Estuary Acidification: A Five-Year Perspective on pH in Possession Sound, Washington
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Ocean acidification, the persistent lowering of pH in marine environments, is influenced by water chemistry, biological aspects, seasonal changes, and human activity. Low pH (acidic conditions) can contribute to hypoxia, coral bleaching, and other dangerous conditions for the environment. Estuarine environments contain all these influences. In this study, changes in pH in Possession Sound, WA were examined over a five-year period, with the context of changes in river discharge. This was accomplished using a YSI EXO Sonde periodically deployed nearshore in Mukilteo, Washington, USA used in partnership with Ocean Research College Academy. This site, being within the Snohomish River Estuary, is affected by both oceanic factors and the Snohomish River, including any runoff that comes through those waters. These measurements create a depiction of changes in pH mostly due to seasonal factors, like river discharge and upwelling. Early results from these data demonstrate a clear seasonal pattern without significant annual trends toward lower pH. As climate change progresses, consistent monitoring of ocean pH will be essential to understanding the effects of ocean acidification and the ways we might combat them in the future. While this study was limited by its short timeframe, these results provide an important baseline for continued collection and analysis of these data.

Predictive Model of the Impacts from Combined Sewer Outflow Overflows on Dissolved Oxygen and Turbidity in Possession Sound
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Combined sewer outflow (CSO) overflows are a threat to water quality, particularly in such urbanized areas as the Puget Sound. CSOs contribute to spills of untreated sewage mixed with stormwater that wash into water systems during heavy rain events. Possession Sound, fed by the Snohomish River, has 13 CSO outfalls in Everett, Washington, some of which experience CSO events fairly regularly. Contaminants in these CSO overflows can release pathogens, solids, nutrients, toxins, and oxygen-consuming pollutants into the water. These variables can in turn affect DO mg/L (dissolved oxygen) and turbidity NTU (measure of water clarity) – two important measures of water quality. Past research has found that wastewater spills cause major decreases in DO and increases in turbidity. DO and turbidity data were collected using a CTD in the Everett Marina throughout 2019. This data, in addition to the combined volume of water discharged from the CSOs during overflows, the duration of these spills, and the depth of precipitation in inches during the overflow, were analyzed using the Principal Component Analysis (PCA) method to find which components were most effecting the change in DO and turbidity. Using the components that covered over 90% of the variability in the data from the PCA, a Principal Component Regression (PCR) was made to be the foundation for two predictive models, one for projected DO, the other for turbidity. It is expected that a regression based on these components will make a model that covers the majority of change in DO and turbidity with a statistically sig-
nificant R2 value. These models may make analysis of the effects of CSO overflows on Possession Sound a much simpler process and provide important insights into the impacts of these overflows on water quality.

**Water Currents and their Effect on Possession Sound**  
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In any marine ecosystem, water currents are an important factor in both the biological aspects and the physical movements of a body of water. The focus of this study, the Possession Sound estuary in the Salish Sea, lies in an interesting area that is affected both by discharge from the Snohomish River and surrounding streams, and incoming ocean currents from the Pacific Ocean. In Possession Sound the currents can affect everything from the regular boat traffic through the area to the transportation of debris and other natural or harmful substances in the water. I used an Acoustic Doppler Current Profiler (ADCP), moored in the Everett marina at the mouth of the Snohomish River, to collect data on current velocity for 10–30-minute intervals over the period of seven months in 2020, and almost two months in 2021. The collated data I then used to analyze the current directions and speeds of the water to determine potential local trends in the currents. Preliminary analysis shows that the currents flowing near the moored ADCP tend to flow north and south with fewer currents going to the east or west. However, the currents going east and west are often faster than the north and south streams. These two trends are likely caused by the north moving ocean currents and the south moving river currents, but more research utilizing related data such as river discharge is necessary. Because of the estuary’s diverse currents sources, the analysis of these data allows for a greater understanding of the movements of the water column, and insight into the transportation of important substances within it such as nutrients and heavy metals.

