

Teja Rasmussen

Marine Invertebrate Zoology - FHL 432

Summer A

July 17th, 2025


### **Acid Trip: A Red Sea Urchin's Journey Through a Low pH**

Ocean acidification is a major consequence of anthropogenic climate change, driven by increased atmospheric CO<sub>2</sub> dissolving into seawater and forming carbonic acid. This process reduces ocean pH and poses a significant threat to calcifying marine organisms. Since the 1950s, ocean surface pH has dropped by ~0.1 units, representing a 26% increase in acidity. Projections indicate that by the year 2100, pH could fall to 7.7, and even further to 7.3 by 2300. Such conditions could severely affect the biology and survival of marine invertebrates.

Red sea urchins (*Mesocentrotus franciscanus*) are large echinoderms found along the Pacific coast and play a vital ecological role as herbivorous grazers in kelp forest ecosystems. Like many echinoderms, their skeletons and spines are composed of calcium carbonate, making them particularly vulnerable to declining pH levels. While previous studies have examined test degradation and growth under acidified conditions, there is a notable gap in understanding how ocean acidification affects the mechanical strength and morphology of their spines. Sea urchin spines are essential for locomotion, defense, and survival.

In this project, I exposed three red sea urchins to both ambient and low-pH seawater conditions and used micro-computed tomography (micro-CT) to observationally assess changes in spine structure. To lower the pH of the urchin's tank, CO<sub>2</sub> was bubbled with an air stone into the water at a very low flow rate. The pH was left to stabilize for ~4 hours, measuring pH periodically to assure stabilization. A true stabilization was never truly achieved due in part to the natural pH oscillations of sea water from photosynthesis during the day and respiration at night. 3 spines per urchin were taken off the skeleton before and after treatment for micro-CT scanning (18 spines total). Urchins were planned to be in treatment for 3 days, but expired after 2. Lowest pH reading taken was 6.7, indicating this level was much too low for urchin survival. My goal was to determine whether short-term exposure to acidified seawater could compromise spine integrity. Micro CT scans clearly show degradation in the spines, even after only 2 days of treatment. After spines were thinner and exhibited more protrusions. Further studies with less time constraint should work to actually quantify change in density of spines with statistics.

By identifying early indicators of structural degradation, this study contributes to broader efforts in predicting species resilience under climate change and offers valuable insight for ecosystem-based management strategies, particularly in the context of fisheries and marine protected areas. Understanding the vulnerability of key species like red urchins is critical for informing conservation efforts as ocean chemistry continues to shift.

A close-up photograph of a sea urchin's spines, which are long, thin, and reddish-brown in color. The spines are arranged in a radial pattern, creating a dense, textured appearance. The background is dark, making the spines stand out.

