**The Evergreen State College**

**Graduate Program on the Environment**

### Thesis Prospectus

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**STUDENT AGREEMENT:**

**SIGNATURE: \_Megan Bungum\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_12/11/2020\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**FACULTY READER APPROVAL:**

**SIGNATURE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_12/11/2020\_\_\_\_**

**MES DIRECTOR APPROVAL:**

**SIGNATURE:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ DATE\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

1. Provide the working title of your thesis[[1]](#endnote-1).

Analysis of Puget Sound nearshore sediment and Ghost Shrimp for mercury, aluminum, and PCB contaminants.

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

Gray whales migrate along the western coast of the US, where fatalities, strandings, and poor body conditions have been on the rise (Usha et al. 1993). As these whales travel past Puget Sound between the months of December-February (south-bound) and February-May (north-bound) (Usha et al. 1993), some have been observed entering this urban coastline in search of benthic prey. Although the vast majority of gray whales on the migratory path do not enter Puget Sound to feed, those that do are referred to as “Sounders”, “Saratoga Grays”, or “Puget Sound Regulars”. These whales have been shown to recruit others to enter Puget Sound and an overall increase in gray whales entering this area has risen yearly (Usha et al. 1993). This rise in individuals entering Puget Sound in search of prey has also been linked to poor body conditions and emancipated whales (Varanasi et al. 1993). This raises the question of a possible lack of food resources for migratory whales, which may force them off their pathways in search of prey.

The prey which these whales seek in Puget Sound is presumed to be the ghost shrimp. Gray whales consume them by sucking in large quantities of water and sediment and then filter out the excess materials to trap the prey in their baleen (Weitkamp et al. 1992). The consumption of urban coastal sediment by this species raises questions about the possible contamination of sediment by metals and anthropogenic compounds, such as PCBs, which may have negative health effects.

1. State your research question(s).

1. What concentrations of PCBs, aluminum, and mercury contaminants are found in nearshore Puget Sound sediments and ghost shrimp species?

2. How do these contaminants affect biological processes in both cetaceans and crustaceans?

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

The presence of potential heavy metal contaminants, in the form of mercury, aluminum, and PCBs could pose detrimental health effects to foraging gray whales (Varanasi et al. 1993). These materials are lipophilic have been shown to move up the trophic levels through biomagnification in organ, brain, and blubber tissue (Kershaw & Hall 2019). It has been determined that mean concentrations of mercury and PCBs, along with other anthropogenic heavy metals, are significantly higher in gray whale tissues which forage in urban coastlines as compared to those who feed in other pelagic areas (Tilbury, et al. 2002). Previous studies have also hypothesized that the urban chemical contaminants in Puget Sound waters may have contributed to overall poor liver and kidney conditions in gray whales (Varanasi et al. 1993).

Although there are no known thresholds for toxicity of mercury or PCBs for gray whales, there are limits placed on food and beverage products labeled for human and animal consumption. The known human health consequences from excessive mercury intake include neurotoxicity and birth deformities (Alva, et al. 2020).

In order to address the research question(s), it is essential to examine the concentrations of PCBs, aluminum, and mercury of the sediment in known Puget Sound gray whale feeding grounds and also in its preferred prey species, ghost shrimp. The main gray whale feeding ground areas in Puget Sound are located on the eastern portion of Whidbey Island, in the Whidbey Basin (DNR 2017).

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?

This research problem is significant because it furthers our understanding of mortality and poor body conditions of migratory gray whales and will also examine the health of our local ecosystem of Puget Sound. It is also significant to understand if the Eastern Pacific gray whales are potentially reaching carrying capacity, at ~26,000 individuals, and if the deaths and poor body conditions are due to a lack of food resources. A common acknowledgement across a literature review of this topic reveals that there are many unknown factors relating to potential sediment contamination and its biological effects to gray whales. The knowledge which can be gained on the presence of potential sediment contamination in Puget Sound coastlines is also applicable to not only the persistence of the Eastern Pacific Gray Whale, but also to human health, recreation, and fish and shellfish industries which drive our economy.

The potential contributions of my thesis work will be to evaluate the presence and levels of anthropogenic contaminants in both near-shore sediment and the preferred prey species in known gray whale feeding sites in Puget Sound. I will collect my own data samples and provide analysis, along with an analysis of previous literature of this subject. I feel that this will offer a contribution to the scientific community and aid in providing insight into possible stressors/pollutants in our ecosystem. I would also like to review literature on the distribution and abundance of the ghost shrimp (*Callianassa californiensis*) species, as it is the preferred prey of Eastern Pacific gray whales entering Puget Sound.

