Factors Regulating Hypoxia in Coastal Water

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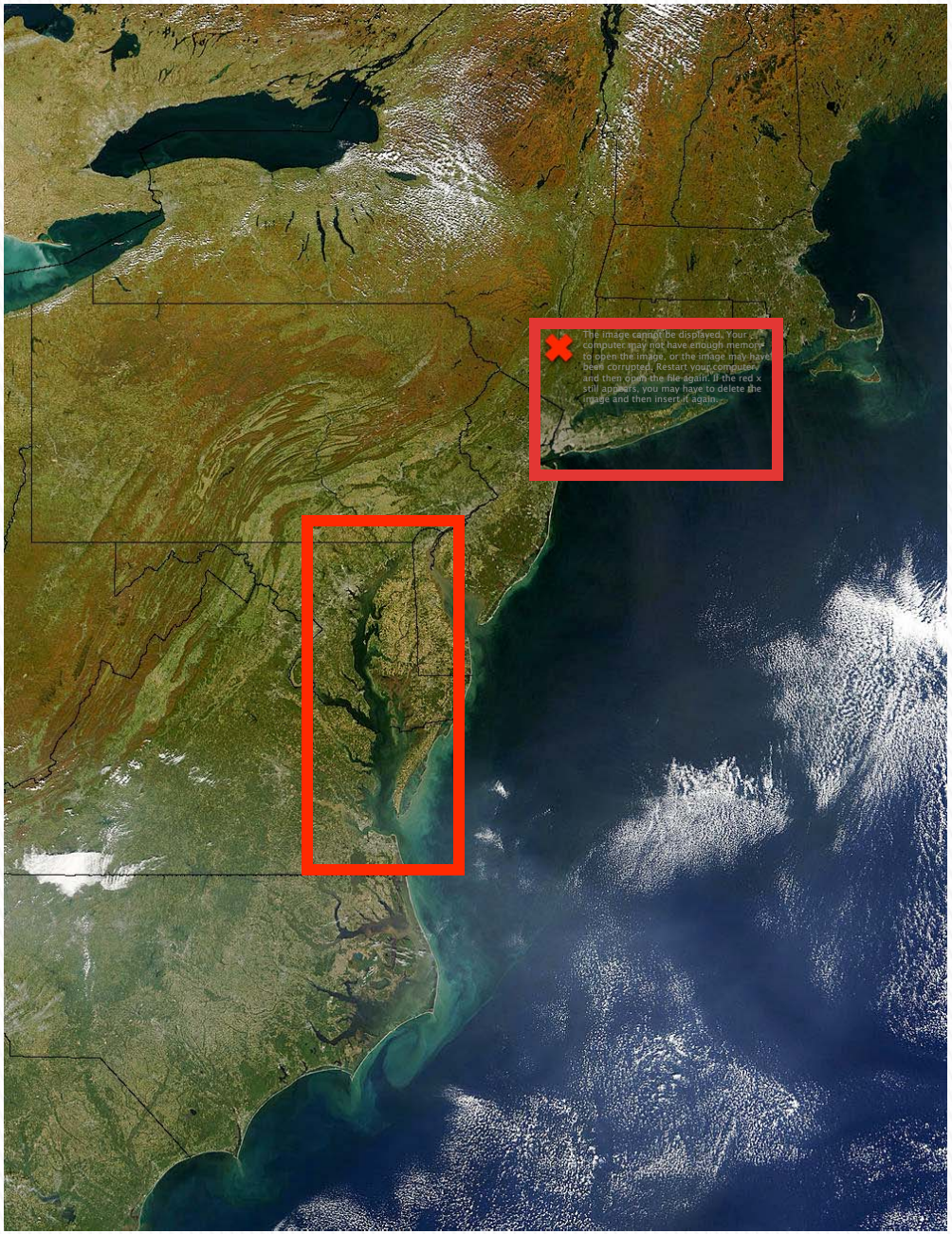
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