



Development of a Dissolved Oxygen Indicator for the Delaware Inland Bays

By: The Inland Bays Water Quality Indicators Subcommittee

Chris Bason
Muns Farestad
Doug Miller
Hassan Mirsajadi
Robin Tyler
Ed Whereat

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.

Time Time Time

Location Location Location

Other factors affecting Dissolved Oxygen

A satellite map of a coastal region, likely the Sussex area in Delaware, showing a large body of water on the right and a complex network of streams and wetlands on the left. Five blue squares are placed at various points along the coastline and inland, indicating specific monitoring or study locations. The word 'Sussex' is visible in green text on the map.

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

Overall Question

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

The Data

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

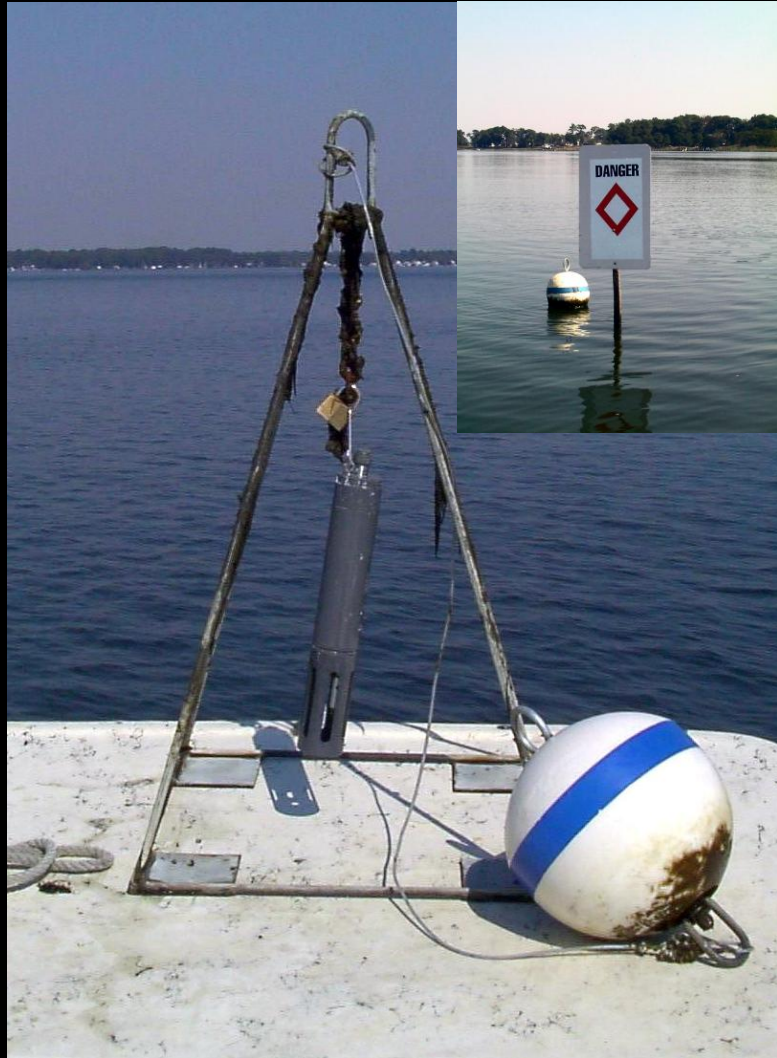
DNREC and University of Delaware – bottom continuous sonde measurements to support research and Harmful Algal Bloom (HAB) projects. 2000 to current.

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

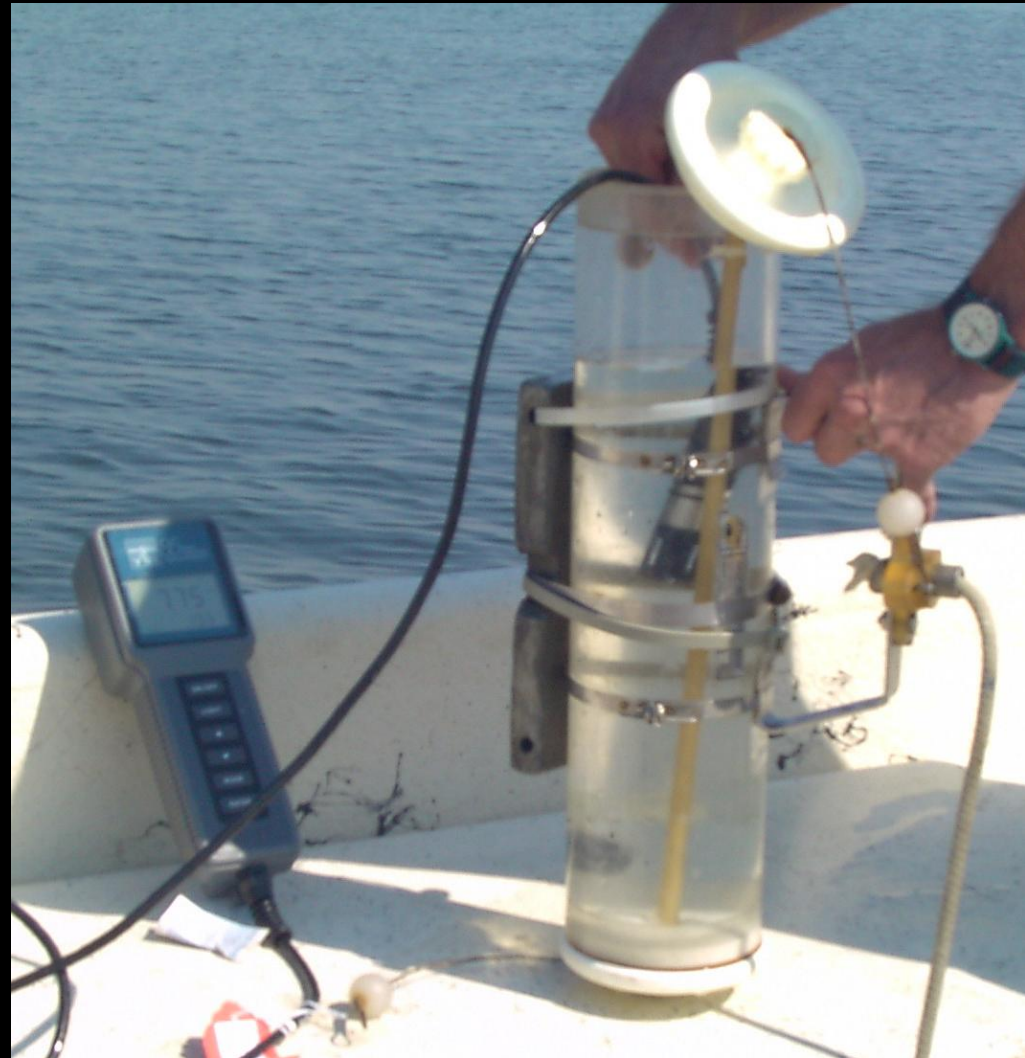
DNREC – surface discrete sampling to support the goals of the federal Clean Water Act (Water Quality Inventory 305(b) Report, TMDL/PCS)

