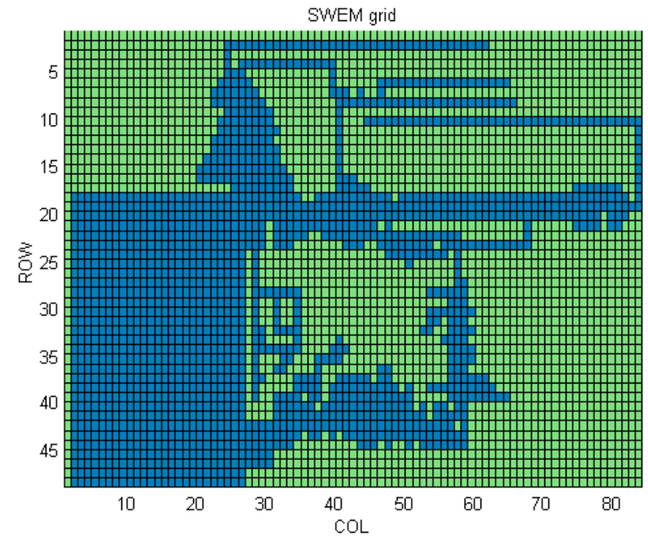
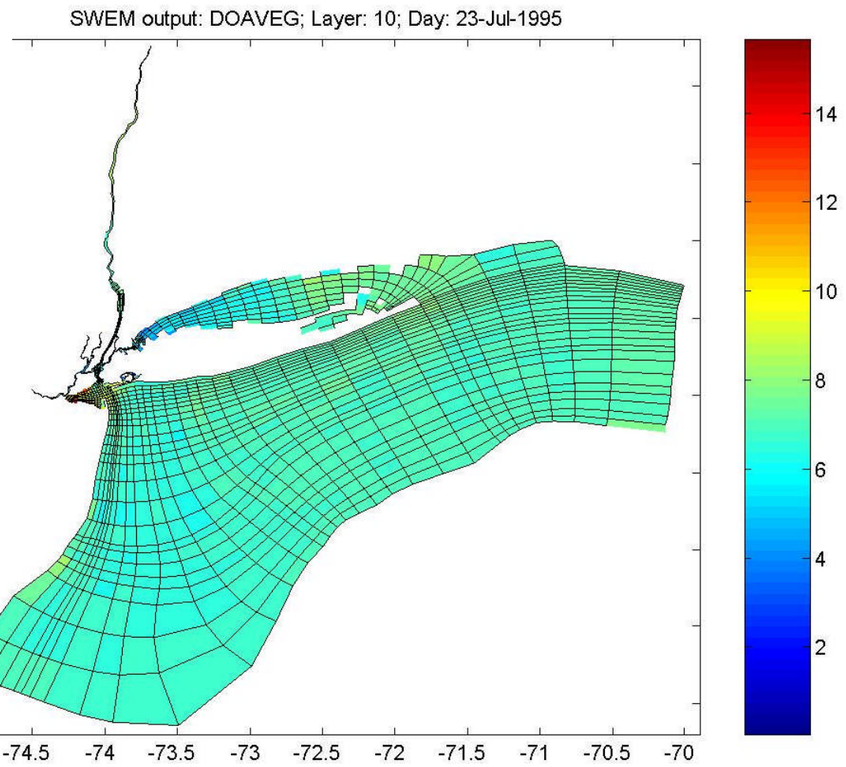
SWEM Sensitivity

1. Model is insensitive to discharge magnitude
2. Model has no vertical turbulent flux in hypoxic zone
3. Respiration is too small
4. Production is too small

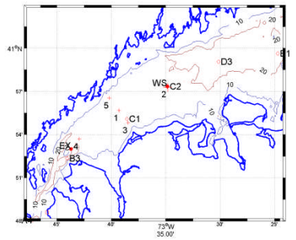
SWEM Overview – the grid

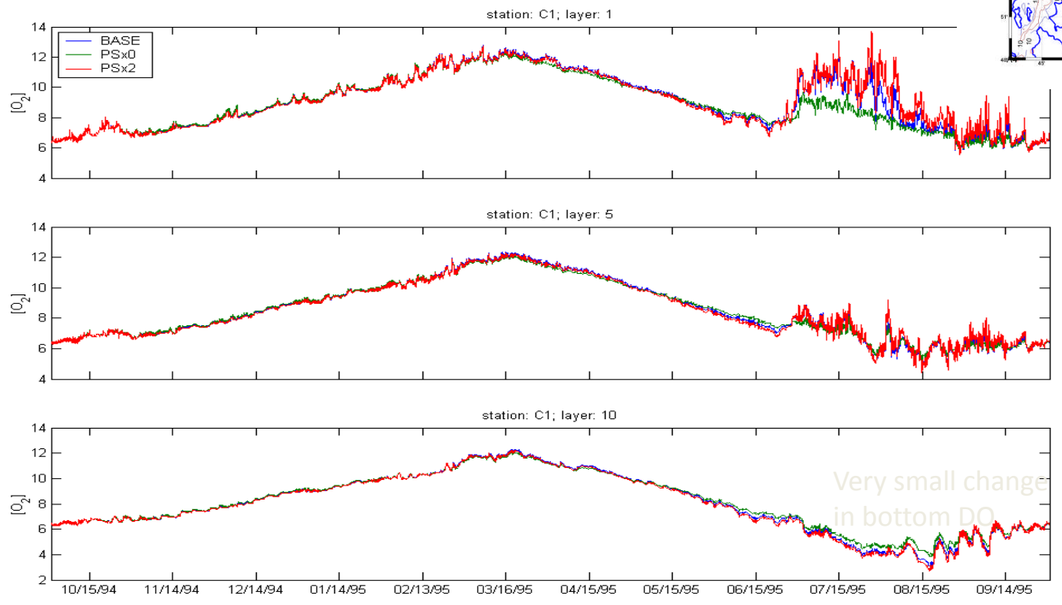




Insensitivity to Discharges

Double Point Source Discharges and Set them to Zero



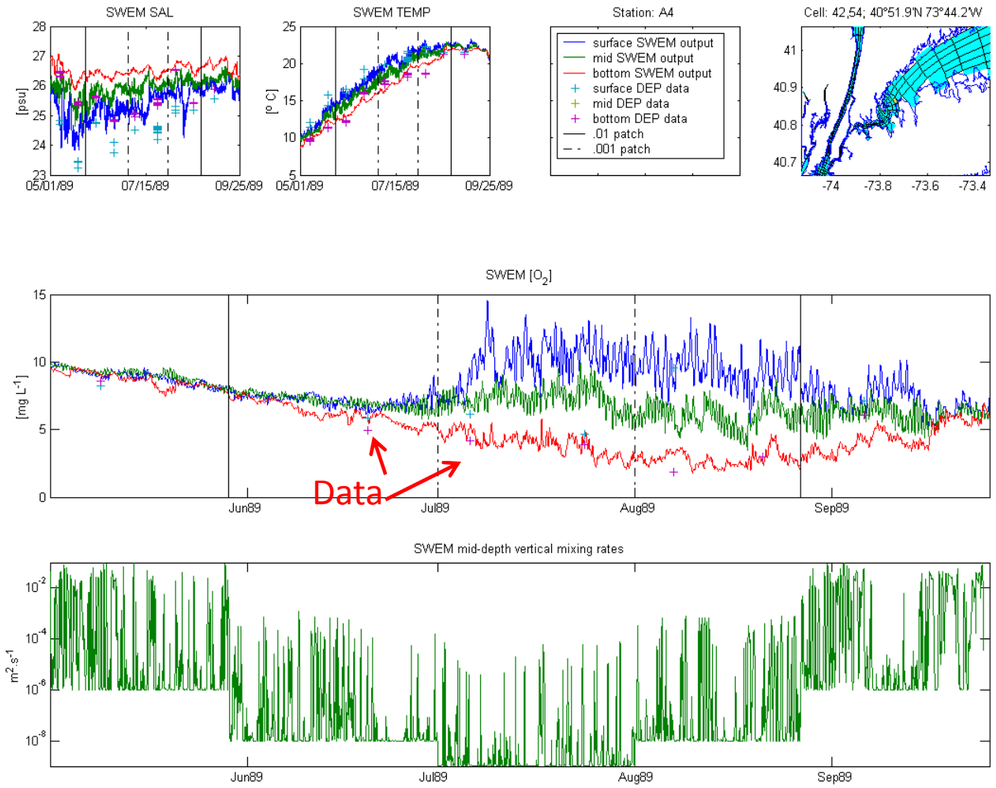


Very small change in bottom DO

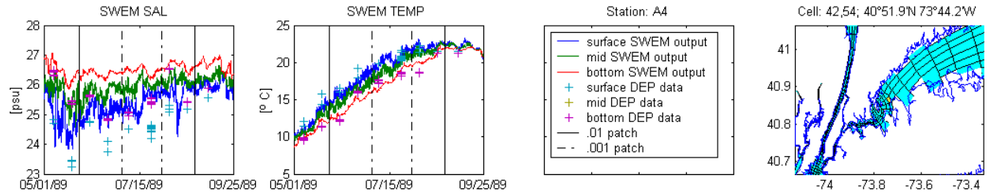
Why is SWEM Insensitivity to Discharge Magnitudes?

