

Effects of tide pool size and elevation on purple sea urchin abundance and reproductive health

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Purple Sea Urchins (*Strongylocentrotus purpuratus*)

- Phylum: Echinodermata
- Diet: Brown and green algae and decayed matter
- Symmetry: Pentaradial
- The test is covered with tube feet and purple spines
- Gas exchange through tube feet
- Five teeth-like plates make up the "Aristotle's lantern"
- An urchin uses its teeth and spines to dig pits in rocky substrates.



Observations

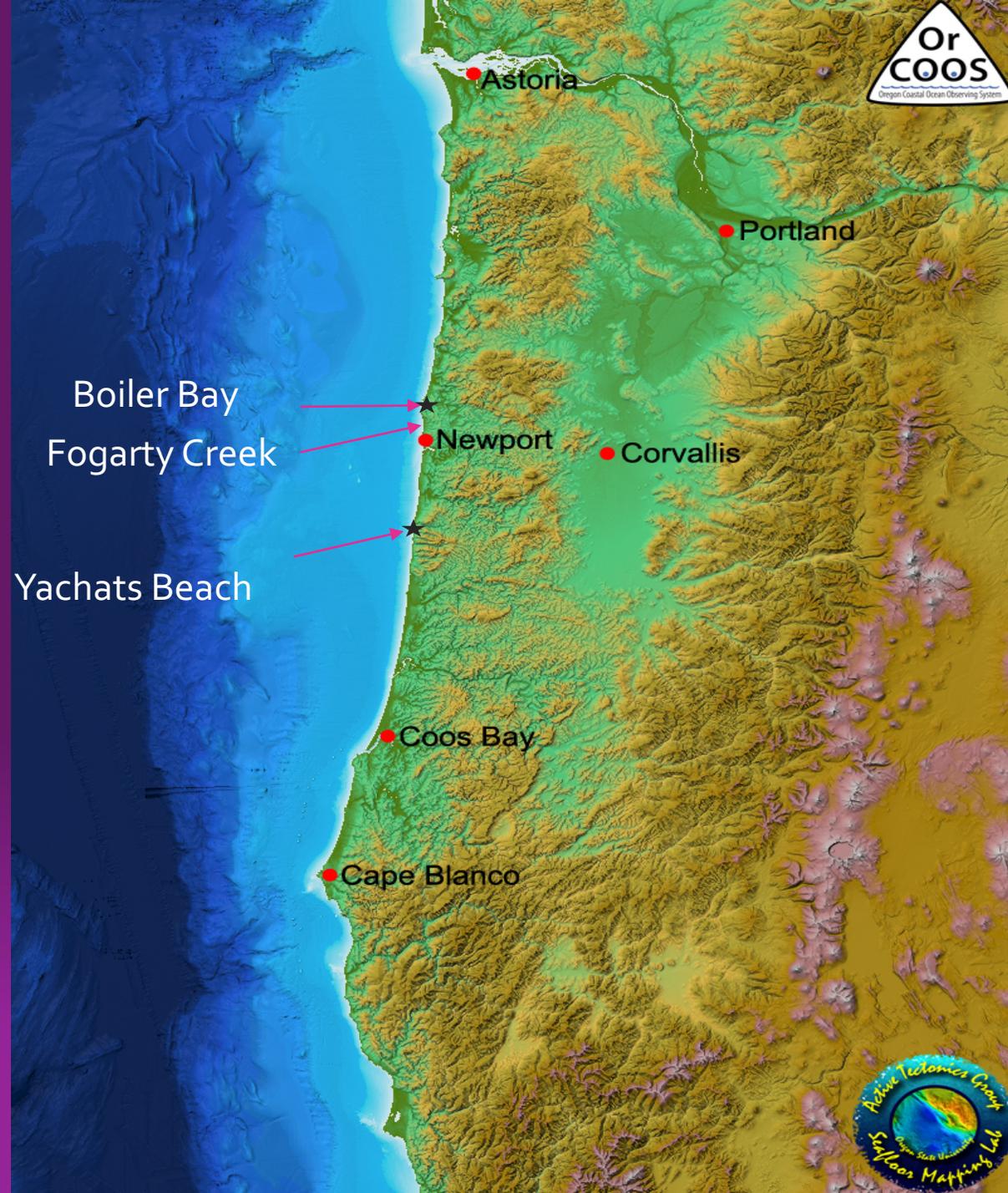
- While in the field, we noticed most urchins were in low intertidal pools.
- We also realized that since they inhabit tide pools, they are at less risk of desiccation, even if they were in high pools.
 - Physical factor fluctuations are lessened in tide pools, allowing some organisms to extend their range to the high intertidal (Metaxas and Scheibling 1993).
- During low tide, small tide pools are expected to rise in temperature and become more saline due to evaporation.
 - Urchins are temperature sensitive (Harvell et al. 2002)
- We wondered what influences the health and abundance of urchins between tide pool elevation.
- Calculating gonad index is a simple way to measure reproductive health (Conor 1972).



