



Detecting Changes in Water Quality in Long Island Sound with NERACOOS Buoy Observations

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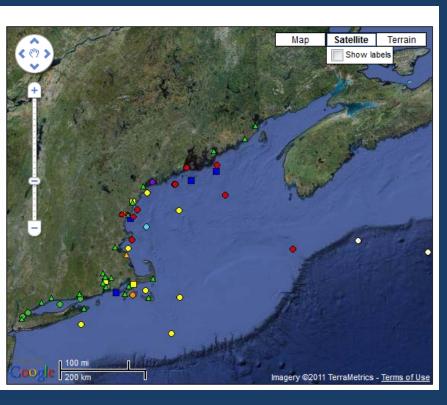


Overview

- NERACOOS
- Hypoxia in Long Island Sound
- Monitoring and Mapping program
- Uncertainty in Area
- Uncertainty in Duration
- Conclusions
 - The current approach in not capable of resolving changes
 - Buoy measurements are better
 - Ship surveys are essential to measure nutrients and plankton.



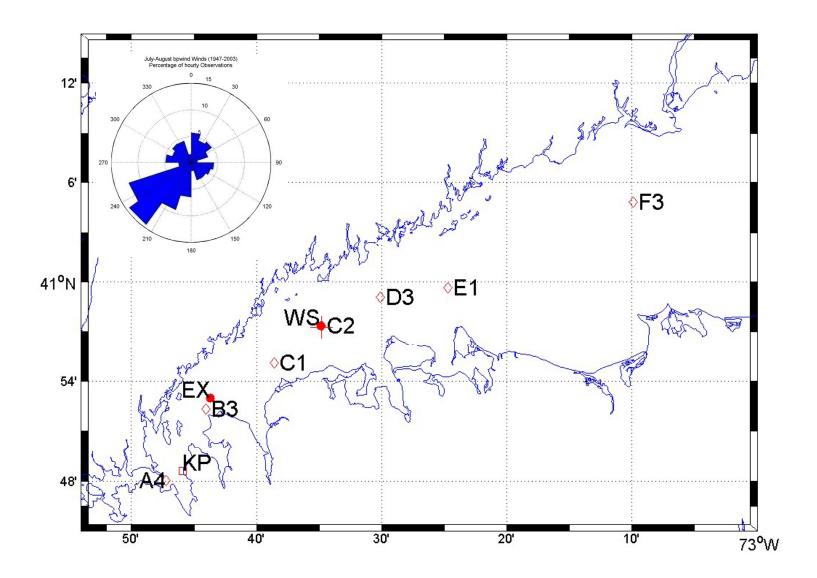




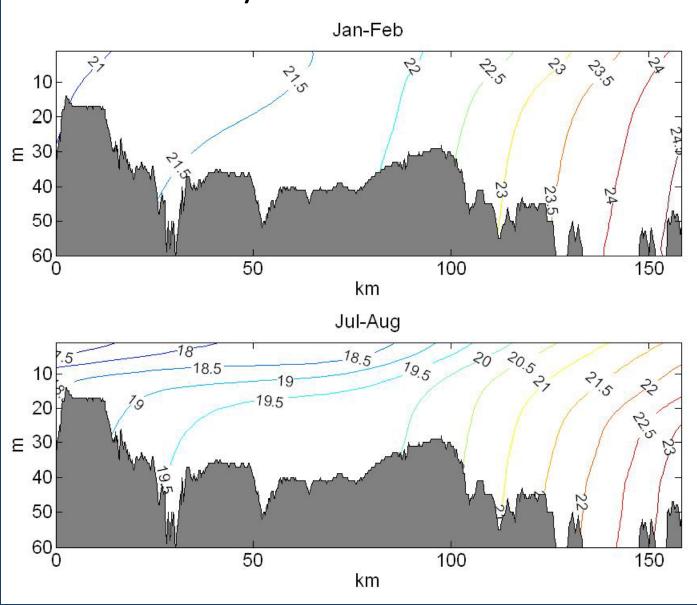
NERACOOS is a NOAA IOOS sponsored regional association that supports Ocean Observations in the northeastern United States and Canadian Maritime provinces.