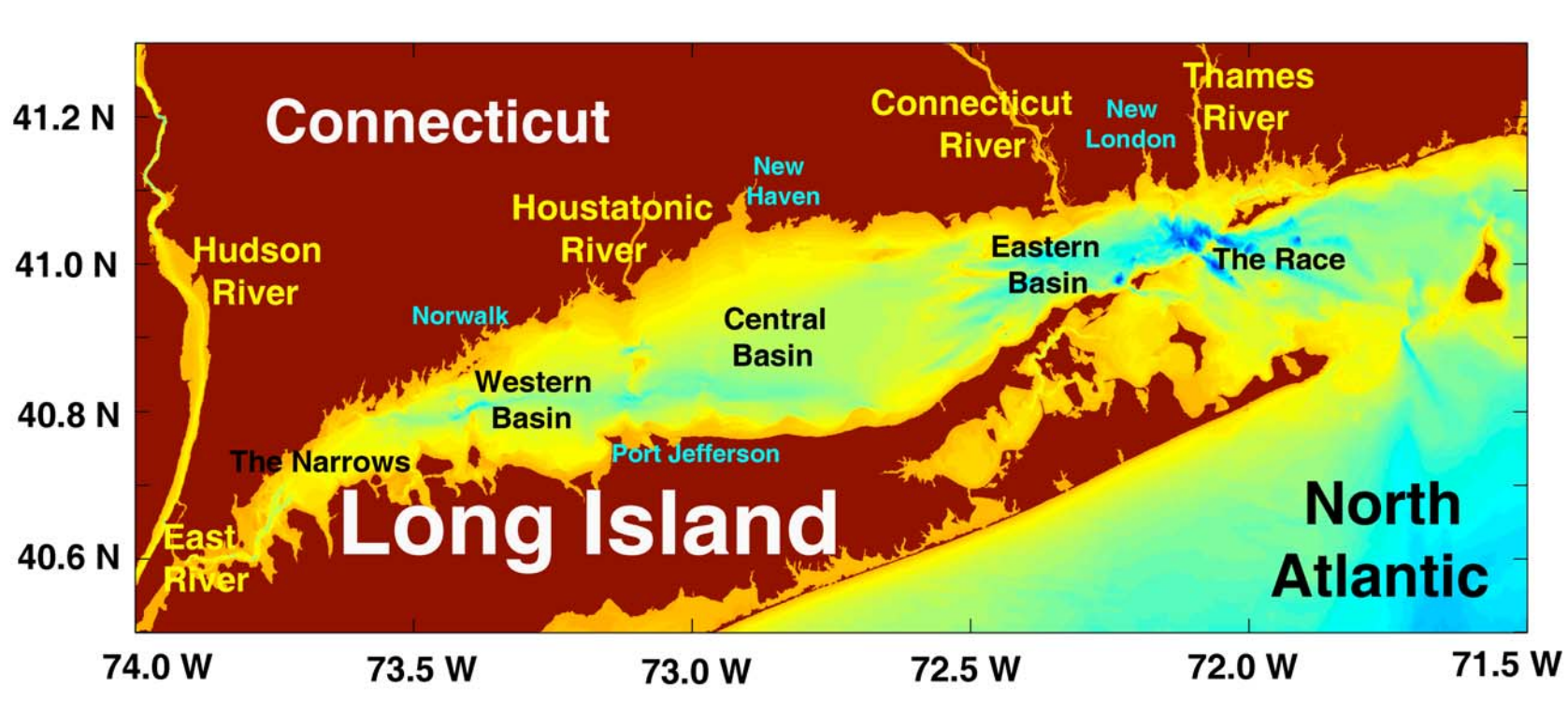
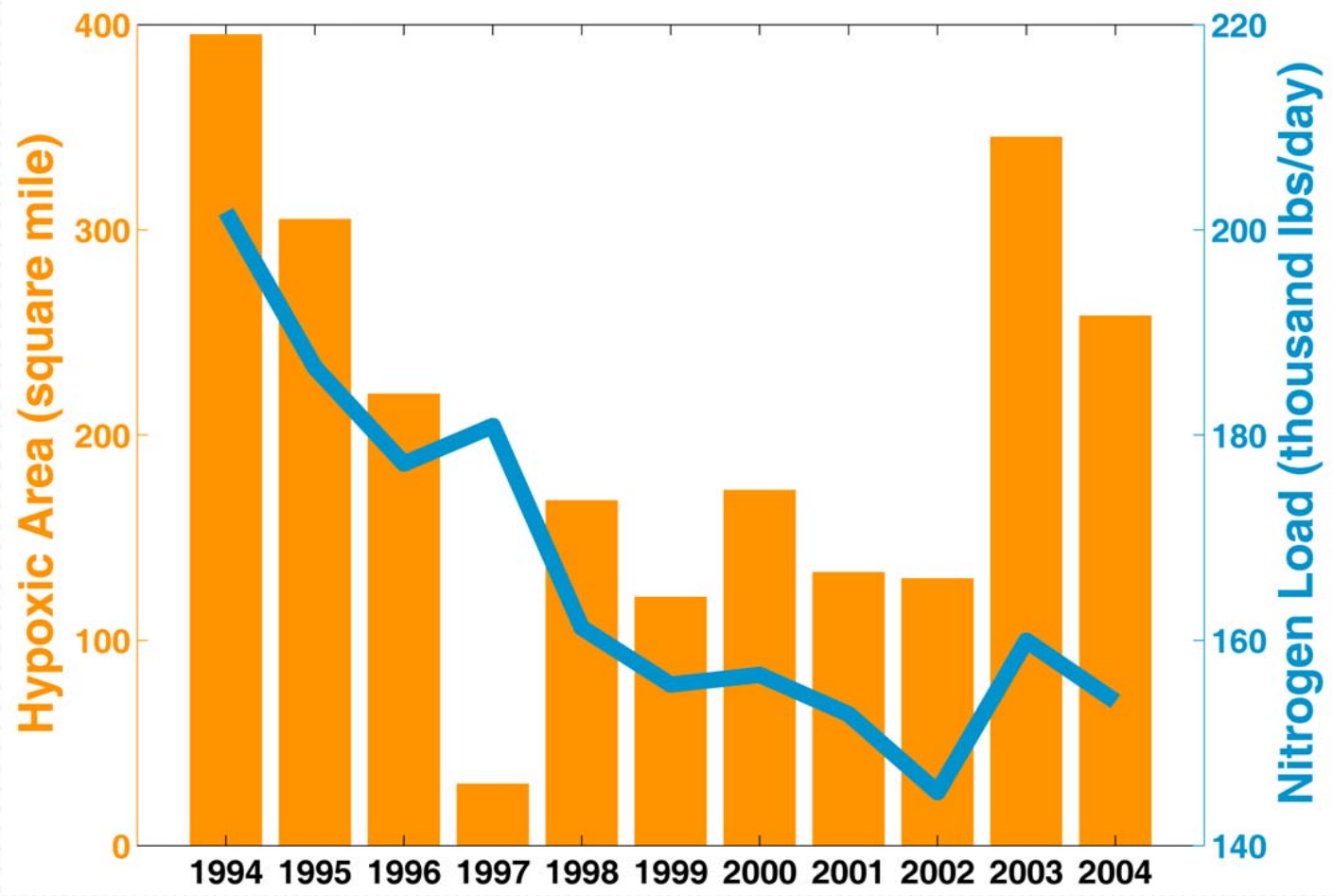
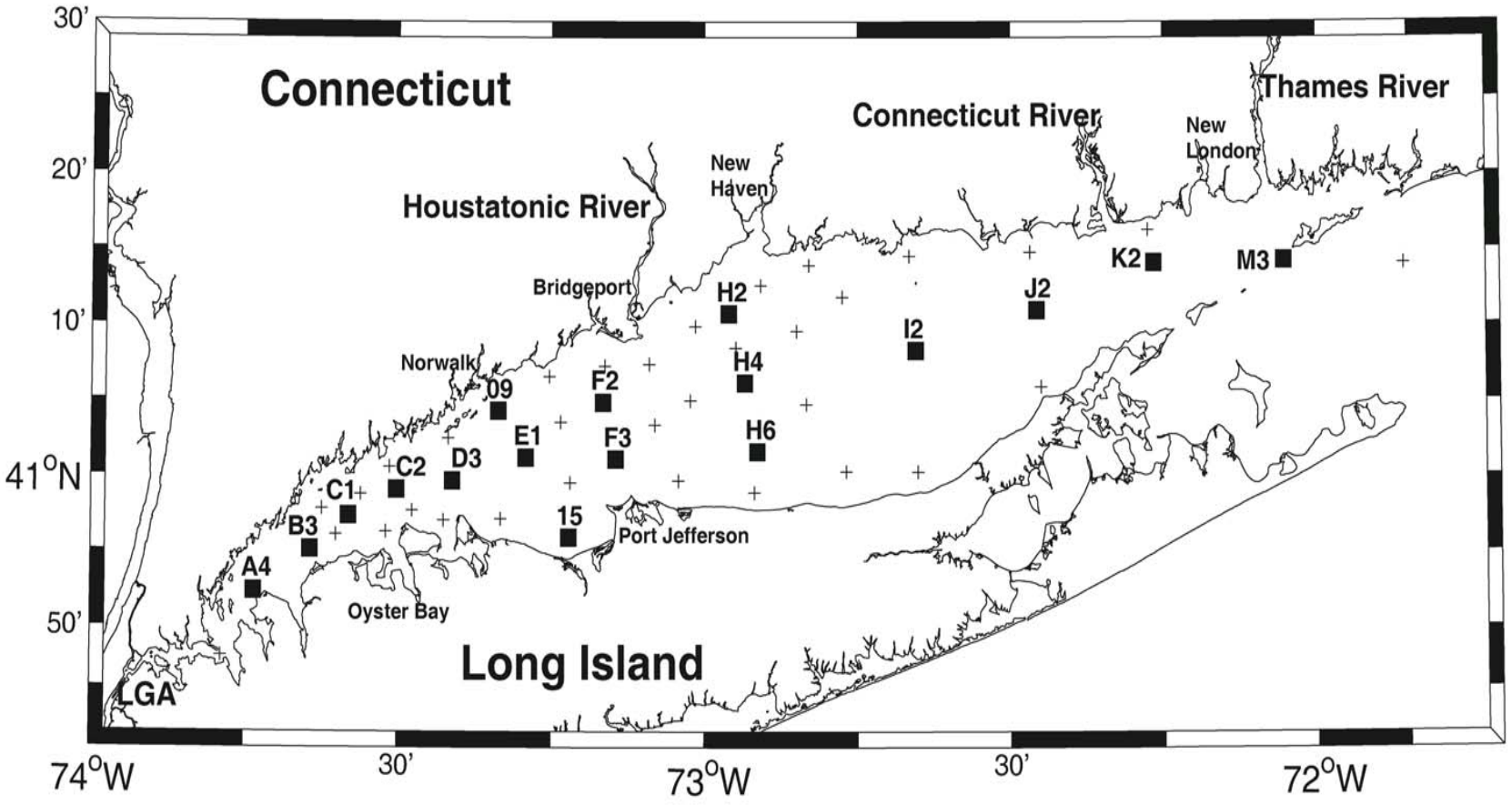
Long Island Sound