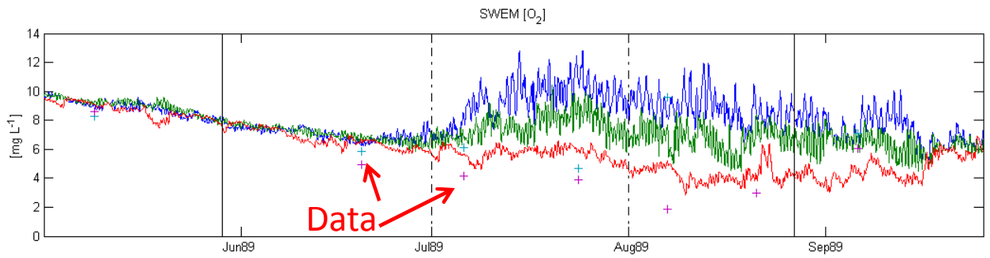
- When discharge is increased production is quickly Si limited
- When the discharges are reduced there is a reduction in productivity in the surface but there is still POC formation using recycled and boundary flux nutrients.

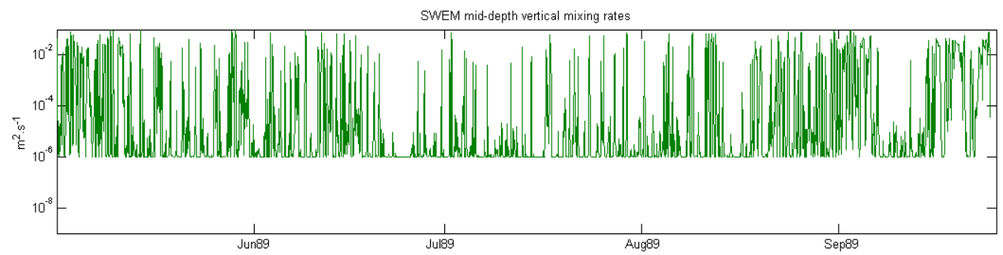
Distortion of physics



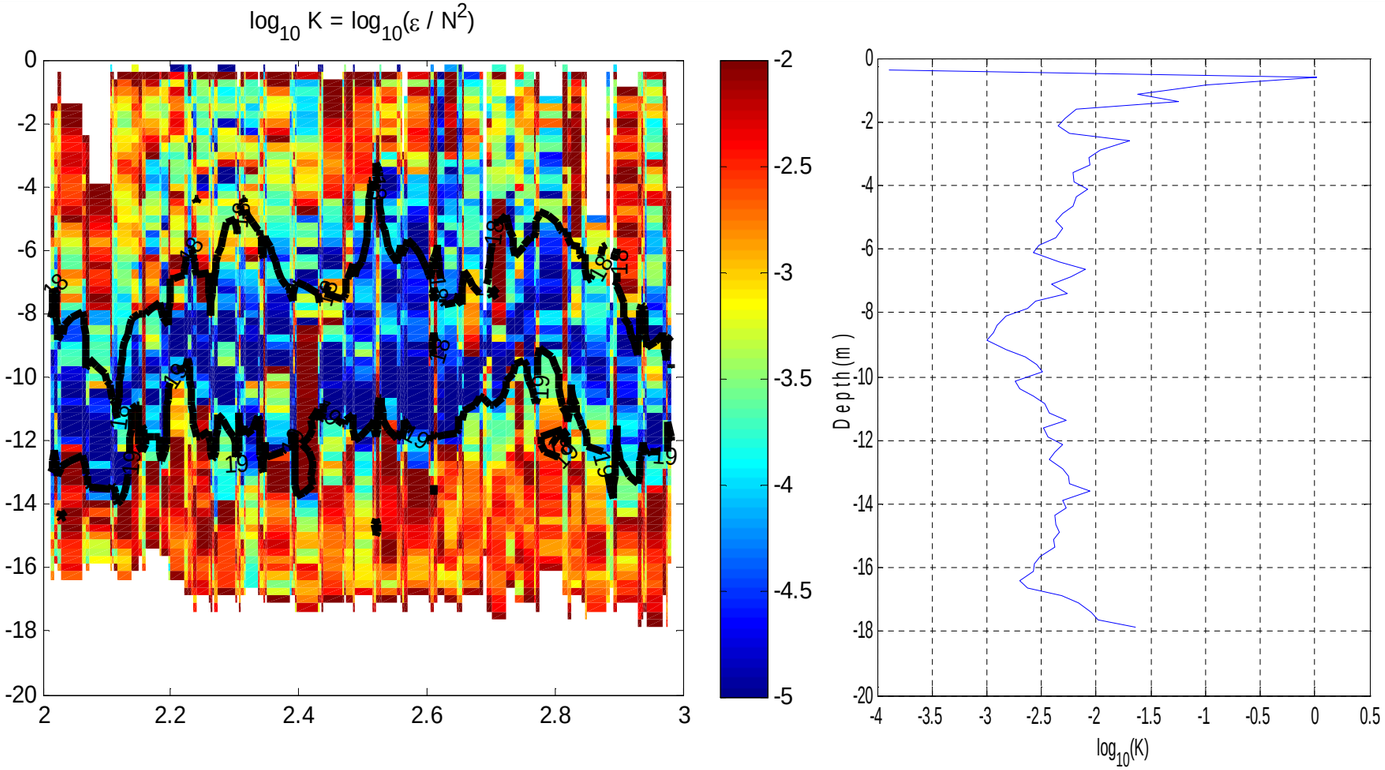
Distortion of physics



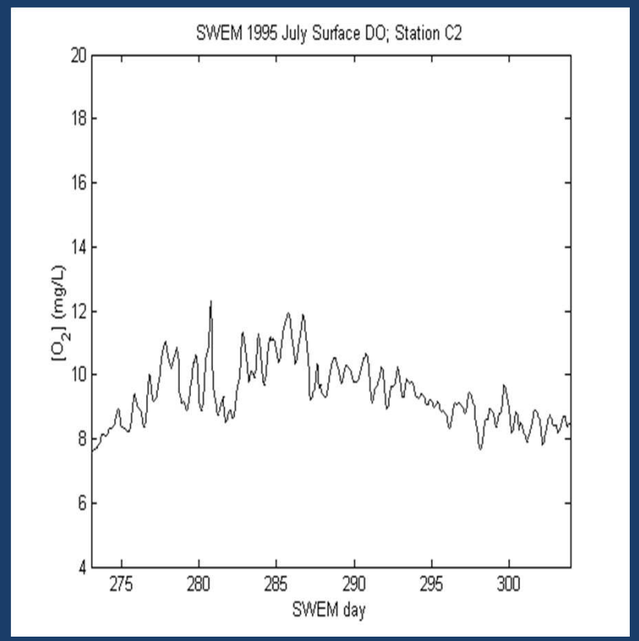


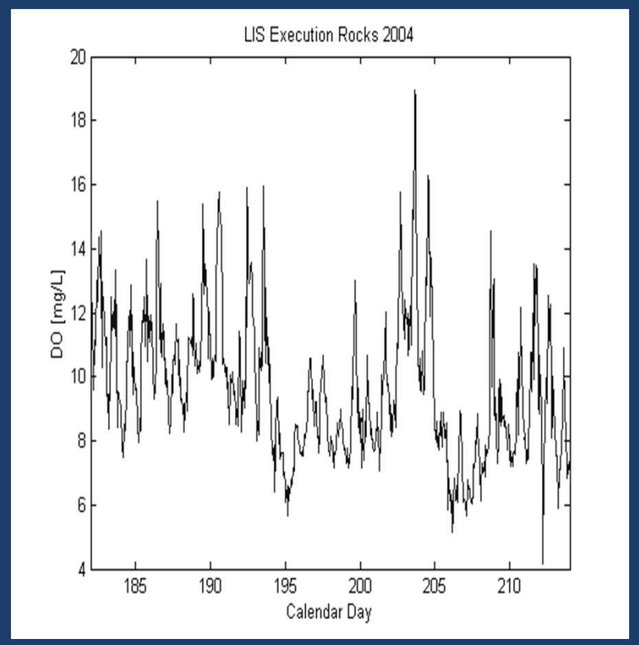


Measured Vertical Eddy diffusion coefficient ~$10^{-(3\text{-}5)}$ m^2/s structure and variability at WLIS (CTDEP C2) in 2006