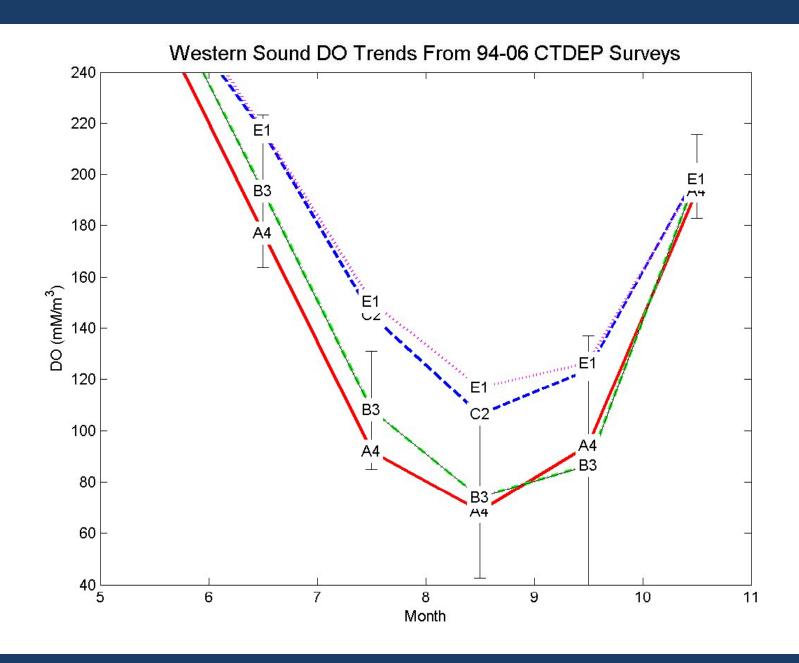
Priorities include

- Coastal hazards
- Ocean & coastal ecosystem health
- Ocean energy planning & management



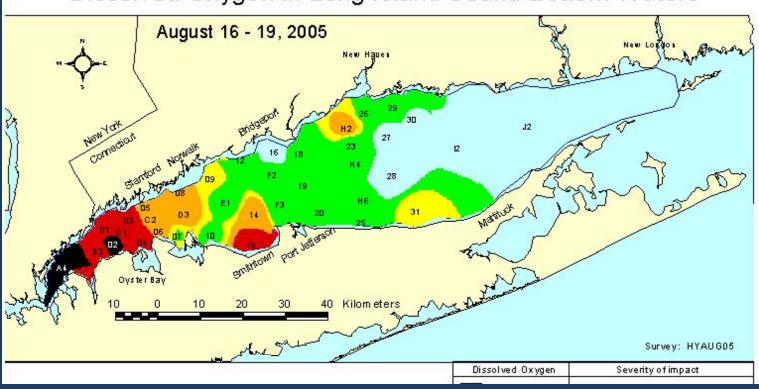
Mean Density Field in winter and Summer





Aug 16-19, 2005

Dissolved Oxygen in Long Island Sound Bottom Waters



- Black is less than 2
- Red & orange are <3.5 and are Hypoxic w.r.t. CT standards

Long Term Trends in WQ

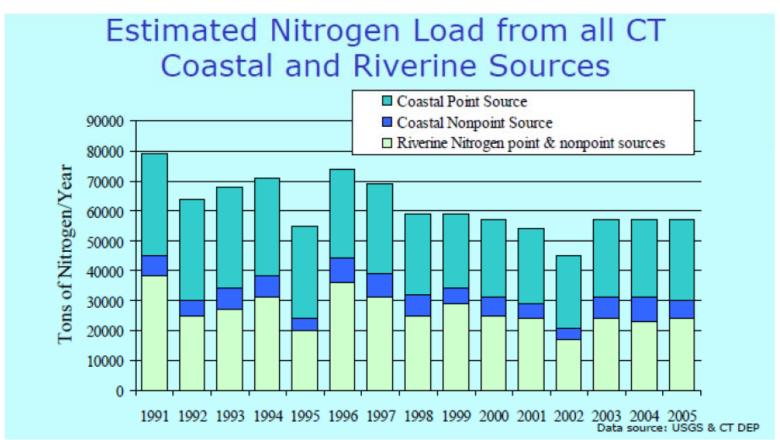


Figure 17. Nitrogen loads to Long Island Sound, 1991-2005 (Source: EPA LIS Study Office, http://longislandsoundstudy.net/wp-content/uploads/2010/02/section2.1_2008.pdf)