# Acid Trip: A Red Sea Urchin's Journey Through Low pH

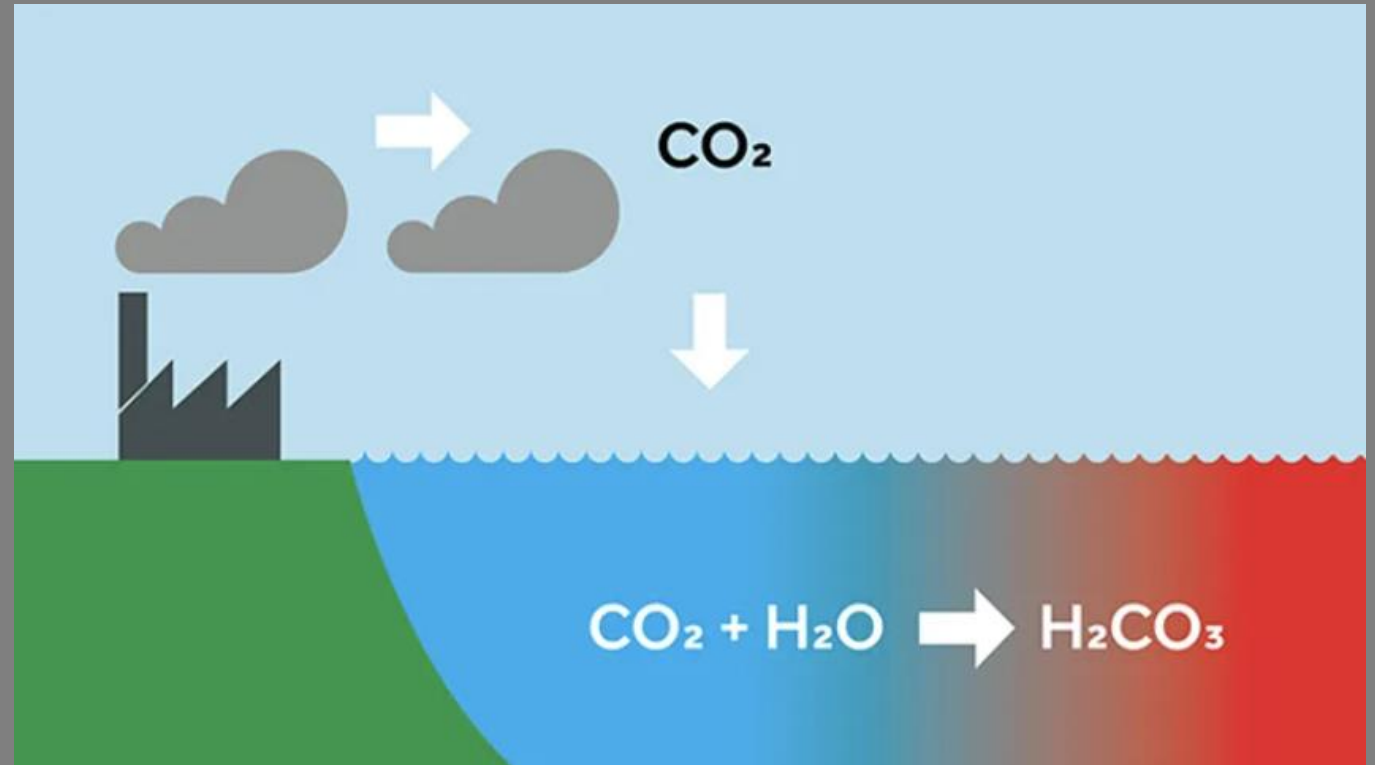
