Temporal Changes in the Upper/Lower Limits of *Fucus* and *Endocladia* at Cattle Point, San Juan Island

Tyler Horner

Research in Marine Biology (FHL 470)

Friday Harbor Laboratories, University of Washington, Friday Harbor, WA 98250

Contact information:
Tyler Horner
University of Washington
Campus Parkway
Seattle, WA, 98195
th92@uw.edu

Keywords: *Fucus distichus*, *Endocladia muricata*, Cattle Point, climate change, Upper and Lower Limit, temporal change, distribution, desiccation.

Temporal Changes in the Upper/Lower Limits of Fucus and Endocladia at Cattle Point, San Juan Island

Tyler Horner
Friday Harbor Labs
Research in Marine Biology, Spring 2023

Abstract

Increases in global and seawater temperatures are a rising concern for communities across the planet. Over the last 20 years, the scientific community has taken great interest in climate change, and attempted to analyze how species respond to its stressors. Analyzing heat resistant algal species, such as *Fucus distichus* and *Endocladia muricata* could provide insights into how the biota of the high intertidal are changing in response to a warming climate. Our study aims to observe how the Upper and Lower Limits (UL/LL) of these two species have changed between 1972 and 2023. Data was collected at Cattle Point, San Juan Isl., WA, in May 2023, and compared to a study done at the same site from 1972. Our data found that the Upper limits of these species has remained constant over time, while the lower limit of these species has risen in elevation. We were unable to produce an accurate proxy for heat stress. Because of this, correlations to heat stress and the changes observed over time in the UL/LL of *Fucus* and *Endocladia* are speculative, and will require more observations over time before significant correlations can be drawn. This study provides recommendations for continuing temporal observations at Cattle Point, San Juan Isl., WA, so that future studies may be able to draw statistically significant correlations between heat stress and changes in species distribution.

Introduction

Global climate change is an issue of existential importance, as its impacts are felt across ecosystems worldwide. One of the critical consequences of this phenomenon is the alteration of species distribution patterns, particularly in marine environments. As global temperatures have increased, many marine species have altered their distribution to cooler environments in response to heat stress (Whalen 2023). The marine rocky intertidal can provide an important metric for observing responses to heat stress due to its large fluctuation in temperature gradient throughout the daily tidal cycle (Wang 2020). Historically, algal species that inhabit the high intertidal display resilience to heat stress, however continued trends of increased global temperatures warrants continued observations of this phenomenon (Lalegerie 2020).

The marine algae *Fucus distichus* (Phaeophyta, Fucales) and *Endocladia muricata* (Rhodophyta, Gigartinales) play important ecological roles in the rocky intertidal. Their desiccation tolerance (DT) allows them to dominate the harsh high intertidal conditions, however their techniques for resisting desiccation vary. *Endocladia sp.* is able to increase its thermal tolerance by losing >90% of its water content and ceasing photosynthesis, resulting in a dormant state in exchange for occupancy in high heat-stress environments. It also grows in clumps allowing the center fronds to remain hydrated for longer (Hunt 2008). *Fucus sp.* tends to lose around 70% of its water content per daily low-tide (Beer 1992) at which time photosynthesis is slowed, however brown algae (*Phaeophyceae*) contain D-Mannitol, a solute that prevents denaturation of cellular tissue during desiccation (Schalerg 2011). As a result of their DT, they are the primary canopy-forming species in these habitats, providing shelter and recruitment substrate for a diverse range of invertebrate species (Klinger 2011). We hypothesize that the upper and lower limits (UL/LL) of key seaweed species, such as *E. muricata* and *F. distichus*, serves as valuable indicators of the ecological effects brought about by increasing global temperatures. Understanding how these desiccation-resistant organisms have changed over time may provide vital insights for predicting and managing ecological transitions to the world's intertidal biota in response to increased global temperatures.

Many potential temperature factors were analyzed as possible proxies for heat stress, such as average global ambient temperatures, average seawater temperatures, and ENSO (El Niño/Southern Oscillation). However upon further investigation we found these measures to be inaccurate representations of the sample region's climate variability overtime. Because we do not have temperature readings at our sample site we decided to use Pacific Decadal Oscillation (PDO) to measure heat stress over time at Cattle Point, San Juan Isl., WA. PDO can be characterized as long-term El Niño/La Niña-like patterns with variability in both seawater and ambient temperatures. These trends are classified as either a positive phase (warming), or a negative phase (cooling). Unlike ENSO (El Niño/Southern Oscillation), these patterns tend to last for 20-30 years, and their effects spread up into the NortheastPacific/North American region, compared to ENSO, whose effects are most prevalent along the equator (Mantua 1999), making it an accurate proctor for measuring variability in both ambient and seawater temperatures for samples taken in northeastern Pacific region.