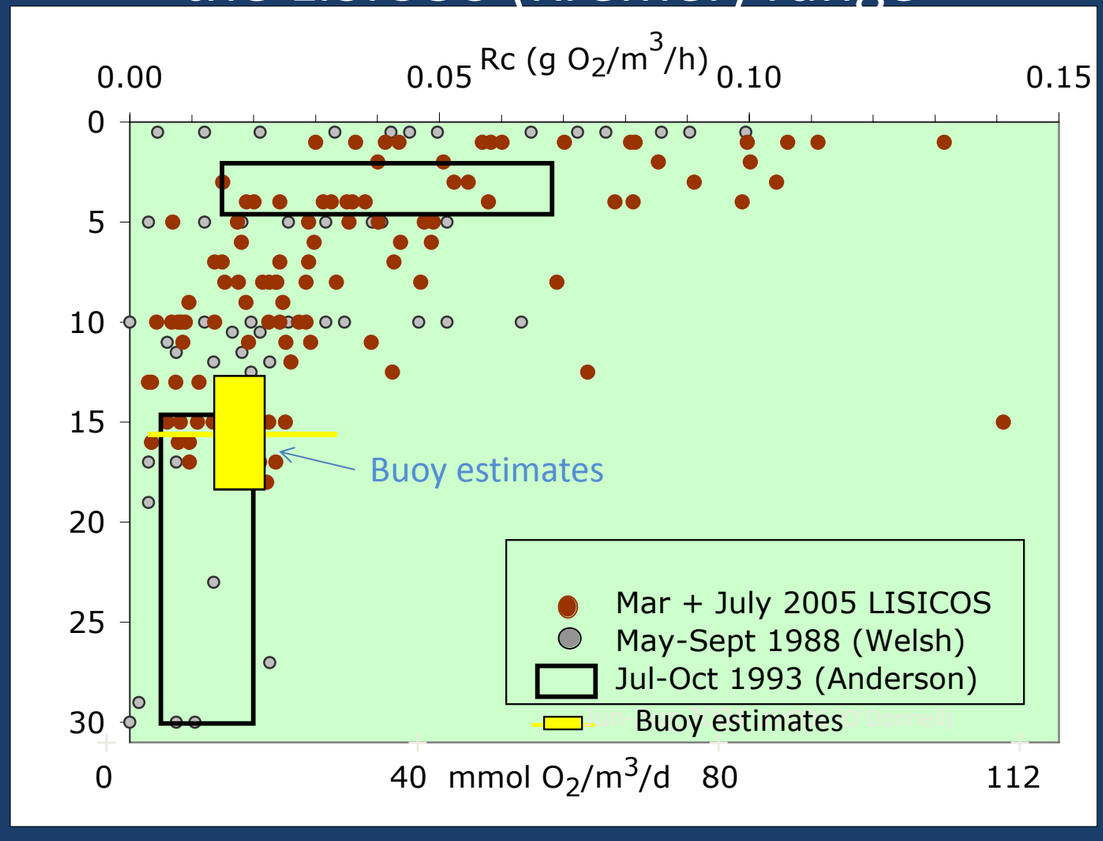
The major issues
- Production understimated