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)?

The study design will be to examine potential mercury, aluminum, and PCB levels in collected samples of near shore sediment and ghost shrimp specimens. In performing analysis of the samples, the X or explanatory variables will be the sample type and sample location. The Y or response variable will be the levels of contaminants measured. The relationship between the variables will be concentration levels to sample type and sample location.

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).

The data that will form the foundation of this research will be measurements of aluminum, mercury, and PCBs from near shore sediment and ghost shrimp samples. The collection of this data will take place during two separate time periods, January-March, and April-June, in order to collect samples during the north and south bound migration paths of the gray whales. I will collect multiple (2-3) sediment samples across several (3) sample sites of the near shore environment of Fox Spit and the Langley Waterfront on Whidbey Island, and Iverson Trail Preserve on Camano Island at low tide in clean/airtight containers. I will also retrieve at least 2 specimens of ghost shrimp from the locations.

For further analysis of the collected data, I will use also outside data from literature of ghost shrimp abundance in Puget Sound, and Gray Whale feeding ground preferences in Puget Sound. I would also like to compare my research findings on PCB, aluminum, and mercury concentrations with known values of these concentrations in other areas of Puget Sound and WA coastline.

1. Summarize your methods of data analysis. If applicable, discuss specific techniques that you will use to understand the relationships between variables (e.g., interview coding, cost-benefit analysis, specific statistical analyses, spatial analysis) and the steps and tools (e.g., lab equipment, software) that you will take to complete your analyses.

To analyze the nearshore sediment and ghost shrimp specimen samples, I will use the ICP MS at Evergreen State College to view the concentration/presence of aluminum. The concentration/presence of PCBs and mercury will be evaluated by an outside laboratory, at the Libby Environmental Laboratory in Boston Harbor, WA.

I will use the statistical software R to generate histograms of my data and decide on which statistical analysis is appropriate to use. I would potentially like to compare the mean levels of PCB, aluminum, and methylmercury concentrations of a normal distribution to the sample site locations, and sample types.

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).

The ethical issues raised from my research are humane treatment of animals, but it is personal, as crustaceans and many other forms of life are not protected by the government for research purposes, etc. I will have to incinerate the ghost shrimp specimens in order to analyze the mercury, aluminum, and PCB concentrations.

There are no known risks that the collection of this data will pose to anyone, but if striking concentrations of mercury, aluminum, or PCBs are found, that could cause alarm. These contaminants are known carcinogens and the adverse health of local sediment and ghost shrimp species could be inferred as bioaccumulation in humans and other forms of life.

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 do not need to obtain permits to collect the samples of near shore sediment at these sites, because I will be using public land. I will need to obtain a Scientific Collection Permit (SCP) through the Washington State Department of Fish & Wildlife to collect the ghost shrimp specimens.

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).

I feel that my positionality of being a middle-class individual with environmental and conservationist passions will influence my results. I will account for this by maintaining a professional and un-biased scientific analysis of both my data analysis and literature review.

1. Provide at least a rough estimate of the costs associated with conducting your research.  Provide details about each budget item so that the breakdown of the final cost is clear.



1. Provide a detailed working outline of your thesis.

* **Title:** Analysis of Puget Sound nearshore sediment and Ghost Shrimp for mercury, aluminum, and PCB contaminants
* **Abstract**

Succinct Overview of Thesis Design and Results

* **Introduction**

Overview of “Sounders”

