Lab Training for Educators: Water Quality

Session I: Dissolved Oxygen

Teacher Handout

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A. Learning Objectives

1. Explain the importance of dissolved oxygen and know the NY State standards
2. Describe the 3 basic methods for measuring dissolved oxygen and the strengths and weaknesses
3. Explain the factors that control dissolved oxygen concentration
4. Plot a vertical profile of dissolved oxygen and explain how it might impact oyster survival

B. NY State Water Quality Standards – Saline Surface Waters:

<table>
<tr><th>Class.</th><th>Description</th><th>Dissolved Oxygen Standard</th></tr>
<tr><td>SA</td><td>The best usages of Class SA waters are shellfishing for market purposes, primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.</td><td rowspan="3">Acute: 3.0 mg/L

Chronic: 4.8 mg/L (daily average)</td></tr>
<tr><td>SB</td><td>The best usages of Class SB waters are primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival</td></tr>
<tr><td>SC</td><td>The best usage of Class SC waters is fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.</td></tr>
<tr><td>I</td><td>The best usages of Class I waters are secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish, and wildlife propagation and survival. In addition, the water quality shall be suitable for primary contact recreation, although other factors may limit the use for this purpose.</td><td>Acute: 4.0 mg/L</td></tr>
<tr><td>SD</td><td>The best usage of Class SD waters is fishing. These waters shall be suitable for fish, shellfish, and wildlife survival. In addition, the water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. This classification may be given to those waters that, because of natural or man-made conditions, cannot meet the requirements for fish propagation.</td><td>Acute: 3.0 mg/L</td></tr>
</table>

Full NY State Regulations from EPA website:

https://www.epa.gov/sites/default/files/2014-12/documents/nywqs-section1.pdf

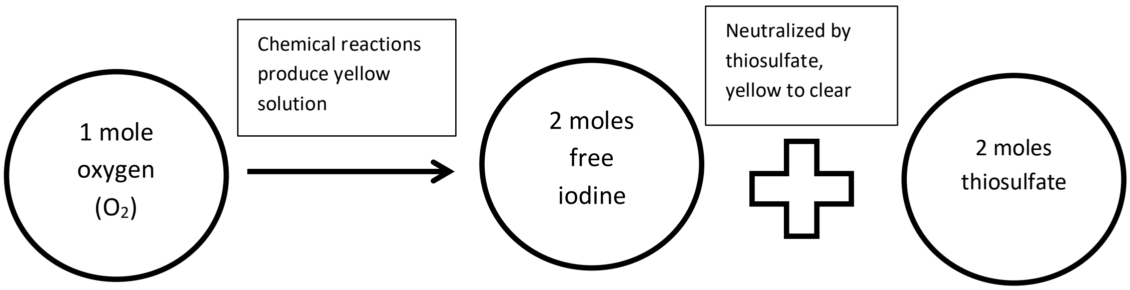
Great resource for water quality and standards in Harbor Estuary water bodies:

https://www.hudsonriver.org/wp-content/uploads/2021/09/2021-WaterQualityReport.pdf

C. Brief Descriptions, Videos and References for Methods:

Method 1: Winkler Titration

Principle – Stoichiometry with titration: Through a series of chemical reactions, oxygen will produce free iodine in solution in a 1:2 molar ratio (1 mole oxygen produces 2 moles of free iodine), turning the solution yellow. The iodine can be removed by thiosulfate in a 1:1 molar ratio (1 mole thiosulfate removes 1 mole of free iodine), thus turning the solution clear. The thiosulfate used is in a 2:1 ratio with the original amount of oxygen.



Video demonstrating the LaMotte kit: https://www.youtube.com/watch?v=FKdzbgHaQQM

Method 2a: Amperometric electrode (Clark type or galvanic)

Principle – Electrochemical reaction. Oxidation-reduction (Redox) reaction produces a current. Oxygen diffuses across a permeable membrane and is reduced (receives electrons) at a platinum electrode. At a silver electrode, the silver is oxidized to form Silver chloride, giving up electrons. The flow of electrons from one electrode to the other is proportional to the amount of oxygen diffusing across the membrane.

Method 2b: Optode

Principle – Fluorescence; Oxygen diffuses across a permeable membrane and reacts with a fluorescent dye. The presence of oxygen quenches the fluorescence. The excitation light for the fluorescence is a blue LED. A photodiode measures the resulting emission light (red). The more oxygen, the more the fluorescence is quenched. A red LED provides a reference value for the emission light and the photodiode produces a voltage output proportional to fluorescence signal.

