The Dissolved Oxygen Status of the Inland Bays 1998 – 2009: *First Draft*

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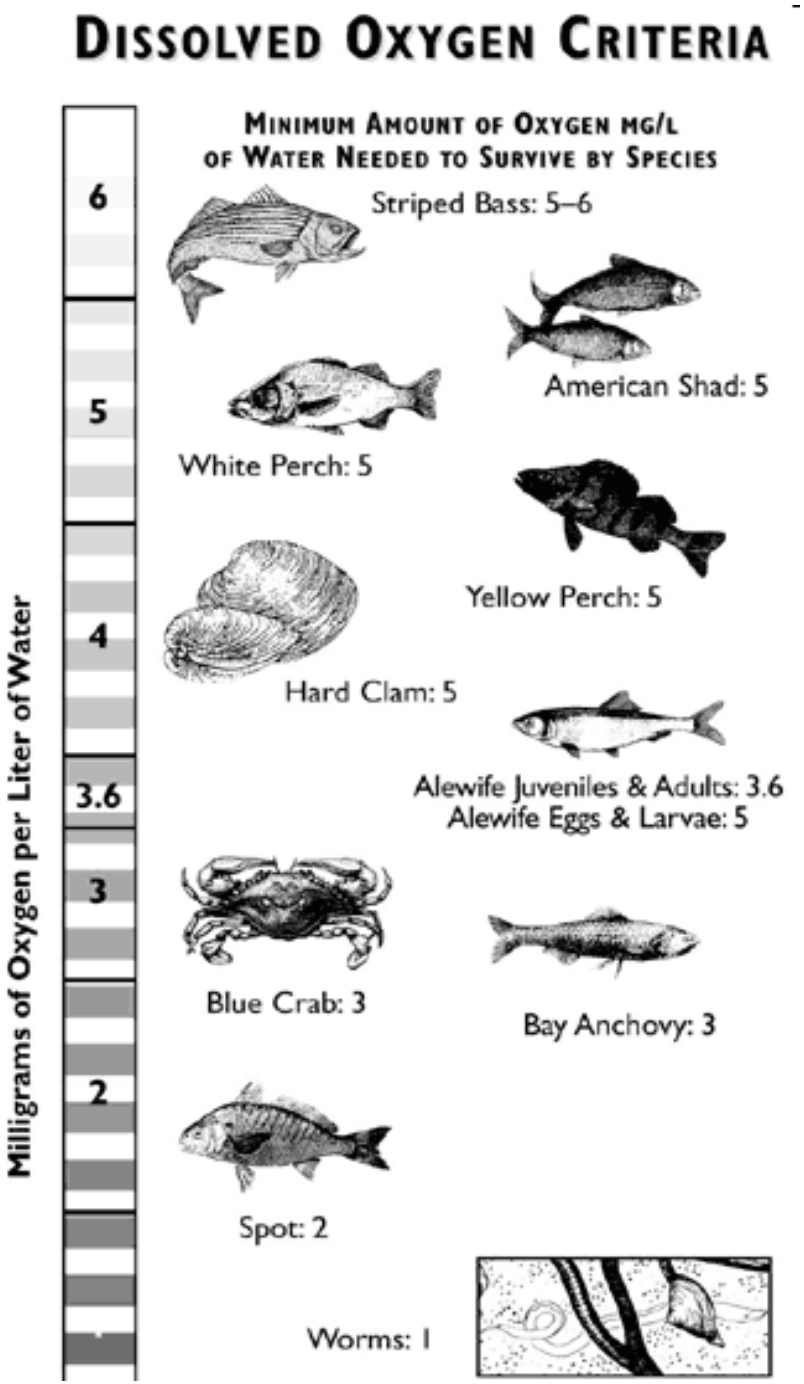
Delaware Center for the Inland Bays

CIB STAC July 16, 2010



Importance

- A primary impairment under the Clean Water Act -- oxygen levels must support a balanced and healthy aquatic community
- Along with the restoration of seagrass habitat, the primary reason for the Total Maximum Daily Loads and Pollution Control Strategy Regulations for the Inland Bays
- Oxygen responds to restoration efforts and is an easily measured environmental indicator

Goals of Analysis

- Determine status of dissolved oxygen using ~ 10 yrs. of available data.
  - Communicate with indicator values and concentrations
  - Explore trends
- Compare spot-sampled and continuously monitored datasets
  - Overall status
  - Spatial & temporal representativeness
- Make recommendations on monitoring

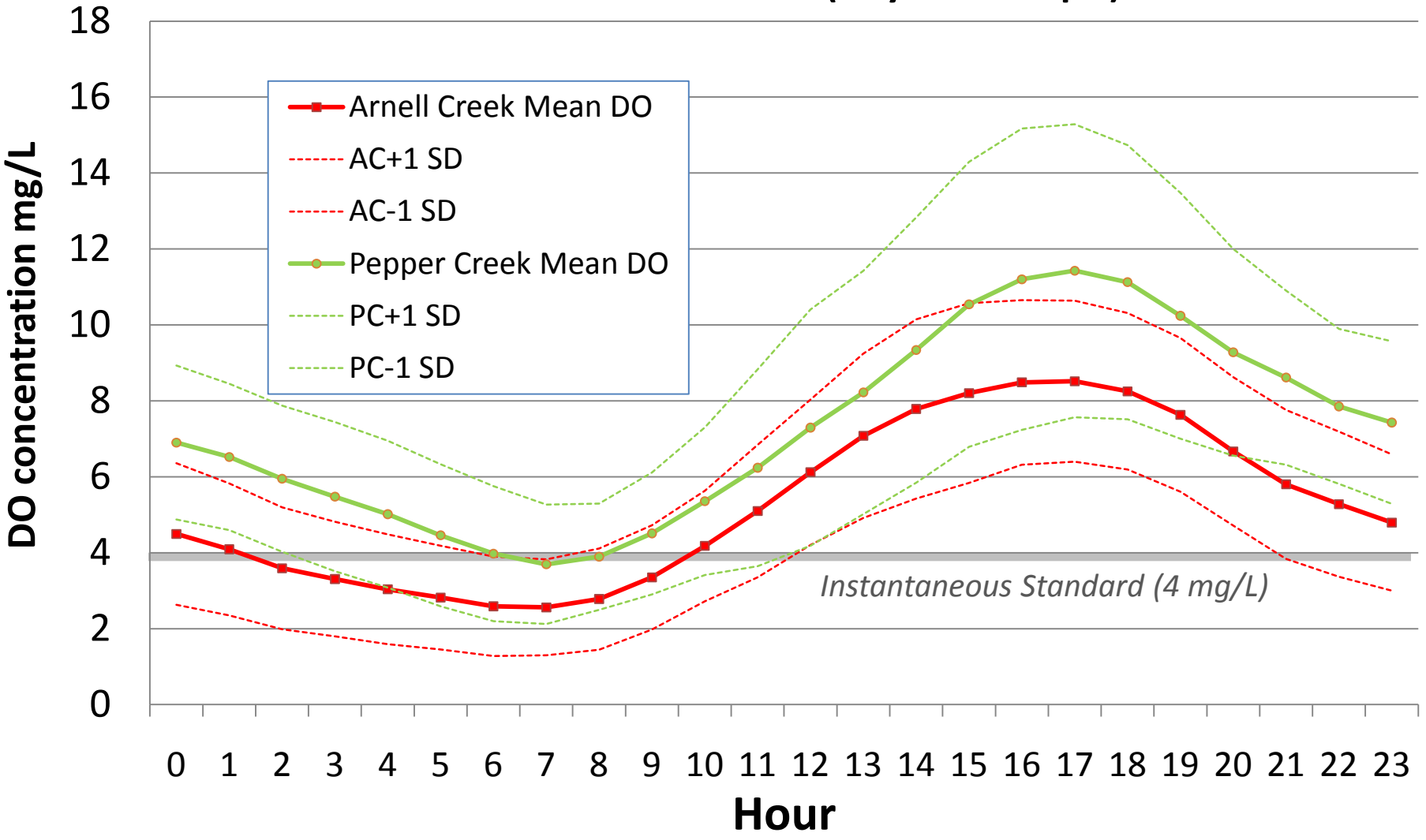
Dissolved Oxygen Indicator

The percentage of summer mornings (or time during summer mornings) that dissolved oxygen levels fall below the State standard set to protect the health of aquatic life

Acknowledgements

- UD Citizen Monitoring Program
- DNREC
  - Mirsajadi Program
  - Tyler Program
- UDCMES
  - Targett Lab
  - Ullman Lab
- STAC Wqsubcom
  - Doug Miller
  - Glenn Christman

