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Measurement of Sediment Oxygen Demand (SOD) in Upper New Meadows River and Quahog Bay Estuarine Areas, Maine

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1.0 INTRODUCTION

The Maine Department of Environmental Protection (MDEP), Bureau of Land and Water Quality and EPA's Regional Office of Environmental Protection requested EPA's Office of Environmental Measurement and Evaluation assistance in evaluating the sediment oxygen demand (SOD) in the New Meadows Rivers and Quahog Bay estuarine areas of south coastal Maine. The New Meadows River and Quahog Bay estuaries are part of the Casco Bay estuarine system east southeast of Brunswick and west of Bath.

SOD is the total of biological and chemical processes in sediment that utilize oxygen. SOD studies are useful in the development of predictive mathematical models that will determine waste load allocations. They are also useful in measuring the depletion of oxygen in stratified waters when there are concerns about nutrient regeneration and the loss of aquatic life.

This project included monitoring six sites in the New Meadows and Quahog Bay areas. These sites were selected based on a previous SOD study conducted in 2003 and knowledge of areas of low dissolved oxygen as determined by assessing data from MEDEP, Bowdoin College, and Friends of Casco Bay. Sites were typically located in deep holes where fine sediment with lower dissolved oxygen was found. Site descriptions are shown in Table 1. Sediment analyses included SOD and grain size analysis to characterize the sediment particle size.

MDEP will use the data to aid in assessing attainment/ non-attainment status of dissolved oxygen criteria and the trophic status of the New Meadows River and Quahog Bay areas. A water quality model may be completed based on the results of the SOD study.

2.0 MATERIALS

SOD analyses were performed by EPA in a climate controlled room at the New Meadows River Cottages in West Bath, Maine. This site provided a controlled environment and proximity to the field study location. An EPA 17 foot McKee Craft was used for collecting the samples with a Wildco KB Corer. SOD measurements were performed with mulitple YSI Model 5100 dissolved oxygen meters. Grain size samples were analyzed at OEME laboratory in North Chelmsford, MA.

3.0 METHODS

3.1 Sampling Locations

The six sampling locations were selected based on local knowledge of fine sediment presence and the low dissolved oxygen measurements. Two station were located in Quahog Bay and four stations wer located in the New Meadows River esturary. Mike Doan from Friends of Casco Bay assisted in the selection of the sample sites. Stations in Casco Bay area were identified with a Casco Bay Map, waterproof chart #101E. Station location descriptions can be found in Table 1. A map with the sample locations is in Appendix C.

Table I. *Station Descriptions*

Station #	Station Description
1-QHS	*North Ledge, North of Pole Island in Quahog Bay*
2-QHS	*Southwest of Pole Island in Quahog Bay*
3-NEWM	*New Meadows Upper Lake*
4-NEWM	*New Meadows South of Rt 1 @ Deep Hole*
5-NEWM	*New Meadows at Marina Docks*
6-NEWM	*New Meadows @ Woodward Cove*

3.2 Sediment Sampling

SOD samples were obtained by using a Wildco K-B Gravity Type Core Sampler. Five sediment cores were retrieved from each site and capped on the top and bottom with #11 stoppers. After SOD measurements were completed, the contents of each core were composited and an aliquot was taken for total organic carbon analysis. These samples were stored at 4°C prior to analysis.

3.3 Dissolved Oxygen Ambient Water Collection

Ambient water was collected by an Alpha water bottle just above the sediment water interface (Appendix B). The water in the Alpha water bottle was poured into an empty core tube to simulate production or respiration in the overlying water in a sediment core tube. The core tube was then analyzed as the same method as the sediment cores. The cores were immersed in a water bath and maintained at 20°C±1° until the end of the test. The results are used in the final SOD rate calculation.

3.4 Sediment Oxygen Demand Determination

This method involves confining a measurable volume of water overlying a known area of sediment in a core tube and measuring the depletion of dissolved oxygen over a period of

time. Procedures were followed based on ECASOP–SODSOP6.0, Sediment Oxygen Demand Determination, Standard Operating Procedure, Rev 6.0, July 18, 2007.

