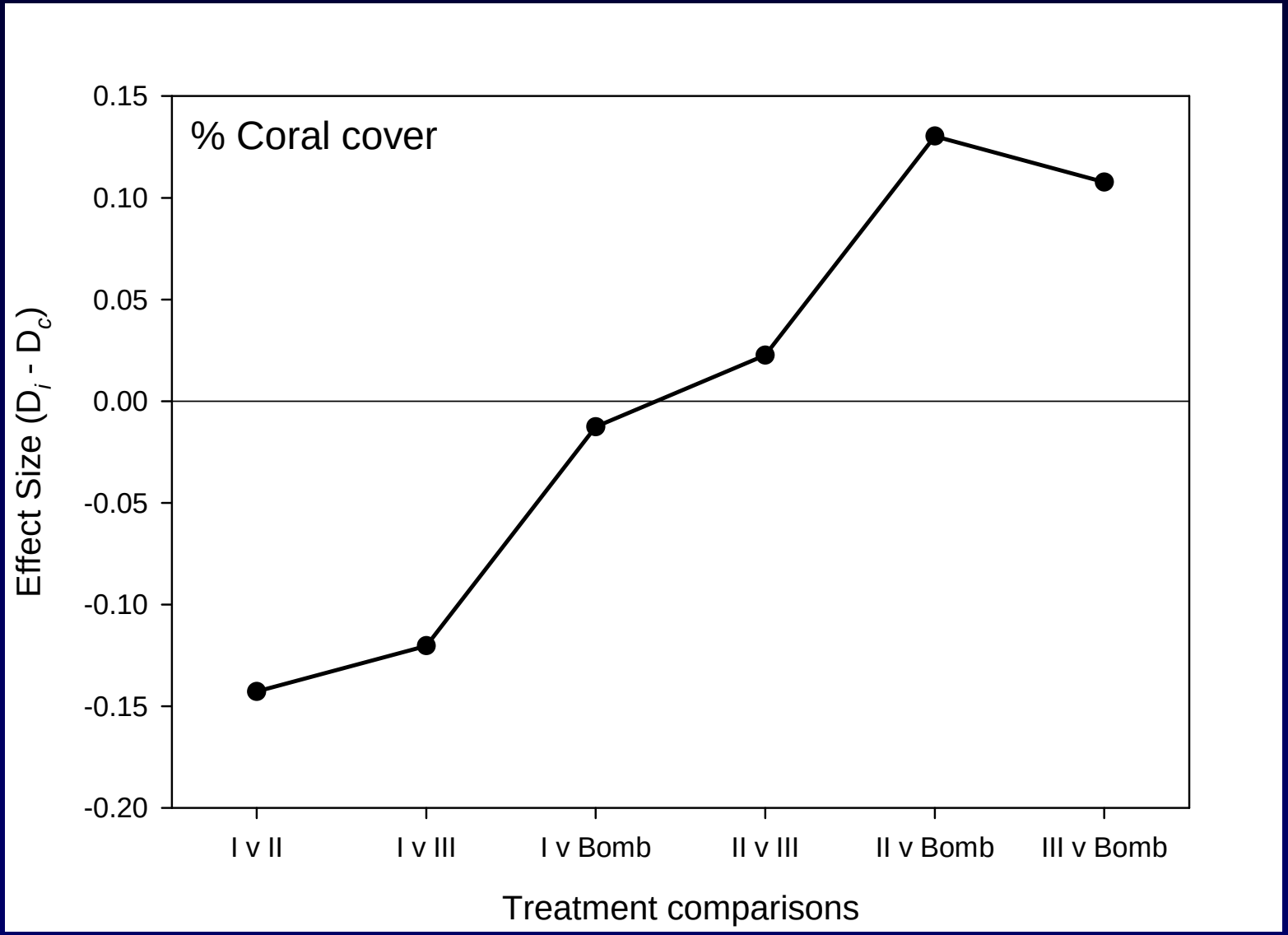
TABLA 7. Componentes principales causantes de diferencias en los patrones espaciales de la estructura de la comunidad.