**Dietary Preference and Consumption Rates of Pugettia产品** in Two Different Environments  
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*Pugettia产品*, native to the Salish Sea, alter their diet seasonally based on availability, shifting from algae in spring and summer to mussels in fall and winter. Our hypothesis was that when presented with both algae and mussels simultaneously, the kelp crabs would prioritize one food over another. Additionally, the environmental conditions of a tank may also have an effect on the amount of food consumed. We also hypothesized that by mimicking the seafloor, the consumption rate would be higher. Crabs were placed in two tanks, one with sediment and one without, and were accompanied by a measured amount of bull kelp and mussels. Tanks were covered nightly at sunset to mimic outdoor lighting conditions, and salinity, pH, water flow, and temperature were regulated evenly for both tanks. Measurements were taken daily of the remaining food supply, and each trial was run for 48 hours. We found that the tank with the sediment had less food remaining, and in both tanks, more algae was consumed than mussels. Algae may have been preferred because it takes less energy to consume, which may mean that kelp crabs spend more energy eating in the winter, and likely suffer a trade-off with less energy to spend on other factors, such as growth and reproduction. Imitating the sea floor may have made a difference in alleviating stress levels in the crabs, which led to more consumption. Understanding dietary preferences is important when considering the potential future effects of anthropogenic climate change and ocean acidification on marine ecosystems. Additionally, mimicking field conditions in a laboratory in conjunction with manipulating variables of interest for any experiment likely provides more accurate results than an empty tank, and may be a viable option wherever possible to obtain results representative of a natural environment when field experiments are not possible.

**Analysis of Tidal Stage Impact on Harbor Seal Haul-Out Behavior in the Snohomish River Estuary of the Salish Sea**  
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Harbor seals fill a critical role in the balance of the Salish Sea. Prey availability is known to be a strong indicator of seal presence; however, there are many more subtle environmental influences on harbor seal presence as well. This study homed in on the harbor seals of the Snohomish River Estuary and how their haul-out habits may be influenced by the unique water circulation of the area. This study analyzed data compiled by the Ocean Research College Academy at multiple log boom haul-out sites in the Snohomish River from 2015-2022. I analyzed seal data through the lens of the tide’s movement of water in this estuary and compiled tide data from the National Oceanic and Atmospheric Administration (NOAA),...
I expected that there would be an increase in seals hauled-out at flood tide as well as in the beginning of the ebbing tide due to the colder temperatures experienced during high tide. Early results suggest no direct or strong correlations between tidal height and overall seal presence at sampling sites. This study seeks to better understand the presence and behavior of harbor seals at the mouth of the Snohomish River.

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Ocean acidification is a global crisis that is mainly caused by too much carbon dioxide in the atmosphere being absorbed by bodies of water, altering the water chemistry. Ocean acidification has large visual consequences, such as the bleaching of coral reefs, but less obvious, small scale influences are also found in the Salish Sea. A major indication of global warming’s effects on local water systems is pH, or the measure of how acidic or basic a solution is. Previous global studies have shown that pH has been decreasing (becoming more acidic) over the years, while the overall temperatures have been rising. The goal of this study is to observe how changes in low-ernig pH are related to temperature changes in the water column of Possession Sound, a salt wedge estuary, near Everett, Washington. We utilized pH and temperature vertical profiles collected from a YSI EXO Sonde, a deployment device that utilizes sensors and precise calibrations to monitor water quality, over six years to assess the degree of ocean acidification locally. Trends were analyzed according to depth and season. Preliminary studies of this particular site have shown minor changes compared to the extreme trends recorded in other ocean environments. Given the potential for negative impacts on the estuary, it is worth expanding the study by investigating a longer time frame. Local estuary data regarding depth and season will allow people to better understand how these variables change in our environment and gain a greater understanding of climate change’s influences on ocean acidification locally.