Using data from over 50 years, this study aims to observe alterations in the UL and LL of *E. muricata* and *F. distichus*, by comparing historical and contemporary distributions of these species at Cattle Point, San Juan County, Washington. University of Washington's Friday Harbor Lab students and researchers have been observing algal zoonation data at this site since 1971. The objective of this study is to determine if the UL and LL of *F. distichus* and *E. muricata* have changed since 1971, and attempt to draw correlations to alterations in their distribution to observed changes or trends in increased global temperatures.

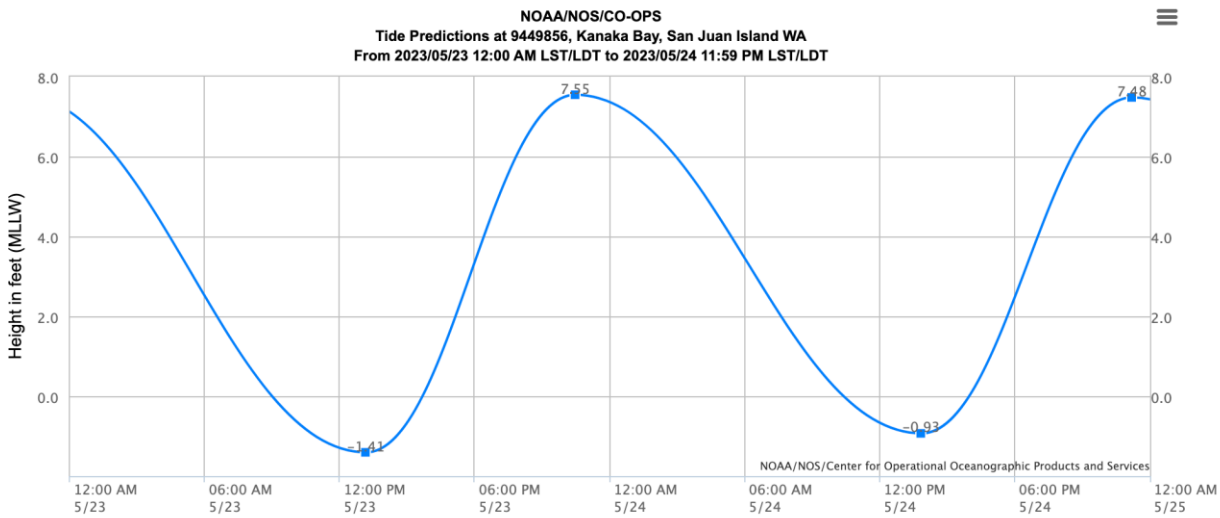
Methods

Sites and Surveys

Data was collected 24 May 2023, replicating procedures done by the University of Washington's 1972 Friday Harbor Labs (FHL) Botany program in their paper titled, "A floral survey of protected and exposed rocky intertidal at Cattle Point, San Juan Island, Washington in July 1972". While similar surveys were done in 1971, the 1972 data set was found to be the most comparable. We measured tidal heights and percent cover of *F. distichus* and *E. muricata* at two sites, along the northeastern side of Cattle Point, San Juan Island, Washington. Each site was established in 1971 by FHL students and researchers using placards distinguishing transects C and D (Broad et al. 1972). Each transect was installed above the intertidal zone. We chose these sites because of their extensive documented research over the last 50 years, which presented the most historical data for use in correlative models. Transects C and D are characterized by; rocky substrate that transitions to cobble near the MLLW elevation, a north-facing aspect with moderate sun exposure, large fluctuations in tidal heights(9-13ft), low wave energy, and diverse intertidal algal biota.

Tidal Elevations

Tidal elevations were measured using a laser level and grade rod receiver. The elevation of the water was measured first, followed by the elevation at each quadrat starting 20m from the transect and working up the intertidal towards the 0m mark for a total of 11 quadrat observations at 11 elevations. A baseline elevation was determined by measuring the elevation at the water line, adding the daily tidal predictions published by NOAA for Kanaka Bay, San Juan Island, WA (-0.9 MLLW) (Tide 2023), and subtracting the elevation of the Laser level above the transect (reading at Om on transect line). The elevation of each subsequent quadrat was calculated using this baseline.



The tidal elevations from the 1972 data did not match our readings. Given the carefully documented procedures published by the 1972 report we assume their error stems from lack of technological advances available at the time. Under the assumption that the MLLW, used to calibrate tidal heights, has not changed significantly in the last 50 years, we re-calibrated their tidal heights at each quadrat reading to match our own. This method is defensible given their articulate documentation and marking of both transect locations, direction and placement of transect lines at both sites, and subsequent quadrat readings.

Data Collection

The data was collected using the belt transect survey method at two sites, transect C and D. The line was implemented using a metric long-tape, with the "0m" mark placed on each transect marker, running down the intertidal perpendicular to the shoreline. The long-tape was able to follow the beach contour. Photographs from the 1972 FHL report and directional markers along the intertidal were used to replicate placement of the transect line (Transect C 7/22/72, Transect D 7/8/72).

