OUTFALL MONITORING SCIENCE ADVISORY PANEL (OMSAP)
Workshop on technical options for monitoring the MWRA outfall
Wednesday May 19, 2004 10:00 AM - 3:00 PM
Woods Hole Oceanographic Institution, Quissett Campus, Carriage House

DRAFT MINUTES

ATTENDANCE

Bob Beardsley	(WHOI, OMSAP, co-chair)
Judy Pederson	(MIT/Sea Grant, OMSAP, co-chair)
Wendell Brown	(U. Mass. Dartmouth)
Brad Butman	(USGS)
Rich Camilli	(WHOI)
Mark Dennett	(WHOI)
Paul Dragos	(Battelle)
Scott Gallager	(WHOI)
Rocky Geyer	(WHOI)
Al Hanson	(URI)
Mingshun Jiang	(U. Mass. Boston)
Jim Kremer	(U. Conn.)
Scott Libby	(Battelle)
Kevin McClurg	(YSI Inc.)
Curtis Olsen	(U. Mass. Boston)
Rob Olson	(WHOI)
Neal Pettigrew	(U. Maine)
Josie Quintrell	(GoMOOS)
Collin Roesler	(Bigelow Lab)
Heather Saffert	(URI)
Heidi Sosik	(WHOI)
Myron Spaulding	(Aanderaa Instruments)
Ajit Subramaniam	(Columbia U.)
Todd Callaghan	(MCZM)
Cathy Coniaris	(MADEP)
Winnie Donnelly	(MADEP)
David Dow	(NMFS)
Matt Liebman	(EPA)
Larry Schafer	(retired)
Wendy Leo	(MWRA)
Mike Mickelson	(MWRA)
Andrea Rex	(MWRA)
Dave Taylor	(MWRA)

MINUTES

Purpose of Meeting – Bob Beardsley (Woods Hole Oceanographic Institution)

At their October 2003 meeting OMSAP requested that MWRA (Massachusetts Water Resources Authority) conduct this workshop: to convene a group of experts to discuss the goals, issues, technologies, and costs of augmenting MWRA's ambient monitoring with continuous water quality monitoring and additional use of satellite data. Workshop discussion and conclusions will be provided to the OMSAP. OMSAP may then recommend further evaluation, or may recommend implementation of specific technology (for example adding chlorophyll sensors to the existing GoMOOS mooring off Cape Ann, or providing USGS mooring data in real-time). Some recommendations could be implemented later in 2004.

MWRA Monitoring Requirements – Mike Mickelson (Massachusetts Water Resources Authority)

MWRA requires that their monitoring use commercially available sensors and platforms that have known cost and proven performance. The practical duration of a technical option could be long-term or short-term, as appropriate.

A technical option would have special merit for MWRA if it could:

1. Reduce or contain costs
2. Provide some advantage over current methods
3. Answer a testable monitoring question
4. Address a key feature
5. Speed the availability and dissemination of data
6. Help explain extreme events, including threshold exceedances
7. Provide early warning of extreme events and potential threshold exceedances

MWRA's workshop briefing lists the monitoring questions that must be addressed, and the key features that must be captured by MWRA's water column monitoring.

Long-term monitoring in Massachusetts Bay: 1989-present – Brad Butman (US Geological Survey)

B. Butman described how 15 years of results from long-term moorings in Mass Bay have addressed USGS program objectives:

1. Understand transport and long-term fate of sediments and associated contaminants.
2. Document infrequent catastrophic events.
3. Provide observations for development and testing of numerical (sediment-transport) models.
4. Document interannual changes in currents, hydrography and suspended sediments.
5. Coordinate with MWRA outfall permit monitoring plan.

The USGS Site "A" (1989-present) is located near the Boston Approach Navigation Buoy about 1 km southeast of the MWRA outfall. USGS Site "B" (1997-2004) was deployed off of Plymouth but has been removed. Two non-USGS moorings provide supplemental data: the GoMOOS "A" mooring (2001-present) located south of Cape Ann, and the NOAA buoy 44013 (1993-present) was previously located near USGS Site "A" but is now further southeast.

USGS Site "A" has instruments that measure salinity, temperature, pressure, light transmission, and currents (Acoustic Doppler Current Profiler). There are also sediment traps and a camera. USGS Site "B" was outfitted with an ADCP and a sediment trap. Data are recorded *in situ* and processed upon recovery at 4-month intervals. Experimental telemetry through an acoustic link was successful at Site "B"; however, acoustic telemetry at Site "A" has not been successful because of noise interference from the Boston Buoy. A surface buoy is probably not feasible at Site "A" because it is in the middle of a major shipping lane. Transmissometers, fluorometers, and conductivity sensors require special anti-fouling measures. Sensors are less fouled near the bottom and can more readily survive the four-month deployment. B. Butman then summarized other USGS measurements in Mass Bay. For more information go to: http://woodshole.er.usgs.gov/.

