Habitat Quality of Oyster Reefs: The Importance of Openness for Reef-Associating Species

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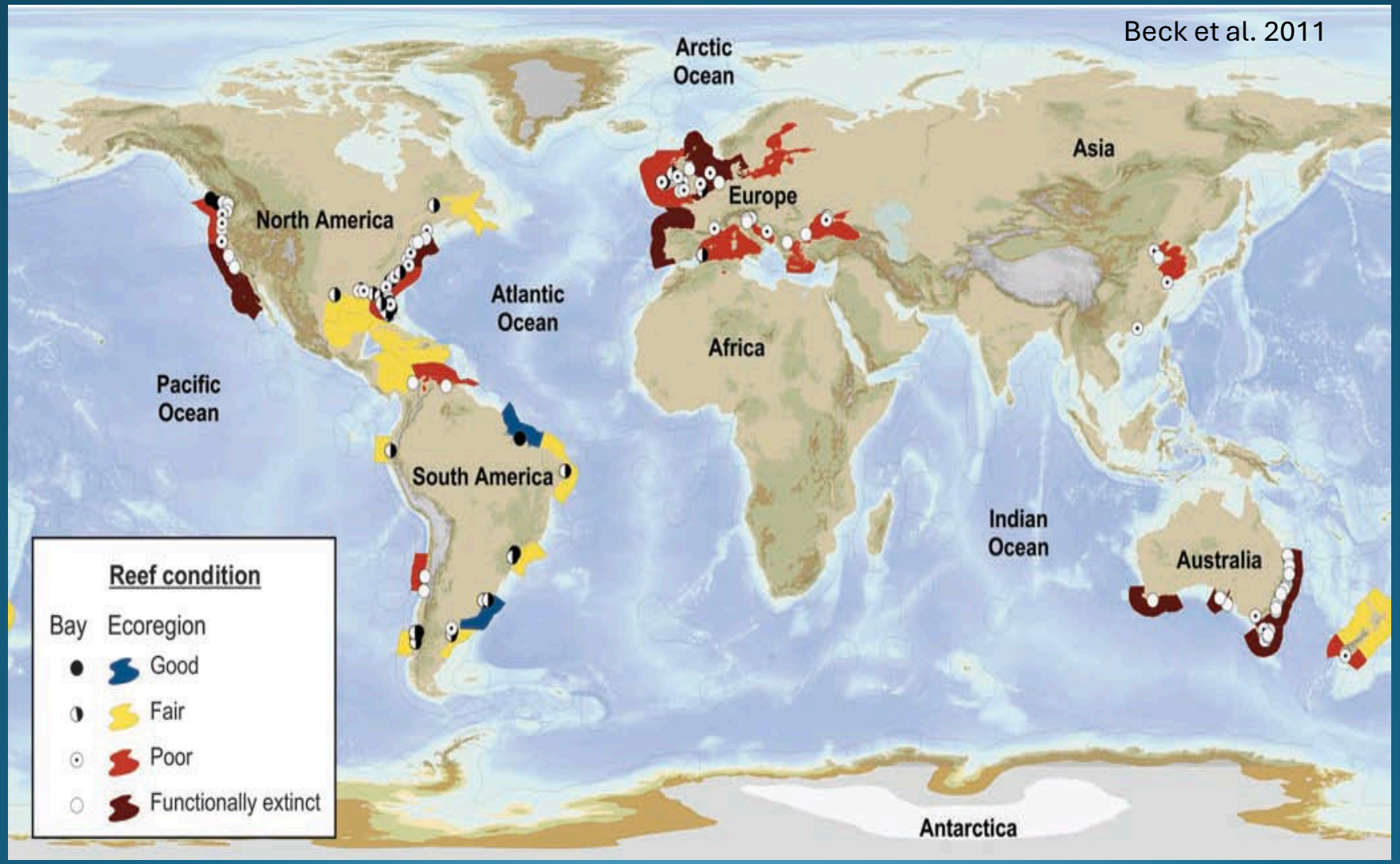
Photo: Chela Zabin, SERC


Beck et al. 2011
Arctic Ocean
Asia
Europe
North America
Atlantic Ocean
Africa
Pacific Ocean
South America
Indian Ocean
Australia
Antarctica
Reef condition
Bay
Ecoregion
Good
Fair
Poor
Functionally extinct

- Olympia oysters (*Ostrea lurida*) are the only native oyster to SF Bay
- Traditionally form shallow, low-profile reefs in the low intertidal to subtidal zone
- Populations have significantly declined, primarily due to anthropogenic causes

Photo: Chela Zabin, SERC

Major Ecosystem Services

- Water Filtration
- Wave Attenuation
- Biogenic Habitat


Photo: Casey Harper (Wild Oyster Project)

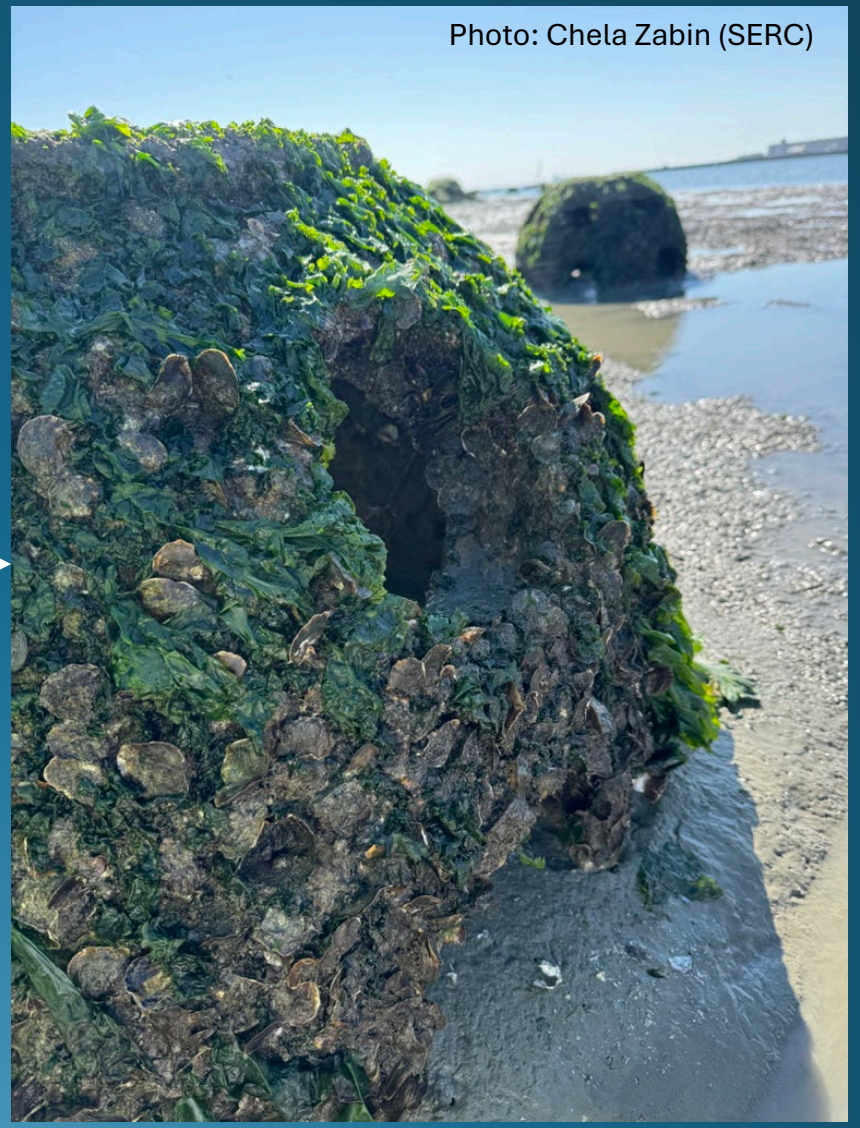
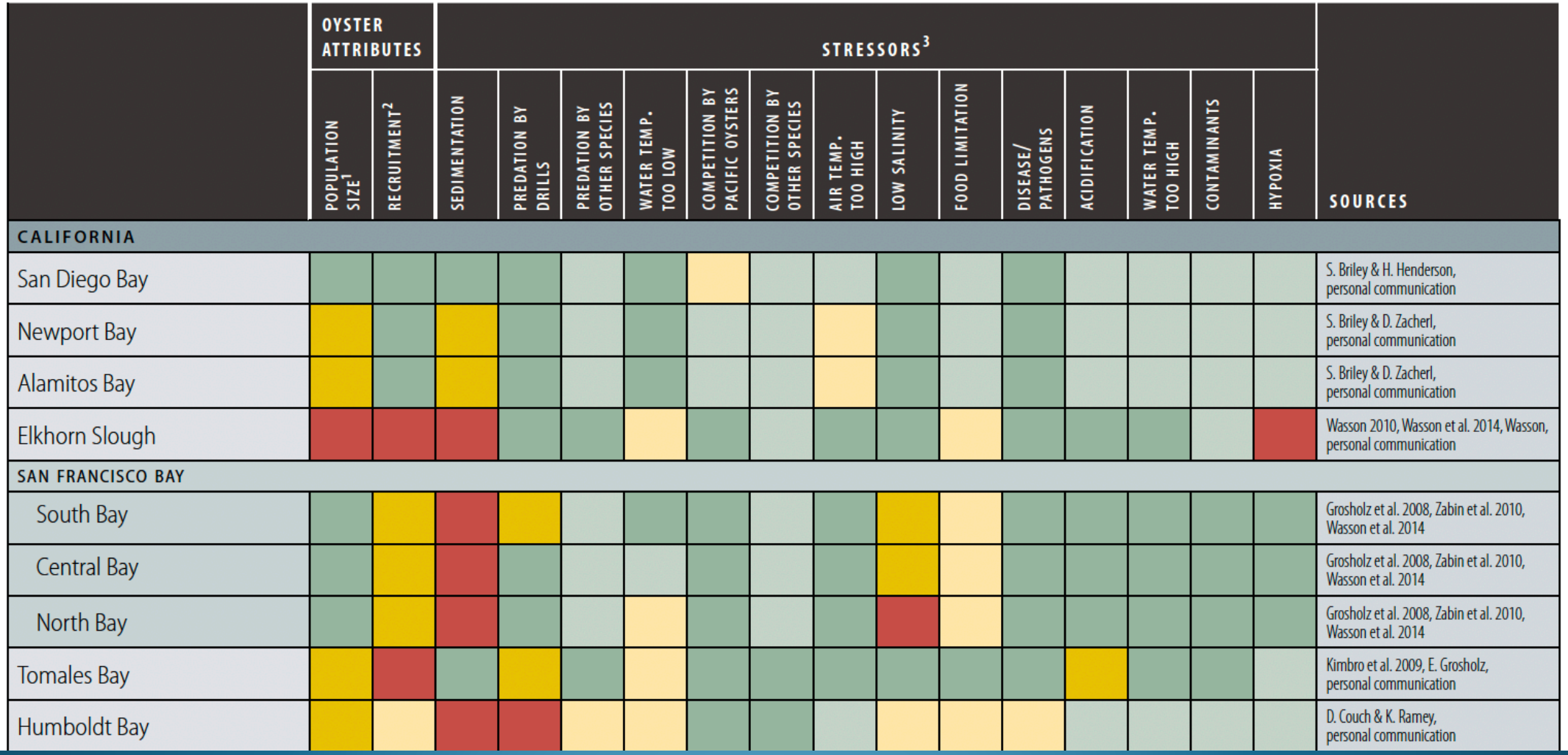