Western Narrows Nitrogen

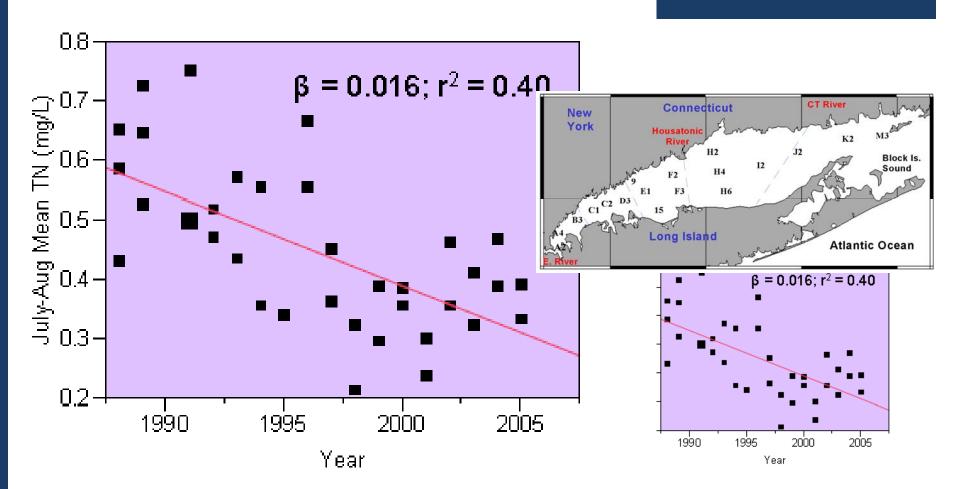
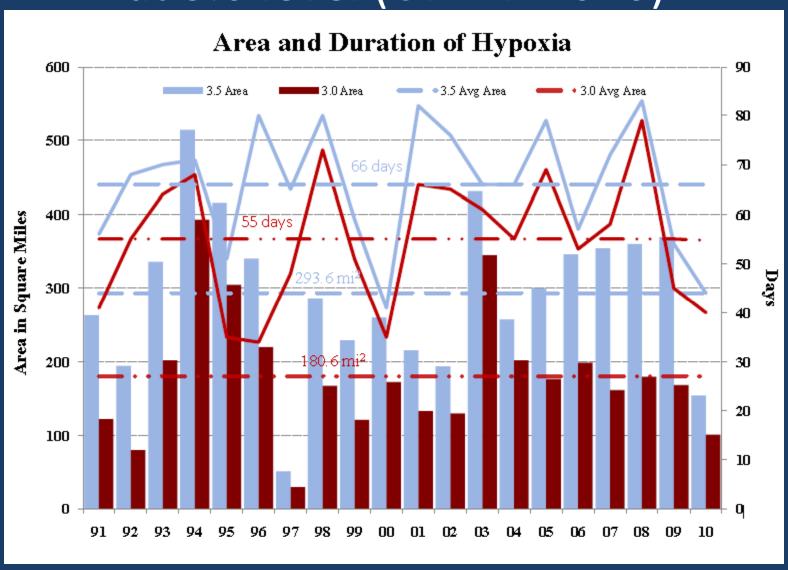


Figure 18. Bottom water nitrogen concentration versus time in the West Narrows region during the peak hypoxia period (July and August), 1988-2005. Points represent the two-month average of each of the three stations in the West Narrows region. Lines in plots represent statistically significant (p < 0.05) linear regression trends. There was no trend for NH₃.