Hypotheses

1. *S. purpuratus* found in tide pools with a surface area larger than 1.5m^2 will exhibit higher gonadal indices than *S. purpuratus* in tide pools with a surface area smaller than 1.5m^2 .
2. *S. purpuratus* will be more abundant and have greater gonad index in low elevation tide pools.
3. Gonad indices and abundance will be higher on Cape Foulweather than Cape Perpetua.
4. Pools with a higher abundance of *S. purpuratus* and increased intraspecific competition will limit the growth of *S. purpuratus* thus smaller individuals will make up the populations of these pools.

Sites



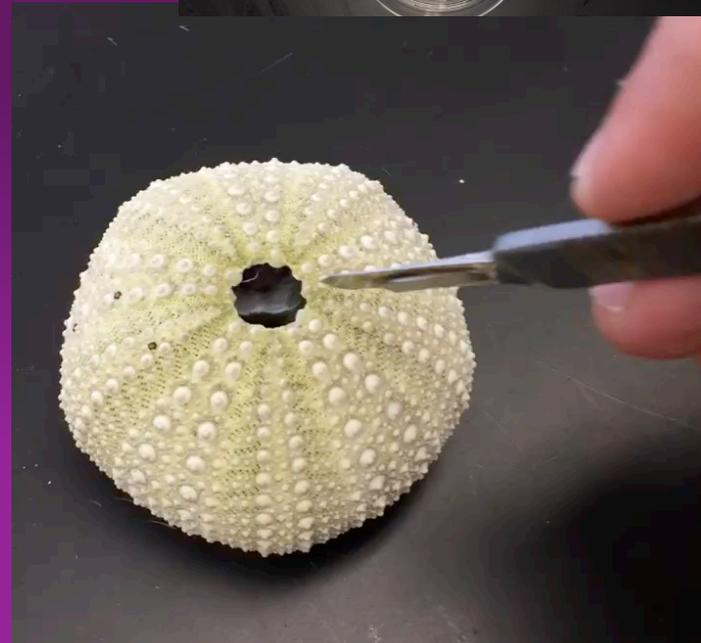
Field Methods



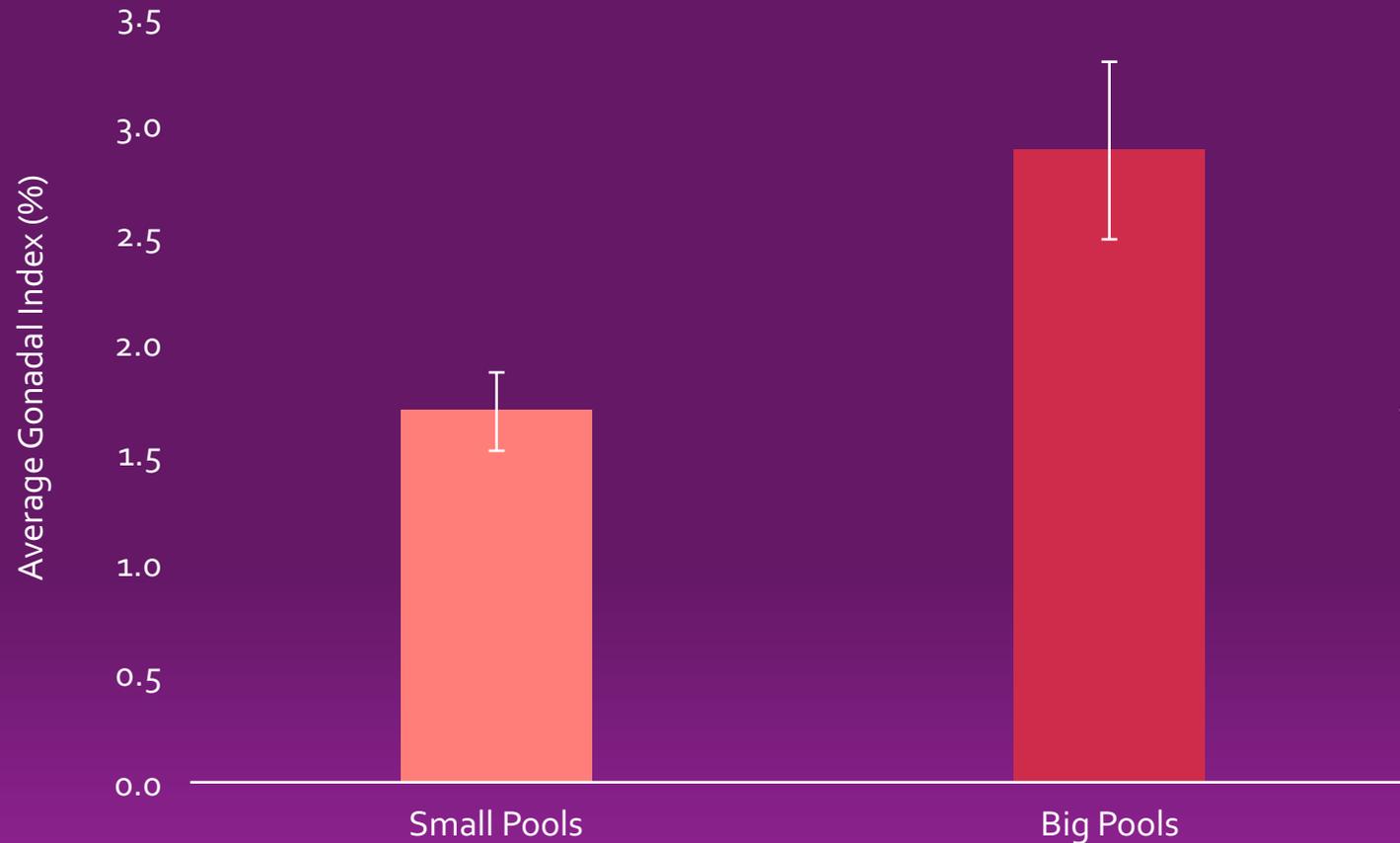
- Sampled on two capes: Cape Perpetua and Cape Foulweather
 - Cape Perpetua: Yachats Beach (YB)
 - Cape Foulweather: Boiler Bay (BB) and Fogarty Creek (FC)
- We sampled five small tide pools and five large tide pools in the low and high intertidal
 - For a total of: 10 high, 10 low, and 20 pools per site (if present)
- In each tide pool, we measured/recorded:
 - Surface area (m²)
 - Depth (cm)
 - Purple urchin abundance
 - At end of low tide we measured the salinity and temperature of each tide pool
 - We collected one average sized urchin from each pool

Laboratory Methods

- Weighed all urchins
- Removed spines
- Measured test diameter
- Dissected urchins to remove gonads
- $GI = \text{gonad weight} / \text{urchin's total weight}$



Hypothesis 1 Results



Average gonadal index by percent body mass of purple urchins in small ($< 1.5 \text{ m}^2$) and big ($> 1.5 \text{ m}^2$) tide pools across FC, BB, YB. (T-test: p-value= 0.011)

- Recap: We thought urchins in big pools would have a higher gonad index.
- Gonad index is higher in urchins found in big tide pools!