After the five sediment cores are collected, the water column height (h) in each of the five cores is measured in meters and recorded in a logbook. Sediment sample cores are transferred to a temperature controlled water bath and incubated at 20°C±1° for a 3 to 4 hour monitoring period. Often a 30-60 minute stabilization period is required for the core tube temperature to reach equilibrium with the water bath. The dissolved oxygen concentration within these cores is measured every 30 minutes for the test duration. Following the monitoring period, SOD rates are calculated for each core sample and then averaged to produce a mean rate at each site. The standard deviation is also calculated to determine the variability of the sediment. See the Sediment Oxygen Demand calculation sheet in Appendix A for site-specific SOD rates and standard deviations.

The formula for calculating SOD rates is as follows:

$$\text{SOD g } O_2/m^2\text{day} = \frac{\{(O_i - O_f) - (B_i - B_f)\}\ (h)}{(t)}$$

O_i = initial dissolved oxygen (DO) mg/ℓ
O_f = final DO mg/ℓ
B_i = initial DO in bottles mg/ℓ
B_f = final DO in bottles mg/ℓ
h = height of water column in meters
t = time in days

Dissolved oxygen and temperature measurements were recorded in a bound logbook for each station sampled. The meters were calibrated before analysis and a post calibration check was performed at the end of each analysis. In the final calculation of the SOD rate, data is used only where oxygen depletion versus time is a constant.

4.0 RESULTS AND DISCUSSION

4.1 Sediment Oxygen Demand

The estimated sediment oxygen demand rates for Quahog Bay and the New Meadows River ranged from $0.8_{g\ O_2/m^2day}$ at station QHG2 to $3.0_{g\ O_2/m^2day}$ for the highest rates which were measured at station 5NEWM at the Marina in the New Meadows River. Three stations in the New Meadows river are considered to be in the high demand range of > 3. The sites are NEWM3, NEWM5 and NEWM6. Station NEWM4, South of the RR

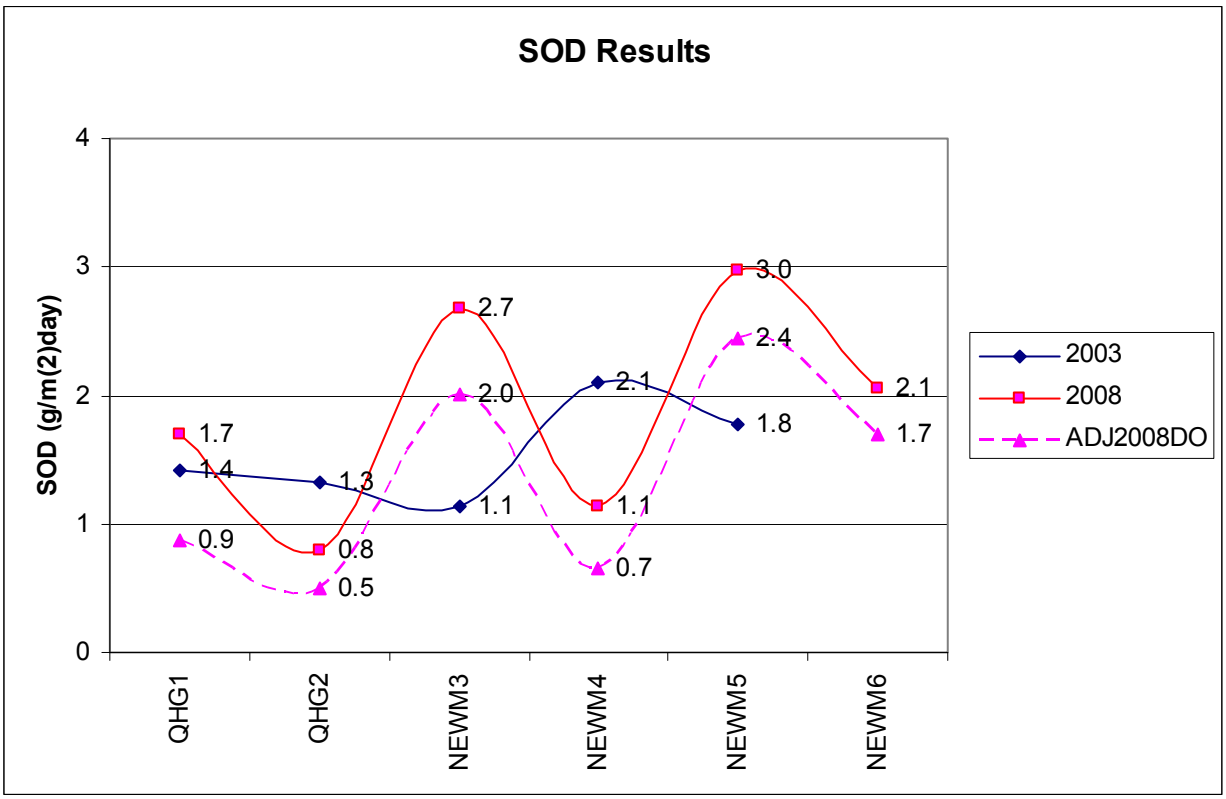
Bridge, had a medium SOD rate. SOD data in Quahog Bay indicates a low demand at QHG2, by the North Ledge, and a medium demand further upstream at QHG1.