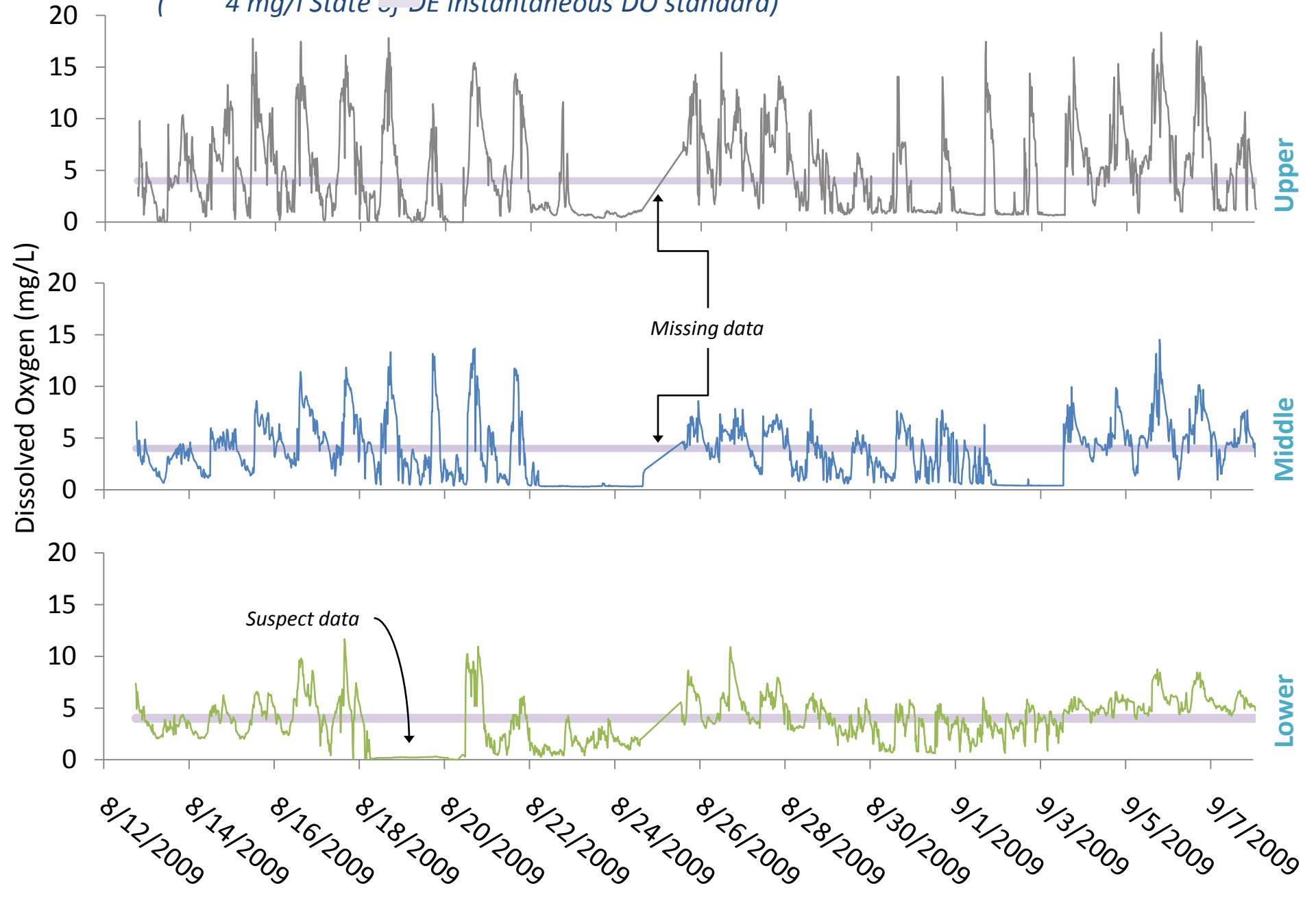
Comparison of Hourly DO Concentration Means from Two Continuously Monitored Tidal Tributaries (July - Mid-Sept.)



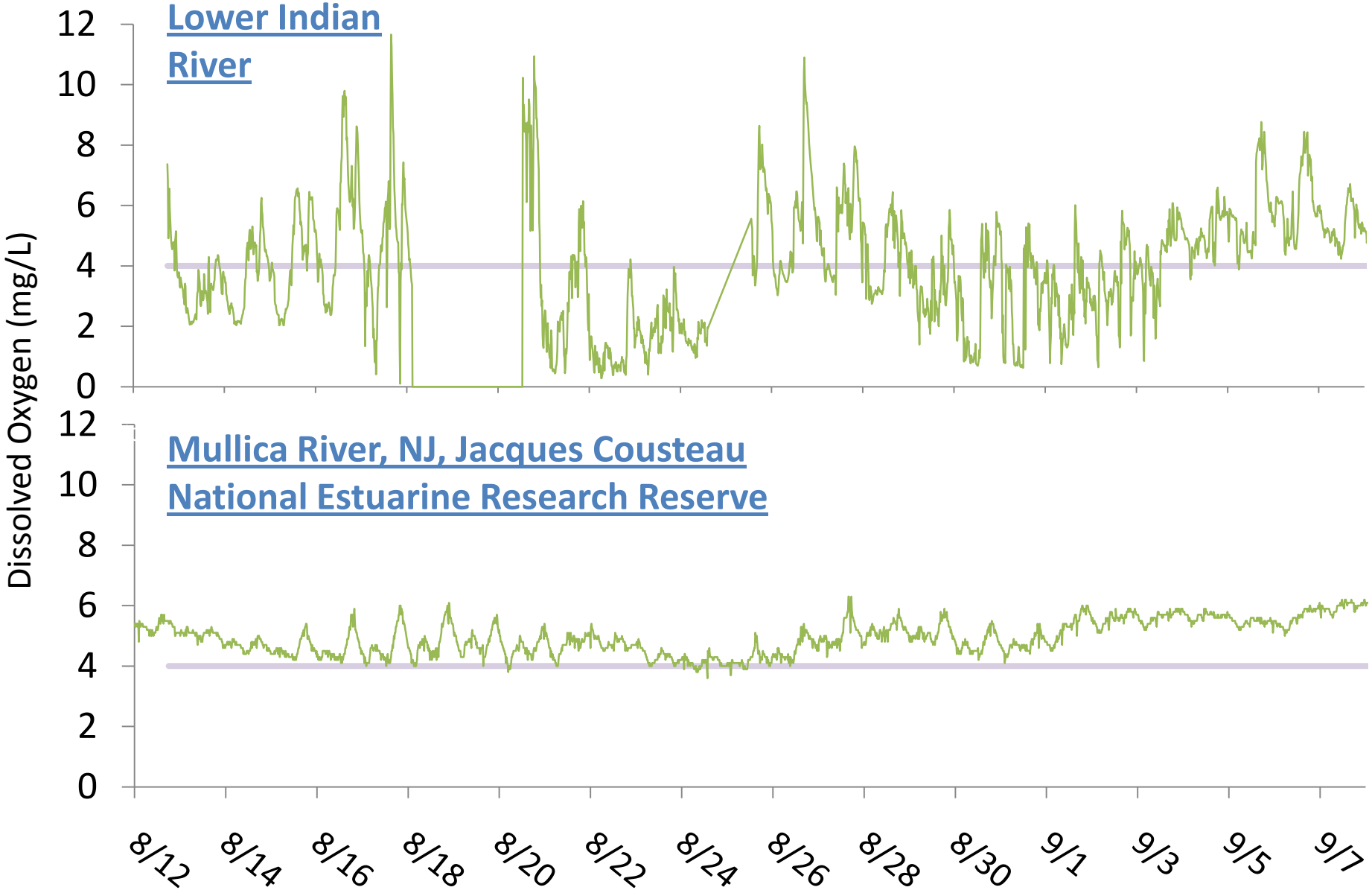
- Oxygen cycles through the day, low in the early morning to high in the late afternoon.
- Different locations have different curves.

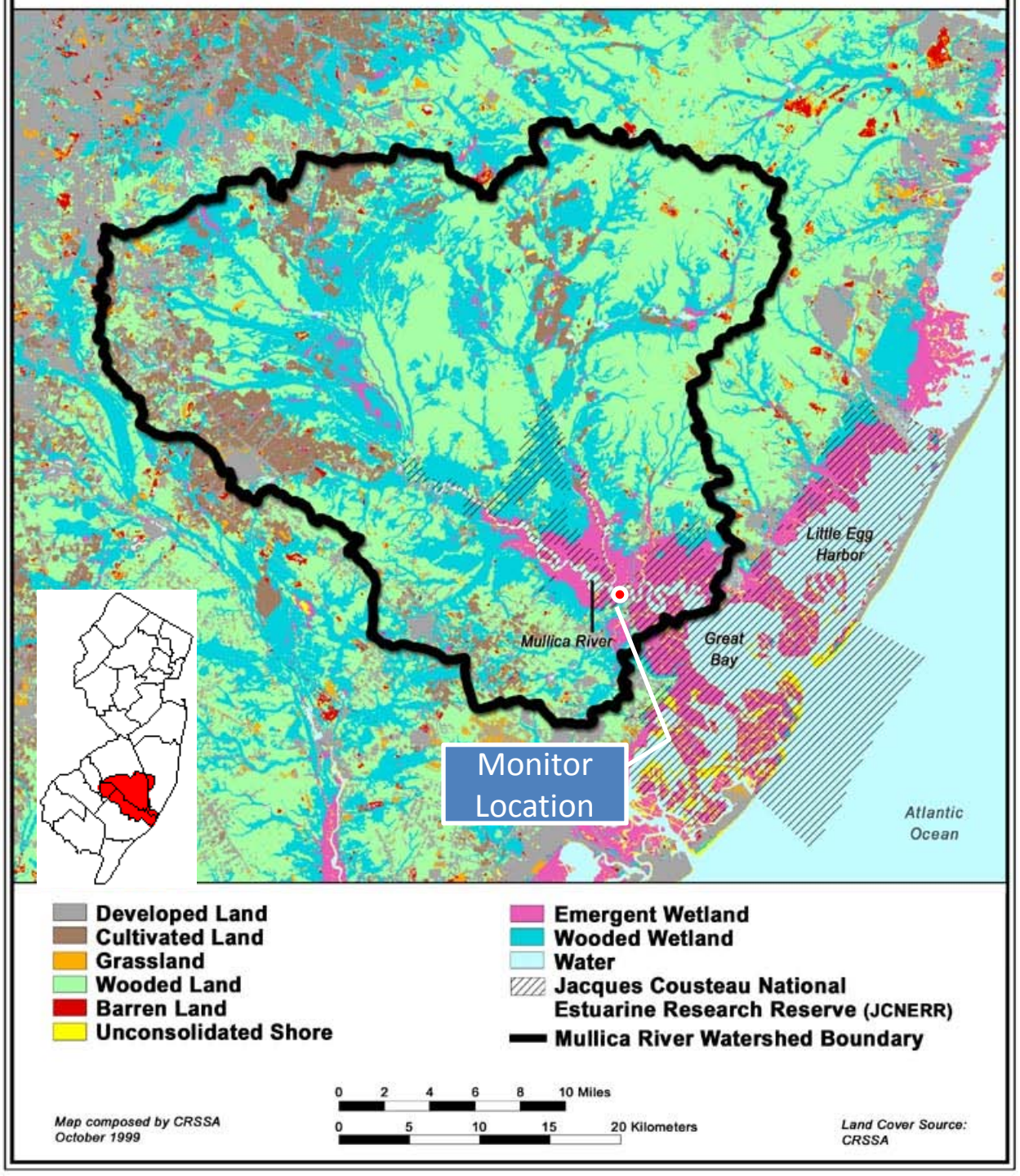
Continuously Monitored DO from 3 Indian River Stations

(4 mg/l State of DE instantaneous DO standard)



What is quality? Does it exist? Will Indian River see it?





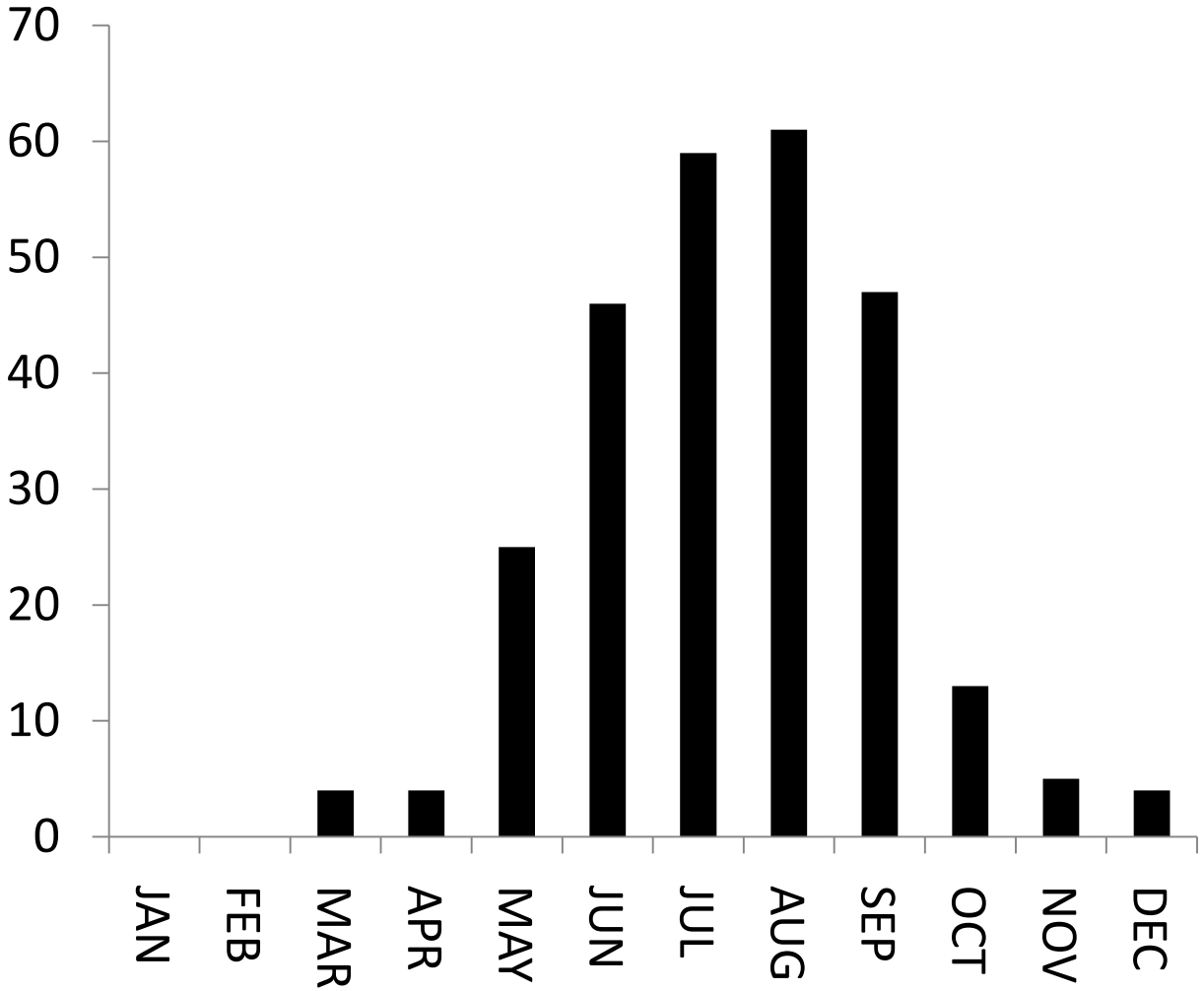
Indian & Mullica River/Watershed Comparison

Parameter	Indian	Mullica
Salinity AVG at meter location (ppt)	22	15
Soils	Sandy	Very Sandy
Watershed Area (sq mi)	100	530
% Watershed not farmed or developed	~40%	~80%

Status Using Continuous DO

- Use JUL-AUG to standardize across sites while maximizing data use and
- Most datasets collected with sensors using membranes, some using optical lenses. Used QAQC procedures when possible.
- Methods not standardized, QAQC variable, membrane sensors bias readings towards lower concentrations.

