# PHYTOPLANKTON COMMUNITY DYNAMICS IN MARYLAND'S TIDEWATERS IN RESPONSE TO HURRICANE ISABEL

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## ABSTRACT

During the summer of 2003, cyanobacterial blooms were encountered across a broad region of the upper Chesapeake Bay and in the Potomac River. While upper Bay cyanobacterial blooms had declined significantly by early September, the cessation of the 2003 Potomac River bloom coincided with diverse impacts to habitat conditions by Hurricane Isabel. Phytoplankton abundance on the Maryland mainstem Chesapeake Bay showed little evidence for phytoplankton response to the storm effects, however, timing in the transition to diatom dominance in the tidewater region appears linked to storm event effects.

## INTRODUCTION

Phytoplankton species composition and abundance are functions of interactions with environmental conditions including salinity, temperature, light, nutrients, turbulence, and water depth [1] in addition to grazing, competition, and disease. In 2003, flows to the Bay increased dramatically over the largely drought years of 1999 to 2002, particularly in the Potomac River basin. Flow conditions influence nutrient loadings to Chesapeake Bay; annual means of phytoplankton production and abundance have been significantly correlated to riverine nutrient inputs [2].

The large-scale seasonal flow effects due to the climatic differences between years significantly impacted the distribution of habitat in the Bay and tributaries well ahead of Tropical Storm Isabel [3]. However, storm events bring wind, storm surge, and runoff effects that can impact habitat conditions for phytoplankton populations. Margalef [4] and Reynolds [5] have shown that changing the physical conditions in surface waters is a major determinant of community change. Pearl [6] has reported that physically stable conditions are necessary for cyanobacterial blooms, but related changes in temperature, wind speed, and wind direction lead to the disappearance of the blooms.

*Microcystis* blooms are primarily warm-water phenomenon; Kruger and Elhoff [7] cite 28.8–30.5$^{o}$ C as the range for optimum growth. During 2003, upper Chesapeake Bay and Bay tributaries, including the Bush and Sassafras rivers, produced cyanobacteria blooms beginning in July with densities reaching $1.6 \times 10^6$ cells·ml$^{-1}$ (MD DNR *http://mddnr.chesapeakebay.net/hab/news_7_30_03.cfm*). A late-season cyanobacteria bloom dominated by *Microcystis aeruginosa* (>$10^4$ cells·ml$^{-1}$) developed on the middle Potomac River from mid-August to mid-September. *Microcystis* abundance peaked in the surface waters at >$1 \times 10^6$ cells·ml$^{-1}$ from 2–15 September. The upper Bay cyanobacteria bloom declined ahead of the tropical storm, but the cessation of the Potomac River bloom appeared more closely tied to storm-related effects. Post-storm effects on the broader phytoplankton community in the upper Bay were also of interest.

For this study, the time series of the 2001–2004 phytoplankton community composition data were reviewed for three long-term monitoring stations in the upper Bay and the cyanobacteria bloom region in the middle Potomac. River flow conditions were examined from U.S. Geological Survey (USGS) data collected at the Little Falls station on the Potomac River near Washington D.C. (station 01646500). Water quality data were reviewed from the Chesapeake Bay Program long-term monitor-