Algal sampling was done using quadrats, placed at 2 meters intervals along the transect line for a total of 11 samples. Each sample was taken using a 50cm x 50cm PVC quadrat frame, subdivided further into x25 10cm x 10cm squares, and placed at the distal end of each 2m reading. Percent cover and presence/absence of each species followed procedures utilized in the 1972 survey. Sub-categories were estimated using Table 1. to assign a Coverage Category for each 10cm x 10cm square; those values were then averaged to find an "Estimated % Coverage" for the entire quadrat.

Table 1. Braun-Blanquet substrate coverage categorization (Kershaw, 1973)

Coverage Category	Estimated % Coverage
1	Present – 5
2	5 – 12.5
3	12.5 – 25
4	25 – 50
5	50 – 100

UL and LL were estimated using Excel, plotting the elevation (ft) against percent cover (0-1.0) to provide an intertidal map of species distribution. The UL was defined as the highest elevation where percent cover was observed above 0%. The LL was defined as the lowest elevation where percent cover was above observed above 0%. A decrease in LL is defined as an increase in its lower distribution elevation, and an increase in LL is defined as a decrease in its distribution elevation. A decrease in the UL is defined as a decrease in its upper distribution elevation, and an increase in UL is defined as an increase in its upper elevation. The data sampled was limited to two points in time, rather than a continuous record. This lack of data resulted in the inability to run statistical analysis. The data analysis conducted used Excel to make comparative models and calculate qualitative comparisons of the UL/LL of each species at two distinct sample sites (Transect C and Transect D).

The PDO index (NOAA 2023) was used to draw correlations between positive and negative phases, and changes in the UL and LL of *F. distichus* and *E. muricata*. Positive and negative phases will end no less than 3 years prior to each field sampling event. This 3-year threshold was chosen because declines in algal recruitment in response to heat stress have shown delays spanning up to 3 years (Hazraty-Kari 2023). The PDO events chosen include a negative phase from 1947-1976, and a negative phase from 2020-2023 (NOAA 2023). Because our sample years were both taken post negative phases we were unable to use it as a proxy for heat stress.

Results

Figure 1A-D. Discrepancies in Tidal Elevation of *F. distichus* and *E. muricata* at each site/year at Cattle Point, San Juan I. WA

Figure 1A.

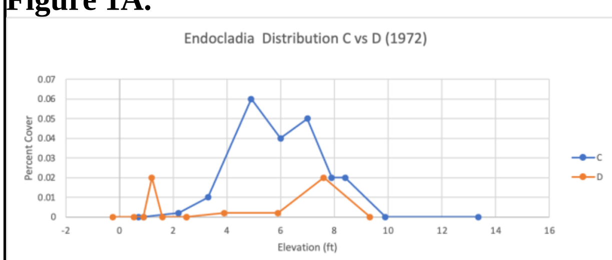


Figure 1B.

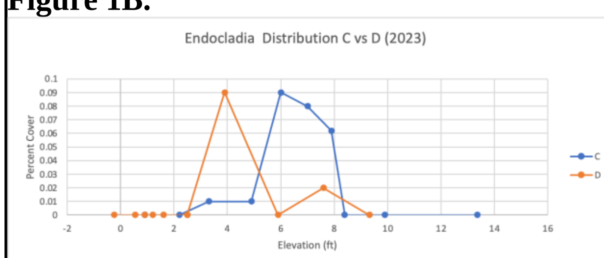


Figure 1C.

Figure 1D.

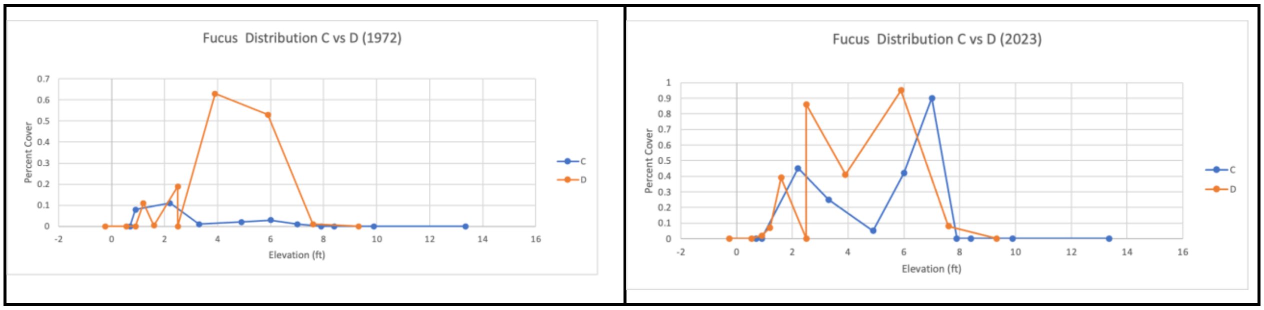


Figure 1A-D. Includes comparative models to determine UL/LL discrepancies between sites C and D, for each species in a given sample year. Elevation(ft) is graphed against percent cover (0-1.0) to determine UL/LL of each species.