Frequency of Inland Bays Continuous DO Monitoring Datasets by Month

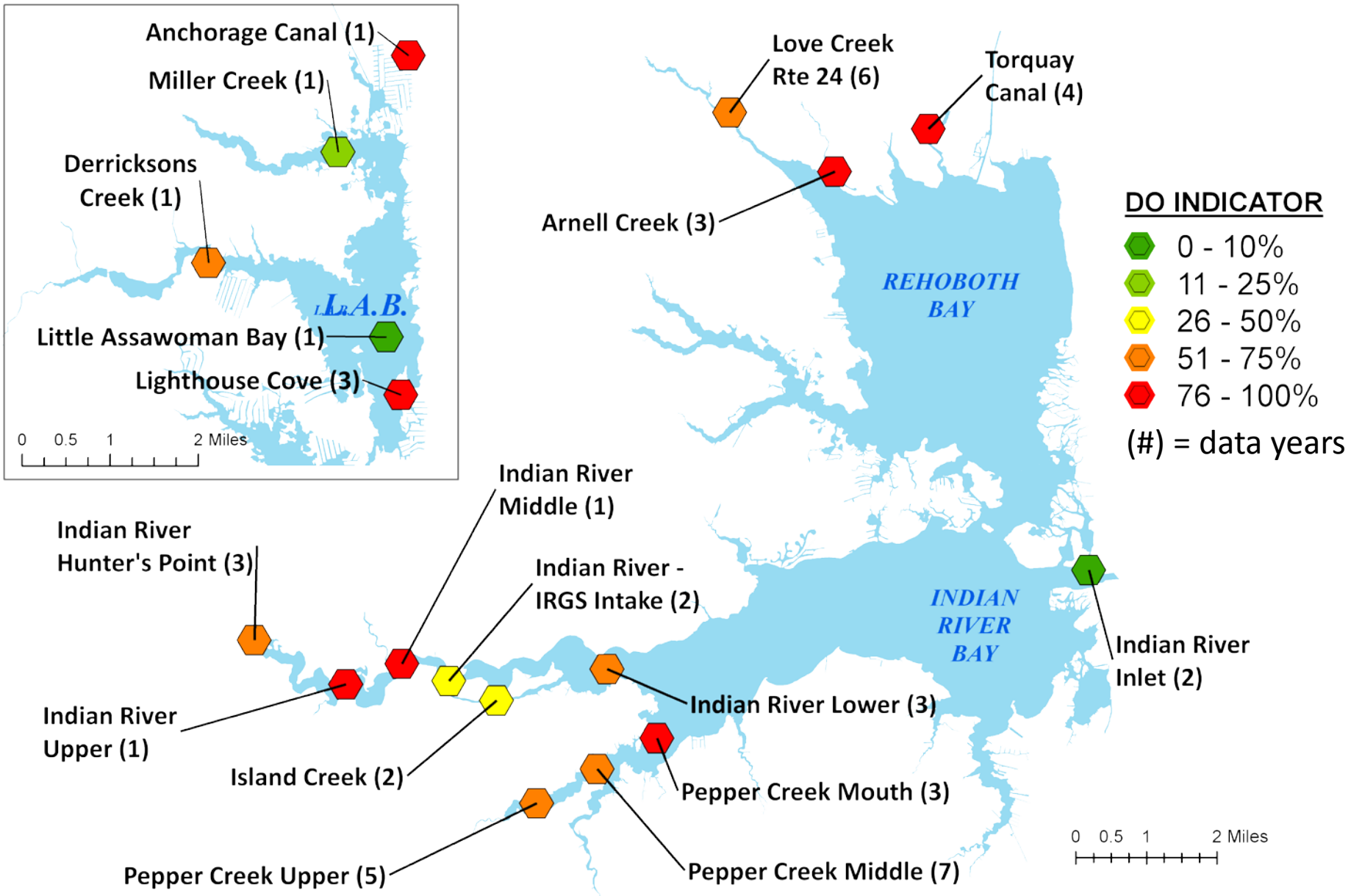


Month	JUL	AUG
AVG MAX TEMP	85.4	83.9
AVG MIN TEMP	67.7	66.6
AVG TOT PRECIP	4.47	4.91

Lewes, DE Climate Summary '45-'09

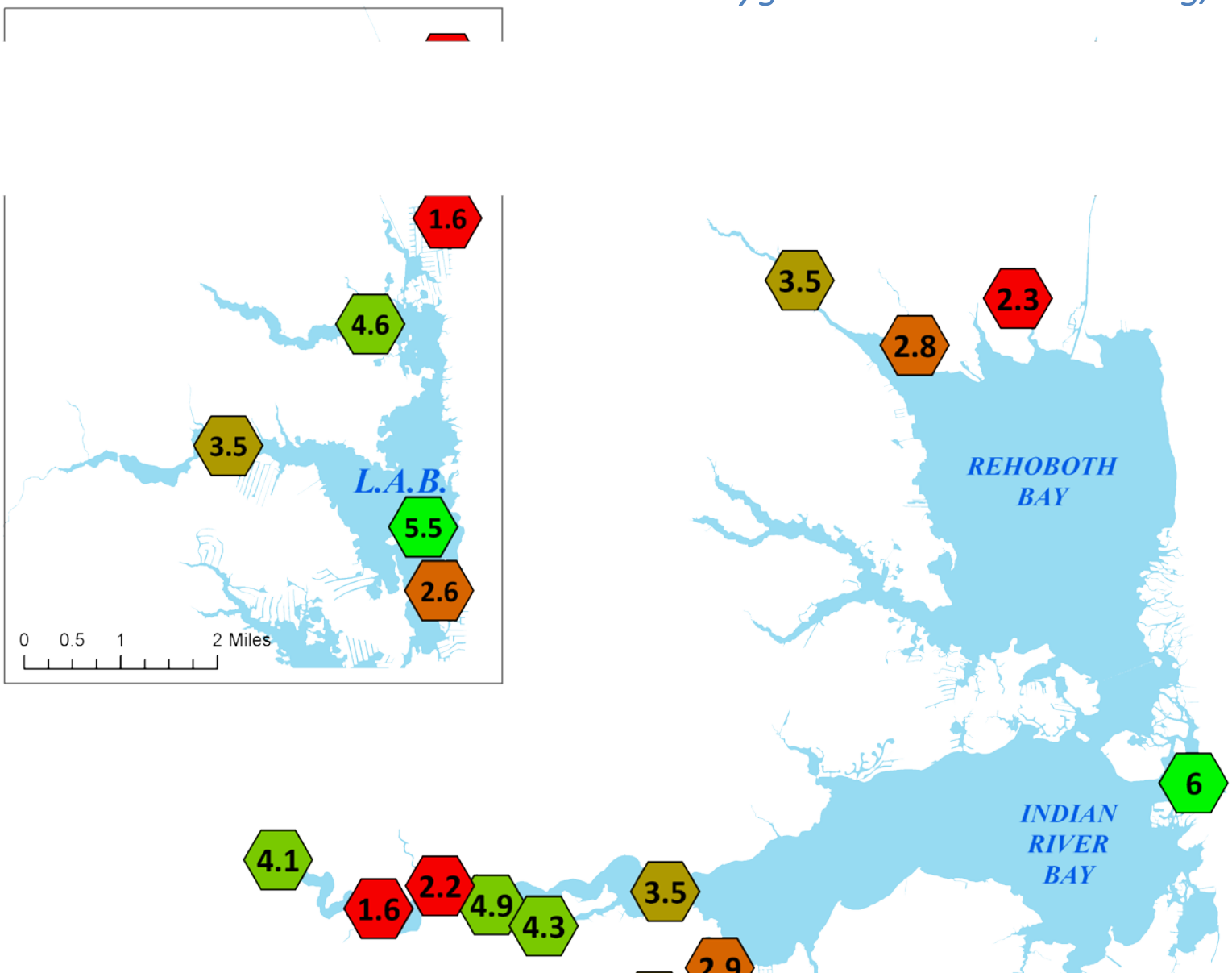
Inland Bays Dissolved Oxygen Status '98 – '09 using Continuous Monitoring Data from July & August.

Indicator is the % of time from 6AM to 9AM DO falls below 4 mg/l (State of DE Instantaneous Standard)

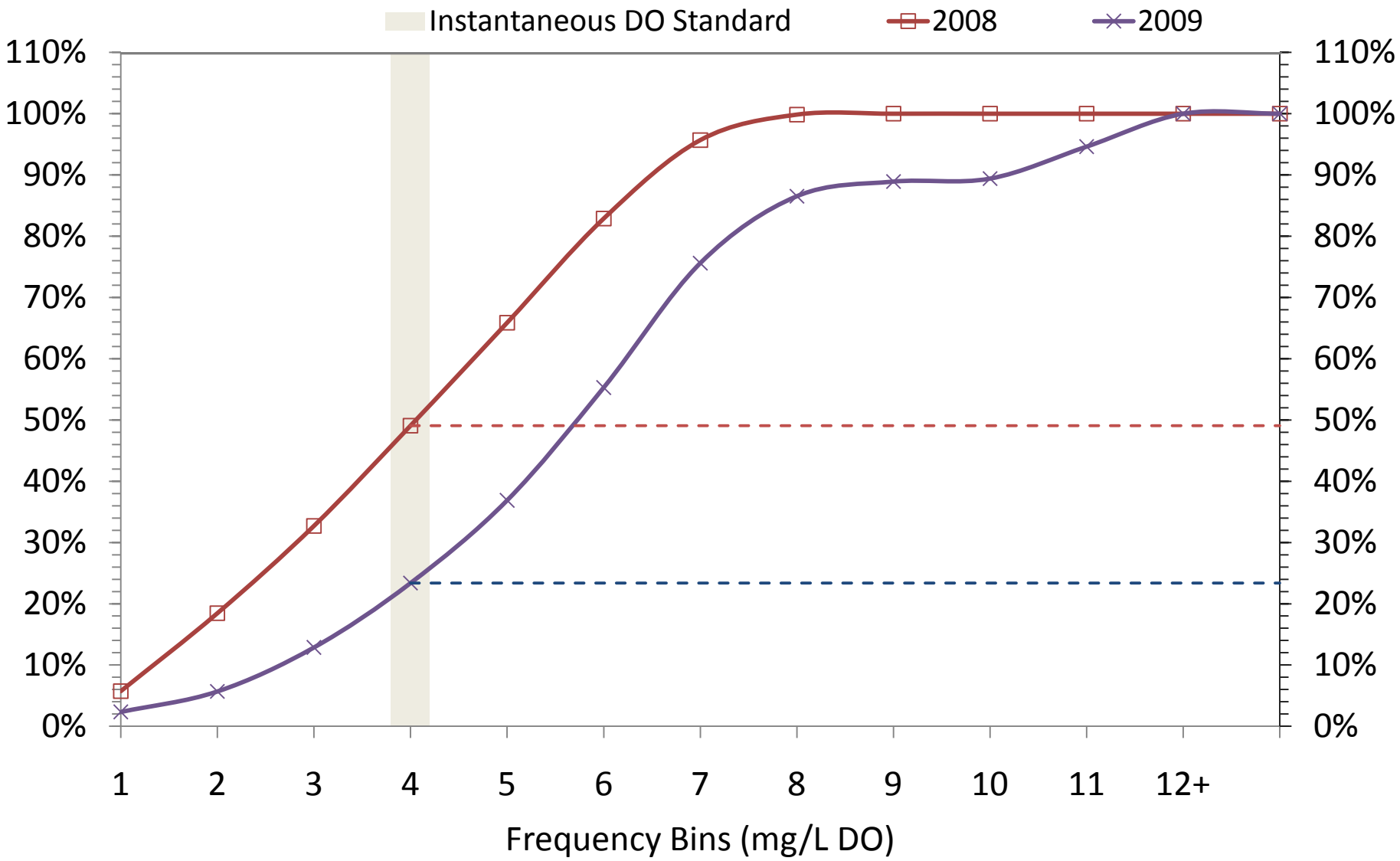


Inland Bays Dissolved Oxygen Status ‘98 – ‘09 using Continuous Monitoring Data from July & August.

Values are mean Dissolved Oxygen Concentrations in mg/L

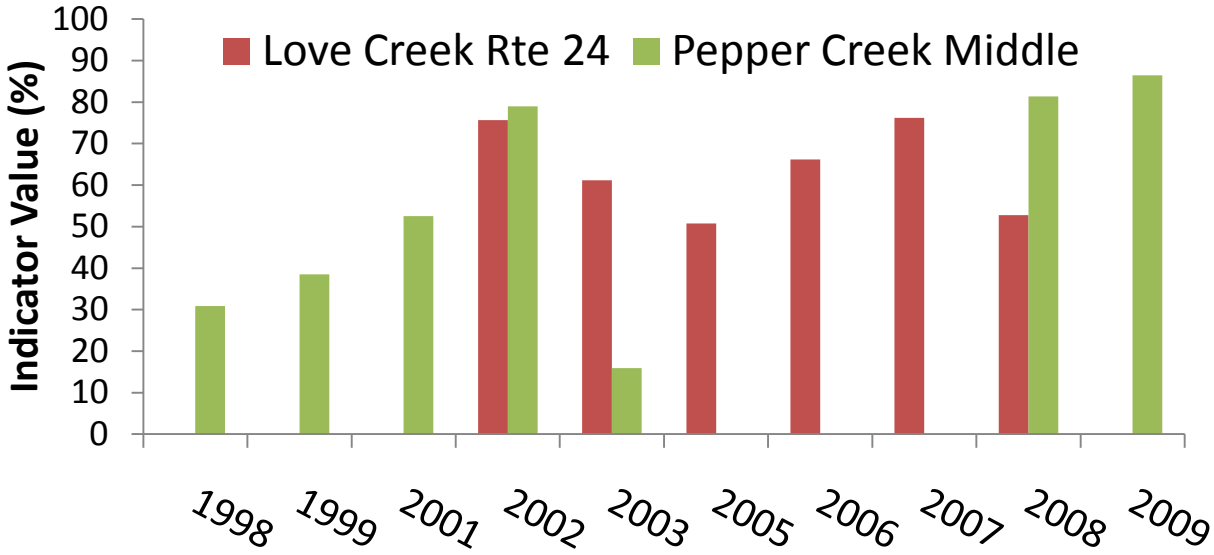


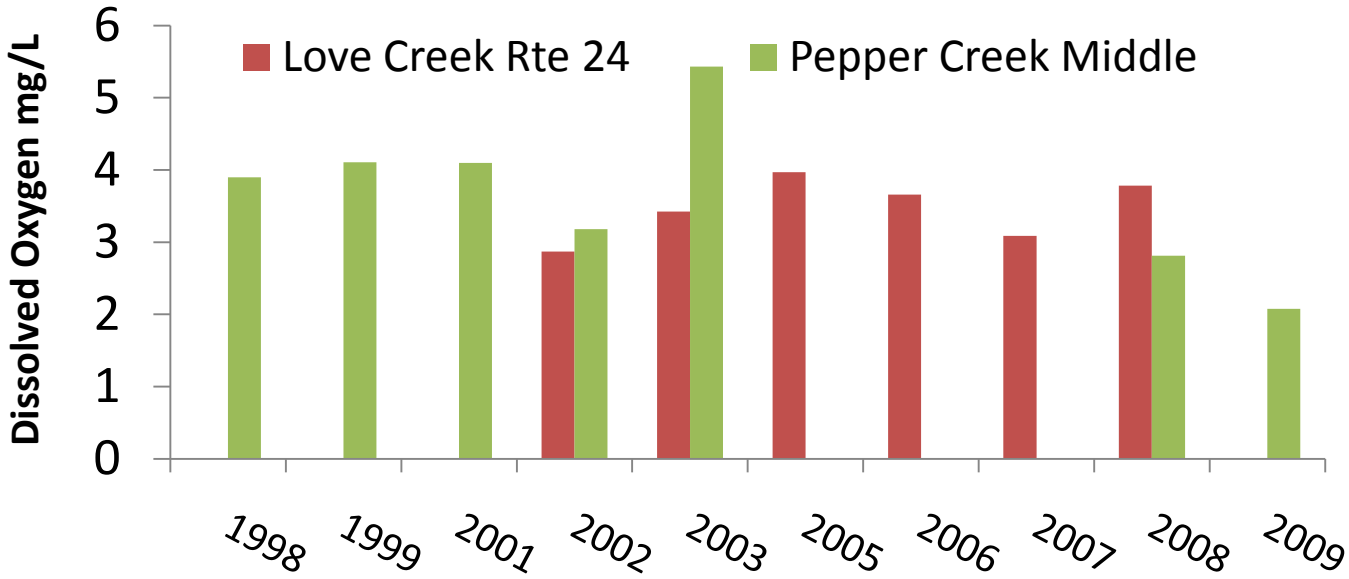
Cumulative Frequency Distribution for Dissolved Oxygen in Little Assawoman Bay near the Town of Fenwick Island, June - September, 2008 & 2009



Trends?: Continuous Data from JUL & AUG

DO INDICATOR: The % of observations falling below 4 mg/L DO between 6 – 9 AM.



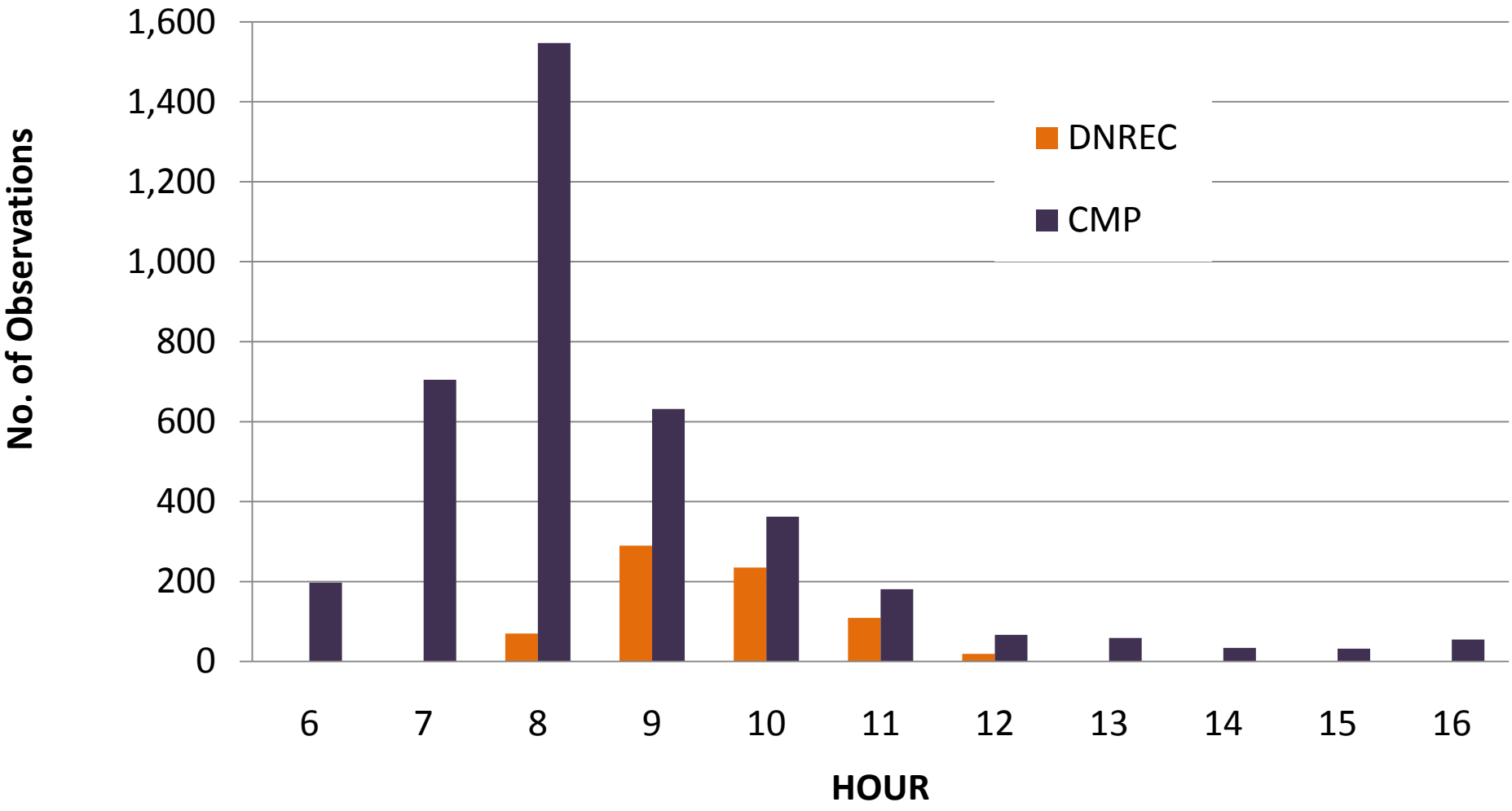


Mean DO concentration between 6 – 9 AM

Spot Sampled Data methods

- Period of analysis 1998 -2008.
- June through September
- Reporting as samples grabbed during critical time period and all samples (comparison)
- Examination of trends by sites

Number of DO Observations by Hour for DNREC and CMP '98-'08

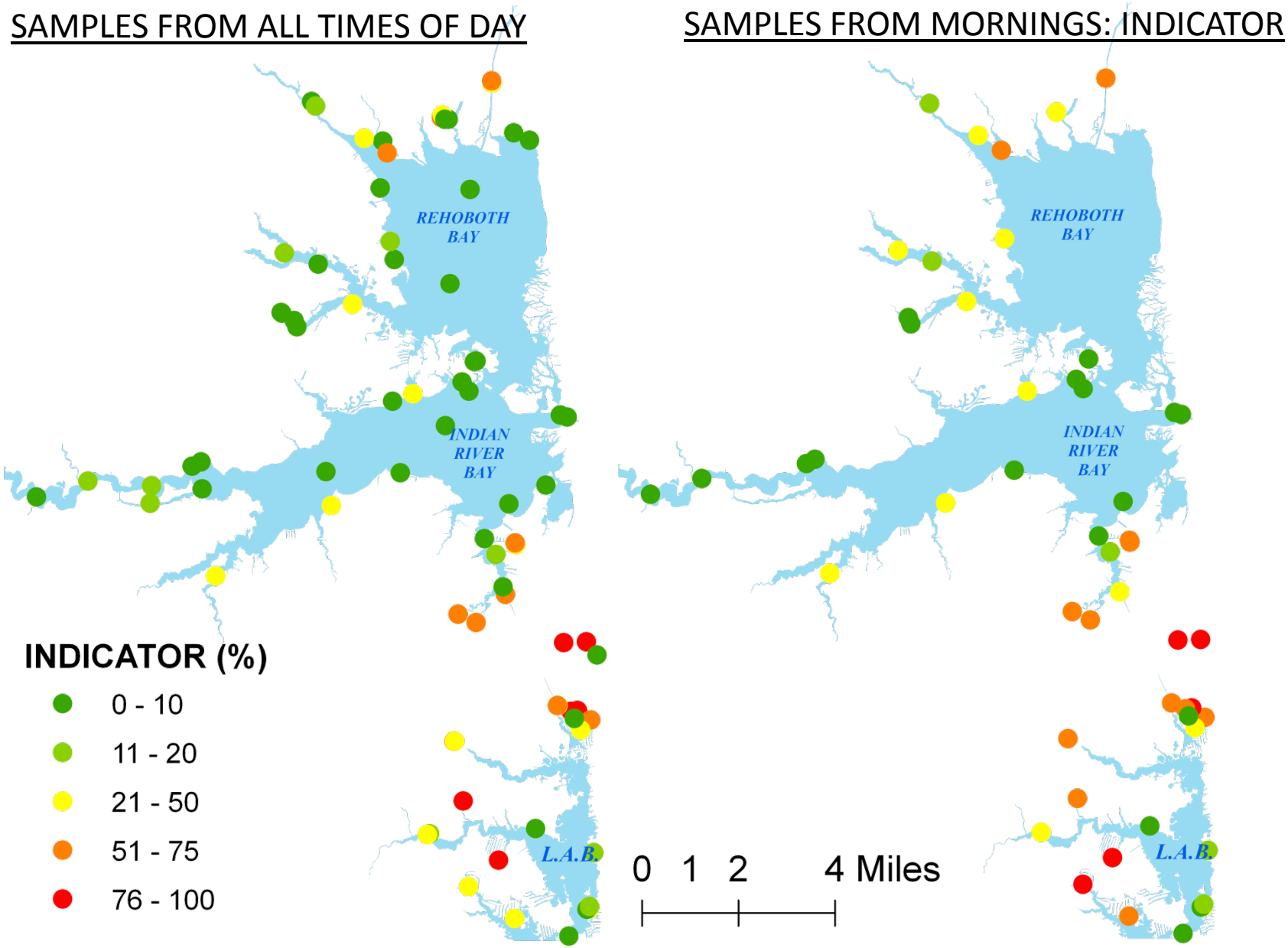


- Citizen Monitoring Program has 5X the total no. of obs.
- The mean CMP obs. is about 1 hr. earlier than the mean DNREC obs.

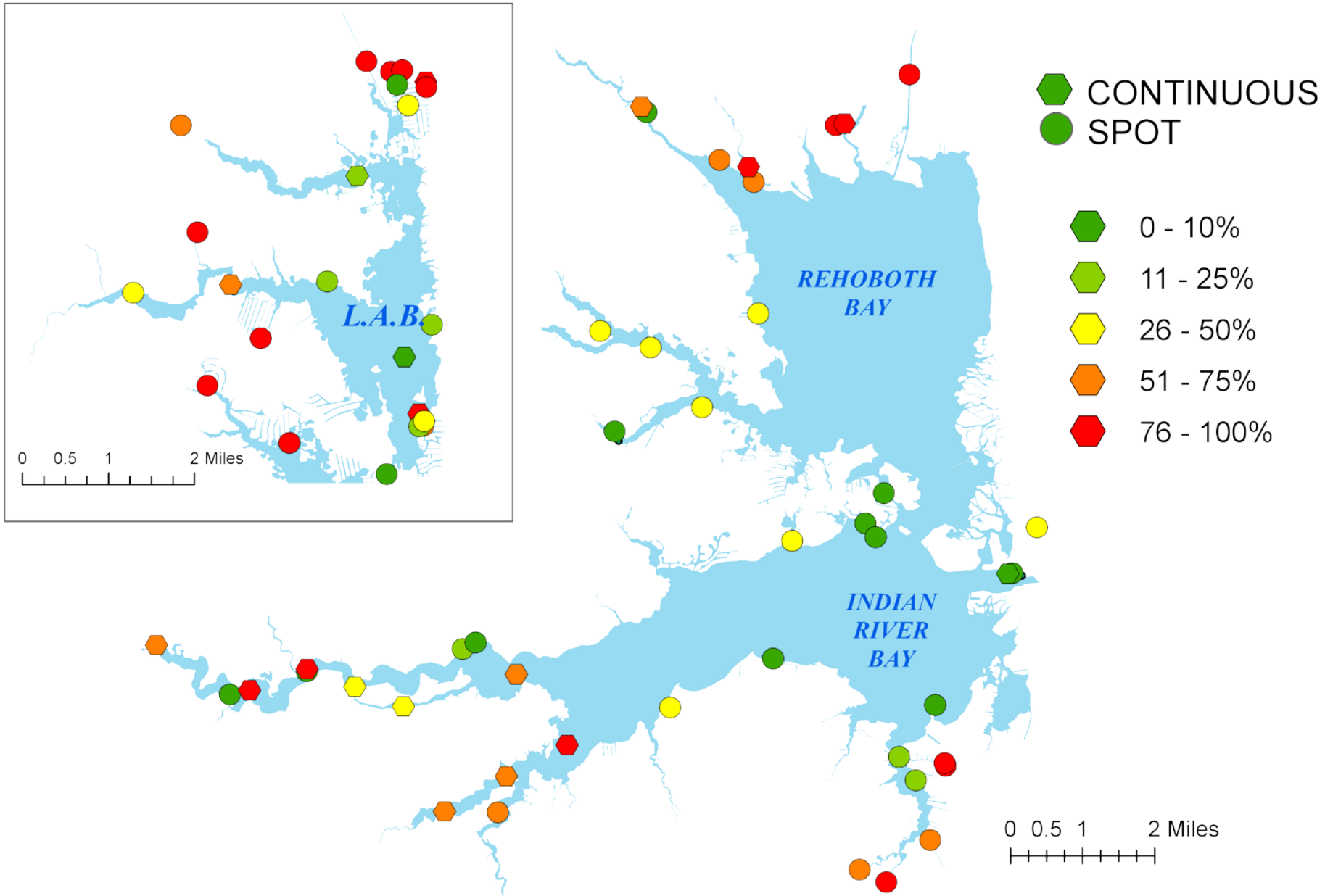
Spot Sampled Data: Indicator Values Map

SAMPLES FROM ALL TIMES OF DAY

SAMPLES FROM MORNINGS: INDICATOR



Dissolved Oxygen Indicator using Spot Sample and Continuous Monitoring data July & August, 1998 - 2008



DO Indicator by Bay:
% <4 mg/l before 9a, June-September
(10 or more observations)