Photo: Chela Zabin (SERC)

Table 1: Synopsis of Oyster Population Attributes and Stressors Across Range of Olympia Oyster



	OYSTER ATTRIBUTES		STRESSORS[3]														SOURCES
	POPULATION SIZE[1]	RECRUITMENT[2]	SEDIMENTATION	PREDATION BY DRILLS	PREDATION BY OTHER SPECIES	WATER TEMP. TOO LOW	COMPETITION BY PACIFIC OYSTERS	COMPETITION BY OTHER SPECIES	AIR TEMP. TOO HIGH	LOW SALINITY	FOOD LIMITATION	DISEASE/ PATHOGENS	ACIDIFICATION	WATER TEMP. TOO HIGH	CONTAMINANTS	HYPOXIA	
CALIFORNIA																	
San Diego Bay																	S. Briley & H. Henderson, personal communication
Newport Bay																	S. Briley & D. Zacherl, personal communication
Alamitos Bay																	S. Briley & D. Zacherl, personal communication
Elkhorn Slough																	Wasson 2010, Wasson et al. 2014, Wasson, personal communication
SAN FRANCISCO BAY																	
South Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
Central Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
North Bay																	Grosholz et al. 2008, Zabin et al. 2010, Wasson et al. 2014
Tomales Bay																	Kimbro et al. 2009, E. Grosholz, personal communication
Humboldt Bay																	D. Couch & K. Ramey, personal communication

Major Environmental Limitations for Oyster Restoration in SF Bay

- Lack of available substrate
- Variable annual recruitment
- Competition for space
- Extreme events including:
  - Low salinity
  - Heatwaves
- Predators

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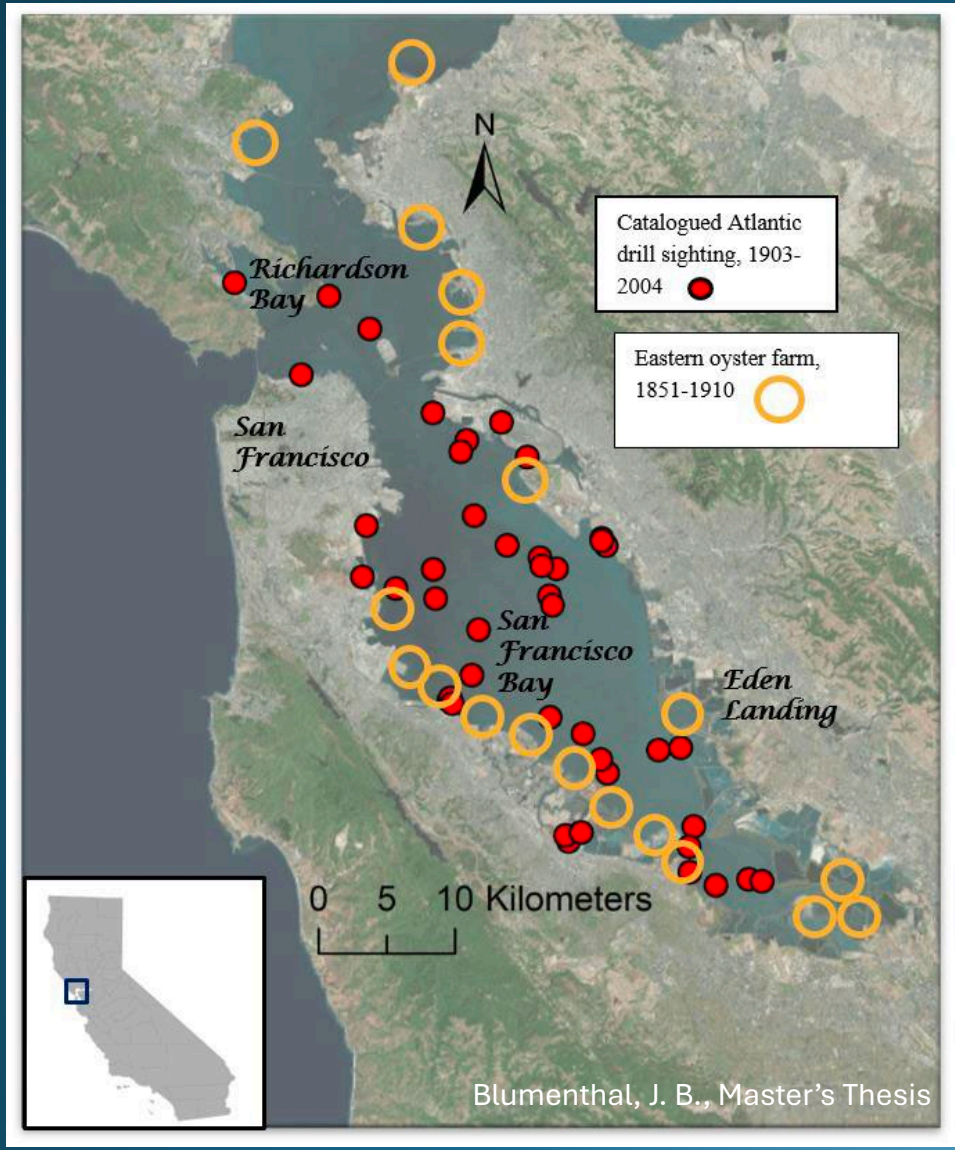


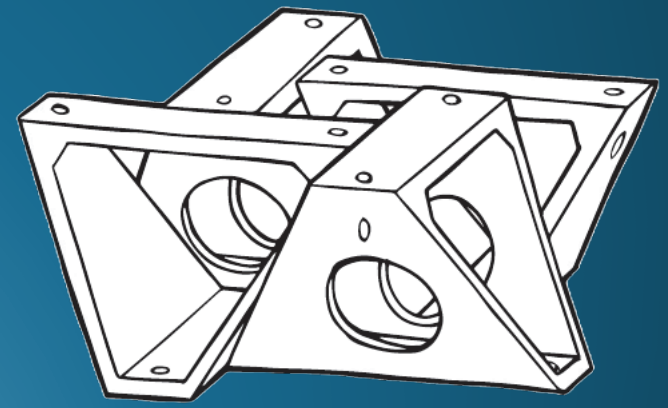
- Atlantic Oyster Drill, *Urosalpinx cinarea*
- Estuarine snail introduced with oyster aquaculture in late 1800s
- Overwhelming predator of oysters, prior attempts to remove from sites have failed
- Current push to better understand reef organism dynamics
  - Rock crabs (cancrid spp.) are a known predator of oyster drills

Research Question

How does the porosity (openness) of an oyster reef structure affect reef-associating organisms?

Reef Design Innovations for Living Shorelines Project

- State Coastal Conservancy funded
- Community constructed, EOS and SERC collaborative monitoring effort
- 9 reef elements installed at each of 3 sites in SF Bay
- Modular with varying porosity configurations



Four Experiments!

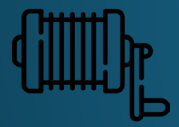
Abiotic Reef Characteristics

1. Reef Flow Assay – Dissolution Blocks

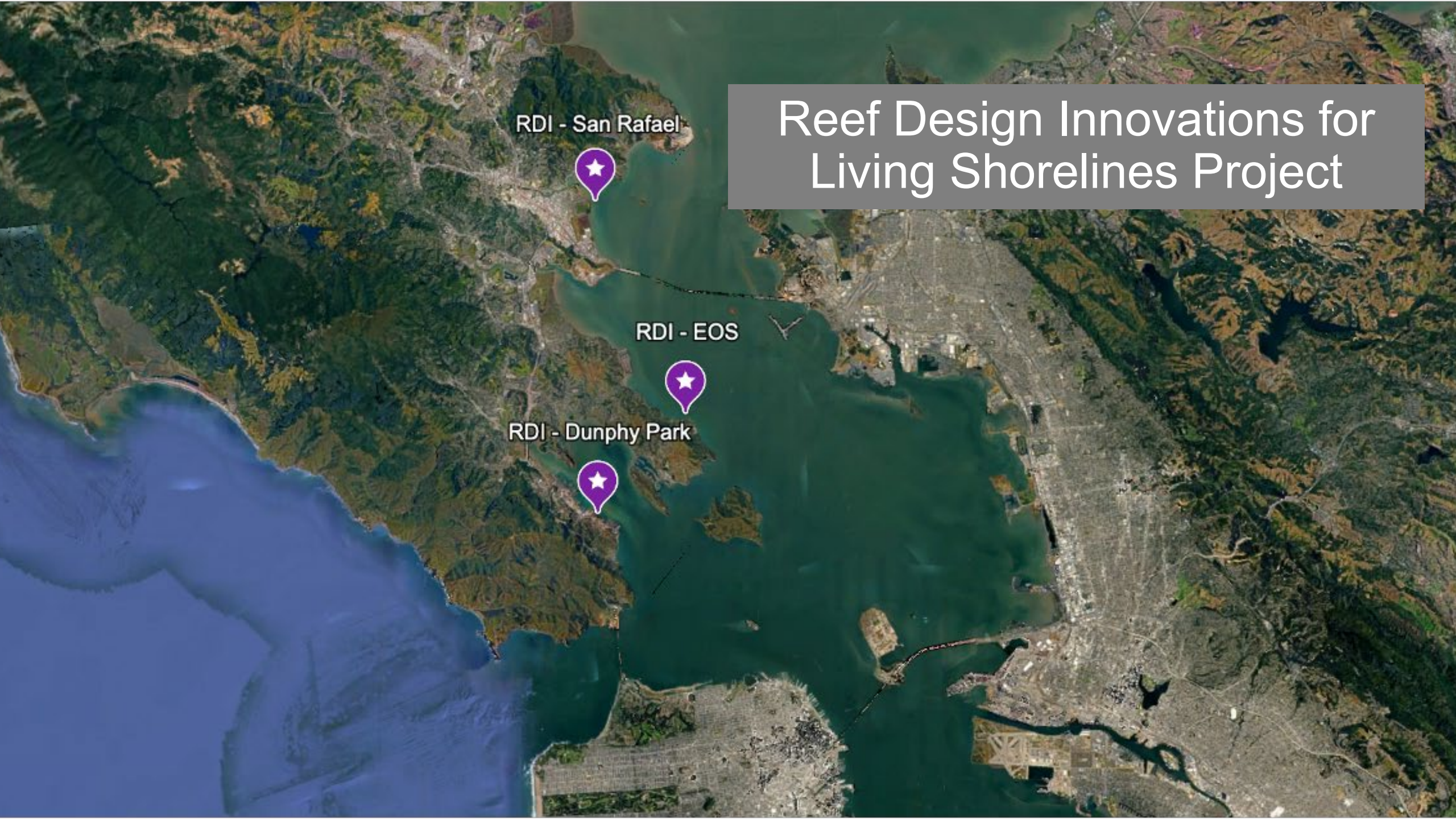
Biotic Reef Characteristics

2. Sessile Species – Quadrat Monitoring

3. Mobile Species – Crab Penning Experiment



4. Predation - Crab Tethering Experiment



Reef Design Innovations for Living Shorelines Project

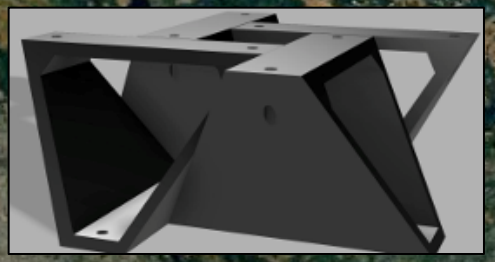
Reef Design Innovations for Living Shorelines Project

RDI - San Rafael

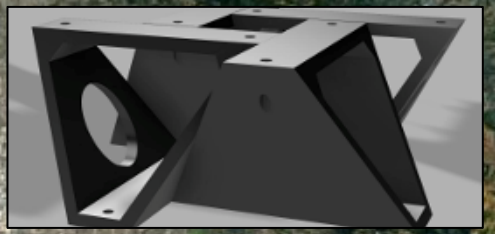
RDI - EOS

RDI - Dunphy Park

Low



Medium



High


High
Low
Medium

Four Experiments!

