OUTFALL MONITORING SCIENCE ADVISORY PANEL (OMSAP) MEETING
Tuesday, December 4, 2007, 10:00 AM - 3:00 PM, WHOI Carriage House

DRAFT SUMMARY

AGENDA TOPICS

- Annual Monitoring Review
  - Changes in Boston Harbor
  - Outfall Monitoring including updates on mooring, flounder lesions, and discussion of toxicity exceedance
- Red tide
- *Phaeocystis* and Summer 2006 chlorophyll

ATTENDANCE

Members Present: Andy Solow, WHOI (chair); Bob Beardsley, WHOI; Norb Jaworski, retired; Judy Pederson, MIT/Sea Grant; and Jim Shine, Harvard School of Public Health.

Observers: Don Anderson, WHOI; Bruce Berman, Save the Harbor/Save the Bay; Jim Blake, ENSR; Mike Bothner, USGS; Brad Butman, USGS; Ellie Baptiste Carpenter, Battelle; Matthew Fitzpatrick, Battelle; Patty Foley, SH/SB; Sal Genovese, Safer Waters in MA; Maury Hall, MWRA; Carlton Hunt, Battelle; Mingshun Jiang, U. Mass Boston; Ken Keay, MWRA; Yong Lao, MWRA; Ben Lasley, SH/SB; Wendy Leo, MWRA; Greg Lescarbeau, Battelle; Scott Libby, Battelle; Matt Liebman, EPA; Nancy Maciolek, ENSR; Mike Mickelson, MWRA; Andrea Rex, MWRA; Lev Rozman, Acton Health Department; Larry Schafer, retired; David Taylor, MWRA; Cathy Vakalopoulos, MADEP; Jianjun Wang, MWRA; and Bob Young, MWRA.

MINUTES

OMSAP approved the August 8, 2006 meeting summary with no amendments.

N. Jaworski reported to the group that he has compiled a water quality report for the Potomac River Estuary 1995-2005 and can provide copies to anyone that is interested.

M. Bothner distributed copies of his USGS publication on the transport and fate of contaminated sediments in Boston Harbor and Massachusetts Bay.

CHANGES IN BOSTON HARBOR, DAVID TAYLOR, MWRA

One of the objectives of MWRA's Boston Harbor monitoring is to examine the effects of the diversion of the MWRA effluent discharge to Massachusetts Bay on eutrophication-related conditions in the water column of Boston Harbor. Total nitrogen (TN) loadings to Boston Harbor were estimated to be among the highest in the country before the outfall was diverted to Massachusetts Bay. With the system upgrades and diversion, total nitrogen, total phosphorus (TP), total suspended solids (TSS) and particulate organic carbon (POC) loadings were reduced by 80-90%. In summary, changes in eutrophication-related water quality parameters varied by season and by variable. In the water column, TN decreased by 35%, TP by 28%, chlorophyll-*a* (chl-*a*) by 28%, total phytoplankton by 14%,

diatoms by 33%, primary production by 50%, and POC by 28%. TSS increased by 5%, the reciprocal of the attenuation coefficient (a surrogate for water clarity) increased by 1% and mid-summer dissolved oxygen (DO) increased by 5%. For the parameters that are also modeled by the Bays Eutrophication Model (TN, chl-*a*, and DO), these results are comparable to values predicted by the model.

N. Jaworski enjoyed the presentation and appreciates whenever interannual comparisons are made. He suggested delineating using river flow and comparing the results. J. Shine also like the presentation and asked about the sediments, sediment oxygen demand, metals, sulfides, ammonium, pore water sulfides, and pathogen indicators. D. Taylor, C. Hunt, and A. Rex explained the work that has been done by MWRA. A. Rex suggested that OMSAP dedicate a future meeting to Boston Harbor. The members agreed.

B. Berman thought that this presentation was very helpful and informative. These data are going to be useful as things continue to change other MWRA projects are completed and on-line. It would be good to examine how these projects affect Boston Harbor. He added that it may help to inform policy decisions with other smaller projects within Boston Harbor. A. Rex said that improvements are more gradual and difficult to track since the inputs are more diffuse (e.g. CSOs). The group then discussed phytoplankton and total suspended solids changes over time.

B. Beardsley asked about changes in stratification in Boston Harbor when the outfall was diverted to Massachusetts Bay. D. Taylor said that they only measured a slight increase in salinity. M. Liebman asked about bottom dissolved oxygen when sludge was still being discharged in the harbor. A. Rex replied that some locations like the Mystic River, Fort Point Channel, and the Inner Harbor were extremely anoxic. B. Berman added that he has heard anecdotal stories about localized fish kills.