Tratamientos	Componentes	A1	A2	% Contribución
I vs. II	*Montastraea annularis*	0.02	0.08	11.76
I vs. III	*Montastraea annularis*	0.02	0.21	16.55
I vs. Bomb.	Zoántidos	0.04	0.10	17.09
II vs. III	*Montastraea annularis*	0.08	0.21	12.81
II vs. Bomb.	Zoántidos	<0.01	0.10	12.51
III vs. Bomb.	*Montastraea annularis*	0.00	0.21	16.13

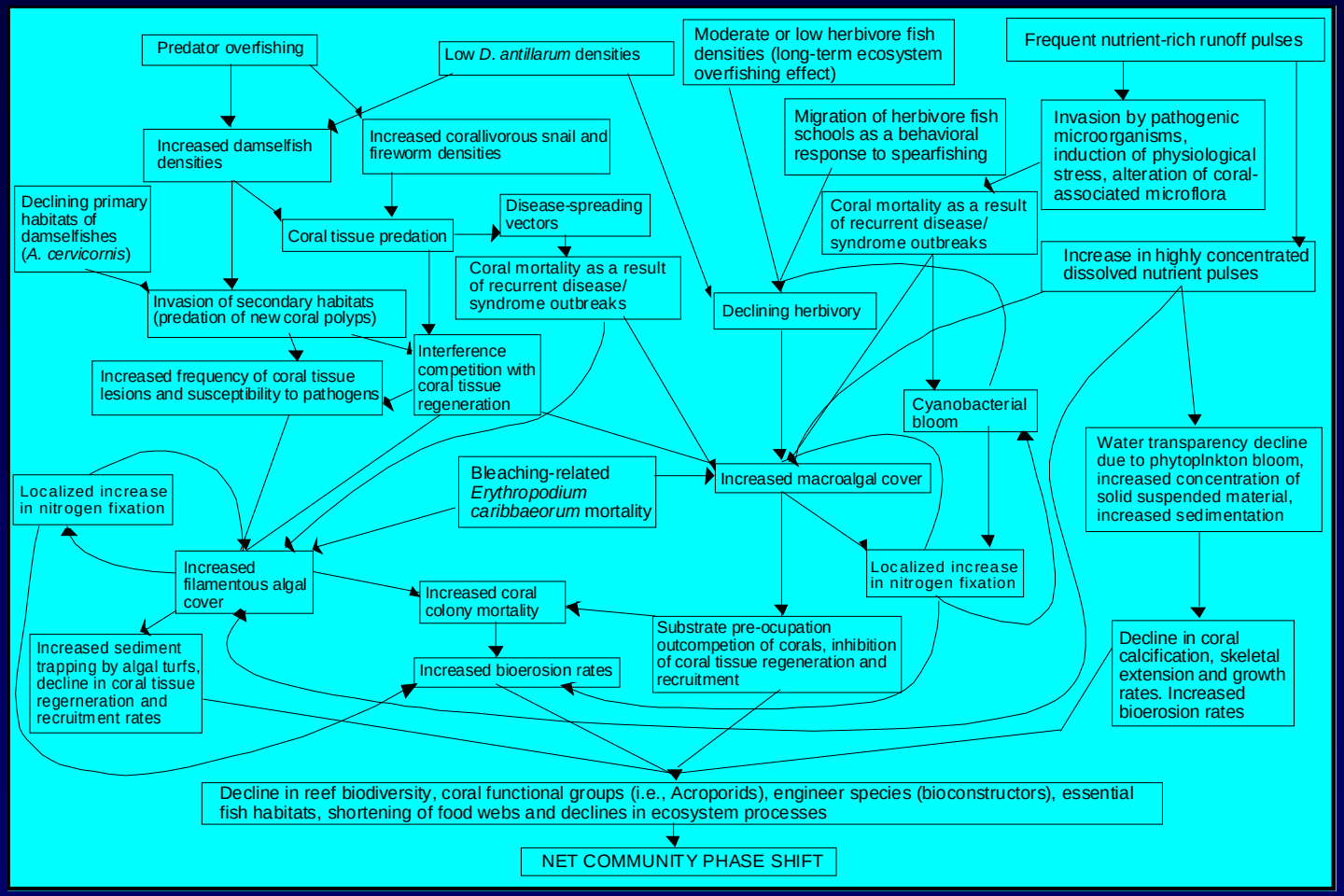
Effect Size (basado en BACIPS)