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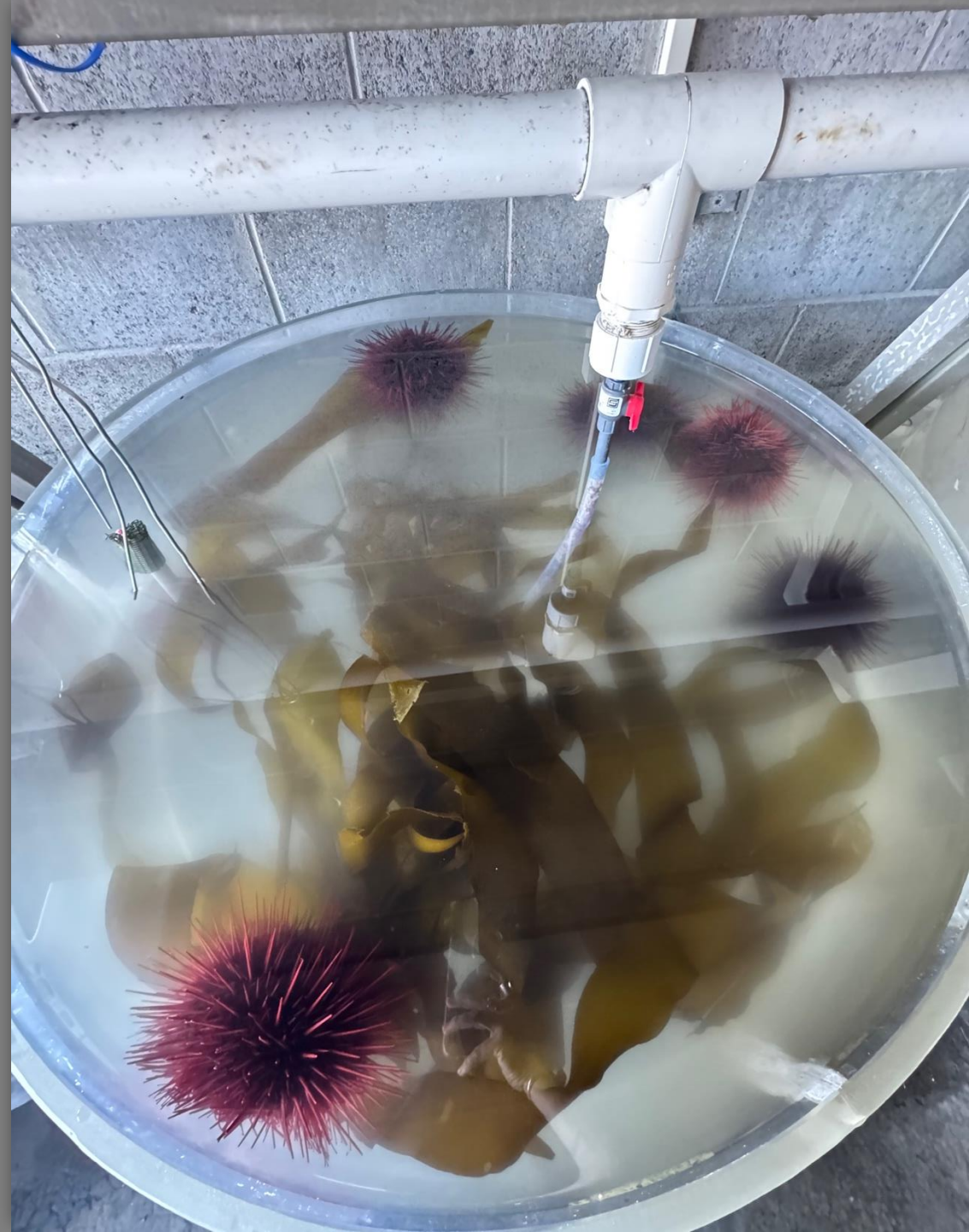
# Background and Knowledge Gap

