

# State of the Water Quality of Casco Bay

## An Analysis of Six Years of Water Quality Data, 1993-1998, for Friends of Casco Bay

Since 1993 Friends of Casco Bay (FOCB) has been conducting the Citizens Water Quality Monitoring Program, supported by the Casco Bay Estuary Project. "Citizen Stewards," volunteers rigorously trained in EPA-approved water sampling protocols, monitor at more than 80 shore-based stations and assist FOCB staff at another ten profile stations located throughout Casco Bay. At each station, monitors record the water temperature, salinity, pH, secchi depth (water clarity), and dissolved oxygen concentration (DO). Most shore-based stations are sampled at the surface monthly from April through October; profile stations, offshore sites sampled by boat, are monitored once a month year-round. A "profile" examines the entire water column by taking measurements every 2 meters from the surface to the bottom.

FOCB commissioned a consulting firm, Battelle Environmental, to analyze data from the first six years of the Citizens Water Quality Monitoring Program, between 1993 and 1998, to evaluate the overall water quality of Casco Bay, to identify ranges for the parameters sampled, and to highlight areas of concern that warrant more detailed studies.

### Characteristics of Casco Bay

The analysis compared data among sites, regions, and years. Summary statistics for all Casco Bay surface data is presented in Table 1. The minimum and maximum values show the great variability found from site to site and over time. The shallowest water depth was measured in Anthoine Creek (South Portland) and the deepest depth was consistently measured at Halfway Rock at the outer edge of Casco Bay. The coldest temperatures were recorded, not surprisingly, in winter at those sites that are sampled year-round. The warmest water temperature was found at the Cousins River site in front of the Muddy Rudder Restaurant on June 19, 1995. During the summer, warm waters were consistently observed at the Presumpscot River site, and for swimmers, Wolfe's Neck State Park offered some of the most inviting waters with an August

mean temperature of almost 20°C (68°F). In contrast, Willard Beach in South Portland provided a bracing August mean temperature of 16°C (60.8°F). Willard Beach also had the highest salinity reading of 33.5 parts per thousand (ppt). The lowest pH and salinity values were obtained at sites at the mouths of both the Royal and Presumpscot rivers, owing to their freshwater inputs. The lowest DO and % saturation measurements were found at Peabbles Cove, Cape Elizabeth. Localized ocean currents sweep large quantities of algae into the cove. Rotting seaweed, rather than human activities, apparently account for reduced oxygen levels here. Water clarity was poorest at a number of shallow, inshore sites, while the clearest water was found at Halfway Rock.

**Table 1 – Summary Statistics for All Estuarine Surface Data**

	Water Depth (m)	Temp (°C)	Salinity (ppt)	DO (mg/l)	DO (% saturation)	pH	Secchi Depth (m)
<b>Mean</b>	7.41	13.15	28.88	9.07	102.37	7.94	2.94
<b>SD*</b>	7.93	5.11	4.55	1.40	12.10	0.18	1.33
<b>Range</b>	52.9	32.0	33.5	12.3	143.6	2.7	12.5
<b>Minimum</b>	0.1	-2.0	0.0	2.6	33.9	6.0	0.2
<b>Maximum</b>	53.0	30.0	33.5	14.9	177.5	8.7	12.7

\*SD – Standard Deviation

# Dissolved Oxygen – The Primary Indicator of Ocean Health

Dissolved oxygen, measured in milligrams per liter (DO) and as percent saturation, is a key indicator of coastal water quality. This is because dissolved oxygen is required for respiration by all forms of marine life; when DO is low, plants and animals may become stressed or may even die. Low DO levels have resulted in periodic fish kills in New Meadows River and Quahog Bay.

The amount of oxygen that is dissolved in seawater depends on a variety of physical, chemical, and biological conditions. Seawater holds less oxygen than fresh water, and cold water contains more oxygen than warm water. Seasonal effects of temperature result in maximum DO values in the winter and minimum DO values in the summer (Figure 1). For any given temperature and salinity, there is a specific DO concentration when the seawater is fully saturated with oxygen. That is, when there is 100% saturation, the water is holding all of the oxygen it can hold under those conditions. However, biological factors can cause seawater to be over- or under-saturated with oxygen. When monitoring water quality, it is these deviations from 100% saturation that reveal the most about the health of the marine environment.