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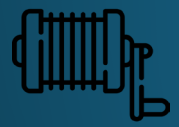

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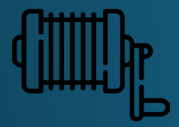

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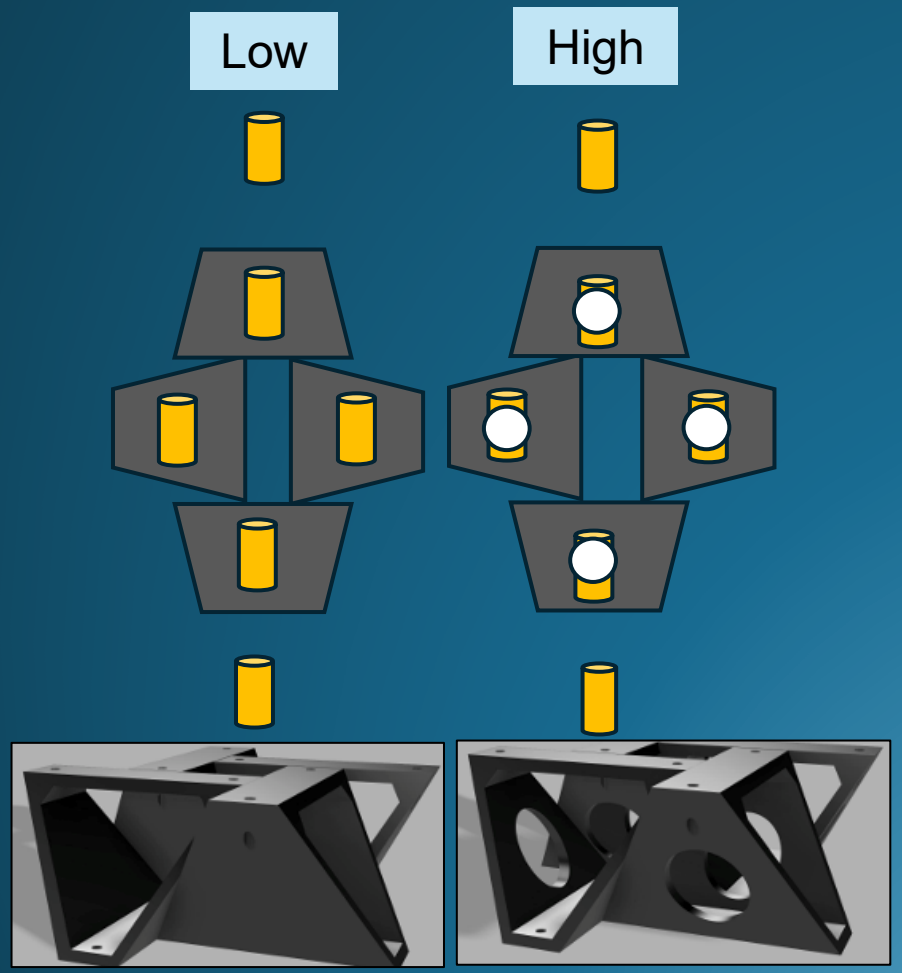
Hypothesis

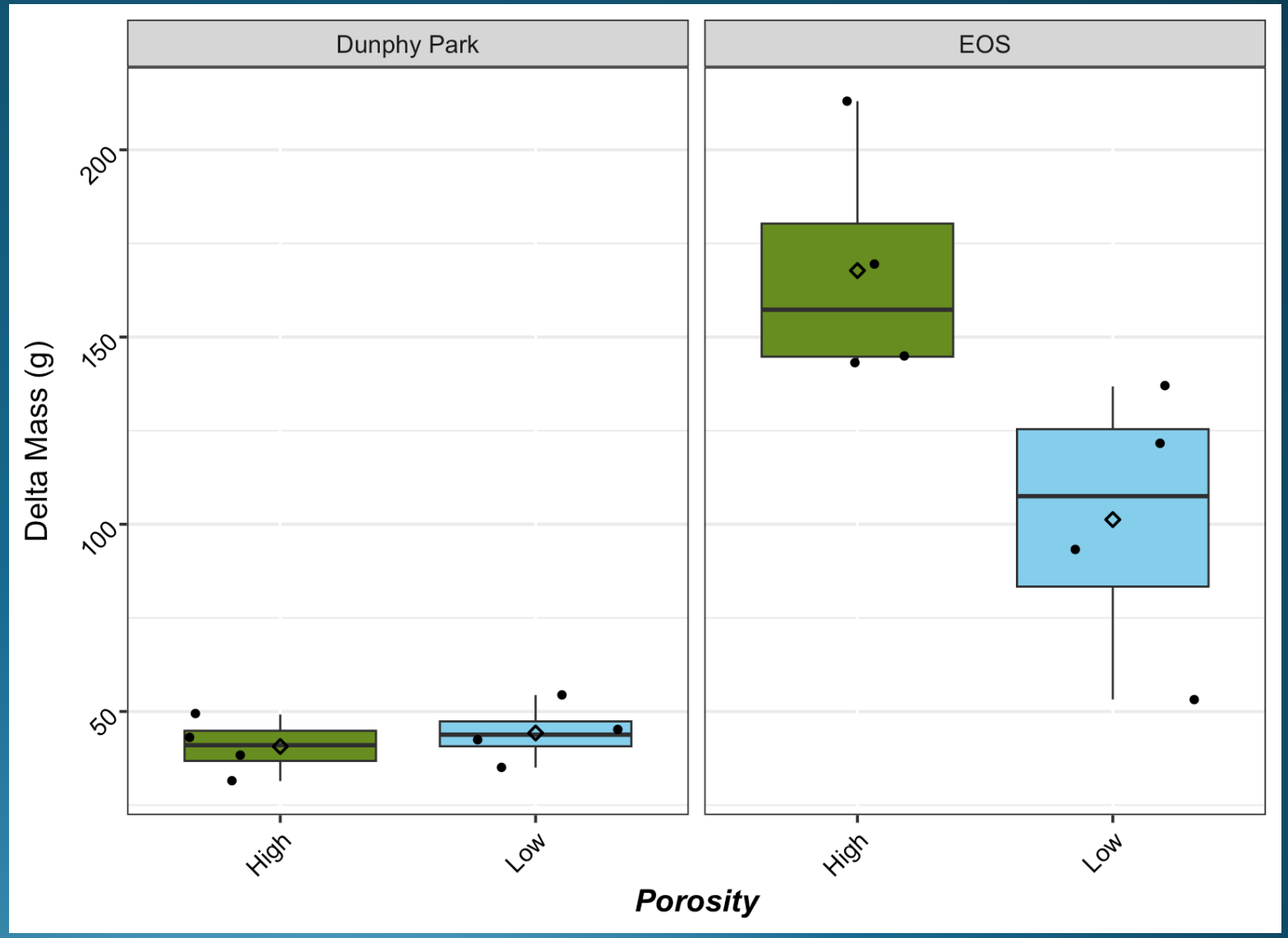
Q: Does the porosity (relative openness) of a reef affect wave energy inside the reef?

- ***H***: The interiors of higher porosity reefs will experience greater wave energy

Methods – Exp 1: Dissolution Blocks



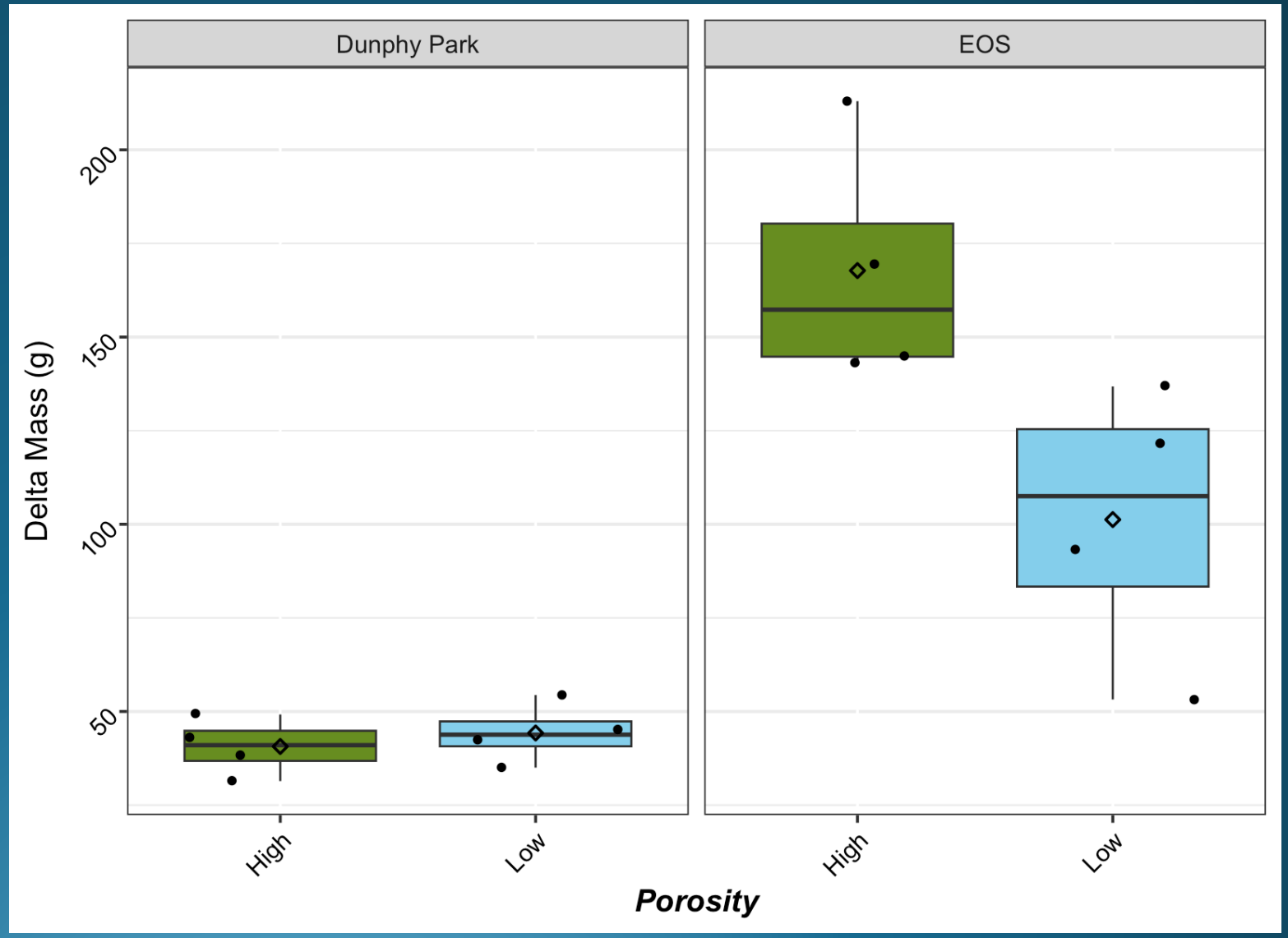
Methods – Exp 1: Dissolution Blocks



Methods – Exp 1: Dissolution Blocks

- High wave energy site showed greater block dissolution in more-open reefs

- No trend between reef types in temperature, light intensity, and block dissolution in front or behind the reef