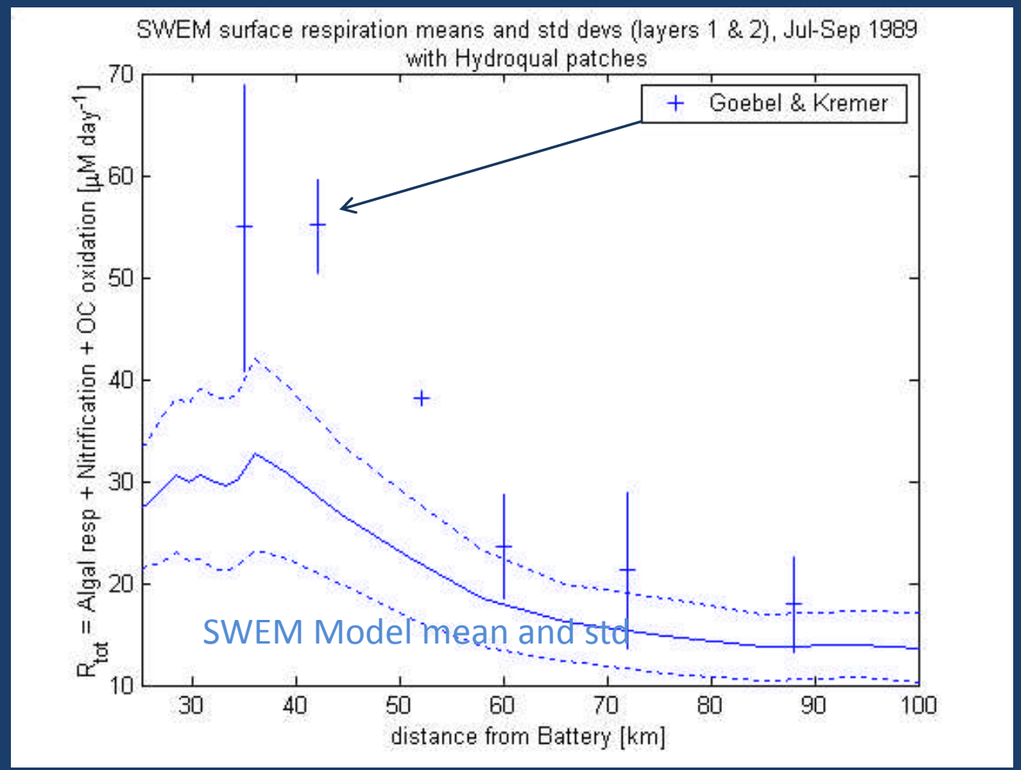


The major issues

- SWEM Respiration is underestimated relative to the LISICOS (Kremer) range

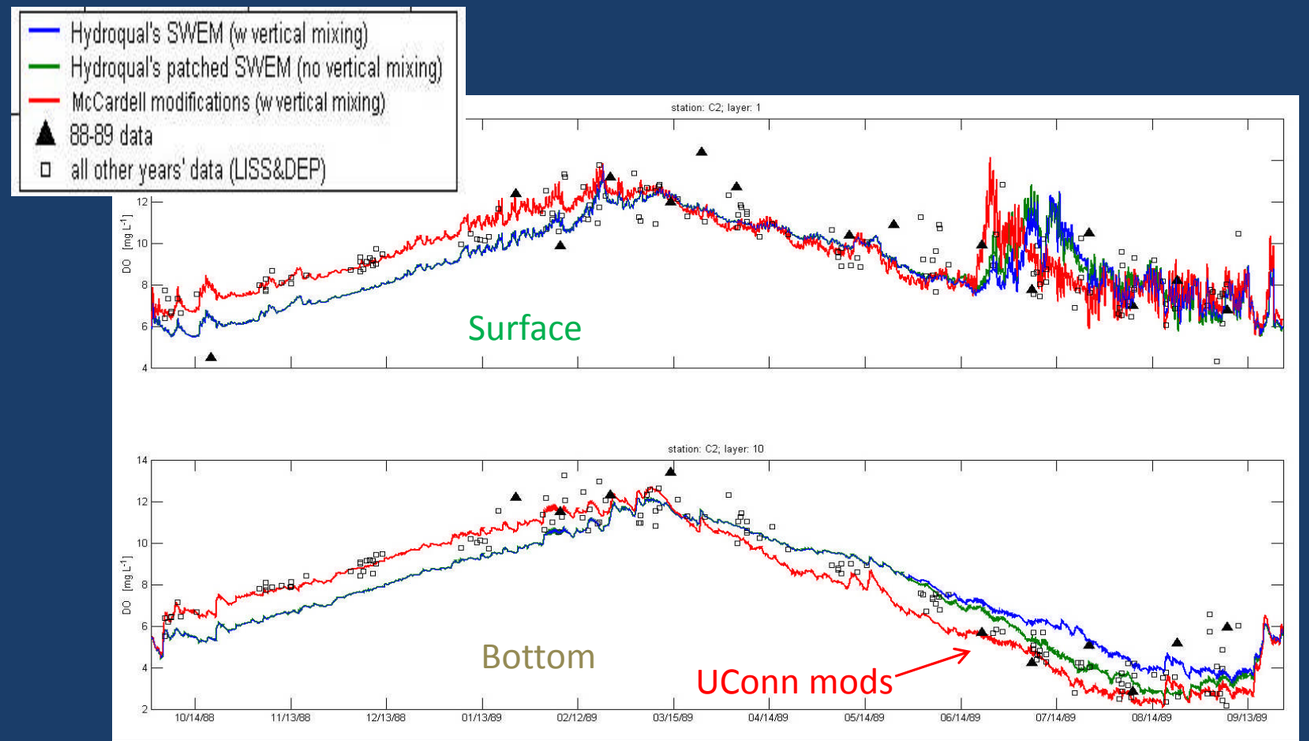


Respiration is underestimated



Performance: DO at C2

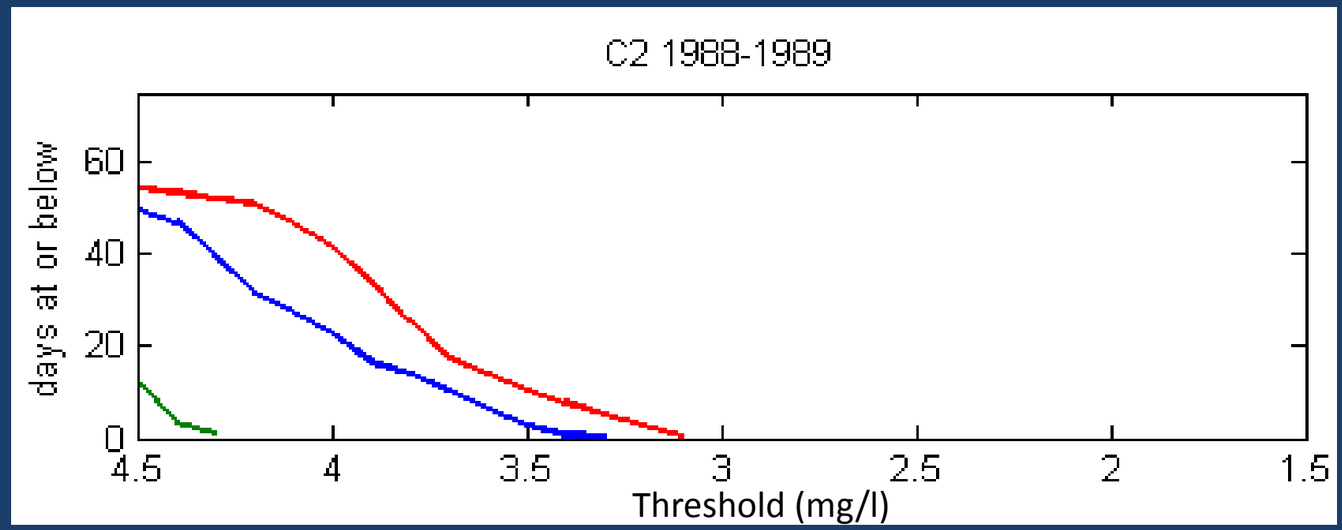
SWEM, SWEM+Mixing, SWEM+Mixing+P&R



Performance: DO at C2

SWEM, SWEM+Mixing, SWEM+Mixing+P&R

Duration of exceedance: more sensitive measure



Number of days that the solution at station C2 falls below a threshold.

blue line represents SWEM

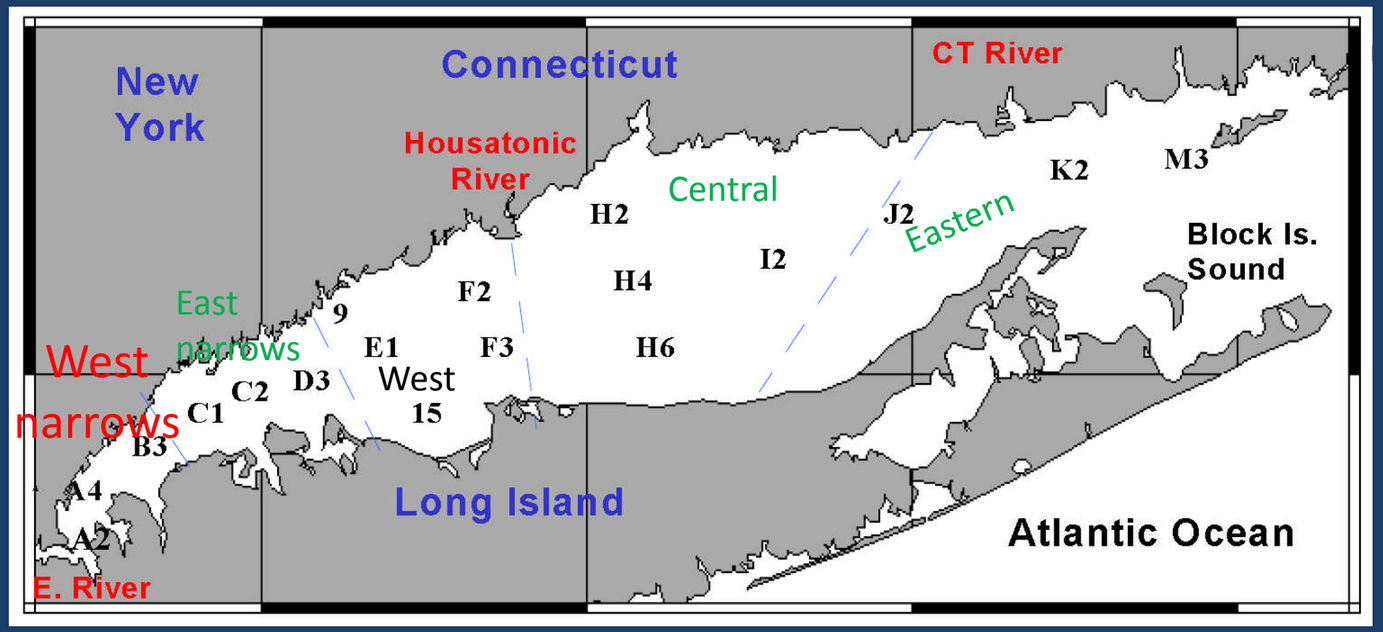
green shows the SWEM mixing

red line show increased production, respiration and mixing.

Conclusions

1. SWEM can be substantially improved through quantitative skill assessment and comparison to observations.
2. We recommend measurements of carbon biomass and the rates of production and respiration to constrain the parameter choices in RCA
3. Some reformulation may be warranted. Several parameters that have very poor skill. Should these be simulated or just prescribed?