Bay	Average of Stations	Pooled Observations	Water Area
Rehoboth	26.5%	23.5% = 153 / 650	41%
Indian River	19.6%	25.5% = 161 / 631	47%
Little Assawoman	41.6%	31.0% = 208 / 671	12%

DO Stations by Bay and Type
(any number of observations)

Bay	Open Water	Tributary / Creek	Canal
Rehoboth N= 32 total	8	13	11
Indian River N=31 total	20	8	3
Little Assawoman N=27 total	4	9	14

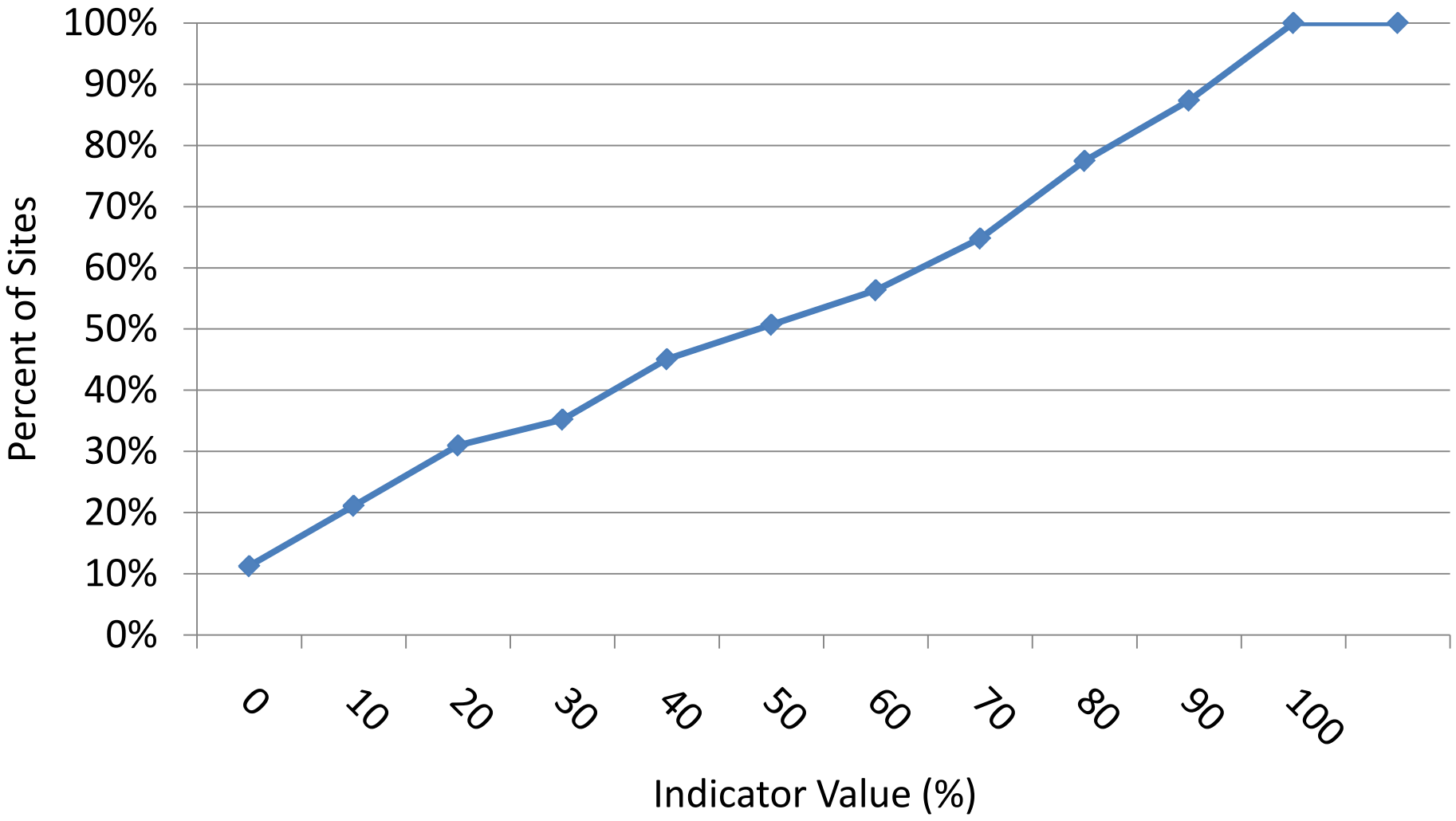
DO Indicator by Bay and Type
% <4 mg/l before 9a, June-September
(average over all stations, all observations)

Bay	Open Water	Tributary / Creek	Canal
Rehoboth	20.3%	14.6%	63.4%
Indian River	7.7%	55.3%	20.0%
Little Assawoman	11.8%	44.6%	53.3%

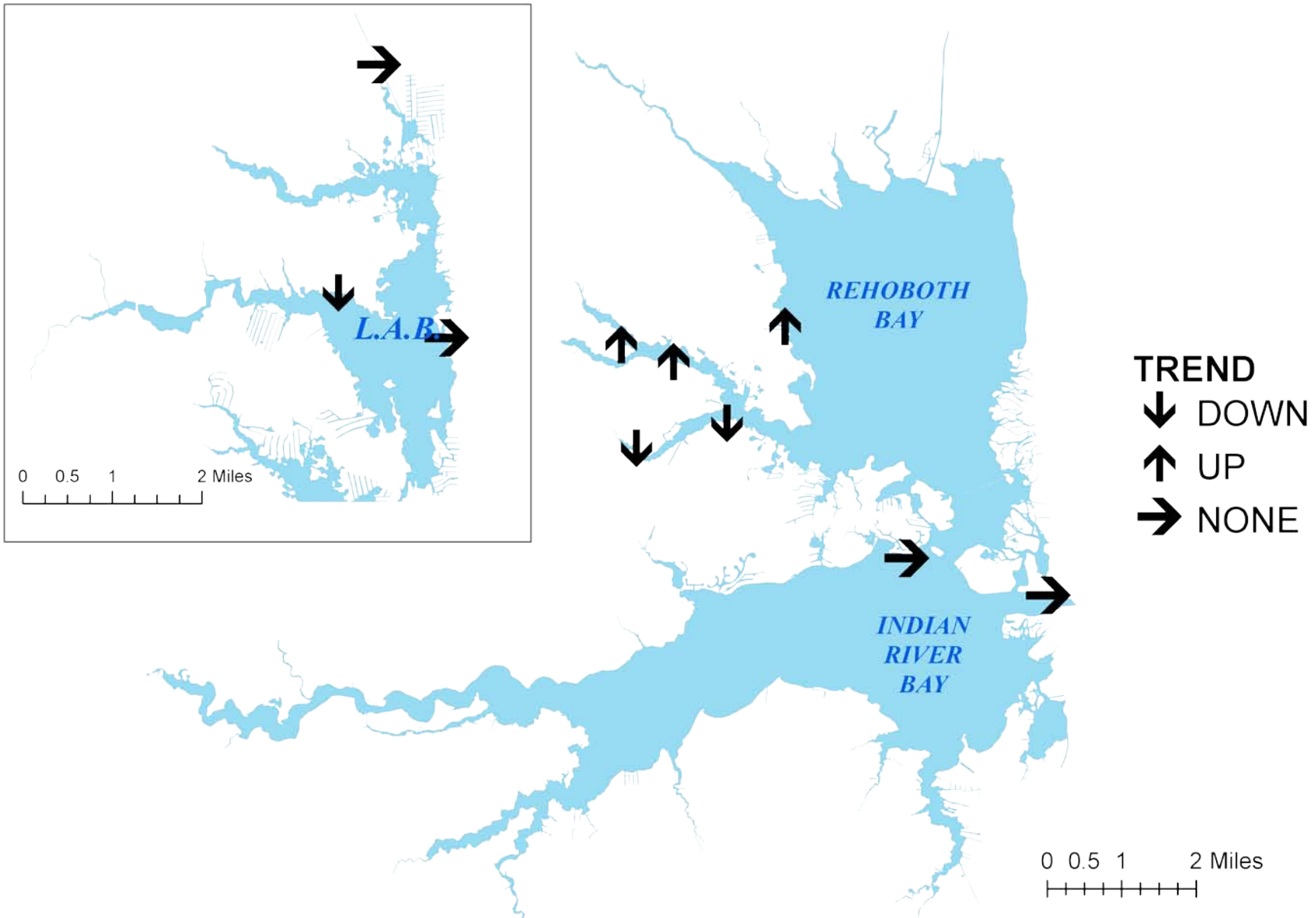
DO Indicator by Bay and Type
% <4 mg/l before 9a, June-September
(all observations pooled)

Bay	Open Water	Tributary / Creek	Canal
Rehoboth	21.4% = 63 / 294	19.4% = 91 / 469	55.6% = 15 / 27
Indian River	18.8% = 85 / 451	45.2% = 85 / 188	17.1% = 6 / 35
Little Assawoman	14.4% = 22 / 153	22.5% = 39 / 173	44.8% = 173 / 386

Cumulative Frequency Distribution of DO Indicator for all Sites (July & August)



Initial look at trends using average concentrations on Spot data (not tested for significance)



