Development of a Dissolved Oxygen Indicator for the Delaware Inland Bays

By: The Inland Bays Water Quality Indicators Subcommittee

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Are the actions working that have been taken to clean up the Inland Bays?

How can we tell?
“Indicators are used to show changes in environmental conditions...”
We want to measure whether:

Dissolved Oxygen conditions are getting better, worse, or staying the same.
News Flash

The two most important factors affecting Dissolved Oxygen and Real Estate are the same.
Other factors affecting Dissolved Oxygen

Water Temperature - seasonal

Light – extent of cloud cover

Tide – ebbing vs. flooding

Streamflow – stormwater inflow
Necessary Indicator Elements

1) Comparative Factor
2) Reference Value
3) Critical Time Period
4) Key Locations
Is the frequency of low dissolved oxygen measurements changing based on results from selected locations sampled within a specified time period of any given day?

when...
**Comparative Factor** = “frequency of low DO measurements”

**Reference Value** = “low” (< 4.0 mg/L of DO)

**Critical Time Period** = “specified time period of any given day” (dawn to 09:00)

**Key Locations** = “selected locations” (A – Z, to be determined)
What has been done thus far?

1) Analysis of existing data

2) Early evaluation of future data collection strategy
Three data sets – all data collected by DNREC and the University of Delaware

1998 to 2008 (June to September)

Methods – bottom continuous sampling (every 15 minutes for periods of days to weeks).

- surface discreet sampling (weekly to bi-monthly)
The Data

DNREC and University of Delaware – bottom continuous sonde measurements to support research and Harmful Algal Bloom (HAB) projects. 2000 to current.

University of Delaware (Inland Bays) Citizen Monitoring Program – surface discreet sampling to support the goals of the Delaware Inland Bays National Estuary Program.

DNREC – surface discreet sampling to support the goals of the federal Clean Water Act (Water Quality Inventory 305(b) Report, TMDL/PCS)
Dissolved Oxygen Monitoring Methods

Continuous

Discreet Electronic
Discreet - Chemical Testing
Continuous Data
Diel-cyclic Bottom Dissolved Oxygen Concentration
June 8 to Sept. 11, 2001
Each hourly-average based on 380 measurements

Sunrise (06:00 hrs)
Sunset (20:00 hrs)

DO (mg O₂ l⁻¹)

- Upper
- Middle
- Lower

WQS Average
WQS Single msmt.

Midnight
Noon

Standard Source: DNREC 2004
Surface Water Quality Standards
Diel-cyclic Bottom Dissolved Oxygen Concentration
June 8 to Sept. 11, 2001
Each hourly-average based on 380 measurements

Sunrise (06:00 hrs)          Sunset (20:00 hrs)

DO (mg O_2 l⁻¹)

- Upper
- Middle
- Lower

Protective Criterion 4.8
Survival Criterion 2.3

Typical pattern of vertical change in [DO] (mg O₂ l⁻¹) from near sunrise to mid-afternoon.

Severely hypoxic
Moderately hypoxic
Normoxic
Generally, dissolved oxygen begins to rise at the surface around 8:00 a.m. and at the bottom by 9:00 a.m.
Citizen Monitoring Program Sampling Sites as of 2007

80 sites, # of samples per site ranges from 1 to 188, median = 20/site, Total Samples = 3,400
CMP Inland Bays Dissolved Oxygen Data from 65 Sites (June to September, 1998 to 2008)

% of DO msmts. < 4.0 mg/L vs. Hour of the Day (i.e. hour 7 = 6:00 to 7:00 a.m.)

- Upper
- Middle
- Lower
DNREC General Assessment / TMDL sampling sites

20 sites,

# of samples per site ranges from 44 to 91

median = 53/site.

Total samples = 1120
DNREC Tidal Inland Bays Dissolved Oxygen Data, from 20 sites (June to September, 1998 to 2008)
Figure 20: The number of measurements of dissolved oxygen \(<2\text{mg/L}\) (black diamonds, left axis) and the average \([\text{DO}]\) (gray squares, right axis) for each hour of the diel cycle from Site 1, (Pepper Creek, Site 1) from June 8 – September 11, 2001. This time period spans the first and last DO measurements of \(<2\text{mg/L}\) during the season. Each hourly concentration value is based on between 381-384 measurements. See Fig. 9 for site location.
Great - Congratulations!!! Now – feed the dogs and finish your coffee - then get out there and do the test no later than 09:00.
DNREC General Assessment / TMDL sampling sites

- **Tributary**
- **Open Bay**
DNREC Dissolved Oxygen Data for the Delaware Inland Bays at 20 tidal locations (1998 - 2008) June - September

Number of DO msmts.

<table>
<thead>
<tr>
<th>Tributaries</th>
<th>Total</th>
<th>&lt; 4.0 mg/L</th>
<th>23%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Bays</td>
<td>Total</td>
<td>&lt; 4.0 mg/L</td>
<td>5%</td>
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</table>
The numeric value of the reference value does not matter. What does matter is the direction in which the frequency of low DO (reference value) results moves over time.

The Inland Bays Citizen Monitoring Program data is critical to the success of the DO indicator because the people involved are local and can collect a lot of data within the daily critical time period (dawn to 09:00).

Key locations need to be determined.
The End

Photo by R. Tyler

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