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Exploring Temporal Patterns in Temperature and Current Speed at the Mouth of the Snohomish River

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Introduction

Haloclines and thermoclines are foundational to the dynamics of estuarine environments. These factors influence the estuary both biotically and abiotically, and they are in turn influenced by the tides. The Snohomish River, which flows into Possession Sound, is significantly influenced by tidal cycles, though the full scope of these influences has not yet been thoroughly investigated by ORCA students. This study will investigate the connections between current speeds at the mouth of the Snohomish River and temperatures. A previous study of the author's suggests that current speeds are inversely correlated with thermocline stratification, but this research lacks scope and statistical support. This study aims to expand both the hypotheses posed previously and their support by increasing sample size and statistical analysis.

Study Site

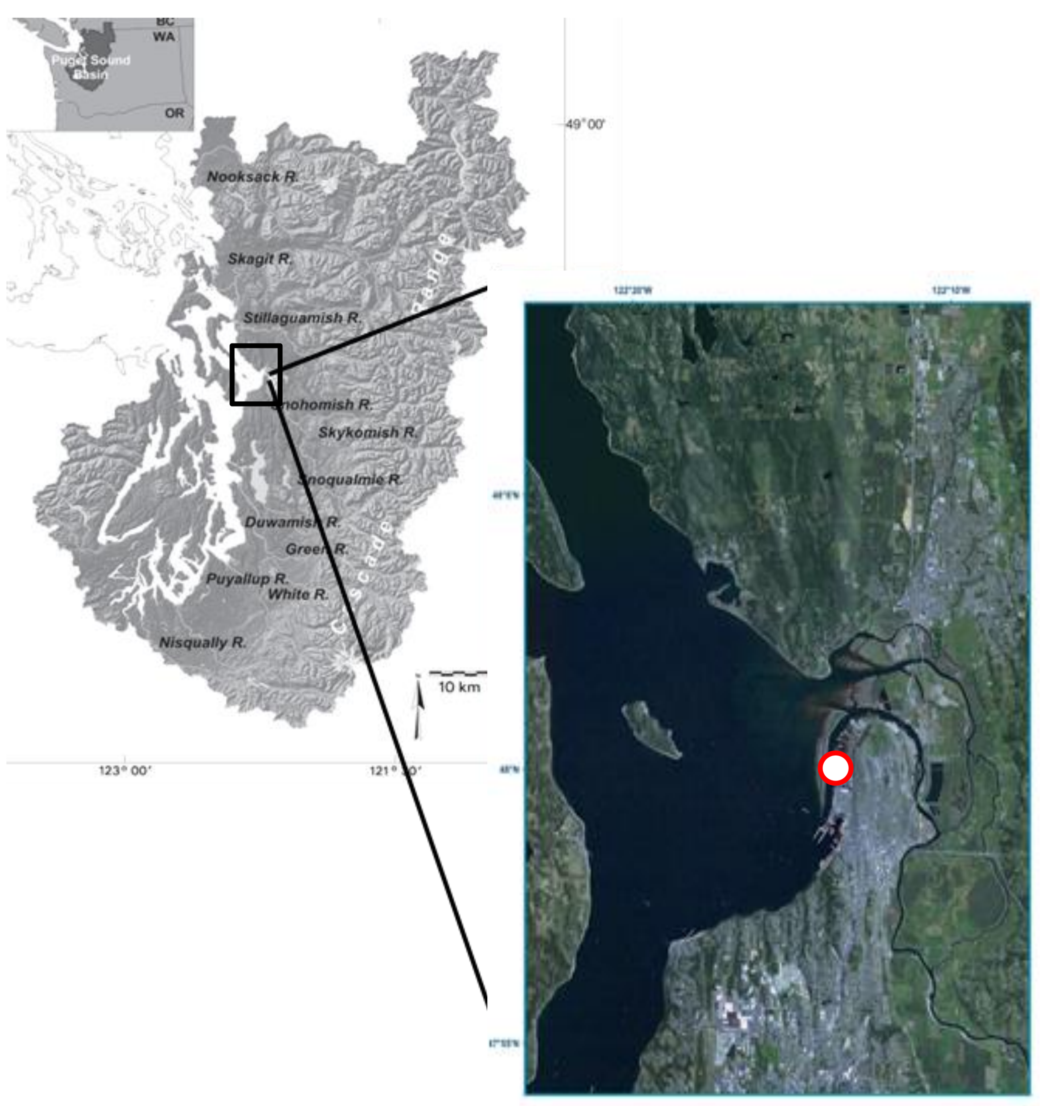

Figure 1: Map of Puget Sound with Possession Sound zoomed in. The dot indicates the location of the Everett Marina ADCP and CTD.