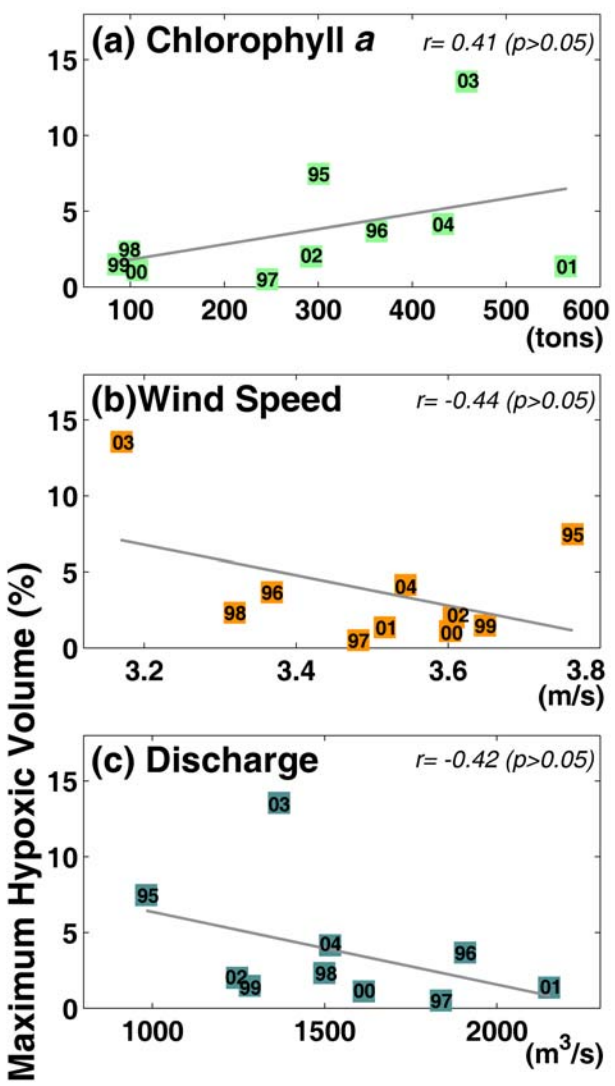
Motivation

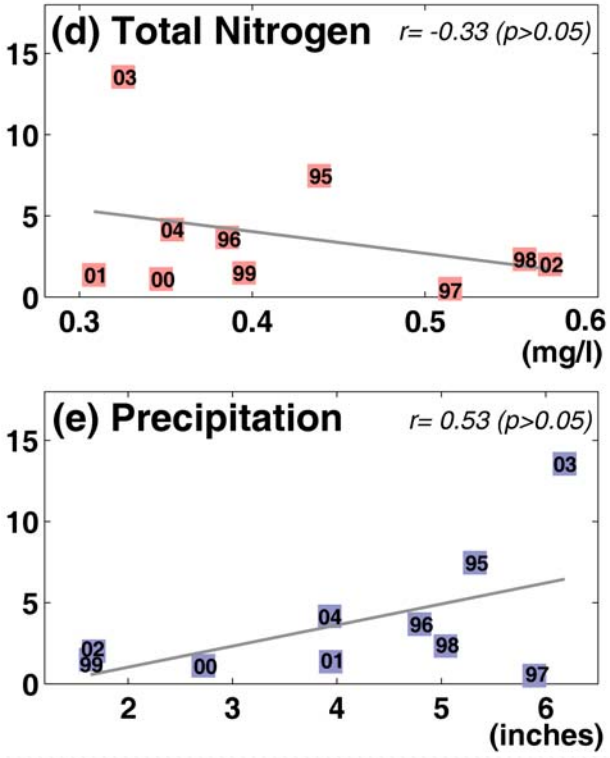

Hypoxic Area (square mile)
Nitrogen Load (thousand lbs/day)
400
300
200
100
0
220
200
180
160
140
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

CTDEP Monitoring Program (1995–2004)



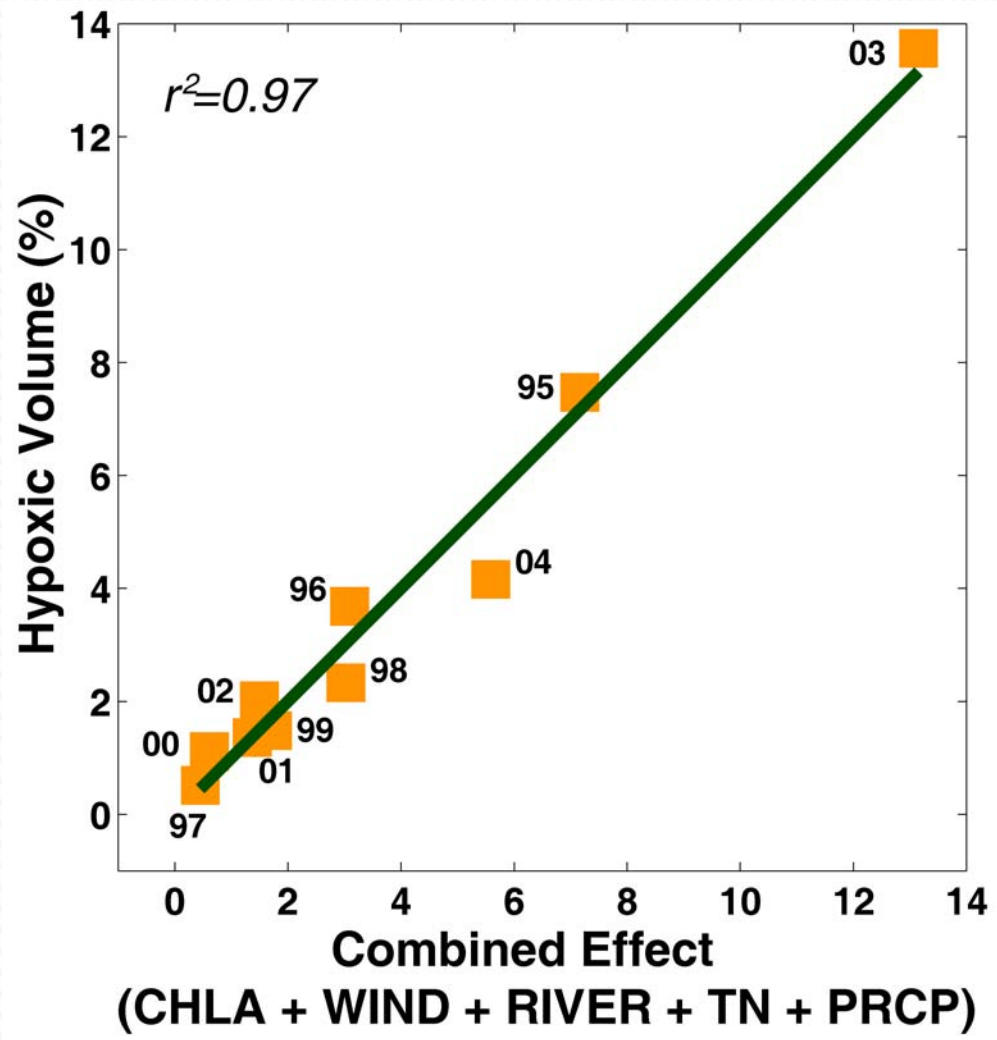
What Controls Hypoxia in LIS?