SOD data in Table II compares the current study to 2003 data and is adjusted for water column oxygen demand. Figure I indicates data collected in 2008 is comparable to the data 2008 adjusted data with the curves matching when plotted for the first five stations. The 2003 data is within the overall range of the 2008 data but has different distribution. At station NEWM6 there was not sample collected at this station in 2003. The station is at Woodward Cove in the New Meadows River Estuary.

Table II. *SOD Results*

		2003 DATA		2008 DATA		ADJUSTED RATES 2008 DATA	
Station #	Station Description	Mean SOD g/m^2day	Standard Deviation	Mean SOD g/m^2day	Standard Deviation	Mean SOD g/m^2day	Standard Deviation
QHG1	*North Ledge, North of Pole Island in Quahog Bay*	1.4	0.4	1.7	0.7	0.9	0.7
QHG2	*Southwest of Pole Island in Quahog Bay*	1.3	0.7	0.8	0.3	0.5	0.2
NEWM3	*New Meadows Upper Lake*	1.1	0.5	2.7	1.8	2.0	1.7
NEWM4	*New Meadows South of Rt 1 @ Deep Hole*	2.1	0.7	1.1	0.2	0.7	0.2
NEWM5	*New Meadows at Marina Docks*	1.8	0.5	3.0	1.8	2.4	1.9
NEWM6	*New Meadows @ Woodward Cove*	N/A	N/A	2.1	1.8	1.7	1.8