Puget Sound Mortalities/Strandings

Feeding Mechanisms

Preferred Prey

* **Literature Review**

Background

Overview of Essential & Non-essential Metals

Toxicity of Non-essential Metals

Overview of PCBs

Toxicity of PCBs

* **Methods**

Research Design

Data Collection

Methods of Data Analysis

* **Results**

Statistical Results

ArcGIS Spatial Analysis

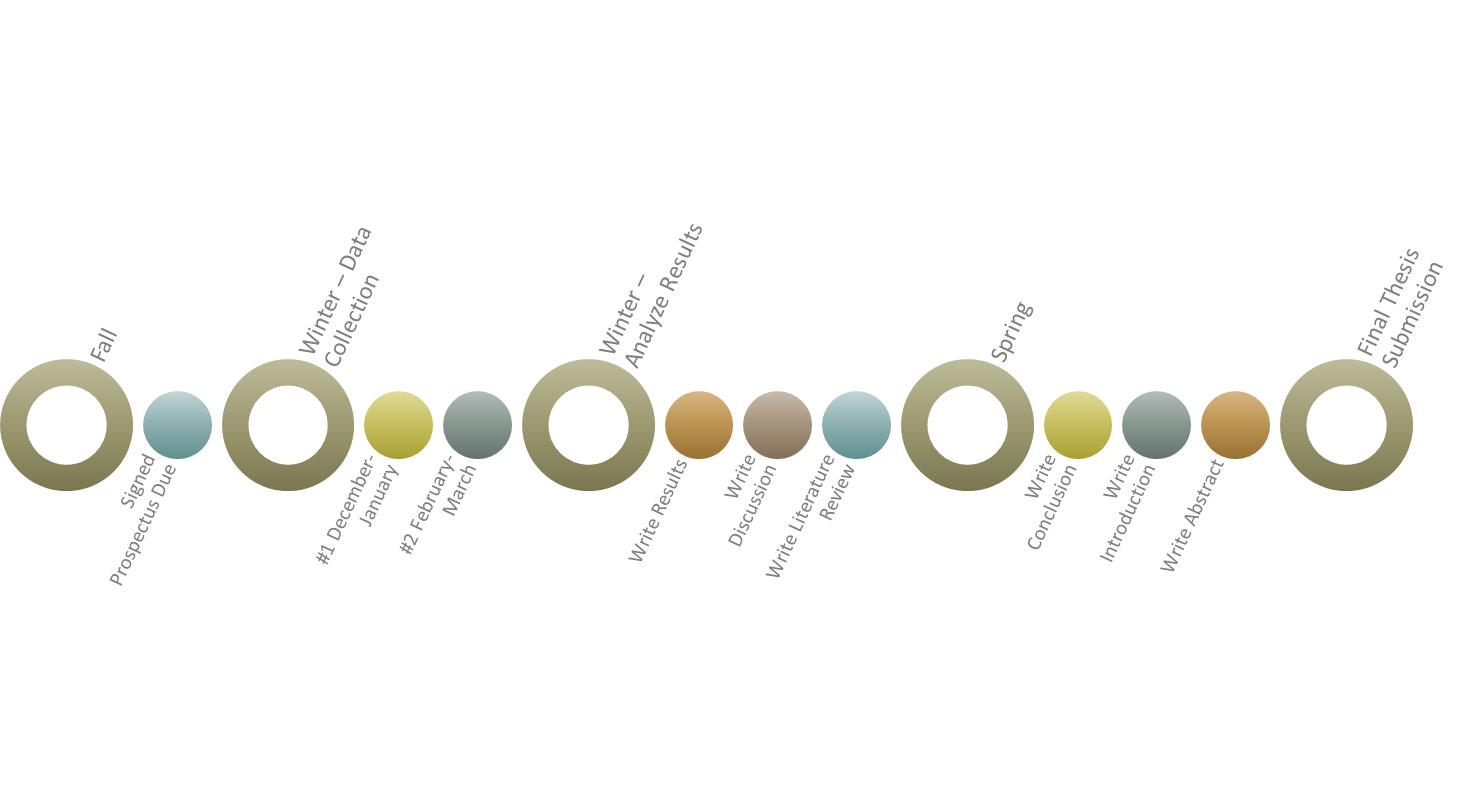
* **Discussion**

Research Results

Current Dept of Ecology Results

* **Conclusion**
* **References**

1. Provide a specific work plan and a timeline for each of the major tasks in the work plan. Be as realistic as you can, even though you will probably need to alter this schedule as you complete the tasks. Remember that faculty readers take time to return your drafts and that the final polishing and formatting of your thesis for binding will take longer than you ever imagined.



* I have submitted a Scientific Collection Permit to the WDFW in order to collect ghost shrimp specimens. The review process is estimated to take 60 days. I have spoken with both the Scientific Collection Permit office and Barbara Baker the vice chair WDFW commissioner, who both assured me that the process of obtaining this permit in 60 days is feasible.
* I have contacted the Evergreen SSC and requested an SIT to assist with ICP training and analysis. I will develop a timeline with my assigned SIT and my reader, John Kirkpatirck, once an SIT assignment has been made.
* I have contacted Libby Environmental and obtained pricing information and a timeline for prospective Hg and PCB sample analysis.
* I have made contacts within the groups of: South Sound Stewards of Island County (Allie Hudec), The Island Adventures Whale Watching (Erin Gless), and Orca Network (Lon Brocklehurst) to receive information on locations and sightings of Eastern Pacific Gray Whales and their respective feeding pits.
* I have contacted NOAA Fisheries and obtained all U.S. West Coast cetacean stranding data from 2010-2019 for ArcGIS and R analysis.
* I have reviewed prospective collection sites in person with a member of South Sound Stewards of Island County, Allie Hudec.