Figure 2A-D. Discrepancies in Tidal Elevation of *F. distichus* and *E. muricata* at each site/year at Cattle Point, San Juan I. WA (Data)

Figure 2A.

Endocladia 1972 C vs D		
	LL (ft)	UL(ft)
Transect C	2.2	8.4
Transect D	1.2	7.6
Discrepancy	+1.0 C	+0.8 C
Distribution discrepancy	+1.8 C	

Figure 2B.

Endocladia 2023 C vs D		
	LL (ft)	UL(ft)
Transect C	3.3	7.9
Transect D	3.9	7.6
Discrepancy	+0.6 D	+0.3C
Distribution discrepancy	UL +0.3C LL +0.6 D	

Figure 2C.

Fucus 1972 C vs D		
	LL (ft)	UL(ft)
Transect C	0.9	7.0
Transect D	1.2	7.6
Discrepancy	+0.3 D	+0.6D
Distribution discrepancy	+0.9 D	

Figure 2D.

Fucus 2023 C vs D		
	LL (ft)	UL(ft)
Transect C	2.2	7.9
Transect D	0.9	7.6
Discrepancy	+1.3 C	+0.6 D
Distribution discrepancy	LL +1.3C UL + 0.6 D	

Figure 2A-D compares site specific data from Figures 1A-D, for each species in a given sample year. Distribution discrepancies were defined as differences between sites C and D, in the UL/LL for a species in a given sample year.

To determine if site specific evaluation was necessary, we compared the UL/LL discrepancy between sites, for each species in a given sample year. From the data we determined sites C and D to have distinct UL/LL for each species sampled in a given year (Figure 1 & Figure 2.). Consequently, this discrepancy justified site specific evaluations when comparing changes over time (reference figure 3./Figure 4.).

Figure 3A-D. Changes in UL/LL of Fucus and Endocladia Over Time at Cattle Point, San Juan Isl., WA, From 1972-2023

Figure 3A.

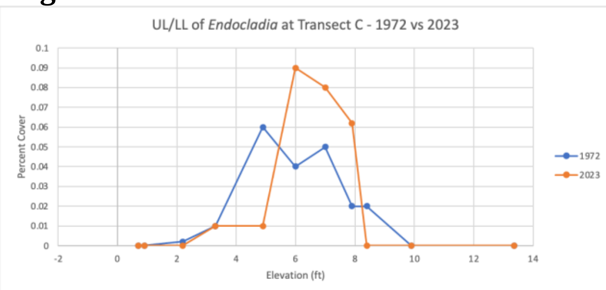


Figure 3B.

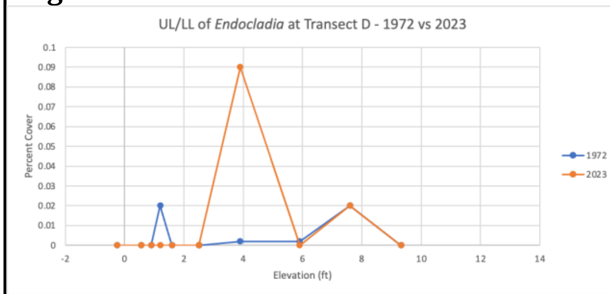


Figure 3C.

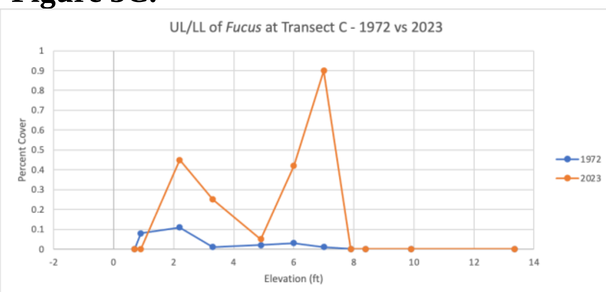


Figure 3D.

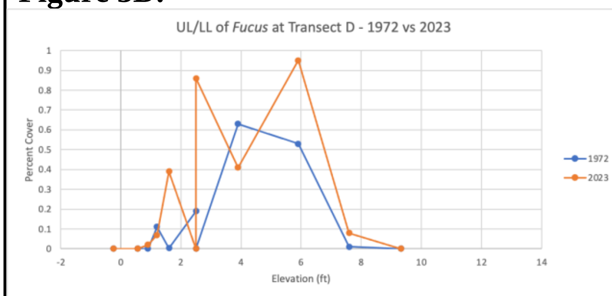


Figure 3A-D. Compares changes over time in the UL/LL limits of Fucus and Endocladia at each sample site. Elevation(ft) is graphed against percent cover (0-1.0) to determine UL/LL of each species. Changes over time are compared by isolating each graph by species (Fucus and Endocladia), and site location (transect C and D).

