Sondes & Sondes-ability: A Tale of Puget Sound Automated Water Quality Monitoring

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INTRODUCTION

The King County Marine & Sediment Assessment Group manages a long-term marine monitoring program designed to assess water quality in the Central Puget Sound Basin. Data are collected monthly for physical, chemical, and biological parameters. To augment monthly data collection, 3 automated water quality monitoring systems were deployed in Puget Sound between 2007 and 2009. The locations have changed several times to meet project needs and currently 2 systems are affixed to docks and consist of YSI 6600 EDS V2 multiparameter sondes, meteorological sensors, and telemetry hardware. One dock system is deployed along the Seattle waterfront in collaboration with the Seattle Aquarium and the other dock system is located at Dockton County Park in a shallow, poorly flushed, embayment (Quartermaster Harbor). This site was chosen due to low dissolved oxygen (<3 mg/L) problems during the summer months.

The third system is deployed on a buoy which has been installed at 3 separate locations and has had several sensor configurations dependent upon its varied use. The buoy is currently deployed in outer Quartermaster Harbor to support an EPA funded grant to study the role of nitrogen, if any, in the harbor's low dissolved oxygen (DO) problems. This system consists of the same sonde/telemetry setup as the other two systems, along with a surface nitrate sensor (Satlantic's SUNA) that was added to the system in early 2009. Figure 1 shows the locations of the current systems.

Data are collected at 15-minute intervals and transferred to a web interface. Data from the moorings are used for a variety of purposes and have shown how inadequate a single monthly data point can be for assessing water quality. Data can be accessed at the following website: http://green.kingcounty.gov/marine/StationMap.aspx

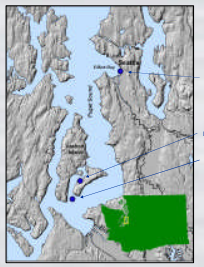


Figure 1. Location of Puget Sound monitoring systems

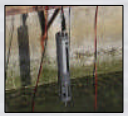
EQUIPTMENT & INSTALLATION

Equipment

All systems include YSI 6600 EDS V2 multiparameter sondes with temperature, conductivity, pressure, optical dissolved oxygen, pH, chlorophyll, and turbidity sensors. The sondes have an anti-fouling wiping system to prolong calibration. As of early 2009, all but one sonde now contain YSI's anti-fouling copper kits and a SUNA nitrate sensor was added to the surface at one site. The 2 dock-based systems also include the following meteorological sensors: rainfall, air temperature, wind speed & direction, % relative humidity, and photosynthetically active radiation.

The buoy system includes a Sound Ocean Systems, Inc 4 ft hull width buoy with a 7.9 ft tall mast, a Coast Guard approved navigation light, and the same sonde/telemetry setup as the dock systems.

Each sonde and meteorological suite is cabled to a YSI 6200 remote data acquisition system (DAS). Data are collected at 15-minute intervals and transferred via a cell phone to a web interface for near real-time viewing.



Installation

Seattle Aquarium: Sondes are deployed off a secure structure (pumphouse) at the Aquarium & the DAS is located inside the pumphouse. Figure 2 shows a schematic of how the sondes are deployed at a fixed depth from the surface. Power and access to the equipment is provided by the Aquarium.

Dockton County Park: Sonde is deployed off a public dock structure (Figure 3) and the depth varies with the tide. The cable from the DAS to the sonde is entirely contained within a PVC tube to avoid vandalism. System is powered by a solar panel.

Outer Quartermaster Harbor: Sondes are deployed off a buoy. Figure 4 shows a schematic of how the 2 sondes are deployed at a fixed depth from the surface & the bottom. A SUNA nitrate sensor is attached to the top sonde.. Power is via 2 solar panels/battery pack.

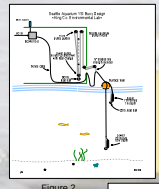


Figure 2

Location	How Deployed	Date Installed	Sonde depth(s)	Meteorological suite	Power Source
Seattle Aquarium	dock-mounted	October 2007	1 & 10 m, fixed depth from surface	Yes	AC
Dockton County Park	dock-mounted	January 2009	~8 m, fixed from mounting	Yes	solar panels
outer Quartermaster Harbor	buoy	February 2009	1 & 50 m, fixed depth from surface and bottom	No	solar panels

Figure 3

Figure 4

MAINTENANCE

Maintenance and Quality Control (QC) includes the following:

- monthly swap-out of freshly calibrated sonde
- monthly cleaning and checking of O-rings
- monthly collection of QC grab samples for laboratory analyses
- monthly end-checks
- e-mail alerts if data are outside pre-determined acceptable ranges

Sondes showing heavy biofouling prior to installation of anti-fouling kits. Sonde on the left shows biofouling after only 2 weeks during a summer phytoplankton bloom. Puget Sound productivity makes maintaining the sondes extra challenging!