OUTFALL MONITORING INCLUDING UPDATES ON MOORING, FLOUNDER LESIONS, AND DISCUSSION OF TOXICITY EXCEEDANCE, ANDREA REX, MWRA

A. Rex presented a timeline of MWRA's wastewater treatment improvements. Some highlights include: sludge discharges ended December 1991, the new primary plant went on-line January 1995, secondary treatment begins to be phased in August 1997, Nut Island discharge ceased July 1998, and the new Mass Bay outfall went on-line on September 6, 2000. With these improvements, solids and metals discharges have dramatically decreased. However, secondary treatment has increased the proportion of dissolved inorganic nitrogen. Last year (2006), there was one effluent Contingency Plan exceedance. *Menidia* chronic survival was lower in the 1.5% concentration effluent than the 6.25% concentration effluent. This result was inconsistent since there should be a decrease in survival as effluent concentration increases. However, there was one sample with high ammonium that may have caused the toxicity. Overall, from 2000 to 2005, priority pollutant loadings were substantially lower than predicted for the Deer Island Treatment Plant.

A. Rex then presented results of 2006 ambient water quality monitoring. Bottom dissolved oxygen results were consistent with previous years and there no threshold exceedances. Since the outfall transfer, primary production rates have not changed significantly near the outfall, but have decreased sharply in Boston Harbor. As with previous years, the nuisance species *Pseudo-nitschia*, that produces the amnesic shellfish poisoning toxin was found in low numbers. Total zooplankton in all areas was comparable to previous post-diversion years. However, there appears to be a region-wide decrease in zooplankton abundance when data are compared back to 1992. Fortunately, *Calanus finmarchicus*

numbers, the type of zooplankton right whales prefer, was slightly above the pre-diversion mean. In 2006, there was a nearfield chlorophyll caution exceedance, a nearfield *Phaeocystis* caution exceedance, and an *Alexandrium* caution exceedance. All three were due to large, regional blooms [details will be discussed later in this meeting]. She then gave a brief mooring update. MWRA uses real time chlorophyll data measured by the Gulf of Maine Ocean Observing System (GoMOOS) A buoy located off of Cape Ann. NOAA is building instrumentation for buoy 44013 with a planned deployment of April 2008. B. Beardsley asked if they will be measuring light radiation on the NOAA mooring. M. Mickelson said no, that instrument was too expensive. The mooring will measure salinity, fluorescence, currents, and dissolved oxygen.

A. Rex then summarized the benthic monitoring results for 2006. The benthos is a sensitive indicator of resource health. For soft bottom sampling, the sediment oxygen demand has remained low in the nearfield and decreased to healthy levels in Boston Harbor. In the nearfield, species diversity varies on what appears to be a cyclical basis and there has been an increase in Boston Harbor diversity. Oxygen penetration is greater than the baseline in the nearfield. One outfall indicator has been an increase in *Clostridium perfringins* spores in the sediments around the outfall. Hard bottom monitoring is done using a camera mounted on a remotely operated vehicle (ROV). Out of 26 stations, an increase in sediment drape has been observed at five stations south of the outfall. Plant and animal communities are normal with abundant growth on active diffusers. Cod, lobster, and rock crab have been seen in greater numbers in the monitoring area since the outfall went on-line.

MWRA also conducts fish and shellfish monitoring. Overall, there has been a decrease in early liver disease in flounder in Boston Harbor and no increase seen near the new outfall. Blind-side flounder lesions first noticed by MWRA in 2003 have decreased to very low numbers in 2006 and 2007 at the outfall, off Nantasket, and Deer Island Flats. Lobster tissue contaminants are low but there is still a tomalley PCB advisory in effect. Mussel tissue bioaccumulation contaminants are at or below baseline values except for PAHs. However in 2006 when mussels were deployed, PAHs concentrations were just below the caution threshold. In summary, there appear to be no adverse impacts that can be attributed to the outfall.

OMSAP discussed Don Harleman's belief that treatment plants with ocean outfall should only have primary treatment (with advanced solids removal). J. Shine noted that secondary treatment increases dissolved inorganic nitrogen which stimulates phytoplankton growth. J. Pederson asked if they noticed the invasive sea squirt *Didenum* that is colonizing Georges Bank. N. Maciolek replied that they looked for it, but didn't see it. J. Pederson asked to be notified if they find it.

B. Berman asked if thresholds were met when MWRA was blending effluent. A. Rex replied that yes and that secondary effluent has improved due to improved treatment during dry weather. B. Berman asked OMSAP if there are other parameters that MWRA should measure in their effluent. A. Solow replied that the monitoring should be built around the kind of treatment that is expected. A. Rex said there have been improvements due to changes in the way the plant is run, the increased age of the activated sludge (which is more difficult to upset), and more constant inputs of nutrients in the sewage. Because of this, they are operating secondary up to 700 mgd. N. Jaworski noted that it can take years to optimize a sewage treatment plant.

