### Thesis Prospectus 2022-23

**Name: Max Wiecek**  **ID Number: A00431589**

**Email: max.wiecek@evergreen.edu**

**Student Final Submission (date): 12/03/2022**

**Faculty Reader Approval (date):**

**MES Director Approval (date):**

1. Working title of your thesis[[1]](#endnote-1).

Density Estimates of Understory Macroalgae and Substrate Classification in Southern Hood Canal

1. In 250 words or less, summarize the key background information needed to understand your research problem and question.

 In the cold, temperate waters surrounding Washington State, including the western coastline and inland channels of Puget Sound, kelp forests serve as critical habitat for a diverse array of marine life and provide valuable ecological and commercial services to nearshore communities (Calloway et al., 2020). Between the different morphological variations of kelp, the floating kelp species *Nereocystis luetkeana (*bull kelp) is the most well-studied within this region. Understory kelps, such as prostrate and stipitate kelps, are still poorly understood despite their relative importance and abundance. In fact, prostrate kelps (kelp that lack a rigid stipe or gas-filled buoy) are the most widely distributed among these species and are believed to provide important primary production, refuge, and habitat for other marine species throughout Puget Sound (DNR n.d.). As a result, more preliminary evidence and data are needed to quantify the density, distribution, and overall trends of understory kelp species.

1. State your research question(s).

Part 1: Are densities of understory macroalgae and kelp greater within Sund Rock Marine Preserve than outside of the preserve?

Part 2: What are the predominate substrate types among the different understory kelp and macroalgae?

1. Situate your research problem within the relevant literature. What is the theoretical and/or practical framework of your research problem?

**Theoretical Framework**

Kelp forests are recognized as highly productive ecosystems that are crucial to the ecological, social, and economic well-being of coastal communities. However, due to both chronic and acute stressors, these vital foundation species are increasingly threatened worldwide (Eger et al., 2020). Given their importance, it is critical to describe their current spatial distributions and overall biomass. One such method is the utilization of species distribution modeling, which requires a solid framework consisting of environmental covariates, a proper sampling strategy, and an independent evaluation dataset (van Son et al., 2020). In reviewing the literature on kelp densities and distributions in Puget Sound, there is an apparent lack of proper sampling strategies that provide reliable density estimates of kelp species, especially understory kelp, throughout the region.

Among the few studies done in the greater Puget Sound area, preliminary estimates have suggested that floating kelp occurs along 11% of shoreline while understory kelp occurs along 31% of shoreline (D.N.R, n.d.). However, these estimates were from a one-time, comprehensive survey and may not accurately depict the current distribution of kelp in the region (Calloway et al., 2020). Additionally, little information exists on changes in the abundance or distribution of the 16 understory kelp species that reside in Puget Sound (Mumford, 2007). Despite this ongoing information gap, it has been suggested that a precautionary framework should be put into place to implement conservation and monitoring actions, even in the absence of scientific certainty (Calloway et al., 2020). By utilizing this precautionary principle, I aim to acquire preliminary understory kelp densities and contribute a small-scale dataset for future management and coordination.

**Practical Framework**

The Washington State Department of Natural Resources manages state-owned aquatic lands and is considered the state steward for Washington’s seaweed resources. They have established the Aquatic Reserves Program to promote preservation, enhancement, and restoration of native aquatic habitats (WAC 332-30-151). Their recent work investigating seaweed harvest of two important understory kelp species, *A. marginata* and *Saccharina spp*., found that unsustainable harvesting practices impacts kelp resources by hindering their regrowth. Unsustainable harvest just once during the early growing season negatively affected kelp density within the same year and the following year (Kilgo, 2019). As such, statewide managers of these aquatic habitats have come to realize the importance of monitoring understory kelp densities which further supports a practical framework.

Detailed density estimates of understory kelp populations have primarily been carried out in other regions, which often includes the use of SCUBA surveys. These surveys often employ a variety of different sampling techniques. Schoenrock et al. demonstrated this by conducting community surveys at three scales in fjord-like environments in Greenland. A 30 x 1 meter swath survey was done at each site, where one observer counted the number of each kelp species on the swath (primarily *S. longicruris* or *A. clathratum*) (2018). However, similar methods have also proven to be effective at estimating understory kelp densities in Puget Sound. Near the Tacoma Narrows bridge, individual species whose holdfasts were attached within five randomly chosen 1 x 30 m transects were counted in a 900 m2 plot. Laminaria saccharina reached the highest densities (5.6 individuals m-2) (Maxwell & Miller, 1996). My study aims to contribute to the literature on understory kelp densities while employing practical survey techniques described within the research.