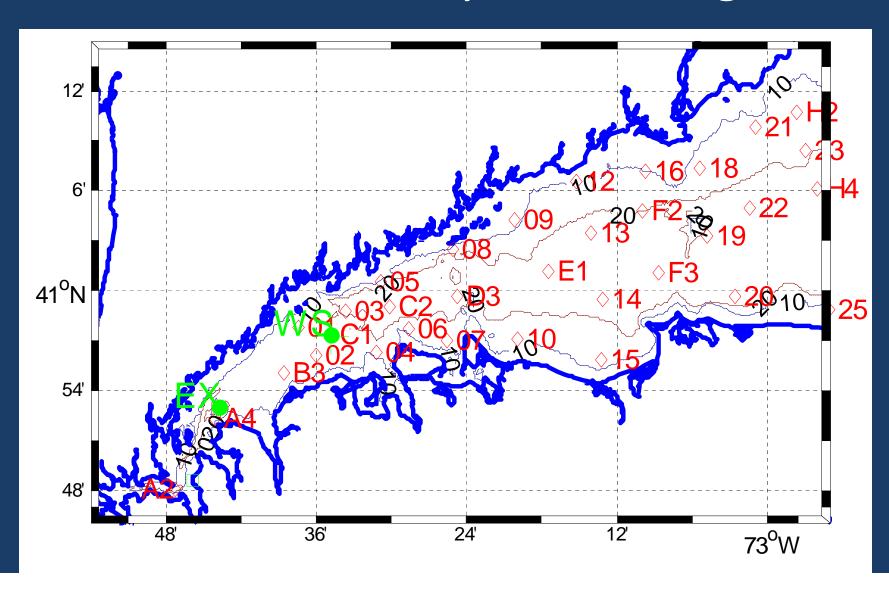
Red bars show the extent of Hypoxia at 3.0 level (CTDEP 2010)



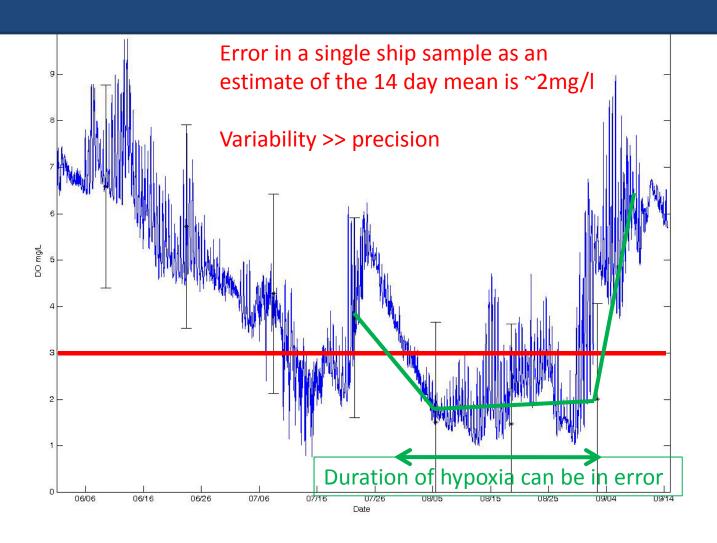
Nitrogen reduction is working, but hypoxia persists?

