Seasonal Sub-Oxic Effects on Ph in the Chesapeake Bay

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Introduction

Seasonal hypoxia and anoxia are well established features of the Chesapeake Bay. The extent and duration of sub-oxic conditions have increased over the last half century, corresponding to human activities that cause eutrophication. Hypoxic conditions set in during the late spring and summer months as the estuary stratifies – warmer and fresher water draining from land overlying a cooler and saltier subducting layer of marine origin. The highly productive surface waters produces algal blooms that eventually sink through the pycnocline . The subsequent decay of the sunken phytoplankton consumes much of the available oxygen in these deep and dark waters. Thus, the physical stratification of the Bay results in an autotrophic layer overlying a heterotrophic layer, and the dominant biochemical processes in each alters the pH. In general, high rates of photosynthesis at the surface reduces concentrations of CO2, while respiration in the deeper waters increases concentrations of CO2 (and organic acids). This tends to drive up pH at the surface and drive it down below the pycnocline. Unlike for inland lakes, historically pH received relatively little attention in marine and estuarine waters, since the prevailing dogma assumed the relatively high buffering capacity of marine waters would prevent any significant swings in pH. Yet recent studies document a 0.1 unit of acidification for the World's oceans as a consequence of CO2 emissions from fossil fuels. The purpose of this study is to characterize pH in the main-stem of the Chesapeake Bay during early summer, to test for changes over time, and to relate pH to other key parameters.