- Ocean Acidification is driven by rising atmospheric CO<sub>2</sub>
- pH has dropped ~0.1 units since 1950
- OA weakens the calcified structures of many marine organisms
- Studies show urchin spine brittleness increases under lower pH, despite normal growth
- Echinoderm species differ in their resilience to acidified conditions
- Effects depend on both pH level and exposure duration
- *M. franciscanus* spine response remains understudied



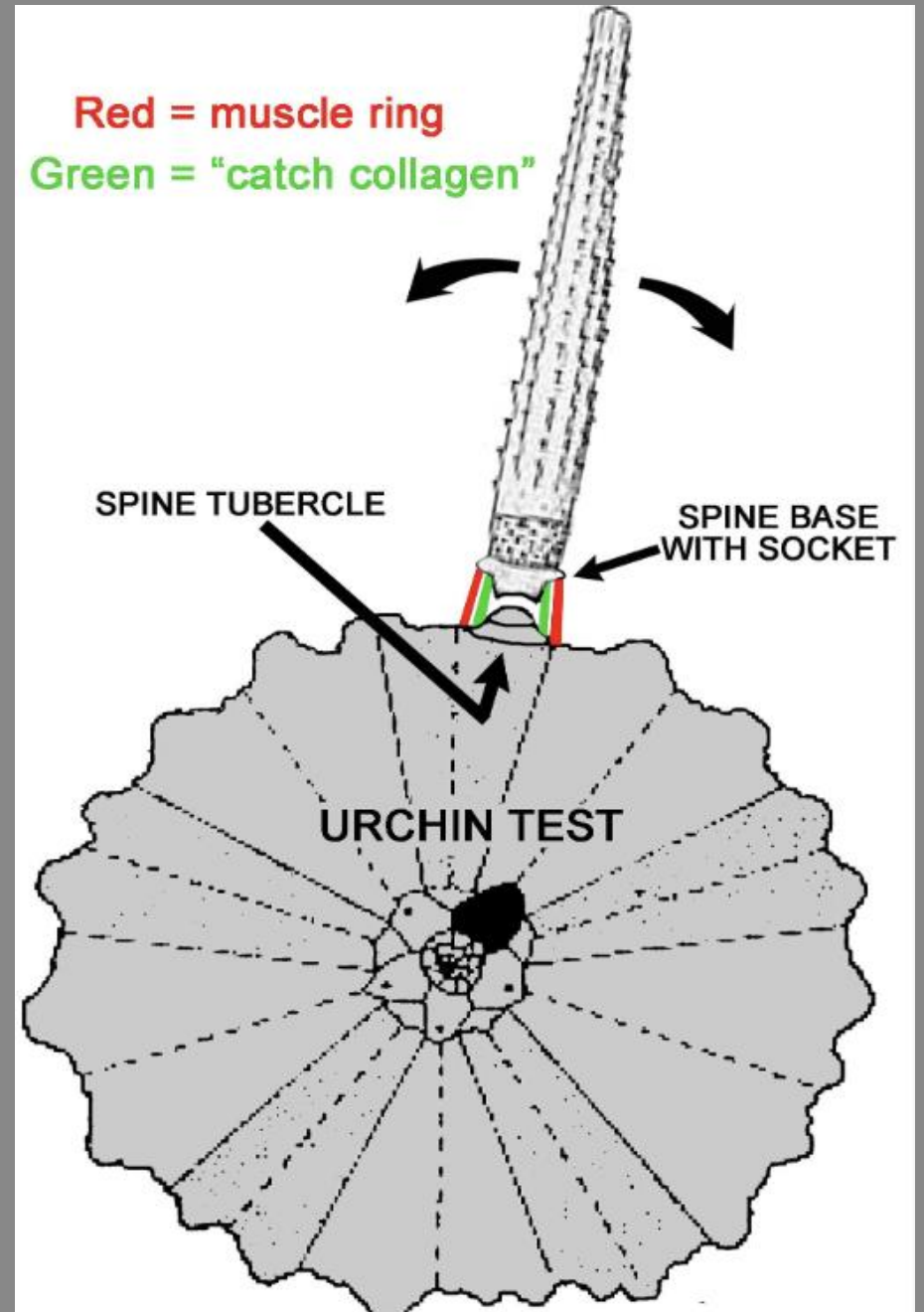
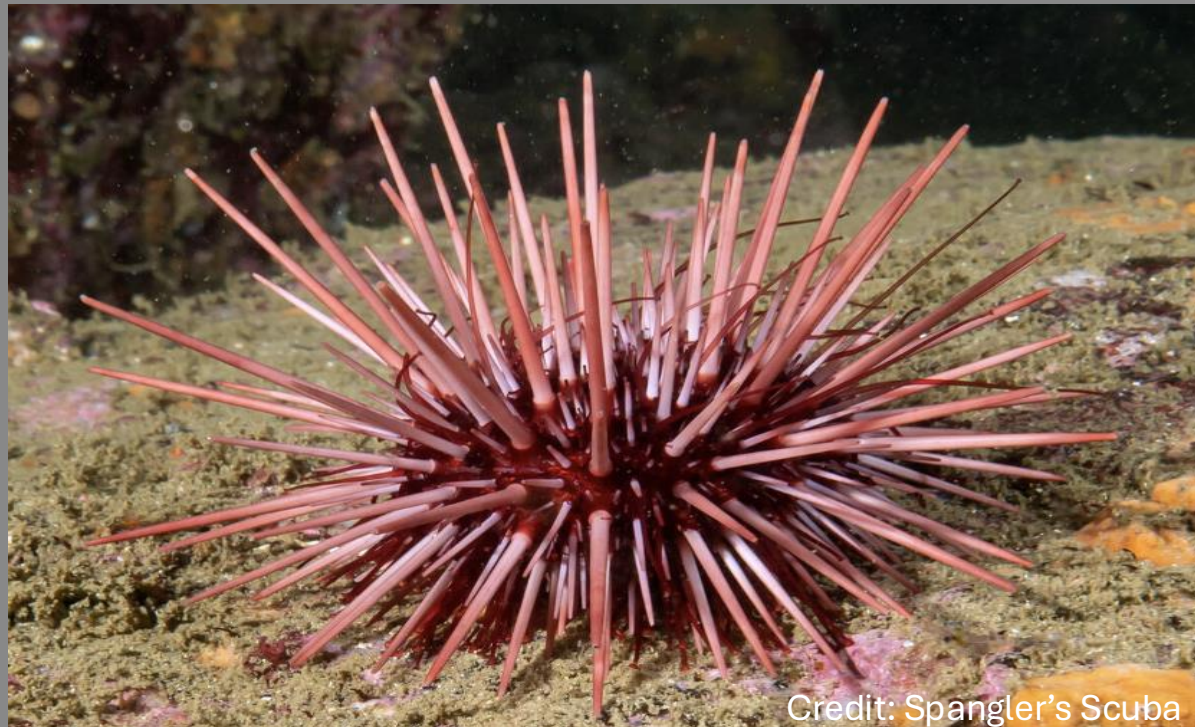
# Experiment Objectives