Methods

Temperature data used in this study were collected by ORCA's Conductivity, Temperature, and Depth sensor (CTD). Current speed data were collected by ORCA's Acoustic Doppler Current Profiler (ADCP). Both sensors were within close proximity of each other as indicated by Figure 1. The CTD was moored to the Everett Marina dock and the ADCP was secured to the riverbed. The data used in this study was collected between July 25th and September 10th of 2019. These data were selected specifically for their convenience: this time frame saw the longest consecutive coincidence of ADCP and CTD readings.

Results

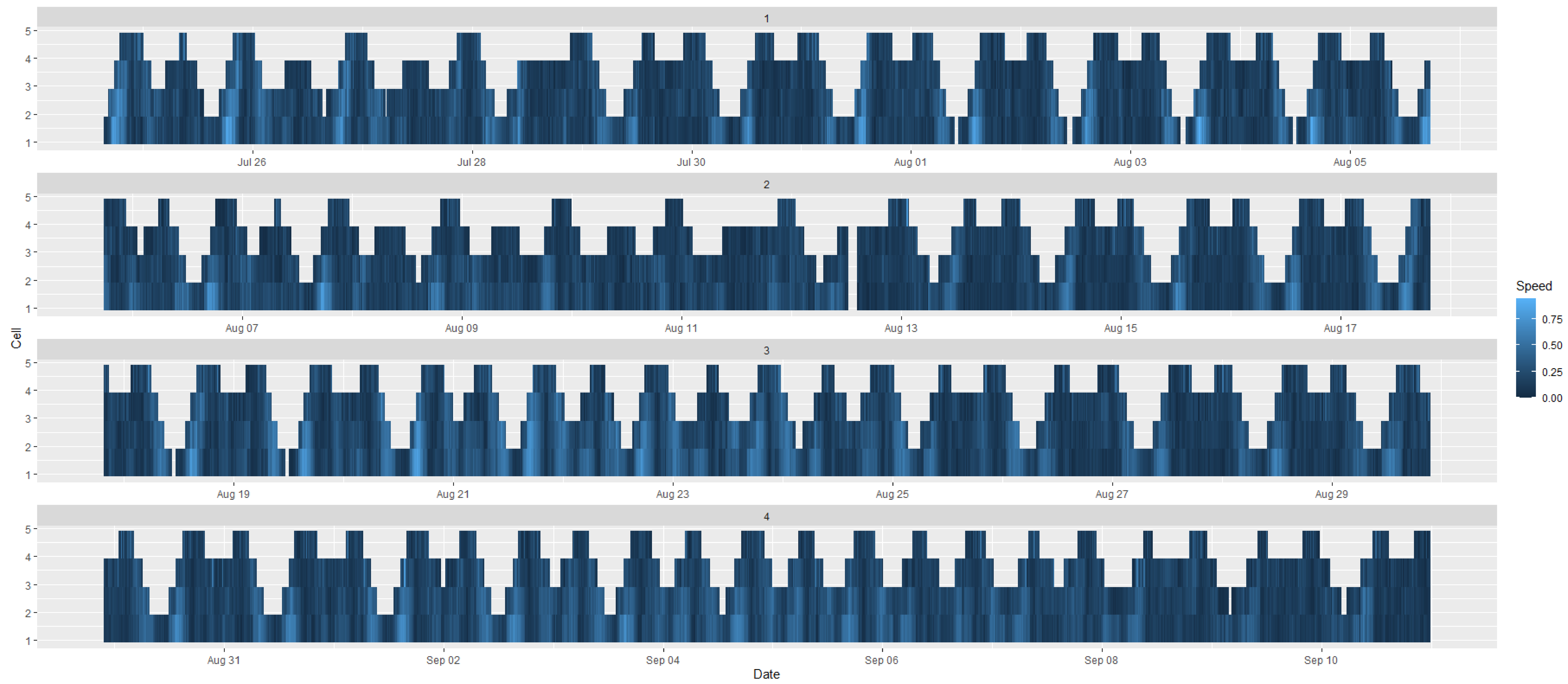

Figure 2: A time-series heatmap of current speeds captured by the Everett Marina ADCP from July 25th to September 10th. The height axis indicates the maximum number of cells detected by the ADCP, with each cell representing two meters of water. When only the first cell is colored, the water is two meters deep above the ADCP and vice versa.