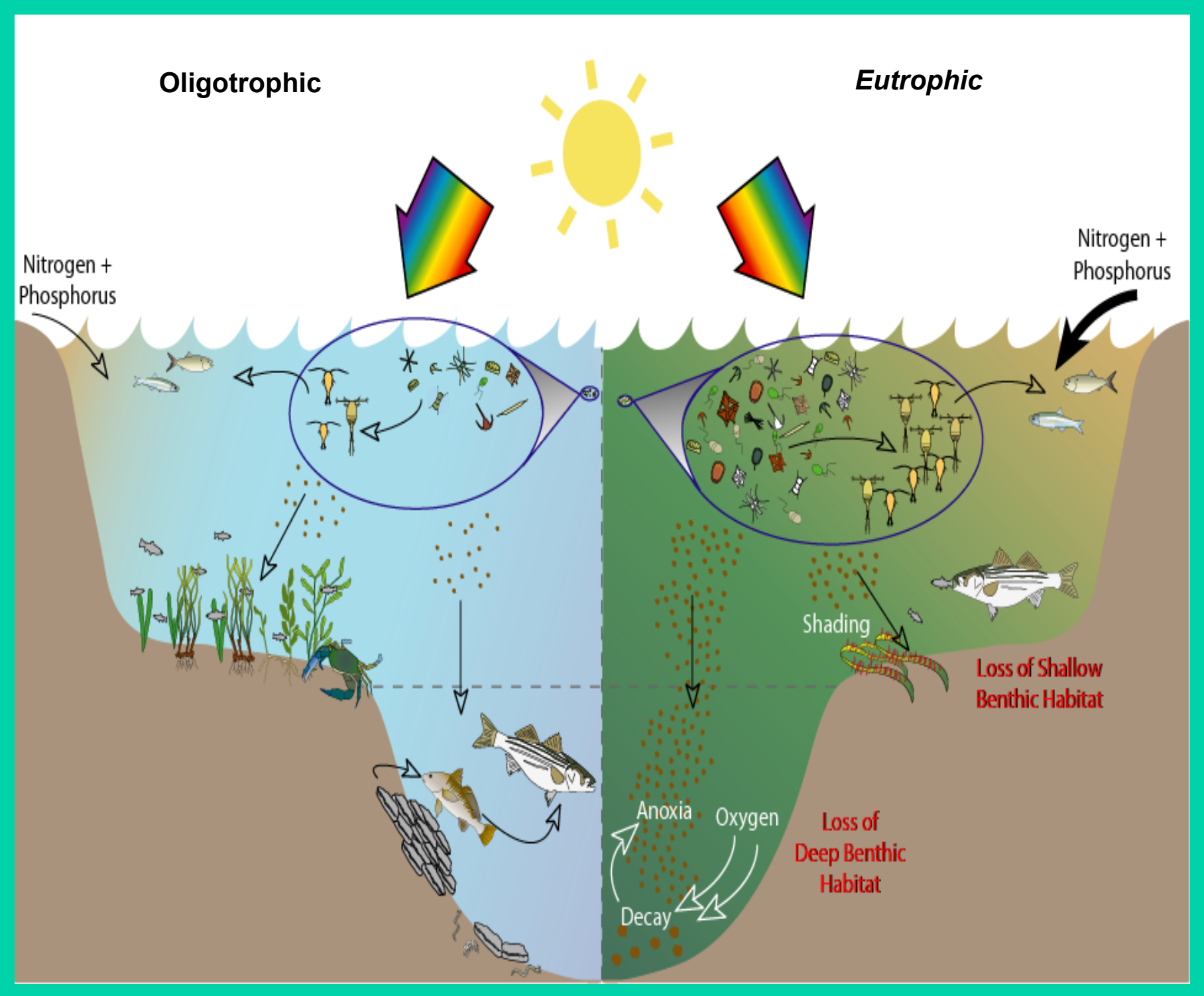


Figure 1: Diagram on how to assess varying eutrophication criteria

Study Site/Methods

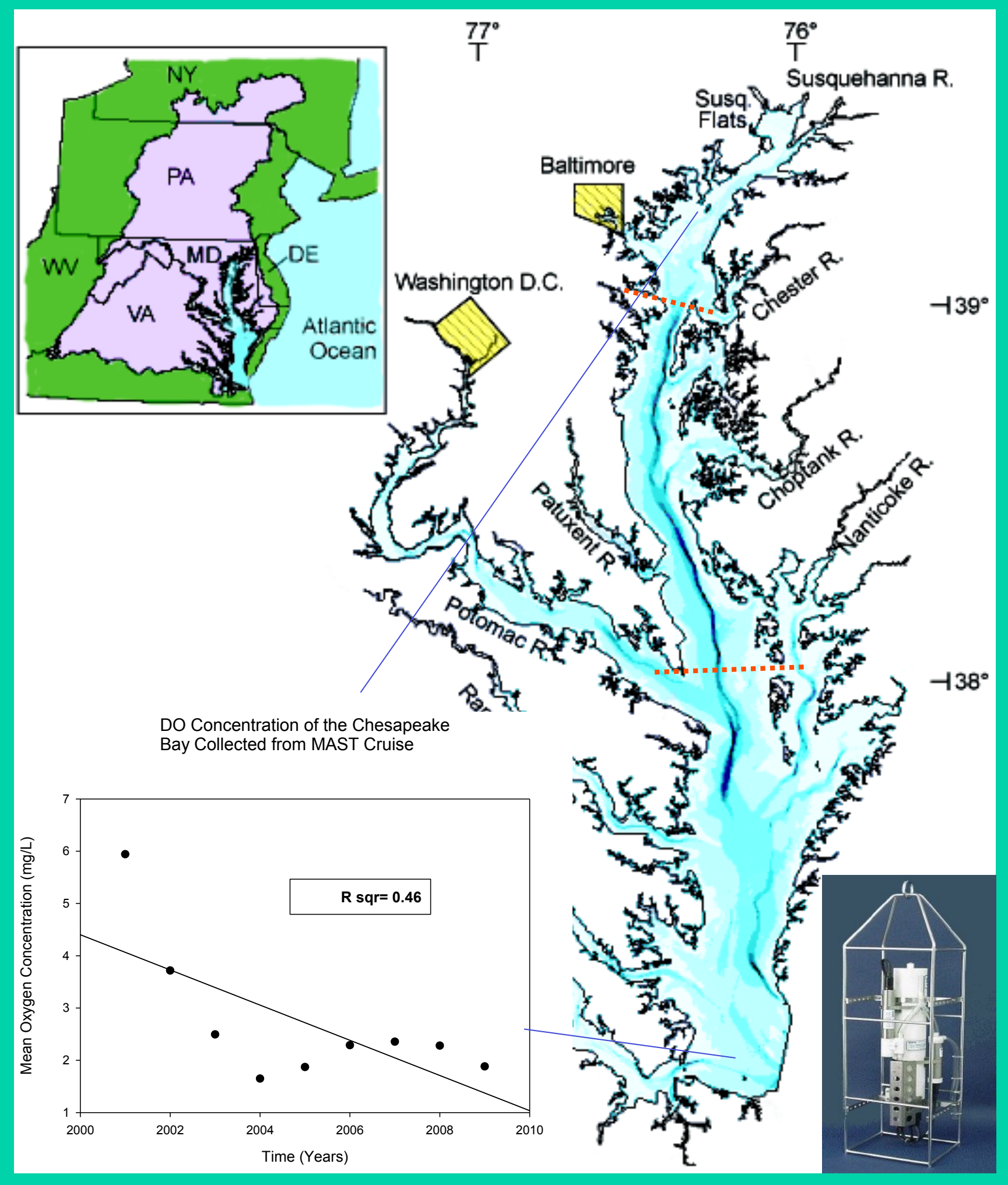


Figure 2: DO over time collected on MAST Cruise using Seabird CTD Probe in the Chesapeake Bay

Objectives

- Characterize the pH of the main-stem of the Chesapeake Bay in early summer.
- Examine inter-annual variation of pH between 2003 - 2009.
- Test the relationship between pH and; chlorophyll, and oxygen concentrations

