



Bet-Hedging Response to Changes in Salinity within Fouling Communities in Different Parts of the San Francisco Bay Estuary

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Bet-Hedging

- ❖ A response to unstable environments
- ❖ Diversifying Bet-Hedging
 - Varying larval sizes
- ❖ Conservative Bet-Hedging
 - Specific larval sizes



Question

Will populations in areas that regularly experience salinity changes (middle of the estuary) utilize bet hedging differently when exposed to salinity changes than populations that aren't typically exposed to changes in salinity (mouth of the estuary)?



Hypothesis

- ❖ Middle Estuary Site - Loch Lomond

- I hypothesize that the individuals from this site will demonstrate diversifying bet-hedging when exposed to the new salinities.

- ❖ Mouth of the Estuary Site - Sausalito

- I hypothesize that the individuals from this site will have more uniform sizes of larvae
- Or
- The change in salinity will prevent them from reproducing at all.



Sites

- ❖ Loch Lomond
 - Fluctuating Salinity
- ❖ Sausalito
 - Stable Salinity



Species

- ❖ *Bugula neritina*
- ❖ *Botrylloides diegensis*
- ❖ *Botrylloides violaceus*



https://www.researchgate.net/figure/The-bryozoan-Bugula-neritina-Bugulidae-From-www-robo-astracom_fig4_302994304



<http://nathistoc.bio.uci.edu/Tunicates/Colonial2.htm>



<https://sites.google.com/view/thefoulingproject/home/master-morph-list-photo-guide/tunicata-select/tunicata-colonial-social?authuser=0>

Set up

- ❖ Each species will be separated into three buckets by site.
 - Bucket one of the three buckets will not have any change in salinity, but will be left in the water it was collected in.
 - This will be the control (29-30 ppt)
 - Bucket two of three will be lowered to a salinity of 25 ppt
 - Bucket three of three will be lowered to a salinity of 20 ppt
- ❖ Water temperature will be controlled with running bay water on the EOS water tables.
- ❖ Light exposure will be limited with black buckets with their lids on as well as a tarp over all of the buckets



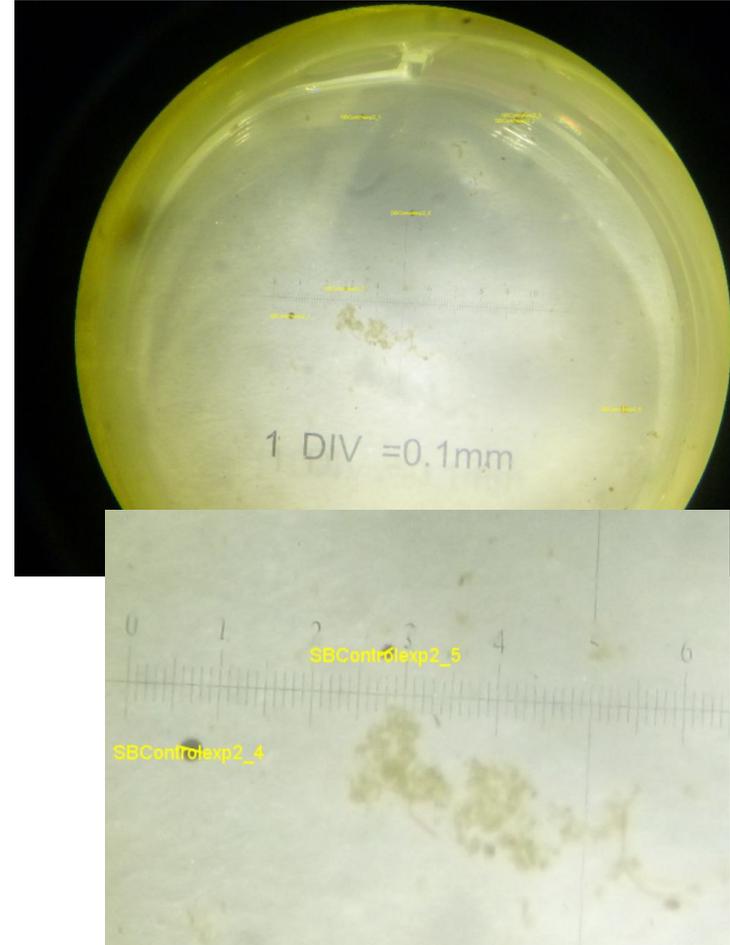
Timeline

- ❖ Organisms collected and spawned the next day
 - Eliminates a majority of the larvae that matured in the field
 - Gives a background for the spawning patterns at the sites
- ❖ Leave organisms in the salinities for three days and spawn again
 - Allows for new larvae to form in stressed environment



Spawning

- ❖ Similarly sized sample pieces were collected from each bucket and put in labeled petri dishes
- ❖ Dishes were left in the light for 60 minutes
- ❖ Larvae was collected into small trays and pictures were taken with a digital camera through the compound microscope
- ❖ Larvae were sized and labeled using ImageJ





