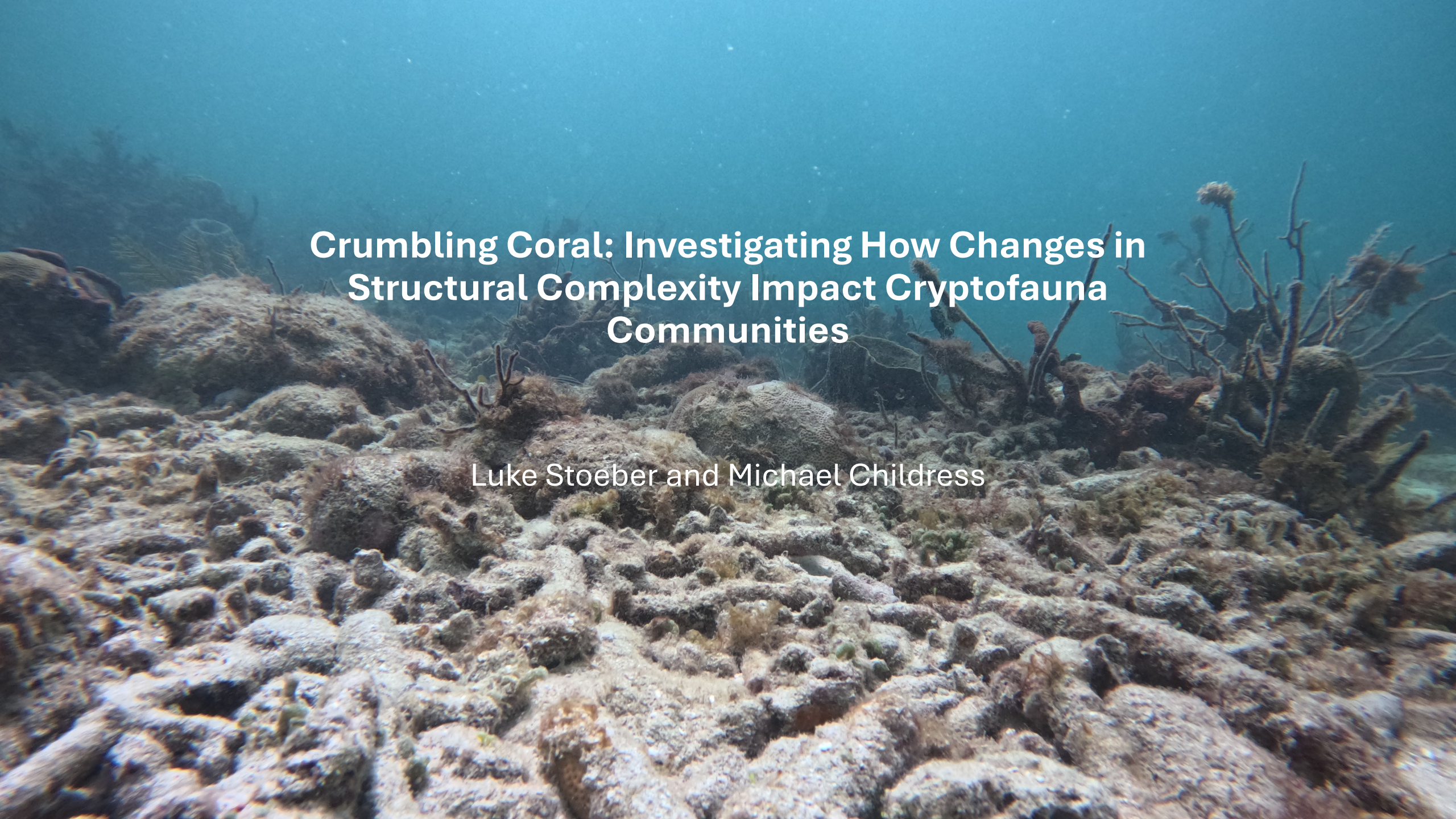
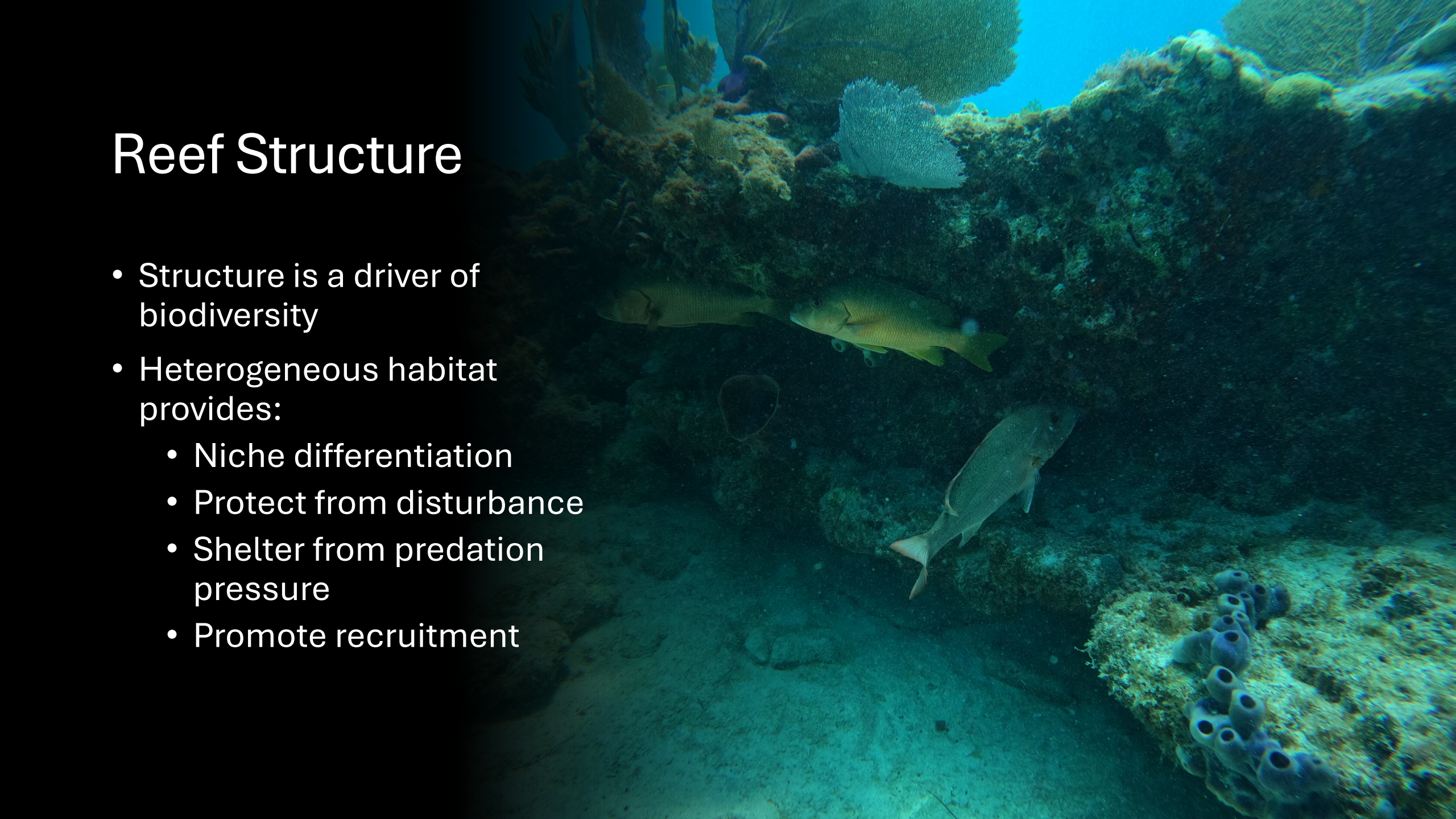


Crumbling Coral: Investigating How Changes in Structural Complexity Impact Cryptofauna Communities

