

# Water Quality



Report for  
State of the Bay 2010

Casco Bay Water Quality Report for State of the Bay 2010  
Friends of Casco Bay, 2009



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## Water Quality report for State of the Bay 2010

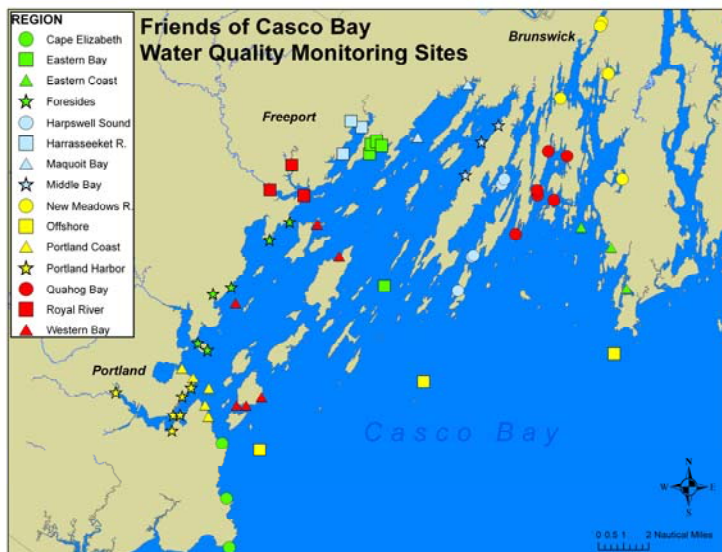
Friends of Casco Bay has collected water quality data through staff and volunteer programs supported by the Casco Bay Estuary Partnership since 1993. All data is collected under the guidance of an EPA-approved Quality Assurance Project Plan.

Water quality in Casco Bay is determined through the use of a number of indicators that are tracked over time. These indicators include Dissolved Oxygen, Water Temperature, Secchi Depth, pH, Nitrate and Nitrite, Ammonium, and Total Nitrogen.

The overall water quality of Casco Bay is good, although there are a handful of sites where indicators have been measured at levels of concern.

Samples are collected at the surface at over 45 sites from April through October. These sites are grouped into the following regions: Cape Elizabeth, Eastern Bay, Eastern Coast, Foresides, Harpswell Sound, Harraseeket River, Maquoit Bay, Middle Bay, New Meadows River, Offshore, Portland Coast, Portland Harbor, Quahog Bay, Royal River, and Western Bay. By looking at the regional means for each parameter we are able to determine any geographical trends in the data. Figure 1 shows the sites grouped by region.

Figure 1



Dissolved Oxygen, water temperature, secchi depth and pH levels have been measured since 1993. Measurements of Dissolved Inorganic Nitrogen, which is the sum of nitrate+nitrite and ammonium, were added in 2001, and Total Nitrogen was added as a parameter in 2007. Total Nitrogen was added since this measurement has the advantage, as the name suggests, of incorporating all of the nitrogen in the water – including that which has been tied up in planktonic marine organisms.

Dissolved oxygen is considered a key indicator of water quality, and is measured as a concentration in milligrams per liter (mg/l). Water with high microbial activity and decomposition resulting from excessive amounts of organic matter is susceptible to low dissolved oxygen conditions. Fish and other marine organisms will become stressed in water with low concentrations of dissolved oxygen (below 5.0 mg/l) and may die if levels drop low enough. Looking at the distribution of all of the data (N=7613), 90% of the dissolved oxygen measurements in Casco Bay were above 7.2 mg/l. Only 0.5% fell below 5.0

mg/l. However, sites in Portland Harbor, the Royal River, the New Meadows, and the Harraseeket River experience low levels of dissolved oxygen. Sites offshore and in the Eastern Bay region have the highest mean concentrations of dissolved oxygen (Figure 2). The chart is arranged so that the regions are sorted from the highest dissolved oxygen levels to the lowest. The charts of the means for water temperature, secchi depth, and dissolved inorganic nitrogen keep the regions in the same order that is found in the dissolved oxygen chart so that comparisons can easily be made between parameters. The standard deviation is included for each mean to show the seasonal and annual variability.

Figure 2.