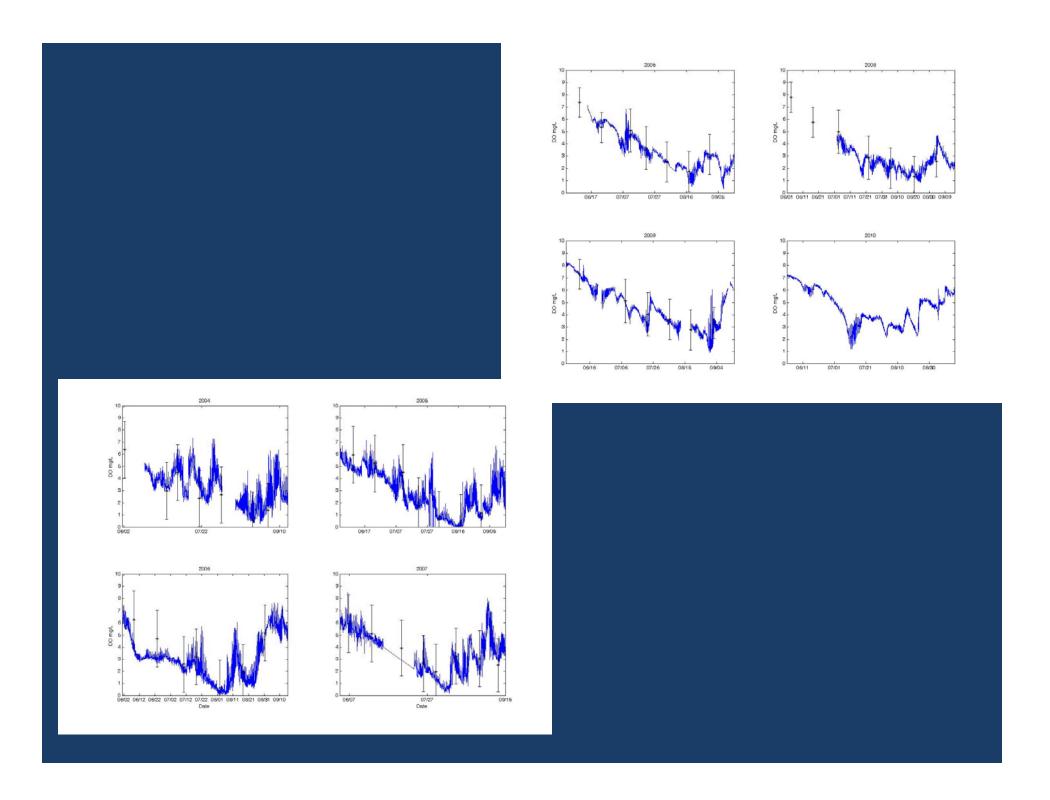
- There is evidence of this in other area
- Nutrient ratio changes allow other species to bloom
- Nitrogen fixation?
- Climate shifts have led to more stratification and less ventilation.
- We are not measuring accurately enough
 - Aliasing of high frequencies
 - Amplitude of inter-annual modulation is large

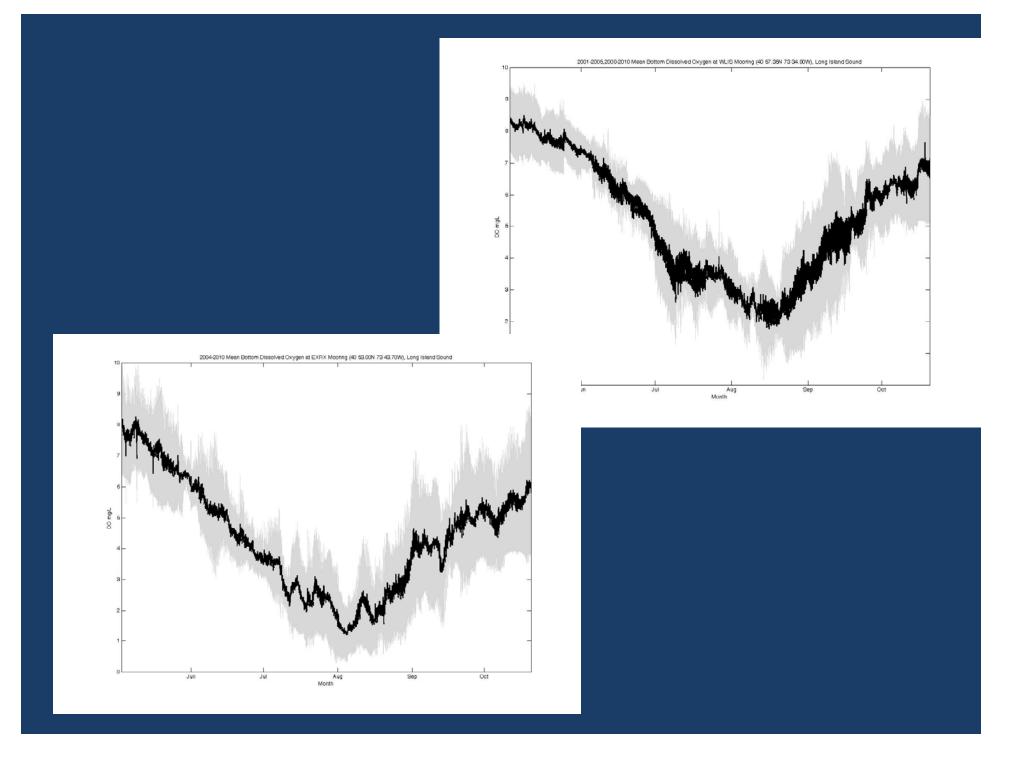
Buoys reveal tidal, daily and weatherband variability and it is big.



