Effects of tidal elevation on the recruitment and survival of *Balanus* and Chthamalus

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Objectives

Balanus and *Chthamalus* barnacles serve as model species providing ecological insights to *Ostrea lurida*, the Olympia oyster whose survival is threatened by *U. cinerea*, the invasive Atlantic oyster drill. In this experiment, recruitment and survival patterns of barnacles were measured at various tidal elevations over the course of 6 weeks. The results may shed light on the predator-driven spatial preferences of *O. lurida*, giving rise to additional questions regarding restoration.

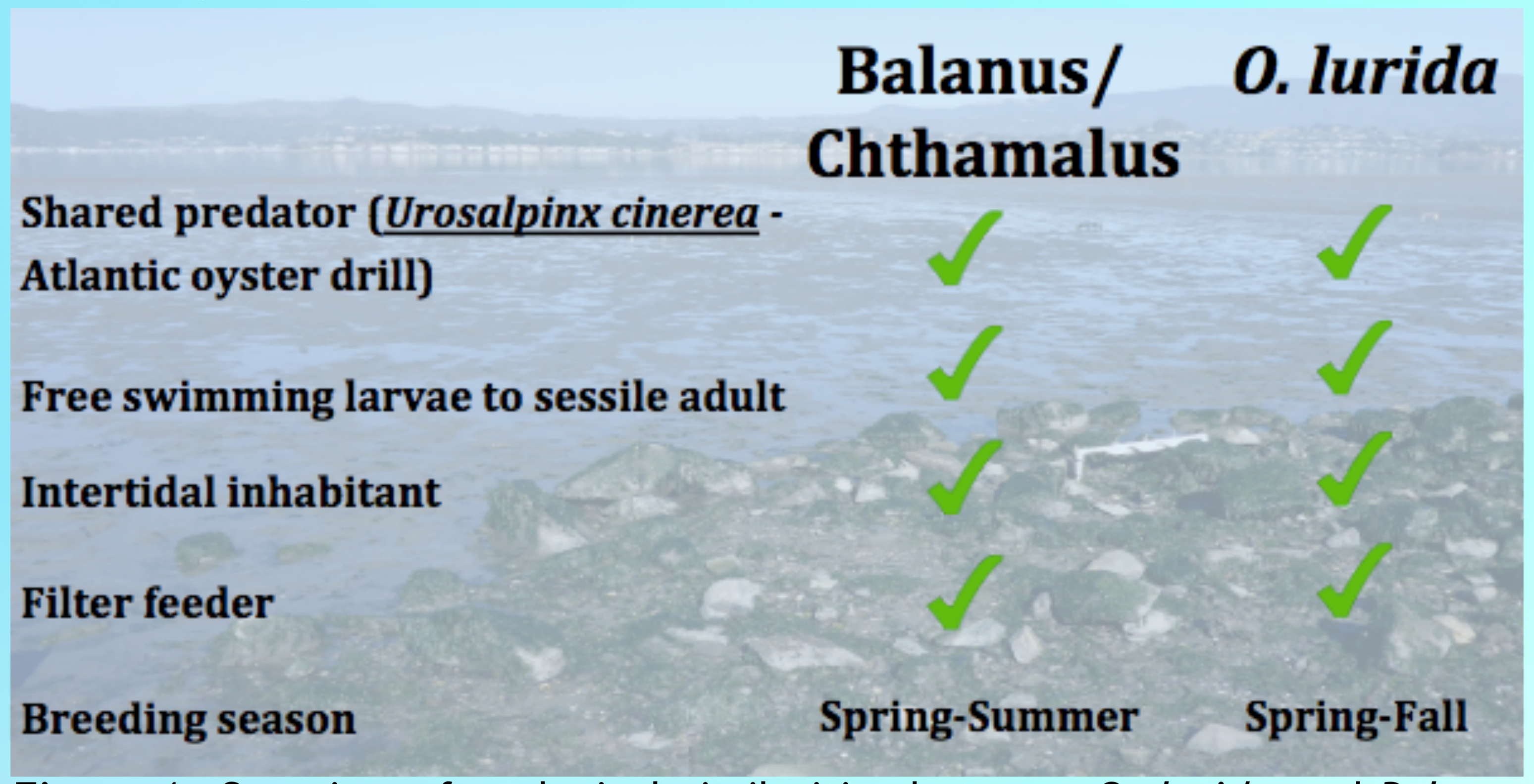


Figure 1. Overview of ecological similarities between *O. lurida and Balanus/ Chthamalus*.

Methods

We tracked short-term recruitment both "R" and "S" tiles, and long-term survival on "S" tiles. 4 PVC frames were installed at each elevation transect: +0.5 feet, +1.5 feet, and +2.5 feet from mean lower low water. Each PVC frame contained 3 porcelain tiles. The frames along each transect were placed in an alternating fashion based on tile type.

Figure 2. Distribution of apparatuses based on tile type.

Procedure

1. Recruitment tiles were collected every two weeks and replaced with new tiles for. Individuals were counted for each two week period.
2. Survival tiles were collected every two weeks and placed back into their respective places on the apparatuses.
3. Individuals were tracked using a 10cm x 10cm quadrant. Survival, removal, and desiccation were accounted for in our records.
4. The duration of the experiment was 6 weeks.

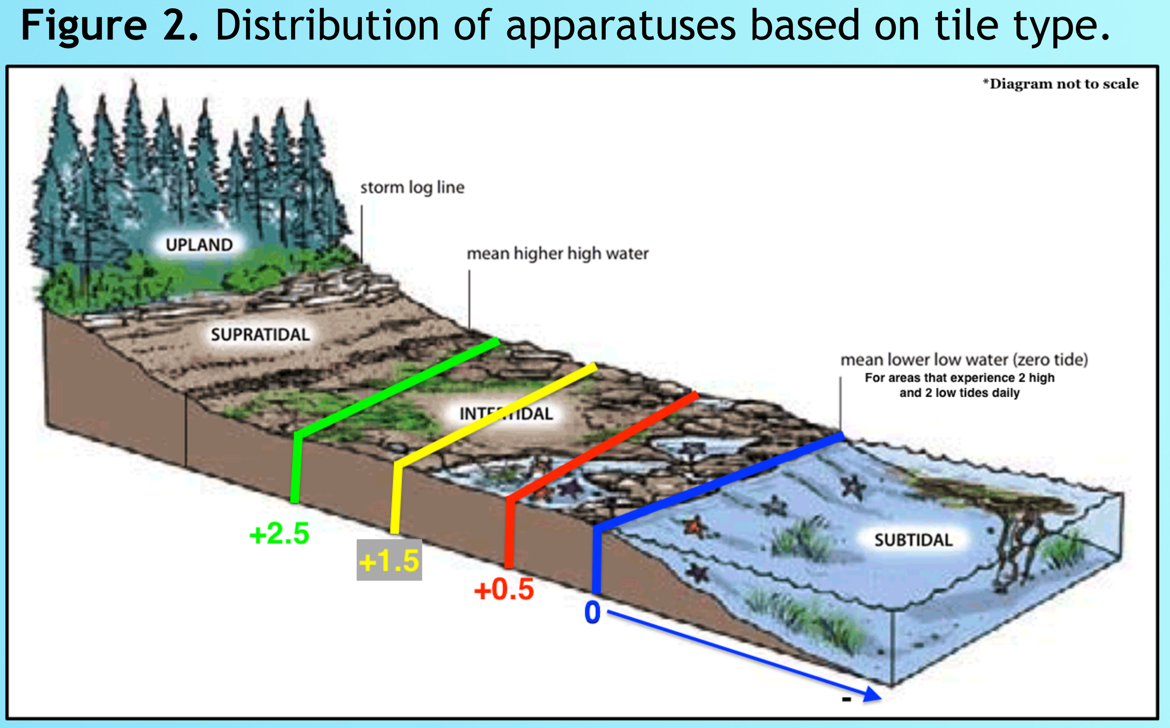
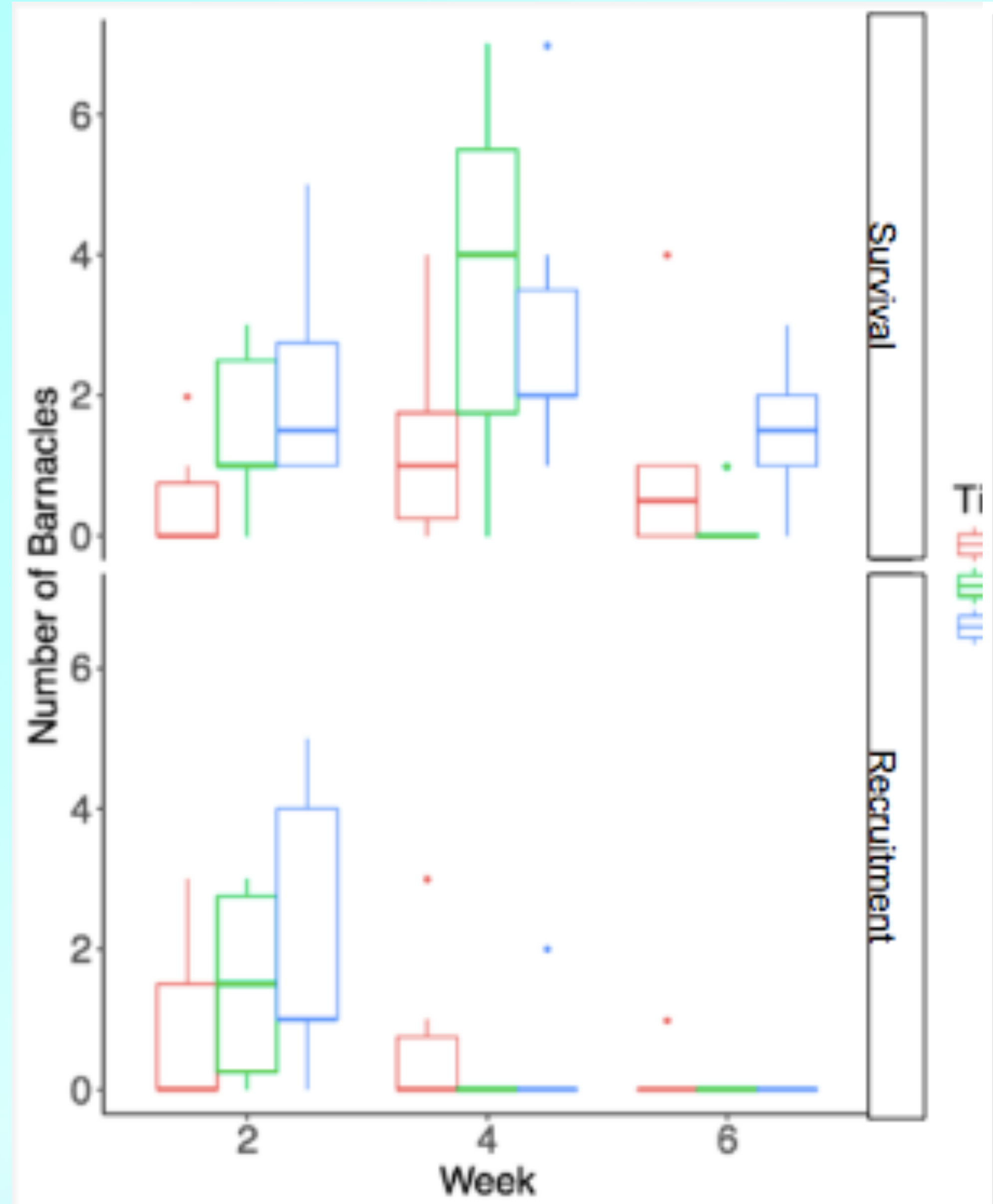


Figure 3. Visual representation of experimental tidal elevations: +0.5ft, +1.5ft, and +2.5ft from mean lower low water.

Results

Recruitment Data

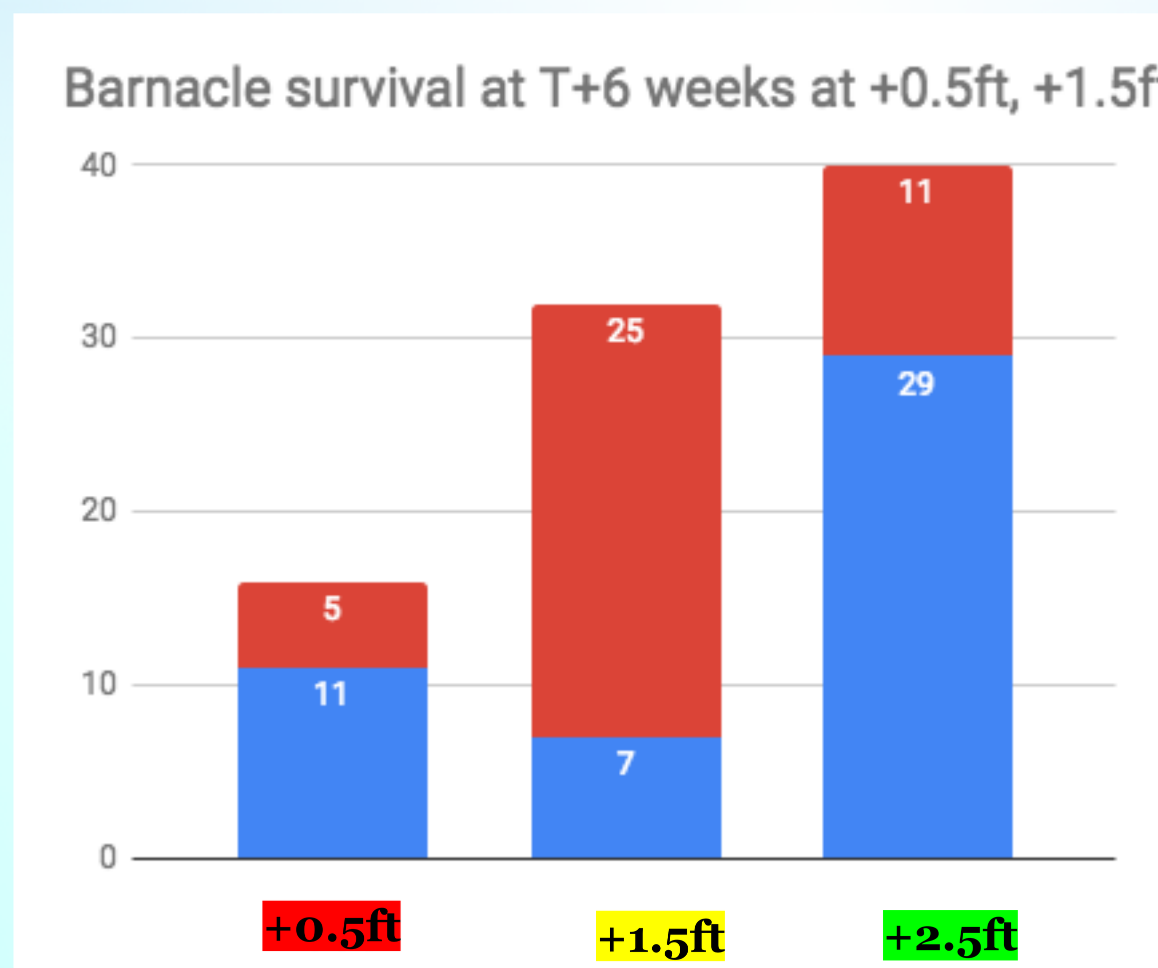


Short-term tiles	+0.5 ft	+1.5 ft	+2.5 ft
+2 weeks	5	1	1
+4 weeks	9	0	0
+6 weeks	13	2	1

Long-term tiles	+0.5 ft	+1.5 ft	+2.5 ft
+2 weeks	3	8	6
+4 weeks	9	22	1
+6 weeks	13	18	9

Figure 4. Plot of number of new barnacle recruits per tile for both survival tiles and recruitment tiles. Chart of total new recruits per tidal elevation per collection for both short-term (recruitment/'R') and long-term (survival/'S') tiles.

Survival Data



Tidal Elevation	Survival Ratio
+ 0.5 ft	0.65
+ 1.5 ft	0.22
+ 2.5 ft	0.73

Figure 5. Total live vs. dead barnacle at 6 weeks and table of survival rates.

Acknowledgements

The 2018 STEM Teacher and Researcher Program and this project have been made possible through support from Chevron (www.chevron.com), the National Marine Sanctuary Foundation (www.marinesanctuary.org), the National Science Foundation through the Robert Noyce Program under Grant #1836335 and 1340110, the California State University Office of the Chancellor, and California Polytechnic State University in partnership with [Your lab site] and [Any other organizations pertinent to your project]. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funders.

Discussion

Barnacles continued to recruit onto 'S' tiles throughout the experiment, whereas 'R' ties attracted little to no recruits following the first data collection. The tendency of barnacles to recruit onto 'S' tiles may be explained by their preference to recruit at locations with existing adult conspecifics (Connell, 1961; Lohse & Raimondi, 2007).

The general decline in recruitment for both tile types over the 6 week period may have been due to deployment of the experiment towards the end of the reproductive period, which occurs between spring and summer (Jarrett, 2003).

+0.5ft had the lowest recruitment, and the +1.5ft had the lowest survival. This indicates +1.5ft produces unfavorable conditions for long-term survival, yet +0.5ft produces unfavorable conditions for the initial recruitment of juveniles.

Applications in Restoration of Ostrea lurida

Both Balanus and Chthamalus and O. lurida have similar life history characteristics including a common predator U. cinerea, the invasive Atlantic oyster drill. However, barnacles are the preferred food source of *U. cinerea* rather than *O. lurida*. A question regarding oyster restoration with *U. cinerea* predation habits in mind could be whether or not tidal elevations of higher barnacle populations are beneficial for the oyster population. For example, where barnacles are abundant, would *U. cinerea* overpower the oyster population due to their closer proximity, or would an increase in barnacles distract the *U. cinerea* away from *O. lurida* due to barnacles being the preferred prey? This is ultimately a questions relating to the bioenergetic mechanisms and behavioural budgeting of *U. cinerea*. An explanation for why barnacles are the preferred food source of *U. cinerea* rather than oysters is due to their comparative anatomical structures. Oysters are bivalve mollusks with meat enclosed beneath the hard shell, requiring the energetically expensive process of drilling necessary for predator access. Barnacles, on the other hand, have a softer calcareous shell with an anterior operculum where the cirri are exposed during feeding (Southward, 1987). Nutritious parts of the barnacle are of easy access for predators at virtually any time due barriers being exclusively soft plates.

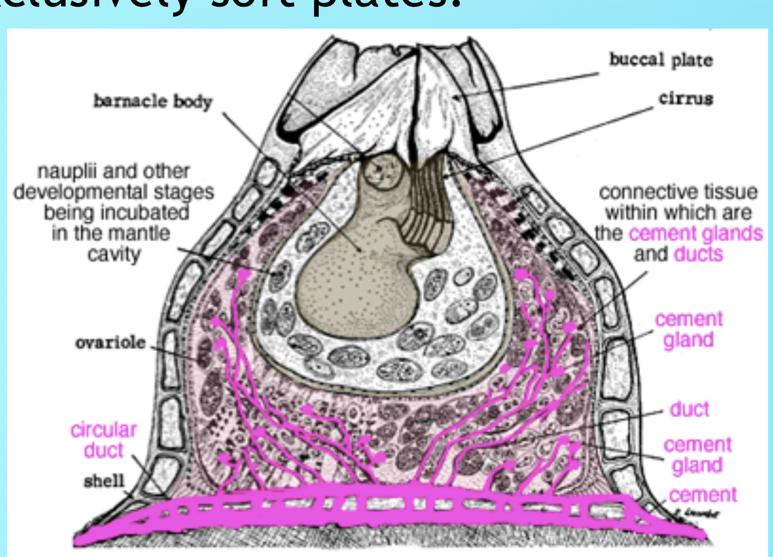


Figure 6. Longitudinal view of barnacle *Balanus* showing cement glands and ducts, as well as the buccal plate structure with the body shown beneath them.

References

[1] Cheng, Brian S., and Edwin D. Grosholz. "Environmental Stress Mediates Trophic Cascade Strength and Resistance to Invasion." *Ecosphere*, vol. 7, no. 4, 2016, doi:10.1002/ecs2.1247.
[2] Southward, Alan J., and D. J. Crisp. Barnacle Biology. A.A. Balkema, 1987.
[3] Connell, Joseph H. "The Influence of Interspecific Competition and Other Factors on the Distribution of the Barnacle Chthamalus Stellatus." Ecology, vol. 42, no. 4, 1961, pp. 710-723., doi:10.2307/1933500.
[4] Jarrett, Jeremiah N. "Seasonal Variation In Larval Condition And Postsettlement Performance Of The Barnacle Semibalanus Balanoides." *Ecology*, vol. 84, no. 2, 2003, pp. 384-390., doi: 10.1890/0012-9658(2003)084[0384:svilca]2.0.co;2.