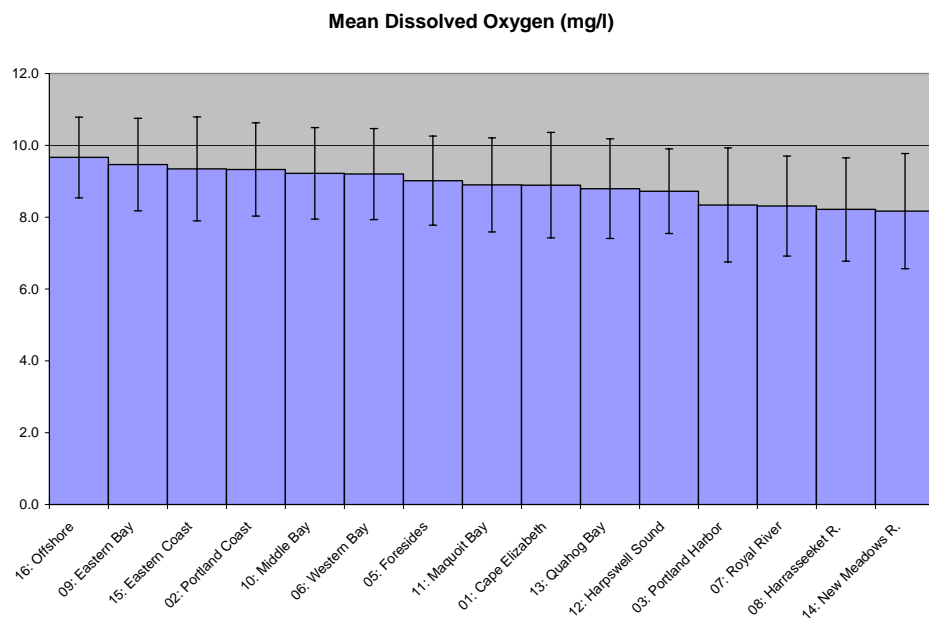


Figure 3.

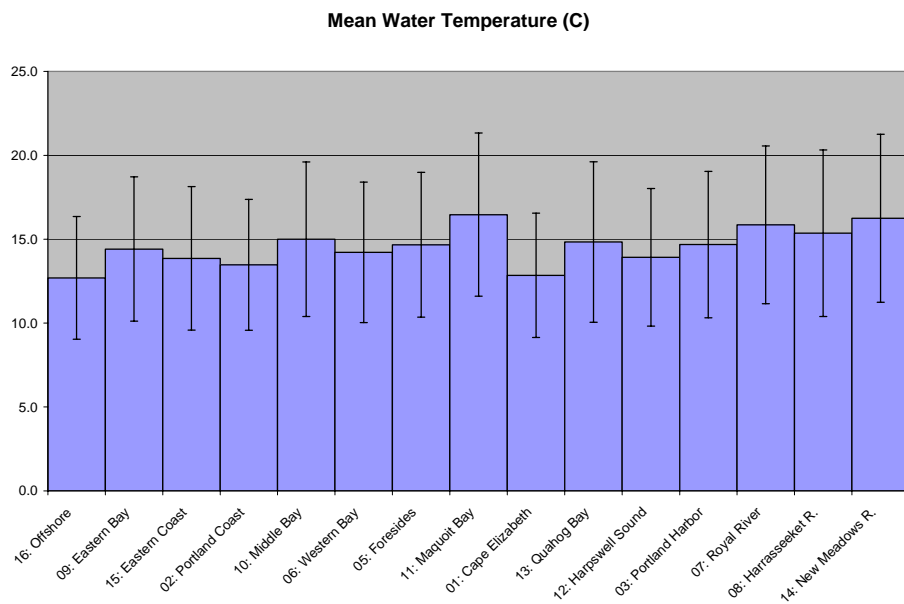


Figure 4.