The State of Maine, through the Department of Environmental Protection, designates classifications of marine waters as SA, SB, or SC, measured by percent of dissolved oxygen (DO) saturation. The standard for class SA waters (the highest quality) is dissolved oxygen “as it naturally occurs.” In Casco Bay, only the offshore waters near Halfway Rock are classified as SA. The DO % saturation standard for class SB is 85% dissolved oxygen and for class SC (lowest quality) waters, 70%. Class SC waters are primarily located in the vicinity of Portland Harbor. As a matter of record, FOCB data was instrumental in the State upgrading the water quality designation from class SC to SB of waters off Peaks and Little Diamond Islands, Two

Lights in Cape Elizabeth, and Willard Beach. (By law, any activities that would degrade the higher standard are prohibited, thus helping to protect water quality.) The State of Maine does not have a water quality standard for DO concentration. In this report and in other comparative studies, a benchmark for DO concentration of 5.5 mg/l was used. DO concentrations below 5.5 mg/l may produce subtle detrimental effects on marine life.



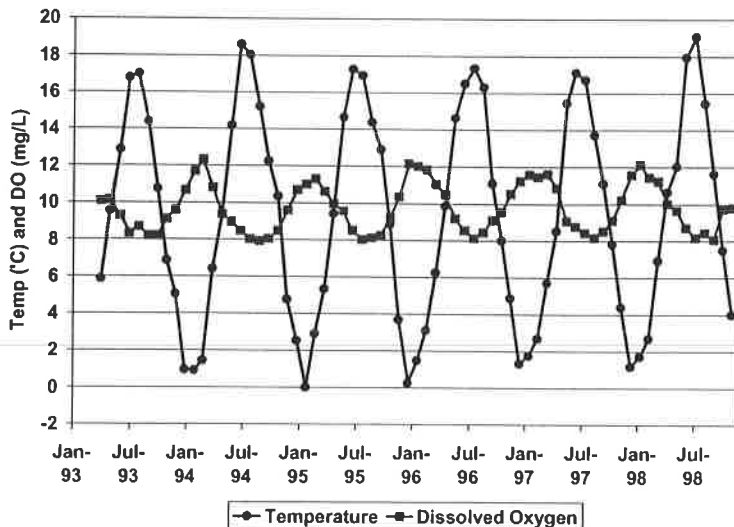
Frank Leavitt performs dissolved oxygen test.

**Overall, the FOCB data indicates that water quality is generally good in Casco Bay and that DO concentrations and DO % saturation levels are only rarely a matter for concern.** About 85% of the DO measurements had concentrations of 7 to 11 mg/l, which is within the normal range of DO concentrations. Only 0.6% of the values were below the 5.5 mg/l benchmark, and just 5% of the values were less than 7 mg/l. The DO % saturation data reinforces this finding. About 55% of the measurements were over-saturated and 38% of the values were somewhat under-saturated, though still above the class SB standard of 85% saturation. In all, almost 95% of the measurements were above the 85% saturation standard and less than 1% of the values were below the class SC standard of 70% saturation.

**Regionally, DO concentration and percent saturation were relatively low in Portland Harbor, the three river systems, and a number of basins in eastern Casco Bay (Maquoit Bay, Quahog Bay, and New Meadows River).**

Since warm water holds less oxygen than cold water, data from these regions was given a closer look during the summer months (July-September) when DO concentrations tend to be at their lowest. In this way, we are able to look at the worst-case conditions. Portland Harbor had the lowest mean DO concentration for this time period (7.6 mg/l) and was significantly lower than all other water bodies except for four sites that also had mean DO concentrations of less than 8.0 mg/l: Presumpscot River, Harraseeket River, Royal River, and Quahog Bay. These five water bodies were also the only sites that were under-saturated (DO % saturation <100%) for this time period. The mean % saturation values for the Presumpscot River and Portland Harbor were significantly lower than all other water bodies except for the Royal River.

**Figure 1 – Time series of monthly mean temperature and DO data from all year-round sites.**



## Areas of Concern

Not surprisingly, urban areas exhibited some of the lowest minimum DO concentrations, possibly owing to direct nutrient loading from point sources and combined sewer overflows in Portland Harbor and freshwater inputs

and potential polluted runoff into sites near the Royal River, Presumpscot River, and Harraseeket River. However, low DO concentrations were also observed in less developed areas in eastern Casco Bay where restricted circulation may exacerbate human impacts (New Meadows River and Quahog Bay). Leaking septic systems in Maquoit Bay have been identified as significant sources of nutrients into that bay. The prevalence of overboard discharge systems still in use along the shores of Harpswell Sound, Quahog Bay, and New Meadows River suggests that they are a likely source of nutrients to these water bodies. Overall, minimum DO levels of less than 5.5 mg/l were observed at ten of the FOCB sites (Figure 2). Those sites identified as areas of greatest concern are, from west to east: Peabbles Cove, Cape Elizabeth; Stroudwater Bridge and Custom House Wharf in Portland Harbor; Wharton Point, Maquoit Bay; Ben Island, Bethel Point, Dyer's Cove, and Perry's Landing in Quahog Bay; and Sebasco Estates and New Meadows Marina in the New Meadows River.