Hypoxia when DO < 3mg/l

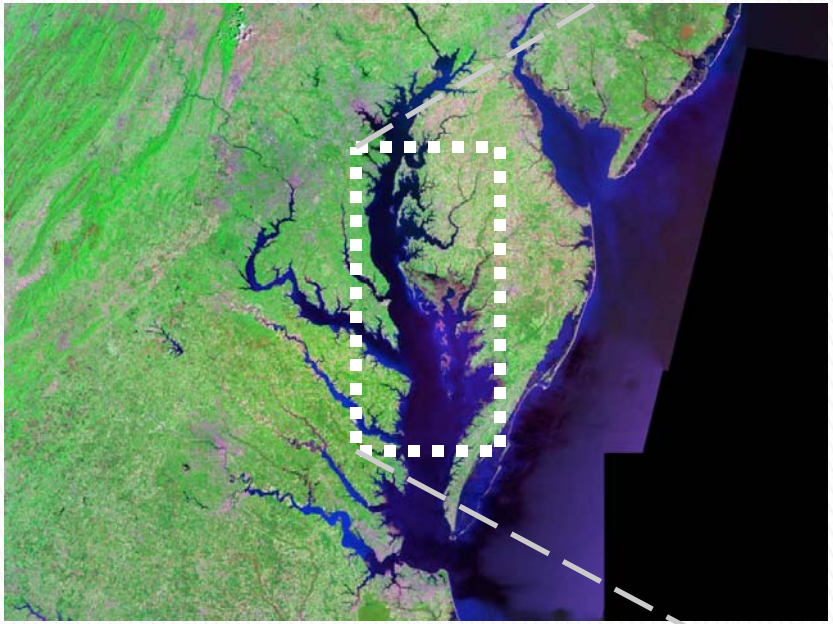
It's complicated

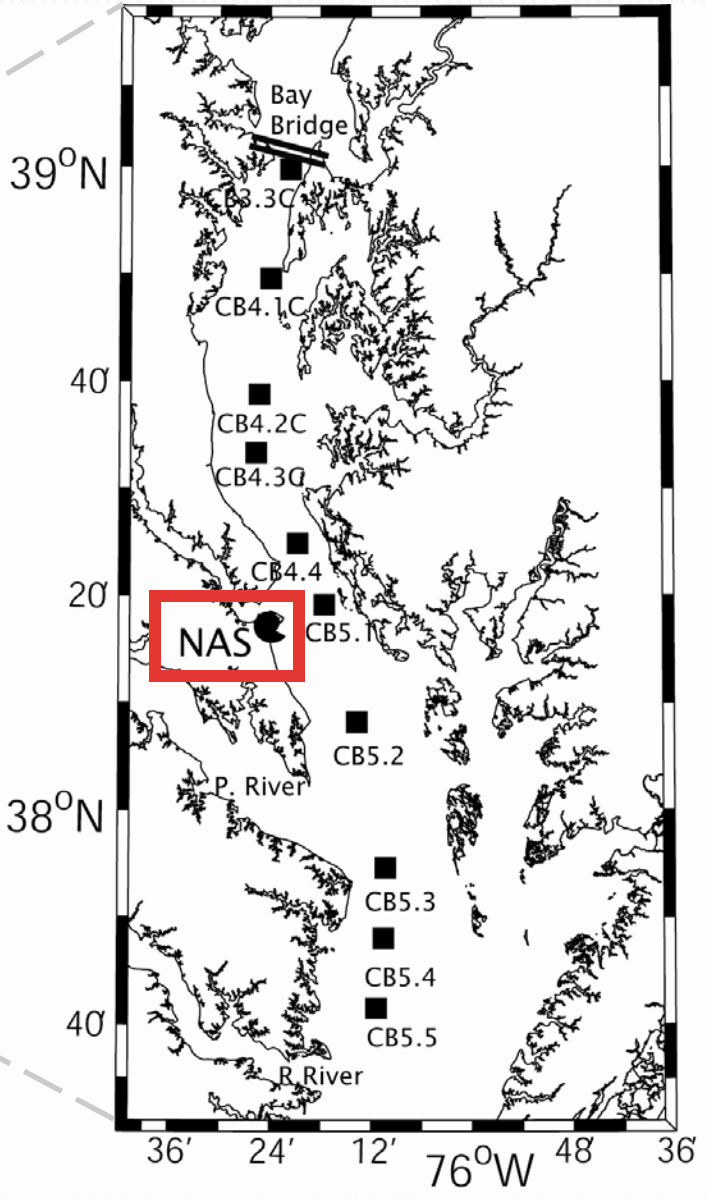


Summary

- The variability of hypoxia in LIS interacts with processes affected by climate change.
- Thus, basing the TMDL policy on nitrogen load alone makes it difficult to manage hypoxia.

