Offshore Stations

Our data suggest that the offshore stations in Cape Cod Bay undergo seasonal patterns typical of coastal temperate ecosystems; well-mixed waters during the winter transition to highly stratified conditions during the summer as surface temperatures warm and freshen. Figure 2 shows the development of a thermocline over the course of a year. The strength of the thermocline demonstrates the degree of stratification each month. These physical conditions affect the biology of a system. In the spring when waters are well mixed from the surface to the bottom, nutrients from bottom waters become readily available in the surface waters. As light becomes more available, phytoplankton take advantage of these conditions, resulting in what is commonly referred to as a winter/spring bloom. Later in the spring, as the temperature difference between surface and bottom waters increases and the water column becomes stratified, the supply of nutrients is cut off, terminating the spring bloom. The summer is generally a period of strong stratification, depleted surface nutrients, and low phytoplankton biomass. In the fall, as stratification deteriorates from cooling weather and increased wind events, mixing supplies nutrients to the surface waters again, resulting in the development of a fall phytoplankton bloom (Figure 3).

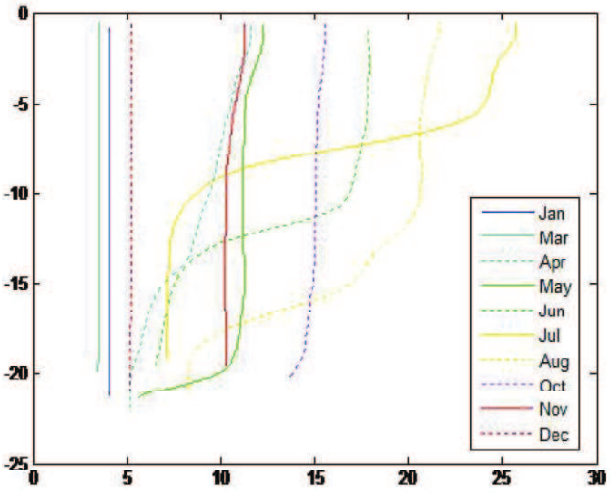

Figure 2

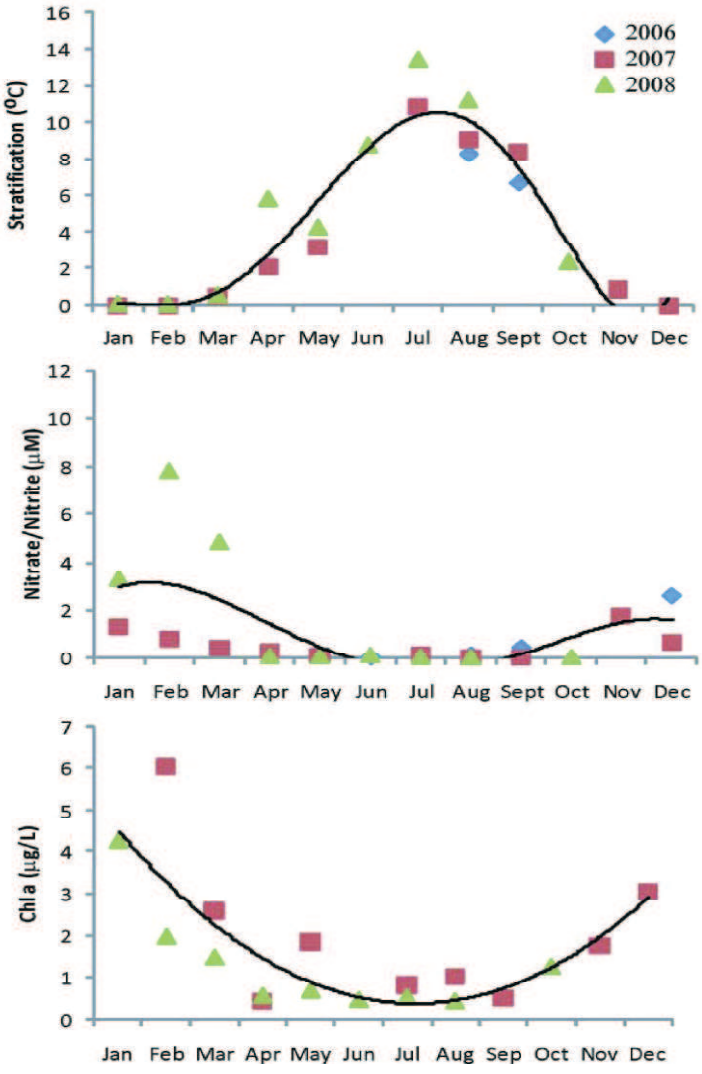

Figure 3

Although these offshore waters currently appear healthy, the Cape Cod Bay Monitoring Program identified an emerging concern. Over the past three years, there has been a steady and significant increase ($p=0.013$) in nitrate (NO_3) levels in the surface waters (Figure 4). This increase has been observed in waters outside of Cape Cod Bay as well, and therefore likely attributed to larger-scale, regional factors such as shifts in circulation patterns or increased loadings to the system from offshore Gulf of Maine waters (Libby et al. 2008). Because there is regional and local concern over increasing nitrate levels in local estuaries and nearshore coastal waters, this trend should continue to be closely monitored.

