HIGH SCHOOL EDITION
Journal of Student Research
Volume 10 Issue 4 (2021)

Dissolved Oxygen and pH Dynamics Coupled to Photosynthesis in Huntington Bay, Western Long Island Sound

William Siegel[1] and Robert Aller[#]

[1]Portledge School, Locust Valley, NY, USA
[#]Advisor

ABSTRACT

With global warming and eutrophication prompting increases in hypoxia and acidification in the oceans, it is important to understand the relationship between pH and O2 in coastal waters. In Huntington Bay (HB), an estuarine extension of western Long Island Sound, a region subject to both hypoxia and eutrophic acidification, summertime pH and O_2 are elevated in surface water during the day at the height of photosynthesis. The high pH (8.4 - 8.6) and O_2 (10 - 16 mg L-1) water may be exported from HB into the adjacent Sound, mitigating conditions there. The effects of nighttime respiration, seasonal variations, and responses to episodic events such as storms remain to be determined.

I. INTRODUCTION

Hypoxia (dissolved oxygen deficiency) and acidification (pH lowering due to CO_2 increases) both threaten organism survival, potentially alter food web structure, and affect the functioning of aquatic ecosystems worldwide [1]. Understanding the causes and effects of hypoxia, acidification and the combination of these two stressors is vital to learn about ecosystem health and activity in bodies of water [1]. Both O2 and pH are influenced by photosynthesis and algal blooms associated with eutrophication and the supply of nutrients from runoff [1,2]. According to Fig. 1, during photosynthesis, phytoplankton consume CO_2 and produce O_2 and as a result, can cause pH to increase and the O_2 concentration to rise.

$$106\ CO_2 + 122\ H_2O + 16\ HNO_3 + H_3PO_4 \rightarrow (CH_2O)_{106}(NH_3)_{16}H_3PO_4 + 138\ O_2$$

Fig. 1: *Redfield-Richards ratio*: Proposed by these scientists in the 1960s from plankton collected in net tows [1].

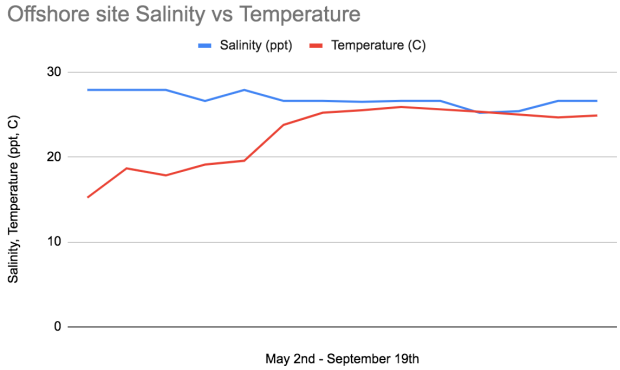
This process can be seen in Fig. 1, which illustrates CO_2 molecules being consumed and yielding O_2 [1]. In contrast, during respiration, CO_2 is produced and O_2 consumed, lowering both pH and O_2 (reaction right to left, Fig. 1). The balance between photosynthesis and respiration is an important determinant of water characteristics.
In this study, I examined the dynamics of O_2 and pH in the surface waters of Huntington Bay, an estuarine extension of western Long Island Sound, New York.
This region of the Sound is subject to both hypoxia and acidification as the recent algal blooms show signs of eutrophication [3]. Eutrophication (increased nutrient supply) enhances carbon production. When C is respired in bottom waters, O_2 is depleted, and CO_2 is produced, in turn acidifying the water. The excess nutrients released during respiration may lead to further algal blooms.

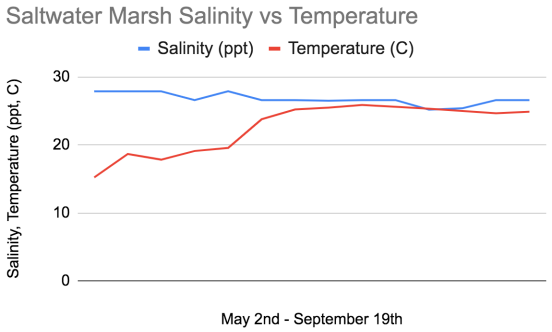
I hypothesized that the shallow waters of Huntington Bay are well oxygenated and had moderate pH conditions. These waters may interchange with the lower O2 and pH of the adjacent Sound.

II. METHODS AND MATERIALS

Two monitoring sites were established in Huntington Bay. At high tide during daylight, surface waters were sampled at an offshore site using a kayak. pH, temperature, salinity, and dissolved oxygen were recorded at the water's surface at this station. Immediately thereafter, a second site located at the edge of an adjacent salt marsh was also sampled using the same methods. Measurements were made 14 times at varying intervals from May to September 2021. The dissolved oxygen was measured using a LaMotte 5860-01, Dissolved Oxygen Kit (Winkler titration). pH was measured with a digital pH meter (NBS scale). Temperature and Salinity were recorded using a salinometer.

III. RESULTS AND DISCUSSION





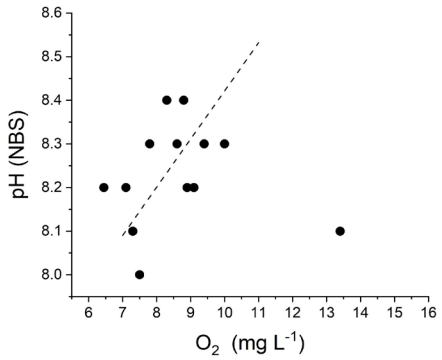


Fig. 4: The relationship between O_2 and pH in the offshore site. The point at ~ 13 mg L^{-1} O_2 is ignored in the geometric regression as an outlier (measurement error).

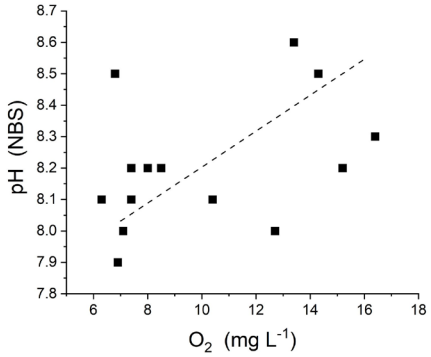


Fig.5: The relationship between O_2 and pH at the salt marsh edge.

The variation between salinity and temperature was minimal. All of the salinity and temperature measurements were in regular relation, as the salinity decreased, the temperature increased, and vice-versa. Both Fig. 4 and Fig. 5 demonstrate that the shallow waters of Huntington Bay are well oxygenated during photosynthetic periods. The pH and O2 parameters in both locations are positively correlated, which corresponds with the *Redfield-Richards Ratio.* Assuming that these shallow regions exchange with the adjacent Sound, they would act to moderate low O_2 and pH conditions.

IV. FUTURE RESEARCH

In order to determine the exact impact of the shallow regions, further measurements of respiration, seasonal variations, and the impact of episodic events such as storms (intense rain, wind) must be made.

V. ACKNOWLEDGMENTS

I would like to thank my mentor, Distinguished Professor, Robert Aller, Ph.D. of the School of Marine Sciences at Stony Brook University (State University of New York) for guidance and for giving me this opportunity to conduct my research.

VI. REFERENCES

[1] Libes, Susan M. *Introduction to Marine Biogeochemistry*. Elsevier/Academic, 2009.
[2] *Acidification & Hypoxia*, https://serc.si.edu/research/research-topics/global-change/acidification-hypoxia.
[3] *Wallace, R. B. and C. J. Gobler, 2021, Mar. Poll. Bull., 172, 112908*