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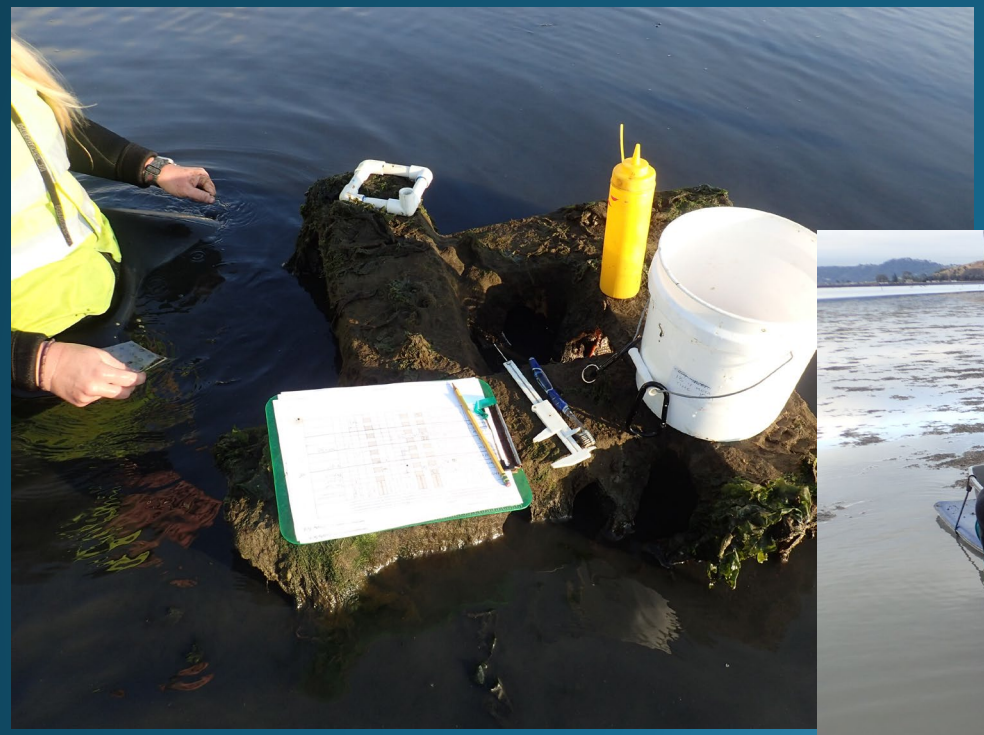
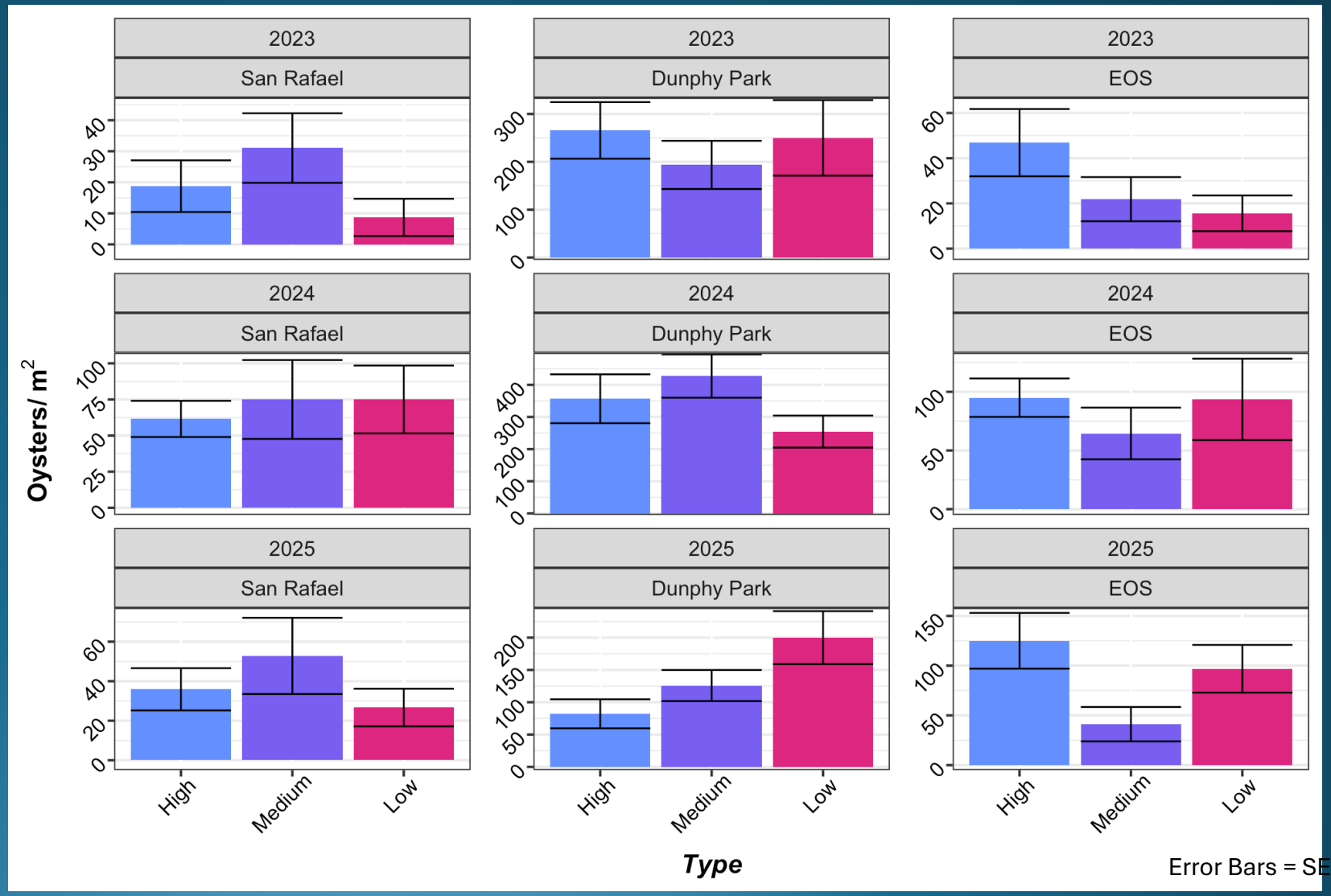
RDI Research Question

Does the porosity (relative openness) of a reef affect sessile organism recruitment?