Figure I. SOD Data Comparison



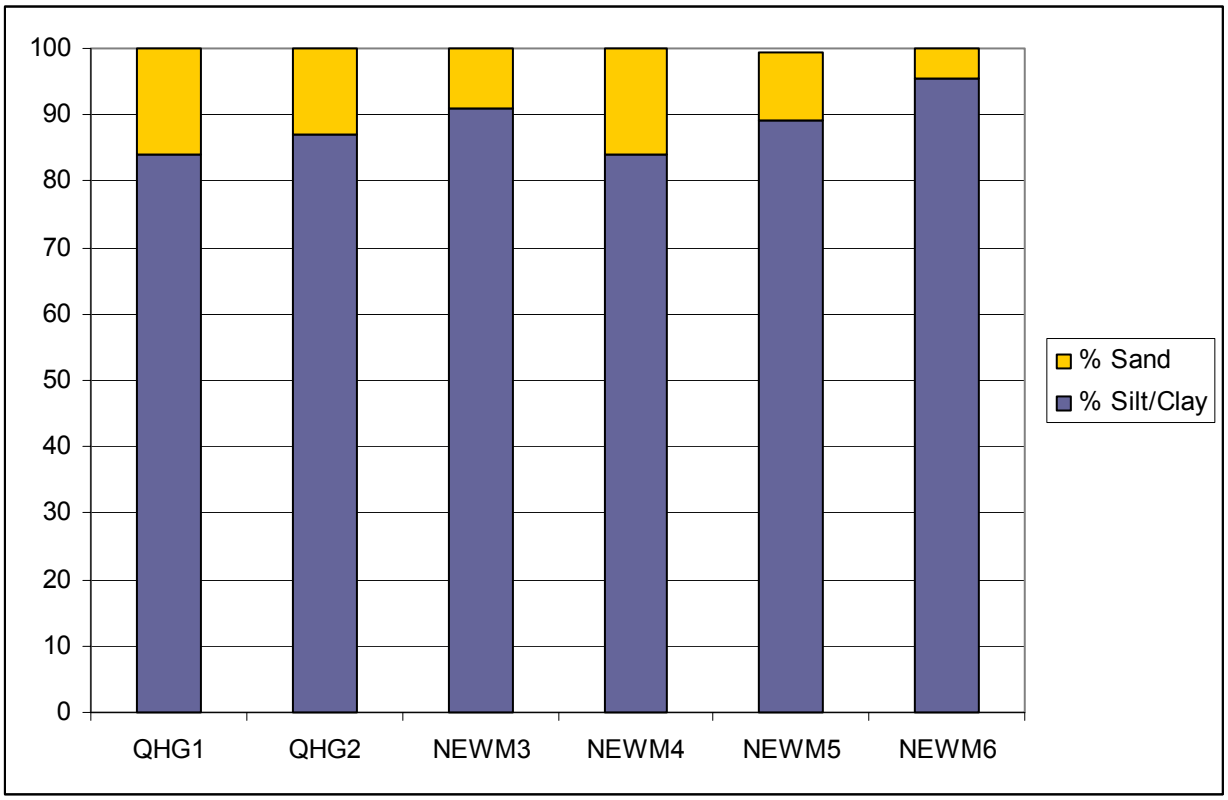
4.2 Grain Size

Table III. *Grain Size Distribution*

Station #	% Sand >0.075mm	% Silt/Clay <0.075mm
QHG1	16.0	84.0
QHG2	13.1	86.9
NEWM3	9.1	90.9
NEWM4	16.0	84.0
NEWM5	10.2	89.2
NEWM6	4.5	95.5

Grain size analysis was performed to categorize sediment particle size at each of the station locations. In general the grain size distribution indicates a silt and clay environment. Station NEWM6 near Woodward Cove in the New Meadow River estuary had a higher sand percentage (95.5%). Figure 2 com pares the results. Finer sediments were sought for the sediment cores because the small particle size and proportionately greater surface area have a higher affinity for binding contaminants.

Figure 2. Sand and Silt/Clay Distribution Percent by Weight



4.3 Quality Control

Field Duplicates for SOD were performed at each site with the use of 4 to 5 cores. The standard deviation varied from a low of 0.2 at station NEWM4 to a high of 1.8 at stations NEWM5 and NEWM6 in New Meadows River estuary.

YSI 5100 Dissolved Oxygen meters were calibrated before each analysis and checked after each test in a 100% air saturated bottle. Quality control accuracy needs o.1 mg/l were met for each test.

5.0 REFERENCES

YSI Inc, *YSI MODEL 5100 Operations Manual,* November 2003

Bowdoin College, Deborah Schaeffer, *Seasonal Trends Affecting Water Quality in the Lower Lake of New Meadows River Estuary*, Spring 2003

EPA Region 1, Measurement of Sediment Oxygen Demand (SOD) in New Meadows/ Quahog Bay Estuarine Areas, Maine, April 2004.

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