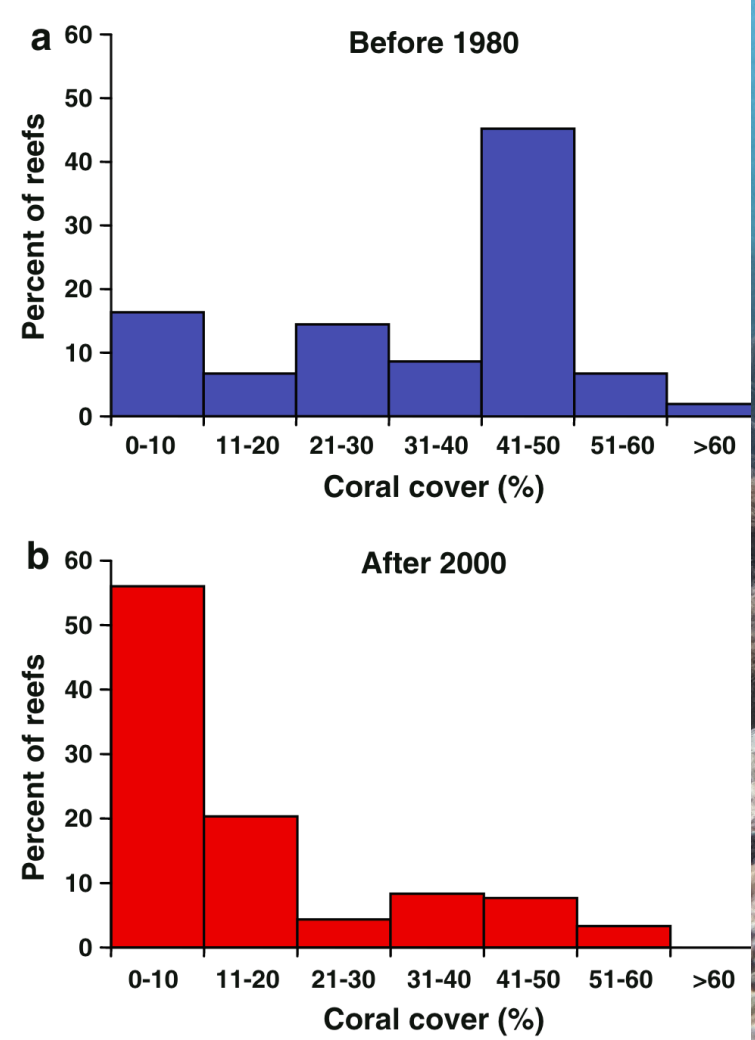
Luke Stoeber and Michael Childress

Reef Structure

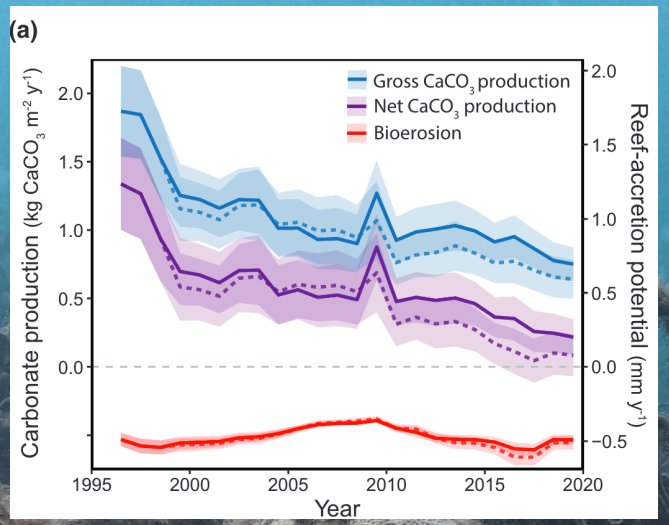
- Structure is a driver of biodiversity
- Heterogeneous habitat provides:
  - Niche differentiation
  - Protect from disturbance
  - Shelter from predation pressure
  - Promote recruitment

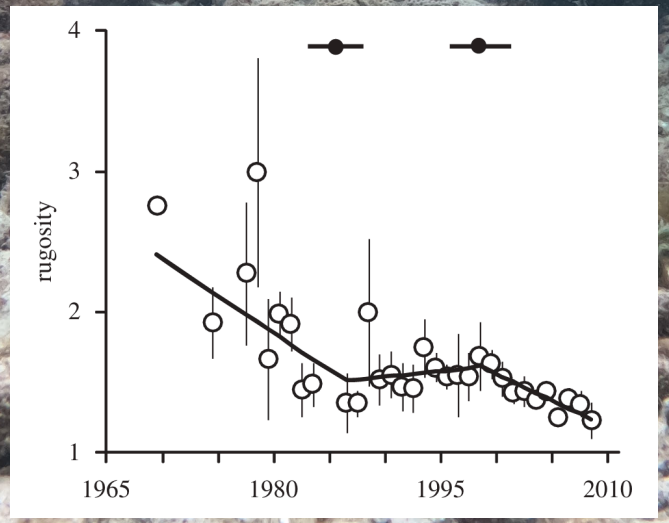


Toth et al. (2022)



Hughes et al. (2011)



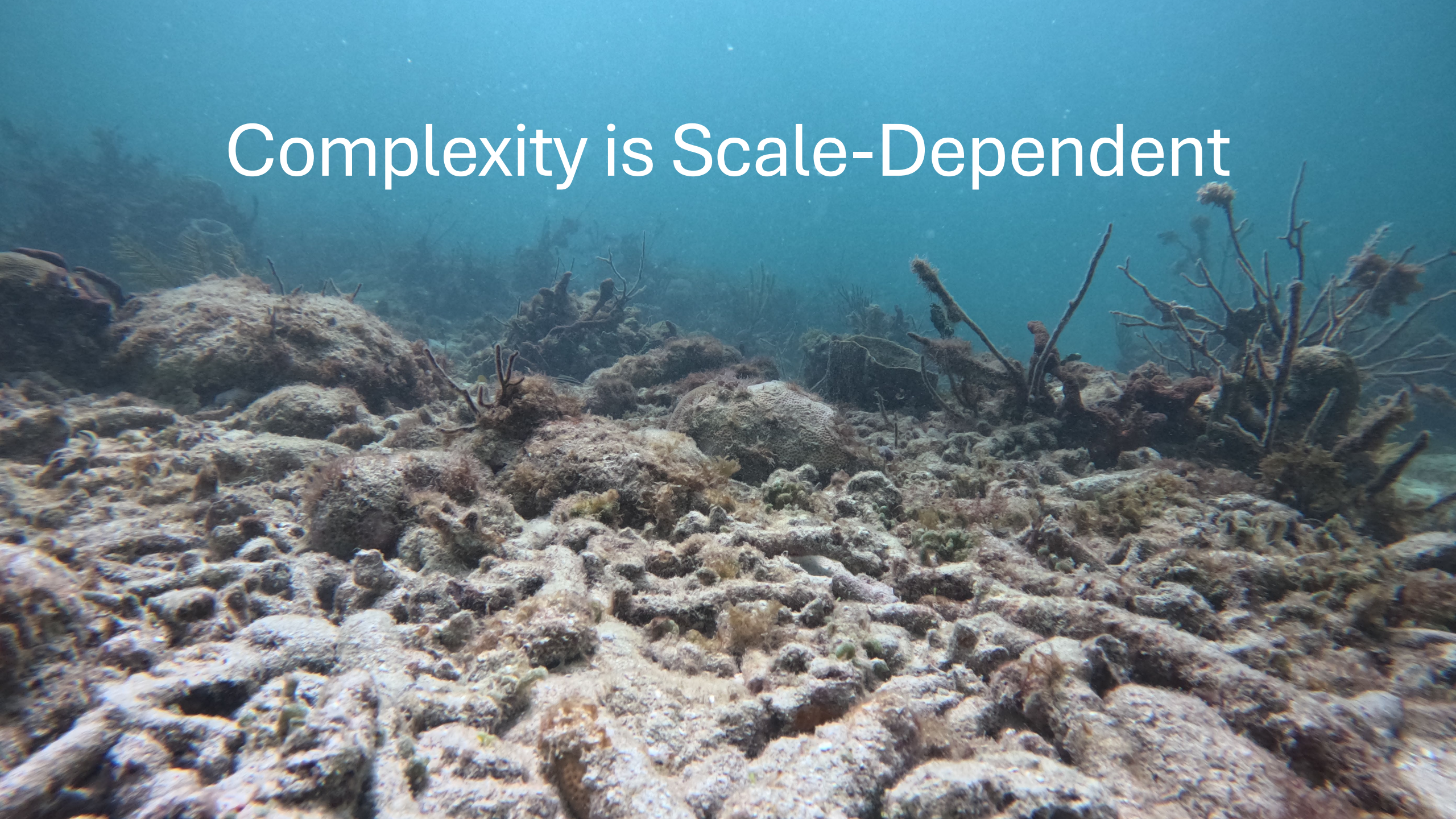


Alvarez-Filip et al. (2009)

Changes in Reef Structure

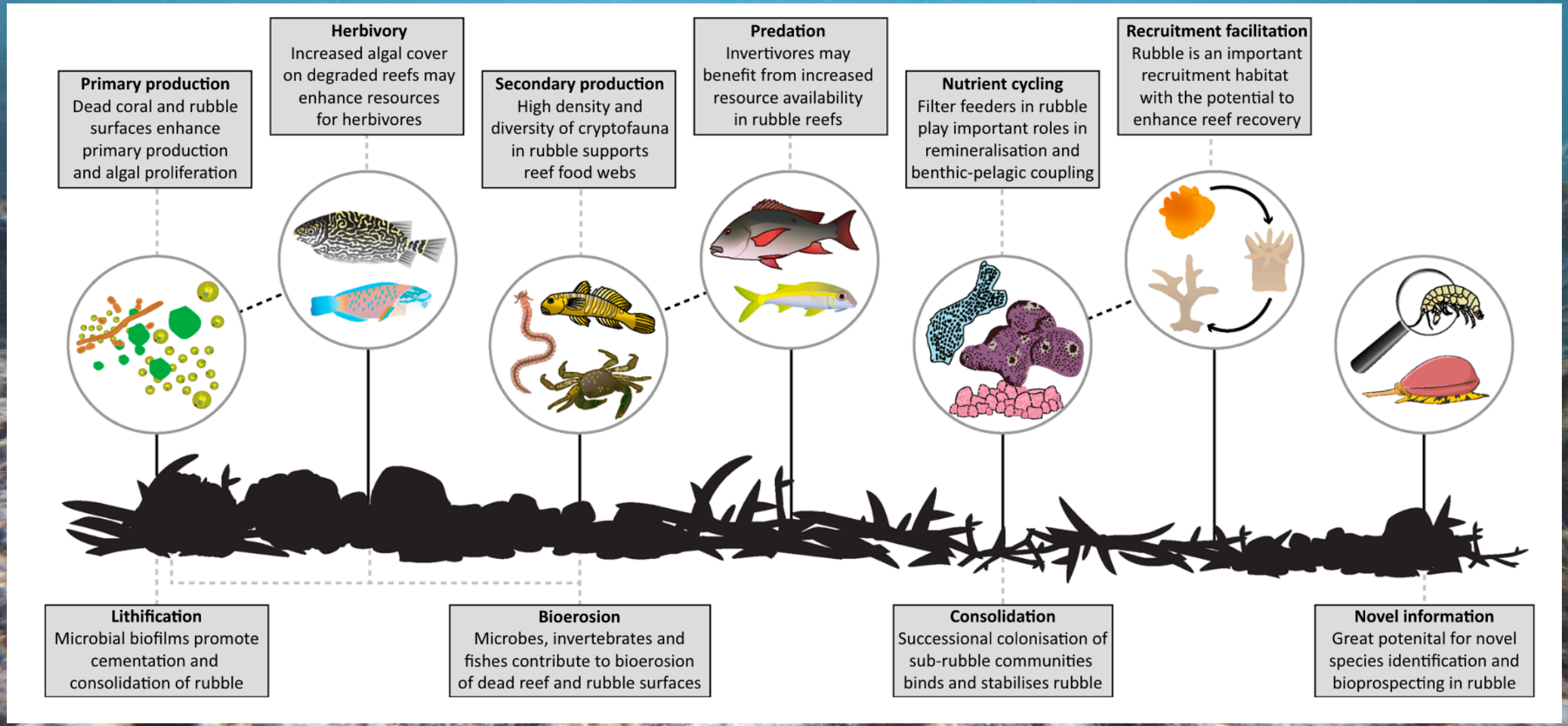
- Losing corals
- Losing calcium carbonate production
- Losing habitat heterogeneity