Chesapeake Bay



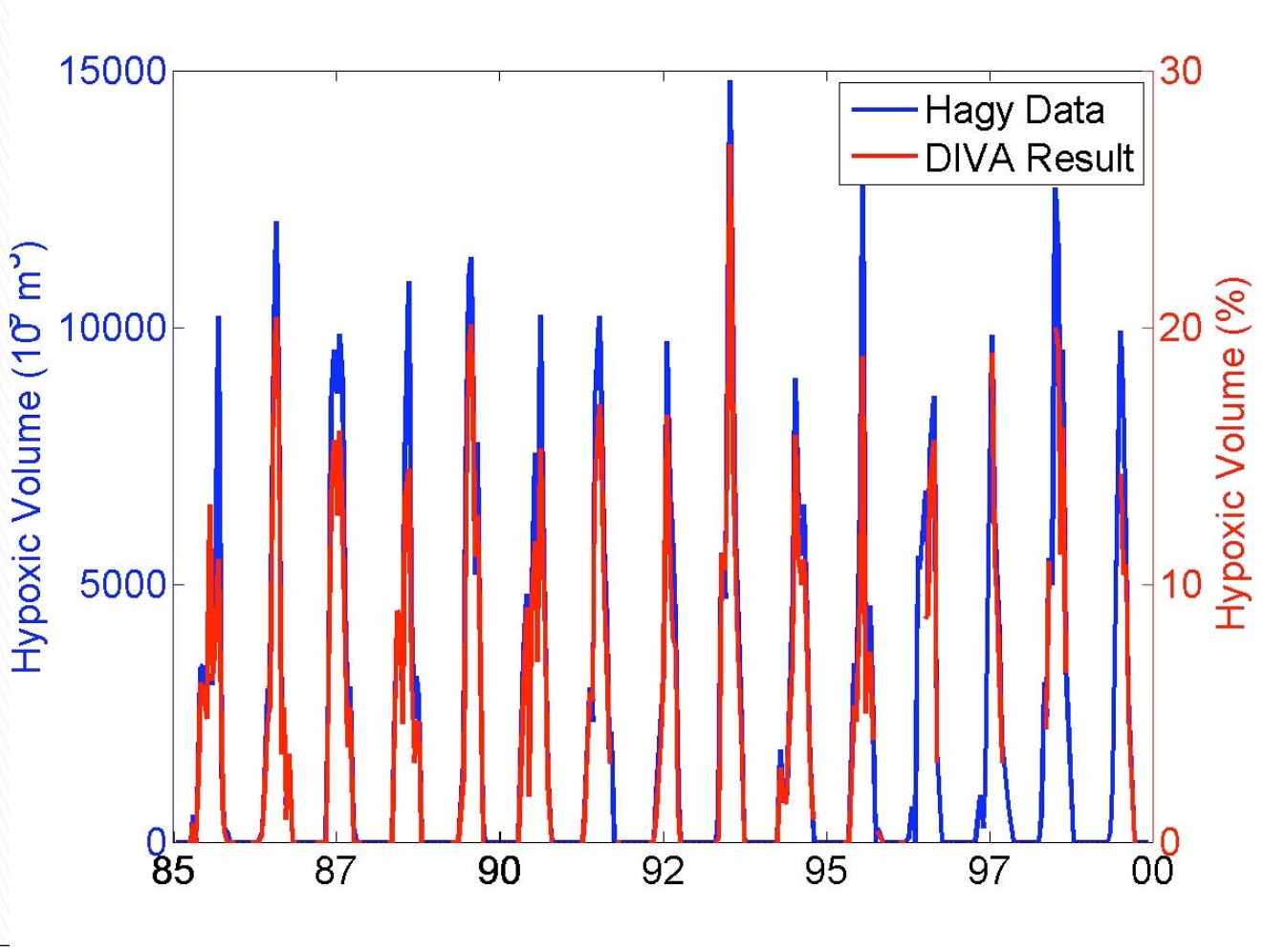


DO Interpolation

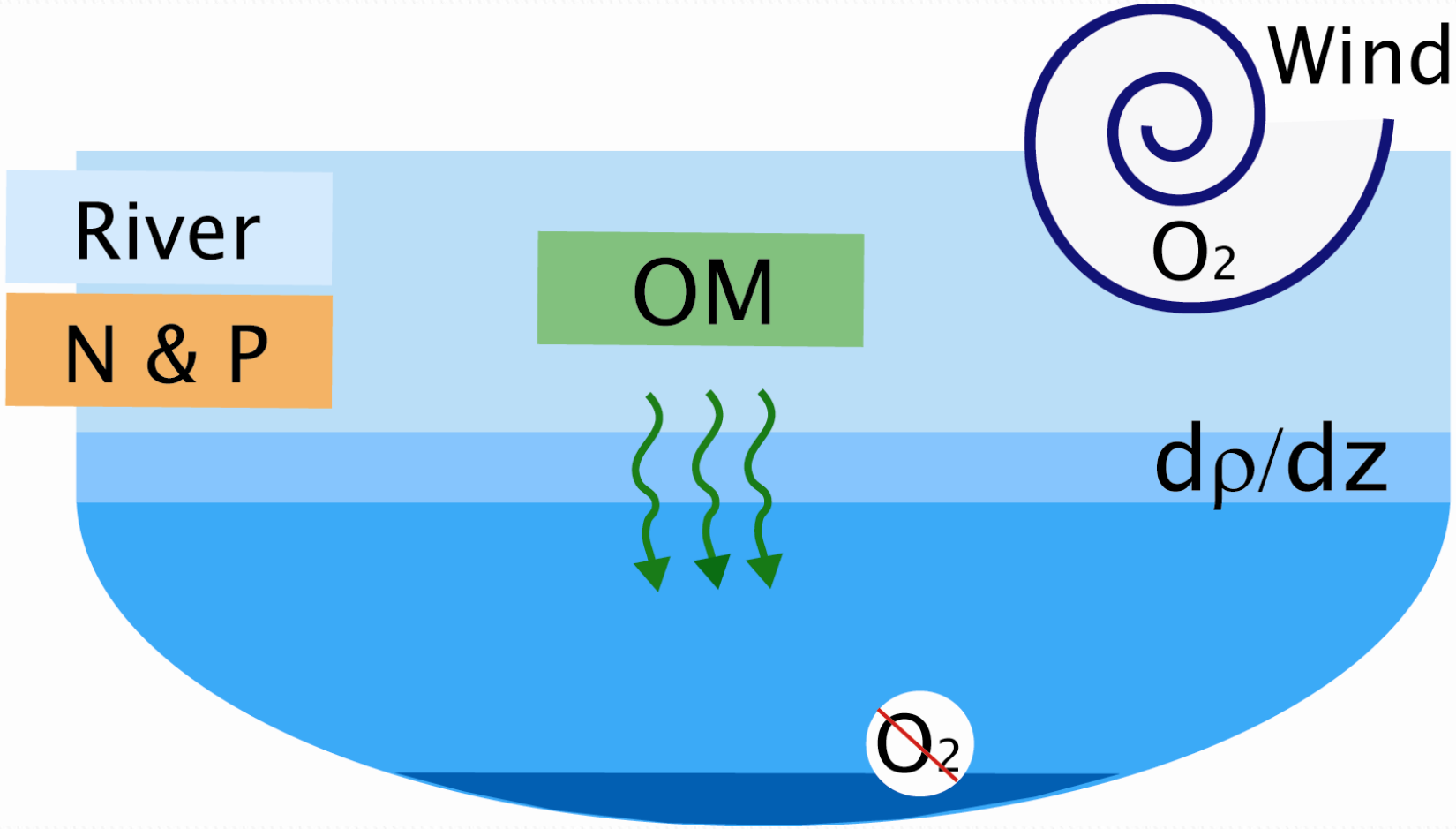
- DIVA (Data Interpolating Variational Analysis) software
- CBP Data from 1985 to 2007 covering the whole bay
- 3-D interpolation = stacking 2-D interpolation for each cruise
- 30-sec horizontal and 1-m vertical resolution [373×157×45]

Hypoxic Volume

$$\% = 100 \times \frac{number\ \ of\ \ cell\ (DO \le 2\,mg/l)}{Total\ number\ \ of\ \ cell}$$



Which Is Important?