Dissolved Oxygen Monitoring Methods

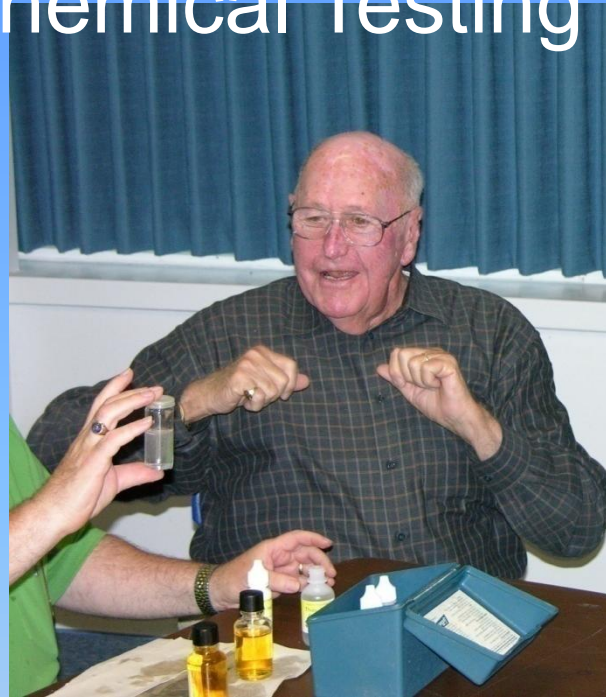
Continuous



Discreet Electronic



Discreet - Chemical Testing

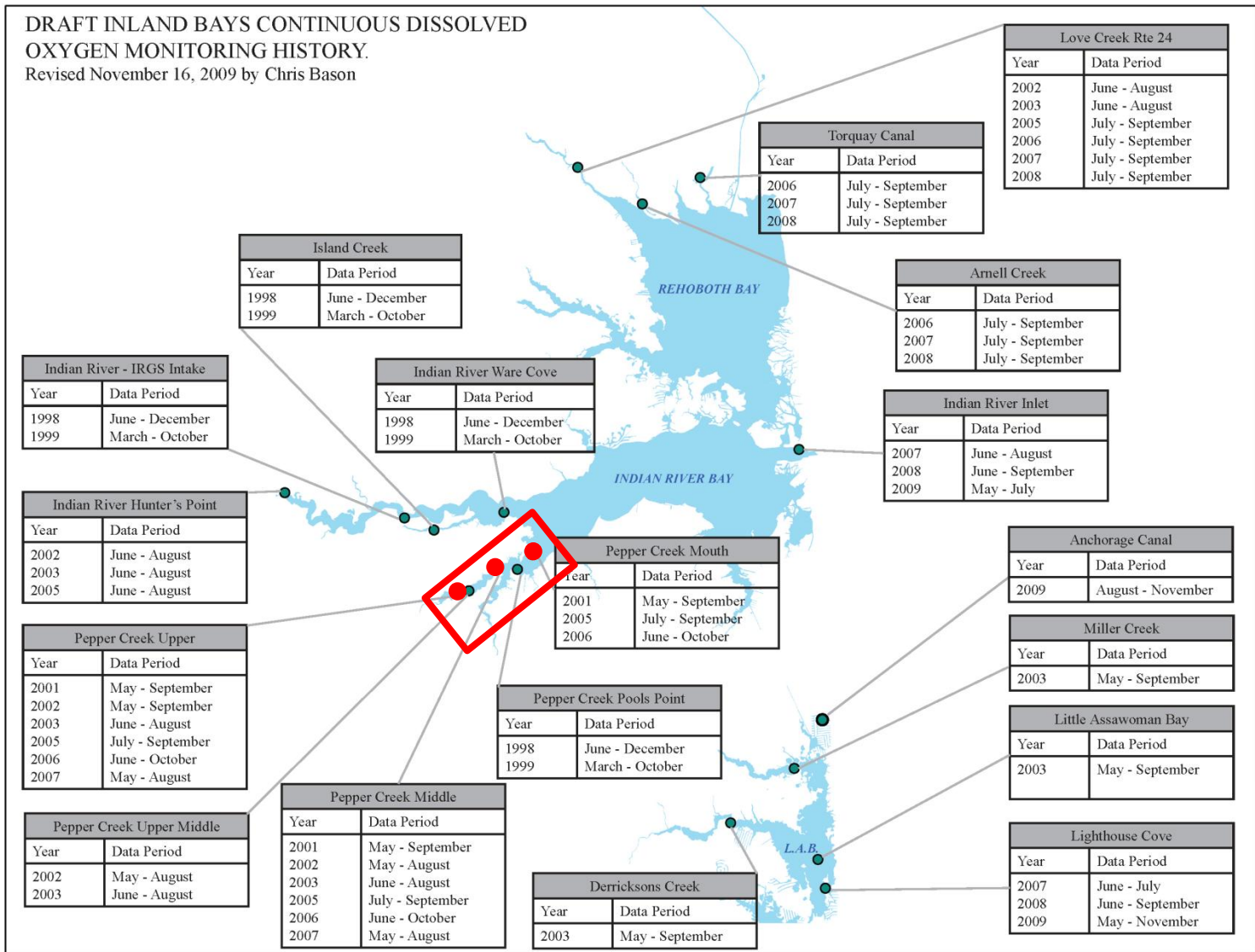


Continuous Data



DRAFT INLAND BAYS CONTINUOUS DISSOLVED OXYGEN MONITORING HISTORY.

Revised November 16, 2009 by Chris Bason



Island



Pepper Creek



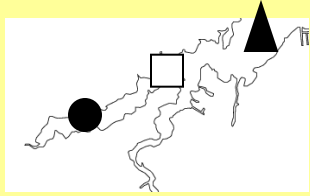
Image U.S. Geological Survey
© 2009 Google
© 2009 Europa Technologies