1. Who, beyond your MES faculty reader, will support your thesis? Indicate support both within and 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.

I am unsure of specific person (persons) who will support my thesis as of yet.

1. List the 3-5 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. For each annotated reference, explain how your project specifically connects to the source by extending, challenging, or responding to the conclusions, methods, or implications. For any other sources cited in this document provide a complete bibliographic citation.

Usha Varanasi, John E. Stein, Karen L. Tilbury, James P. Meador, Catherine A. Sloan, Donald W. Brown, Sin-Lam Chan, and John Calambokidis. (1993). Chemical contaminants in Gray Whales (*Eschrichtius robustus*) stranded in Alaska, Washington, and California, U.S.A. NOAA Technical Memorandum NMFS-NWFSC-11.

The bulk of the information that I reviewed for this mini prospectus came from this NOAA memorandum on chemical contaminants to gray whales. The contributing author, John Calambokidis, is a pioneer in research studies of migrating gray whales which forage in Puget Sound and on WA coastlines. This memorandum includes studies of deceased gray whale tissues for potential anthropogenic contaminants and notes a lack of information on a link between chemical contaminants and poor whale health and body conditions. The memorandum mentions a possible issue of sediment contamination as a link and I chose to springboard off of this idea to perform data collection and analysis of Puget Sound nearshore sediments.

Kershaw, L., Joanna, Hall, J., Alisa (2019). Mercury in cetaceans: Exposure, bioaccumulation, and toxicity. *Science of the Total Environment*. Vol 694.

This peer-reviewed research article provided background information on the toxicity and effects mercury has on pelagic mammals. The article also provided information on how mercury is transported into marine environments, its bioaccumulation methods, and which species were most at risk for toxicity effects. This article was important to my research, because it aided in which heavy metal I would include in my analysis measures. The inclusion of mercury into my data collection and analysis is useful because I will be able to measure it concentrations with equipment on campus and will not have to send it out for expensive outside laboratory analysis.

Weitkamp, L. A., R. C. Wissman, and C. A. Simenstad. 1992. Gray whale foraging on ghost shrimp (*Callianassa californiensis*) in littoral sand flats of Puget Sound, U.S.A. Can. J. Zool. 70:2275-2285

This peer-reviewed research study was an essential contribution to my research design because it provided background information on my topic and also gave me with the idea to collect sediment samples in gray whale feeding sites. This study provides information on the diet preference and location of known gray whale feeding grounds of foraging whales which enter Puget Sound and WA coastlines during migration. The source mentions possible consequences of gray whales feeding in urban coastlines and I would like to expand on this by providing information about heavy metal and PCB concentrations.

**Bibliography**

Alva, Valente, Camila, Marisco, Teixeira., Eliane, Ribeiro, Roberta, Carneiro, Carla, Simones, Siqueira., Julia, Ferreira, da Silva., Micheli. (2020). Concentrations and health risk assessment of total mercury in canned tuna marketed in Southeast Brazil. *Journal of Food Composition and Analysis.* Vol. 88. 103357.

Tilburry, L., Karen, Stein, E., John, Krone, A., Cheryl, Brownell Jr, L., Robert, Blokhin, S.A., Bolton, L., Jennie, Ernest, W., Don. (2002). Chemical contaminants in juvenile gray whales (*Eschrichtius robustus*) from a subsistence harvest in Arctic feeding grounds. *Chemosphere.* Vol. 47. Issue 6. Pages 555-564.

Various authors 2017. Intertidal ghost shrimp in Puget Sound: enough for gray whales and a sustainable commercial harvest? Washington State Department of Natural Resources.

Retrieved from: <https://www.dnr.wa.gov/publications/aqr_aamt_shellfish_conf_022216.pdf?wocmrf>

1. You are not locked into this title; its purpose is to help you identify the main point or topic of your thesis at an early stage. [↑](#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)