Time Series from EXRK and A4







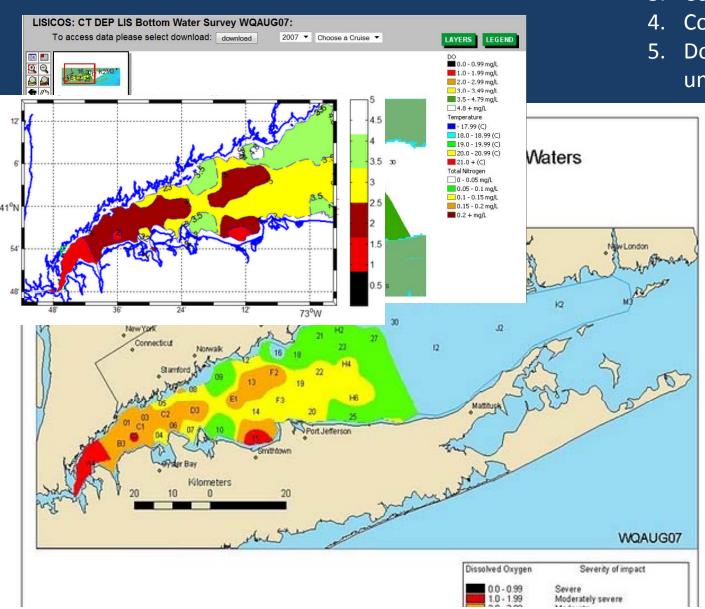
How does the error influence the uncertainty in the hypoxic area?

Monte Carlo Simulation

- 1. Assume the statistics of the error
 - 1. Gaussian normal with zero mean and std specified
 - 2. Errors at stations are independent
- 2. Generate sample with these characteristics and add it to the data –compute A_i.
- 3. Repeat a large number (1000) times.
- 4. Compute standard deviation of A_i.

Need procedure to make contour maps and compute areas in the same way as CTDEP.

WQAUG07



- 1. Download cruise data
- 2. Make Map with inverse distance weighting
- 3. Compute area < 3.5
- 4. Compare to CTDEP
- 5. Do MC simulation to get uncertainty

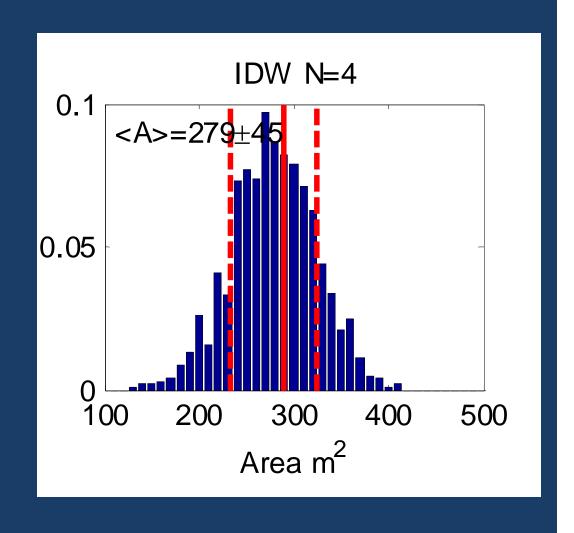
Uncertainty in the Area of hypoxia due to 2mg/l uncertainty in the survey data ~45 square miles or 15%.

Note the median is significanty lower than the data alone value

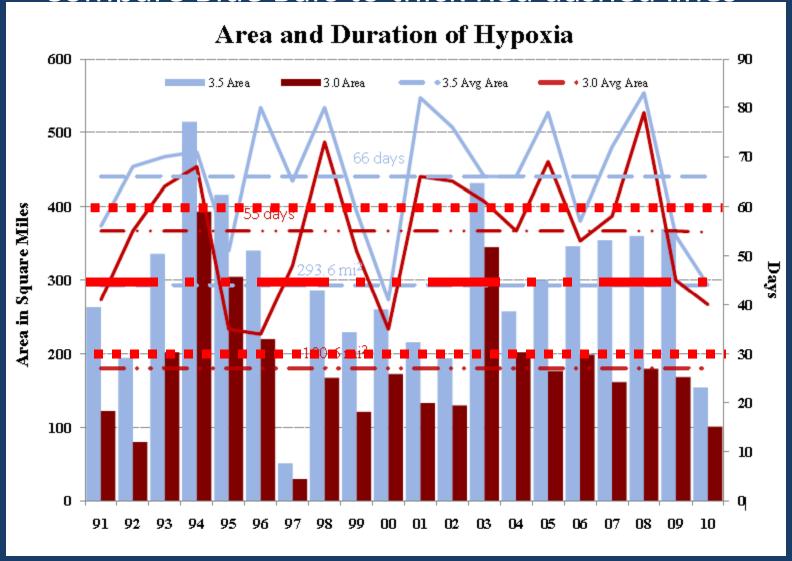
This is a consequence of the sensitivity of the mapping algorithm to station spacing