© 2007 Google™

Diel-cyclic Bottom Dissolved Oxygen Concentration

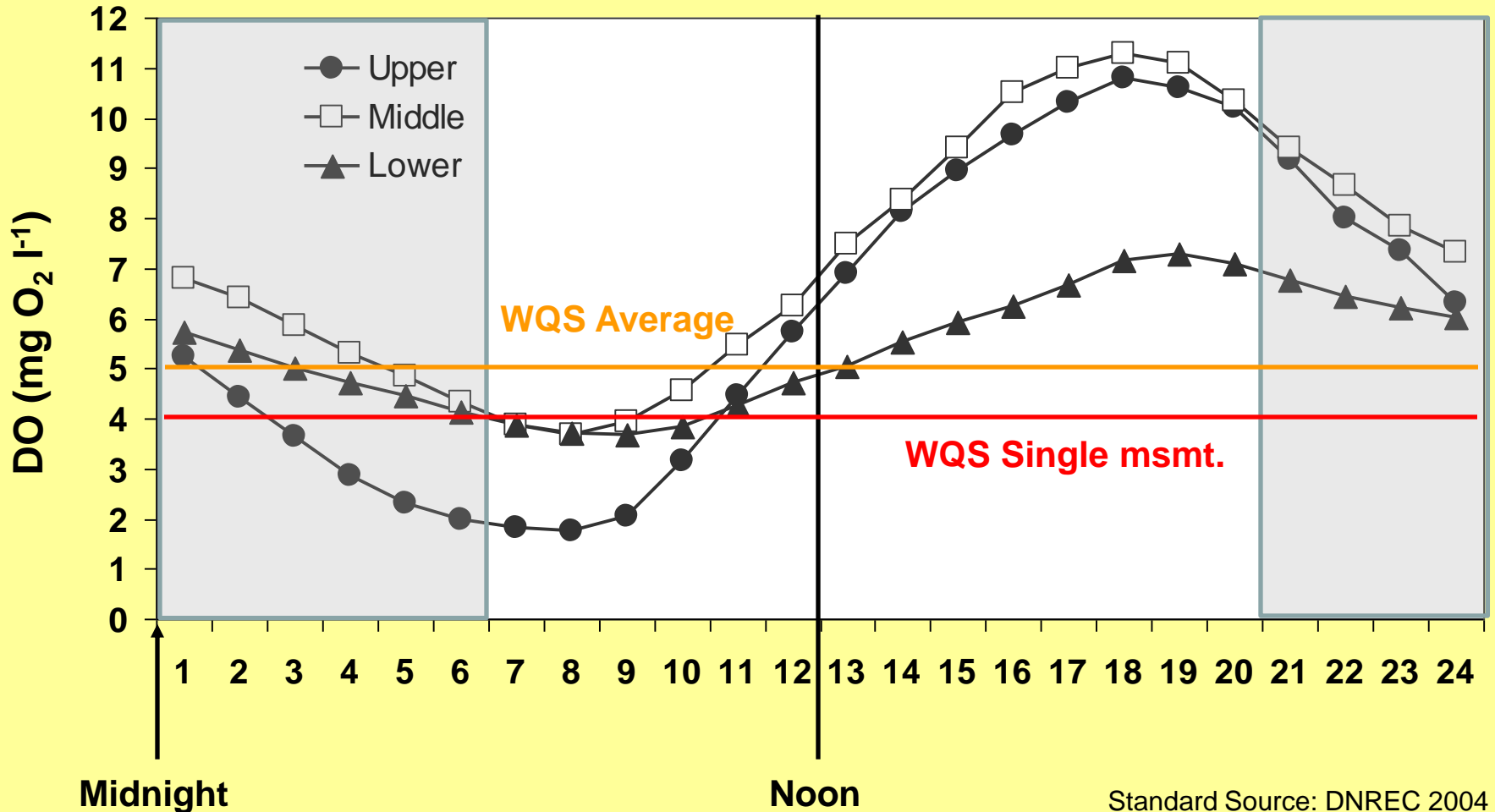
June 8 to Sept. 11, 2001

Each hourly-average based on 380 measurements



Sunrise (06:00 hrs)

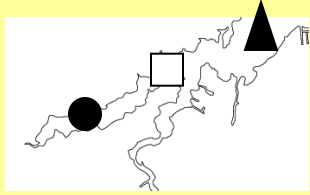
Sunset (20:00 hrs)