Measuring Change in Long Island Sound



Long Term Trends in WQ

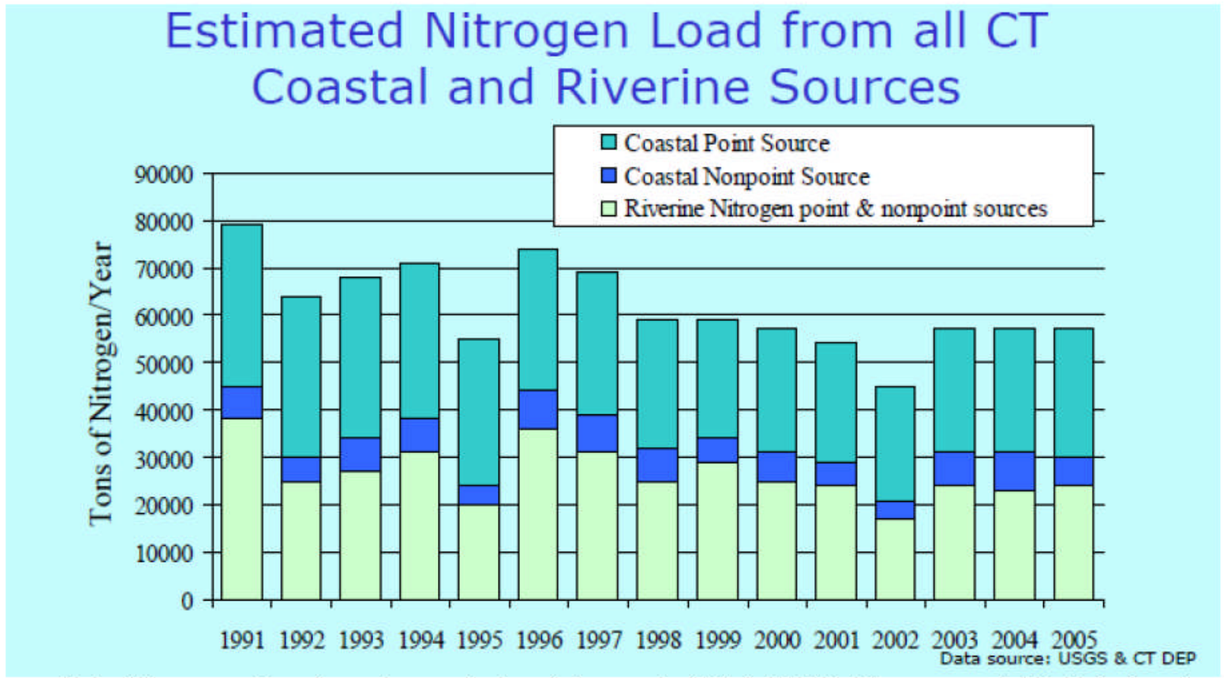


Figure 17. Nitrogen loads to Long Island Sound, 1991-2005 (Source: EPA LIS Study Office, http://longislandsoundstudy.net/wp-content/uploads/2010/02/section2.1_2008.pdf)

Western Narrows Nitrogen

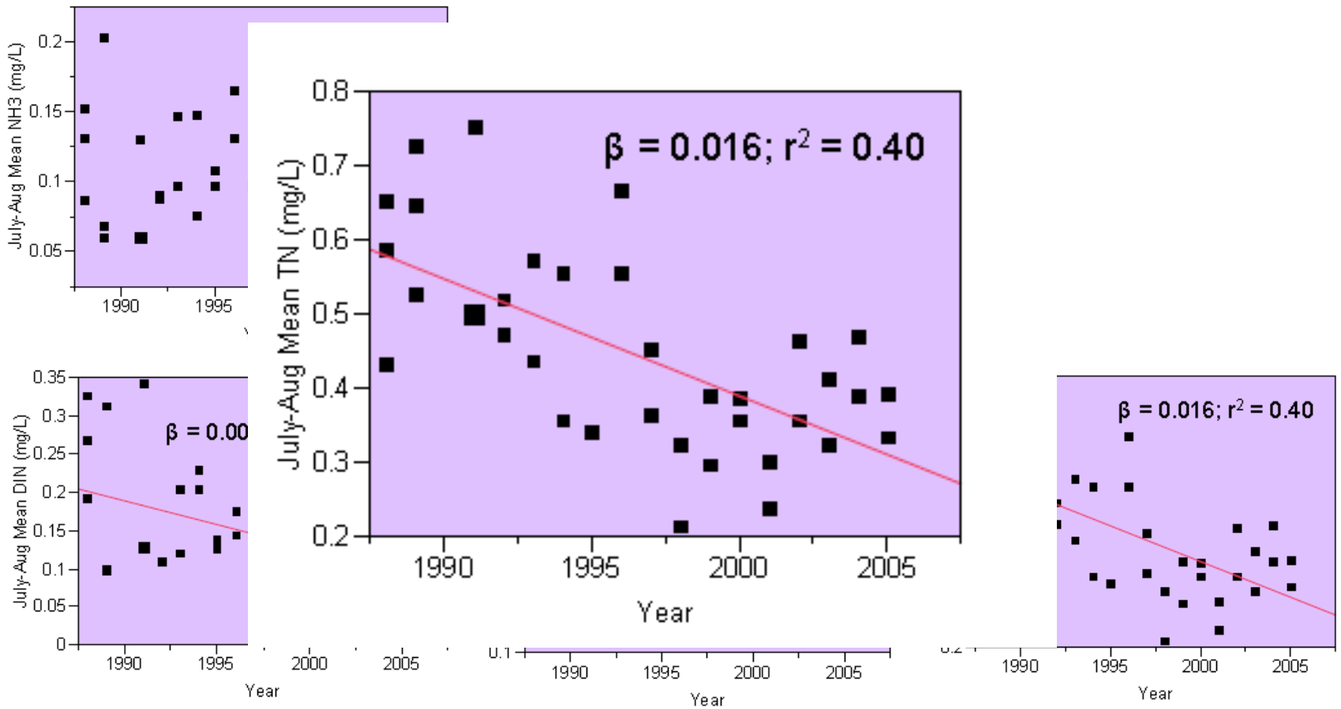
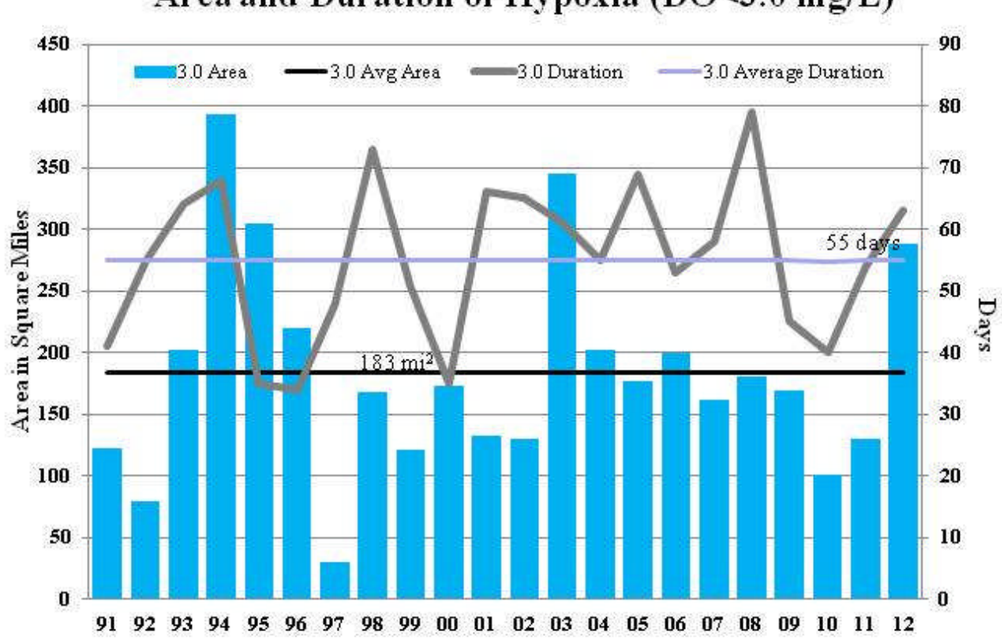


Figure 18. Bottom water nitrogen concentration versus time in the West Narrows region during the peak hypoxia period (July and August), 1988-2005. Points represent the two-month average of each of the three stations in the West Narrows region. Lines in plots represent statistically significant ($p < 0.05$) linear regression trends. There was no trend for NH_3.