Exploring Temporal Patterns in Temperature and Current Speed at the Mouth of the Snohomish River
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Possession Sound, a fjord-type estuary system in the Salish Sea, is home not only to incredible biodiversity but also to some unique clines. A cline, such as a thermocline or a halocline, is a portion of the water column where a physical property changes significantly with depth. The haloclines of the Possession Sound fjord system vary periodically in stratification, particularly at river mouths. One such area can be found at the mouth of the Snohomish River, where cold freshwater flows into warmer seawater, creating a stratified but unstable water column. This study aims to draw connections and seek out patterns between current speeds and temperatures. Temperature data was collected from the Ocean Research College Academy’s Conductivity, Temperature and Depth (CTD) sensor mooring at the Everett Marina, and current speed data was collected from their Acoustic Doppler Current Profiler (ADCP) in the same location. Prior research suggests that during most parts of the tidal cycle, temperature readings at the surface correlate strongly with tidal stages: the surface becomes colder when river water flows out to sea at low tide and warmer as the seawater pushes the river water back at high tide. However, when the tide cycle becomes less intense and current speeds decrease, this correlation becomes muddled. It is hypothesized that this pattern represents a decrease in thermocline stratification during periods of slower current speeds. Prior research done on this correlation at the mouth of the Snohomish River lacked in scope and statistical support. By expanding the scope by several months and incorporating statistical support, this study has reinforced previous findings, supporting the hypothesis posed previously: a linear correlation between the variables was supported with a p-value of 2.89E-25, and the inverse linear correlation between temperature and tide height was stronger during periods of greater average current speed.
Plankton Predence and Gradients along the Merge between Estuary and River Water
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Possession Sound, located in Everett, Washington, includes the second largest source of freshwater in Puget Sound from the Snohomish River. This salt-wedge estuary serves as a home to a wide selection of phytoplankton, which provide energy to a variety of organisms farther up the food chain. Water chemistry often determines where phytoplankton accumulate prior to their recycling as nutrients. Ocean Research College Academy students utilize water chemistry data (temperature, salinity, dissolved oxygen, pH, turbidity and chlorophyll concentration) from two sensors deployed in Possession Sound: One in the river and one two miles away at Mukilteo. While plankton samples are collected in the Sound, rarely are plankton collected in the river and compared to chlorophyll concentrations. This study will look at abundance and diversity of phytoplankton collected in the river at various tide stages and compare these to Mukilteo samples. I hypothesize that flood tide samples will be similar, while ebb tide phytoplankton and chlorophyll levels will decrease. The preliminary data revealed that chlorophyll and temperature levels did not vary significantly between the two sites despite the widely differing salinity levels. The next steps of the study are to determine the plankton density of phytoplankton species across the two most recent years of data. Results will enable us to explore further into plankton presence in relation to chemical variance in water systems.

A 13-year Temporal and Spatial Analysis of Nutrient Levels in Possession Sound and Their Seasonal Relationship with the Snohomish River Estuary
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Nutrient levels in marine environments can vary widely due to local geography, the placement of various manmade input sources, seasonal factors, and tidal patterns. They are important in understanding the overall health of an ecosystem, as they can be an indicator of potential pollution. They also have a significant impact on plankton populations and, as a result, primary production. Unnaturally high nutrient levels can affect other water chemistry variables, contributing to events such as harmful algal blooms, hypoxia, and ocean acidification. In this study, I analyze 13 years of nutrient data from ten Possession Sound sampling sites, at varying distances from the mouth of the Snohomish River. Nitrate and phosphate levels were analyzed temporally, and tidal, weather, and river discharge data was overlaid to analyze the relationship between nutrients and other facets of the surrounding environment. My early analysis indicates that seasons play a large role in nutrient levels, likely due to the weather of the Pacific Northwest and runoff from the Snohomish River. Figures also support the relative similarity of values between sites, showing that nutrient levels in the Snohomish River estuary are collectively affected by nutrient flow rather than having site specific characteristics. Studies of this type can provide insight about specific characteristics of our local nutrient pathways and can provide context for changes in our ecosystem. For further research, oceanic parameters such as dissolved oxygen, pH levels, and plankton densities should be analyzed in comparison to nutrients in order to gain a better understanding of the actual relative impact of nutrients in this local marine system.