Method 3: Colorimetrics

Principle – The reduced form of indigo carmine reacts with dissolved oxygen to form a blue dye. The intensity of the blue color increases with the amount of dissolved oxygen in the sample. Oxygen is determined by visually matching the intensity of the blue with known standards, or by measuring the amount of light at ____ nm absorbed by the solution.

Video demonstrating use of colorimetric kit:
https://www.youtube.com/watch?v=9Jk0AmmuLSY

D. Exercise: Visualizing and Interpreting Dissolved Oxygen Data

August 15, 2019; Head of Shellbank Creek, Jamaica Bay

	Depth(meters)	Temperature (C)	DO (mg/L)
9:00 AM- High Tide			
	0	24.2	4.34
	0.5	25.1	2.68
	1	25.3	3.01
	1.5	25.3	2.57
	2	25.1	0.94
	2.5	24.7	0.65
12:00 PM- Ebb Tide			
	0	26	6.41
	0.5	26.2	6.08
	1	26	4.7
	1.5	25.6	2.98
	2	25.1	1.37
	2.5	24.3	0.72
3:00 PM- Low Tide			
	0	27.7	8.04
	0.5	27.5	8.77
	1	27.2	8.87
	1.5	26.6	7.13
	2	25.6	1.52
	2.5	24.5	0.79
6:00 PM- Flood Tide			
	0	26.5	9.98
	0.5	27.3	10.82
	1	27.4	11.09
	1.5	27	7.85
	2	26.1	6.24
	2.5	24.9	1.05
9:00 PM- High Tide			
	0	26.4	9.46
	0.5	26.4	10.15
	1	26.5	8.74
	1.5	26.4	8.69
	2	26	7.43
	2.5	25.6	3.02

1. Sketch and label a set of axes with arrows at the end. Label the x-axis as depth of water in meters, and the y-axis is dissolved oxygen in milligrams per liter (mg/L).

2. Rotate your paper clockwise so that the x-axis is now pointing down and the y-axis is along the top of the paper pointing to the right. Title the graph “Dissolved Oxygen on August 15, 2019 at the head of Shellbank Creek”

3. Sketch some visual cues to provide perspective. For example, waves at the water surface, a dissolved oxygen probe being lowered, an arm sticking down from the water surface, etc.

4. Sketch in a vertical dashed line at 3 mg/L and 5 mg/L. Dissolved oxygen below 3 mg/L is dangerous for marine life including oysters. Dissolved oxygen above 5 mg/L is safe. Dissolved oxygen between3 and 5 mg/L can be harmful over long periods of time.

5. For the 9:00 AM data, plot the dissolved oxygen concentration at each depth. Connect the points with straight lines. Don’t worry about being too precise with your points. Label the line “9:00 AM”

6. Is the dissolved oxygen the same at every depth? If not, annotate your plot with possible reasons dissolved oxygen is different at different water depths.

7. Comment on the suitability of this location for farming oyster based on your sketch.

8. For the 3:00 PM data, plot the dissolved oxygen concentration at each depth. Use a different color, or a different symbol than you used for the 9:00 AM data. Connect the points with straight lines. Don’t worry about being too precise with your points. Label the line “3:00 PM”

9. Is the pattern at 3:00 PM different than 9:00 AM? Annotate your plot with reasons why they might be different.

10. Comment on the suitability of this location for farming oysters based on your sketch. If you were hanging an oyster cage in the water, how deep would you hang it?

11. Other questions you could ask:

    a. Assume that August 15, 2019 was a very sunny day. How might the plots of dissolved oxygen be different on a very cloudy day?

    b. What would you expect a dissolved oxygen plot at 6:00 AM to look like? Why?

    c. What would you expect a dissolved oxygen plot at 6:00 PM to look like? Why?

d. How often would you want to measure dissolved oxygen at the head of Shellbank Creek to determine the suitability for farming oysters there? What dissolved oxygen methods would you use and why?

Reflection questions:

What dissolved oxygen measuring method would you most want to use with your students and why?

Your students have just completed measurements of dissolved oxygen during a field trip to a BOP oyster station. They collected the water at a single depth and measured dissolved oxygen using colorimetric method with a visual comparison to standards. What would you explain to them in order to put that measurement into context? Rank your ideas by “most important” to “least important”.