Yearly Comparison of Maximum Areal Extent and Duration of Hypoxia

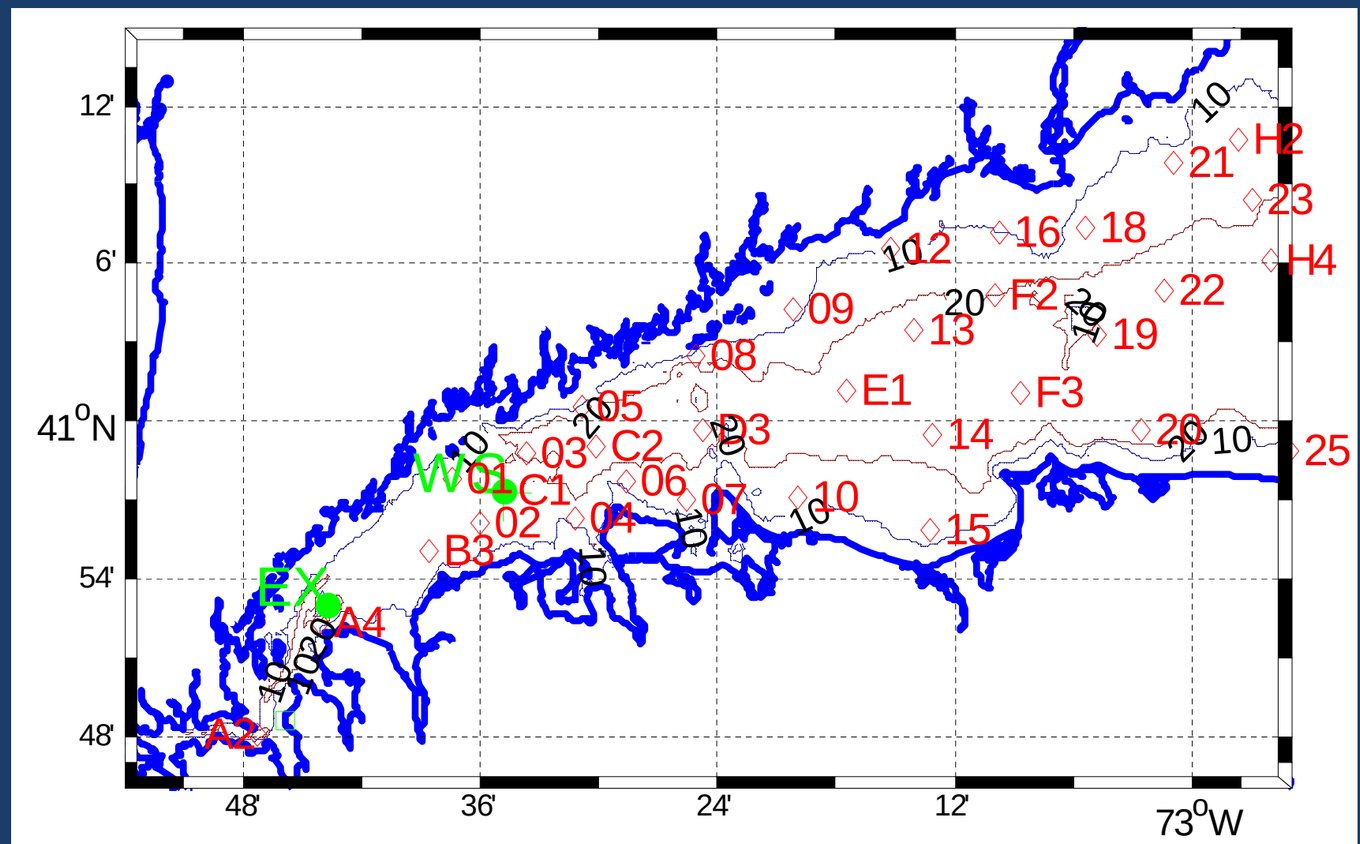
This graph utilizes the data presented on the previous page to illustrate the year-to-year differences in the maximum areal extent of hypoxic conditions. Based on the 3.0 mg/L DO standard the average areal extent was 183 mi^2 and the average duration was 55 days.



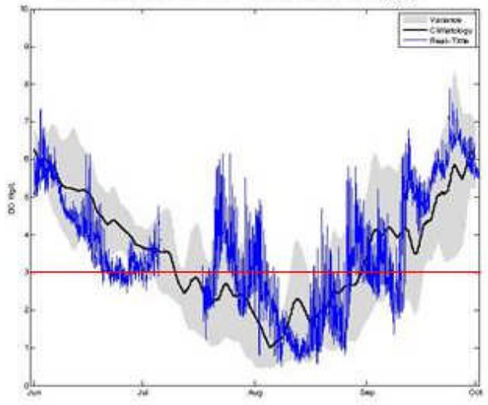
Nitrogen reduction is working, but hypoxia persists ?

- 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

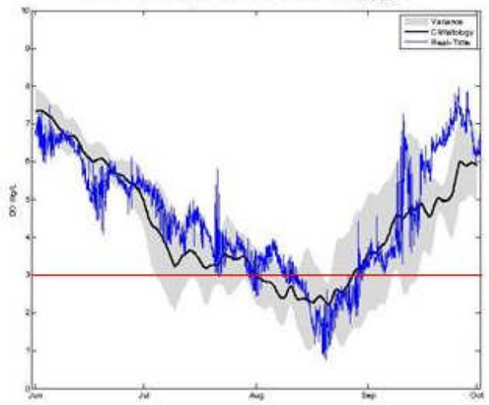
Buoys reveal tidal, daily and weather-band variability and it is big.



Execution Rocks Bottom Dissolved Oxygen



Western LIS Bottom Dissolved Oxygen



Based on LISICOS Execution Rocks Buoy Data Collected Between 1 June to 18 October

Estimated Start Date	6/20/2012
Estimated End Date	9/11/2012
Duration below 3.0 mg/L (cumulative days)	42.17
Duration below 2.0 mg/L (cumulative days)	18.89
Duration below 1.0 mg/L (cumulative days)	4.04
Minimum DO value (mg/L)	0.52 on 8 August

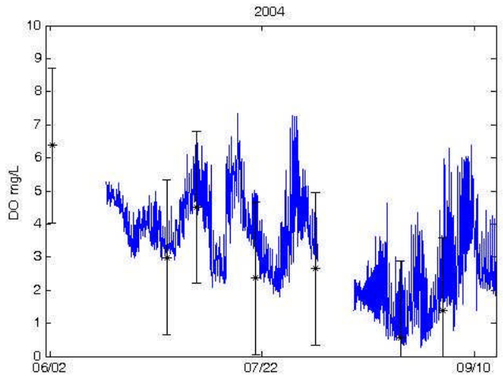
Data obtained from the LISICOS Execution Rocks Bottom Dissolved Oxygen Prediction Tool webpage (http://lisicos.uconn.edu/do_fcst.php?site=exrx). Data are also available for the Western Sound Buoy (http://lisicos.uconn.edu/do_fcst.php?site=wlis) where DO was less than 3.0 mg/L for 20.91 days. Duration is calculated by LISICOS by summing the time (in days) of the number of samples where DO was below the specified value (T. Fake, pers comm. 18 October 2012). ***Data are provisional and subject to change.***

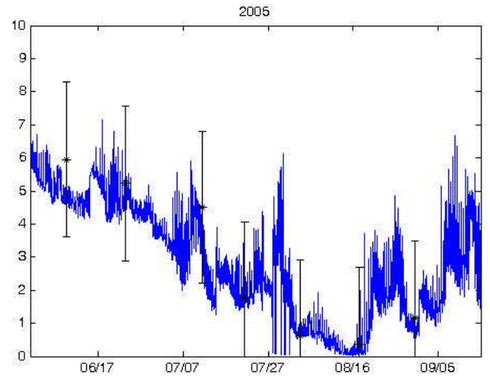
Based on CT DEEP and IEC data

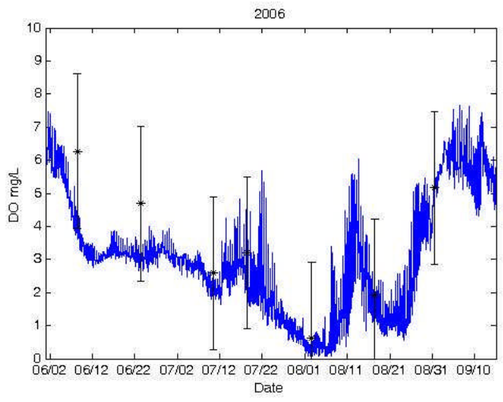
Estimated Start Date	7/10/2012
Estimated End Date	9/10/2012
Duration (days)	63
Maximum Area (mi^2)	288.5

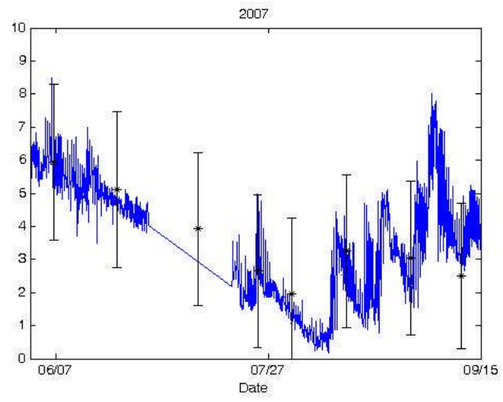
The Long Island Sound Study has defined hypoxia as dissolved oxygen concentrations below 3.0 mg/L. On 25 February 2011, CT DEEP adopted revised water quality standards that specified dissolved oxygen in Class SA and SB waters (applicable to LIS) shall not be less than 3.0 mg/L at anytime.