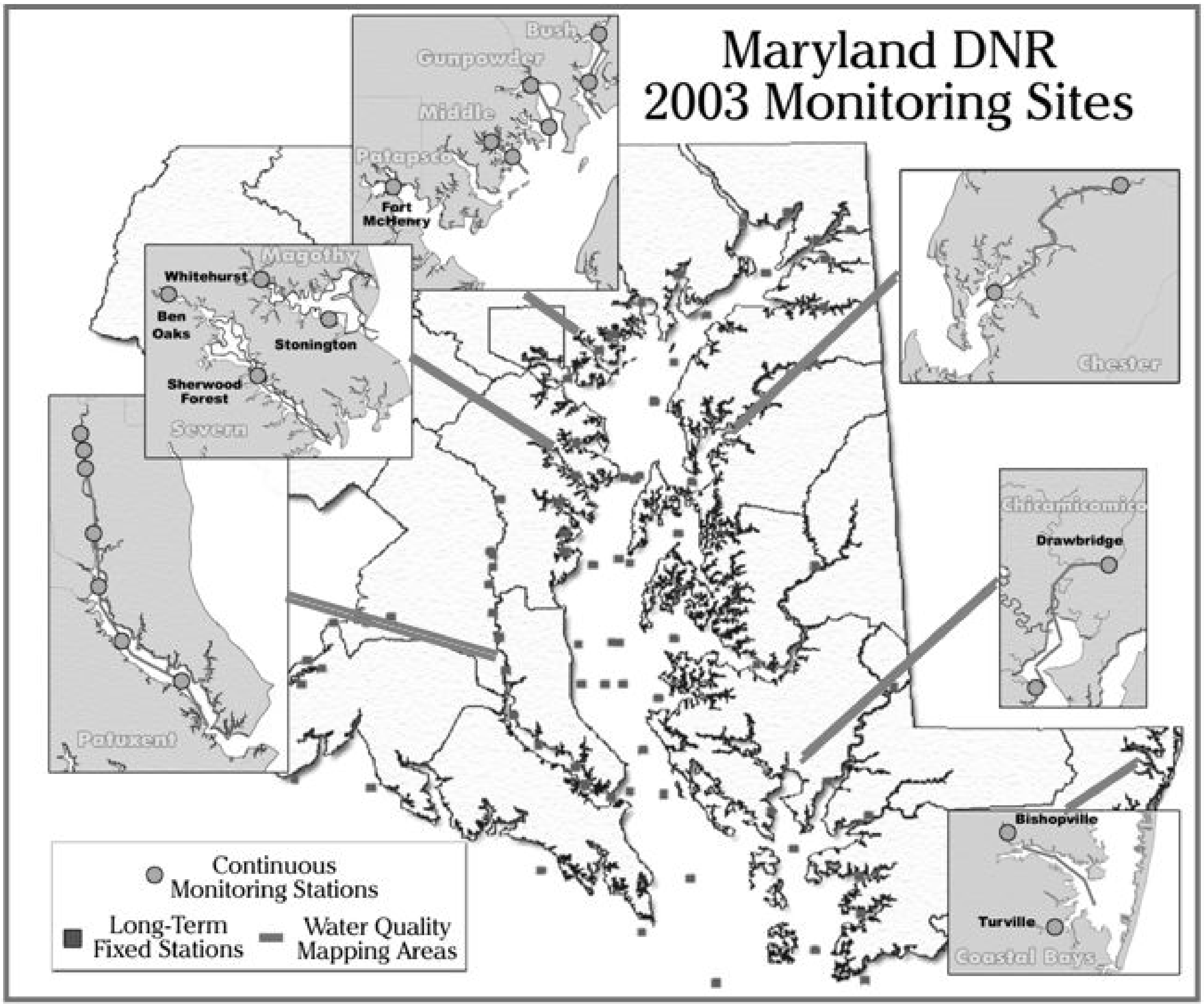


**Figure 1.** Distribution of relevant Chesapeake Bay Water Quality Monitoring Program station locations for mainstem Chesapeake Bay and the bloom region on the Potomac River (2003).

ing stations. Phytoplankton data were examined for patterns of short-term response to the storm-related effects in flow and water quality parameters. Annual-scale time series of phytoplankton abundance, community composition, and timing of possible storm response were graphically compared to assess community level changes.

## METHODS

The Maryland Phytoplankton Monitoring Program samples 20 stations distributed on the mainstem of the Chesapeake Bay (n=3), Potomac River (n=10), Patuxent River (n=4), Choptank River (n=1), Chester River (n=1), and Patapsco River (n=1). A harmful algal bloom response program provides additional samples from other sites in response to human health or living resources events. Phytoplankton samples are collected monthly (fall and winter) to biweekly (spring and summer). Samples analyzed for this paper were grab samples of 500–750 ml of surface water from three mainstem Chesapeake Bay long-term monitoring stations and additional stations on the Potomac River (Figure 1).