Analysis

- ❖ Levene's test
 - Comparison of variance of larval size
 - Higher variance in the stressed treatment as compared to the control suggests diversifying bet-hedging
 - Smaller variance in the stressed treatment as compared to the control would suggest conservative bet-hedging
- ❖ Welch's pairwise comparison
 - Comparison of mean larval size



Larvae Counts

Experiment 1	Loch Lomond		Sausalito	
	Bryozoans	Tunicates	Bryozoans	Tunicates
Initial	21	0	30	0
Control (30 ppt)	6	0	2	27
25 ppt	11	0	2	18
15 ppt	0	0	0	0

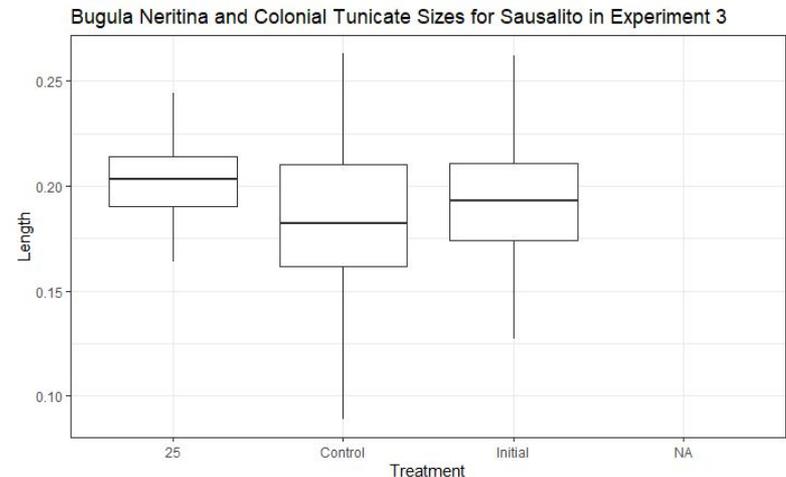
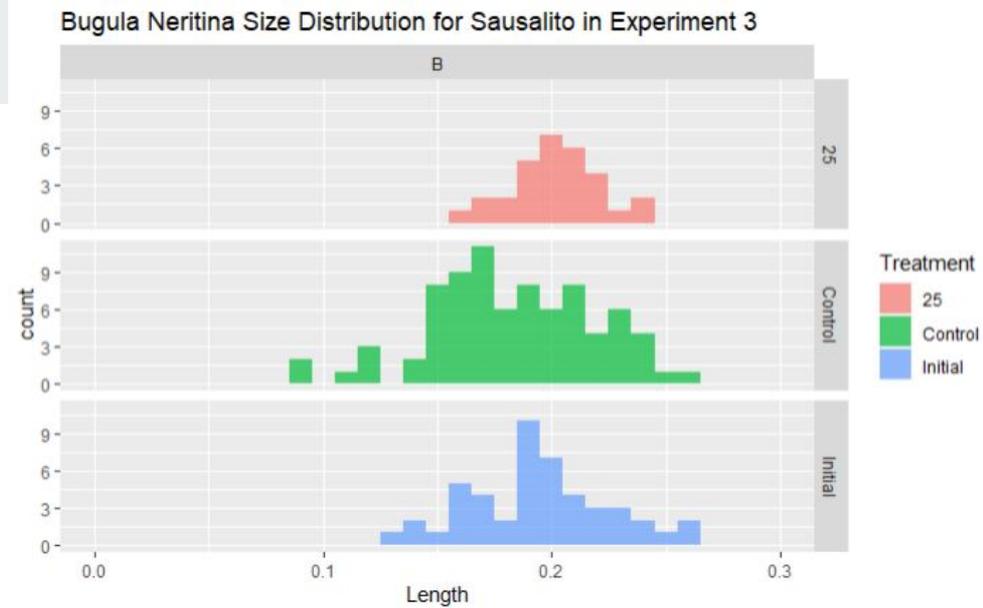
Experiment 2	Loch Lomond		Sausalito	
	Bryozoans	Tunicates	Bryozoans	Tunicates
Initial	0	0	82	0
Control (30 ppt)	2	34	9	8
25 ppt	0	0	118	3
20 ppt	0	3	0	0

Experiment 3	Loch Lomond		Sausalito	
	Bryozoans	Tunicates	Bryozoans	Tunicates
Initial	2	0	47	0
Control (30 ppt)	37	0	80	0
25 ppt	70	0	30	0
20 ppt	0	0	0	0