1. Explain the significance of this research problem. Why is this research important? What are the potential contributions of your work? How might your work advance scholarship?

The significance of this research problem is reinforced by the fact that substantial losses in kelp species have been observed throughout Puget Sound, with most of these observations being limited to bull kelp (Calloway et al., 2020). However, it has been suggested that the effects of climate change may put other species of kelp at risk, especially in wave-sheltered environments such as those commonly found throughout Puget Sound (Starko et al., 2019). As such, this research aims to fill in a large information gap on understory kelp density and ecology at a smaller scale, which may serve to be useful within the broader scope of this issue.

This work may potentially advance scholarship by prompting other researchers to study understory kelp communities and the role that they play in the greater Puget Sound ecosystem. I hope that environmental management agencies, private consulting firms, and other organizations may build upon the dataset collected in this research. As understory kelp species are known to be prolific throughout the region, it is imperative that we collect more data on their overall densities and the impact they have on other wildlife. Even though other methods are available for studying understory kelp communities, I believe that SCUBA surveys are an important component to an adaptive management framework for these nearshore ecosystems.

1. Summarize your study design[[2]](#endnote-2). If applicable, identify the key variables in your study. What is their relationship to each other? For example, which variables are you considering as independent (explanatory) and dependent (response)?

In order to acquire the necessary data on understory kelp density, I will conduct SCUBA surveys during the months of June and July, when annual kelp growth and densities are believed to be at their peaks. Two sites in the southern Hood Canal will be assessed for macroalgal densities, including Sund Rock Marine Preserve and another site with no protection status. As such, I will be considering understory kelp densities as my dependent response variable and protection status as my independent variable. Part 2 of my research, which is concerned with substrate types, is simply an additional parameter for characterizing these sites. Their relative importance to kelp densities will be noted using a different statistical test (yet to be determined).

1. Describe the data that will be the foundation of your thesis. Will you use existing data, or gather new data (or both)? Describe the process of acquiring or collecting data[[3]](#endnote-3).

My research will be focused on the collection of new data, particularly preliminary estimates of understory kelp densities. Additionally, I aim to characterize these sites by identifying predominant substrate types among the different samples. This process will include implementing 5 line transects at two different sites, with 5 quadrat placements (1 square meter each) on each line to measure macroalgal and kelp densities. Measurements will be taken at regular depth intervals of 10 feet. Adjustments will be made to reference these depths to mean lower low water (MLLW) at each site. Substrate types will be noted for each quadrat placement while density estimates are being taken.

1. Summarize your methods of data analysis. If applicable, discuss any specific techniques, tests, or approaches that you will use to answer your research question.

Densities of both understory macroalgae and kelp will be transferred to an excel spreadsheet after each fieldwork session. I anticipate that the data will follow a non-normal distribution, therefore it will be analyzed using a Mann Whitney U-Test to determine whether mean densities between the two sites are significantly different. All the data analysis will be conducted using the R statistical software. Additionally, site characterization based on substrate type will be assessed as a type of categorical variable. Once all the substrate types have been categorized for each sample, I aim to identify their relative importance to kelp densities.

1. Address the ethical issues[[4]](#endnote-4) raised by your thesis work. Include issues such as risks to anyone involved in the research, as well as specific people or groups that might benefit from or be harmed by your thesis work, perhaps depending on your results. List any specific reviews you must complete first (e.g., Human Subjects Review or Animal Use Protocol Form).

Ethical issues regarding this work mainly involves the various risks of scuba diving. Utilizing SCUBA for research comes with its own inherent risks and is potentially more dangerous as it requires task-loading and deployment of additional equipment. As such, potential volunteers will go through some level of screening before joining me in the field. This will be done in an effort to avoid diving-related injuries and ensure a safer working environment for all. I do not anticipate that any groups will be harmed from my thesis work.

I will also need to consider the environmental impact of my thesis work. In order to prevent any disturbance to wildlife at both sites, I will practice great caution when deploying the transect lines and PVC quadrats. Sund Rock Marine Preserve is recognized as a site containing significant biodiversity in the Hood Canal, and I will respect any limitations or recommendations provided by the owners if they so wish.

Lastly, I am currently developing a safety plan for conducting fieldwork. This plan is being drafted in coordination with my thesis reader and edits will be made periodically as needed. Potential hazards associated with utilizing SCUBA will be addressed, along with subsequent safety measures for all participants. Once the plan has been updated and a final draft is available, we will seek approval before beginning field work.

1. List specific research permits[[5]](#endnote-5) or permissions you need to obtain before you begin collecting data (e.g. landowner permissions, agency permits).