Figure 4A-D. Changes in UL/LL of Fucus and Endocladia Over Time at Cattle Point, San Juan Isl., WA From 1972-2023 (Data)

Figure 4A.

Endocladia **(Site C) - 1972 vs 2023**		
	LL (ft)	**UL(ft)**
1972	2.2	8.4
2023	3.3	7.9
Change	-1.1 2023	-0.5 2023
Total	-1.7 UL/LL 2023	

Figure 4B.

Endocladia **(Site D) - 1972 vs 2023**		
	LL (ft)	**UL(ft)**
1972	1.2	7.6
2023	3.9	7.6
Change	-2.7 2023	0
Total	-2.7 LL 2023	

Figure 4C.

Fucus (Site C) - 1972 vs 2023		
	LL (ft)	**UL(ft)**
1972	0.9	7
2023	2.2	7
Change	-1.3 2023	0
Total	-1.3 LL 2023	

Figure 4D.

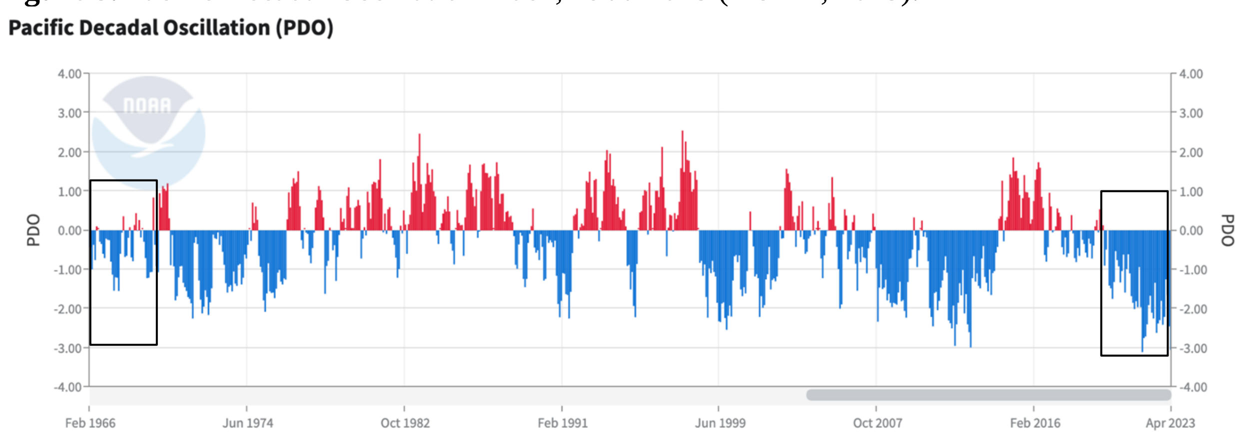
Fucus (Site D) - 1972 vs 2023		
	LL (ft)	**UL(ft)**
1972	1.2	7.6
2023	0.9	7.6
Change	+0.3	0
Total	+0.3 LL 2023	

Figure 4A-D. Compares data from Figure 3. to quantify changes over time in the UL/LL of Fucus and Endocladia at each sample site.

From 1972-2023, *Endocladia* showed a decrease in its vertical distribution, with the UL/LL narrowing at site C, and the LL decreasing at site D. *Fucus'* changes in distribution over time varied by site, with site C showing a decrease in the LL by -1.3ft, and site D showing an increase in the LL by +0.3ft.

Heat Stress (PDO)

Figure 5. Pacific Decadal Oscillation index, 1966-2023 (NOAA, 2023).



The PDO was determined to be the most accurate indicator for measuring heat stress in our sampling region. However upon further investigation we discovered both of our sampling years to be during cooling phases, consequently we do not have data collected during or shortly after a heating event. In summary, we were unable to procure heat stress as a factor in our data analysis.

Discussion

Comparing how UL/LL at each site has changed

Using our comparative models we observed changes over time in the UL/LL of *Fucus* and *Endocladia* at two transect sites (C and D), at Cattle Point, San Juan Isl., WA.

Comparing Sites

When comparing changes over time at each site, we observed all sites to show little to no change in the UL of *Fucus* and *Endocladia*. We observed the most change in species distribution over time at site C, with an average decrease in LL distributions of -1.2ft among species sampled. Site D did not show consistent changes in species distribution over time.

Comparing Species

When comparing changes over time for each species, *Endocladia* was observed to have the largest change. Its LL showed an average decrease of -2.2ft between sites. *Fucus* was observed to show the least change over time. Its LL showed an average decrease of -0.5ft between sites.