Diel-cyclic Bottom Dissolved Oxygen Concentration

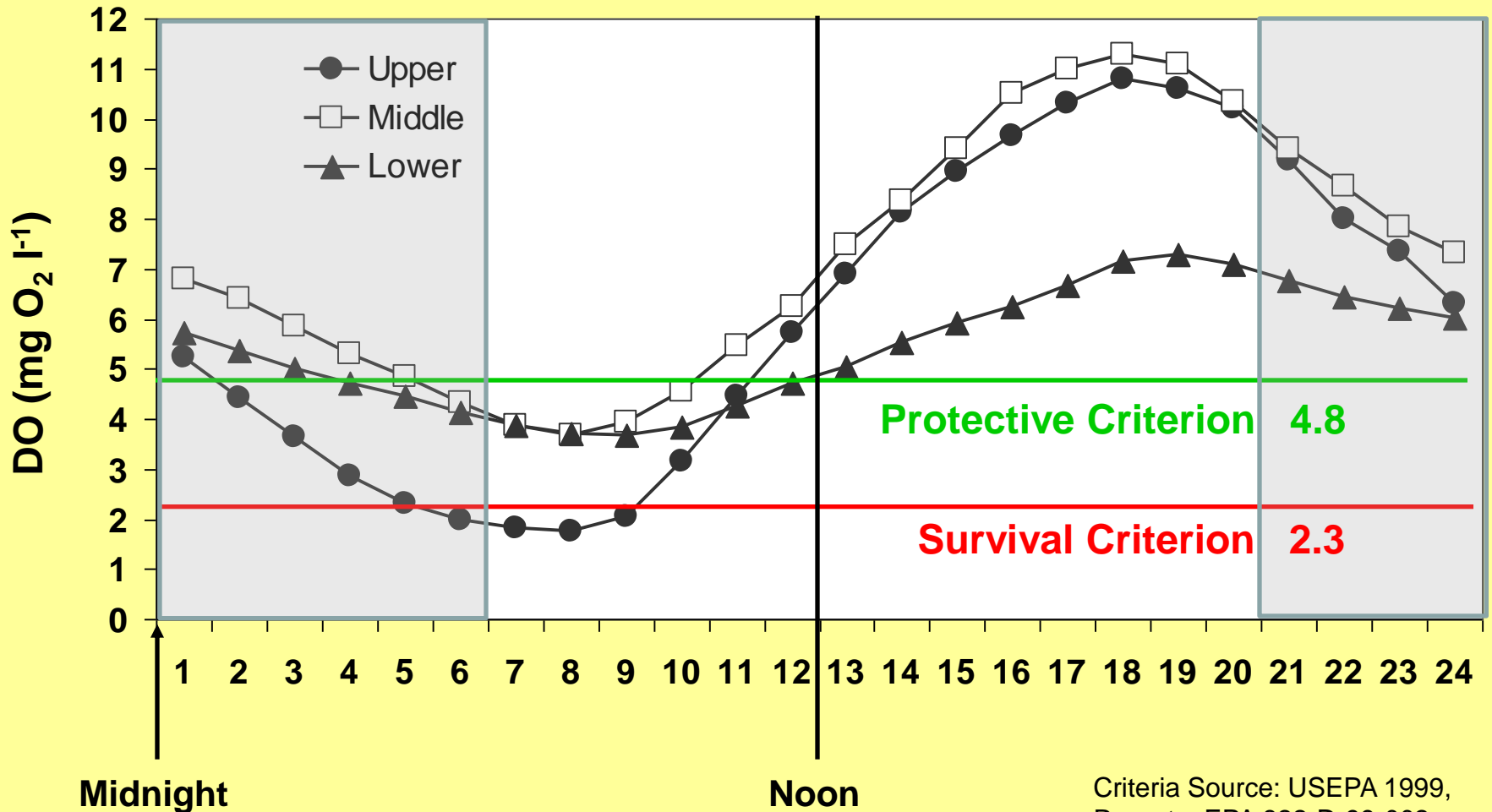
June 8 to Sept. 11, 2001

Each hourly-average based on 380 measurements



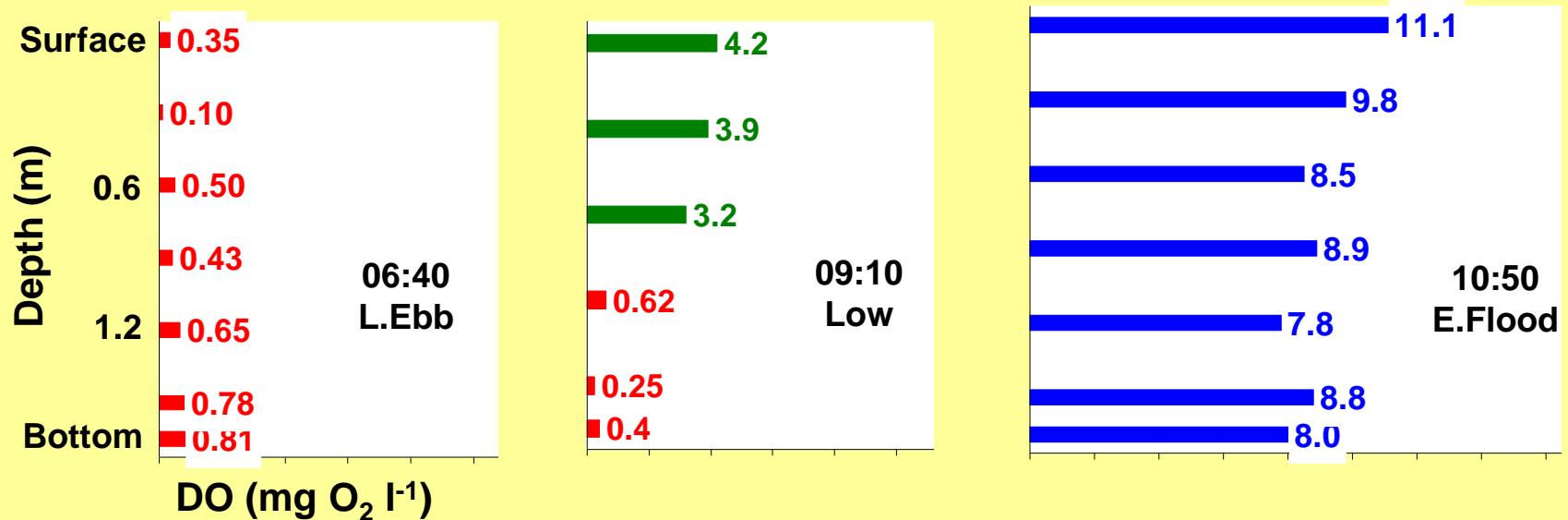
Sunrise (06:00 hrs)

Sunset (20:00 hrs)

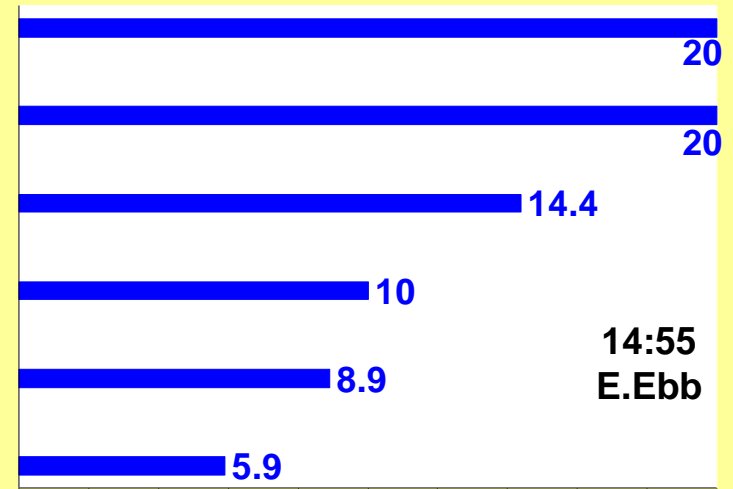


Criteria Source: USEPA 1999, Report – EPA 822-D-99-002

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.