Correlations with Hypoxia

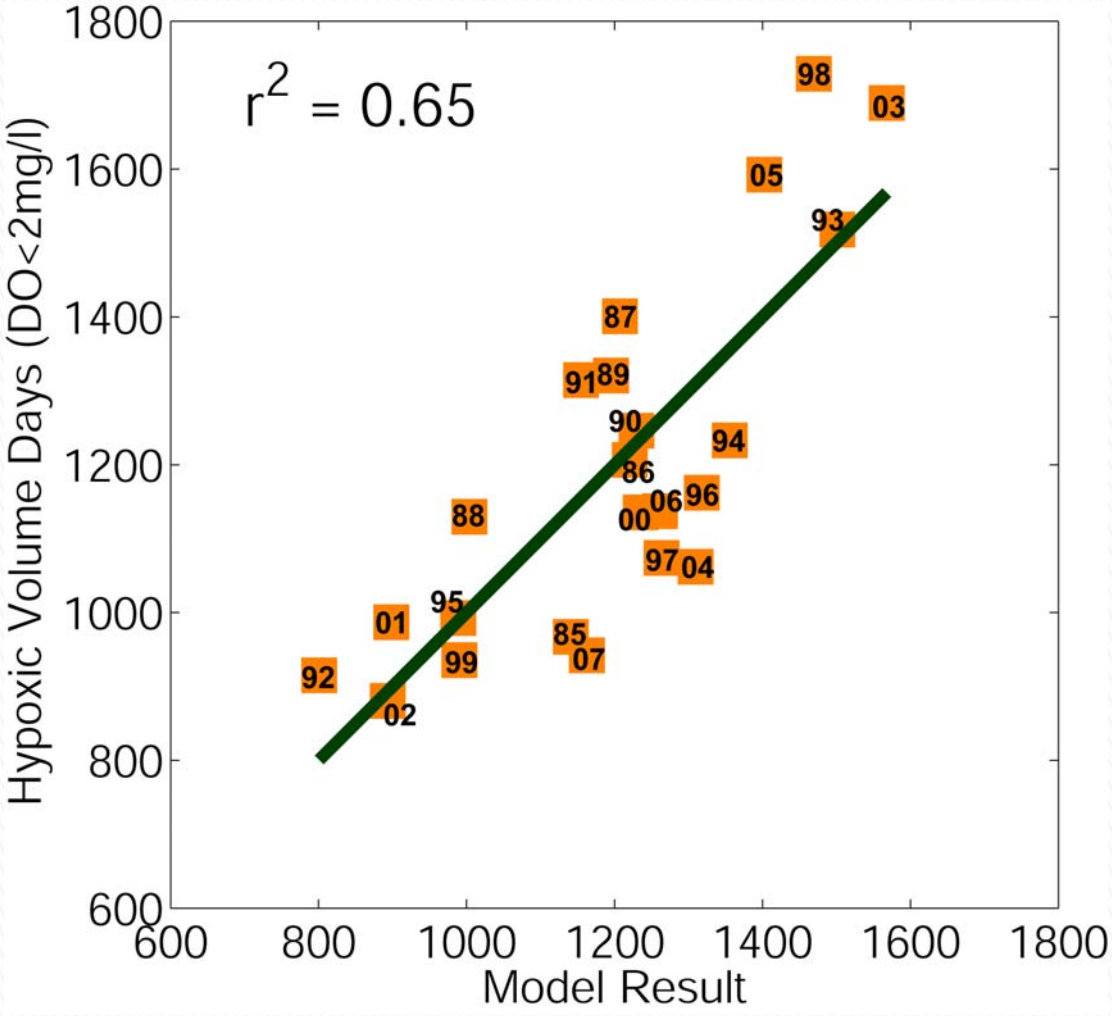
	Hypoxic Volume-Days* (DO≤2mg/l)
Stratification** (N^2 in July)	$r=0.61$ ($p<0.01$)
Algal Biomass** (Jan-Apr Chl-*a*)	0.58 ($p<0.02$)
River Discharge (Jan-Apr)	0.61 ($p<0.01$)
Total Nitrogen Load (Jan-Apr)	0.63 ($p<0.01$)

* [%・day] integration of daily hypoxic volume that was linearly interpolated

** mean values from station CB3.3C to CB5.5

When Combined

[Spring Discharge + Spring chlorophyll-a + Summer Stratification]

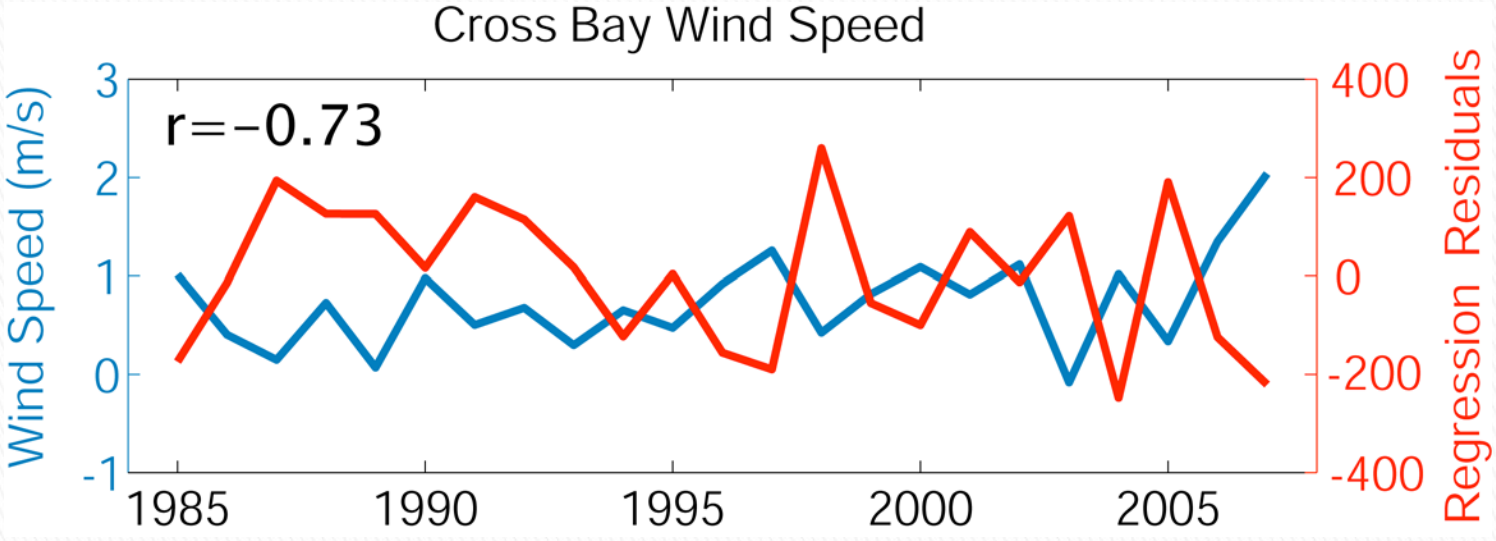


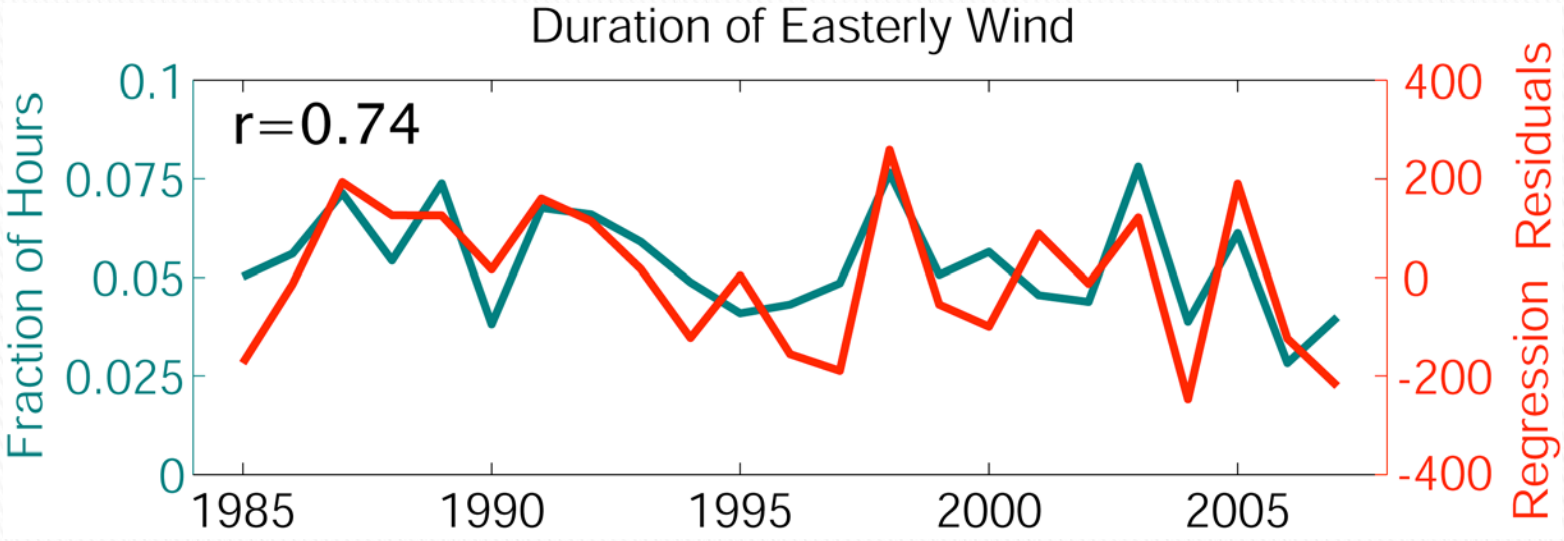
Correlations with Summer Wind

	Duration of Summer Wind* (May–August)			
	N	NE	E	SE
Regression Residuals ♪	r=–0.29	0.13	0.31	0.06
	S	SW	W	NW
	–0.26	–0.37	0.22	0.09

