Plankton and water quality monitoring in Buzzards Bay, 1987–2000

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Research supported by the Massachusetts Department of Environmental Protection
Funding for this study was provided by the Massachusetts Department of Environmental Protection (DEP) and the Executive Office of Environmental Affairs (EOEA), managed by DEP project managers Arthur Screpetis, John Jonasch and John Vivieros, with administrative support by Dr. Russell Isaac and Alan N. Cooperman of the DEP, and EOEAs Buzzards Bay Watershed Team Leader, Karl Honkonen.

Able seamanship was provided by present and past Captains of the R/V Lucky Lady, in chronological order, the late Leonard Hathaway, John Gage, Ronald Rock, Ray Rock, and their mates. Research Associates David Borkman, David Gauthier, and Jean Lincoln collected, produced, and managed much of the data in this study. Dozens of undergraduate and graduate students from the University of Massachusetts Dartmouth participated in this project, including (in approximate chronological order) William Lima, Richard Pierce, Lynn McInnes, Joe Battaglia, Maile O'Brien Lyons, John O. Hill, Jr., Antonie S. Chute, Melissa Semple, Christiana Mellican, Cameran Sassman Heustis, Christine James, Katie Rose Boissonneault, Bart Harrison, Shane Duclos, John Darga, Jim Woodburne, James Kang, Carrie A. Dunn, John T. Kieser, Ross Kessler, Sean Buckley, and John Fearing.

On the cover

Graduate student collecting sample with a zooplankton net.

UMass Dartmouth's research vessel, R/V Lucky Lady leaving New Bedford Harbor.
Paired cells of *Alexandrium tamarense*, the New England red-tide dinoflagellate.

Analyses are completed for eleven years (1987-1998) of hydrographic, nutrient, chlorophyll, bacterioplankton, and water clarity data for all eight stations, as well as quantitative taxonomic data for 372 phytoplankton samples collected from 1988-1998 at three stations along a gradient from the middle of the bay, to New Bedford’s outfall, to the inner harbor of New Bedford. The goal of these studies was to ascertain whether recurrent blooms of toxic algae, that can cause shellfish to be toxic, or other harmful phytoplankton, could be correlated with fluctuations in nutrient and water quality parameters. Observations from the first year of phytoplankton community composition data (1987-88) revealed that there was a bloom of the toxic New England “red tide” dinoflagellate *Alexandrium tamarense* in New Bedford Harbor in summer of 1988. This species has periodically reappeared several times since then. Also, many areas historically closed to shellfishing due to sewage pollution are now in the process of being opened, due to upgrading of New Bedford’s sewage treatment facilities from primary to secondary treatment in September, 1996. These newly open areas would continue to be affected by any blooms of toxic algae that occur from time to time in this and many other coastal waters.

Ammonium levels (points are averages, vertical bars are ranges) showing high concentrations at Station 7, the New Bedford sewage outfall, compared to Station 6 in mid-bay and Station 8 in New Bedford inner harbor (see station map on the inside front cover).

Students observing swimming zooplankton from a fresh tow.
Since October, 1987, Dr. Jefferson T. Turner and his research associates and students from the University of Massachusetts Dartmouth have conducted over 160 biweekly or monthly cruises monitoring environmental parameters in Buzzards Bay, in order to establish temporal and spatial trends of hydrography, water quality and plankton community structure. This program has been funded by the Massachusetts Department of Environmental Protection (DEP) under its Research and Demonstration (R & D) and Watershed Initiative Programs.

This monitoring has quantified temperature, salinity, water clarity, inorganic nutrients (ammonium, nitrate + nitrite, phosphate, silicate) chlorophyll a + phaeopigments, and bacterioplankton abundance on monthly cruises at eight stations throughout the bay. Samples have also been collected and preserved for quantitative taxonomic analyses of abundance and community composition of phytoplankton, zooplankton, and ichthyoplankton. Additional parameters measured at some but not all stations, or for part but not all of the sampling period include dissolved oxygen, primary productivity (photosynthetic rates) and age and growth of larval fish. From October, 1987 to the present, there has been a monitoring cruise every calendar month, year-round, with no interruptions. In addition to providing environmental data, this program has served as a means for involving dozens of UMass Dartmouth undergraduate and graduate students in marine biological research.
Diatoms from Buzzards Bay. These microscopic plants make glass shells from silicate in the water.