N=4 makes maps lumpy when stations are widely spaced.

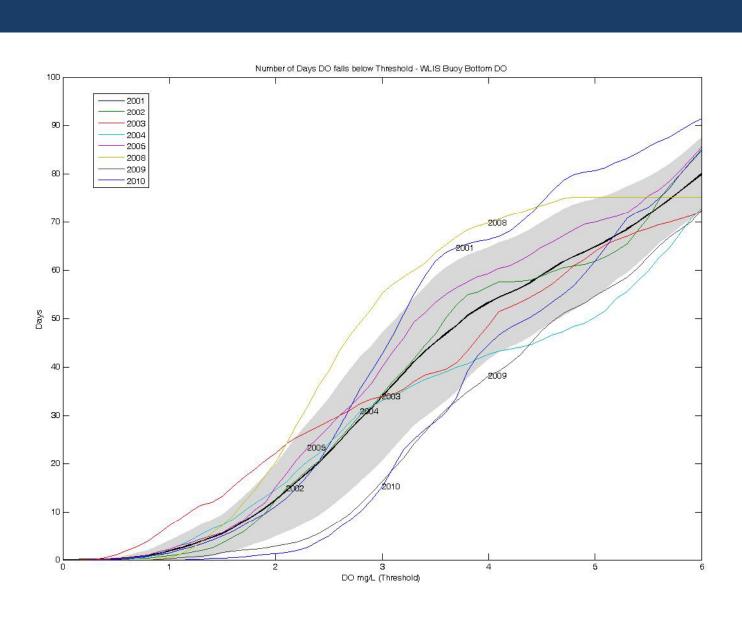
Map depends on the units chosen for the x&y dimensions.



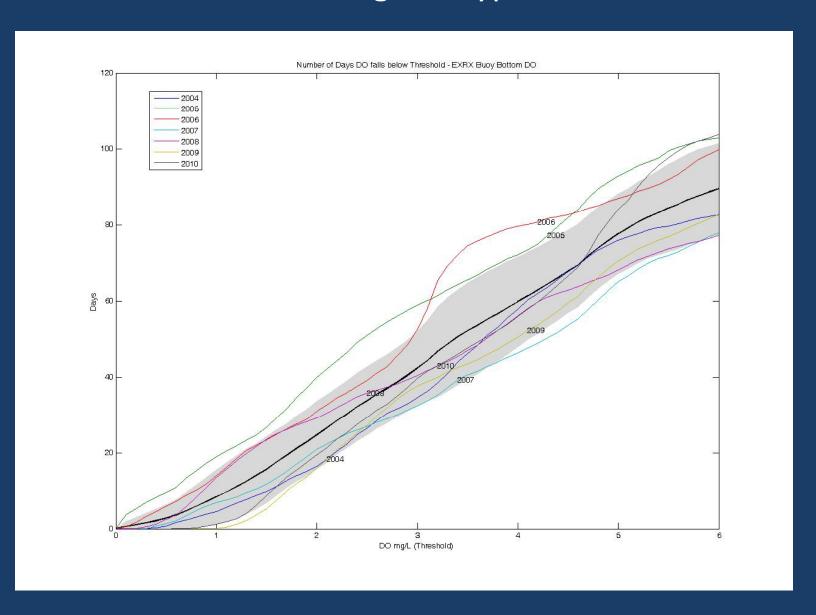
Extent of Hypoxia (CTDEP 2010) with PRELIMINARY 95% confidence intervals for 3.5mg/l Compare Blue Bars to thick Red dashed lines