Start date and end date are estimated by plotting DEEP and IEC data from stations A4 and B3 in Excel using a line with markers chart and then interpolating when the DO concentration drops below 3.0 mg/L.


2004
DO mg/L
10
9
8
7
6
5
4
3
2
1
0
06/02
07/22
09/10


2005
10
9
8
7
6
5
4
3
2
1
0
06/17
07/07
07/27
08/16
09/05


2006
DO mg/L
10
9
8
7
6
5
4
3
2
1
0
06/02
06/12
06/22
07/02
07/12
07/22
08/01
08/11
08/21
08/31
09/10
Date


2007
10
9
8
7
6
5
4
3
2
1
0
06/07
07/27
09/15
Date

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

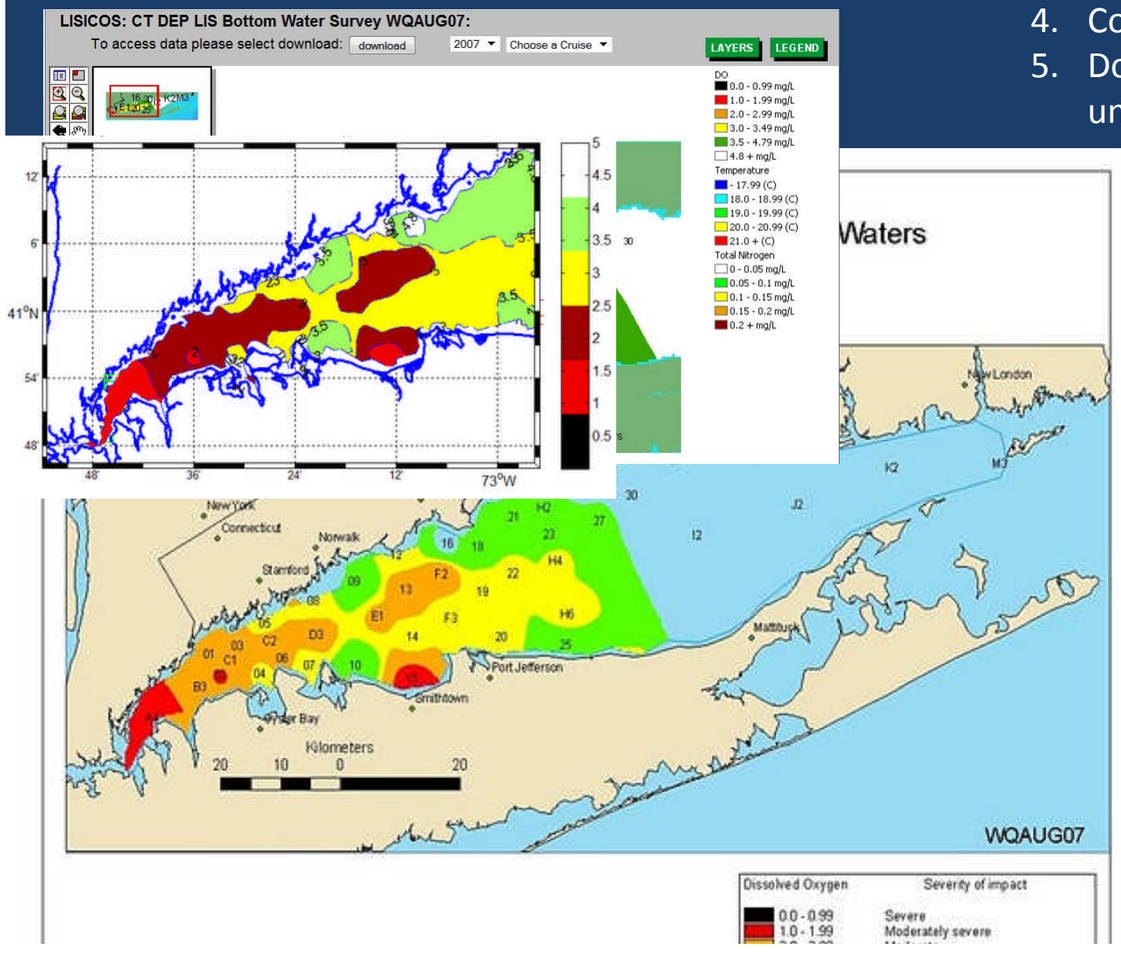
Monte Carlo Simulation

1. Assume the statistics of the error - gaussian normal with zero mean and std specified
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



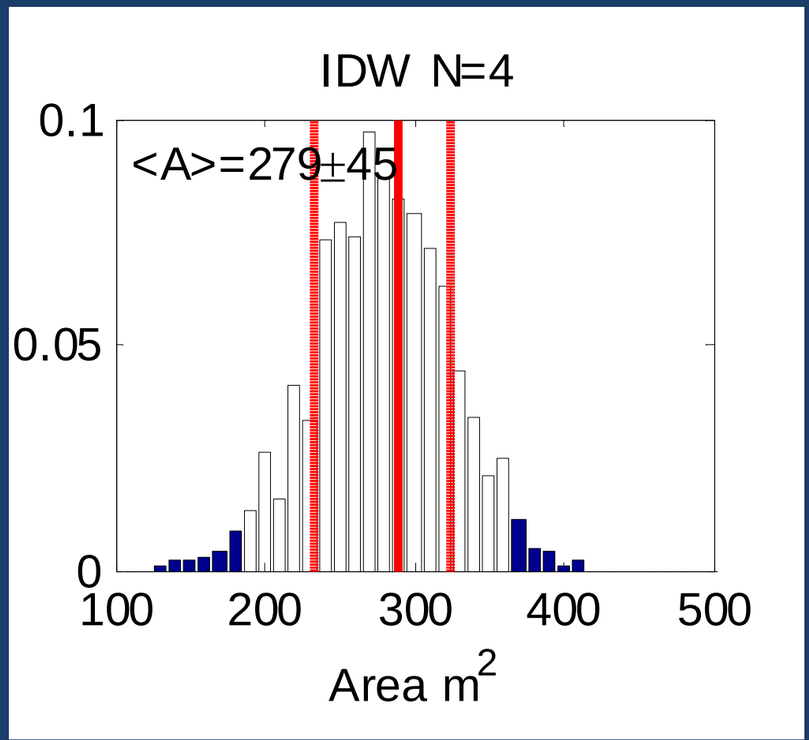
Uncertainty in the Area of hypoxia due to 2mg/l uncertainty in the survey data ~45 square miles or 15%.

Note the median is significanlty 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.

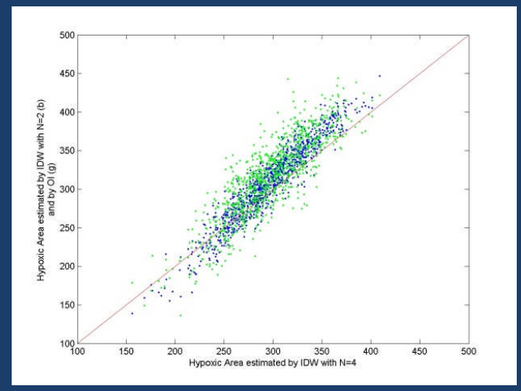


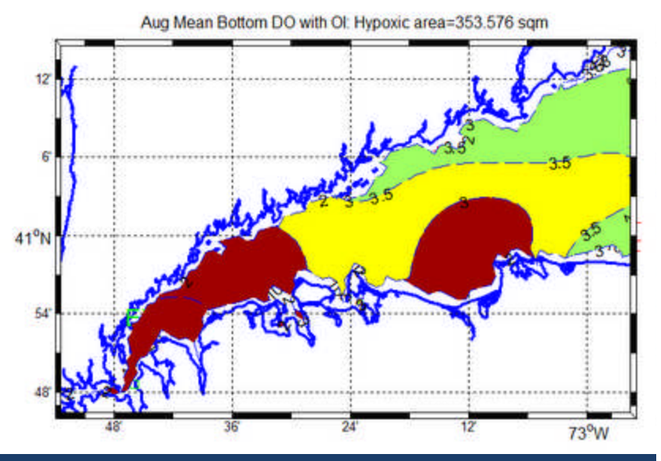
Gauss Markov/Krigging in space and time.