Live samples were returned to the laboratory for light microscope analysis. Live samples (1 ml) were used for species identification and counting

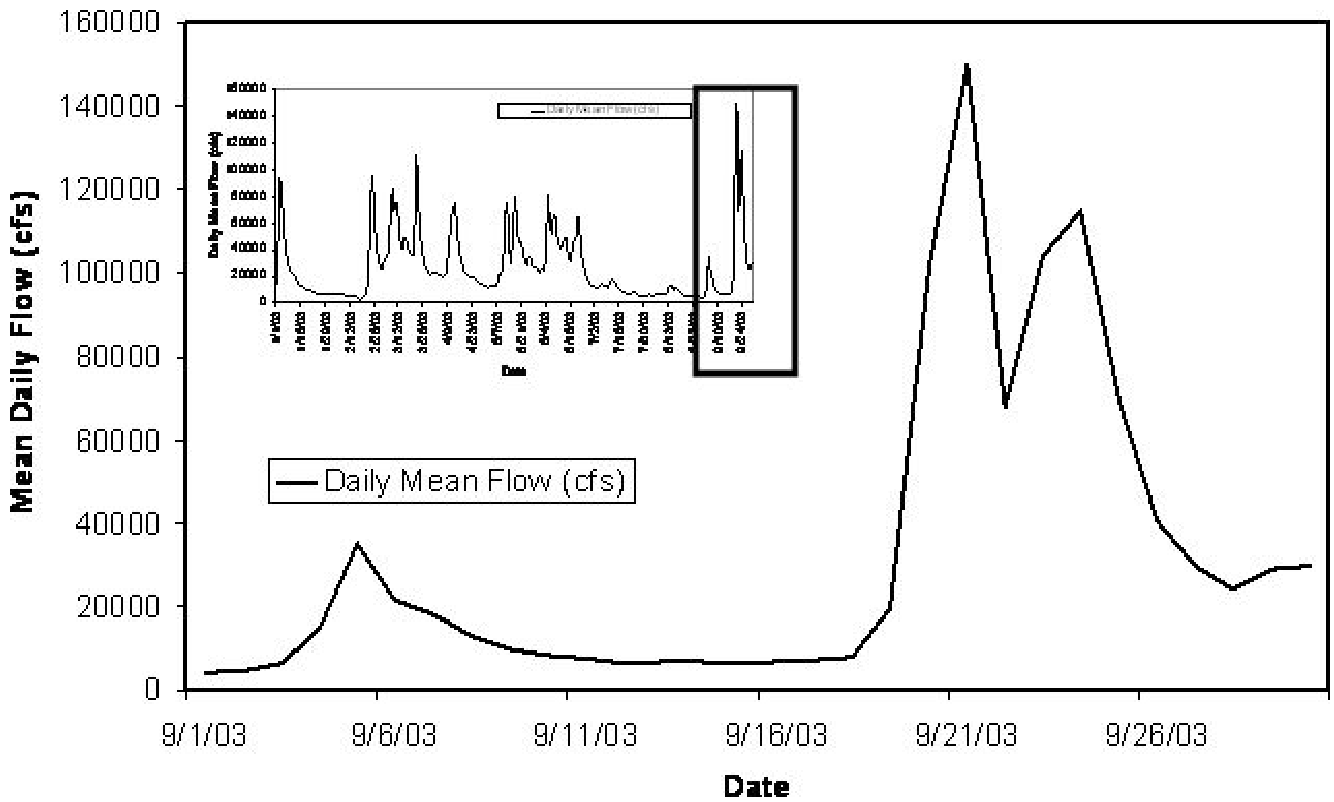


**Figure 2.** Potomac River flows at Chain Bridge, Maryland showing post-storm flows arriving September 21. The January to October 2003 flow time series is inset for reference.

on a Sedgewick-Rafter cell at 100x and 200x magnification. Preservative fixed high-density samples for counting after species identification. Sample dilutions were conducted on high-density samples and counts multiplied according to the dilution factor to estimate the original density with bloom species. Phytoplankton community composition was summarized by sampling event; water quality data collected coincident with phytoplankton sampling were compared with the plankton data.

## RESULTS

### Cyanobacteria

During 2003, the upper Bay and Bay tributaries produced cyanobacteria blooms first detected in July with densities reaching 1.6 x $10^6$ cells·$ml^{-1}$ in upper Bay tributaries (*http://mddnr.chesapeakebay.net/hab/news_7_30_03.cfm)*. By 4 September, upper Bay blooms had declined with cell counts of 1.2 x $10^4$ cells·$ml^{-1}$ measured on the Sassafras River, but visible scum was still accumulating in local areas *(http://mddnr.chesapeakebay.net/hab/news_ 9_16_03. cfm).*