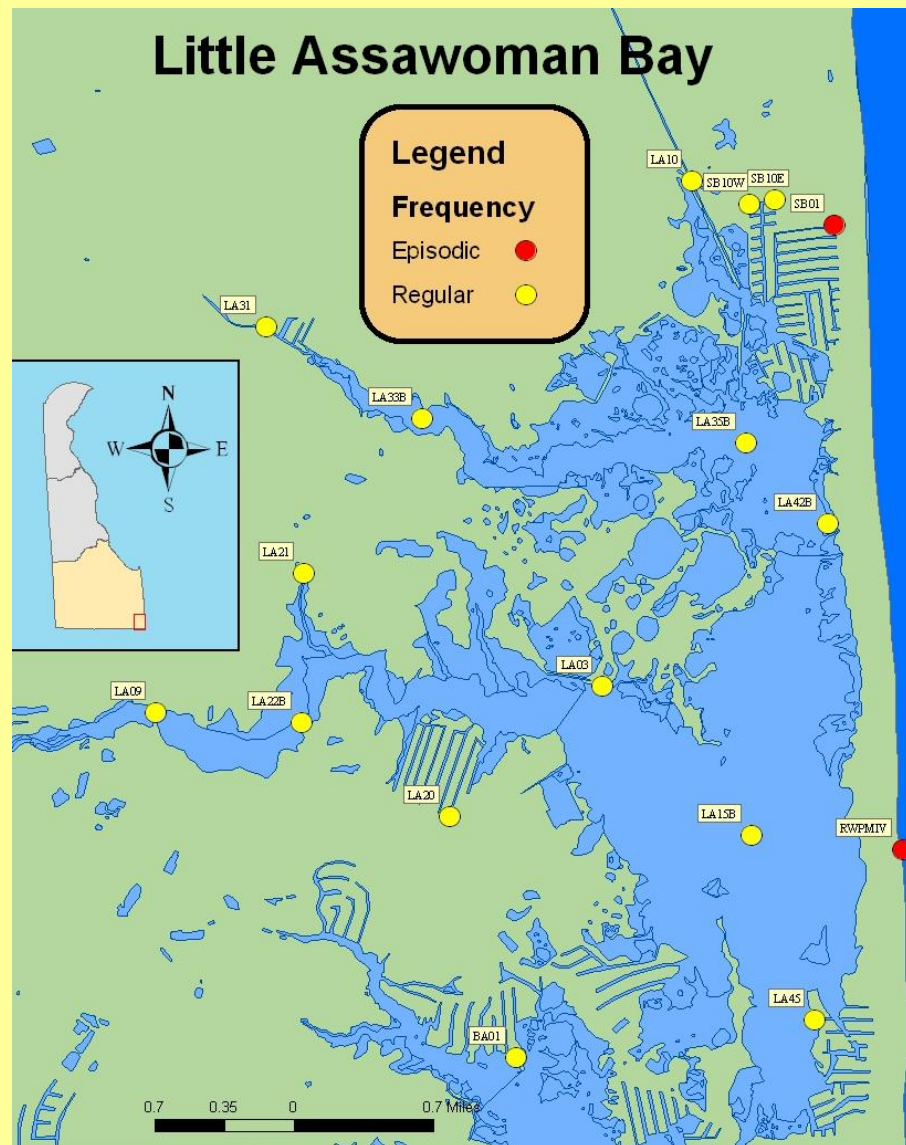
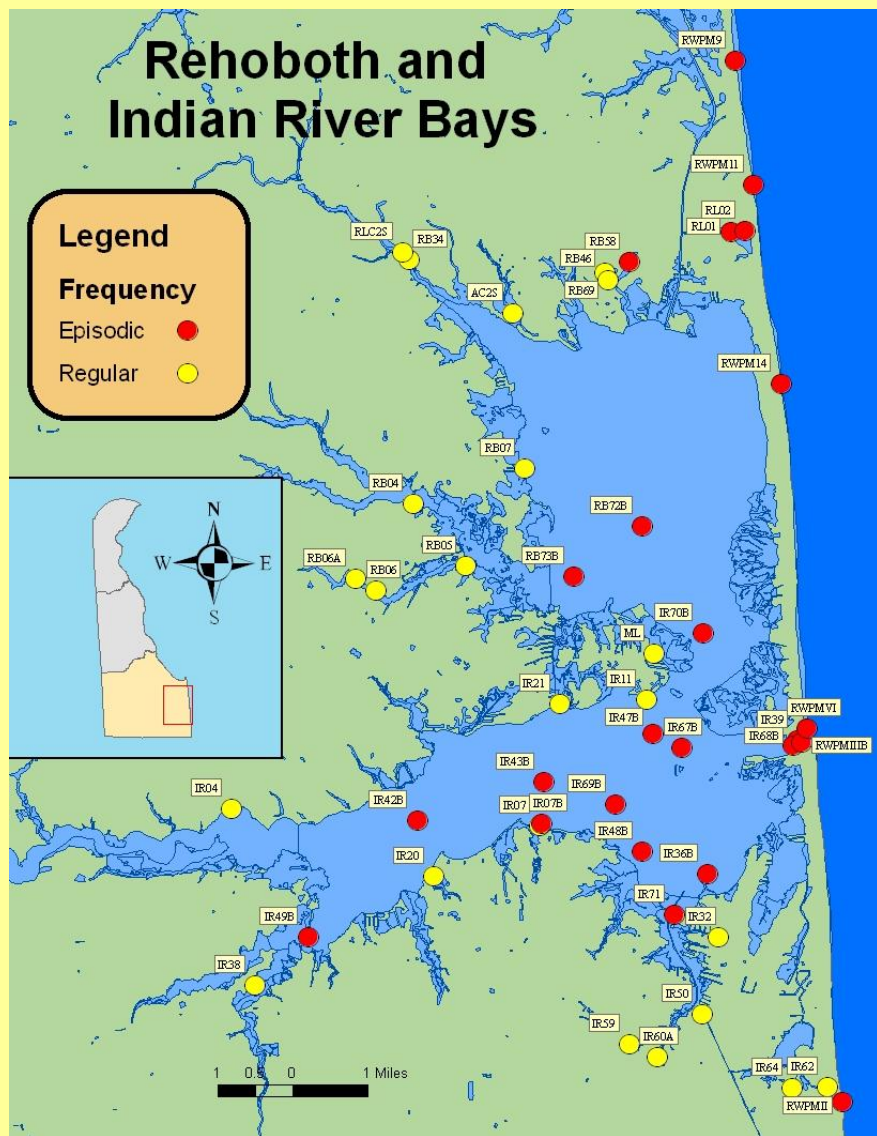


Discreet Data

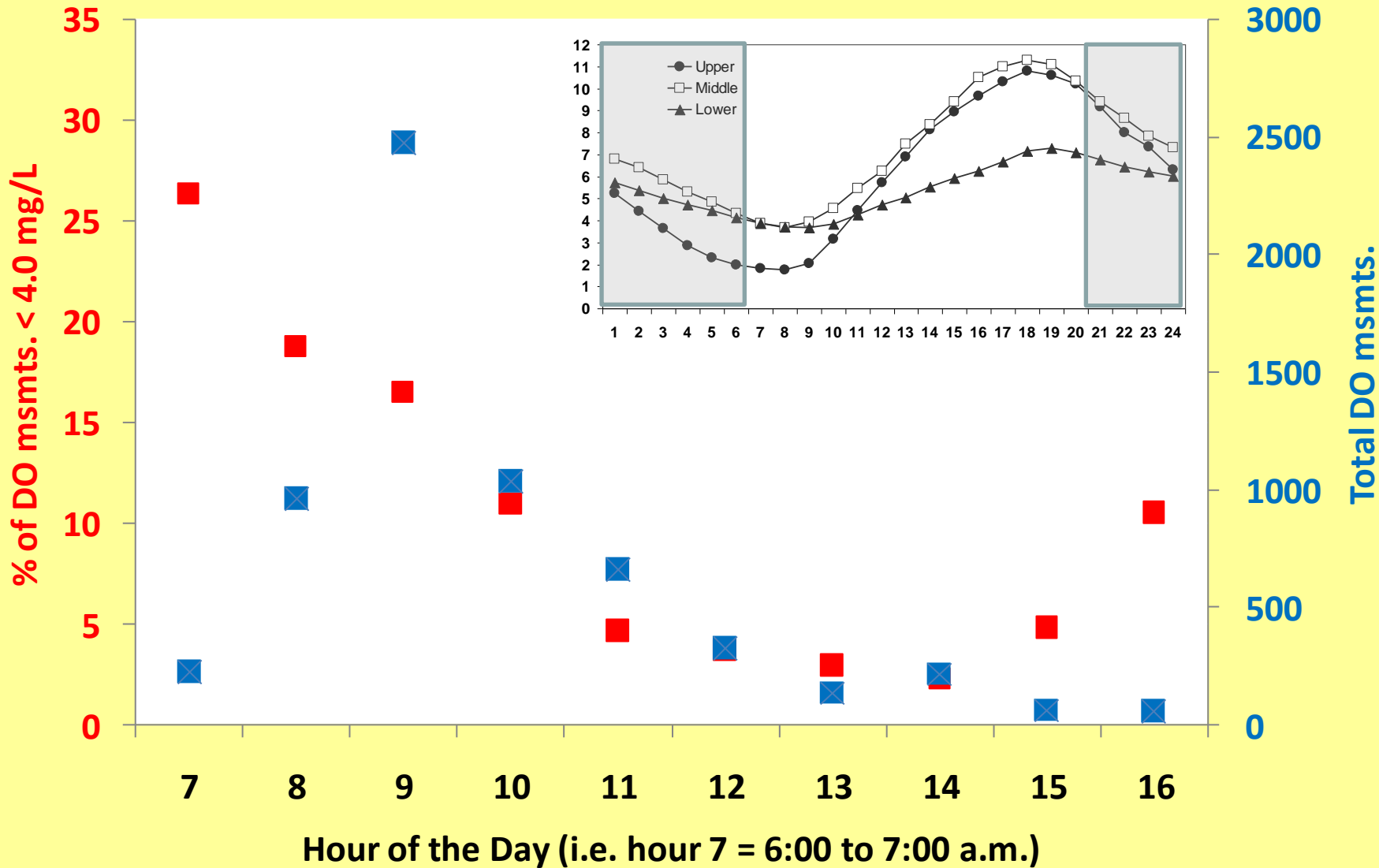


Citizen Monitoring Program Sampling Sites as of 2007

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)



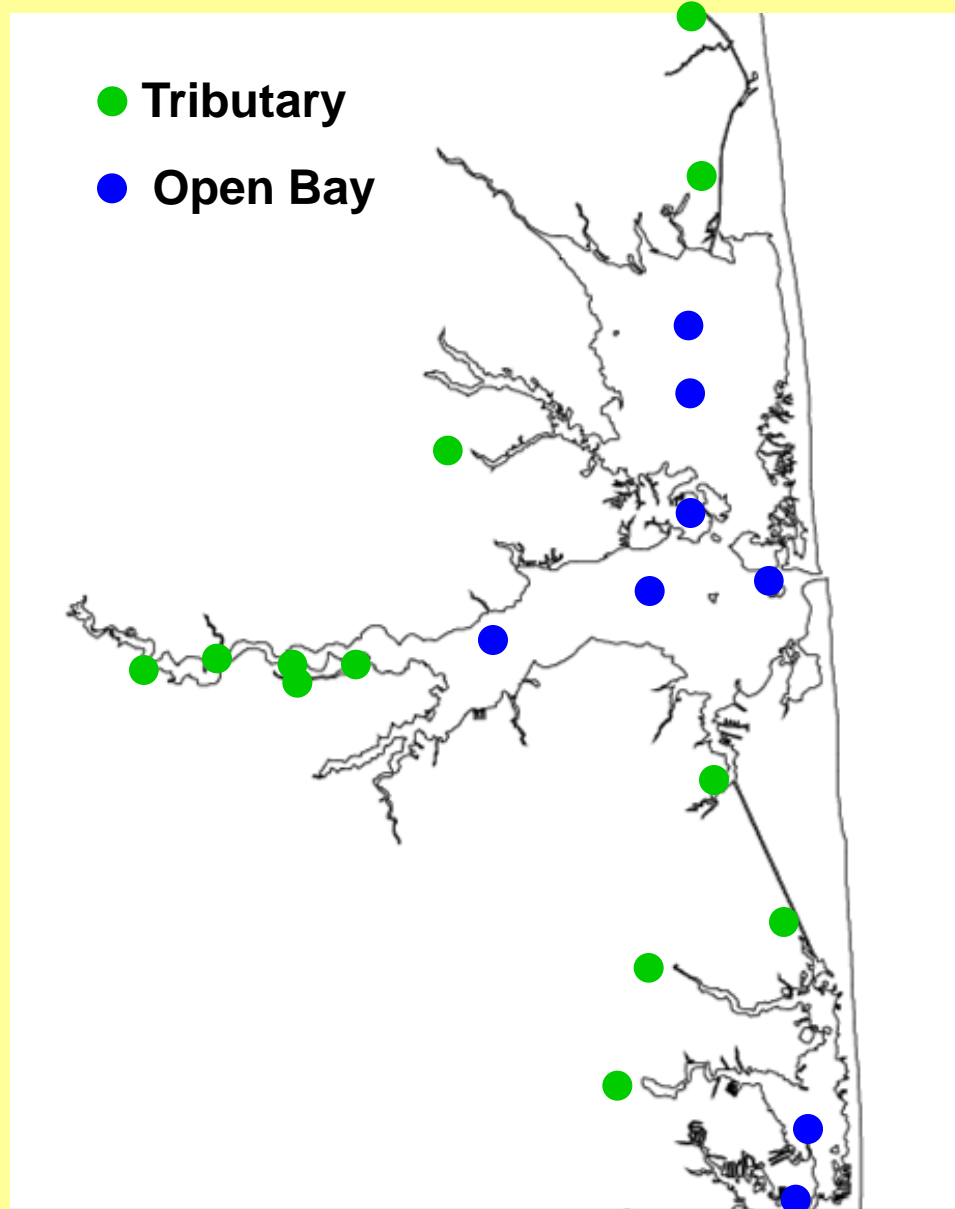
DNREC General Assessment / TMDL sampling sites

20 sites,

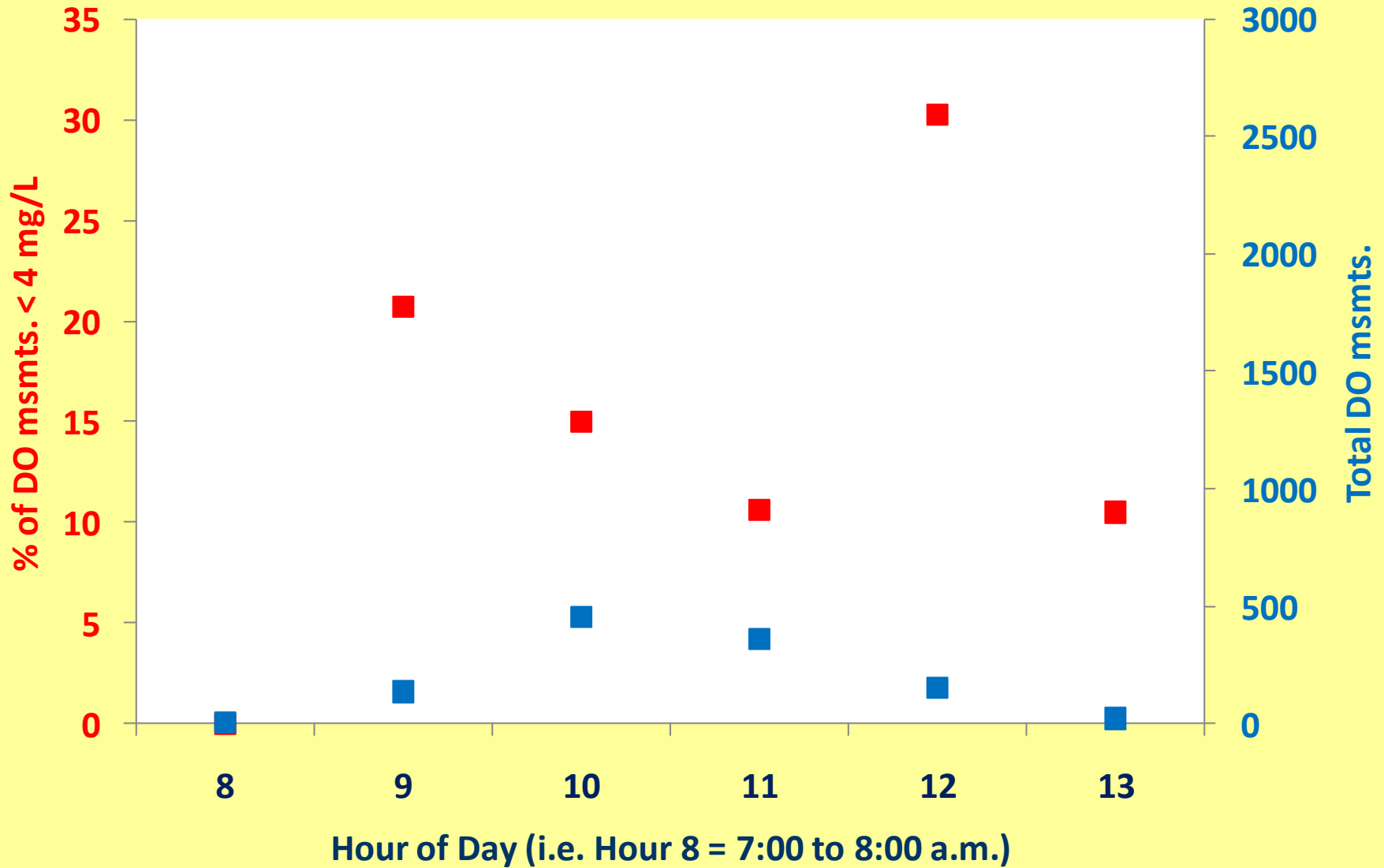
of samples per site
ranges from 44 to 91

median = 53/site.

Total samples = 1120



DNREC Tidal Inland Bays Dissolved Oxygen Data, from 20 sites (June to September, 1998 to 2008)



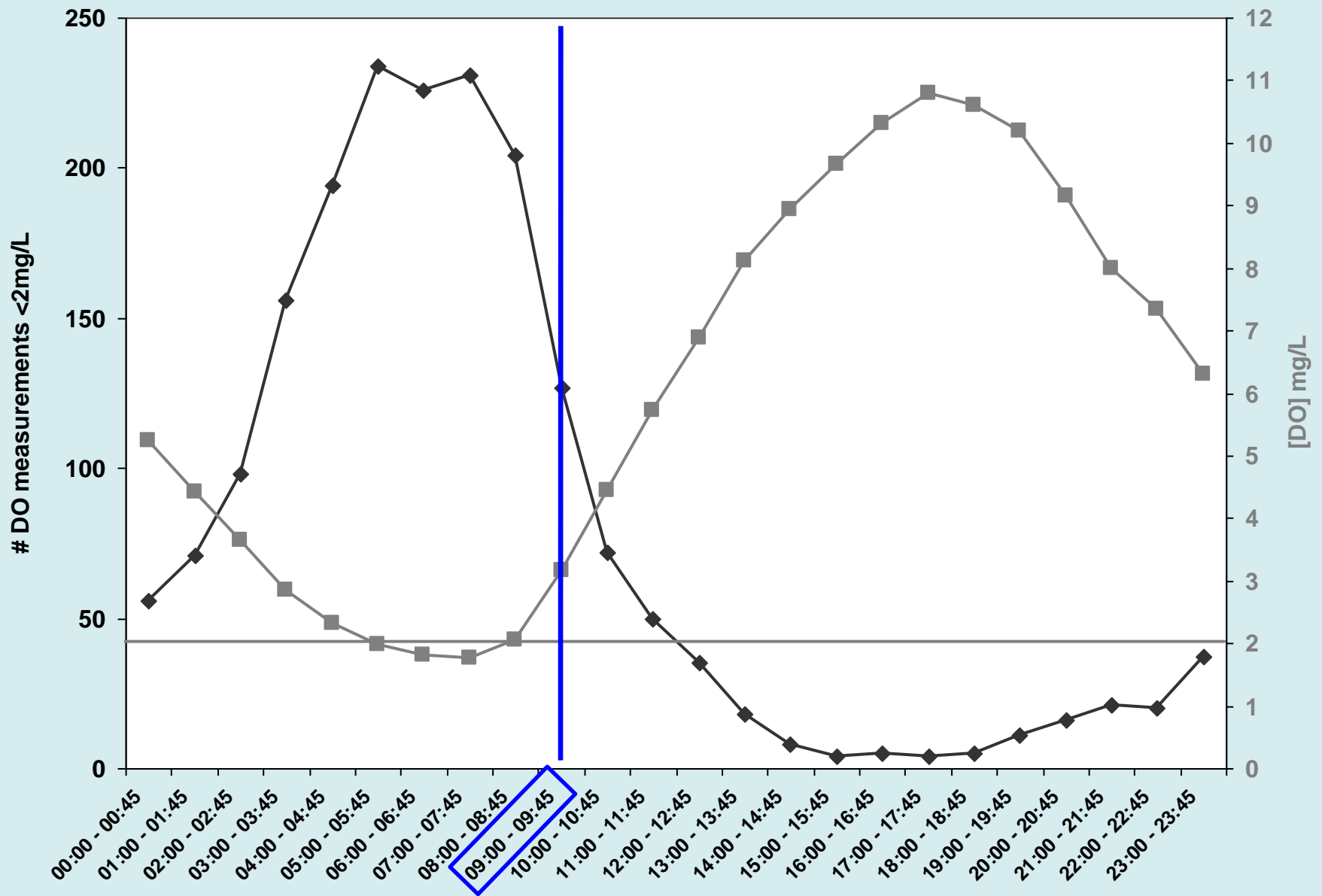


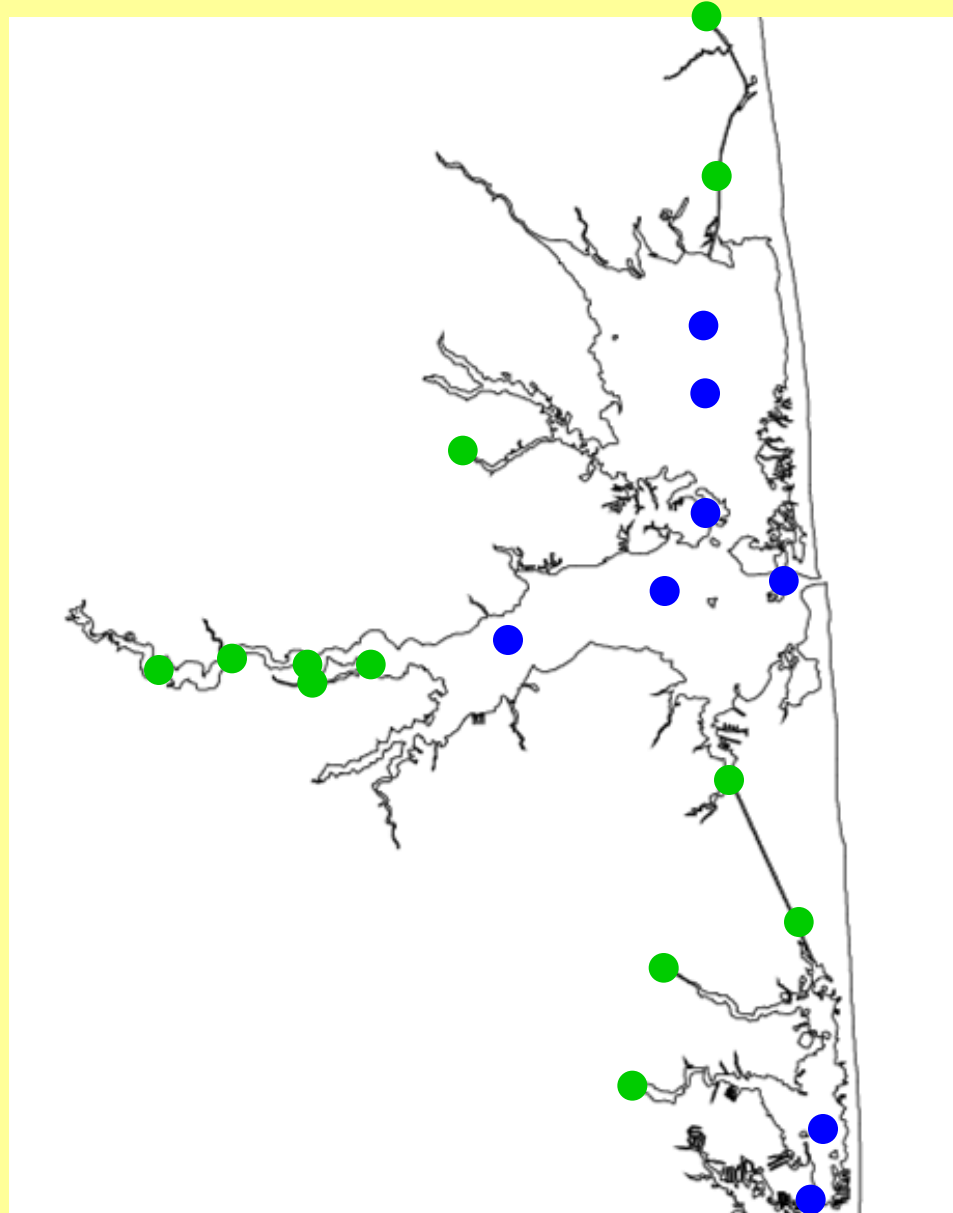
Figure 20: The number of measurements of dissolved oxygen ≤ 2 mg/L (black diamonds, left axis) and the average [DO] (gray squares, right axis) for each hour of the diel cycle from Site 1, (Pepper Creek, Site 