L. Rozman said that it looks like everything is going well. He asked if secondary treatment is needed. A. Rex replied that we are operating on the presumption that the more secondary treatment there is, the better chance that contaminants that we don't measure are being taken out. N. Jaworski added that at

the time that the new treatment plant was being planned, the technology for secondary was available and there wasn't much debate about whether or not to use it.

C. Hunt commented on how well the models worked in the early days in predicting dilution, dissolved oxygen, etc. B. Beardsley agreed that there has been a lot of positive work done and asked how much is presented and published. A. Rex replied that MWRA does both and C. Hunt noted that many of these conferences bring together researchers from all over the world. J. Pederson said that there are many other treatment plants that do not operate on the level of MWRA, and they can learn from this. It would be good to get this information to regulators and other treatment plants. N. Jaworski noted that this is an ocean outfall so there is no phosphorus removal. There is an increased movement towards nitrogen and phosphorus removal at other treatment plants that discharge to fresh water. B. Beardsley agreed and said that it would be up to EPA to get this information out to others so they can learn from MWRA.

RED TIDE, DON ANDERSON, WHOI

The 2005 *Alexandrium* red tide bloom was extremely large and extended from Maine to Buzzards Bay. The 2006 bloom was also large but not as extensive. The 2007 bloom was much smaller. D. Anderson showed an animation from a conceptual red tide model that creates animations of bloom dynamics based on field data inputed into the model. To examine whether there was an outfall effect, he and his colleagues looked at phytoplankton community changes, nutrient relationships, and conducted two modeling efforts.

Shellfish toxicity data from 1972-2000 show that significant toxicity at northern stations is a predictor of the occurrence of toxicity at Massachusetts south shore stations. Blooms in the southern part of Massachusetts occur later, are smaller, and are less toxic. Therefore it was assumed that an "outfall effect" would be seen if southern shellfish beds became more toxic first or ended up more toxic than northern stations. During 2005, these conditions were met, so scientists looked at whether this was indeed an outfall effect.

There are three hypotheses as to what factors played a role in the magnitude and extent of the 2005 bloom: (1) unusually high numbers of cysts in the western Gulf of Maine sediments, (2) timely and powerful northeast storms caused strong onshore advection of cells, and (3) anomalously high river runoff provided increased micro and macronutrients and contributed to alongshore transport. To test these hypotheses, they ran their nested physical/biological numerical model for *Alexandrium* bloom dynamics in the Gulf of Maine using 2005 wind and river runoff and climatological nutrient fields with varying cyst abundances (2004 vs. 1997). D. Anderson showed the modeling results. It appears that the high cyst abundance was the most important factor in the 2005 bloom. Winds were also important in bringing the cells nearshore. However, this model does not take into account increased nutrients from the higher than average river runoff in 2005.

They then examined whether the outfall influenced the bloom locally by looking at the phytoplankton community and whether there were correlations between nutrient concentrations and *Alexandrium* cell abundance. During the 2005 bloom in Massachusetts Bay, *Alexandrium* numbers were much lower (by an order or magnitude) than other commonly found species of phytoplankton.

The 2005 bloom occurred within a diverse phytoplankton community that was about 400 to 1000 times more abundant than *Alexandrium*. The bloom in Massachusetts Bay was likely due to water mass

changes rather than a change in phytoplankton species succession. The highest *Alexandrium* abundances tended to be found in areas with low concentrations of nutrients. No other nutrient-bloom patterns were apparent. When the regional bloom declined, there was no evidence that the outfall was prolonging the bloom in the nearfield.

D. Anderson then described a simple ocean dispersion model used to estimate the impact of MWRA loading on phytoplankton outside of the initial mixing zone. Results estimate a ~10% increase in dinoflagellates, but this is quickly diluted by oceanic dispersion. Numerical modeling was also conducted to assess the effects of ammonium on *Alexandrium* in Mass Bay. Ambient ammonium was unusually low for May 2005, most likely due to lower MWRA nitrogen loading, greater dilution due to strong currents, and storm-related mixing and advection. Dispersion modeling showed that in worst case calm conditions, there was a 10% increase in *Alexandrium* within the outfall plume. Ocean dispersion more than keeps pace with this amount of bloom stimulation. They then ran a sensitivity test using a numerical model to evaluate the effects of the discharge on the bloom. The model showed that at most, the outfall ammonium would have caused a 10-15% increase in *Alexandrium* "downstream" of the outfall. Previous work showed that the outfall provides only about 3% of total nitrogen to Massachusetts Bay and 90% comes from the Gulf of Maine.