SUNA sensor attached to YSI sonde

Quartermaster Harbor buoy surface sonde after 1-month deployment with anti-fouling kit. Clean as a whistle and more importantly, no interruptions in data collection.

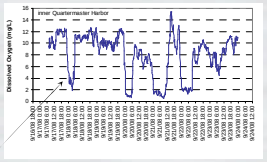
DATA USAGE

Data are used for a variety of purposes:

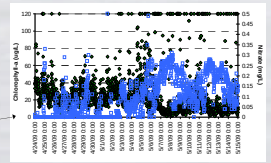
- fill in knowledge gaps inherent to monthly sampling,
- in-water construction regulatory compliance monitoring for turbidity, dissolved oxygen, and pH parameters,
- assess the quality of the intake water at the Seattle Aquarium & cutting back on water changes in the tanks when warranted,
- assess the extent of daily variation for various parameters,
- capture both intensity and duration of phytoplankton blooms (using chlorophyll levels) that are missed by monthly sampling,
- recreational sailors use wind data to plan their outings,
- assist interpretation of bi-weekly semi-quantitative phytoplankton data
- support hydrodynamic modeling efforts, and
- support an EPA grant-funded nitrogen loading study.

INTERESTING RESULTS

Although this entire poster could be filled with interesting results obtained so far, the graphs below show a select few (i.e., as many as would fit).



Graph shows significant dissolved oxygen (DO) diurnal variation during a 1-week period due to phytoplankton respiration & production. The inner harbor is a shallow embayment with poor tidal flushing and prone to large phytoplankton blooms, which results in both high & very low DO concentrations.

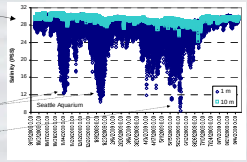


Amid the myriad of data points, the graph above shows the inverse relationship between nitrate and chlorophyll-a during mid-May. Chlorophyll-a also shows a nice diurnal pattern in May. Note: data points on the top grid line are off the scale.

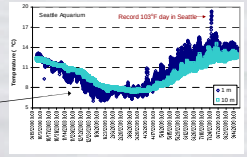
Graph shows the influence of freshwater input from the Duwamish River along the Seattle waterfront as evidenced by low salinities at the surface. The saltier, near-bottom water shows much less variation.

big rainfall events

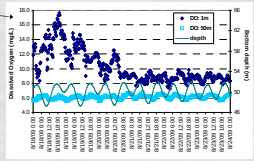
We haven't found a reason for this yet



Graph shows the influence of cold, Duwamish River freshwater at the surface during large rain (Nov '08) and snowfall (Dec '08) events. Surface water becomes warmer than near-bottom water in late April.



Graph shows DO during a 1-week period at the Quartermaster Harbor buoy. DO at 50 m shows tidal variation & is highest during a flood tide. DO peak in late afternoon on July 18th corresponds to phytoplankton production.



LESSONS LEARNED

- Biofouling was a bigger problem than anticipated. Purchasing copper anti-fouling kits was money well spent.
- Locating & designing systems in non-secure areas, such as public docks, is especially challenging.
- The realization of how inadequate monthly sampling is and how fabulous it is to have data every 15-minutes.
- Fill out paperwork for the required permits early….as in much earlier than you think should be necessary.
- Regulators and project managers love the use of automated, high-frequency, data collection systems for compliance with in-water construction permits.
- The diurnal variation and drop in dissolved oxygen levels at night at the shallow embayment site was both eye-opening and alarming.
- Having 2-way communication with the DAS and sonde has saved money by not having to trouble-shoot via boat/car trips.

AKNOWLEDGEMENTS

Jim Devereaux, King County Environmental Laboratory
John Blaine, King County Environmental Laboratory
Stephanie Hess, King County Environmental Laboratory
Shawn Larson, The Seattle Aquarium
Randy Hadland, YSI Inc.

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