Methods: Quadrat Monitoring



Results: Quadrat Monitoring



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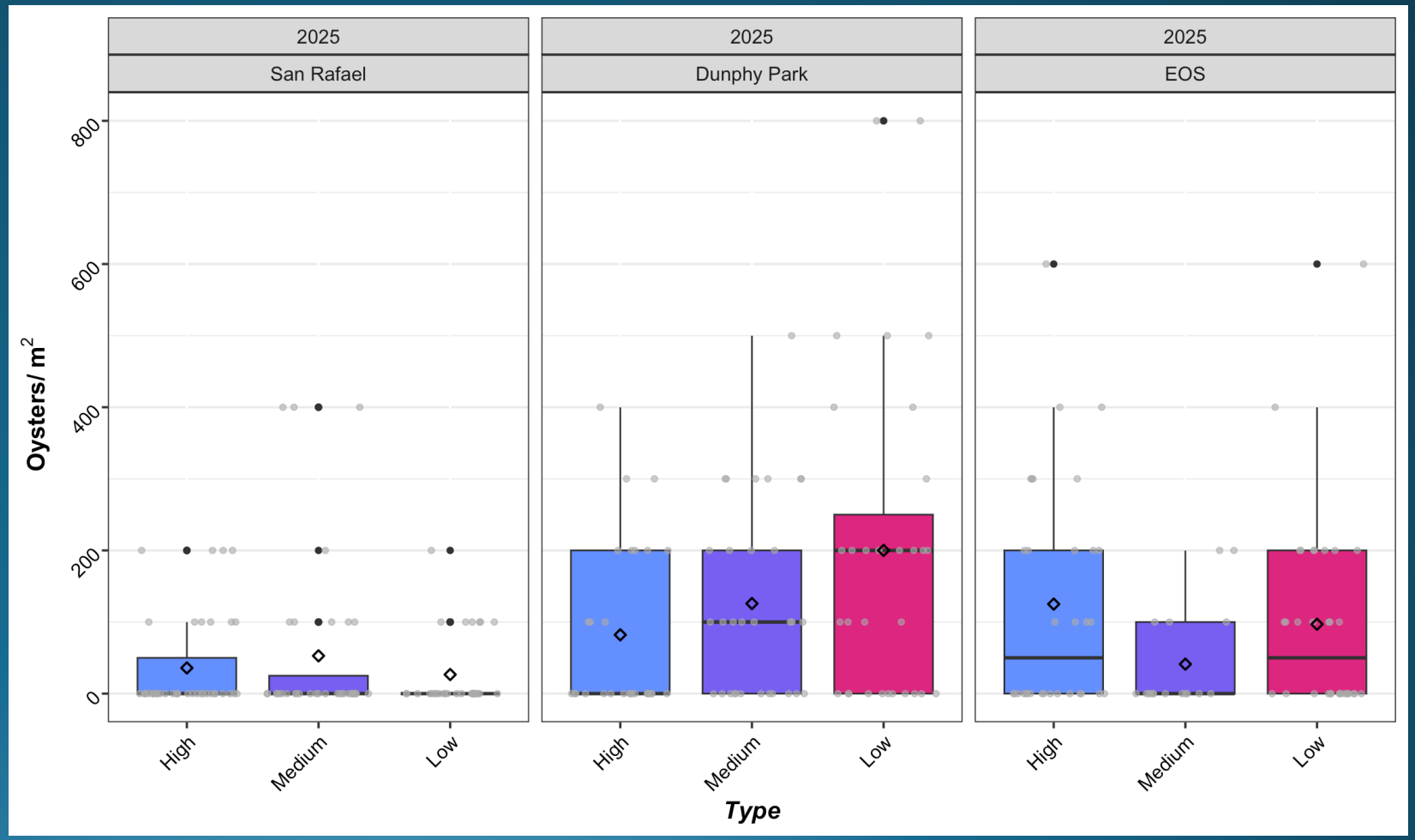
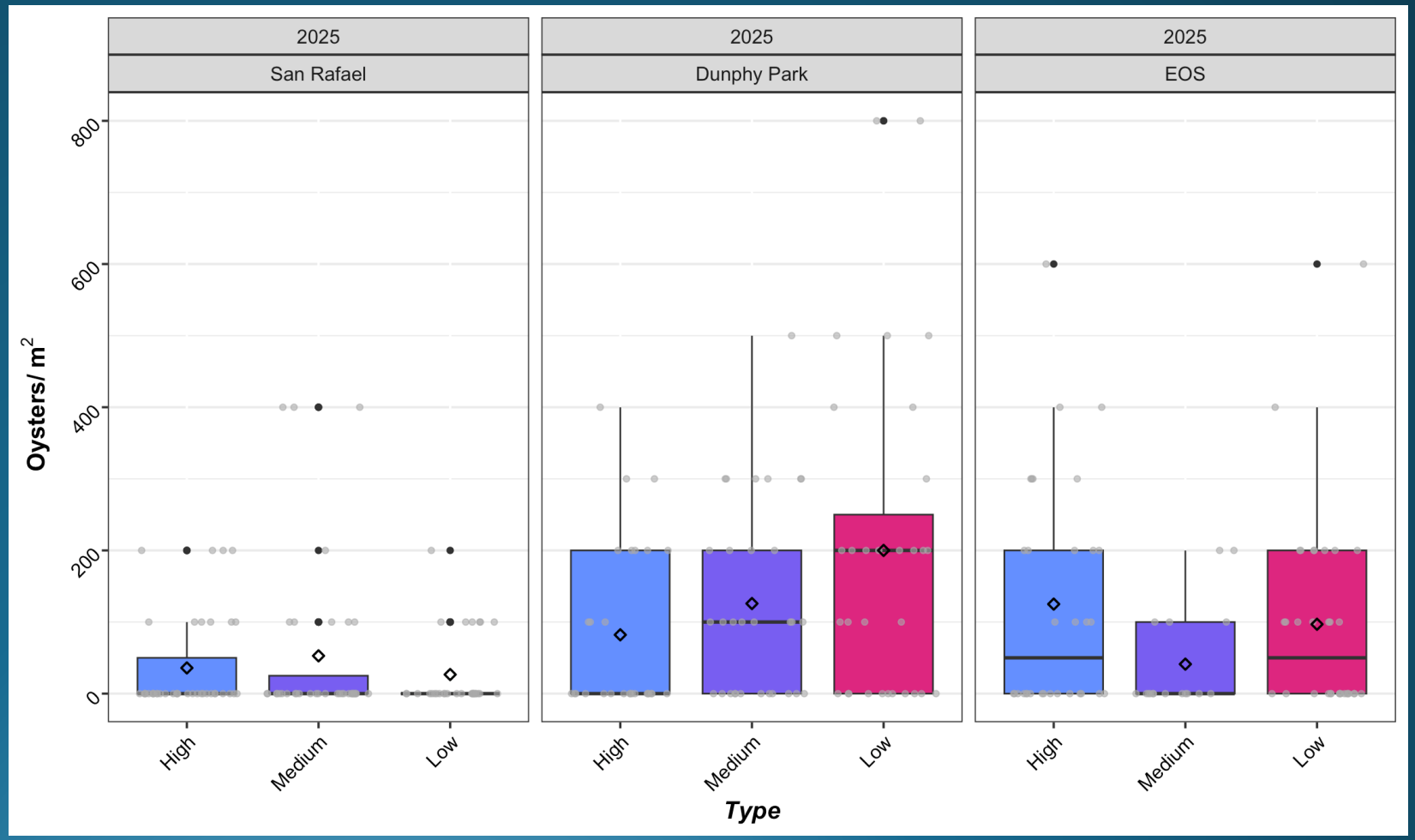
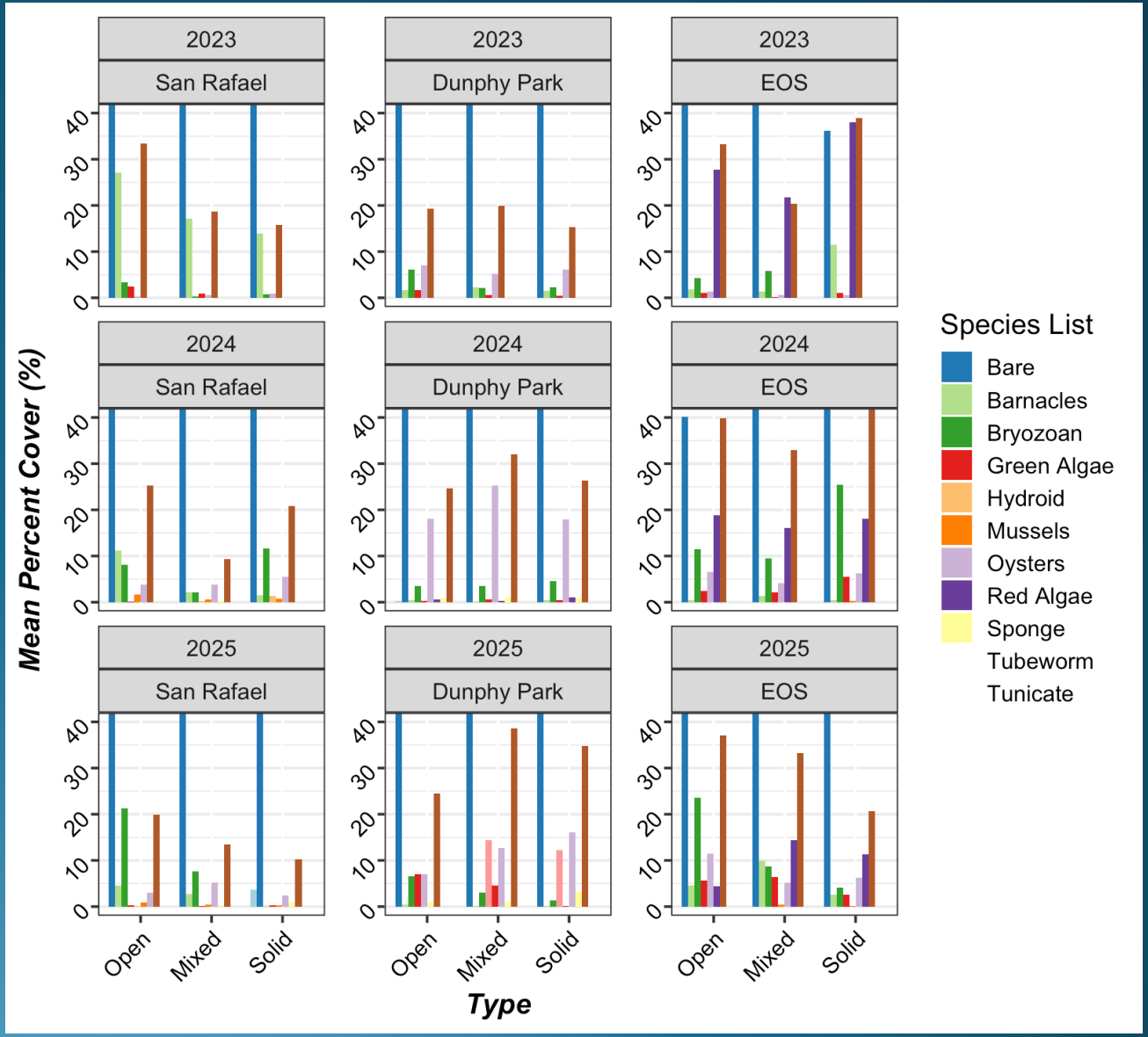


Results: Quadrat Monitoring

- Oyster recruitment varied by site
- All reef designs recruited oysters
- Oyster densities similar or higher than natural populations