Sausalito Results



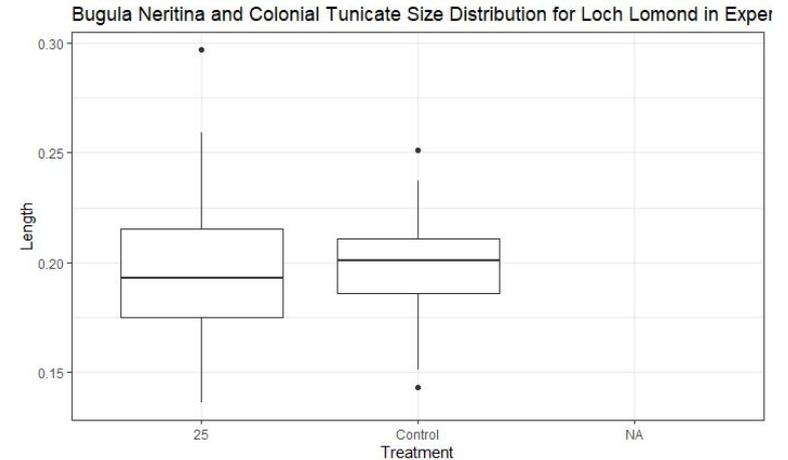
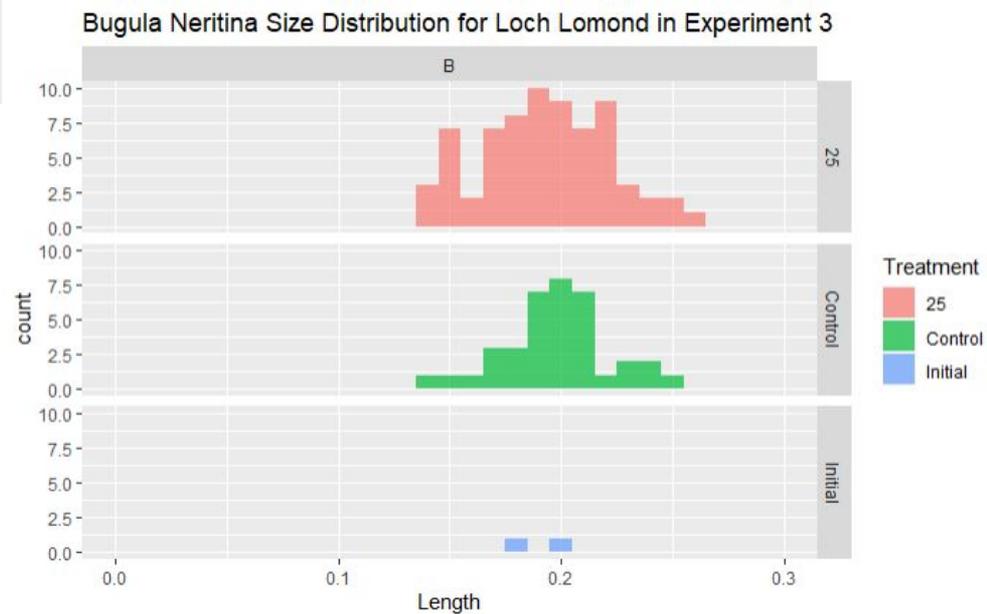
- ❖ **Levene's Test**
 - Significant p-value for the control to 25 ppt and the initial to 25 ppt comparison of variances, but no significant difference between the control and the initial variances in larval sizes
- ❖ **Welch's Pairwise Comparison**
 - Significant p-value for the control to 25 ppt comparison of mean sizes, but no significant difference between the control and the initial and the initial to 25 ppt mean larval sizes



Loch Lomond Results



- ❖ **Levene's Test**
 - No significant p-value when comparing the control and 25 ppt variances in larval sizes, however the a p-value of 0.06106 shows a strong trend.
- ❖ **Welch's Pairwise Comparison**
 - No significant difference between the control and 25 ppt treatment's mean larval sizes.





In Relation to the Hypothesis

❖ Loch Lomond

- I hypothesize that the individuals from this site will demonstrate diversifying bet-hedging when exposed to the new salinities.
- Loch Lomond showed a strong, but non significant trend towards a larger variance in the stressed treatment. This would suggest **diversifying bet-hedging**.

❖ Sausalito

- I hypothesize that the individuals from this site will have more uniform sizes of larvae
- Sausalito had a significantly larger mean size and a significantly smaller size range in the stressed treatment, showing possible **conservative bet-hedging**.
- Or
- The change in salinity will prevent them from reproducing at all.
- Overall, Sausalito spawned more consistently than Loch Lomond did.



Discussion

- ❖ Loch Lomond results
 - Only 2 larvae in the initial spawn
- ❖ Early attempts of the experiment
 - Shorter and brighter first experiment
 - Inconsistent spawning
- ❖ No 15 ppt or 20 ppt data
 - Adult colonies did not survive the lowest salinity treatment
- ❖ Future work
 - More repetitions
 - Equal biomass in the treatment groups so larvae counts could be analyzed.



Conclusion

This data shows that some bet-hedging strategies are being used in the San Francisco Bay Estuary and can give us an idea of what fouling organisms may do in order to survive larger scale changes in salinity due to climate change. Studies have shown that larger *Bugula neritina* larval size is directly correlated with better survival (Marshall et al. 2003).



Thank you!

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