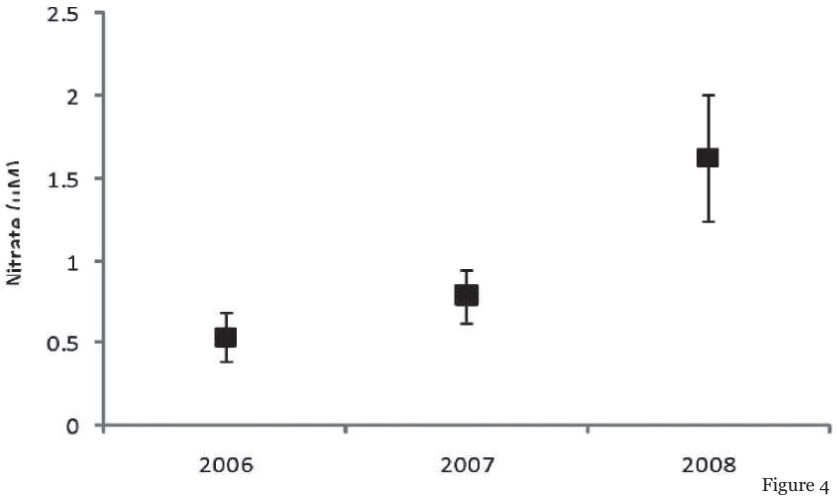

Figure 4

Inshore Stations

Typically 10-15 inshore stations are monitored by volunteers (citizen scientists) each year (Table 1). Data collected from most of these stations show that water quality conditions are much more impaired than those measured in nearshore and offshore stations. In general the farther inshore the station, the poorer the water quality. Compared to the nearshore stations, the inshore stations have lower levels of dissolved oxygen, higher levels of all forms of nutrients (nitrate, ortho-phosphate, total N and total P), and higher turbidity (Figure 7).

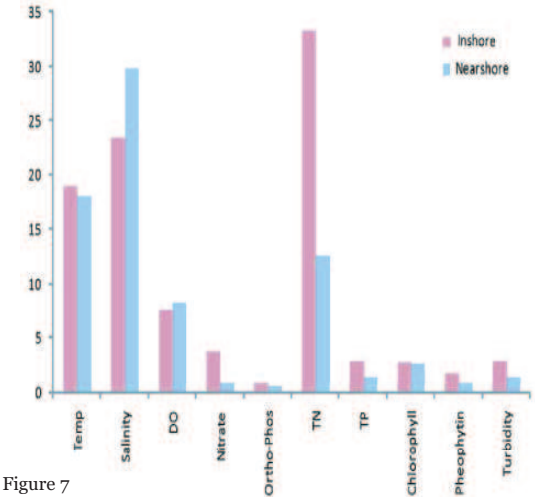

Figure 7

Site	Citizen Scientists		
	2006	2007	2008
Provincetown Harbor	Aimee Teaby		
Pamet	Karen Kramer		
Herring River	Aimee Teaby	Nina Kaars	Nina Kaars
North Sunken Meadow			Elizabeth Skelton
Boat Meadow		Phil and Betty Suraci	Phil and Betty Suraci
Little Namskaket	Joann Figueras	Joann Figueras	Joann Figueras
Upper Namskaket		Scott and Heather Grenon	Traute and David Bushley
Namskaket	Val Magor	Val Magor	Val Magor
Cole Road Beach		Keith Harrison	
Paines Creek	Bill and Lois Edwards	Bill and Lois Edwards	Bill and Lois Edwards
Paines Creek Tributary A		Bill and Lois Edwards	Bill and Lois Edwards
Paines Creek Tributary B		Scott and Heather Grenon	Scott and Heather Grenon
Grays Beach	Theresa Barbo		
Scorton Creek	Diana Stinson	Diana Stinson	Diana Stinson
Old Harbor	Diana Stinson	Diana Stinson	Diana Stinson
Ellisville Harbor	Regina Asmutis-Silvia	Regina Asmutis-Silvia	Regina Asmutis-Silvia
Plymouth Harbor	Regina Asmutis-Silvia	Regina Asmutis-Silvia	Regina Asmutis-Silvia
Jones River	Carol "Krill" Carson	Carol "Krill" Carson	Carol "Krill" Carson