I will need permission from the owners at Sund Rock Marine Preserve to conduct the necessary surveys at the site. As of right now, I have been cleared by the owner to conduct SCUBA surveys at the preserve either during the months of June or July. No further research permits are required to do research in this area. The other potential site will need to be cleared by Hoodsport N’ Dive as the study site is part of their commercial and open-water training programs. I will ensure that I have their permission to conduct surveys at this location.

1. Reflect on how your positionality as a researcher could affect your results and how you will account for this in the research process[[6]](#endnote-6).

As someone who has been scuba diving at these sites at least once, I understand that I have some notions of where understory kelp species might be found. To avoid any bias in my research, I will assign completely random transect lines at each site to ensure that samples are part of a randomized sampling strategy. Additionally, I want to acknowledge my position as a researcher in this setting. Although I have a clear goal or research question in mind, I understand that conducting surveys and collecting samples in this type of environment may impact the quality of the data at times. To avoid unwanted human error, I will be following strict guidelines for conducting benthic surveys.

1. Provide at least a rough estimate of the costs associated with conducting your research, if any.  Provide details about each budget item so that the breakdown of the final cost is clear.
* Travel expenses – Approx. **$80.00**
* Sund Rock Marine Preserve Access -- $17.00 per day (x4) = **$68.00**
* PVC Quadrat -- **$40.00**
* Transect Line (Open Reel Tape Measure) – **$12.00**

**Total: $200.00**

1. Provide a detailed working outline of your thesis.

**Thesis Outline**

Abstract

* Background information on kelp and understory kelp in Puget Sound
	+ Ecological value of prostrate and stipitate kelps
	+ Lack of information on changes in abundance or distribution for understory kelp species within the region
* Understory kelp densities were evaluated at two different sites in southern Hood Canal using SCUBA surveys
	+ 5 randomly selected line transects were deployed perpendicular to shore at each site, with 5 quadrat placements along each line at intervals of 10 feet
	+ Additionally, substrate type was noted for each quadrat placement in order to characterize the benthic environment for the two different sites.
* Briefly summarize the findings of the study
	+ Were understory kelp and macroalgae densities significantly different?
	+ Summarize the predominant substrate types for each site

Introduction

* Broad overview of kelp and seaweed and their primary ecosystem functions in Puget Sound
* Floating kelp are the most well-studied within the region
	+ Understory kelps are still poorly understood despite their relative importance and abundance
* This presents a significant gap in the literature and more evidence is needed to quantify their densities, trends, and changes in distribution

Literature Review

1. *Kelp Biology and Life History*
2. *Current Status, Trends, and Threats*
3. *Cultural, Ecological, and Commercial Significance*
4. *Kelp Restoration and Conservation*
5. *Measuring Kelp Densities*
6. *Importance of Substrate in Kelp Populations*

Methods

* Understory kelp densities were evaluated at two different sites in southern Hood Canal using quadrat surveys and with the use of SCUBA
	+ Utilizing survey methods adapted from the Consortium for Ocean Science Exploration and Engagement (COSEE)
* Brady, J., & Francis, L. (n.d.). Monitoring a Habitat.

*Collection of Macroalgal Densities*

* 5 randomly selected line transects were deployed perpendicular to the shore at each site, with 5 quadrat placements along each line at intervals of 10 feet (referenced to MLLW)
* An open reel tape measure was placed along the seafloor, starting at a depth of about 5 ft, down to depths of around 60 ft
* Beginning at the first depth interval at 10 ft, the 1-m2 quadrat was placed adjacent to the transect line and scientific names and abundances of all macroalgal species within the quadrat were recorded
	+ Stipe counts were taken for the different species of kelp while blades were counted for both red and green algae
	+ Organisms were classified down to the species level, except for red algae (Class-Florideophyceae) and green algae (Genus-Ulva) as these algae can be difficult to accurately identify in the field



*Classifying Substrate*

* For each quadrat sample, substrate type was noted in order to characterize the benthic environment for these two sites
* Substrate type was dividing into three categories: Bedrock, Cobble, and Debris
	+ Cobble, as classified by the Udden-Wentworth size scale, is any rounded stone that has a diameter from 64-256 millimeters (2.5-10.1 in).
	+ For the interest of this research, debris is classified as any material other than bedrock and cobble, including material such as wood, shells, metal, etc.