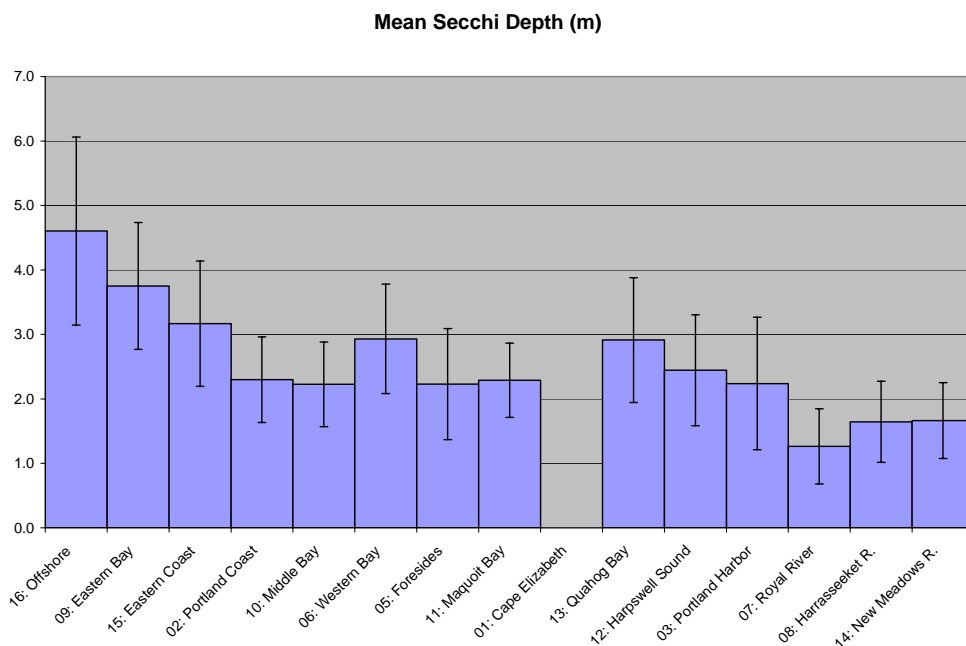
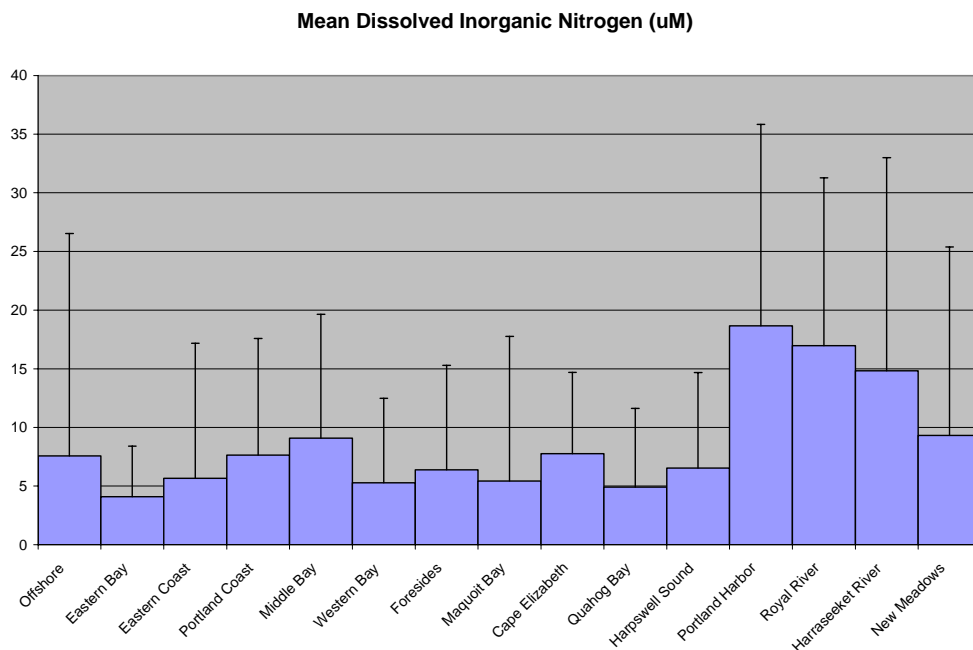
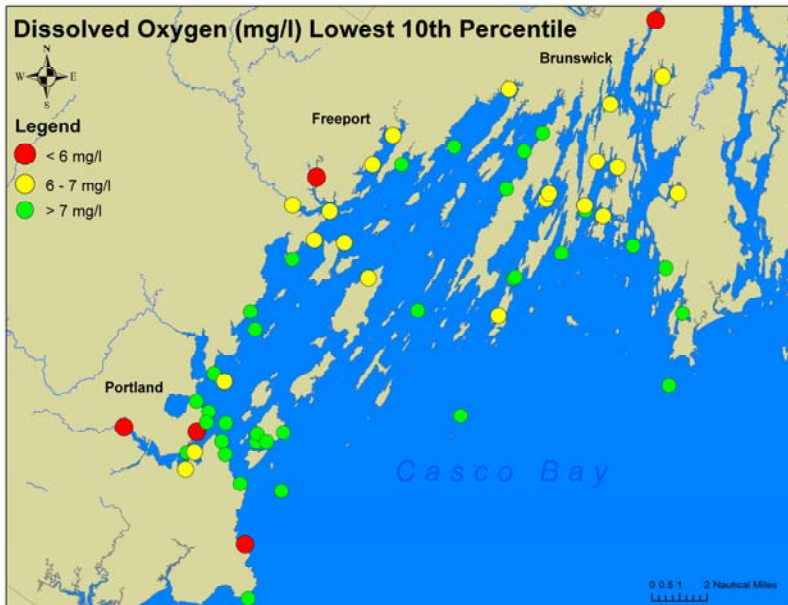


