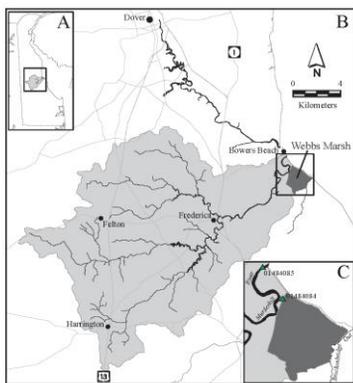


Background:

The Murderkill watershed is located in southern Kent County, Delaware and has a drainage area of approximately 270 km². Based on a 2002 assessment, the land use in the watershed is predominantly agricultural (55%) but like many coastal watersheds the amount of urban and residential development (14%) is increasing (Delaware Department of Natural Resources and Environmental Control (DNREC 2005). There are two wastewater plants within the watershed, the larger of which is the Kent County Regional Wastewater Treatment Facility (KCRWTF). The KCRWTF receives water from the five urban centers and from urban and urbanizing areas throughout greater Kent County. Therefore, the Murderkill Estuary has an effective population burden much larger than implied by its own watershed area, land use, and population.



William Ullman (2012) The Kent County Land Ocean Biogeochemical Observatory: Real-time Hourly Determination of Water Quality in the Delaware Bay Ecosystem. Retrieved July 15, 2013 from <http://delawareestuary.org/sites/default/files/P4%20Ullman.pdf>



Bowers Beach. Photo by: Nichole Halsey

Water sampling in the Murderkill watershed and estuary by DNREC established that a number of streams and estuarine segments have high levels of nutrients, low levels of dissolved oxygen, high bacteria counts, and/or impaired habitats and ecologies. These deficiencies are inconsistent with their state designated uses (contact recreation, fish, aquatic, and wildlife, and water supply) and are therefore in need of nutrient management to meet the requirements of the Clean Water Act of 1972 (as amended in 1977 and 1987; DNREC, 2001). In order to meet the requirements for designated water uses, DNREC created total maximum daily loads (TMDLs) for the watershed in 2001, and subsequent to appeals and negotiated modifications, these were made final in 2005 (DNREC, 2005). The TMDLs required reductions in wastewater loads of N, P, and oxygen demand from the then three wastewater plants in the watershed and reductions in N and P loads from the upland agricultural watershed in order to meet designated uses.

Tasks:

- To better determine, and ultimately model, water, nutrient, and other material exchange between the Murderkill Estuary and Delaware Bay at their confluence near Bowers, Delaware and the ecological impacts of this exchange
- To document seasonal and higher frequency nutrient loads within the Murderkill Estuary and to Delaware Bay due to
 - loadings from the watershed and marginal marshes
 - discharge from the Kent County Regional Wastewater Treatment Facility
 - internal cycling in the Murderkill Estuary.

To this end, data from the recently installed Sea-Bird Coastal Land Ocean Biogeochemical Observatory (LOBO), from the collocated USGS gauging station (USGS DE01484085; Murderkill River at Bowers, DE), and from present and historical data collected at the Bowers site and at other locations in and near the estuary is being used.

The LOBO data is being used: (1) to better understand how estuarine physics (conductivity and turbidity) and nutrient loads affect and other biogeochemical parameters such as Chlorophyll a, dissolved oxygen concentrations and saturation, and CDOM within the Murderkill Estuary and nearby regions of Delaware Bay; (2) to determine how episodic event, such as rainfall and wind events affect nutrient loads; and (3) to assess the success of the implementation of pollution control strategies in the watershed and estuary.

Monitoring Solution:

Sea-Bird Coastal LOBO: The LOBO instrument is an integrated, real-time, water quality monitoring package that integrates a diverse set of sensors that provide routine, robust, and accurate measurements in high fouling environments, such as estuaries. This particular LOBO was equipped with the following instrumentation from Sea-Bird Coastal: WQM, ECO CDOM, SUNA, and Cycle PO4.

The measurands include temperature, conductivity, dissolved oxygen, turbidity, chlorophyll, chromophoric dissolved organic matter (CDOM), nitrate, and phosphate.