*Statistical Analysis*

Average density of *species a* per quadrat = $\frac{Total number of species a found in all plots}{(size of quadrat)(\# of plots sampled)}$

* Following the collection of kelp and macroalgal densities in the field, the average density of each species was calculated using the formula above
* After average densities were calculated for each species, these averages were compared between the two sites using the Mann Whitney U-Test

Results

* Explain whether the mean densities of kelp and macroalgae varied significantly between the two sites
	+ Which species was most prolific throughout the study sites?
	+ Did one site show greater overall diversity or abundance for a given species?
* Include a table for species encountered between the study sites… List all species in alphabetical order and include general taxonomic information

Discussion

* Discuss the significance of the results… were understory kelp densities greater or less than hypothesized for each site?
	+ How might protection status at Sund Rock Marine Preserve impact the observations?
	+ Explain why SCUBA surveys were conducted at the site over other methods
* Quadrat surveys were deployed as they are a time-tested tested survey method that are best suited for coastal environments where access to a habitat is relatively easy

Conclusion

* For this study, understory macroalgae and kelp densities were measured using quadrat surveys at two nearshore sites in southern Hood Canal 🡪 Preliminary observations for densities of understory kelp populations
* Transect lines were arranged perpendicular to shore and quadrat surveys were conducted at regular intervals of 10 ft
* Summarize some of the key findings 🡪 which site contained the greatest densities, which species was most abundant among the two sites
* Why is it important to monitor kelp densities? What does this work mean at a larger scale? 🡪 Re-visit some work done on understory kelp in other regions & in Puget Sound
1. Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic and specific as you can at this point, including the deadlines for Spring quarter.

**Winter Quarter 2023**

1. Update my literature review based on any suggestions given by thesis reader
	1. Include more information under sections such as Cultural, commercial, and ecological significance
2. Conduct some preliminary field work at both Sund Rock Marine Preserve (Site 1) and Yellow House Cove (Site 2) to ensure field work methods can be properly deployed
3. Solidify Methods section for thesis and get most of the section completed before the end of the semester

**Spring Quarter 2023**

* Finish methods section for thesis
* Run statistical analysis on mock data to ensure the right test is used… generate graphs and tables
* Generate a calendar for field workdays… weather & tide permitting

**Summer (June/July) 2023**

* Collect field data at Sund Rock first… tentative timeline around the last week of June 🡪 I am hoping to finish sampling over the course of one week (2 transects, 10 quadrats, done in two dives each day)
* Collect field data at Yellow House Cove… tentative timeline around the first/second week of July 🡪 Hoping to finish sampling in one week
* Transfer field data onto excel file after each field day
* Generate graphs, tables, plots, etc.
* Create tables for species encountered and site descriptions

**Summer (August/September) 2023**

* Continue writing thesis… complete results and statistical analysis section
* Continue writing discussion and conclusion section
* Finalize all writing for thesis by mid-September
* Prepare thesis presentation for Fall Quarter
1. Who (if anyone), beyond your MES thesis reader, will support your thesis (in or outside of Evergreen)? Be specific about who they are and in what capacity they will support your thesis. If you are working with an outside agency or expert, be specific about their expectations for your data analysis or publication of results.

There is currently no one other than my MES thesis reader who will be supporting my thesis. Although I will be utilizing facilities offered by Hoodsport N’ Dive, they are not directly involved in the data analysis or publication of my results.

1. Provide the 5 most important references you have used to identify the specific questions and context of your topic, help with issues of research design and analysis, and/or provide a basis for interpretation. Annotate these references with notes on how they relate to/will be helpful for your thesis. For any other sources cited in your prospectus in other answers, provide a complete bibliographic citation here as well.

Calloway, M., D. Oster, H. Berry, T. Mumford, N. Naar, B. Peabody, L. Hart, D. Tonnes, S. Copps, J. Selleck, B. Allen, and J. Toft. 2020. Puget Sound kelp conservation and recovery plan. Prepared for NOAA-NMFS, Seattle, WA. 52 pages plus appendices. Available at: <https://nwstraits.org/our-work/kelp/>.

Christiaen, B. (2020). Spatial and depth distribution of understory kelp and other marine vegetation in Central Puget Sound. *Salish Sea Ecosystem Conference*. <https://cedar.wwu.edu/ssec/2020ssec/allsessions/83>

The preliminary evidence gathered by Christiaen in this technical report sheds light on the spatial distribution of understory kelp species throughout Puget Sound. It will serve as an important source of background information for my research, as it contains estimates of percent cover for different species of understory kelp along significant portions of Puget Sound’s coastline.