Hypothesis 1 Discussion

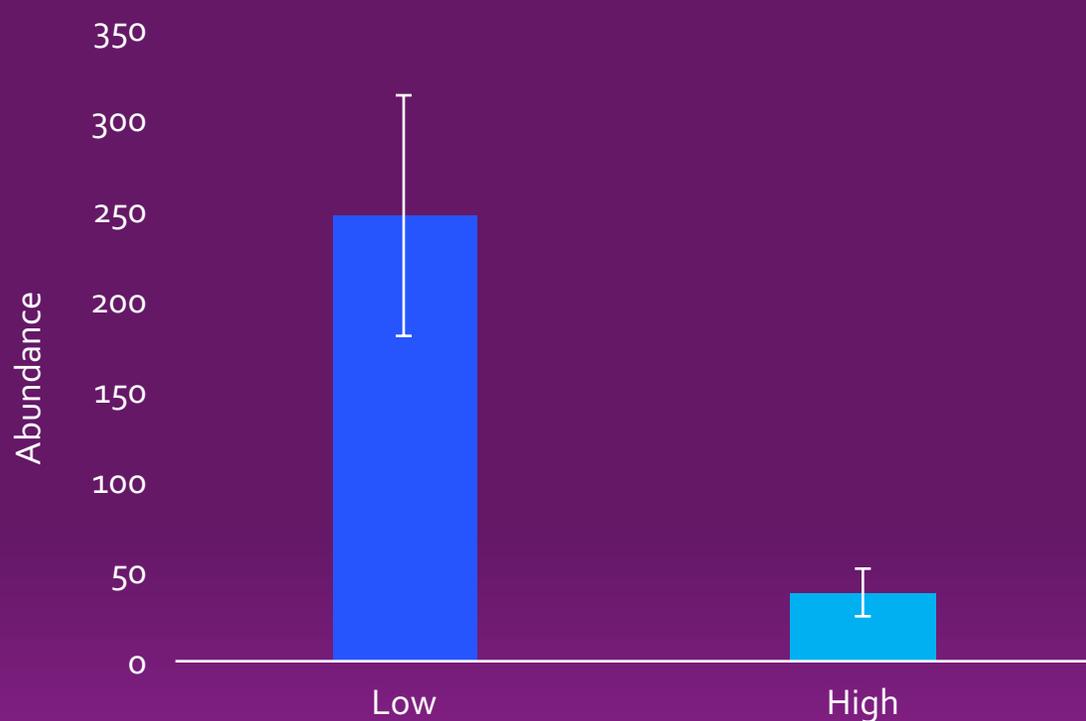
- Larger pools undergo smaller fluctuations in salinity and temperature while exposed.
 - Energy can be spent on metabolic and reproductive processes rather than on physiological coping mechanisms.