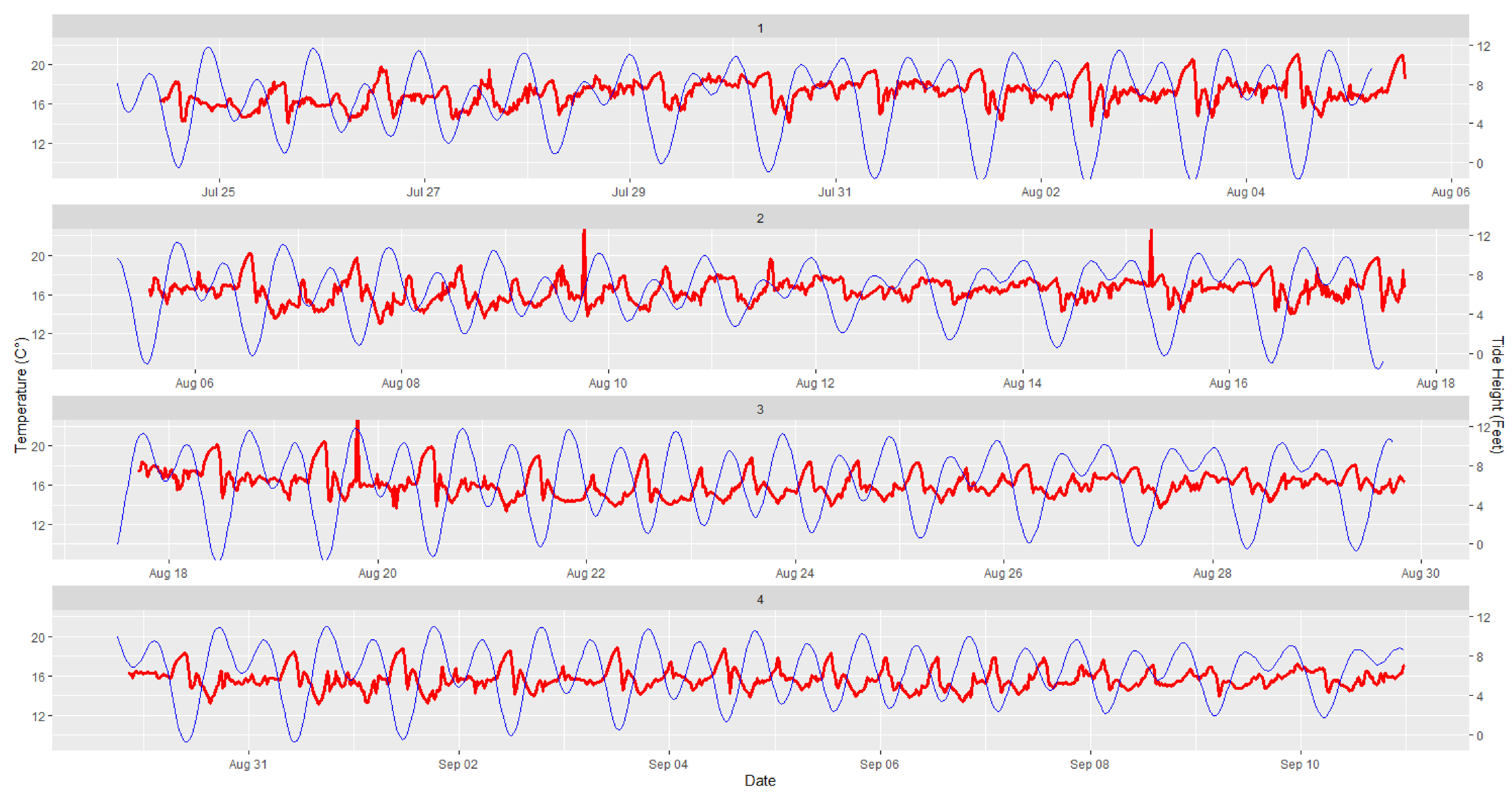

Figure 3: A 2019 time-series graph of temperatures 2 meters below the surface and tide heights from July 25th to September 10th. Temperature readings were taken from the Everett Marina CTD indicated in Figure 1. Tide data courtesy of NOAA.