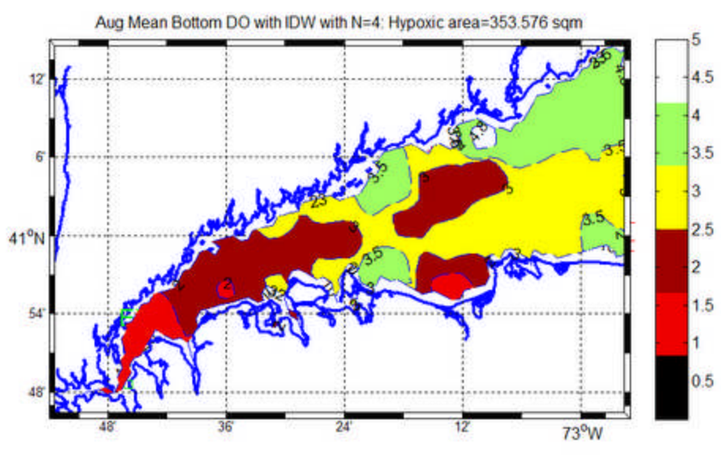
- This approach has a lot of advantages
  - Uses more data
  - Doesn't require repeated stations
  - Can look for the largest areas if they occur between cruises.
  - This is what I used for the Temperature Stress Index

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.

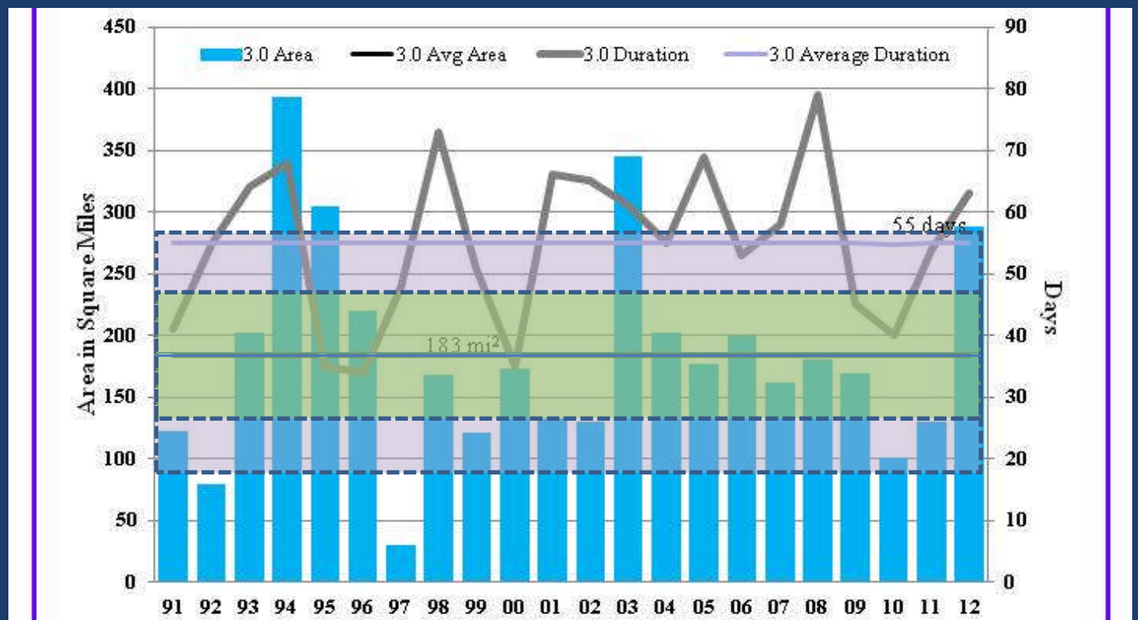




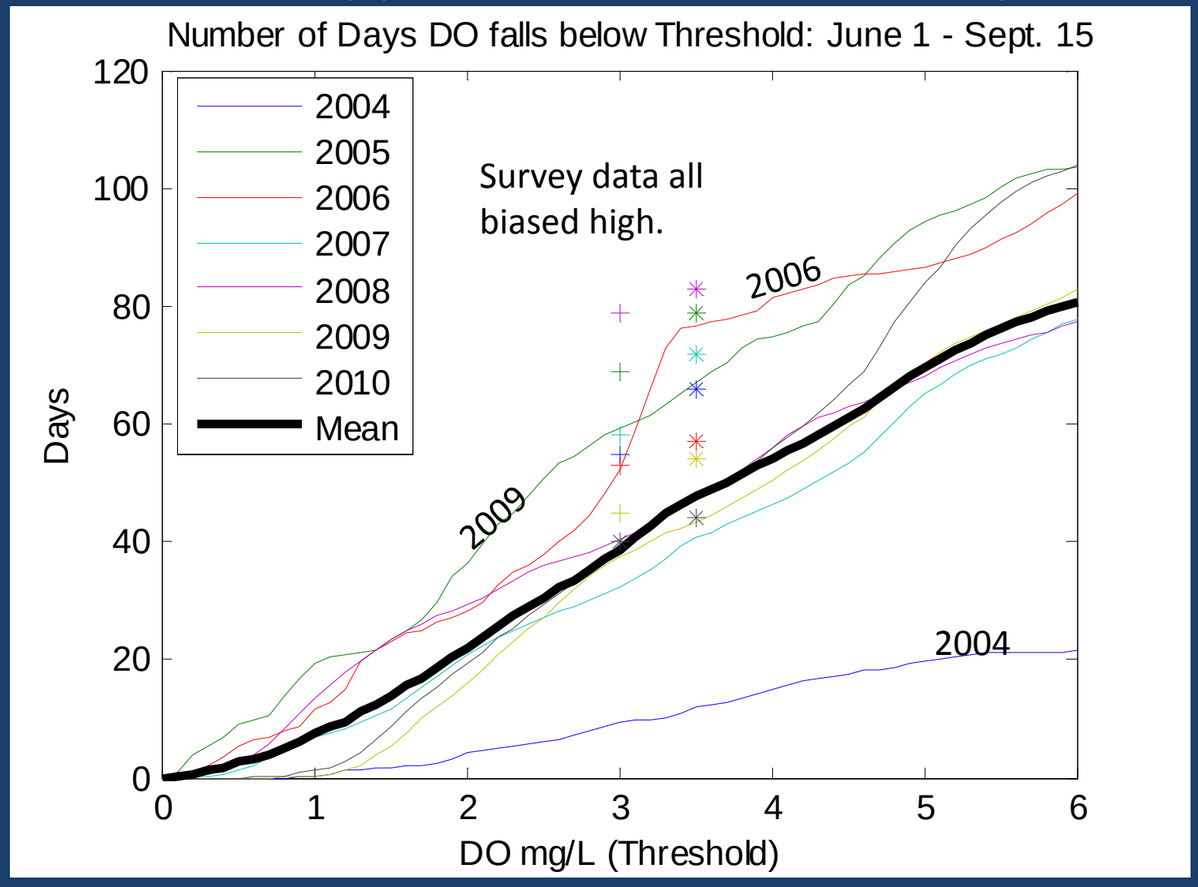


Area of Hypoxia with uncertainty intervals of 68 and 99%

1994-5 and 2003 were bad, 97 was good



Other more precise metric – duration of hypoxia at EXRK buoy



Recommendations

- Establish the consequences of the errors on SWEM in management decisions.
- Commit to support greater access to model code, parameter choices and results.
- Support greater data sharing.
- Develop analysis tools for hypoxic area, volume and duration with objective analysis and uncertainties.
- Commit to support sustained buoy observations and expanded instrument deployment (nutrients)
- Consider upgrades to ship surveys- production and respiration, species, currents, towed vehicles
- Integrate buoy observations to WQ goals.