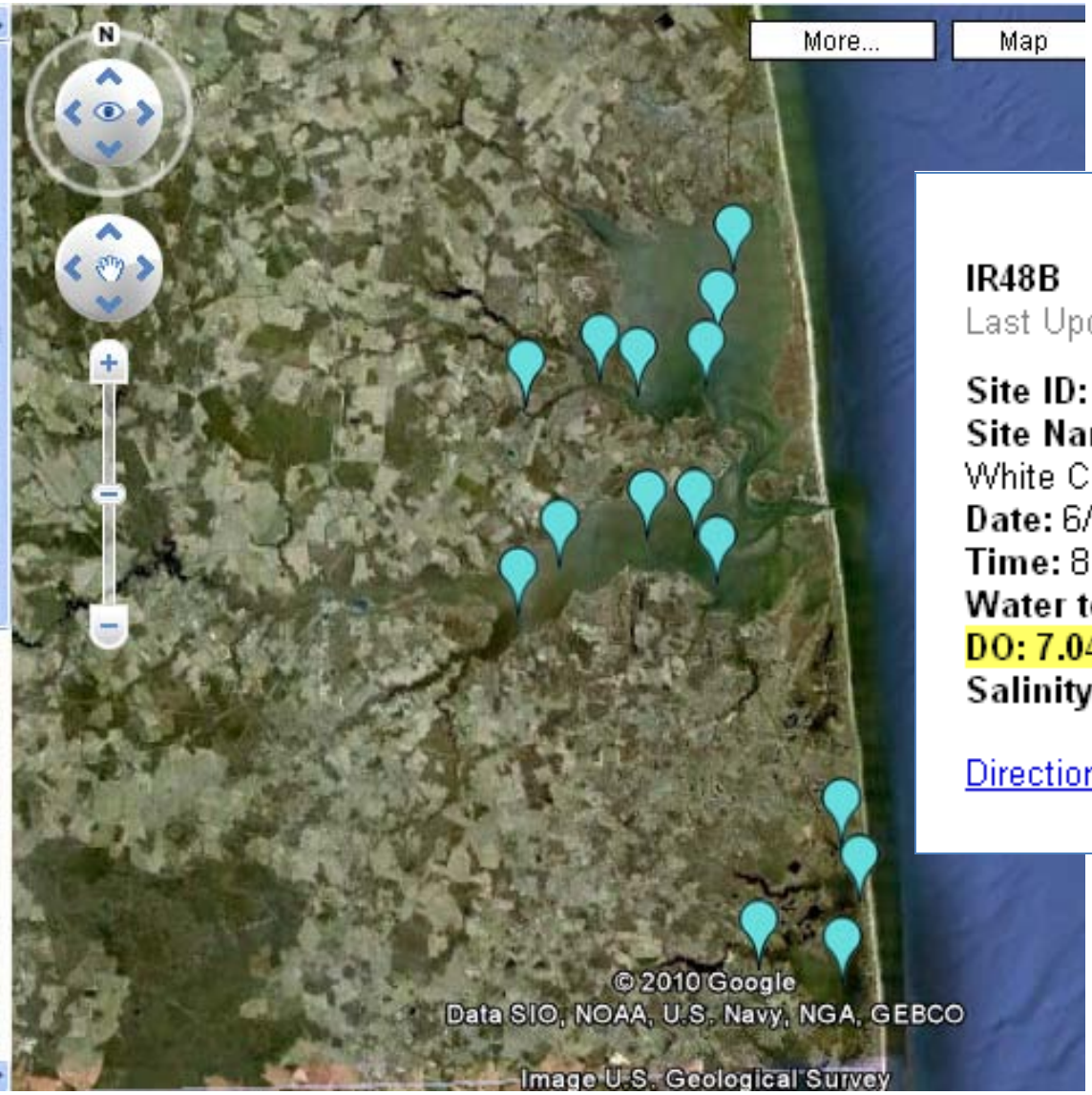
Conclusions

- Moderate to severe hypoxia is widespread in the tributaries of the Inland Bays
  - 90% of sites exceeded instantaneous standards
  - Most tributaries experience moderate to severe diel cycling hypoxia
- What we see at the Site Scale transfers well to the Watershed Scale.
- No evidence of overall trend in condition
- Site scale variation and inter and intra annual variation is very high making trend detection difficult.

Monitoring Recommendations

- Future continuous monitoring efforts should
  - adopt end of deployment calibration/"drift" quantification (data quality)
  - record the battery voltage to quantify deployment durations
  - attempt to sample June through September for standardization among datasets
  - Account for effect of change in meter type in analyses
- An increase in the number of fixed continuous DO monitoring stations should be phased in as costs allow with focus on the tributaries.
  - To support the first additional meter stop collecting pH on all others.
- Maintain and increase spot sampling stations for spatial representativeness not provided by continuous (UDCMP).

Additional Citizen Monitoring Sites added to improve spatial representation

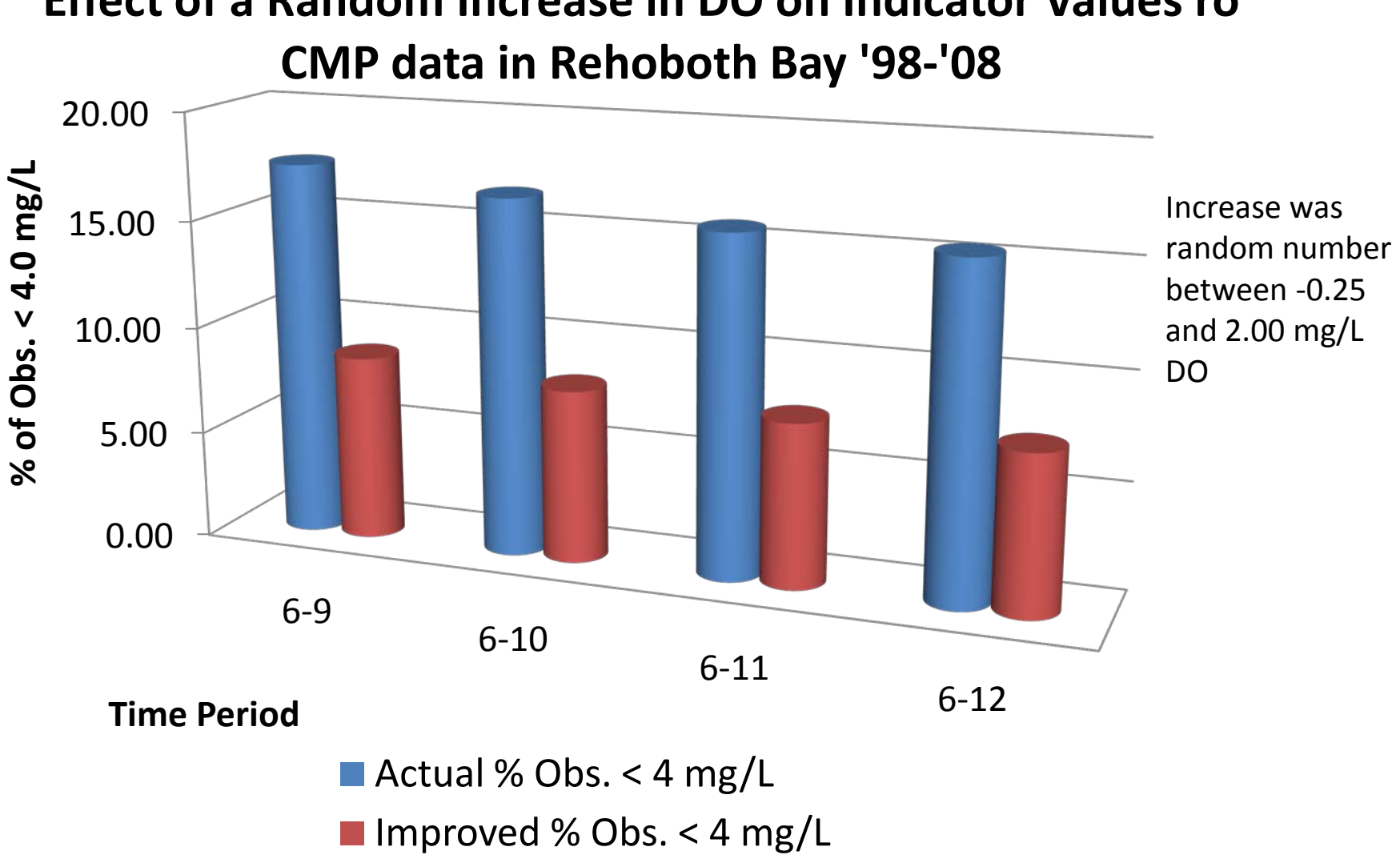


IR48B

Last Updated by Nicole on Jun 24

Site ID: IR48B
Site Name: Indian River green buoy #G5 west of White Creek
Date: 6/16/2010
Time: 8:13 a.m.
Water temperature: 22.9
DO: 7.04
Salinity: 28

Directions Search nearby Save to... more▼



- Indicator is sensitive to change in conditions
- Time period does not appear to significantly affect sensitivity