

Assessment report – Greenwich Bay

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The fish kill in 2003 was a harsh visual reminder of the ecological damage caused by the history of organic enrichment of Greenwich Bay¹. Scientists ([Insomniacs/DayTrippers](#), [URI Watershed Watch](#), and [DEM/GSO](#)) have been monitoring the dissolved oxygen content of the waters in Greenwich Bay (and upper Narragansett Bay) for several years to track hypoxia, or low oxygen conditions. Despite the success of these programs, we still know very little about the ecological effects of dissolved oxygen status on the benthic (bottom) environment of Greenwich Bay, and the important species that inhabit this environment, such as quahogs, soft-shelled clams, bottom-dwelling fish, and several other types of fish and invertebrates.

Habitats in Greenwich Bay

There is a diverse array of geologic habitats in Greenwich Bay for benthic organisms to take advantage of, ranging from sand flats, to muddy channels, to rocky outcrops. These bottom types were mapped by scientists at URI in 2003², and the data can be found online as part of the [Greenwich Bay Special Area Management Plan](#). Ideally, these diverse habitats will support a wide-range of benthic communities that perform various ecosystem functions such as nutrient cycling, sediment irrigation (oxygenation), water-column filtering, and serving as food for larger organisms like fish (and humans). Ecological theories predict that the most stable communities are composed of patches of small, opportunistic species, like surface-dwelling worms, nearby patches of larger, long-lived species, such as deep-burrowing crustaceans. However, stressors, such as hypoxia, can interrupt these patterns and cause changes habitat structure³. It is hypothesized that the different geologic habitats (e.g., sand, mud, rock), with different biological communities, will each be impacted in a different way by hypoxia, and will have different rates of recovery.

¹ Rhode Island Department of Environmental Management (RIDEM). 2003. The Greenwich Bay fish kill - August 2003 - Causes, impacts and responses. Providence, RI. Available online: <http://www.dem.ri.gov/pubs/fishkill.pdf>

² Oakley, B.A. & J.C. Boothroyd. 2003. Benthic geologic habitats of Greenwich Bay, Rhode Island. Dept. of Geosciences-URI

³ Pearson, T., & Rosenberg, R. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: An Annual Review* 16: 229-311.

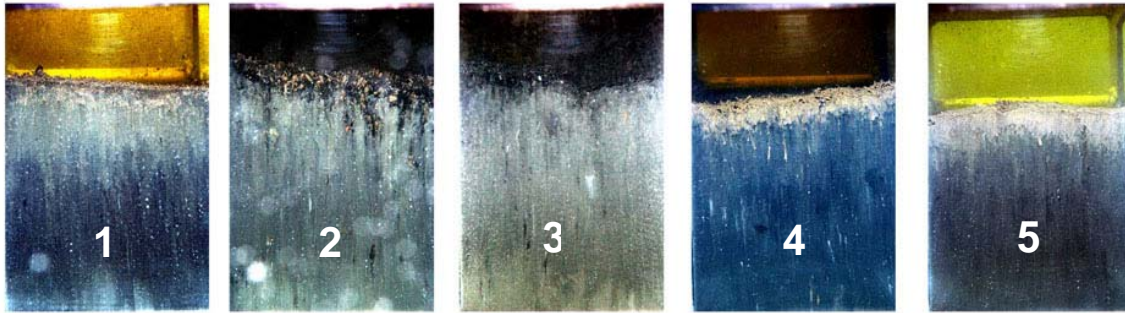


Figure 1. *Rapid changes in the benthic community at the mouth of Greenwich Cove in 2006. From left to right, images were taken in June, July, early August, late August and October. The most obvious difference between each of the images is the depth of oxidized sediment, seen as a brown-gray color in images 1, 4 and 5. Images 2 and 3 do not show any oxidized sediment, indicating low-oxygen conditions near the bottom.*

Ongoing Research

Data collected by the Graduate School of Oceanography (GSO) at URI, through the use of several water quality monitoring stations in 2006 and 2007, has shown that dissolved oxygen conditions are different depending on the location in Greenwich Bay⁴. The northern and southern shallow sandy habitats have very variable dissolved oxygen concentrations. Hypoxia can occur here, but it is rarely persistent. The organic muddy habitats in the western portion of the bay (including Greenwich and Apponaug coves) are highly susceptible to persistent hypoxia, most likely due to naturally weak circulation. The deeper muddy channel off Warwick Neck towards the West Passage of Narragansett Bay can also experience hypoxia, but it is not as long-lived as in the western portion of Greenwich Bay.

To complement the water quality data, GSO also conducted several surveys per year in 2006 and 2007 with a sediment profile camera. The sediment profile images (SPI) help characterize the status of the biological communities present in Greenwich Bay. The SPI photos have demonstrated that the benthic communities in Greenwich Bay are subjected to different levels of stress due to hypoxia, presumably because hypoxic events of different duration and intensity occur depending on location⁵. These data also suggest that stress from organic enrichment (and perhaps hypoxia) over the past several decades⁶ may have altered some of the benthic communities to actually make them more tolerant to recent hypoxic events. A potential consequence of this is that the ecosystem functions previously performed by the original benthic communities can be lost or diminished. This means that some habitats in Greenwich Bay may not be as efficient at cycling nutrients, aerating sediments, or producing food as others are. A major goal of this GSO research is to create a biological map that shows where benthic communities experience the most stress due to hypoxia, and where ecosystem functions may be affected.

⁴ Shumchenia & King, unpublished data, Graduate School of Oceanography-URI.

⁵ Shumchenia & King, unpublished data, Graduate School of Oceanography-URI.

⁶ Valente, R., Rhoads, D., Germano, J. D., & Cabelli, V. 1992. Mapping of benthic enrichment patterns in Narragansett Bay, Rhode Island. *Estuaries* 15: 1-17.

An analysis was conducted to evaluate the ability of the features in SPI to reflect the dissolved oxygen history of the environment. The purpose of the study was to refine SPI analysis, so that the prediction and diagnosis of poor water quality in the future will be improved by using the most relevant factors. The best indicator of dissolved oxygen status in the images is the depth of oxidized sediment, also known as the apparent redox potential discontinuity (aRPD)⁷. The map below illustrates the spatial and temporal variability in dissolved oxygen in Greenwich Bay. The depth of oxidized sediment in this case serves as an initial indicator of change to benthic communities. Sites several red and yellow in the bars in a row are highly affected by low-oxygen conditions, whereas sites with several green boxes show resilience to and quick recovery from low-oxygen conditions. Future studies will look at how this variability influences patterns and processes observed in the benthic communities Greenwich Bay.

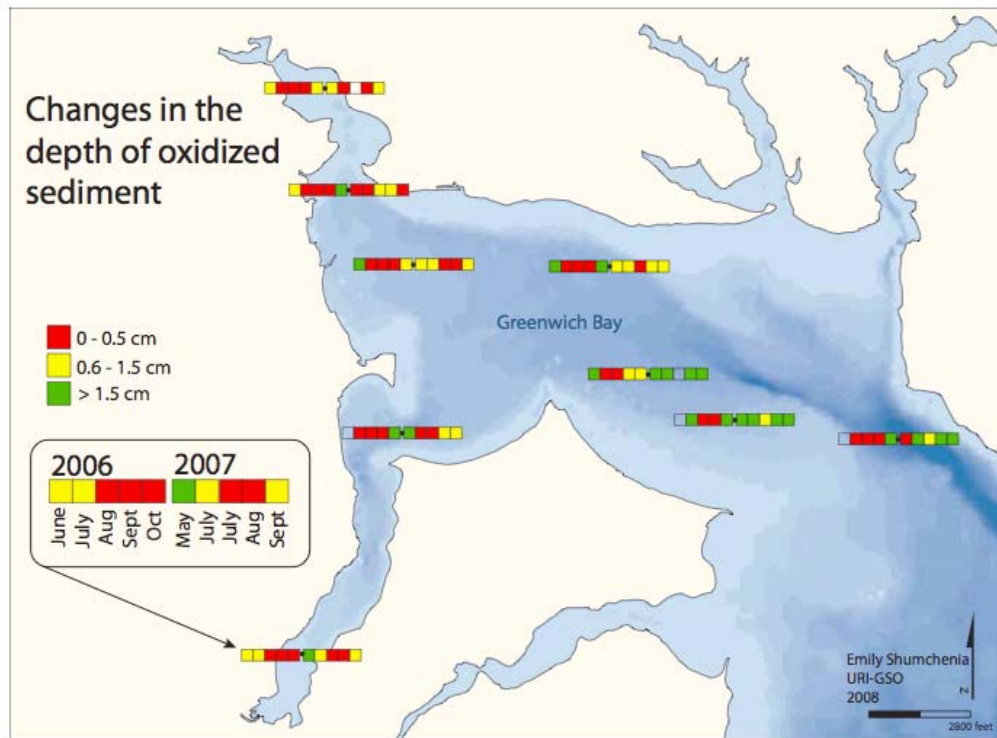


Figure 2. Each colored box represents data from a single sediment profile image taken in Greenwich Bay. Red indicates no or low oxygen penetration, yellow indicates some oxygen penetration, and green indicates high oxygen penetration. See text for further explanation.

⁷ Shumchenia & King, unpublished data, Graduate School of Oceanography-URI.