* total time (fraction of hours) that wind (>2m/s) was observed from 8 directions

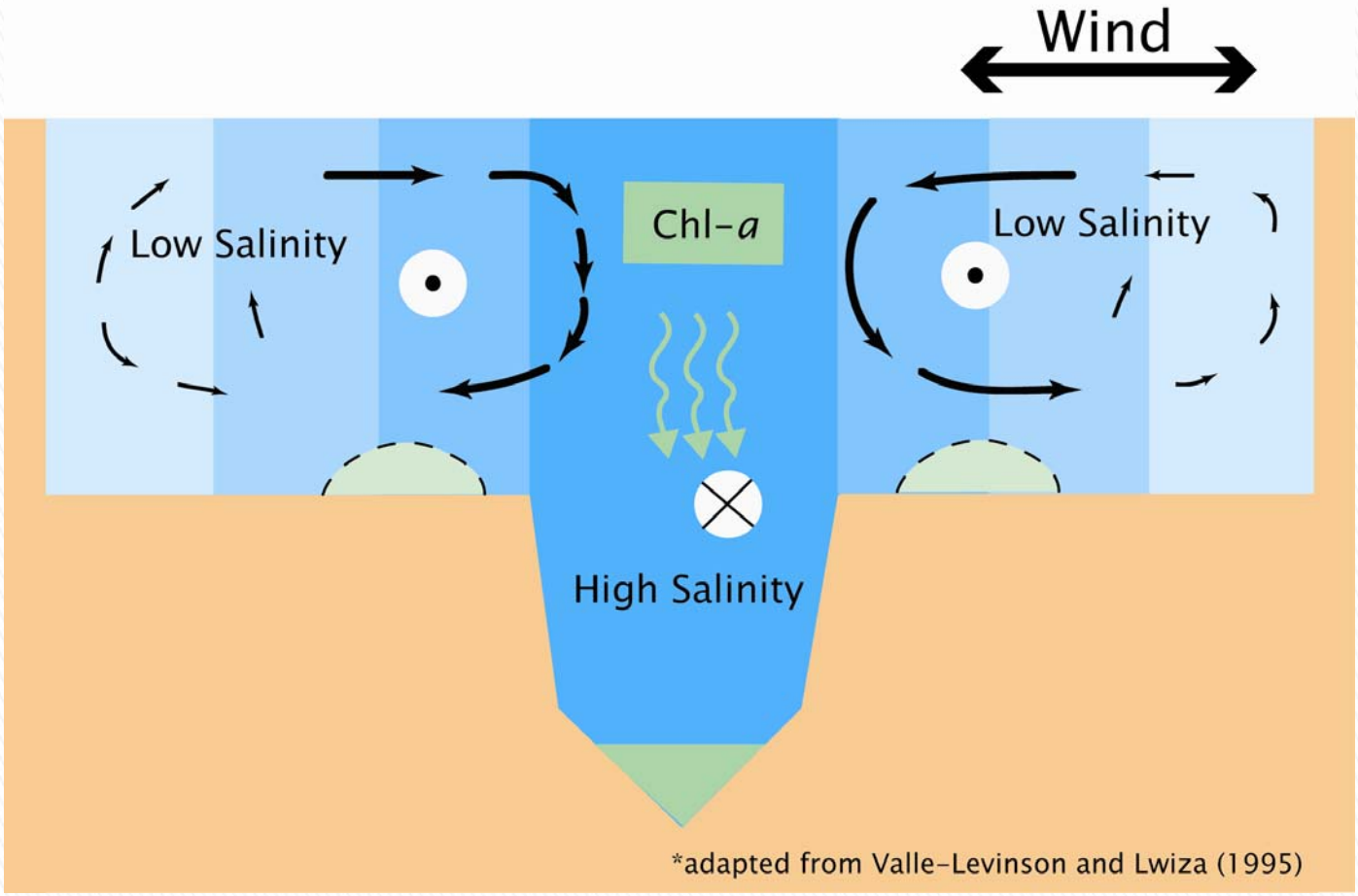
Winter/Spring (Jan-Apr) Wind



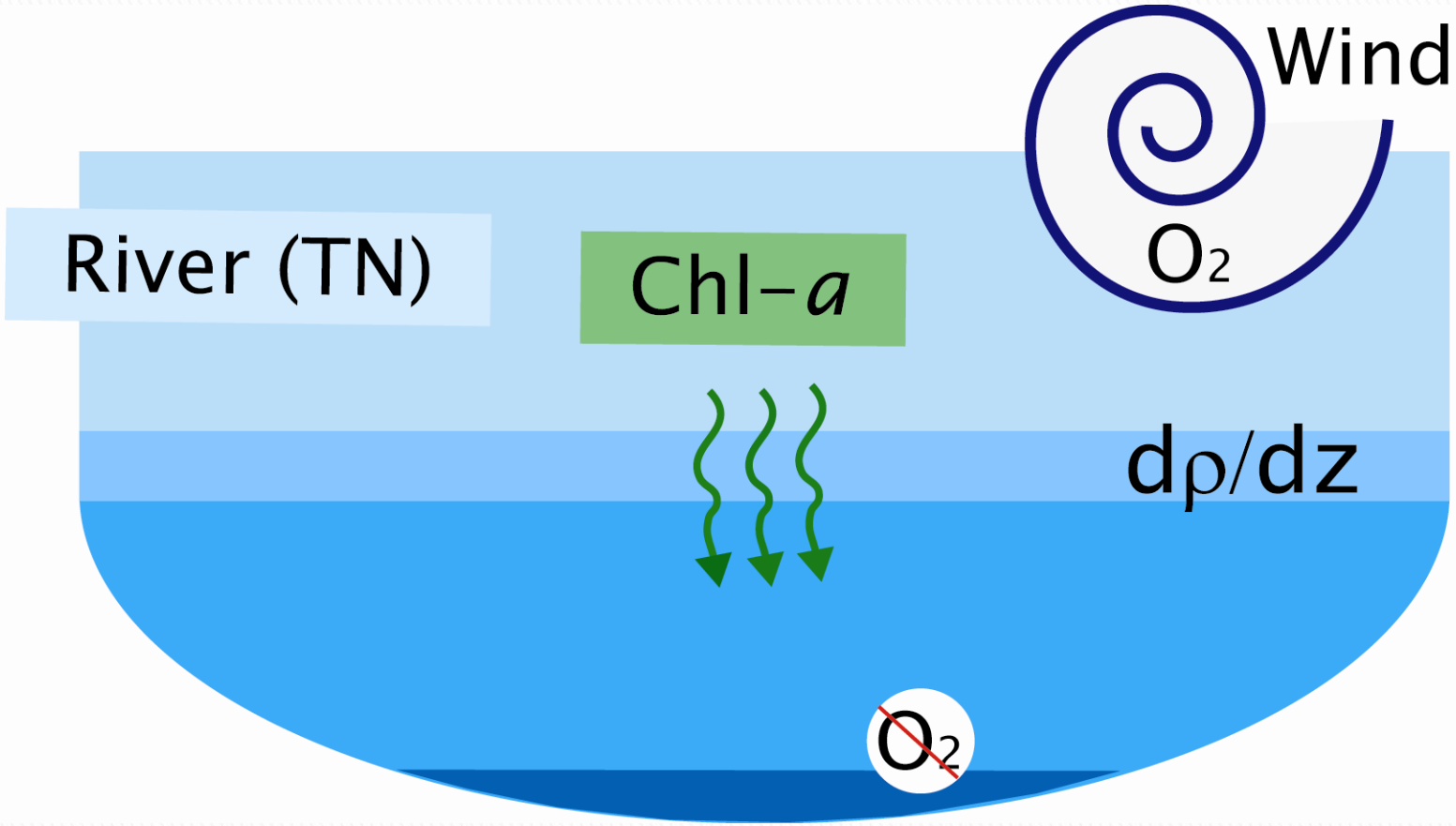


Role of Winter/Spring Wind

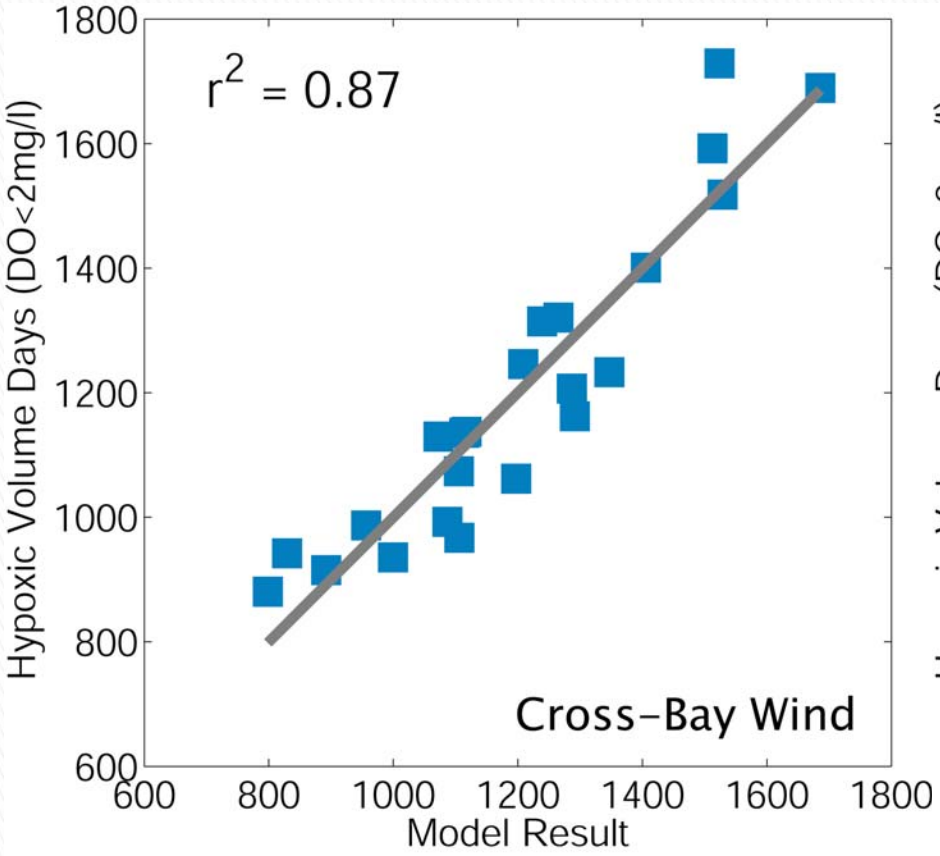
- Lateral circulation

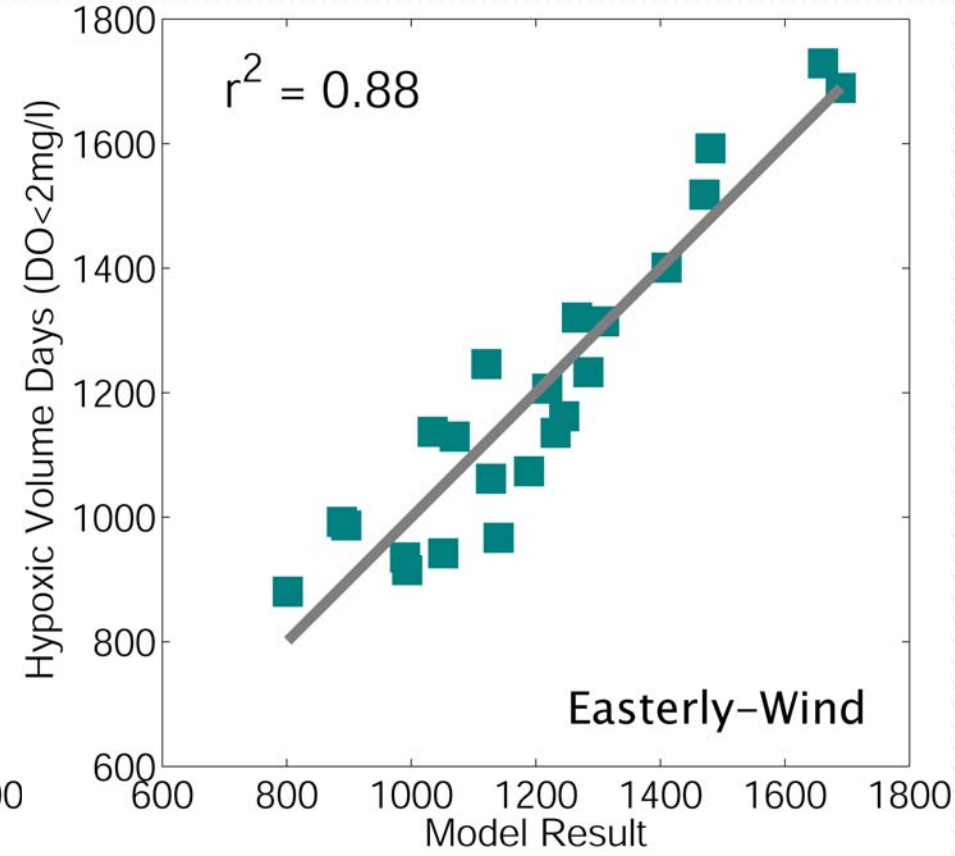


Regression Analysis



Regression Analysis (85-07)





* Without N^2, r^2 is 0.83 and 0.84, respectively.

Further Study

- Numerical Simulation
  - To examine the development of near-surface convergence in lateral structure.
  - To investigate the shift of the convergence under different river discharge and wind forcing
- Observational Effort
  - To explore the lateral structure of residual flows and to calculate the fluxes during spring season via extensive hydrographic survey

Summary

- Hypoxia in the Chesapeake Bay are mostly influenced by the conditions during winter/ spring season.
- Wind > Chl-*a* > Discharge > Stratification
- Near-surface convergence in lateral structure may be enhanced (weakened) or shifted due to cross-bay wind.
- Thus, it most likely affects lateral transport of organic matter during spring bloom.

Acknowledgement

- This work is the part of the project *"CHRP07: Modeling Hypoxia and Ecological Responses to Climate and Nutrients"* which is funded by NOAA under grant NA07NOS4780191.

- Thank You!