1) from June 8 – September 11, 2001. This time period spans the first and last DO measurements of ≤ 2 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.

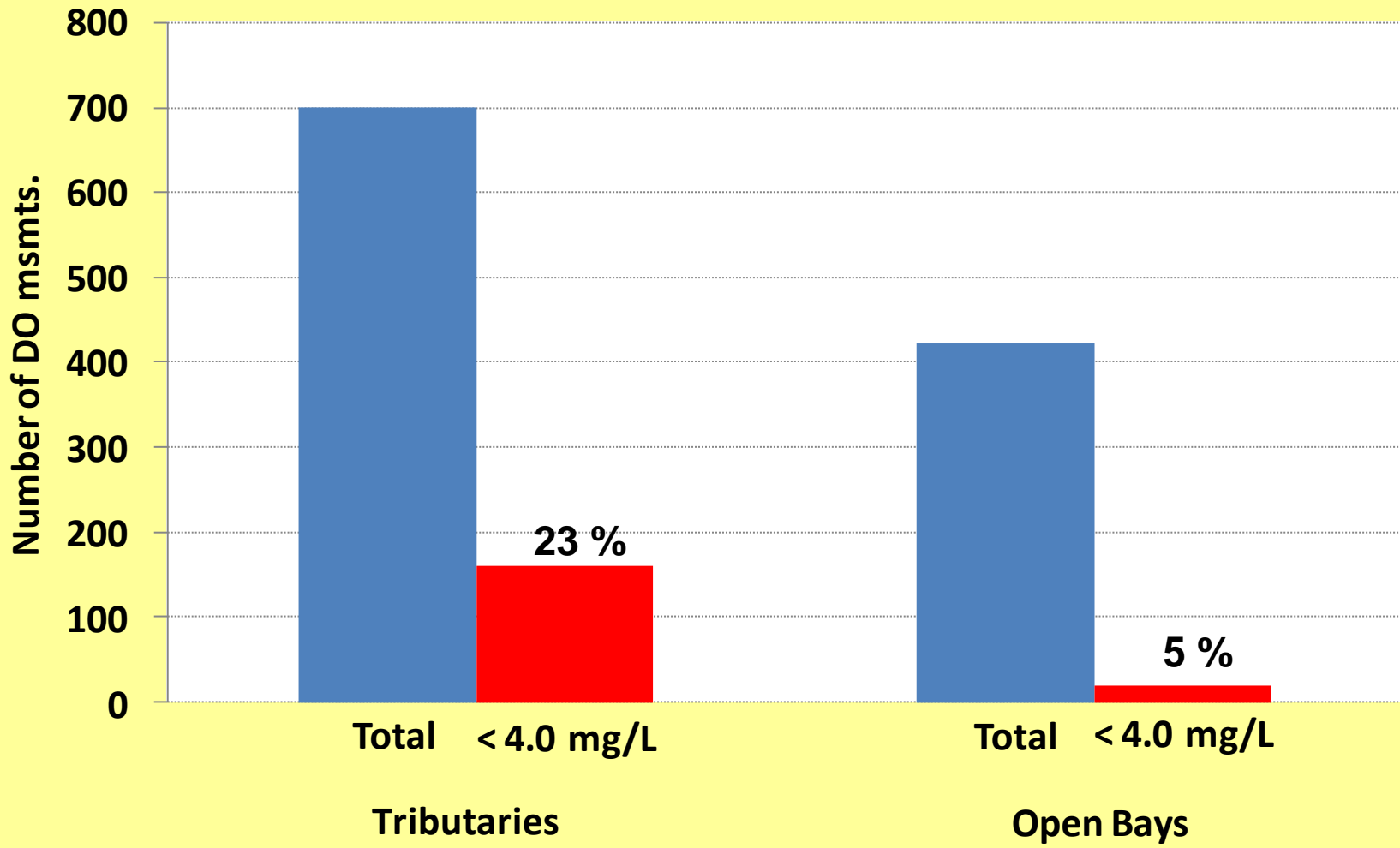


DNREC General Assessment / TMDL sampling sites

- Tributary
- Open Bay



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





Main Points



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



Photo by R. Tyler