pH Data/Results

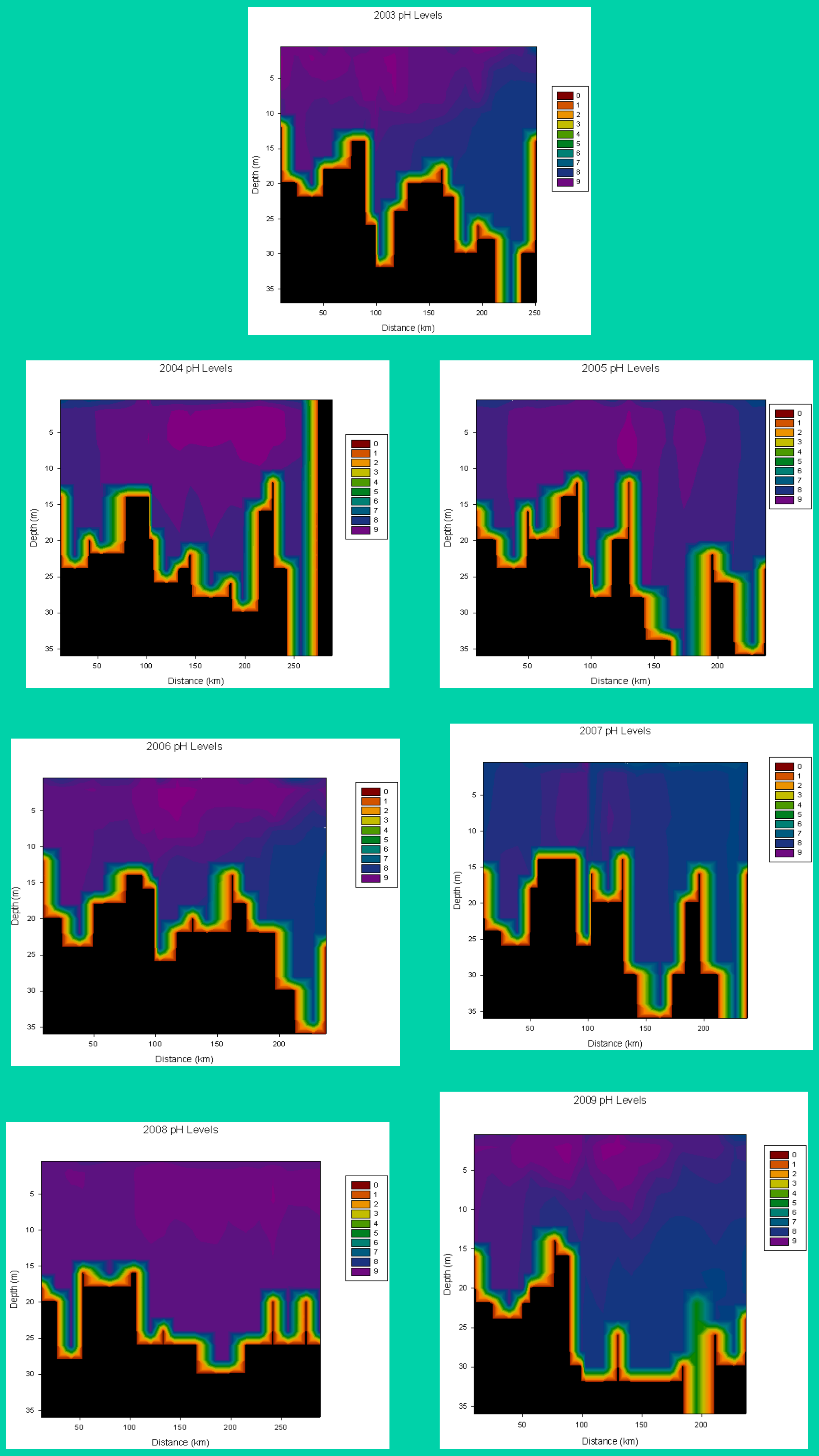


Figure 3a-g: Contour map of pH levels in the Chesapeake Bay from the mouth to the