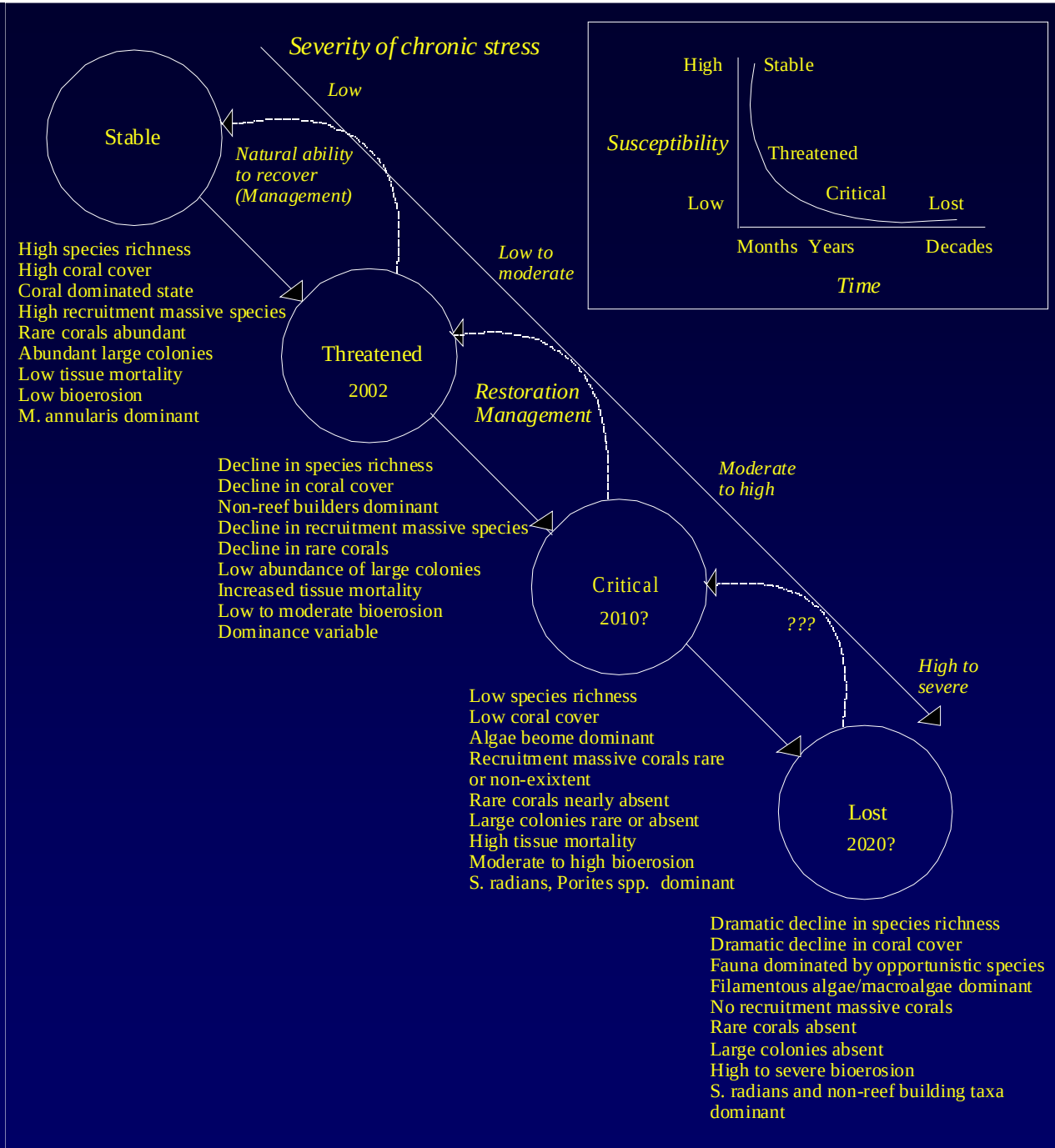
Effect Size (basado en BACIPS)