Figure 5.



Overall, dissolved oxygen levels in Casco Bay are very good. For each site, the lowest 10<sup>th</sup> percentile values show where issues with dissolved oxygen may be occurring (Figure 6). These values also reflect the comparatively high dissolved oxygen levels found offshore. There is a strong inshore to offshore trend of improving dissolved oxygen conditions. Sites with low levels of dissolved oxygen include the Stroudwater Creek and Custom House Wharf sites in Portland Harbor, the Cousins River site, the New Meadows River Marina site, and the Pebbles Cove site in Cape Elizabeth.

Figure 6.



Water temperature influences the rates of microbial activity and photosynthesis, the amount of dissolved oxygen the water can hold, and the vertical mixing of nutrients, and is measured here in degrees Celsius ©. Warming water temperatures are a concern world-wide as a result of global climate change.

In Casco Bay, sites in the Offshore region and the coast along Cape Elizabeth have the coldest mean water temperatures, while Maquoit Bay, the New Meadows, and Royal and Harraseeket Rivers are the warmest regions (Figure 3). By comparing the water temperature regional means chart to the dissolved oxygen regional means chart, a slight relationship can be detected between colder water and higher dissolved oxygen levels.

Secchi depth is a measure of the clarity of the water. As an indicator, secchi depth is used to estimate the amount of organic material in the water and is measured in meters (m). Generally, water with less organic material, and therefore greater clarity, is considered healthier. Critical submerged aquatic vegetation such as eelgrass requires high levels of sunlight to penetrate through the water column.

Figure 4 shows the regional means for secchi depth. None of the sites in the Cape Elizabeth region have secchi depth measurements collected. The deeper offshore sites show the greatest water clarity, while the Royal River, Harraseeket River and New Meadows regions had the lowest mean secchi depths. Once again, a trend is apparent among the indicators, in this case a relationship between higher dissolved oxygen and higher secchi depths, both of which correlate to colder water temperatures.

Dissolved Inorganic Nitrogen (DIN) is the sum of nitrate, nitrite and ammonium, and is measured in micromoles ( $\mu\text{M}$ ). The mean values for dissolved inorganic nitrogen show increased levels near freshwater sources and/or urban areas, and lower levels offshore (Figure 5). The regional means for DIN track well with the previous three parameters, in this case with higher DIN levels found in regions with lower dissolved oxygen, warmer water, and lower secchi depths. What is somewhat surprising about the DIN results is the relatively high ratios of ammonium to DIN (Figure 7). Very generally, nitrate is the dominant fraction of DIN in coastal waters. This may indicate that Casco Bay is highly productive. DIN mean values are also presented by site (Figure 8), so that the inshore to offshore trend of decreasing values can be seen. This same trend is evident in the total nitrogen mean values for each site (Figure 9).

Figure 7.