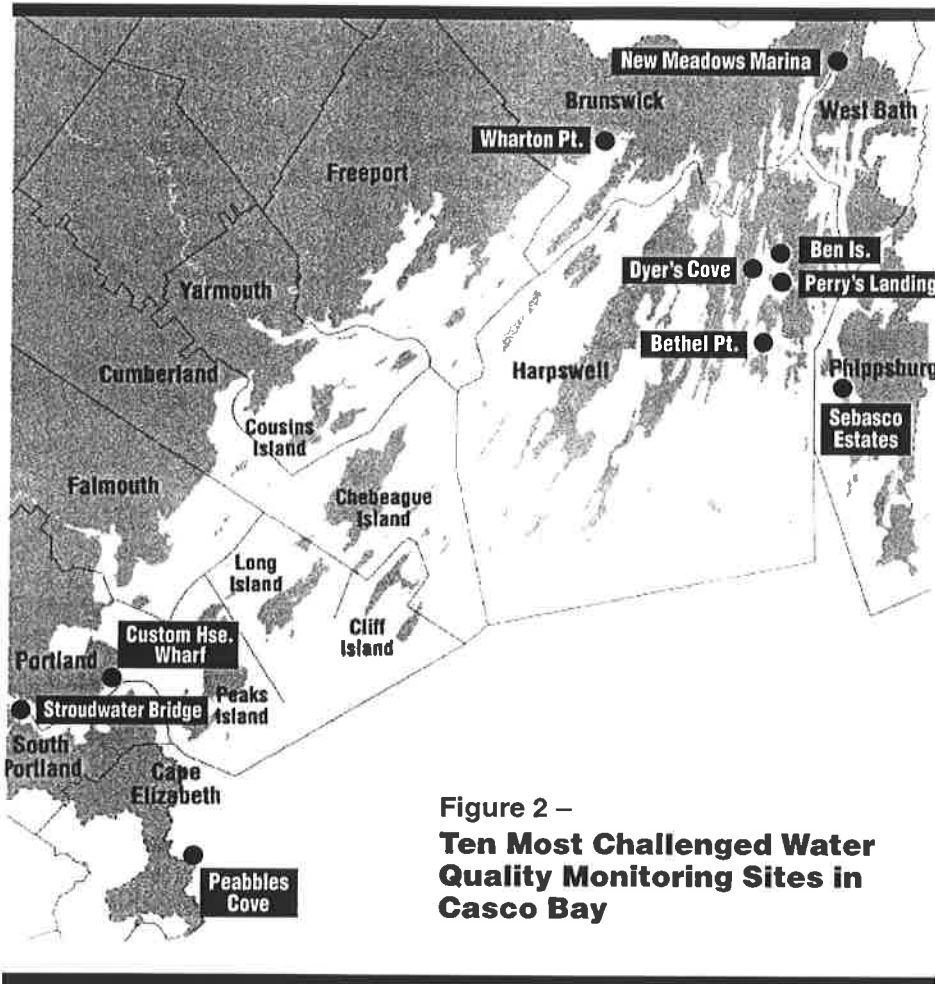


Figure 2 – Ten Most Challenged Water Quality Monitoring Sites in Casco Bay

## Offshore Sites

Water quality conditions at the ten offshore profile stations we sampled were consistently healthy. Measurements at these sites were collected throughout the water column. Even during summer stratified conditions (see *Note* at end of paper), the majority of profile DO measurements had concentrations of 8 to 11 mg/l. None of the values was below the benchmark of 5.5 mg/l and only ~1% of the values were less than 7 mg/l. The DO concentrations at these 10 sites are unlikely to pose any harm to marine life. However, the low temperatures of the bottom waters at Halfway Rock and Broad Sound, which are the two deepest sites (over 30 meters), resulted in an unexpectedly high number of DO % saturation values that were below the class SB water standard of 85%. The low DO % saturation values observed in the bottom waters at these deep-water stations resulted from a combination of extended seasonal stratification and biological utilization of oxygen. An ex-

amination of trends over several years suggests that values of less than 85% saturation may be naturally occurring events.