Biotic Competition/Herbivory

From our observations and correlative analysis we observed *Endocladia* to show a consistent decrease in its LL distribution over time. Given the increases in global temperatures, this observation seems counter intuitive, and begs the question, what could contribute to this anomaly? The objective of this study was to determine if the UL and LL of *F. distichus* and *E. muricata* have changed since 1972, and correlate these changes to trends in increased global water temperatures. However, given the absence of a heat stress proxy, defined by PDO phases, present during each sample year, we must turn our attention to other biotic/abiotic factors. One such factor could be competition and herbivory. Despite sampling during negative PDO phases, average sea-surface temperatures in the northern hemisphere have shown a 0.86°C increase since 1968(Our World in Data 2021). In addition, heat waves in the northern hemisphere have seen a 46% increase in mean spatial extent, a 17% increase in intensity, and a sixfold increase in frequency (Rodgers 2022). Combined, these factors could make the high/mid-intertidal inhospitable to species less adapted to resist heat and desiccation. Thus, these species could retreat to lower elevations, pushing the LL of more desiccation-resistant species, such as *Fucus* and *Endocladia*, higher given their propensity to resist such harsh environments.

Another possible explanation for our results could be competition between Fucus and Endocladia. Our data showed Endocladia to have a larger decrease in its LL than Fucus, this could be a result of Fucus out competing Endocladia at lower elevations. No research was found to reinforce this theory, and could be the subject of future studies if continued observations observe this trend.

Replicating Historical Methods

One explanation for our decreases in the LL of both species could be our ability to replicate the methods of data collection documented by the 1972 study. The elevations at each transect marker, done by the 1972 study did not match ours, nor previous studies following the same procedures at the same site location. A report done by OSU student, Sarah Close, titled "Interannual and interdecadal variations in a sheltered seaweed assemblage at Cattle Point, San Juan Island.", attempted to replicate the 1972 procedure and also noted discrepancies in their tidal elevations. Although I'm confident in our ability to re-calibrate their tidal heights, this finding questions the quality of their data collection as a whole.

Another issue in replicating the 1972 study was the time of year the data was collected. Given the time constraints of the Spring 2023 FHL course, we were forced to collect data in May, compared to the 1972 study, who collected their data in July. Despite being only two months apart, the cooler climate of late spring could explain why our LL of each species was higher than those observed in mid-summer of the 1972 study.

Limited Amount of Data

Given that our data samples were limited to two points in time, rather than a continuous record, we were unable to accumulate enough data to run statistical analysis. As a result we could not determine if the observed changes were statistically significant or just yearly anomalies. This left our analysis to be more qualitative than quantitative.

Our intention was to have three years of data to compare, 1972, 2008, 2023. However, the data collected in 2008 lacked clarity on transect location, tidal elevation, and date collected. Because of this, we were unable to verify the quality of this data, and unable to use it in our analysis.

Re-creating Experiment

Given the opportunity to do future research here, we would have future classes at FHL follow the methods outlined in this paper to accurately recreate sampling and data collection, and compare changes over the next 10 years. PDO's phases have shown a decrease in duration, making fluctuations between heating and cooling phases more frequent (NOAA 2023), given this phenomena, futures studies would more than likely take observation during and after a heating phase to allow for a more accurate observation of heat stress at Cattle Point, San Juan Isl, WA. Furthermore, I would continue documenting all species present during quadrat sampling, as done in the 1972 study. This information could glean insight into the overall distributions of species at each site, and determine if species less resistant to desiccation have altered in distribution over the years.

Acknowledgements

I would like to thank my amazing professors and teaching staff, Tom Mumford, Megan Dethier, Sophie George, and Megan Powers, for the tireless work, endless encouragement, and dedication to their craft as both professors and researchers. Additionally I would not have had this opportunity if not for the University of Washington allowing me to attend Spring quarter at Friday Harbor Labs.

I would like to extend my dearest gratitude towards Ms. Dorothy Mills, Dr. Claudia Mills, Profs. Katherine Graubard and William Calvin, Drs. Alan and Marian Kohn, and Prof. Dennis Willows and Dr. Susan Mahoney, The Margy Gates Foundation, and the FHL Financial Aid board for their financial support through the FHL Biology Department Scholarship Award, The Mary Gates Endowment Scholarship, and The FHL Financial Aid Dispersal awards.

I would also like to thank my peers, Hailey Guthery, Julia Pop, and Ben Eklun, for assisting me in my field work and data collection.

Finally I would be remiss to not mention my research mentor, Tom Mumford. I cannot express how your positive attitude, constant encouragement, and unending support of my fungal endeavors helped me through this research project.

References

Beer, S., & Kautsky, L. (1992). The recovery of net photosynthesis during rehydration of three fucus species from the Swedish West Coast following exposure to air. *Botanica Marina, 35*(6), 487–491. https://doi.org/10.1515/botm.1992.35.6.487

Broad, A. C., Thompson, R. K., & Smart, J. G. (1972). A floral survey of protected and exposed rocky intertidal areas at Cattle Point, San Juan Island, Washington in July, 1972. *Friday Harbor Laboratories - Marine Algology*. Bound student reports in FHL Library.

Gasulla, F., del Campo, E. M., Casano, L. M., & Guéra, A. (2021). Advances in understanding of desiccation tolerance of lichens and lichen-forming algae. *Plants*, *10*(4), 807. https://doi.org/10.3390/plants10040807

Hazraty-Kari, S., Morita, M., Tavakoli-Kolour, P., Nakamura, T., & Harii, S. (2023). Reactions of juvenile coral to three years of consecutive thermal stress. *Science of The Total Environment, 863*, 161227. https://doi.org/10.1016/j.scitotenv.2022.161227

Hunt, L. J., & Denny, M. W. (2008). Desiccation protection and disruption: A trade-off for an intertidal marine alga1. *Journal of Phycology*, *44*(5), 1164–1170. https://doi.org/10.1111/j.1529-8817.2008.00578.x

Klinger, T., & Fukuyama, A. K. (2011). Decadal-scale dynamics and response to pulse disturbance in the intertidal rockweed Fucus Distichus (Phaeophyceae). *Marine Ecology*, *32*(3), 313–319. https://doi.org/10.1111/j.1439-0485.2011.00481.x

Lalegerie, F., Gager, L., Stiger-Pouvreau, V., & Connan, S. (2020). The stressful life of red and brown seaweeds on the temperate intertidal zone: Effect of abiotic and biotic parameters on the physiology of macroalgae and content variability of particular metabolites. *Advances in Botanical Research*, *95*, 247–287. https://doi.org/10.1016/bs.abr.2019.11.007

Mantua, N. J., & Hare, S. R. (2002). The Pacific Decadal Oscillation. *Journal of Oceanography*, *58*(1), 35–44. https://doi.org/10.1023/a:1015820616384

NOAA. (2023), June 8. *Pacific Decadal Oscillation (PDO)*. Pacific Decadal Oscillation (PDO) | National Centers for Environmental Information (NCEI). 2023, June 8. https://www.ncei.noaa.gov/access/monitoring/pdo/

Our World in Data, Met Office Hadley Centre. (2021). *SEA SURFACE TEMPERATURE ANOMALY (RELATIVE TO 1961-90 AVERAGE)*. Our World in Data. https://ourworldindata.org/grapher/sea-surface-temperature-anomaly?tab=table&time=1968..latest

Pacific Decadal Oscillation (PDO)(2023). Pacific Decadal Oscillation (PDO) | National Centers for Environmental Information (NCEI). (2023, June 8). https://www.ncei.noaa.gov/access/monitoring/pdo/

Rodgers, C. D. W., Kornhuber, K. K., Perkins-Kirkpatrick, S. E., Loikith, P. C., & Singhi, D. (2022). Sixfold increase in historical northern hemisphere concurrent large heatwaves driven by warming and changing atmospheric circulations. *Journal of Climate*, *35*(3), 1063–1078. https://doi.org/10.1175/jcli-d-21-0200.1

Sarkar, S., Dey, A., Kumar, V., Batiha, G. E.-S., El-Esawi, M. A., Tomczyk, M., & Ray, P. (2021). Fungal endophyte: An interactive endosymbiont with the capability of modulating host physiology in myriad ways. *Frontiers in Plant Science*, *12*. https://doi.org/10.3389/fpls.2021.701800

Tide Predictions - Tides & Currents - NOAA. (2023). Tides & Currents. https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=9449856&units=standard&bdate=20230523&edate=20230524&timezone=LST%2FLDT&clock=12hour&datum=MLLW&interval=hilo&action=dailychart

Wang, H.-Y., Tsang, L. M., Lima, F. P., Seabra, R., Ganmanee, M., Williams, G. A., & Chan, B. K. (2020). Spatial variation in thermal stress experienced by barnacles on rocky shores: The interplay between geographic variation, tidal cycles and microhabitat temperatures. *Frontiers in Marine Science*, *7*, 553. https://doi.org/10.3389/fmars.2020.00553

Whalen, M. A., Starko, S., Lindstrom, S. C., & Martone, P. T. (2023). Heatwave restructures marine intertidal communities across a stress gradient. *Ecology*, *104*(5). https://doi.org/10.1002/ecy.4027

Appendix of Raw Data

transect	quadrant	distance	elevation	species	percent	absence	year
C	1	0	13.36	endocladia	0	0	1972
C	2	2	9.9	endocladia	0	0	1972
C	3	4	8.4	endocladia	0.02	1	1972
C	4	6	7.9	endocladia	0.02	1	1972
C	5	8	7	endocladia	0.05	1	1972
C	6	10	6	endocladia	0.04	1	1972
C	7	12	4.9	endocladia	0.06	1	1972
C	8	14	3.3	endocladia	0.01	1	1972
C	9	16	2.2	endocladia	0.002	1	1972
C	10	18	0.9	endocladia	0	0	1972
C	11	20	0.7	endocladia	0	0	1972
D	1	0	9.32	endocladia	0	0	1972
D	2	2	7.6	endocladia	0.02	1	1972
D	3	4	5.9	endocladia	0.002	1	1972
D	4	6	3.9	endocladia	0.002	1	1972
D	5	8	2.5	endocladia	0	0	1972
D	6	10	2.5	endocladia	0	0	1972
D	7	12	1.6	endocladia	0	0	1972
D	8	14	1.2	endocladia	0.02	1	1972
D	9	16	0.9	endocladia	0	0	1972

D	10	18	0.55	endocladia	0	0	1972
D	11	20	-0.25	endocladia	0	0	1972
C	1	0	13.36	fucus	0	0	1972
C	2	2	9.9	fucus	0	0	1972
C	3	4	8.4	fucus	0	0	1972
C	4	6	7.9	fucus	0	0	1972
C	5	8	7	fucus	0.01	1	1972
C	6	10	6	fucus	0.03	1	1972
C	7	12	4.9	fucus	0.02	1	1972
C	8	14	3.3	fucus	0.01	1	1972
C	9	16	2.2	fucus	0.11	1	1972
C	10	18	0.9	fucus	0.08	1	1972
C	11	20	0.7	fucus	0	0	1972
D	1	0	9.32	fucus	0	0	1972
D	2	2	7.6	fucus	0.01	1	1972
D	3	4	5.9	fucus	0.53	1	1972
D	4	6	3.9	fucus	0.63	1	1972
D	5	8	2.5	fucus	0	0	1972
D	6	10	2.5	fucus	0.19	1	1972
D	7	12	1.6	fucus	0.004	1	1972
D	8	14	1.2	fucus	0.11	1	1972
D	9	16	0.9	fucus	0	0	1972
D	10	18	0.55	fucus	0	0	1972
D	11	20	-0.25	fucus	0	0	1972

C	1	0	13.36	endocladia	0	0	2023
C	2	2	9.9	endocladia	0	0	2023
C	3	4	8.4	endocladia	0	0	2023
C	4	6	7.9	endocladia	0.062	1	2023
C	5	8	7	endocladia	0.08	1	2023
C	6	10	6	endocladia	0.09	1	2023
C	7	12	4.9	endocladia	0.01	1	2023
C	8	14	3.3	endocladia	0.01	1	2023
C	9	16	2.2	endocladia	0	0	2023
C	10	18	0.9	endocladia	0	0	2023
C	11	20	0.7	endocladia	0	0	2023
D	1	0	9.32	endocladia	0	0	2023
D	2	2	7.6	endocladia	0.02	1	2023
D	3	4	5.9	endocladia	0	0	2023
D	4	6	3.9	endocladia	0.09	1	2023
D	5	8	2.5	endocladia	0	0	2023
D	6	10	2.5	endocladia	0	0	2023
D	7	12	1.6	endocladia	0	0	2023
D	8	14	1.2	endocladia	0	0	2023
D	9	16	0.9	endocladia	0	0	2023
D	10	18	0.55	endocladia	0	0	2023
D	11	20	-0.25	endocladia	0	0	2023
C	1	0	13.36	fucus	0	0	2023
C	2	2	9.9	fucus	0	0	2023

C	3	4	8.4	fucus	0	0	2023
C	4	6	7.9	fucus	0	0	2023
C	5	8	7	fucus	0.9	1	2023
C	6	10	6	fucus	0.42	1	2023
C	7	12	4.9	fucus	0.05	1	2023
C	8	14	3.3	fucus	0.25	1	2023
C	9	16	2.2	fucus	0.45	1	2023
C	10	18	0.9	fucus	0	0	2023
C	11	20	0.7	fucus	0	0	2023
D	1	0	9.32	fucus	0	0	2023
D	2	2	7.6	fucus	0.08	1	2023
D	3	4	5.9	fucus	0.95	1	2023
D	4	6	3.9	fucus	0.41	1	2023
D	5	8	2.5	fucus	0.86	1	2023
D	6	10	2.5	fucus	0	0	2023
D	7	12	1.6	fucus	0.39	1	2023
D	8	14	1.2	fucus	0.07	1	2023
D	9	16	0.9	fucus	0.02	1	2023
D	10	18	0.55	fucus	0	0	2023
D	11	20	-0.25	fucus	0	0	2023