In 2006, another major regional bloom occurred. The highest toxicity was measured in the north shore, however there was one station in the South Shore (Cohasset) with high toxicity levels over a two week period. It is difficult to determine why this occurred at one South Shore station. The 2007 bloom did not cause extensive shoreline closures but there was a large bloom over Georges Bank.

This recent change in bloom dynamics is being studied by several researchers. Darcie Couture from Maine DMR developed an index for Maine that measures bloom activity. It appears that around 2003, Maine entered a more active bloom phase. This may be a due to greater cyst abundances in the mid-coast Maine cyst deposit when compared to historical levels. Based on patterns since the 1972 hurricane that brought Alexandrium to the western Gulf of Maine, including Massachusetts Bay, it appears that we are entering a new period of more frequent and intense toxicity in this area.

B. Beardsley asked about the large bloom on Georges Bank and whether there is a cyst bed on the Scotian Shelf. D. Anderson replied that they haven't sampled that far out, but there is no record of cyst beds out there. He thinks that there is a link from the Bay of Fundy to Georges Bank. J. Pederson asked if there are high cell counts in the Bay of Fundy in the fall. D. Anderson replied yes. J. Pederson asked why there aren't higher counts further south. D. Anderson said there is no spring runoff to facilitate transport. B. Beardsley added that transport is also more difficult in the fall because the stratification breaks down. B. Butman thinks it's possible that cells came down from the outer shelf of Nova Scotia. N. Jaworski asked if this increase is being seen globally. D. Anderson replied yes, and there are several possible reasons why (e.g. transport in ballast water and an increase in nutrient discharges).

J. Shine asked why in the conceptual model, the discrete cyst beds are not connected. D. Anderson replied that the Bay of Fundy is isolated due to circulation patterns. Other beds form when nutrients are limited. That's how they conceptually determine where the cyst beds are. After the large 2005 bloom, they were surprised to have not seen an expansion of cyst beds. B. Beardsley think there is something "special" about what is discharged by the Maine rivers that keeps cysts beds active off the coast.

2007 *PHAEOCYSTIS* BLOOM, SCOTT LIBBY, BATTELLE

In 2007, there was a winter/spring exceedance of the *Phaeocystis* Contingency Plan caution threshold. *Phaeocystis* blooms have been observed in 11 out of 16 years of monitoring and in recent years, the frequency has changed from once every two to three years to annual blooms. Currently researchers are trying to gain a better understanding of the factors that influence bloom dynamics both here and in other parts of the world.

Phaeocystis blooms in Massachusetts Bay tend to be part of larger regional blooms with abundances of greater than 85% of the phytoplankton biomass. Within Mass Bay, bloom patterns vary by location and intensity. There is no discernible pattern that can be related to the outfall. In addition, abundances have been consistently higher to the north (or "upstream") of the outfall. MWRA evaluated potential causes of the increase in frequency of blooms in a 2006 synthesis report [this report is the 2005 Nutrient Issues Review and is located at http://www.mwra.state.ma.us/harbor/enquad/pdf/2006-02.pdf]. Though the cause(s) have not been determined, there does not appear to be a strong linkage to the outfall.

SUMMER 2006 CHLOROPHYLL, SCOTT LIBBY, BATTELLE

The MWRA Contingency Plan contains seasonal chlorophyll thresholds. In 2006, there was an exceedance of the summer (May-August) threshold. The threshold is 93 mg/m^2 and the 2006 summer average was 97 mg/m^2. This was the first summer exceedance since the outfall went on-line in 2000. This exceedance was due to one survey on July 19, 2006. Typically the water column is stratified in the summer months due to temperature difference between surface and bottom waters. Nutrients are depleted by the phytoplankton in the upper layers and spring blooms fade. During the summer of 2006, there is evidence of upwelling from satellite surface temperatures and wind stress data. This brought colder nutrient-rich waters to the surface phytoplankton allowing them to bloom.

The dominant species of this bloom was a chain-forming diatom, *Dactyliosolen fragilissimus*. This is a common North Atlantic species and is not harmful or a nuisance. This bloom did not affect bottom water dissolved oxygen. Evidence of this bloom was seen as a layer of high chlorophyll in sediments (in nutrient flux cores) from one station south of the outfall. However, there were not adverse impacts to the sediment oxygen demand and penetration from this. Satellite imagery suggests that this bloom covered a larger area than Mass Bay. Data from this bloom will be further analyzed using the Bays Eutrophication Model.

M. Liebman asked if these upwelling events are from southwest winds, and why are they occurring so far offshore. S. Libby replied that yes, upwelling is due to winds from the southwest and it can occur in water that is up to 20-25 m deep. M. Liebman asked how come there aren't more upwelling events since southwest winds are common in the summer. S. Libby thinks this is a good question that can be addressed by the Bays Eutrophication Model.

ADJOURNED

Summary prepared by C. Vakalopoulos.