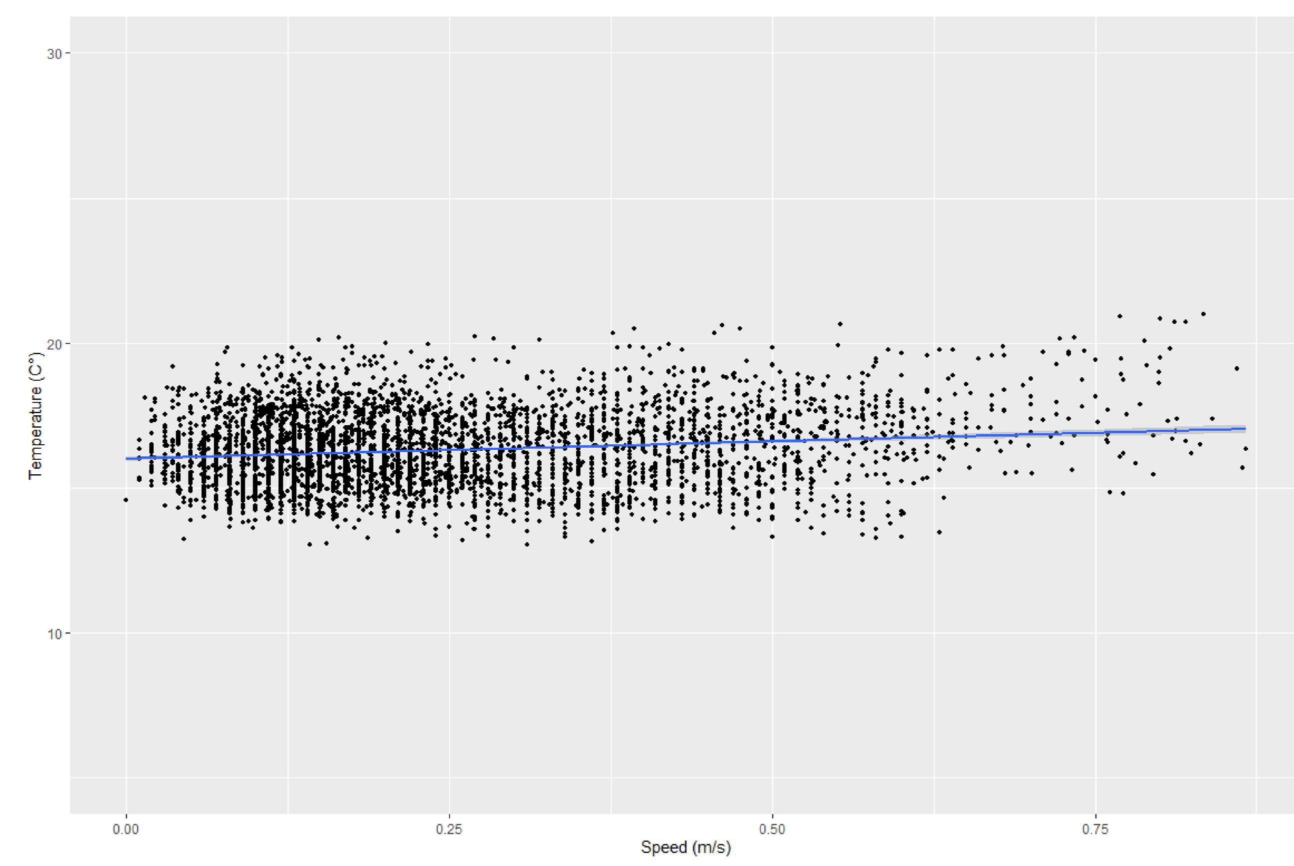

Figure 4: A scatter plot of current speeds in the first cell versus temperature. The line of best fit is indicated in blue. In support of a linear correlation: $r = 0.1525$; $p < 0.001$.

Conclusions

Figures 2, 3, and 4 are inconclusive at best when considered on an individual basis, but patterns begin to emerge when they are evaluated collectively. Figure 2 has several time frames which see higher average current speeds, and these same time frames in Figure 3 see a stark inverse relationship between tide height and temperature. It is hypothesized that this is caused by the lateral movement of the CTD mooring throughout the water column as its position in relation to the water's surface is fixed. In contrast to this connection, during time frames where Figure 2 shows decreased average current speeds, the inverse relationship between temperature and tide height in Figure 3 becomes muddied, disappearing entirely in some cases. This pattern supports hypothesis that decreased current speeds lead to increased vertical mixing and decreased stratification. In addition, Figure 4 statistically supports a linear correlation between current speed and temperature, though the statistical soundness of the computed p-value may not be entirely present due to the extreme scale of the dataset. One of the drawbacks of this study is the method of data collection: the CTD oscillates with the tides while the ADCP remains stationary. In addition, the study only encapsulates data from one season of one year: gaining access to more reliable consecutive coinciding measurements would allow for a more rigorous analysis.

ORCA

The Ocean Research College Academy is a dual enrollment program where high school juniors and seniors experience innovative, interdisciplinary and student-centered learning. A longitudinal study of the local estuary forms the backbone of the first-year experience, and leads students to conduct independent research in their second year of the program. ORCA has received grants for a research lab, research vessel, and summer research funded by the National Science Foundation.

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