B. Butman identified ideas and opportunities but cautioned that it is important to decide what observations are needed to test specific hypotheses:

1. Develop partnerships to develop a "Massachusetts Bay Ocean Observatory".

2. Telemeter and distribute the data through existing infrastructure.
3. Increase measurements throughout the water column.
4. Measurements at the upstream boundary for modeling.

Sensors: nutrients – Al Hanson (University of Rhode Island & SubChem Systems, Inc.)

A. Hanson and colleagues have used novel electro-fluidic and optical detection technologies to develop a series of *in-situ* submersible chemical analyzers to study thin plankton layers, steep nutrient gradients, fine-scale chemical variability, and chemical plumes of oxygen, pH, nitrite, and iron.

The chemical analyzers work well on moving platforms for rapid sampling, but power and reagent consumption limit deployments to a couple of days. In general, moored chemical analyzers are still in development, although one optical nitrate sensor is fully operational.

Sensors: oxygen – Paul Dragos (Battelle)

MWRA's monitoring team has shipboard experience with three brands of dissolved oxygen (DO) sensors (Beckman, YSI, and SeaBird Model 43) in conjunction with two brands of CTD (Seabird and Ocean Sensors). It has been valuable to compare shipboard and moored DO data. USGS Mass Bay Mooring “A” has been collecting data since 1989, and began using the newer types of DO sensors (Seabird 43 and Aanderaa Optode) in 2001. GoMOOS “A” has been collecting data since 2001 including DO at 50-m depth using a Seabird 43 DO sensor.

In 2002, the Seabird 43 DO data were found to be lower than other DO measurements and it was discovered that the Seabird 43 needed to be pumped longer to get rid of build-up within the instrument. Increasing the pumping time seems to have solved this problem.

Although dissolved oxygen sensor technology is improving, there are caveats. The Seabird 43 has to be pumped longer than expected on moored deployments. The Aanderaa Optode needs no pumping because it does not consume O2, but being optical instrument it may still be sensitive to fouling. We need to gain more experience with the Optode in real applications to determine its sensitivity to fouling and overall reliability.

Moored sensors provide good temporal coverage and reveal short-term variability, but biofouling is one of the attendant problems. Telemetry, redundant systems, and contingency plans are needed to increase mooring reliability.

Sensors: phytoplankton and productivity – Collin Roesler (Bigelow Laboratory)

C. Roesler described GoMOOS’ real time hourly reporting buoy array. She also described how phytoplankton biomass, community structure, and productivity are measured using sensors. Phytoplankton biomass is measured using either chlorophyll fluorescence or chlorophyll absorption. Phytoplankton community structure can be measured using spectral absorption or by examining size structure. Phytoplankton productivity can be estimated by using light/chlorophyll models, light/absorption models and photochemical quenching. She believes that robust technology exists for real time *in situ* observations of phytoplankton biomass and production. This technology requires in-house calibration/characterization, and pre/post calibrations to assess biofouling. There is redundancy for each parameter as well as a range of bio-optical products that are operational.

Integrated Sensor Systems: The Autonomous Vertically Profiling Plankton Observatory – Scott Gallager (Woods Hole Oceanographic Institution)

S. Gallager described recent innovations in long-term sensor deployment in arrays and new concepts for integration of many types of simultaneous measurements into an operational observatory. Issues to consider are: reliability, self-calibration, fouling, power efficiency, cost, and environmental impact.

He then described recent work using an autonomous vehicle to study plankton and other parameters (including conductivity, temperature, depth, light absorption and attenuation, downwelling irradiance, upwelling radiance, and fluorescence). Plankton are measured using a Video Plankton Recorder (VPR) that records digital images for taxonomic composition analysis. S. Gallager showed data from the 2001 and 2002 three-month deployments over Stellwagen Bank.

He then proceeded to outline suggestions for the research community:

1. Accelerate development of miniaturized analytical and molecular systems using Micro Electro Mechanical devices (MEMS) and microfluidic technologies but maximize robustness, long-term reliability, sensitivity, resistance to fouling, novel methods of sample preparation, common interface.
2. Integrate multiple sensors into instruments and high-density arrays to address specific questions and increase functionality (e.g. carbon cycling- pCO2, DIC, POC, pH, microbial biosensor, plankton abundance, temperature, conductivity, u, v, w).
3. Develop a sensor coordinating committee to advise funding agencies, science users, and engineers on issues in 1 and 2. Use NASA sensor development program as model and operate under ORION.

For more information go to "The Next Generation of *in situ* Biological and Chemical Sensors in the Ocean" http://www.whoi.edu/institutes/oli/activities/symposia_sensors.htm and "The Autonomous Vertically Profiling Plankton Observatory" http://4dgeo.whoi.edu/vpr/.

General Discussion

The group then discussed technical options for MWRA monitoring.