- **Objective:** To better understand how acidification affects spine integrity in red sea urchins over time in a simulated worst-case-scenario ocean pH level
- **Hypothesis:** Acidified conditions will cause observable degradation in the spines of Red Sea Urchins because acidified seawater limits the building blocks needed for maintaining their calcium carbonate spines, making them more prone to erosion, brittleness, and breakage.



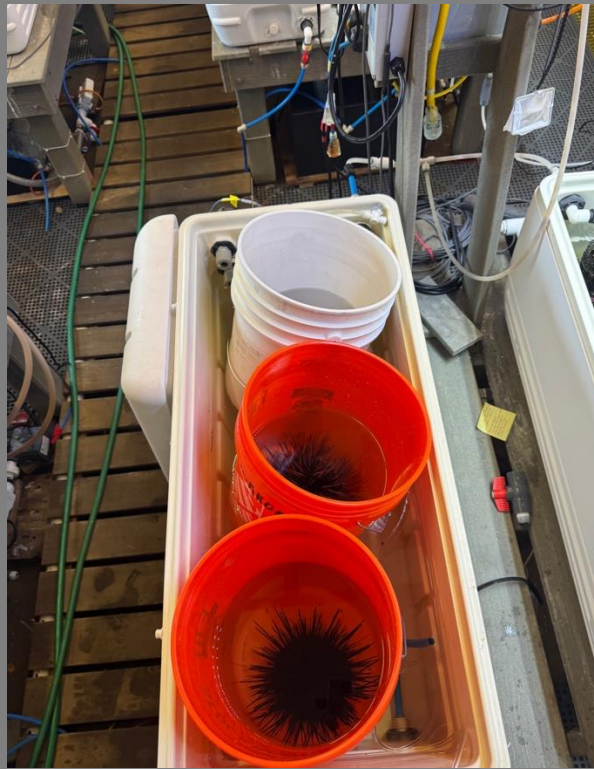
# The Red Sea Urchin

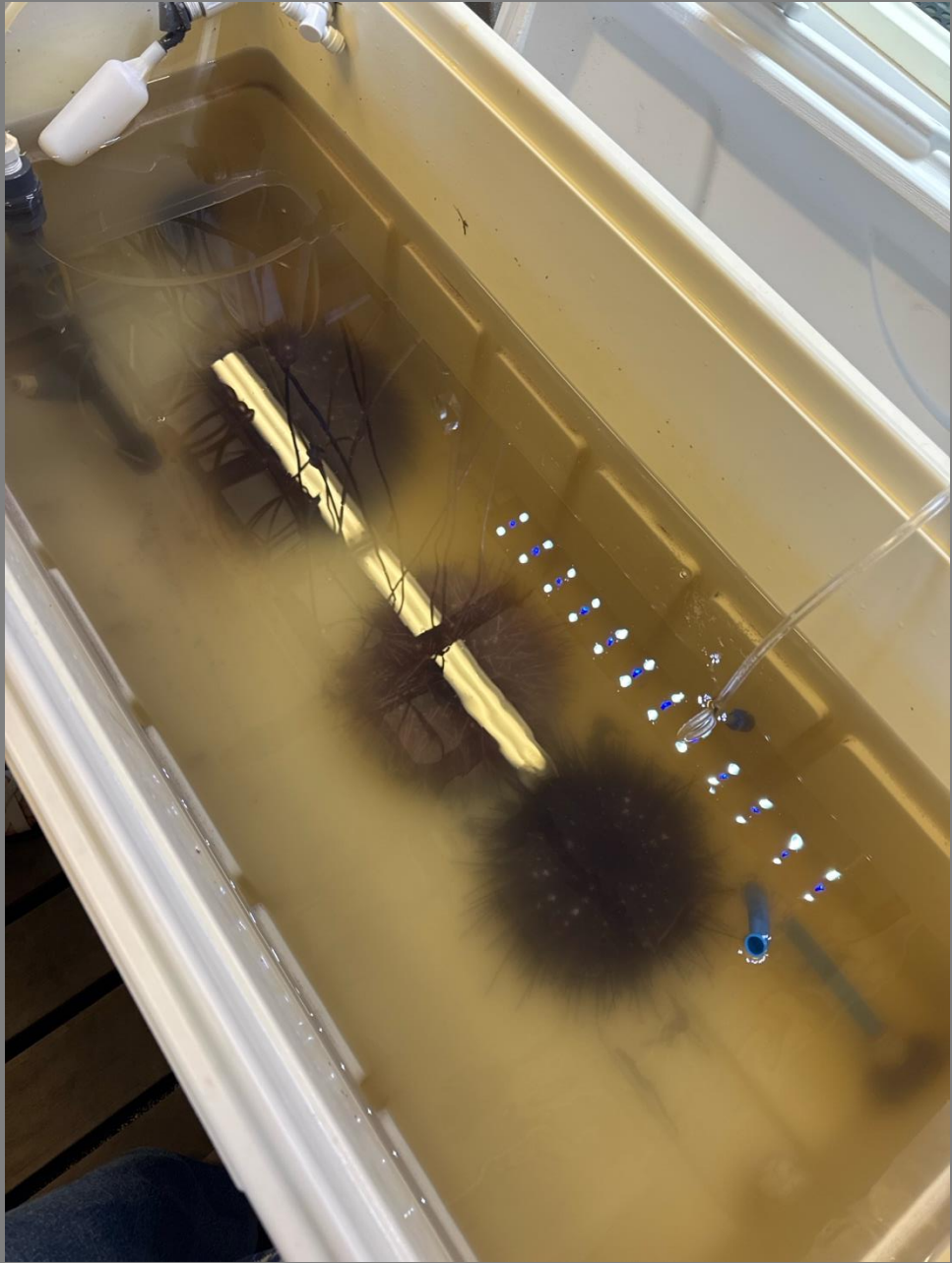
- Who is *Mesocentrotus franciscanus*?
- Role in ecosystem
- Importance of spines



# Methods

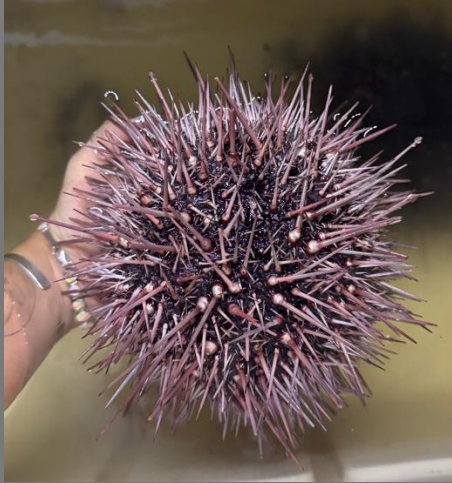
- 1 tank for urchins, 1 CO2 tank with regulator
- Urchins were kept in ambient sea water for 24 hours to acclimate and serve as control. pH ~8.0
- CO2 was bubbled into the tank and left to stabilize before placing urchins back into water with pH of ~7.2
- Urchins were left in the acidified sea water for 2 days before being removed
- 3 Spines per urchin were removed before and after treatment
- Spines were then Micro CT scanned and analyzed in slicer to observe any degradation





# Observations

Darla



Gladys



Agatha



- Urchins went from strongly stuck to substrates (tanks, buckets, anything they were placed on), to barely any use of tube feet after 1 and a half days in acidic waters
- Spines were much easier to remove post treatment
- Spines were extremely brittle post treatment
- Loss of pigmentation along spines and test

After



Before

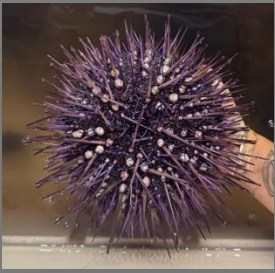


Urchin A (Darla) Before Spines

# Results

Urchin A (Darla) After Spines





Urchin B (Gladys) Before Spines

# Results

Urchin B (Gladys) After Spines





Urchin C (Agatha) Before Spines

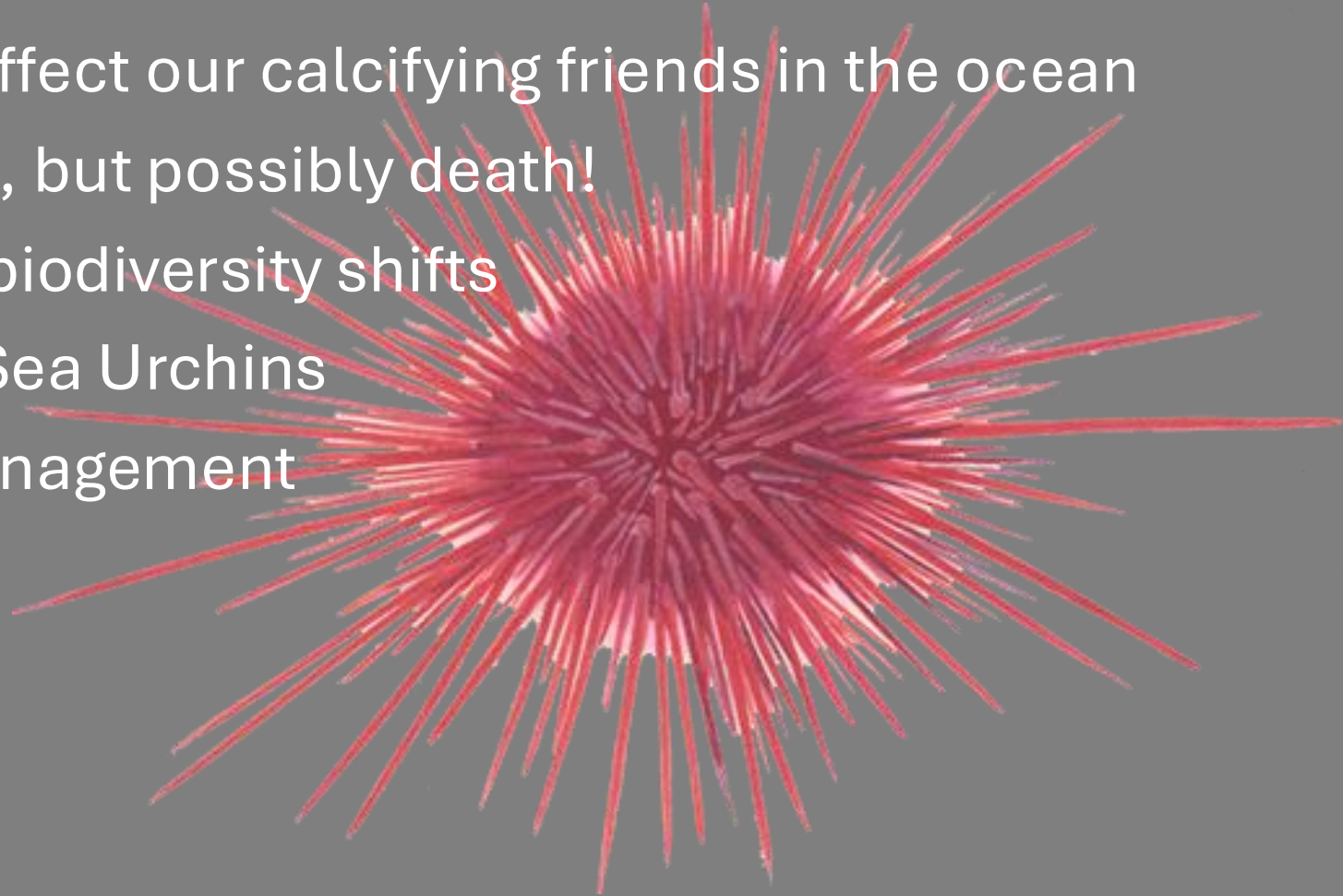
# Results

Urchin C (Agatha) After Spines



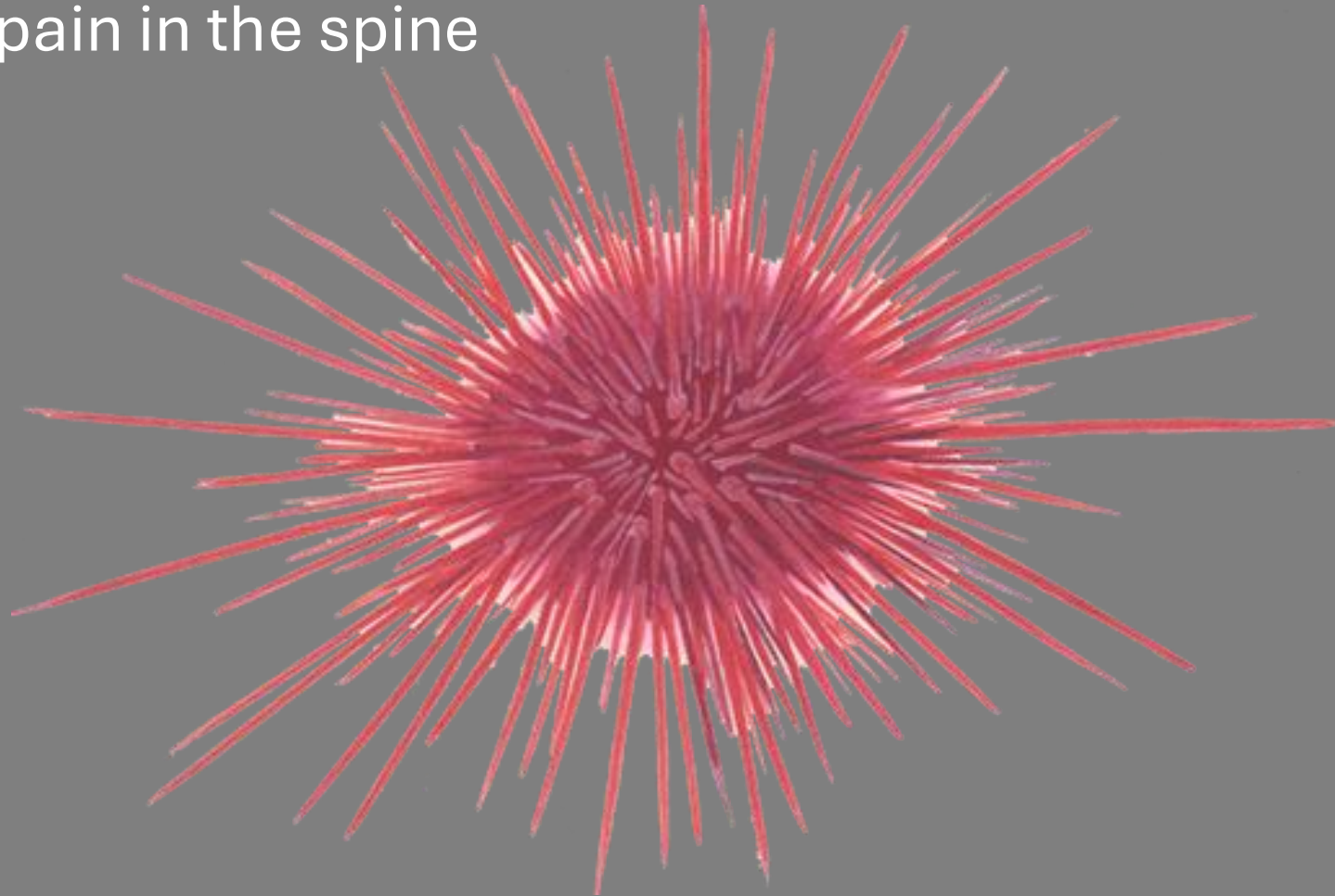
# Broader Impacts

- Ocean acidification WILL affect our calcifying friends in the ocean
- Not only spine degradation, but possibly death!
- Community structure and biodiversity shifts
- Vulnerability/resilience of Sea Urchins
- Informing conservation management
- Micro CT imaging



# Conclusion

- Acidified oceans are a real pain in the spine



# Acknowledgments

Friday Harbor Laboratories & Lab 3

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Maddie and Eric in Lab 10

All my fellow invert peers!

# Questions? Thank You

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