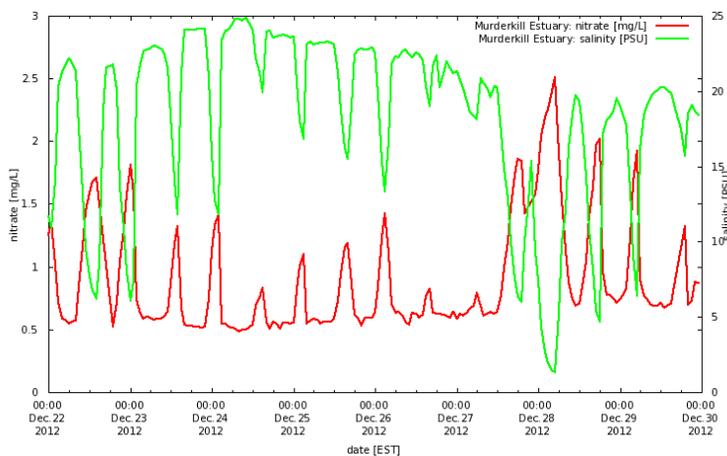
In addition these sensors are integrated into the Stor-X submersible datalogger and connected to an external modem which transmits the hourly data to the web. The web interface allows the operators and the public to view and graph the preliminary data within minutes of the sample being analyzed. Power is supplied by solar panels.



Delaware LOBO. Photo by: Nichole Halsey

Initial Results:

-Data from the LOBO together with freshwater discharge from the gauging station collocated on the dock can be used to accurately estimate the total loads of that substance from sources in the Murderkill Watershed to Delaware Bay.



Retrieved September 18, 2013 from <http://www.kentcounty.loboviz.com>

- The data from the LOBO can effectively capture tidal, daily, and seasonal fluctuations in water quality and the impacts of episodic events in the watershed, in Delaware Bay, and regionally.
- The data from the LOBO can be used to monitor and differentiate changes in NO_3^- loads associated with upland, estuarine, and wastewater contributions.
- By comparing the water quality measurements during ebb tide with those during the following flood tide, the impact of nutrients on biogeochemical processes in nearby Delaware Bay can be determined.
- Storm events, particularly those associated with offshore downwelling-favorable winds, lead initially to increases in salinity and decreases in watershed associated NO_3^- loads. Immediately following these events, however, are periods with lower salinity and higher contributions of NO_3^- and higher loads from the watershed.

Application Article: In Situ Nutrient Monitoring in the Murderkill Estuary

Summary:

Without the use of high accuracy and stable *in situ* sensors it would be impractical to achieve the temporal resolution needed to detect and differentiate between periodic, event-driven, and long-term (management-driven) changes in the water quality of the Murderkill Estuary and their impact on Delaware Bay. It is the combination of high quality and high resolution data from the LOBO combined with flow data from the site that has enabled the State of Delaware and Kent County Levy Court to refine their models and ultimately promulgate new and scientifically rigorous TMDLs (Total Maximum Daily Load) for the Murderkill Estuary and watershed.

See live data online at
<http://kentcounty.loboviz.com/>

The screenshot displays the LOBO website interface. On the left, there is a table of 'Latest' data for the Murderkill Estuary at Bowers, Delaware, with columns for parameter name and value. The data includes parameters like Chlorophyll, Conductivity, Depth, Nitrate, Dissolved O₂, Salinity, Phosphate, Saline, Temperature, and Turbidity. The main content area features a map of the Murderkill Estuary and a detailed description of the site's location and purpose. A 'Configuration' table is visible at the bottom, listing various sensors and their measurements. Logos for USGS and SEA-BIRD COASTAL are also present.

Parameter	Value
Chlorophyll	27.26 (000)
Conductivity	31.71 µS/cm
Depth	1.56 (5m)
Nitrate	0.890 (M)
Dissolved O ₂	0.960 (mg/L)
Salinity	31.03 (ppt)
Phosphate	0.47 (µM)
Saline	14.05 (µg/L)
Temperature	19.08 (°C)
Turbidity	100.76 (NTU)

References:

Delaware Department of Natural Resources and Environmental Control, 2005. Technical Analysis for Amendment of the 2001 Murderkill River TMDLs. Prepared by Watershed Assessment Section, Division of Water Resources. March 1, 2005. (http://www.dnrec.delaware.gov/swc/wa/Documents/TMDL_TechnicalAnalysisDocuments/10_MurderkillTMDLAmendmentAnalysis.odf)

<http://delawareestuary.org/sites/default/files/P4%20Ullman.pdf>

<http://www.kentcounty.loboviz.com>