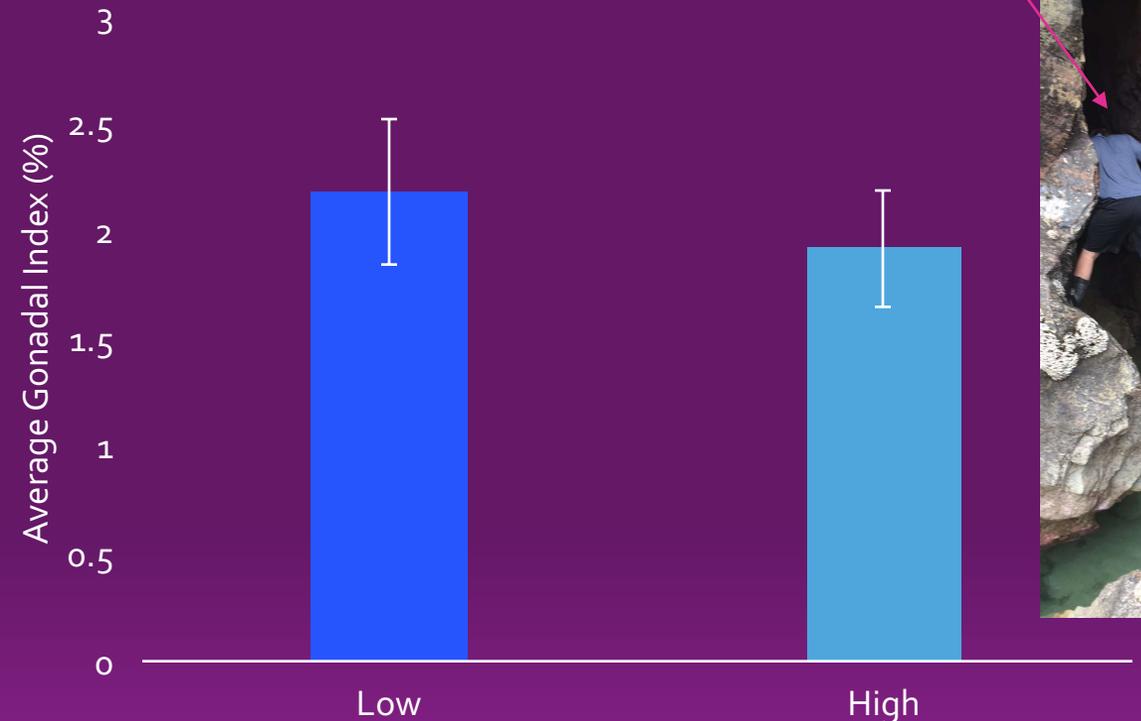
Hypothesis 2 Results

Searching for significance

- Recap: Urchins in low tide pools will be more abundant and have higher gonadal indices



Average abundance of purple urchins was significantly higher in low intertidal pools than in high elevation tide pools (T-test: p-value= 0.008).



The difference in the average gonadal index of purple urchins between low elevation and high elevation tide pools was determined to be statistically insignificant (T-test: p-value= 0.555).



Hypothesis 2 Discussion

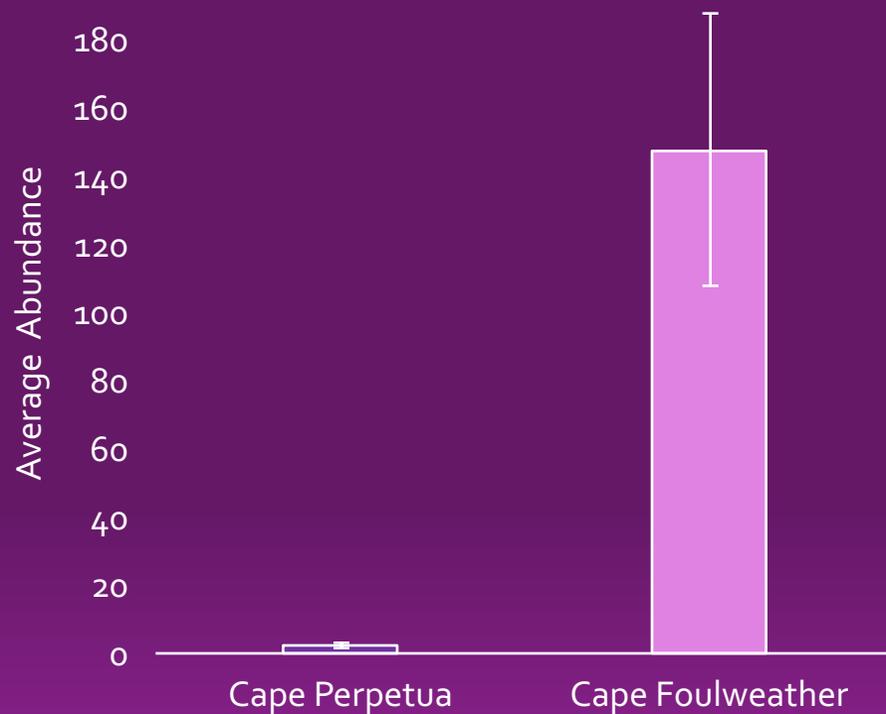
- Tide pool elevation explains purple urchin abundance
- Tide pool elevation does not explain GI
- Optimal living conditions in the low intertidal and subtidal habitats
 - High elevation pools are suboptimal
- Tide pools allow urchins to expand their range vertically
 - Escape competition
 - Escape predation
 - *Pycnopodia* (sunflower sea star) locally extinct