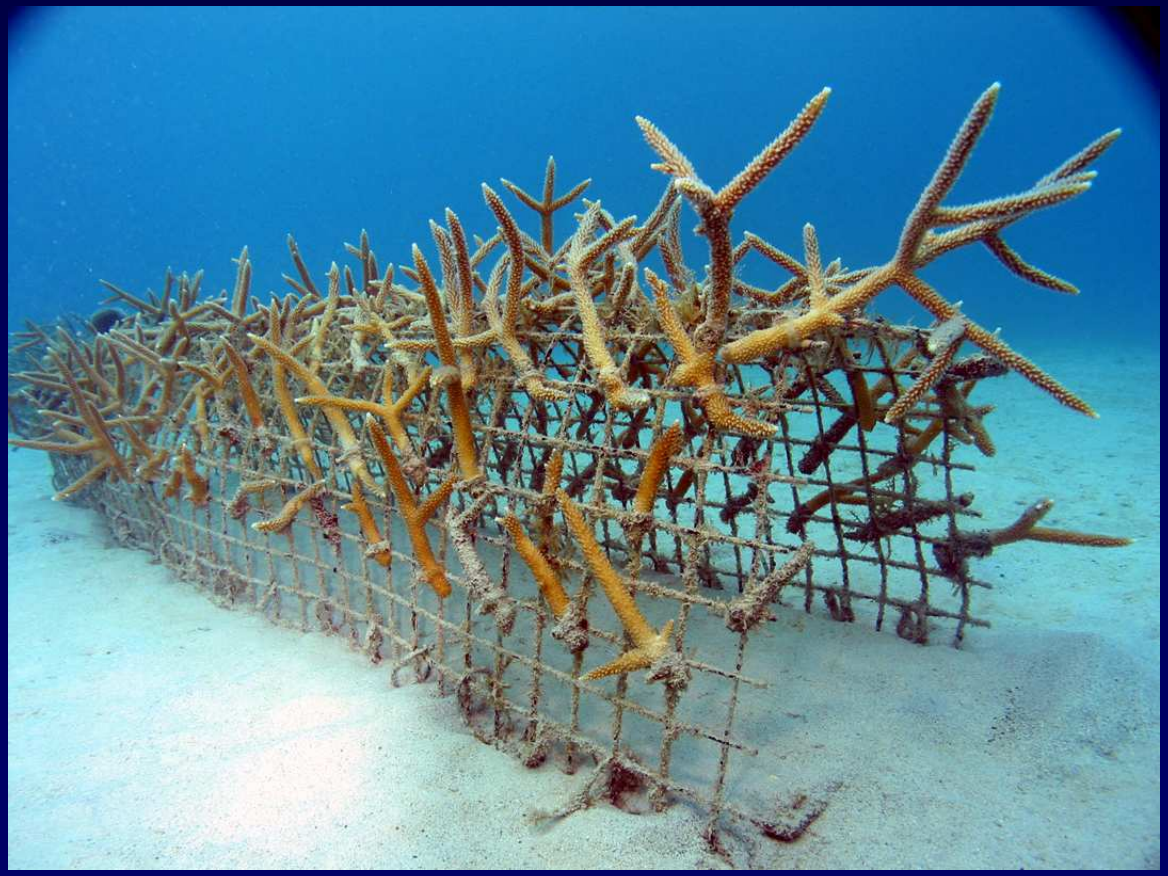


Hypothesis development



Oh, oh!!!!
Qué es eso?


Severity of chronic stress
Low
Stable
Natural ability to recover (Management)
High species richness
High coral cover
Coral dominated state
High recruitment massive species
Rare corals abundant
Abundant large colonies
Low tissue mortality
Low bioerosion
M. annularis dominant
Low to moderate
Threatened
2002
Restoration Management
Decline in species richness
Decline in coral cover
Non-reef builders dominant
Decline in recruitment massive species
Decline in rare corals
Low abundance of large colonies
Increased tissue mortality
Low to moderate bioerosion
Dominance variable
Moderate to high
Critical
2010?
???
High to severe
Low species richness
Low coral cover
Algae beome dominant
Recruitment massive corals rare or non-exixtent
Rare corals nearly absent
Large colonies rare or absent
High tissue mortality
Moderate to high bioerosion
S. radians, Porites spp. dominant
Lost
2020?
Dramatic decline in species richness
Dramatic decline in coral cover
Fauna dominated by opportunistic species
Filamentous algae/macroalgae dominant
No recruitment massive corals
Rare corals absent
Large colonies absent
High to severe bioerosion
S. radians and non-reef building taxa dominant
High
Susceptibility
Low
Stable
Threatened
Critical
Lost
Months
Years
Decades
Time



¡Gracias! ¿Preguntas para papá?

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