Complexity is Scale-Dependent



Marine Cryptofauna

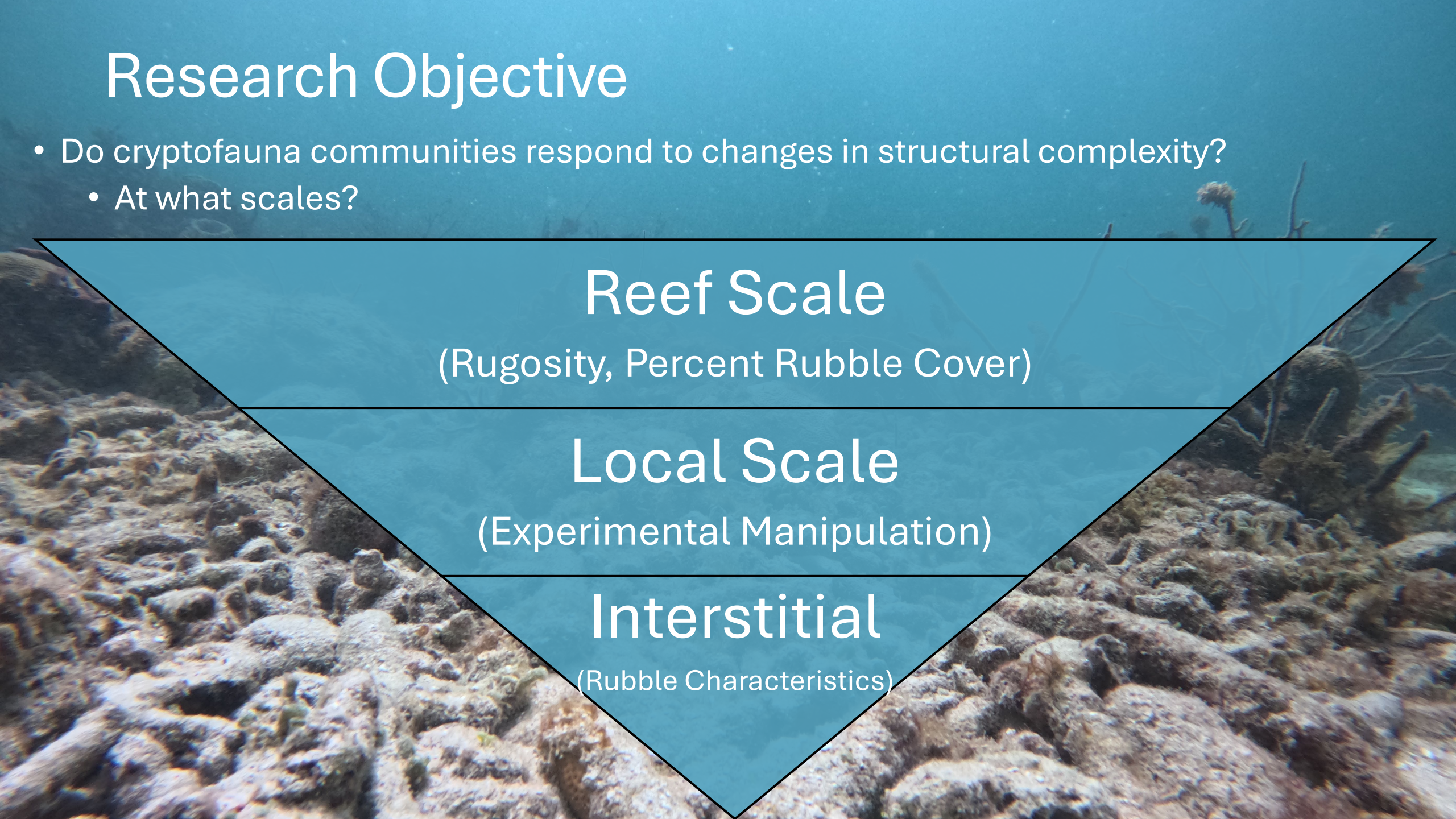
- Small organisms living in concealed microhabitats
- Most diverse metazoan community on coral reefs
- Play critical roles in reef trophodynamics and ecosystem functioning



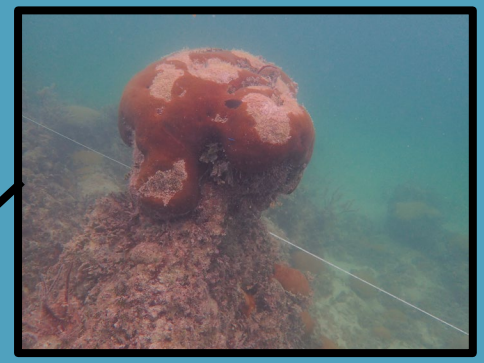
Wolfe et al. (2021)

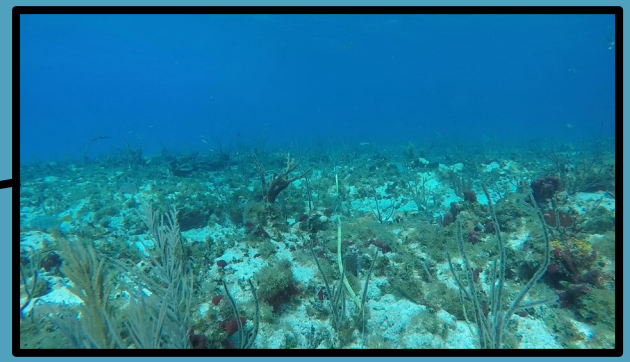
Research Objective

- Do cryptofauna communities respond to changes in structural complexity?
  - At what scales?