Duggins, D. O., Eckman, J. E., Siddon, C. E., & Klinger, T. (2003). Population, morphometric and biomechanical studies of three understory kelps along a hydrodynamic gradient. *Marine Ecology Progress Series*, *265*, 57–76. <https://doi.org/10.3354/meps265057>

While this research is more concerned with morphometrics rather than kelp density measurements, it provides a plethora of valuable information on understory kelp species that can be found throughout Puget Sound. Their research sheds light on how wave-impacted sites can lead to higher mortality rates in certain species, which is interesting as I plan to conduct my work in a highly sheltered environment. As I expect to encounter some of the species mentioned in this article during my own research, it serves as a useful source of background information on their biomechanical attributes and overall biology.

Hamilton, J., & Konar, B. (2007). Implications of substrate complexity and kelp variability for south-central Alaskan nearshore fish communities. *Http://Aquaticcommons.Org/Id/Eprint/8891*. <https://aquadocs.org/handle/1834/25535>

This study conducted by Hamilton and Konar is relevant to part 2 of my research question, which is concerned with the types of substrate preferences among the understory kelp species. In their study, they found that understory kelp species were positively associated with structurally complex substratum, and their methods included scuba surveys and quadrat deployments. As I am interested in deploying a similar approach, this source will prove to be useful over the course of my research.

Maxell, B. A., & Miller, K. A. (1996). *Demographic Studies of the Annual Kelps Nereocystis luetkeana and Costaria costata (Laminariales, Phaeophyta) in Puget Sound, Washington*. *39*(1–6), 479–490. <https://doi.org/10.1515/botm.1996.39.1-6.479>

This research conducted by Maxwell and Miller represents one of my primary sources of information on overall study design. They employ kelp density measurements and share demographic information on understory kelp species found in southern Puget Sound. It will serve as a guiding source for taking mean density measurements in my proposed study sites. Also, their use of SCUBA surveys, band transects, and quadrats closely aligns with my study design plans.

Rubin, S. P., Miller, I. M., Foley, M. M., Berry, H. D., Duda, J. J., Hudson, B., Elder, N. E., Beirne, M. M., Warrick, J. A., McHenry, M. L., Stevens, A. W., Eidam, E. F., Ogston, A. S., Gelfenbaum, G., & Pedersen, R. (2017). Increased sediment load during a large-scale dam removal changes nearshore subtidal communities. *PLOS ONE*, *12*(12), e0187742. <https://doi.org/10.1371/journal.pone.0187742>

Schoenrock, K. M., Vad, J., Muth, A., Pearce, D. M., Rea, B. R., Schofield, J. E., & Kamenos, N. A. (2018). Biodiversity of Kelp Forests and Coralline Algae Habitats in Southwestern Greenland. *Diversity*, *10*(4), Article 4. <https://doi.org/10.3390/d10040117>

In this study conducted in fjord-like habitats in Greenland, the researchers deployed a variety of methods using SCUBA surveys. Their methods included swath surveys, photo quadrat analysis, and grab sampling. Additionally, their work involved measurements of understory kelp density which closely aligns with what I am interested in doing for my thesis work. Overall, this article is one of my primary references when it comes to study design and statistical analysis.

Starko, S., Bailey, L. A., Creviston, E., James, K. A., Warren, A., Brophy, M. K., Danasel, A., Fass, M. P., Townsend, J. A., & Neufeld, C. J. (2019). Environmental heterogeneity mediates scale-dependent declines in kelp diversity on intertidal rocky shores. *PLOS ONE*, *14*(3), e0213191. <https://doi.org/10.1371/journal.pone.0213191>

1. You are not locked into this title; we want you to identify the main point or topic of your thesis. [↑](#endnote-ref-1)
2. You might discuss selection of case studies, sampling methods, experimental design, and/or specific hypotheses you will test. You should also address any specialized knowledge or skills that are necessary to complete the research. [↑](#endnote-ref-2)
3. If you are planning to use existing data, explain the specific source, contact information, arrangement with collaborating agencies, and expectations about use of data and final products of your research. If you are planning to gather new data, describe specific methods, time, place, and equipment that will be required. [↑](#endnote-ref-3)
4. If you’re not sure where to start, consult a ‘Code of Ethics’ or other similar document from an academic society in an applicable field of study. [↑](#endnote-ref-4)
5. If you are collecting ANY samples or data, even observational data, on public lands (city, county, state and/or federal) it is your responsibility to find out the permit requirements BEFORE you collect data. Conducting research with tribal members/on tribal lands will have different and additional requirements. [↑](#endnote-ref-5)
6. Your *positionality as a researcher* refers to the fact that one’s “…beliefs, values systems, and moral stances are as fundamentally present and inseparable from the research process as [one]’s physical, virtual, or metaphorical presence when facilitating, participating and/or leading the research project…” (The Weingarten Blog 2017). [↑](#endnote-ref-6)