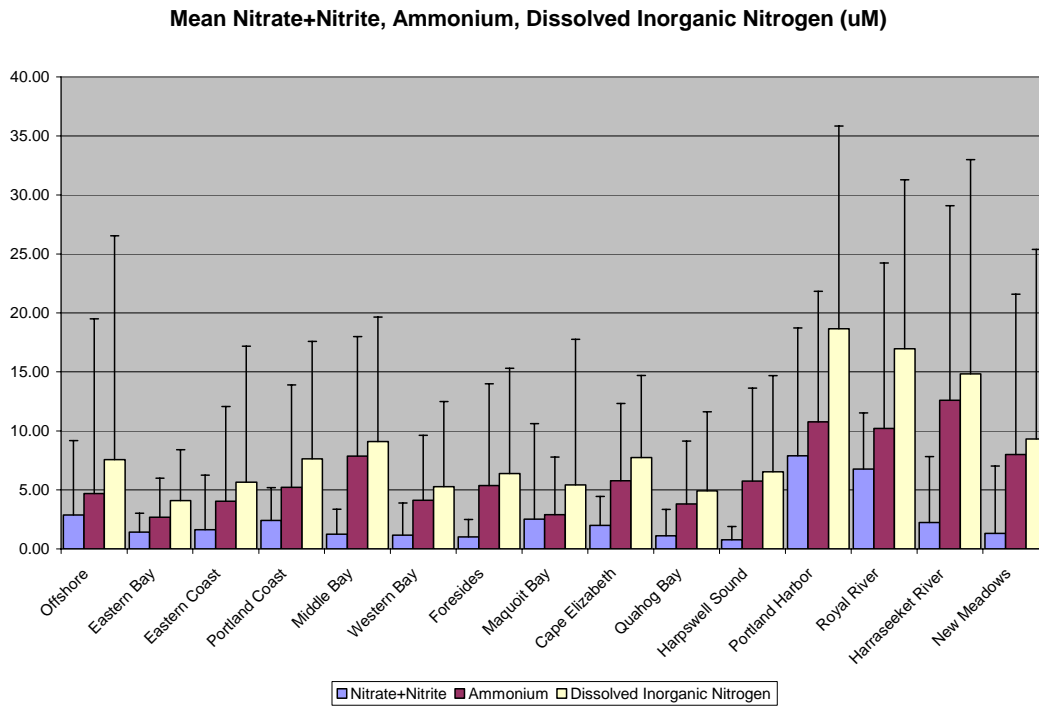


Figure 8.