headwaters (Susquehanna mudflats)

pH Monitoring data

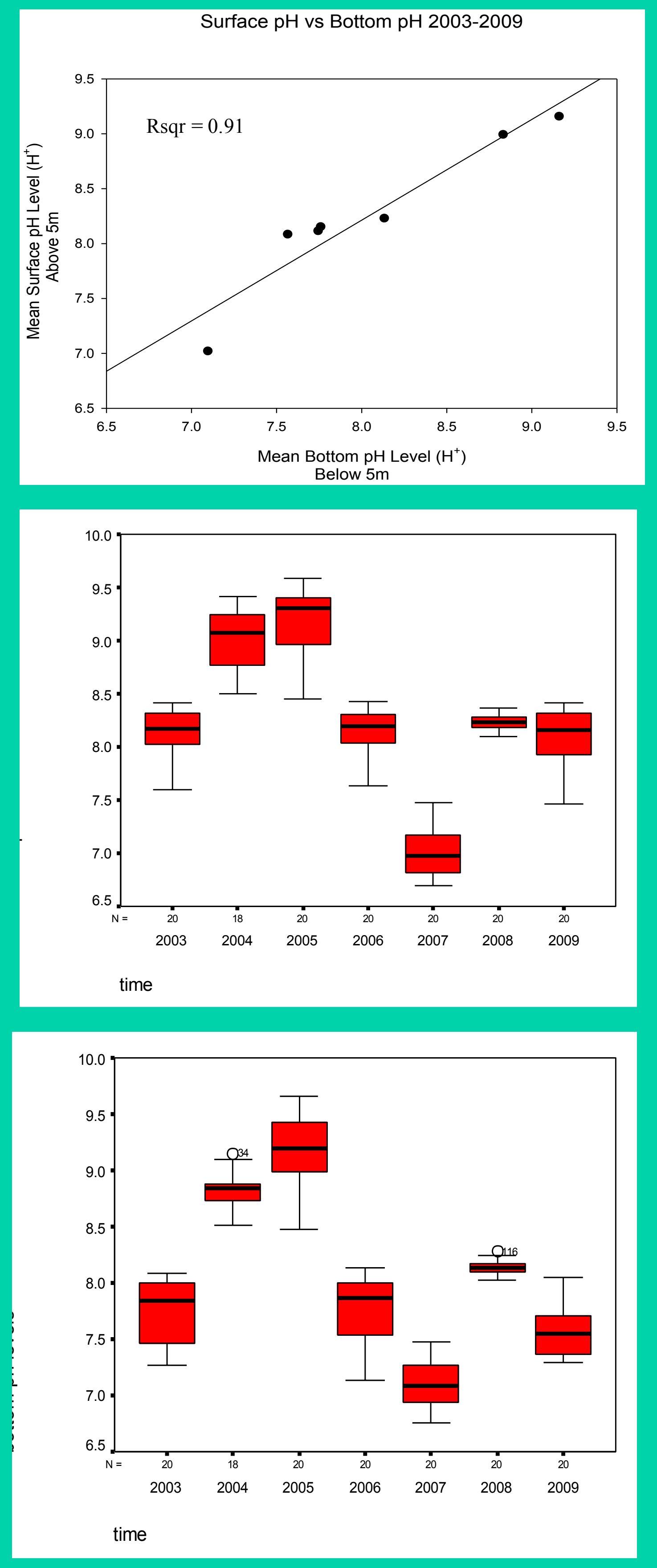
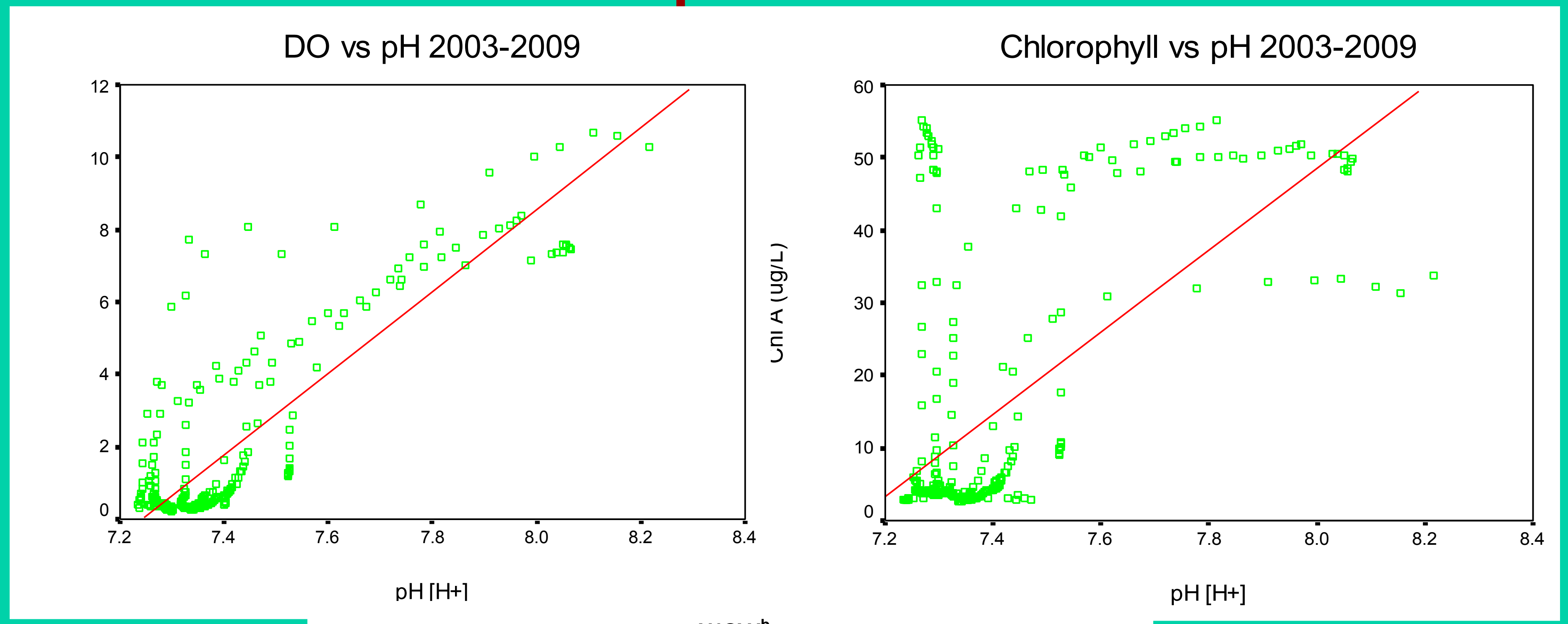