Pop-up mooring. Real-time data acquisition requires a surface radio antenna, but the surface is hazardous in the shipping lane. A bottom-mounted profiler would be less exposed in shipping lanes because it is rarely at the surface. S. Gallager's profiler is bottom mounted with heavy winches from Deep-Sea Systems Inc but that platform is not off-the shelf. YSI is in the process of commercializing a bottom-mounted profiler based on another WHOI design http://www.ciceet.unh.edu/bulletins/geyer.html. K. McClurg said that the YSI vehicle would rest on the seafloor except when profiling and can carry two CTD-sized devices. The target battery length is 6 months and this instrument can be used in coastal waters up to 50m deep. (Surface-mounted profilers are of course commercially available, for example YSI's profiler traverses 100m at hourly intervals.) C. Roesler mentioned that a variable-buoyancy feature could reduce a profiler's power requirements.

Use existing big buoys. The existing USCG "B" buoy and NOAA's buoy 44013 survive in the shipping lane. Either could provide a mount for a surface radio antenna if underwater acoustic telemetry were effective. The "B" buoy however is too noisy. K. McClurg suggested that MWRA work with the Coast Guard to replace the Boston Buoy with a less noisy one so that data could be telemetered from USGS Site “A”. This has been done at other locations (e.g. U. Southern Florida http://comps.marine.usf.edu/). B. Beardsley and B. Butman thought that was a very good idea. B. Butman added that if the Coast Guard replaces the buoy with a newer model, then the USCG would not have to service it as often (such servicing tends to break fragile equipment).

Move out of the shipping lane. C. Olsen asked if there is a better location to add a mooring. R. Geyer suggested a location in the nearfield 0.5-1 km from the diffusers, but not in the zone of initial dilution (60m). Someone noted that effluent would take about two hours to flow that distance. C. Olsen pointed out that a bloom takes about a day to form so 1 km away from the outfall may not be far enough.

C. Roesler said that since the GoMOOS mooring is collecting data upstream of the outfall and these data are used in the modeling, model results should be able to tell us where to put a mooring downstream of the outfall. D. Dow thinks that the location of a new mooring should be chosen based on episodic events such as low DO and nuisance/harmful algal blooms.

Someone asked about the status of the GoMOOS model. N. Pettigrew said that the GoMOOS model is a circulation model. A biological model is currently being developed. It can successfully pick up blooms off of Nantucket Shoals but not near the coast (the model predicts higher chlorophyll for nearshore areas than what is actually measured). W. Brown stressed the importance of combining observations with model results.

R. Geyer thinks that given the subtle effects of the outfall, MWRA should invest in technology that looks for subtle long-term ecosystem changes. A. Rex said that some of that is already done with the collaborative USGS/MWRA project.

Partnerships. J. Pederson thinks that there should be a state coastal monitoring/research effort but since the likelihood for this is not good, perhaps if we can provide a list of questions, then collaborative efforts with organizations such as MITSG, USGS, and others can fund such work. B. Beardsley suggested that one option for MWRA could be to fund the addition of instruments that measure biological parameters (e.g. phytoplankton) to the GoMOOS mooring off of Cape Ann.

Sensors. R. Geyer suggested that the first step is to make sure the basics are covered – temperature, salinity, DO, light transmission, photosynthetically active radiation (PAR), and fluorescence. J. Kremer suggested that nutrients be added to the list after year three or four of the study.

Processes. The group then discussed biomass and flow at the outfall. B. Butman said that net mean flow is zero at the outfall. M. Jiang added that over a larger area, there is a net flow downstream of the outfall. J. Kremer thinks that if a small stock of phytoplankton were stimulated to grow by nutrients, it would take about a week for a bloom to form. C. Roesler suggested adding a biomass measurement at the GoMOOS "A" mooring (off of Cape Ann). Since this is already being measured at the GoMOOS "B" mooring (between Portland, ME and Portsmouth, NH), this would give us an idea of biomass growth rates. A. Subramaniam supported this idea by describing temporal coupling in SeaWiFS chlorophyll between those buoy locations. C. Olsen suggested that pCO_2 be added to the list of parameters measured so that we have an idea of how much atmospheric CO_2 is being sequestered (and thus seek DOE funding).

A. Hansen suggested that MWRA fund a "white paper" to further develop these technical options.

Summary. B. Beardsley then summarized the workshop. Today we heard about new technologies and the group discussed suggestions for MWRA monitoring.

The telemetry problem could potentially be solved by: (1) collaborating with the Coast Guard to replace the noisy Boston Buoy, (2) using a bottom-mounted profiler, or (3) moving out of the shipping lane.

Augmenting existing moorings with additional sensors - GoMOOS A, USGS - biooptics package, nutrients.

Promoting collaborative efforts and seeking additional funding.

ADJOURNED

MEETING HANDOUTS:

- Agenda and MWRA briefing packet TechnicalOptions-briefing.pdf

PRESENTATIONS

1Mickelson-20040519.pdf
2Butman-20040519.pdf
3Hanson-20040519.pdf
4Dragos-20040519.pdf
5Roesler-20040519.pdf
6Gallager-20040519.pdf