Buzzards Bay exhibits large seasonal and interannual variations in levels of certain parameters. These were particularly apparent for nitrate, silicate and phytoplankton abundance and composition. Other parameters showed more uniform distributions, with the exception of the two stations in New Bedford Harbor. Distributions of phosphate and chlorophyll a had concentrations that were generally similar bay-wide on a given day, and over seasons and years for the six stations away from New Bedford Harbor. However, the signals for elevated concentrations of ammonium, phosphate, and chlorophyll a at the sewage outfall, were apparent. High concentrations of these parameters would be expected to reflect sewage effluent, and these data, particularly prior to upgrading of the treatment plant, clearly identify the New Bedford effluent as a major point source of these constituents, which are primary factors in eutrophication. However, the increased water transparency and decreased levels of ammonium, total bacterioplankton, and rod-shaped bacteria after conversion to secondary treatment clearly indicate improved water quality at the effluent discharge site.

Phytoplankton abundances recorded here (0.012 – 26.0 million cells per liter for Cruises 18-141, 1988-1998) are higher than generally reported from previous studies in other coastal waters of New England. The reason is that our preservation of samples with Utermohl's solution did not destroy the delicate microflagellates and phytoflagellates which so completely dominated phytoplankton abundance. Most other studies of phytoplankton abundance in New England coastal waters have used formaldehyde as a preservative, thus destroying the delicate microflagellates, and biasing records in favor of hard-shelled diatoms and armored dinoflagellates which survive formaldehyde preservation.

The bay-wide patterns for silicate suggest the possibility of biological control of silicate levels due to variations in silicate utilization by phytoplankton. Since diatoms are the dominant phytoplankters utilizing silicate, and summer dominance by...
Electron microscope view of the head and filtering appendages of a copepod. These microscopic crustaceans are the most abundant portion of the zooplankton, and they eat the microscopic plants that comprise the phytoplankton.

Student filtering water onboard the R/V Lucky Lady, to measure concentrations of inorganic nutrients such as nitrate, ammonium, silicate and phosphate. These chemicals are used by marine plants as fertilizer, but sewage can add excess nutrients, causing harmful algal blooms.

non-silicate-utilizing microflagellates and dinoflagellates is a common pattern in estuaries of the northeastern United States, the possibility is raised that summer increases dissolved silicate in Buzzards Bay were due to differential utilization of silicate due to changes in phytoplankton community composition.

Phytoplankton community analyses suggest that dissolved silicate levels generally decline from early to mid-summer highs in response to a late summer phytoplankton blooms. These blooms are typically composed of diatoms. Thus, the typical late-spring to early-summer spikes in silicate levels frequently coincided with the seasonal maximum in dominance by microflagellates and dinoflagellates, and annual low in diatom dominance. These patterns are apparent when comparing silicate levels and percentage of the phytoplankton comprised by diatoms, where periods of diatom dominance are seen to occur at low levels of silicate, and vice versa. Potentially-harmful algal species recurrently recorded (at low abundances) for Buzzards Bay include toxic diatoms of the genus Pseudo-nitzschia, and the dinoflagellate Alexandrium tamarense. Both taxa have been associated with shellfish toxicity, and their continued presence in Buzzards Bay suggests a need for continued phytoplankton monitoring.
In conclusion, Buzzards Bay appears to be a favorable habitat for phytoplankton in that it is well-mixed and well-illuminated, and nutrient-replete. Although there were obvious eutrophication signals from the New Bedford sewage outfall prior to secondary treatment, in terms of high ammonium and chlorophyll a, and low light penetration, the rest of the estuary appears relatively unimpacted. Hydrography, bacterioplankton abundance, nutrients and phytoplankton pigments were highly variable in time and space. While most locations away from New Bedford Harbor exhibited similar values on a given day, the stations at the sewage outfall and inner harbor usually had much higher values than the rest of the bay. There were also major fluctuations in nutrients and phytoplankton pigments on time scales ranging from biweekly to monthly to seasonal to interannual. Although much of this fluctuation appeared due to physical forcing, some such as dissolved silicate appears to be biologically-driven. Consideration of parameter variability in Buzzards Bay is essential for proper understanding and management of this system.

Depth of light penetration, as measured by disappearance of the Secchi disk, at Station 7, the New Bedford sewage outfall. Note that water transparency generally increased after conversion to secondary treatment after Cruise 116 in September, 1996.
Collecting water samples from Buzzards Bay during a snow storm.

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