Figure 4a-c: Monitoring data of surface and bottom ph levels collected on MAST Cruise

Correlation between pH and Sub-Oxic Parameters



ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.715	3	3.238	345.823	.000[a]
	Residual	2.893	309	.009		
	Total	12.608	312			

a. Predictors: (Constant), DO, Chlorophyll

b. Dependent Variable: pH

Figure 5a-c: Statistical analysis comparing pH, DO, Chl A from MAST

Discussion/Future Work

The distribution of pH along the main-stem of the Bay clearly reflected the organizing influence of seasonal stratification. Surficial pH always higher than that below the pycnocline (Fig4a-c). While reduced levels of oxygen dominate traditional thinking about the deleterious effects of "dead zones," pH and perhaps other chemical parameters (DMS or H_2S for example) may also play important roles in determining the viability of habitats impacted by eutrohication.

Inter-annual variation in pH hints at a decline over the last 7 years, yet no definitive pattern emerges. While annual increases in atmospheric CO2 might drive such a pattern, although our data suggests that pH changes driven by annual variation in productivity and mixing with no significant correlation; indeed, we found a positive relation between pH, chlorophyll concentration and oxygen concentration (Fig 5a,b).

As was typical of traditional thinking regarding pH, we began the overall larger study focused on oxygen and other indicators of eutrophication, with little attention to buffering capacity. Extracting historical records of alkalinity would further inform our understanding as well as:

- Biochemistry (O2 budget, Photosynthesis & Respiration rates, diurnal comparison)
- Physical Nature (Wind, Hurricanes, etc.)
- Kinetics (ΔTemp, Δradioisotopic compostion, etc)
- Gas Exchange and how it relates to alkalinty

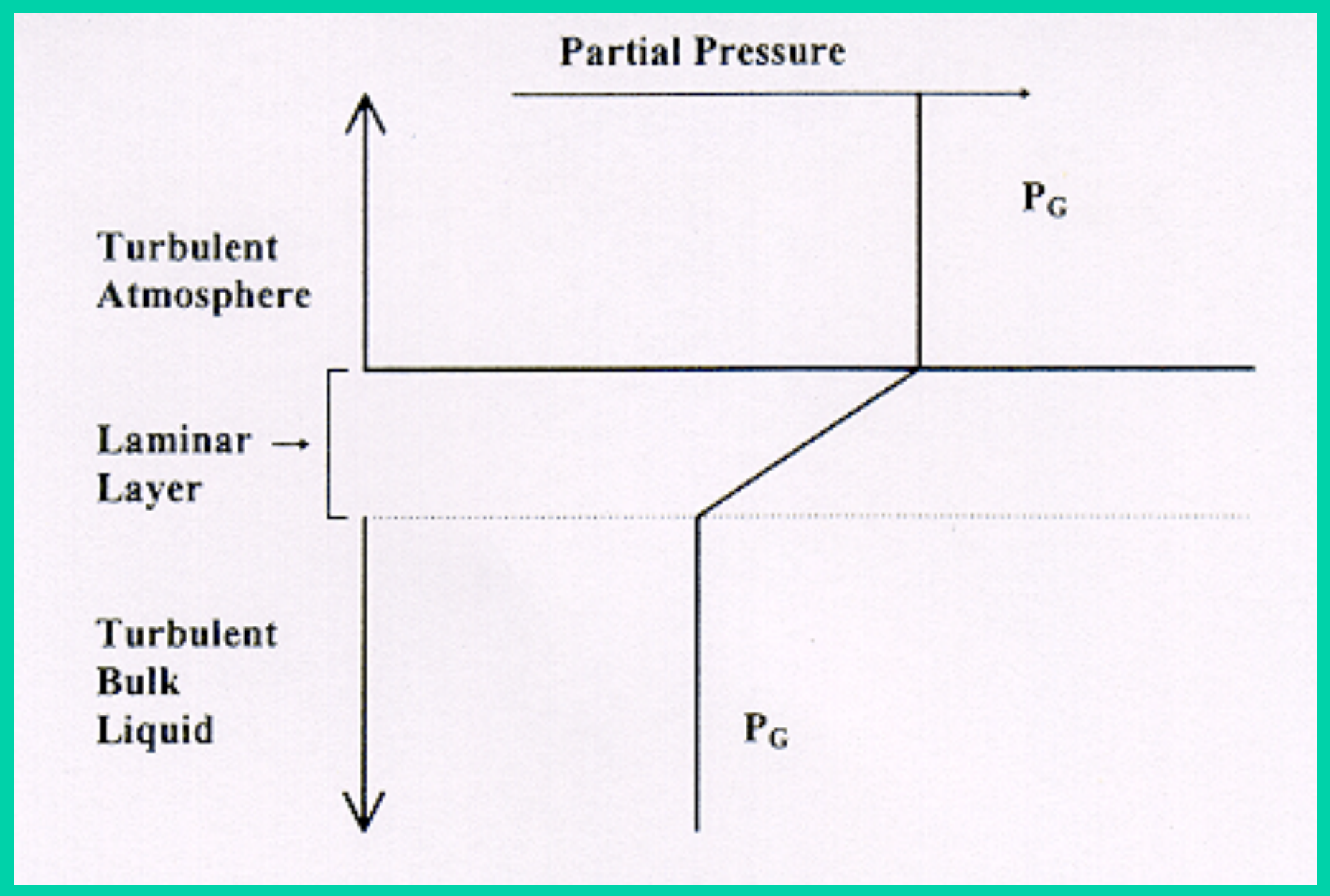


Figure 6: Stagnant Film Model

Acknowledgements: