Monitoring the oxygen dynamics of a coastal embayment of the Salish Sea (Bellingham Bay)
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INTRODUCTION

Hypoxia is an issue affecting coastal ecosystems, including those of Salish Sea and Puget Sound. It is a problem in Bellingham Bay, where conditions in the summer, caused by natural and anthropogenic factors, allow for hypoxia to occur. Seasonal stratification driven by cold and saline bottom water and warm, freshwater input from Nooksack River restricts water circulation and depletes oxygen in the deeper parts of the bay. In this ecosystem, hypoxia is considered to be dissolved oxygen levels below 4 mg/L. Data have been collected in the past to confirm the presence of hypoxic water in the summer, but little is known about spatial and temporal dynamics of dissolved oxygen in this system.

OBJECTIVES

In order to better understand the dissolved oxygen dynamics in Bellingham Bay, research was conducted throughout the summer of 2011 with three objectives in mind:

1. Observe long-term trends in dissolved oxygen of Bellingham Bay using historical data;
2. Track changes in dissolved oxygen and map the spatial extent of hypoxia;
3. Compare trends in dissolved oxygen with Hood Canal, a local ecosystem that experiences chronic hypoxia during the summer.

MATERIALS AND METHODS

Experimental Design:
Sampling sites were based on locations visited previously as part of an ongoing study in this system. Previous data were used to determine the best locations for transects. The transects consisted of eight east-west sampling sites and eleven north-south sites.

Field Sampling:
We went on four weekly research cruises in Bellingham Bay on the RV Zoea to visit the 28 designated sites. At each site we sampled with a CTD, going about two meters short of the bottom. With each sample, data were collected at the surface and the bottom for temperature, salinity, fluorescence, dissolved oxygen, and transmission. We also collected water samples at the surface of every site for chlorophyll-a analysis and samples at select locations at certain depths in order to perform Winkler titrations. The data collected was used to graph the dissolved oxygen of Bellingham Bay, along with other factors when needed.

RESULTS

1. Identifying historic trends in dissolved oxygen and hypoxia in Bellingham Bay

Previous studies reveal a decrease in dissolved oxygen concentrations in Bellingham Bay. Data collected as part of periodic sampling by Washington Department of Ecology suggest a gradual decrease in dissolved oxygen concentrations in the bay from 1990 to 2008, as well as four instances when hypoxic conditions were recorded. Data from two stations in Bellingham Bay sampled during summer 2010 show the typical decrease in dissolved oxygen expected in the summer, culminating in three sampling events in which hypoxic conditions occurred.

2. Spatial extent of hypoxia in Bellingham Bay summer 2011

Spatially intensive transects of water column profiles conducted during summer 2011 reveal explosive but variable volume of hypoxic waters (i.e. < 4 mg/L) in Bellingham Bay. Based on transects conducted on 15 July 2011, the volume of hypoxic water exceeded 36 million cubic meters (Figure 6). Contour plots of data collected as part of E-W transects reveal that areas of low dissolved oxygen concentrations move through the water column and are not static in the deeper regions of the water column. In the week of the first transect, the hypoxic area was located in the lower part of the bay, whereas it was higher in the water column the following week.

3. Comparison of oxygen dynamics in Bellingham Bay and Hood Canal

Although the oxygen concentrations in Hood Canal are consistently lower than Bellingham Bay, they follow a similar pattern over time (Figure 8). Another similarity between the two ecosystems is the intrusion of cold, saline water which displaces low dissolved oxygen bottom water. Figure 9 illustrates this process in Hood Canal, where waters from Admiralty Inlet force low DO bottom waters higher in the water column. A similar phenomenon was observed in Bellingham Bay on July 15, 2011, when a small layer of hypoxic water was seen in the upper water column (Figure 10), presumably driven by input of more saline, dense water from adjacent Hale’s Passage.

CONCLUSIONS

• Hypoxic bottom waters in Bellingham Bay tend to occur in the area of longest residence time, as opposed to the deepest part of the bay (Figure 11);
• The mass of low dissolved oxygen water in Bellingham Bay does not have one fixed location, but rather is dynamic and moves throughout the water column;
• Similarities between Hood Canal and Bellingham Bay oxygen dynamics indicates similar large-scale drivers of hypoxia (e.g. climate) and suggest that Hood Canal may be an example of Bellingham Bay’s future.

Future Research:
• Further investigate trends in dissolved oxygen, focusing on the effect of tides and freshwater input on the distribution of hypoxia in Bellingham Bay;
• Monitor sites near the sill in Bellingham Bay to better understand the input of water from Hale’s Passage and its effect on the distribution of hypoxic waters.

ACKNOWLEDGEMENTS

I would like to thank the following organizations and people for their help in this research:

• Shorenine Point Marine Center, Western Washington University
• Centers for Ocean Science Education Excellence (COSEE) Pacific Partnerships
• COSEE PRIME Summer internship
• Northwest Indian College
• Washington Department of Ecology
• Nate Schwark
• Karl Mauker
• Hannah Clark
• Nate Xu