Nearshore Stations

The seasonal patterns observed in the nearshore stations located along the coastline of Cape Cod Bay are very different from those in the offshore and much more immediately influenced by anthropogenic (human) impacts. Water quality is impaired primarily during the summer months, coincident with the seasonal increase in population in the towns around the Bay. Each year during the summer months, the data have shown a decline in dissolved oxygen levels (Figure 5a), an increase in nitrogen and phosphorous concentrations (Figure 5b, c), and a decline in water clarity (Figure 5d). Both the spatial and temporal variability in these data suggest that anthropogenic influences are negatively impacting the health of Cape Cod Bay.

Figure 6 shows a comparison of data, presented as seasonal averages for each year. The only statistically significant changes were in ortho-phosphate, which was significantly lower in 2008 compared to 2006 and 2007 ($p<0.001$), and chlorophyll a, which was significantly lower in 2008 compared to 2007 ($p=0.0417$). Other differences observed over the course of the three years of monitoring, though not statistically significant, are:

- water temperature increased 0.5°C
- salinity increased by 0.4 ppt
- dissolved oxygen levels decreased by 0.2 mg/L
- nitrate/nitrite concentrations fluctuated by 0.3 uM
- total nitrogen increased by 1.2 uM
- total phosphorous increased by 1.1 uM
- turbidity declined by 0.02 NT

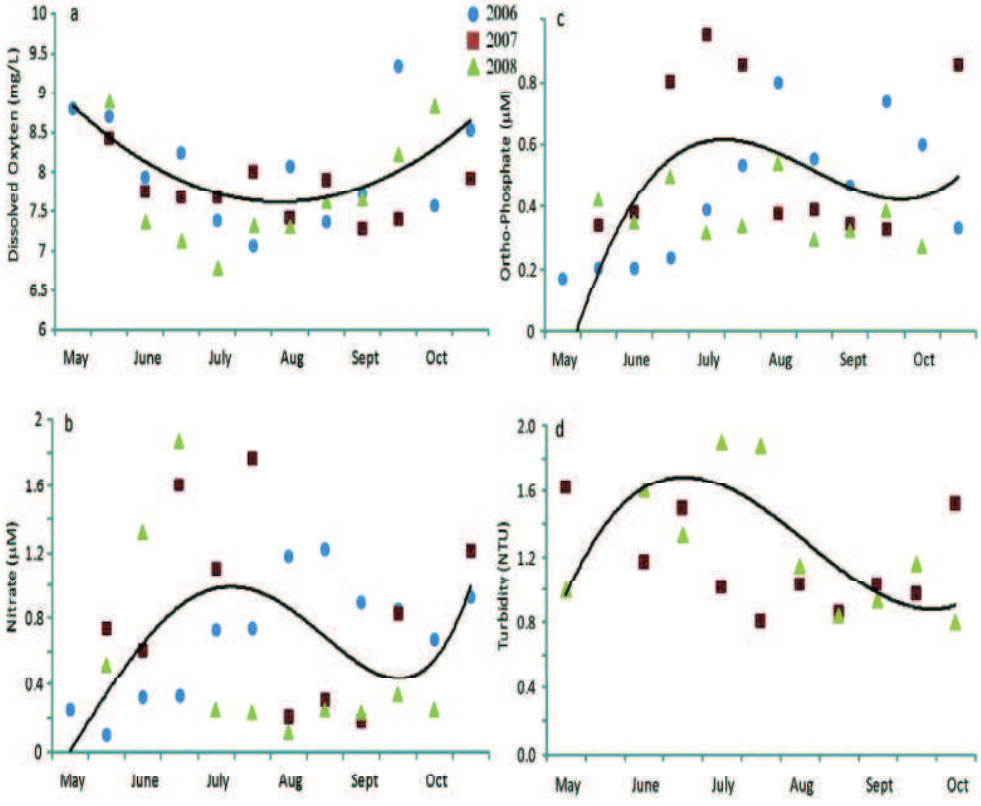

Figure 5