Study Sites – Reef Scale



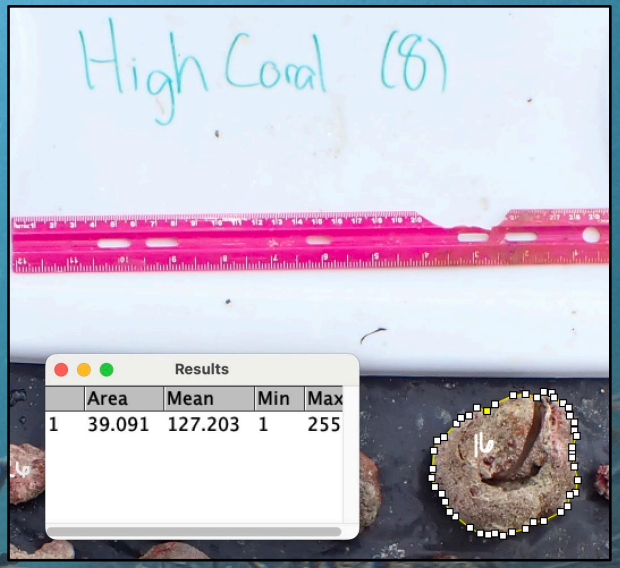


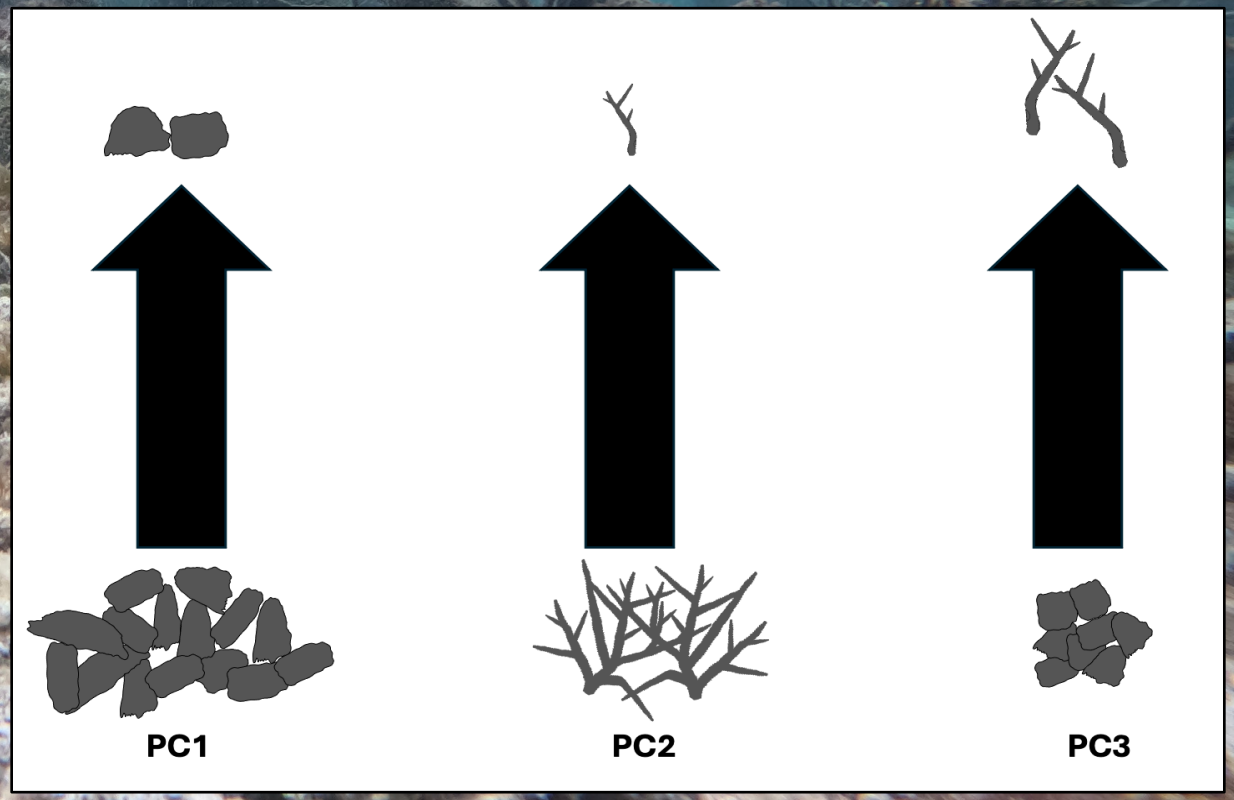
Local Scale – Experimental Manipulation

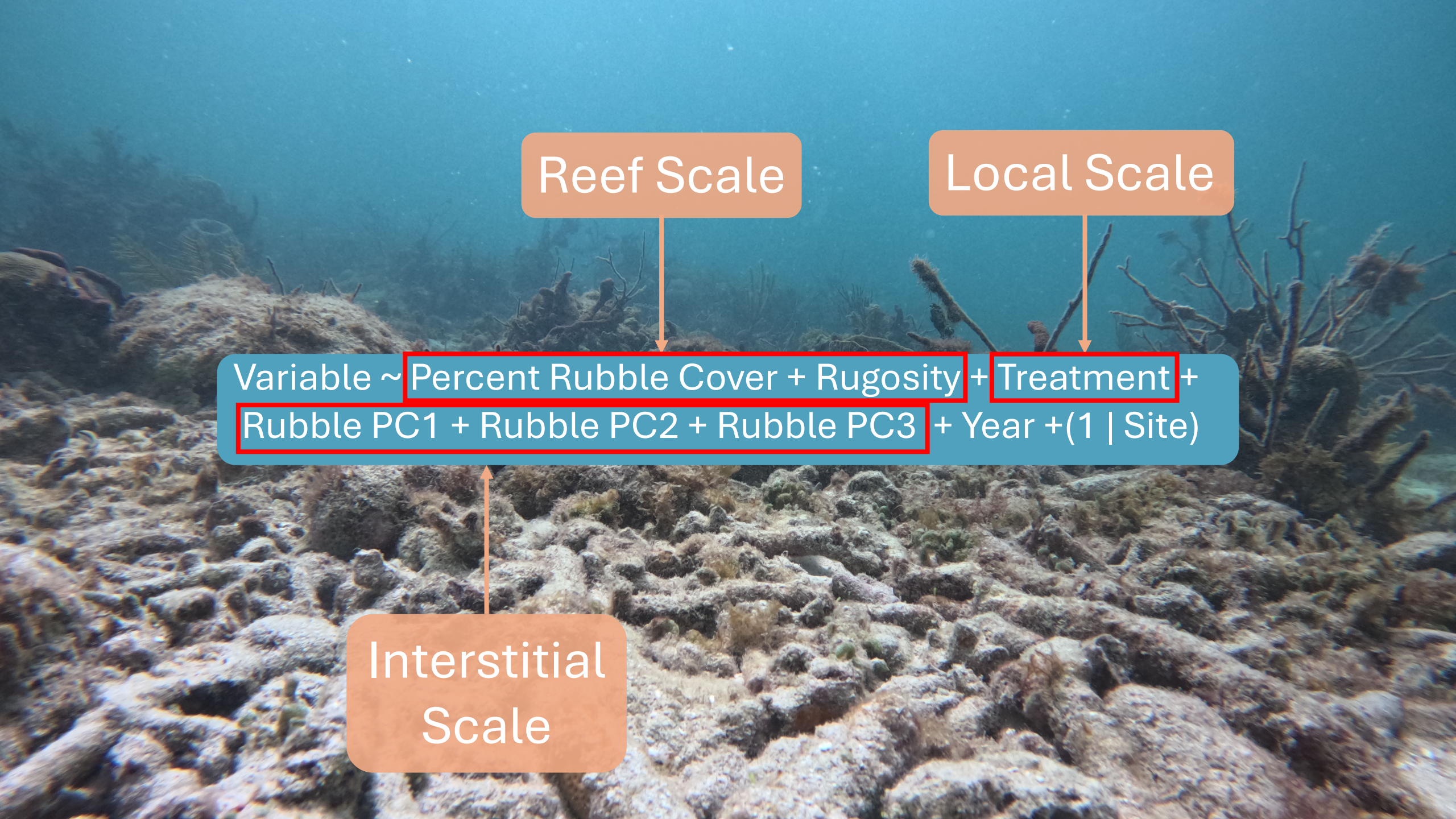
- Coral rubble offers a dynamic cryptic habitat
- *Acropora* fragments to manipulate structure
- 2-4kg of rubble haphazardly collected
- Rubble sterilized via freshwater soak
- 21-day deployment
- 4 trays per site across 10 sites
- Repeated for two field seasons

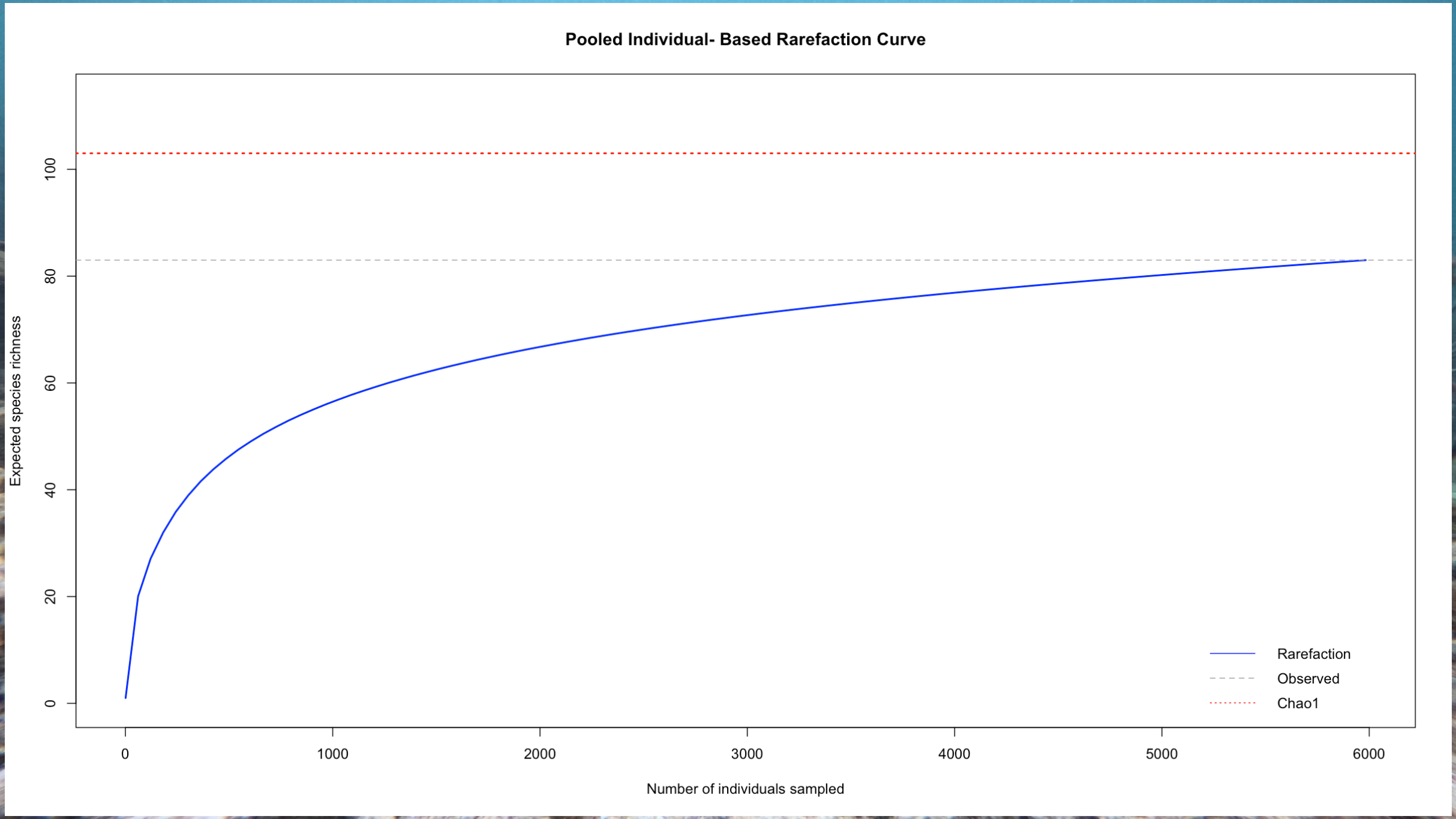
Interstitial – Rubble Complexity

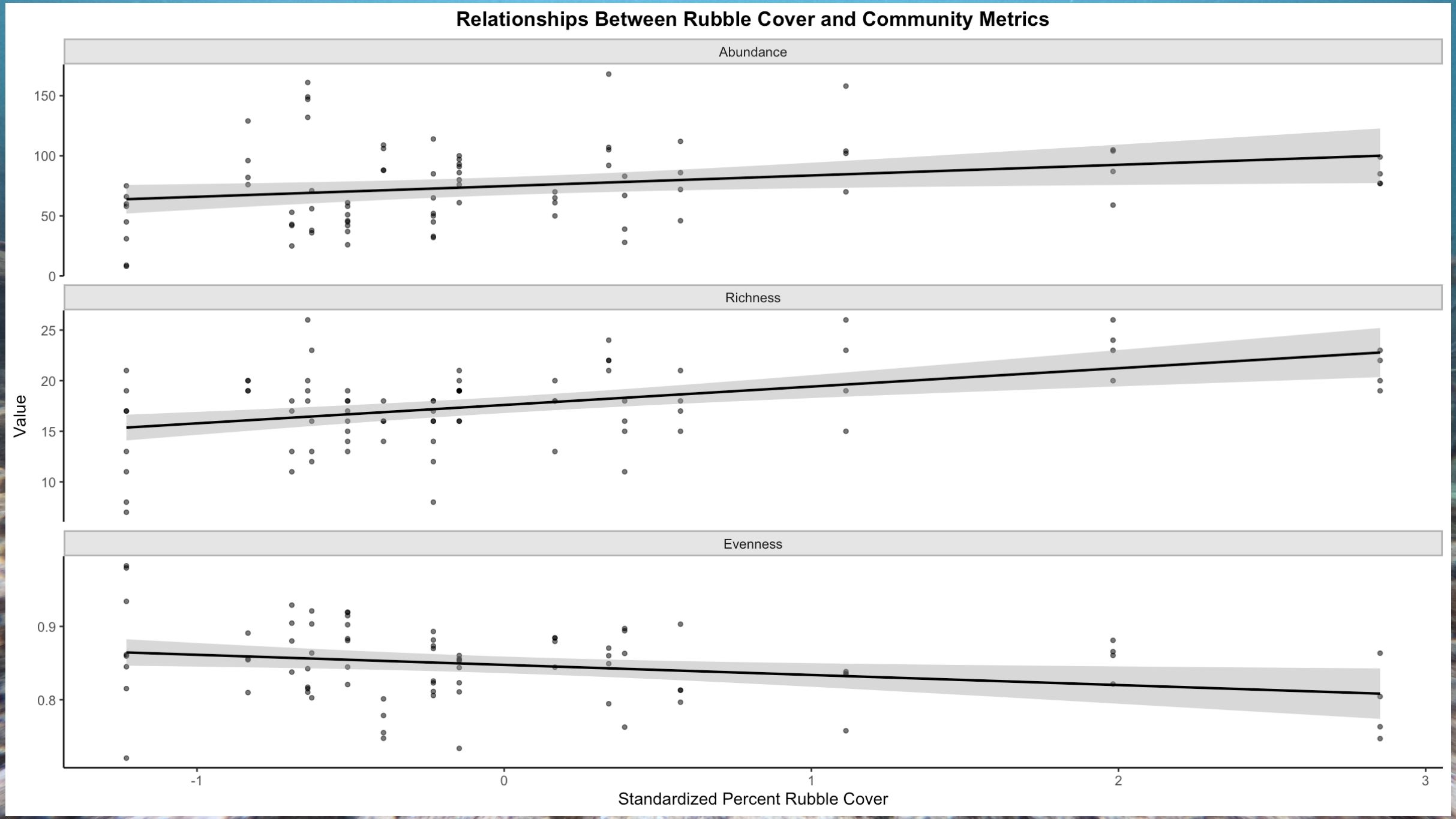
- Amount of Rubble:
  - Mass
  - Volume
  - Number of Pieces
- Shape of Rubble:
  - Length + Width
  - Area
  - Number of branches

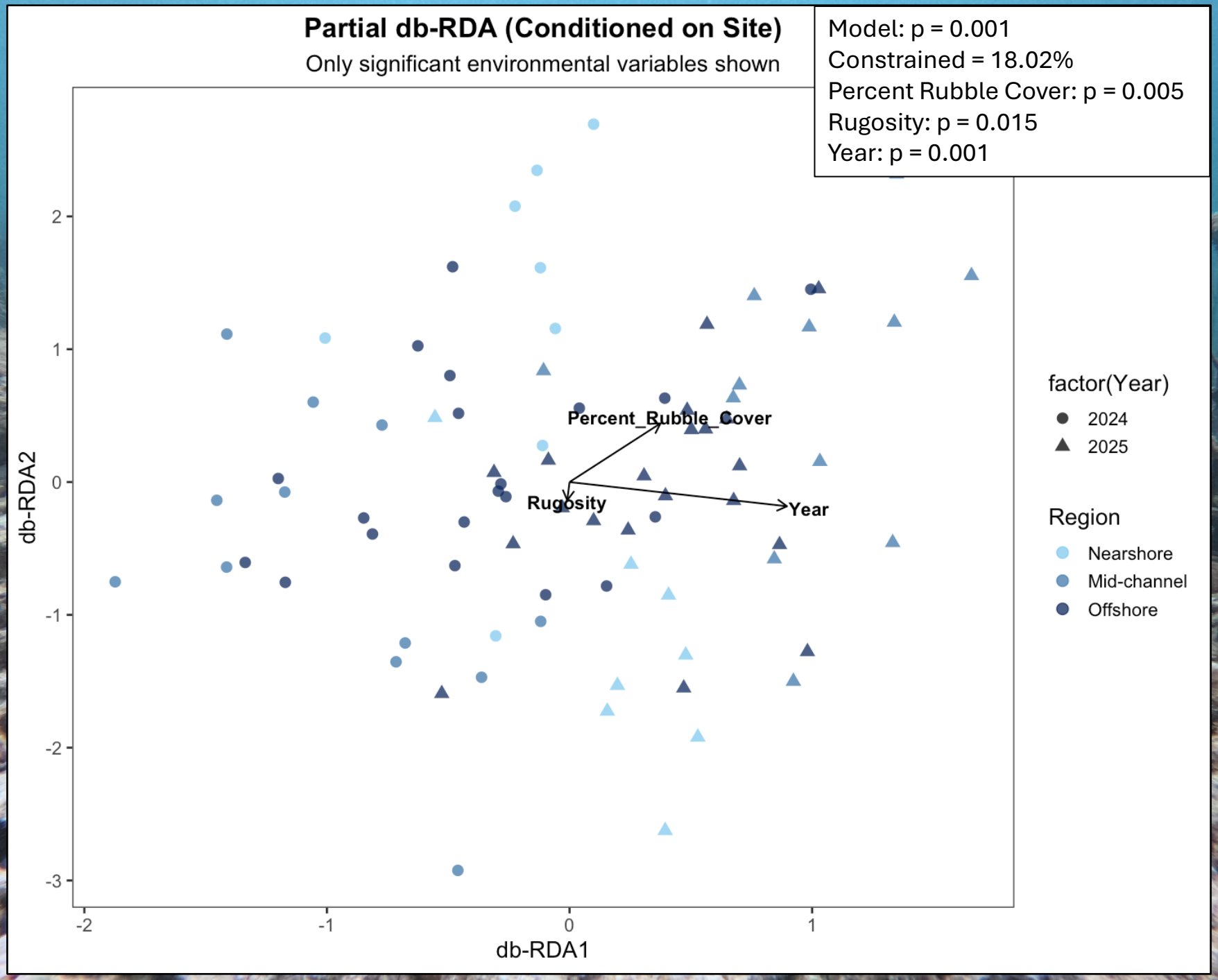


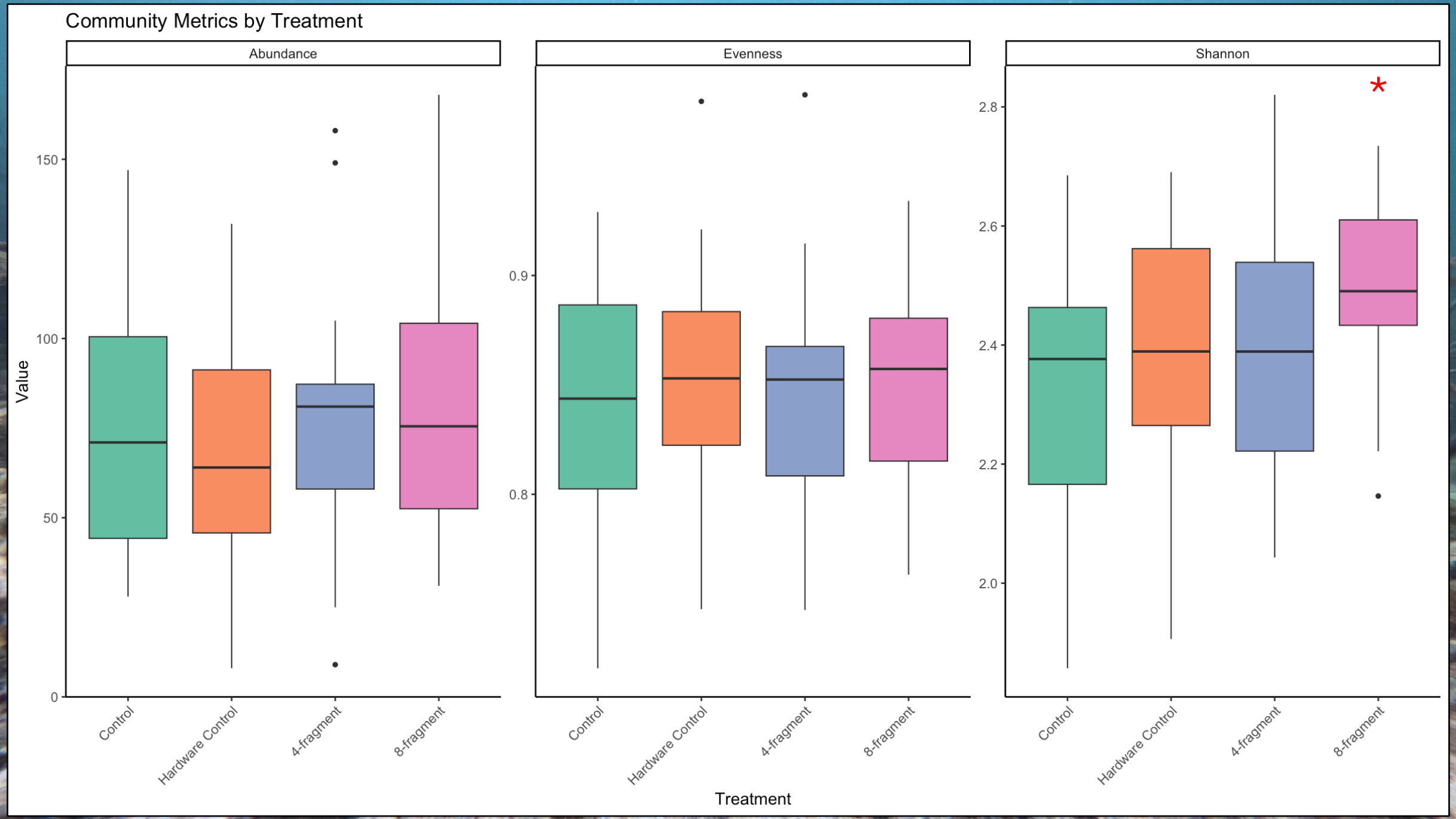



Reef Scale
Local Scale
Variable ~ Percent Rubble Cover + Rugosity + Treatment +
Rubble PC1 + Rubble PC2 + Rubble PC3 + Year +(1 | Site)
Interstitial Scale


Pooled Individual- Based Rarefaction Curve
Expected species richness
0
20
40
60
80
100
0
1000
2000
3000
4000
5000
6000
Number of individuals sampled
Rarefaction
Observed
Chao1


Relationships Between Rubble Cover and Community Metrics
Abundance
Richness
Evenness
Value
150
100
50
0
25
20
15
10
0.9
0.8
-1
0
1
2
3
Standardized Percent Rubble Cover

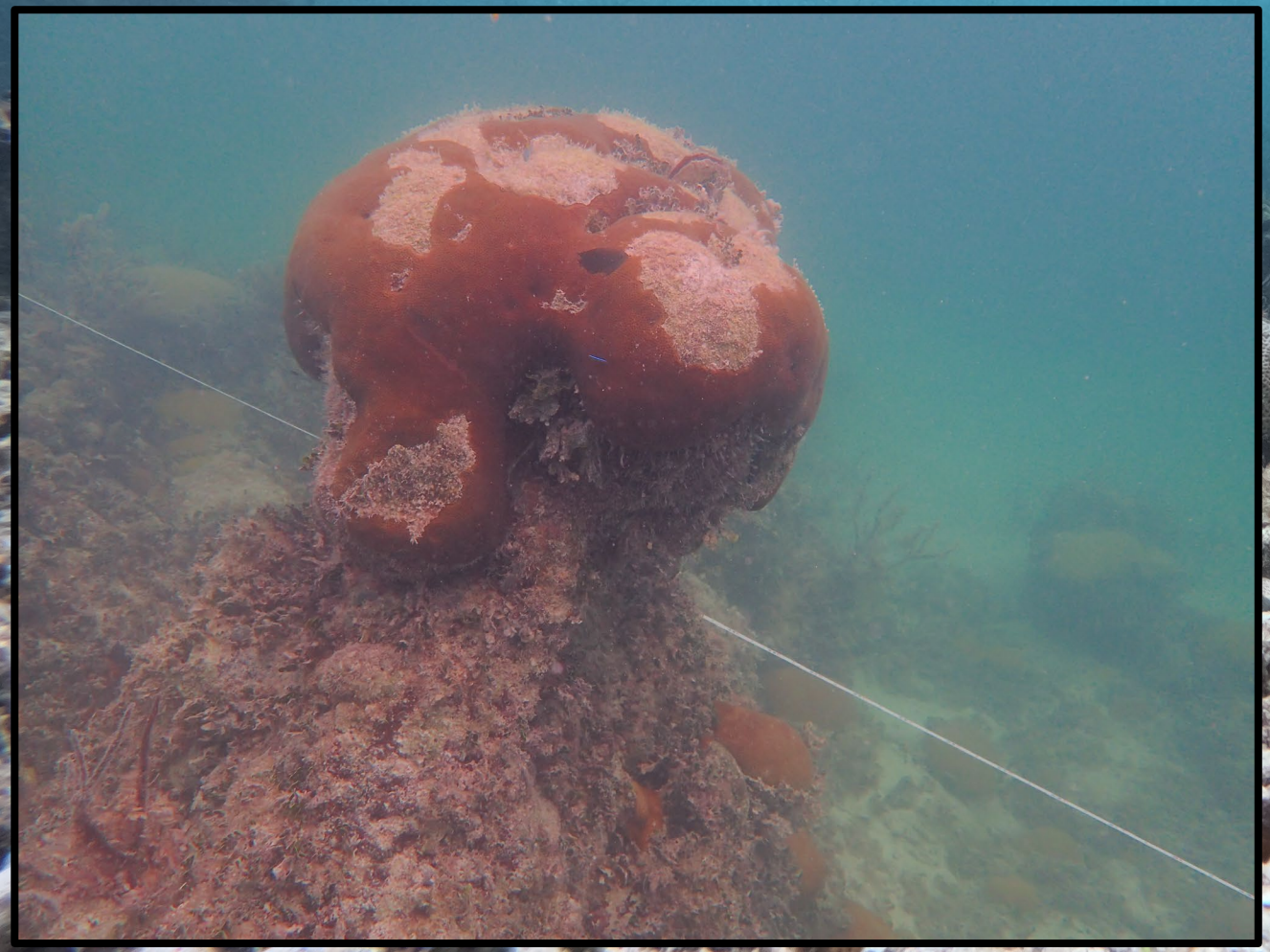

Partial db-RDA (Conditioned on Site)
Only significant environmental variables shown
Model: p = 0.001
Constrained = 18.02%
Percent Rubble Cover: p = 0.005
Rugosity: p = 0.015
Year: p = 0.001
Percent_Rubble_Cover
Rugosity
Year
db-RDA1
db-RDA2
2
1
0
-1
-2
-3
-2
-1
0
1
factor(Year)
2024
2025
Region
Nearshore
Mid-channel
Offshore

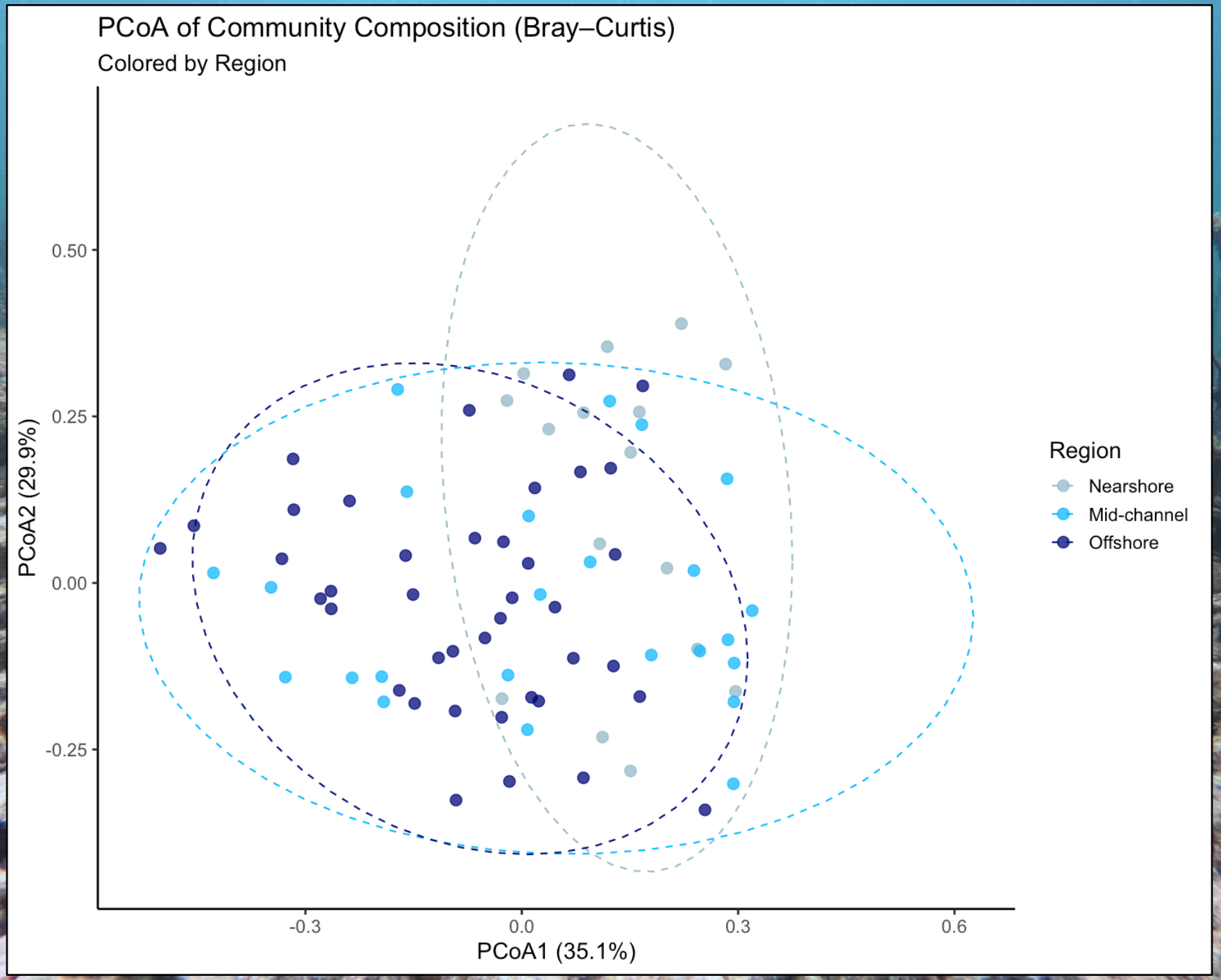

Community Metrics by Treatment
Abundance
Evenness
Shannon
Value
150
100
50
0
0.9
0.8
2.8
2.6
2.4
2.2
2.0
*
Control
Hardware Control
4-fragment
8-fragment
Treatment

Results – All Sites

- Multiscale influences of structure on cryptofauna
- Reef-Scale Factors
  - Percent Rubble Cover
    - Strong effect abundance, richness, evenness, and community composition
  - Rugosity
    - Weak Effect on community composition
- Local Scale Structure
  - 8-fragment treatment had the strongest effect on species diversity of all predictors
- Interstitial
  - No strong relationship

Do all regions respond in the same way?




PCoA of Community Composition (Bray–Curtis)
Colored by Region
PCoA2 (29.9%)
0.50
0.25
0.00
-0.25
-0.3
0.0
0.3
0.6
PCoA1 (35.1%)
Region
Nearshore
Mid-channel
Offshore


Direction of Effects by Metric and Region
Nearshore
Mid-channel
Offshore
Abundance
Evenness
Richness
Shannon
Simpson
Count
1.00
0.75
0.50
0.25
0.00
Direction
Negative
Positive
Percent Rubble Cover
Rugosity
Hardware Control
4-fragment
8-fragment
Rubble PC1
Rubble PC2
Rubble PC3
Year
Explanatory Variable

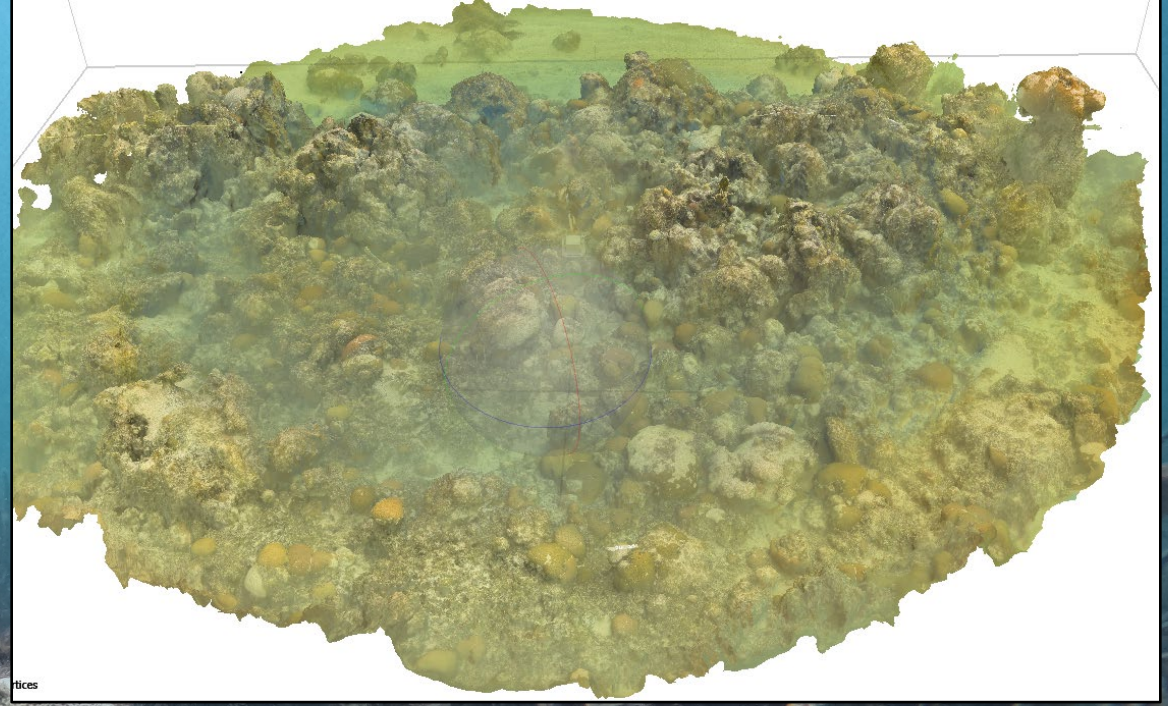
Consideration for Coral Restoration

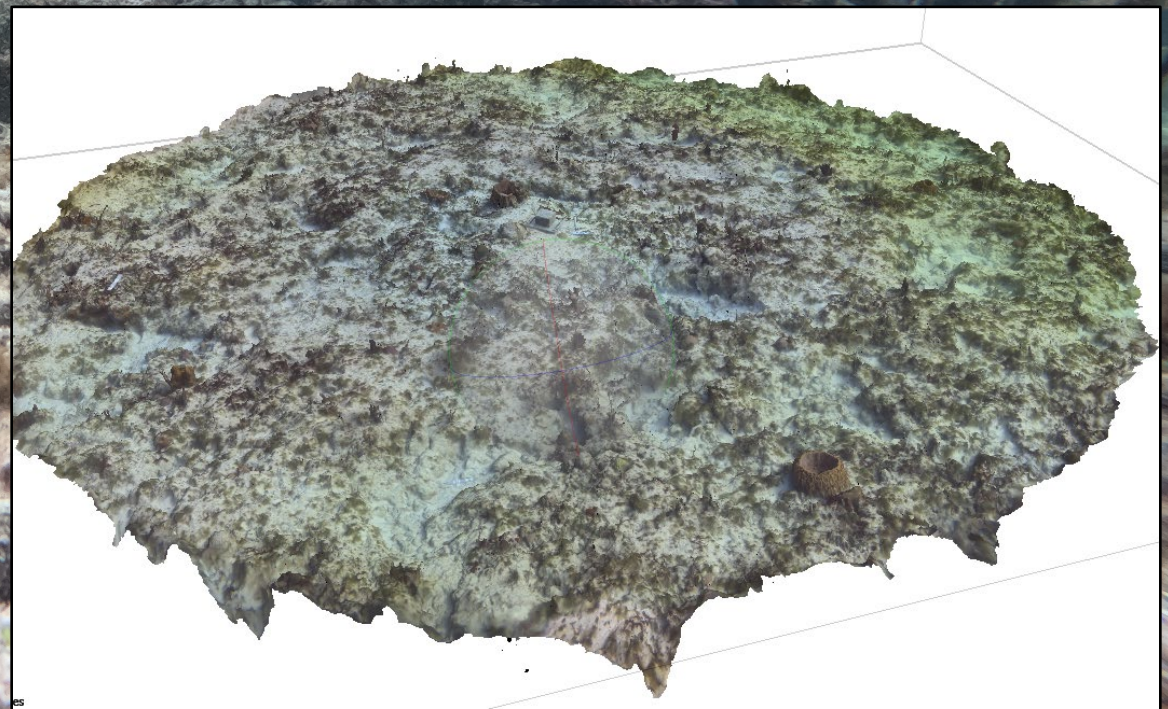
- Restoration may have the potential to benefit cryptic communities by enhancing structure around cryptic habitat
  - Specifically on highly degraded, rubble-dominated sites
- Relationship between cryptic communities and long-term restoration success needs to be further explored

ICARE (2024)

Future Directions

- Functional Perspective
  - Does structure impact functional redundancy?
  - Continuation of the reef ecosystem functioning through cryptic pathways
- Inclusion of sessile cryptofauna communities
  - Response to structure across spatial scales using SfM Photogrammetry and Autonomous Reef Monitoring Structures (ARMS)





Acknowledgments

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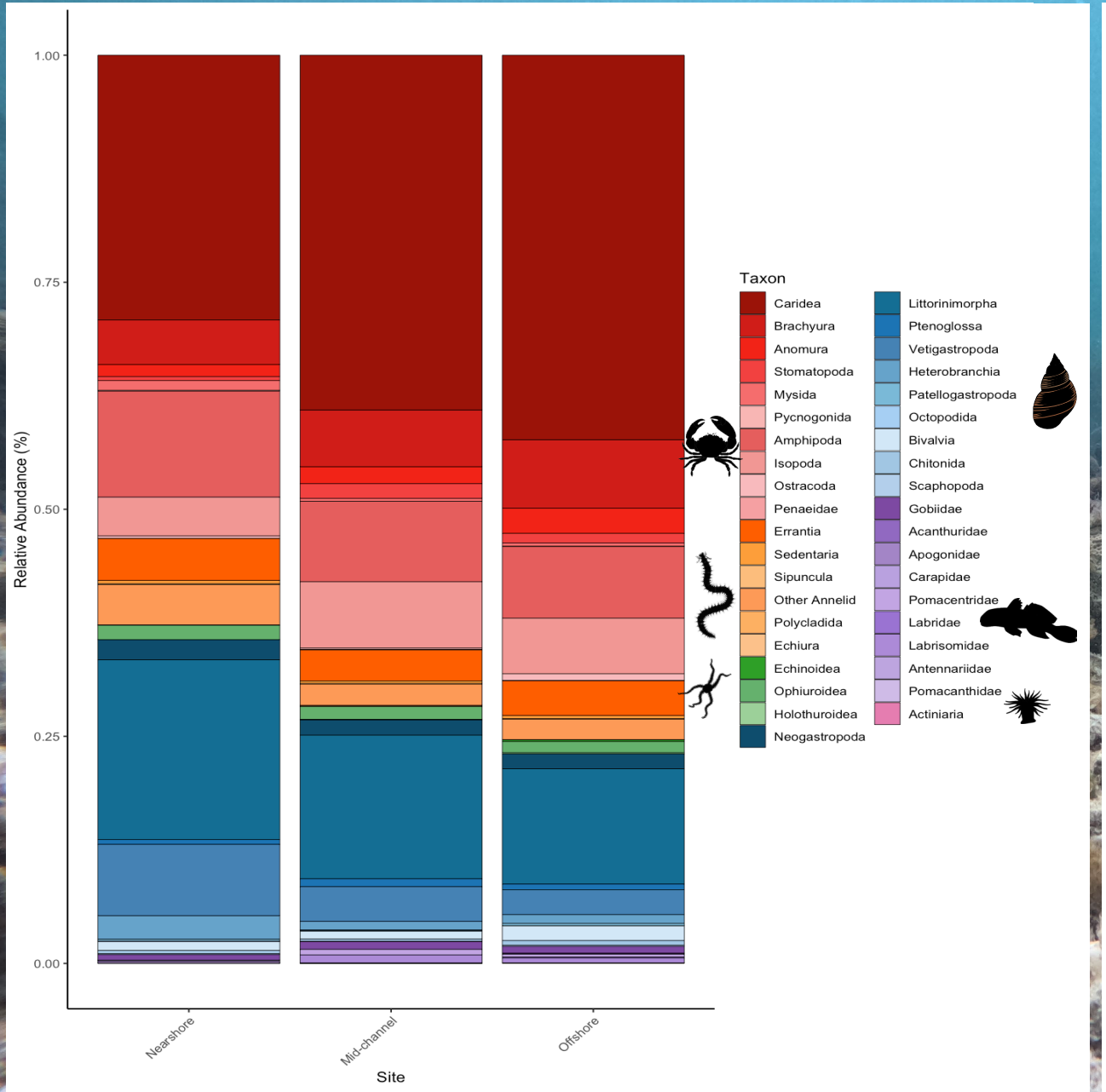
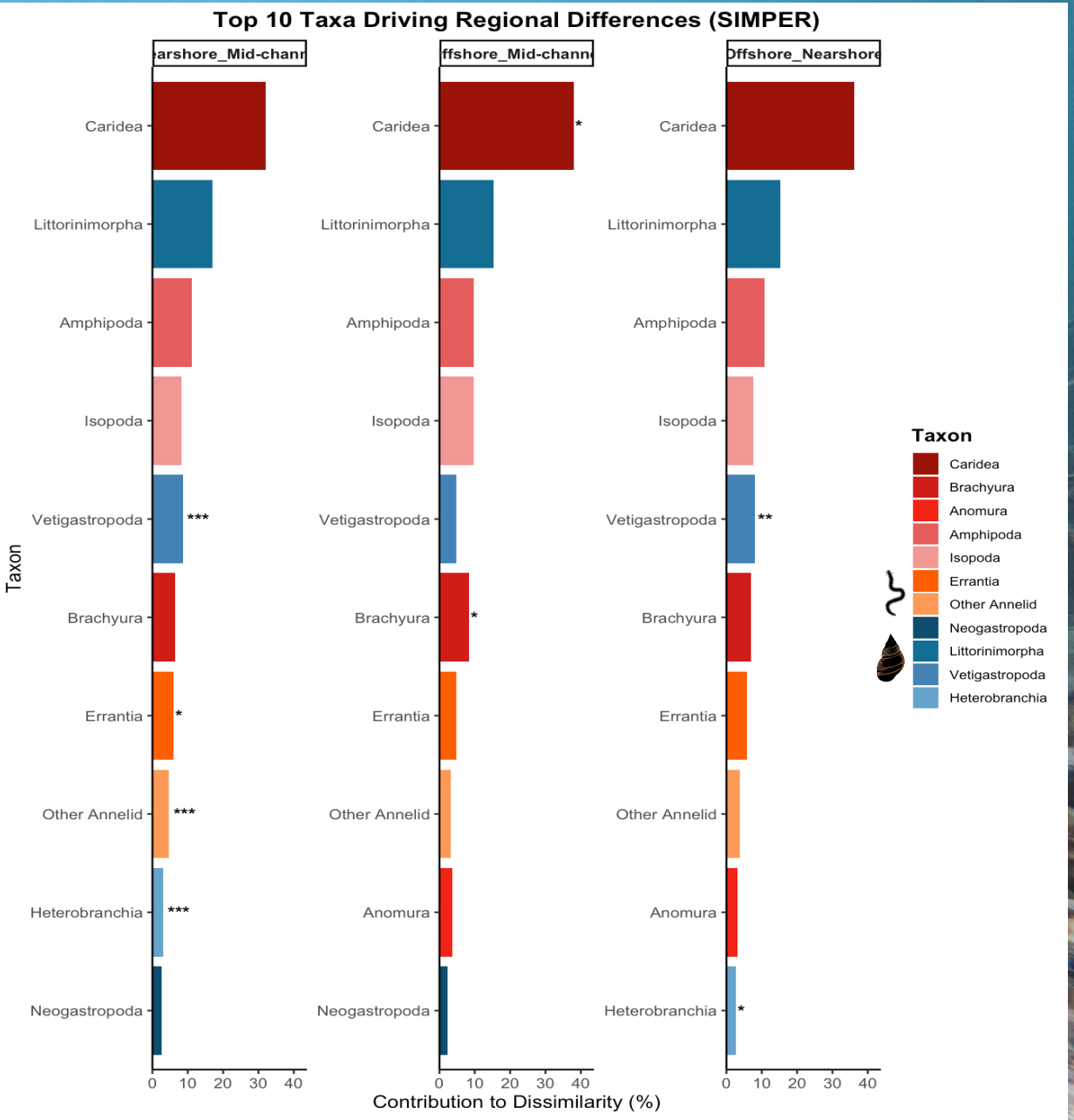
  - Dr. Kea Payton
  - Tara Cronin
  - Camille White
  - Sarah Rider
- Current and Former Undergraduates
  - Nick Williams
  - Ashley Gambrell
  - Anna Metzger
  - Sophie Dzieciolowski
  - Amanda Kellerhals
  - Addie Thomas
  - Shea Ehrhard
  - Abigail Cumbee
  - Tess Abrams
  - Chapman West

Questions?


1.00
0.75
0.50
0.25
0.00
Relative Abundance (%)
Nearshore
Mid-channel
Offshore
Site
Taxon
Caridea
Brachyura
Anomura
Stomatopoda
Mysida
Pycnogonida
Amphipoda
Isopoda
Ostracoda
Penaeidae
Errantia
Sedentaria
Sipuncula
Other Annelid
Polycladida
Echiura
Echinoidea
Ophiuroidea
Holothuroidea
Neogastropoda
Littorinimorpha
Ptenoglossa
Vetigastropoda
Heterobranchia
Patellogastropoda
Octopodida
Bivalvia
Chitonida
Scaphopoda
Gobiidae
Acanthuridae
Apogonidae
Carapidae
Pomacentridae
Labridae
Labrisomidae
Antennariidae
Pomacanthidae
Actiniaria


Top 10 Taxa Driving Regional Differences (SIMPER)
arshore_Mid-chan
ffshore_Mid-channe
Offshore_Nearshore
Caridea
Littorinimorpha
Amphipoda
Isopoda
Vetigastropoda
Brachyura
Errantia
Other Annelid
Heterobranchia
Neogastropoda
Anomura
Taxon
***
*
**
0
10
20
30
40
Contribution to Dissimilarity (%)
Taxon
Caridea
Brachyura
Anomura
Amphipoda
Isopoda
Errantia
Other Annelid
Neogastropoda
Littorinimorpha
Vetigastropoda
Heterobranchia