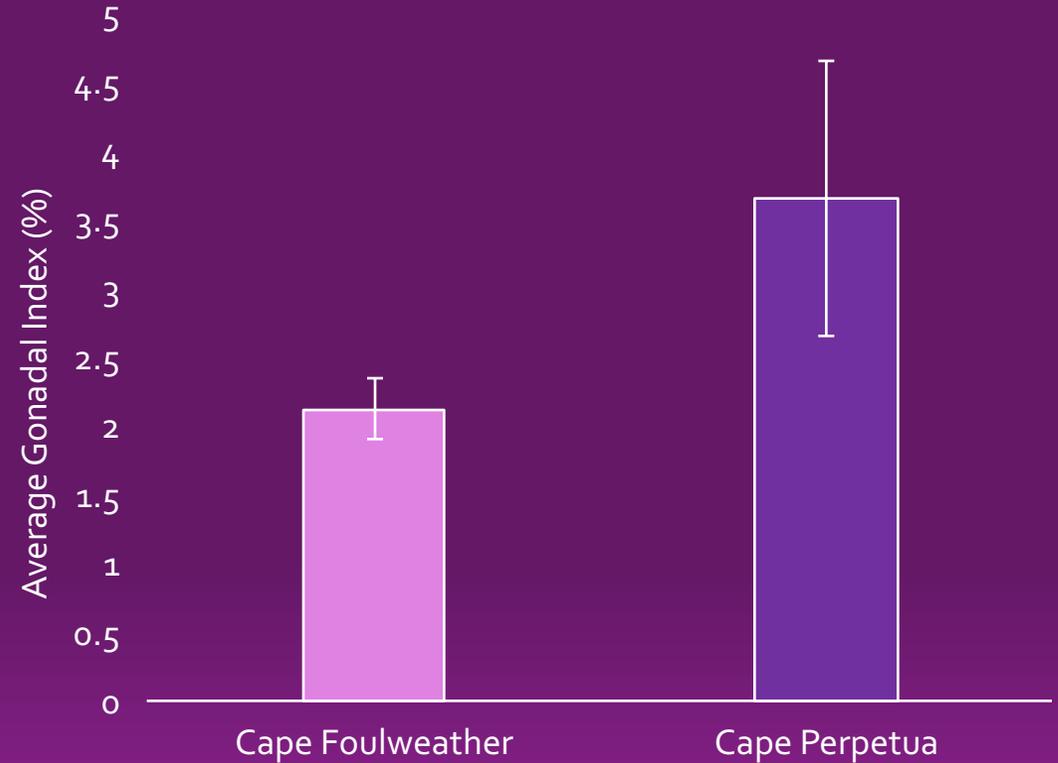
High tide pool at Fogarty Creek

Hypothesis 3 Results

➤ Recap: Cape Foulweather will have higher abundance and GI



At Cape Foulweather, purple urchin was significantly more abundant in tide pools than at Cape Perpetua. (T-test: p-value <0.001).



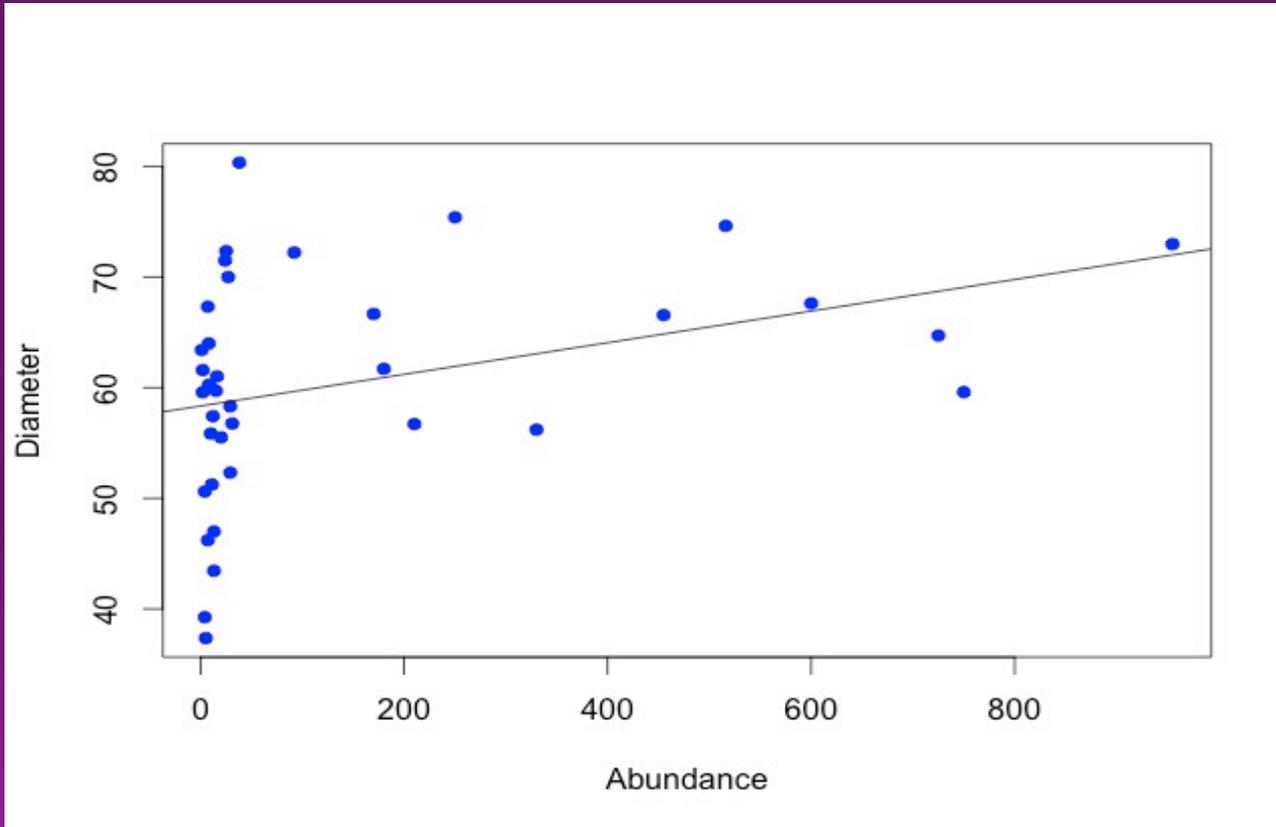
The difference in average GI between Cape Foulweather and Cape Perpetua was not statistically significant (T-test: p-value = 0.179).

Hypothesis 3 Discussion

- We expected to see a difference in abundance and GI between capes because a higher diversity and abundance of macro algae is present on Cape Foulweather.
- Low abundance was observed site wide at Yachats Beach (CP)
 - Low competition on Cape Perpetua
 - We attributed the low abundance to the lack of softer rock formations that the urchins use as substratum/habitat
- No difference in GI between capes could be linked to:
 - Low competition
 - Limited ideal habitat limits abundance but not health

Hypothesis 4 Results

➤ Predicted that urchins in pools with high abundance would be smaller



Our data suggests there's a positive linear relationship showing increased purple urchin abundance per tide pool was a predictor of test diameter at BB and FC ($R^2= 0.103$, $p\text{-value}=0.028$).

Hypothesis 4 Discussion

- Most pools we measured had a low abundance (1-50) of purple urchins
 - Within these pools urchin test diameter varied greatly
 - There is no apparent trend with abundance.
- If pools with low abundance were excluded, we would see a much stronger correlation between abundance and test diameter.
- The size of tide pool was determined to be a significant predictor of urchin test diameter ($R^2= 0.14$, $p\text{-value}= 0.0095$).
 - Other factors such as food availability and disturbances play a larger role than intraspecific competition within pools.

Areas of Concern

- Only one sample site on Cape Perpetua
- Problems of gonad index
 - Assumes allometric growth of body and gonads
 - Different life stages
 - Seasonal variation in spawning: some individuals had spawned prior to collection, and some had not yet spawned.



Conclusions

- Purple urchins have a higher GI when temperature and salinity are less variable
 - Climate change
 - OA
- Pathogenic and parasitic disease susceptibility
- Impact on fisheries

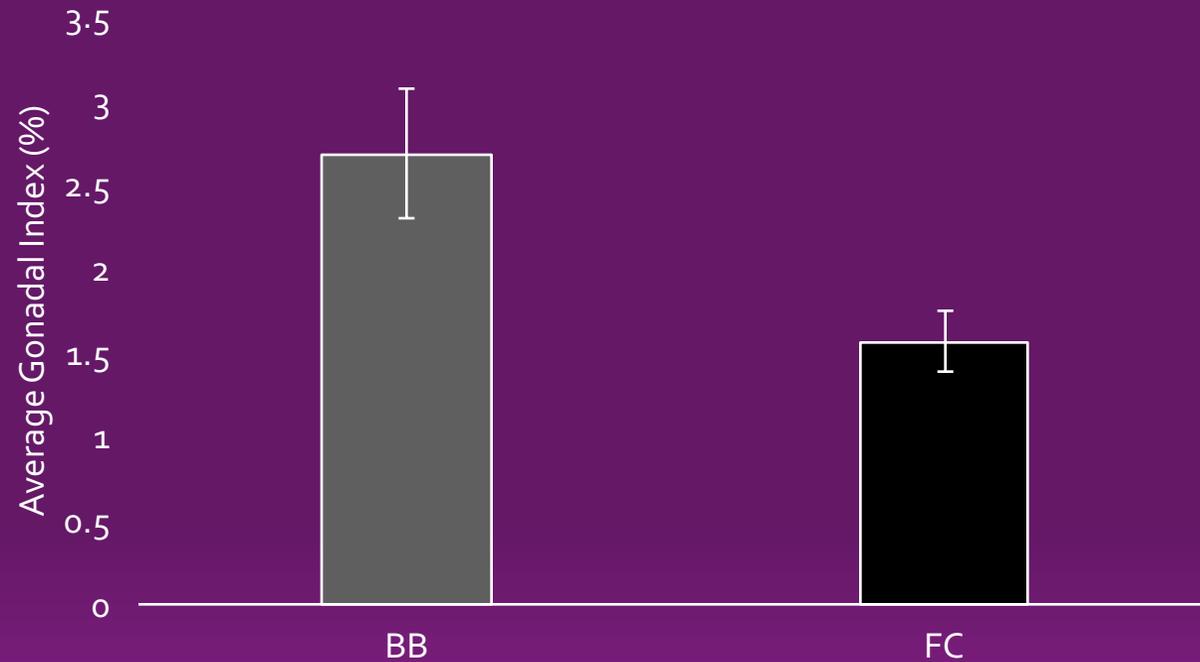


Questions



References

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Cape Foulweather (BB and FC), there is some evidence to suggest that *S. purpuratus* displayed a higher average GI at BB than at FC (T-test: p-value=0.013), where *S. purpuratus* was more abundant