The data for our offshore sites is consistent with data gathered elsewhere in the Gulf of Maine. The interannual trends observed for the Casco Bay profile data – lowest bottom water DO concentrations in 1994, increasing bottom water concentrations from 1994-1997, and lower DO



Citizen Steward Linda Cardente prepares to monitor surface site.

concentrations again in 1998 – are exactly the same trends observed in Massachusetts Bay over this same time period. The correlation of Casco Bay data with broader regional trends is important not only for understanding past trends in the data, but for evaluating future trends as well. If our data deviates from that of other monitoring programs in the Gulf of Maine, it will be a clear indication of

significant local influences. At the same time, the regional data comparison will provide an understanding as to what may be driving some of the conditions observed. The low DO % saturation values in the bottom waters at the deep, offshore sites are not necessarily due to local problems or inputs, but may be attributable to variations in temperature and circulation in the Gulf of Maine.

## What Else Should We Be Testing?

2002 begins the tenth year of the Citizens Water Quality Monitoring Program. At the end of this sampling season, Friends of Casco Bay will have a solid, ten-year baseline of information with which to compare future data. How should our water quality monitoring program change to respond to the findings of the analysis of our first six years of data?

The report recommended reducing the number of sites that we monitor while increasing the frequency of sampling at some sites. This would allow us to use our limited resources to conduct short-term projects on the areas of greatest concern. FOCB has already undertaken a number of focused studies, such as hypoxia studies from 1997 to 2000 to study areas where the lowest dissolved oxygen levels have been found consistently. A synoptic sampling (when many sites are monitored simultaneously) provided a “snapshot” of conditions across the Bay in 1998 and 1999.

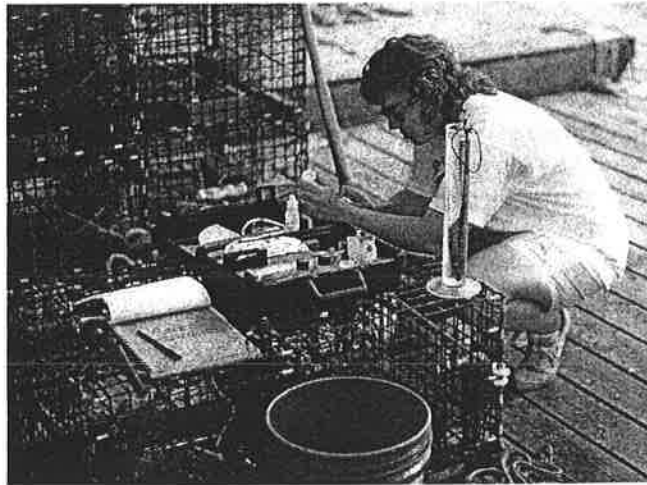
It was recommended that we sample for additional parameters, such as nutrient and chlorophyll concentrations. Fortunately, Friends of Casco Bay, in cooperation with the University of Maine School Marine Sciences and GoMOOS, has recently begun monitoring for dissolved inorganic nutrients and chlorophyll at some of the stations.

Building on these partnerships will also allow us to expand our scope of work, as well as to focus on detailed analyses of individual water bodies. The Gulf of Maine Ocean Observing System (GoMOOS), for instance, is deploying 13 instrument moorings in the Gulf of Maine—one of which is in Casco Bay—to continuously monitor temperature, salinity, and dissolved oxygen, as well as wind and wave conditions. Working with groups such as GoMOOS, Bowdoin College, and the New Meadows River Watershed Project will allow us to collect data on circulation, tidal flushing rates, and food web dynamics. This broad body of data will help us better characterize and understand the Casco Bay system.

*Note: During the summer, sharp differences in water temperature and salinity between surface waters and deeper waters often create stratification, physically distinct layers of seawater. The*

*two layers do not mix with each other until storms stir up the water or until temperatures become more similar in the fall. In the summer, the upper layer may exhibit higher levels of dissolved oxygen, while the deeper water layer is reduced in DO because of bacterial respiration and lack of access to atmospheric oxygen.*

*Barbra Whitten, FOCB Volunteer Monitor, processing sample taken at one of Casco Bay's busy lobster pounds.*



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## State of the Bay Conference

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