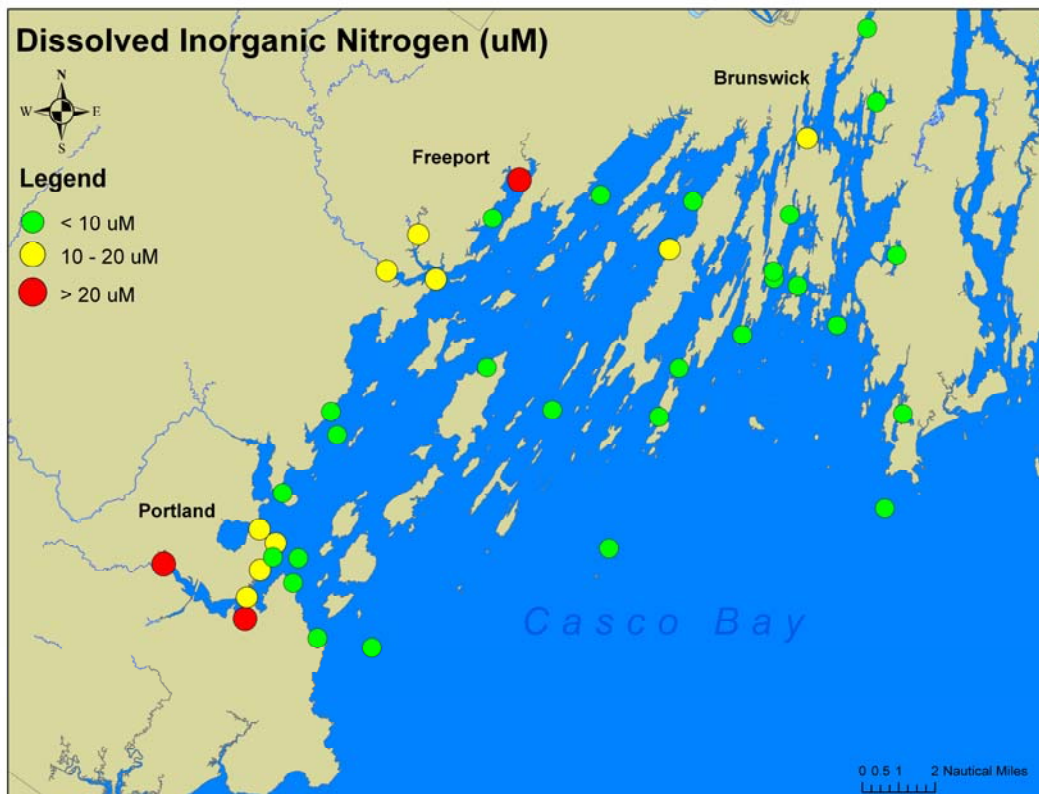
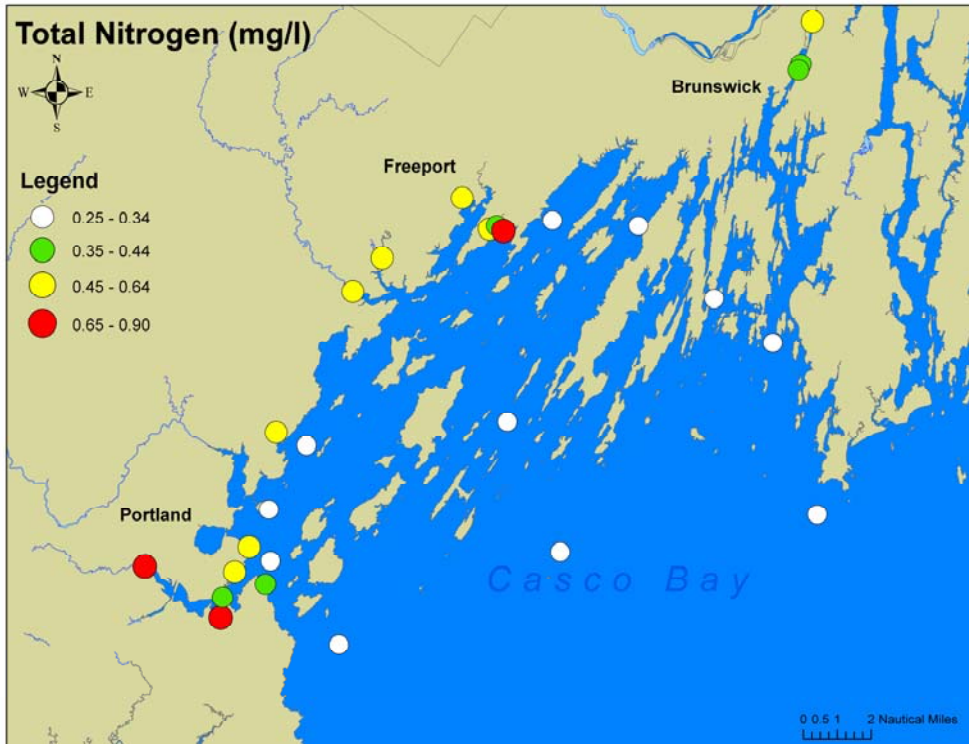