Duration of hypoxia from 10 years of buoy observations at WLIS for a range of hypoxia thresholds



Duration of hypoxia from 10 years of buoy observations at EXRK for a range of hypoxia thresholds

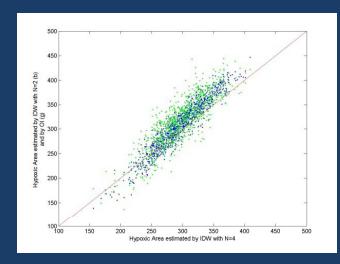


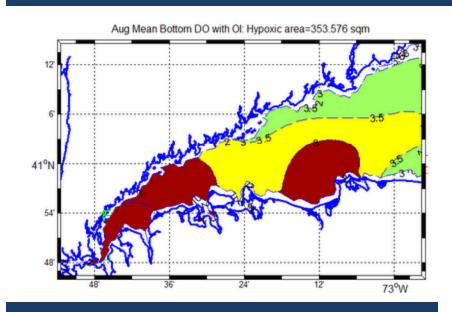
 Uncertainty in AREA estimates suggest all areas are consistent with the proposition that the area has remained constant.

 Note that the STD of the DURATION is ~15-20 days so 14 day survey intervals will not resolve inter-annual variability or long term changes due to management actions

Other Mapping Approaches

- IDW with N=2
- Krigging/Gauss Markov
 Estimation/Objective Analysis
- They don't make much difference to the A but they do change the structure.





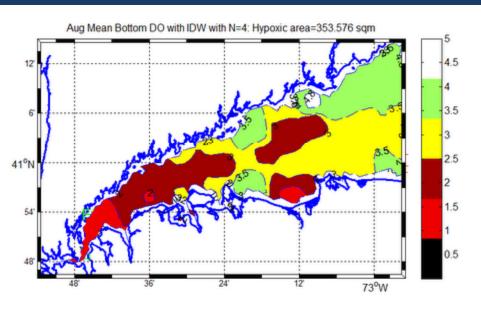
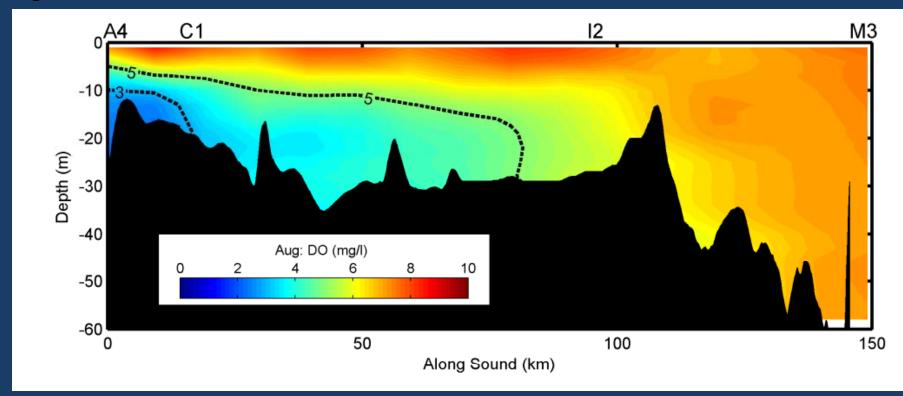


Figure 33



Along Sound cross sections of the distribution of dissolved oxygen concentration along the dot-dashed line in map during (a) June, (b) July, (c) August, and (d) September computed by monthly averaging the CTDEP data set and objective analysis.

Caveats on Analyses

- We need to carefully establish the effect of station spacing and examine uncertainty in other years. The uncertainty is not independent of the data.
- The "errors" in the ship samples may not be independent
- Magnitude of aliasing for other variables needs to be established to make more sense of trend and correlation analyses.

Conclusions and Recommendations

- Duration measured by buoys is the best (least uncertain) metric
- Commit to support sustained buoy observations and expanded instrument deployment (nutrients)
- Use analysis tools for hypoxic area, volume and duration with objective analysis and uncertainties.
- Add Instruments to buoys to enhance resilience
- Add buoy east of the WLIS buoy to detect changes earlier.