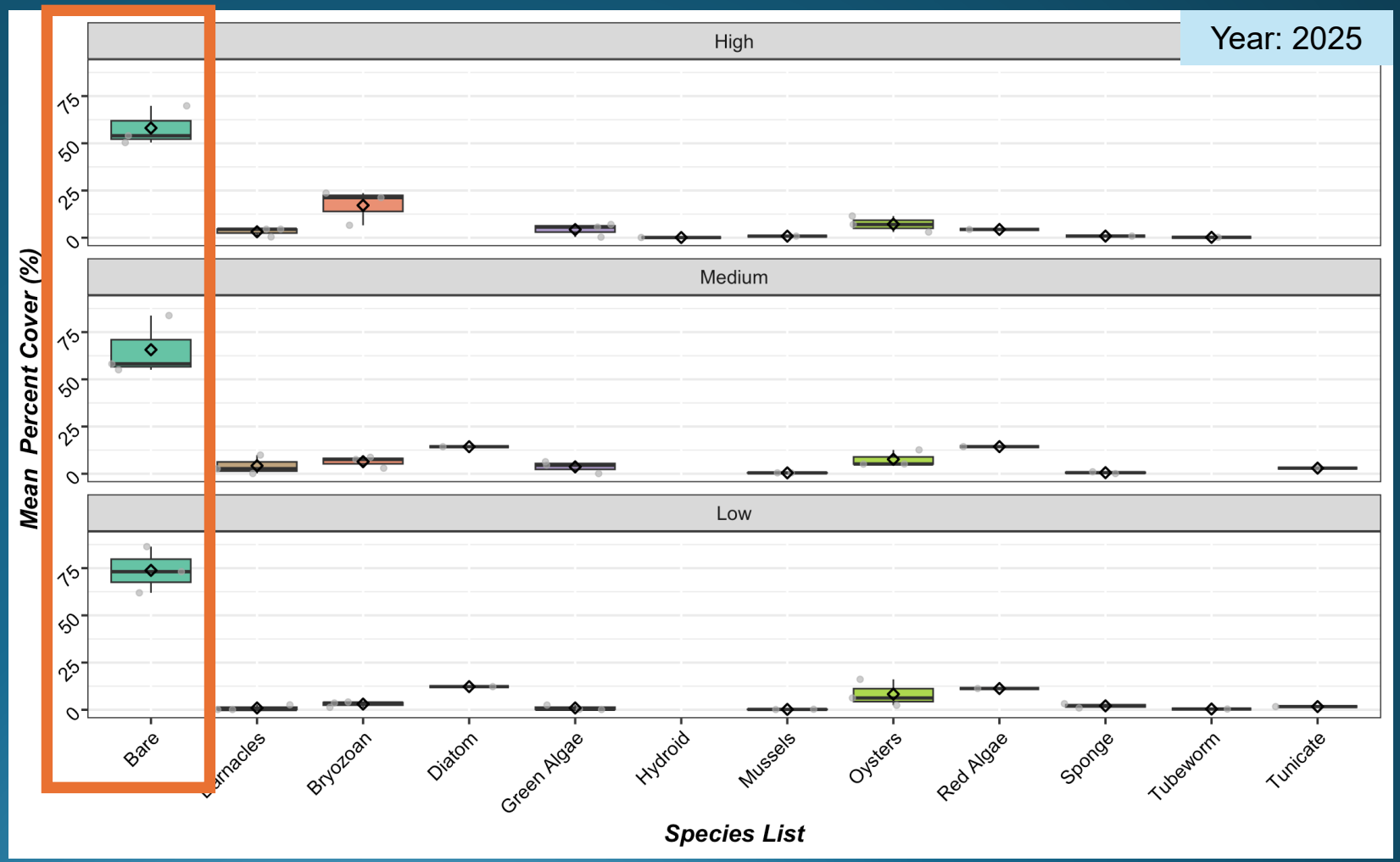


Results: Quadrat Monitoring



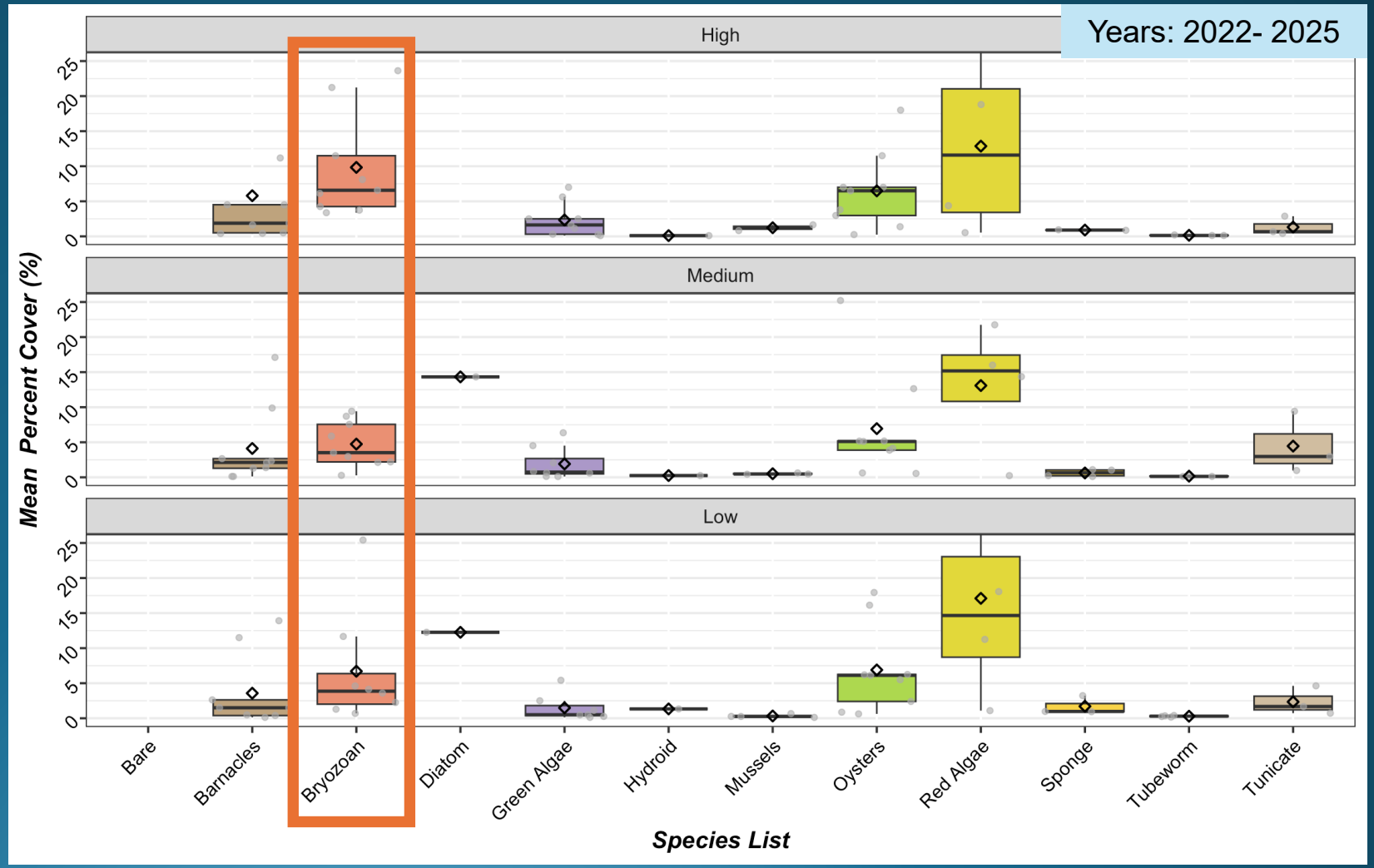
Results: Quadrat Monitoring

- 55-75% bare space, plenty of space for more native oyster recruitment
- Reefs not overrun by non-native species cover



Results: Quadrat Monitoring

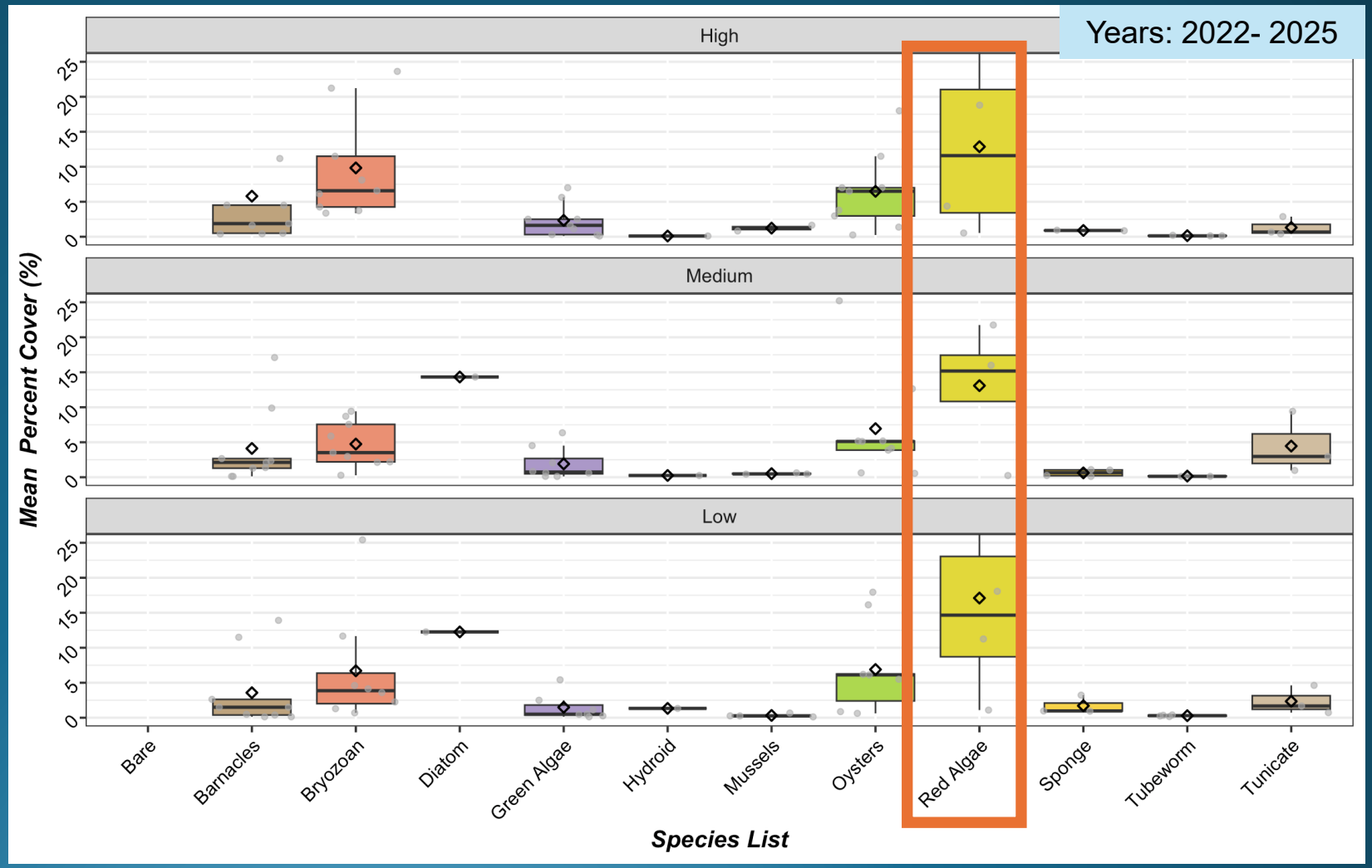
- Bryozoans only notable non-native species on reefs
- Less than 10% cover on average



Results: Quadrat Monitoring

- Red algae (native) are the other abundant (10-20%) non-focal sessile organism on the reefs

- Native species cover exceeds non-native cover



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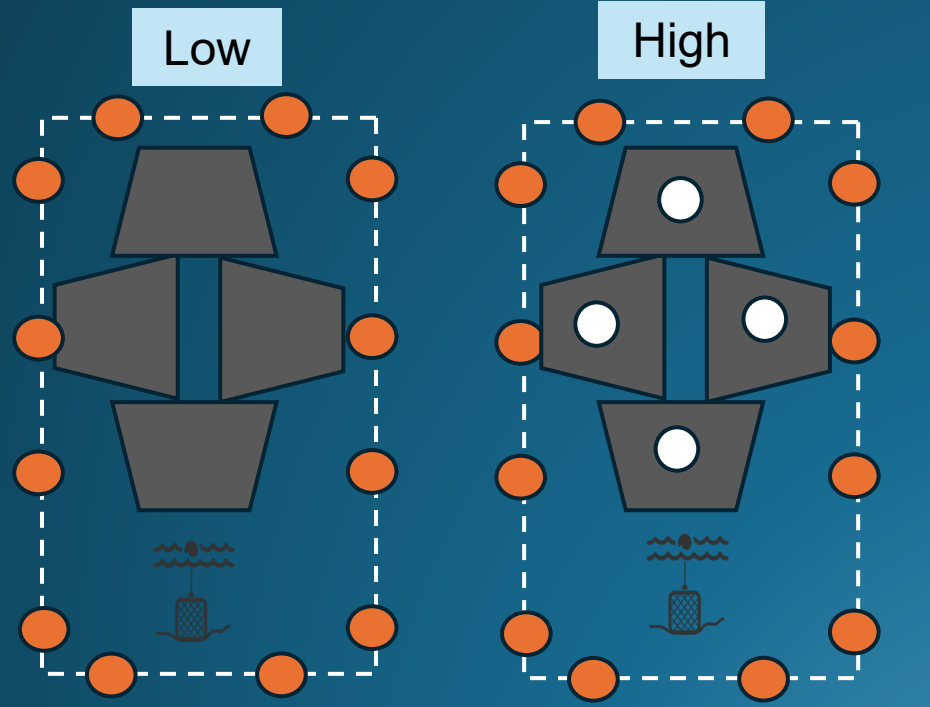
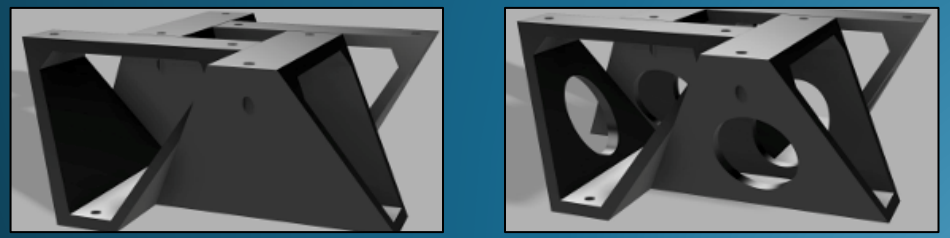
Hypothesis

Q: Does the porosity (relative openness) of a reef impact crab usage?

- ***H***: Crabs will associate to less-porous reef structures, perhaps through increased refugia from reef shading and cover

Methods: Crab-Porosity Association





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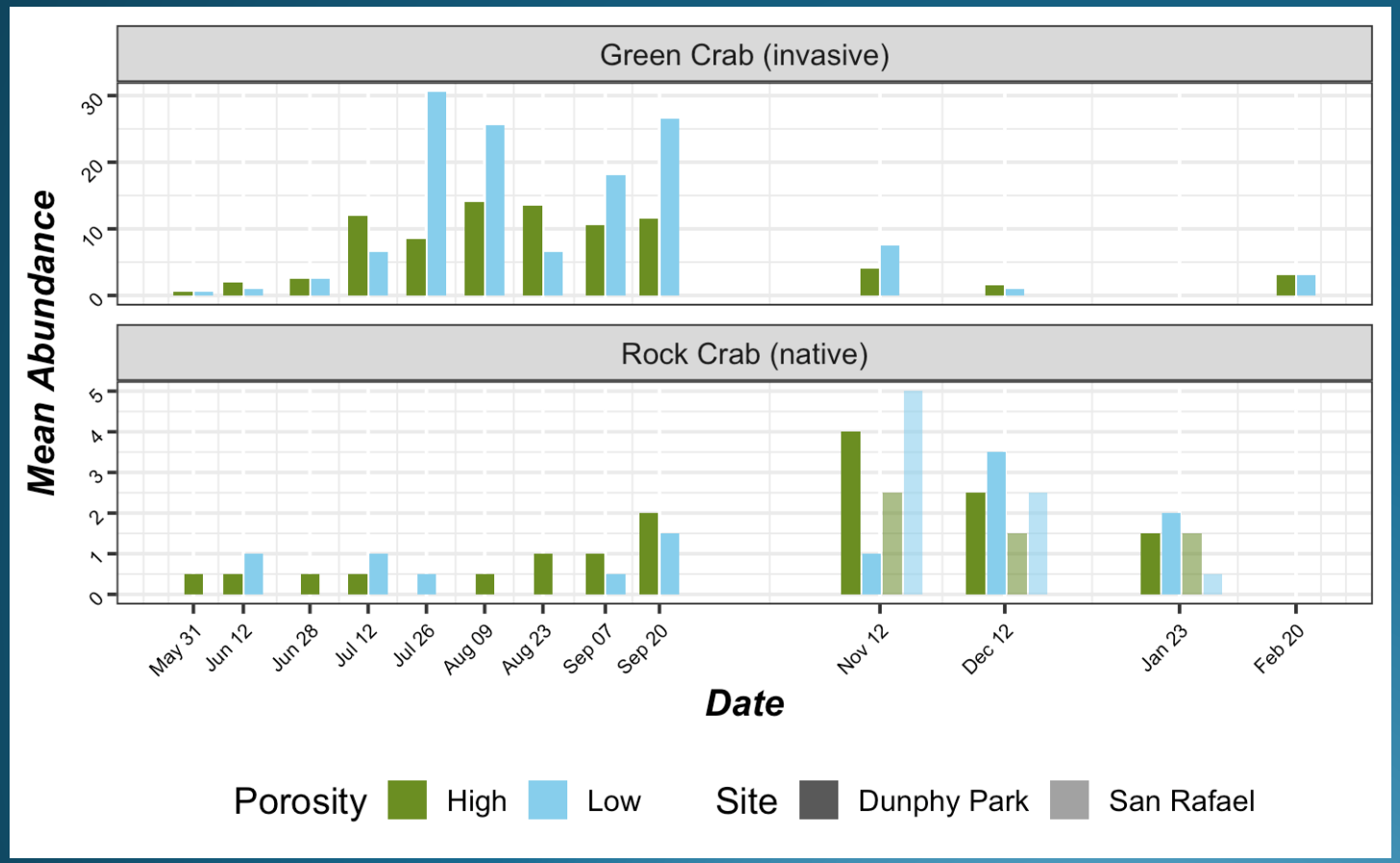

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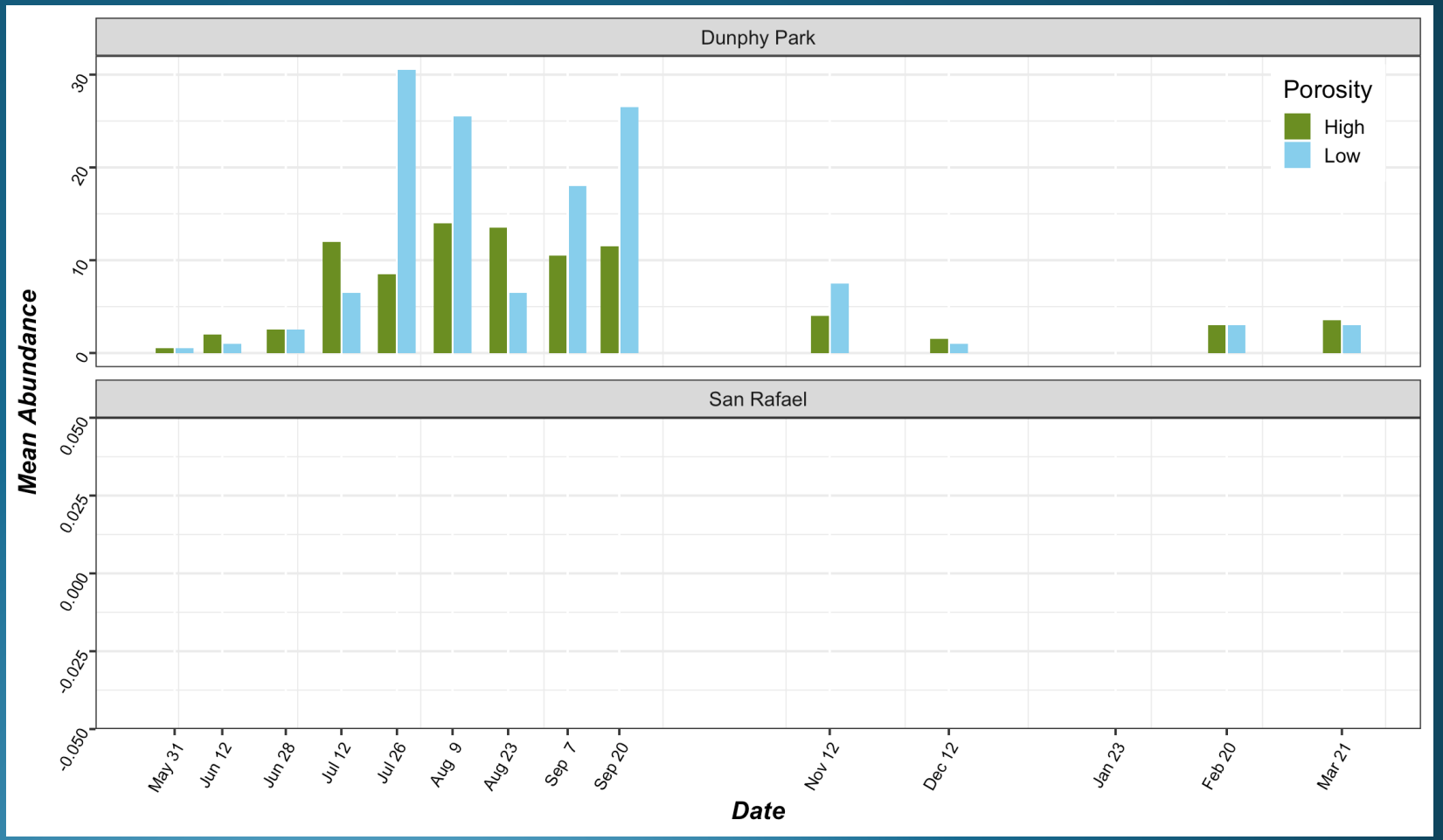

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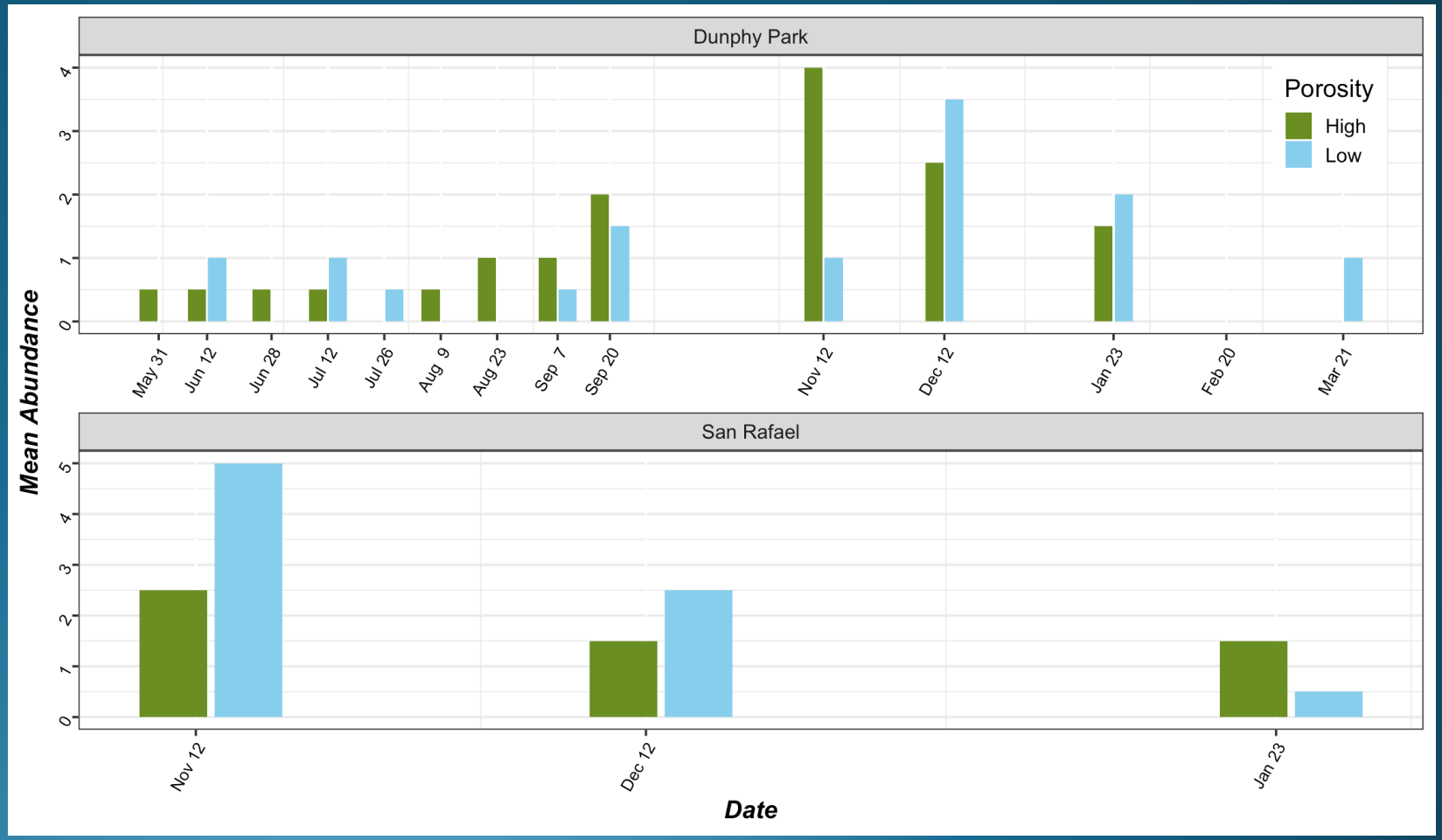

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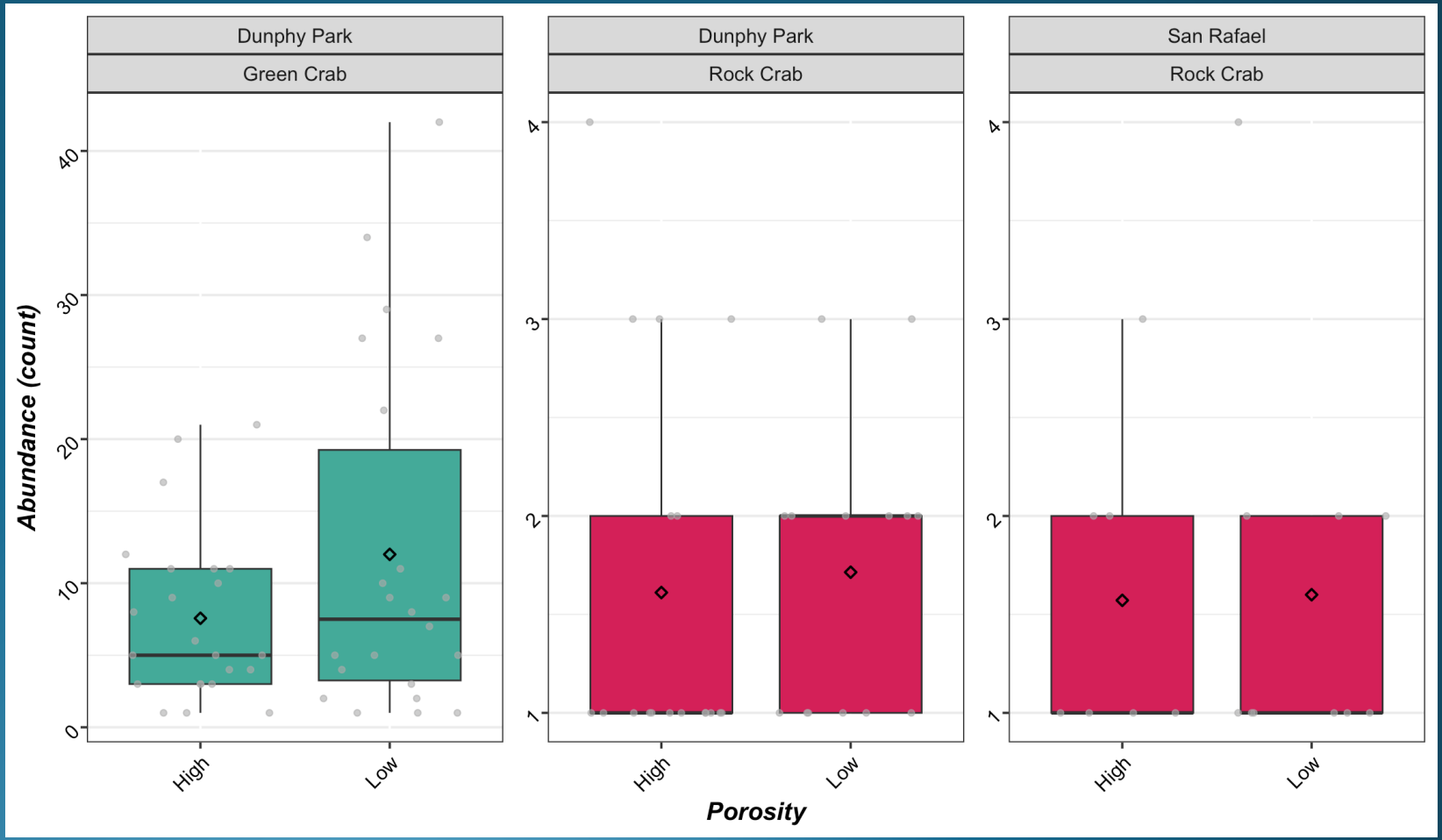
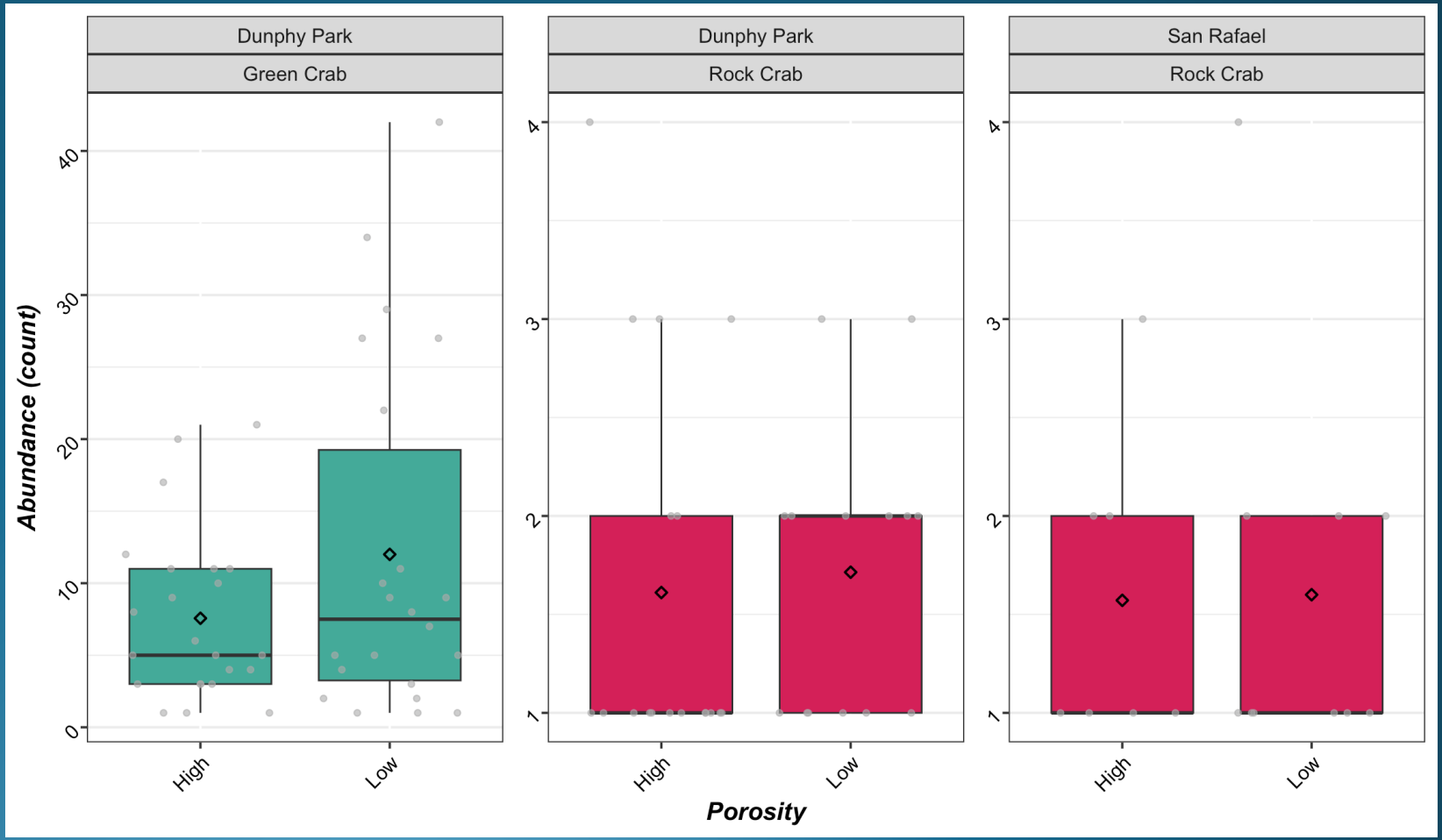


Results: Crab-Porosity Association

- Trend in green crabs associated with more-closed reefs at Dunphy Park
- No trend in rock crab association to reef types



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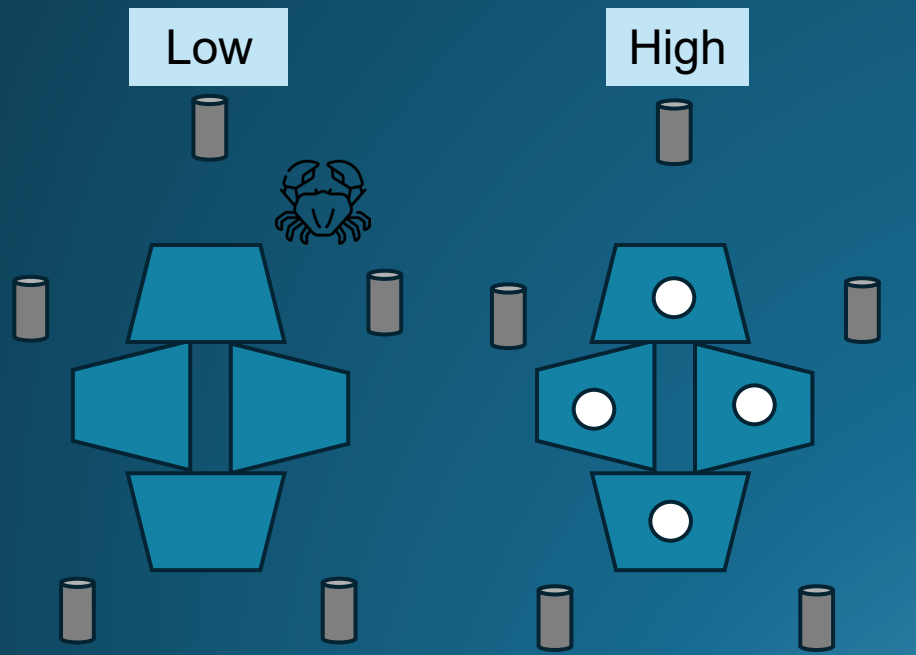
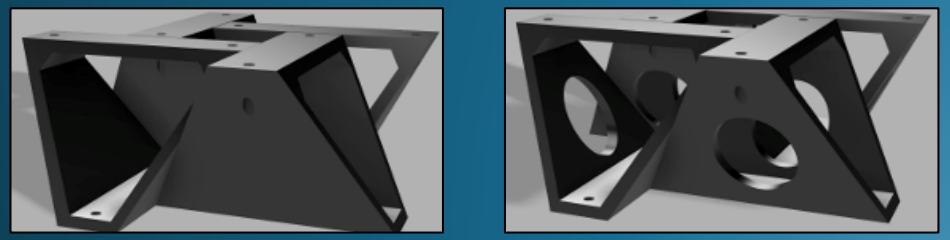
Hypothesis

Q. Does the porosity (relative openness) of a reef affect crab predation?

- *H*: Crabs will experience higher predation rates on higher porosity reefs, possibly due to decreased refugia from reef cover

Methods: Crab Tethering





Methods: Crab Tethering

Results: Crab Tethering

- Minimal predation of green crabs overall
- No difference between reef porosities

Conclusions

Research Question: How does the porosity (openness) of an oyster reef structure affect reef-associating organisms?

More-open (higher porosity) reefs had:

- Greater plaster dissolution (higher flow) at the high energy site

- Trend of lower abundance of non-native green. (No difference in native rock crabs)

No difference in the focal species (native Olympia oyster), no patterns in other sessile species observed with respect to reef porosity

Management Implications

- Reef designs could be tailored to the site (wave energy, local taxa) or aimed at recruitment of specific organisms along with oysters
- More open reefs may be better choice overall for fewer non-native green crabs
- All the designs can be used to support abundant native oysters; non-native species never excluded oysters, given abundance of bare space
- Reef designs that foster rock crab association should be further explored at oyster drill impacted sites in future restoration projects

Acknowledgements

Coastal Conservancy

mcf Marin Community Foundation

EOS center

Smithsonian Environmental Research Center

Maxwell | Hanrahan FOUNDATION

COAST

NSF

STUDIO FOR URBAN PROJECTS

CONSERVATION CORPS NORTH BAY
A path to a better future.

Images: Boyer Lab, Chela Zabin

Questions?