Figure 9.



Total nitrogen (TN) is the sum of Dissolved Inorganic Nitrogen, Dissolved Organic Nitrogen, and Particulate Organic Nitrogen and is measured in milligrams per liter (mg/l). Total Nitrogen data has only been collected for the past three years, since 2007, and is collected at fewer sites and sampling events than DIN. Sites without standard deviation bars indicate that only one sample has been collected at that site. This data shows the distribution of values for TN around Casco Bay. As with DIN, higher mean values are found inshore, and near lower salinity, while lower mean values are evident offshore. This pattern of increased freshwater, most likely as runoff, resulting in higher nitrogen, can be seen in the following plots which include all DIN and TN data and salinity. For the DIN and salinity plot (Figure 10),  $n = 2433$  and  $P < .0001$ ; for the TN and salinity plot (Figure 11),  $n = 364$  with  $P < .0001$ . These plots show that generally nitrogen in Casco Bay is terrestrial, and not marine, derived.

Figure 10.

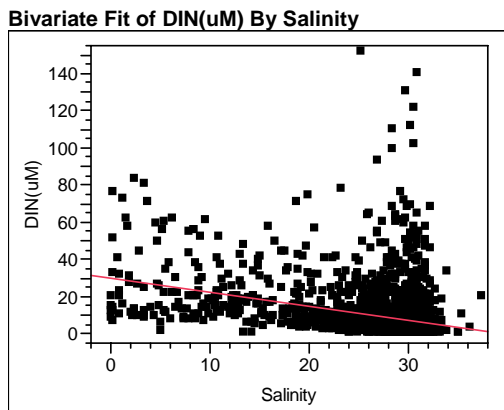
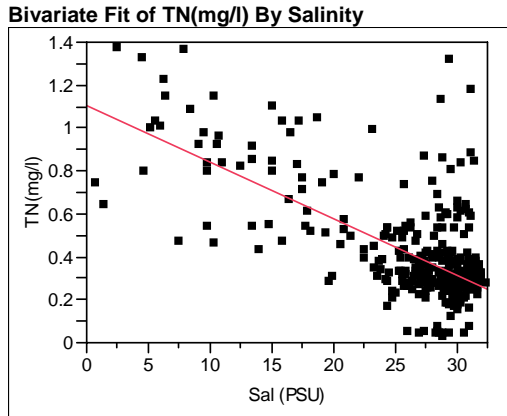
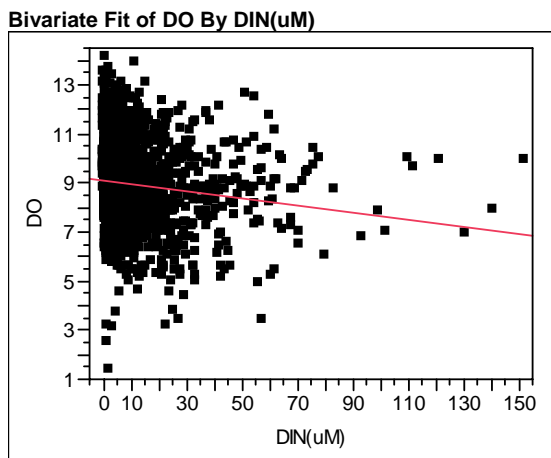


Figure 11.



Also of interest is the relationship between dissolved oxygen and dissolved inorganic nitrogen, with DO concentrations decreasing as DIN concentrations increase. This negative correlation is presented in Figure 12. The n is 2384 for this plot, and  $P < .0001$ .

Figure 12.



Another indicator, pH, which measures the acidity or alkalinity of the water, varies with proximity to fresh water or changes in the amounts of photosynthesis and respiration. As with the previous indicators, pH also exhibits a relationship with dissolved oxygen. The regions with the lowest mean pH values, Portland Harbor and Royal River, also have some of the lowest mean dissolved oxygen levels in Casco Bay. Since pH variability can be tied to photosynthesis and respiration, this relationship has a seasonal pattern. Higher pH values are found in the spring when productivity peaks, and values fall slightly in the summer and early fall when productivity is more stable.

In 2005 the water quality monitoring protocol was modified so that sampling was conducted in the morning and in the afternoon as opposed to just once anytime during the day. This modification allowed for the comparison of all sites around the Bay synoptically, as well as allowing for a measure of productivity at each site by looking at indicators in the morning and again in the afternoon. In order to determine annual trends in the data, however, only samples collected prior to 10:00 am are used. These analyses show that on an annual basis, there are interesting trends with water temperature and secchi depth.



Water temperature has been increasing by a tenth of a degree C annually (Figure 13), while secchi depth has been decreasing by slightly less than a tenth of a meter (Figure 14). The water temperature by year plot is based on 2007 observations and has a  $P < .0001$ . The secchi depth by year plot is based on 1310 observations and has a  $P < .0001$ . These trends are troubling, as both indicators seem to be reflecting reduced water quality over time.

Figure 13.

#### Bivariate Fit of Water Temperature By Year

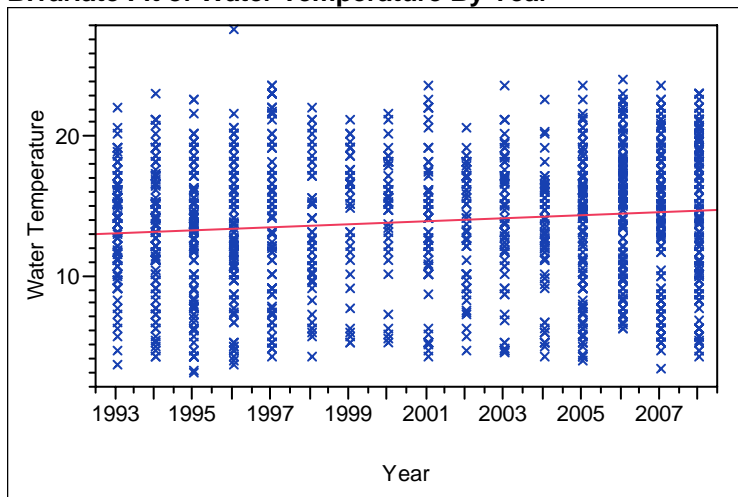


Figure 14.

#### Bivariate Fit of Secchi Depth By Year

