Direct Intervention to Improve Hypoxic Conditions: A Baltimore Harbor Pilot Study

Presentation to the Environmental Management of Enclosed Coastal Seas Conference (EMECS 9)

In Partnership With: August 29, 2011
Agenda

- Background
- Direct Intervention
- Pilot Study
- Summary
Key pollution problem in Chesapeake Bay is excess nutrient loading.

- Nitrogen & Phosphorus
- Creates a negative feedback loop which leads to hypoxic and anoxic “dead zones” throughout the bay

These organisms tolerate different levels of dissolved oxygen in the water, but not all can move to a different location when dissolved oxygen levels are too low. From left to right: striped bass, hard clams, blue crab, spot, and bristleworm. (Photo credits: NOAA Photo Library, D. Wilson, www.jaxshells.org, USGS, URI)
The Problem

Dead Zones

- Reduced productivity in the Bay
- Less volume of livable space
- Reduced capacity to absorb pollution
- Seasonal - April to October

Source: NOAA, Chesapeake Bay Program
Bay Cleanup Efforts

- Estimated at $6 Billion to date
  - Treatment plant upgrades
  - SW management improvements
  - BMP for agriculture
  - Bay grass planting
  - Education programs for citizens
  - Reduction in NO$_2$ air emissions

- After 40 years something is still missing –
  - Another tool for the ‘Bay’ restoration tool box
A new tool to help restore the bay.....

- Aeration to reduce/eliminate dead zones.

- Aeration would act in parallel with pollution reduction efforts to restore the Bay.

  - It would not take the place of these ongoing efforts
The Aeration Concept

- Aeration is a ‘direct intervention’ method to assist in dealing with the issue.
  - Approach similar to:
    - Environmental dredging
    - Artificial reef to restore oyster populations
    - Tidal pump systems

- Utilize technology to insert enough oxygen into the Bay water column to:
  - Impact localized oxygen deficits
  - Remove localized dead zones
  - Provide the technology in parallel with ongoing efforts to eventually remove dead zones
Pilot Study

- Install an aeration device with a known capacity to transfer oxygen to the water column

- In a known location of seasonal dead zones
  - Baltimore Harbor

- Data is lacking
Pilot Study Program

- Compile background information at the site
- Installation of the mixing / aeration device
- Monitoring how a plume of oxygen created by the aeration will move and increase in real world conditions
- Establish correlation data for new units
Field Sampling & Operations

- DO, temp, salinity, density, and conductivity
  - Control
  - Area of influence

- Drogues
  - Shallow and Deep
  - Current tracking

- Tide/Wind

- Dye Testing

- Diel Monitoring

- Additional Sampling Univ. of Maryland & Bluewater Baltimore
  - Nutrients and Chlorophyll
  - Particle count
Mixing - SolarBee

Direct flow from the SolarBee mixes with surface water from the induced flow and falls to the thermocline.

Warm, Less Dense Epilimnion

Weak Counter-Flow Gyre

Water falls through the thermocline to make up water removed from the bottom.

Oxygenated Water

Thermocline

Cool, Dense Hypolimnion

Anoxic Water

Prevents soluble P, Mn, Fe and H₂S from diffusing into upper waters.

To WTP
Mixing/Aeration System Operational
Dye Testing
Current Tracking – Drogue Use
Zig-Zag and Cast Sampling

- To Track the Oxygen ‘Plume’
  - Use of Hypack and GPS
Depth Profiles from Cast Data
Comparison at Distance

Solar Bee Casts: 8/02/11

Coast vs. SBCast - 8/02/11

Depth (m)

Temperature (°C)

Oxygen

pH

Salinity (PSU)

Sigma T (kg/m³)

Coast vs. SBCast - 8/02/11

10 m

Coast vs. SBCast15C - 8/02/11

10 m

Coast vs. SBCast15C - 8/02/11

15 m

Coast vs. SBCast15C - 8/02/11

20 m
DO vs. Distance – Zig Zag Data

DO vs Distance from Solar Bee: 7/26/11
1 ft depth
DO vs. Distance – Linear Cast

- DO (mg/L) vs Distance from Solar Bee: 7/21/11
  1 ft depth

- DO (mg/L) vs Distance from Solar Bee: 7/21/11
  3 ft depth

- DO (mg/L) vs Distance from Solar Bee: 7/21/11
  5 ft depth

- DO (mg/L) vs Distance from Solar Bee: 7/21/11
  7 ft depth
Pilot Study

▶ Results of the Study:
  ❖ How much power it will take to effectively aerate Bay dead zones
  ❖ How long it takes to effect DO levels
  ❖ How long it takes for ambient DO levels to return if aeration is ceased.
  ❖ For several magnitudes of aeration what area and volume of water will be impacted over what distance.
Results and Future Steps

The results of the pilot study will provide the necessary framework for a full demonstration project to succeed.