A late-season cyanobacteria bloom dominated by *M. aeruginosa* developed on the Potomac River from mid-August to mid-September. *Microcystis* abundance peaked in the surface waters at >1 x $10^6$ cells·$ml^{-1}$ from 2–15 September. The cessation of the bloom concentrations coincided with storm events. Between 18 and 19 September, the Washington D.C. metro area experienced wind gusts of 78 mph at Quantico Air Force Base and 69 mph at Andrews AFB and Patuxent Naval Air Station; National Airport on the Potomac River sustained a two-minute period of 45 mph with a peak gust of 58 mph during the storm (*http://www.weatherbook.com/Isabel_report.htm*). Rainfall was 2–3 in (5.1–7.6 cm) in the D.C. area but 6–12 in (15.2–30.5 cm) fell in the Shenandoah Valley and Blue Ridge Mountains creating localized flash flooding (*www.weatherbook.com/Isabel_ report.htm*). Two days after the storm, on 21 September, the mean daily water flow at Little Falls on the Potomac River near Washington D.C. peaked at 1.5 x $10^5$ cfs, the highest level of the year (Figure 2). Coincident with flow effects in the river were: declines in salinity

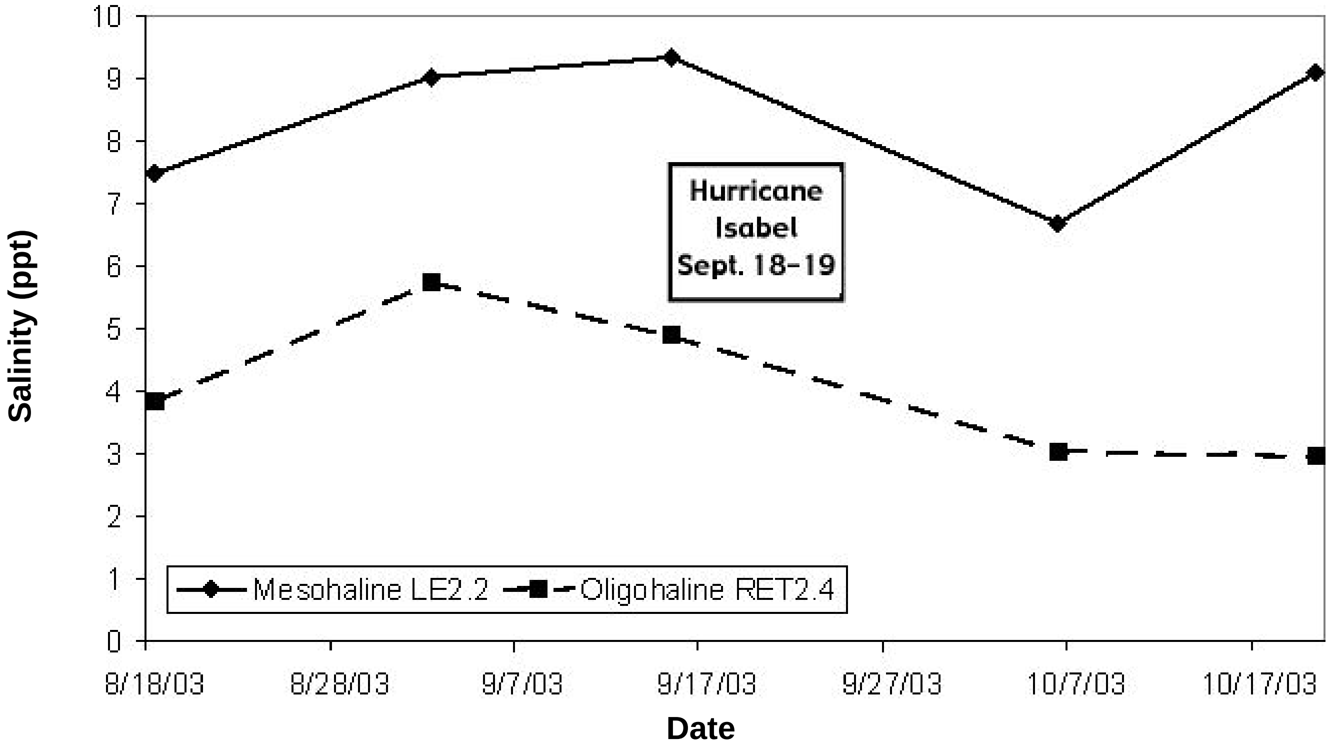


**Figure 3.** Storm flow impacts on the surface salinity distribution in the Potomac River, 2003.

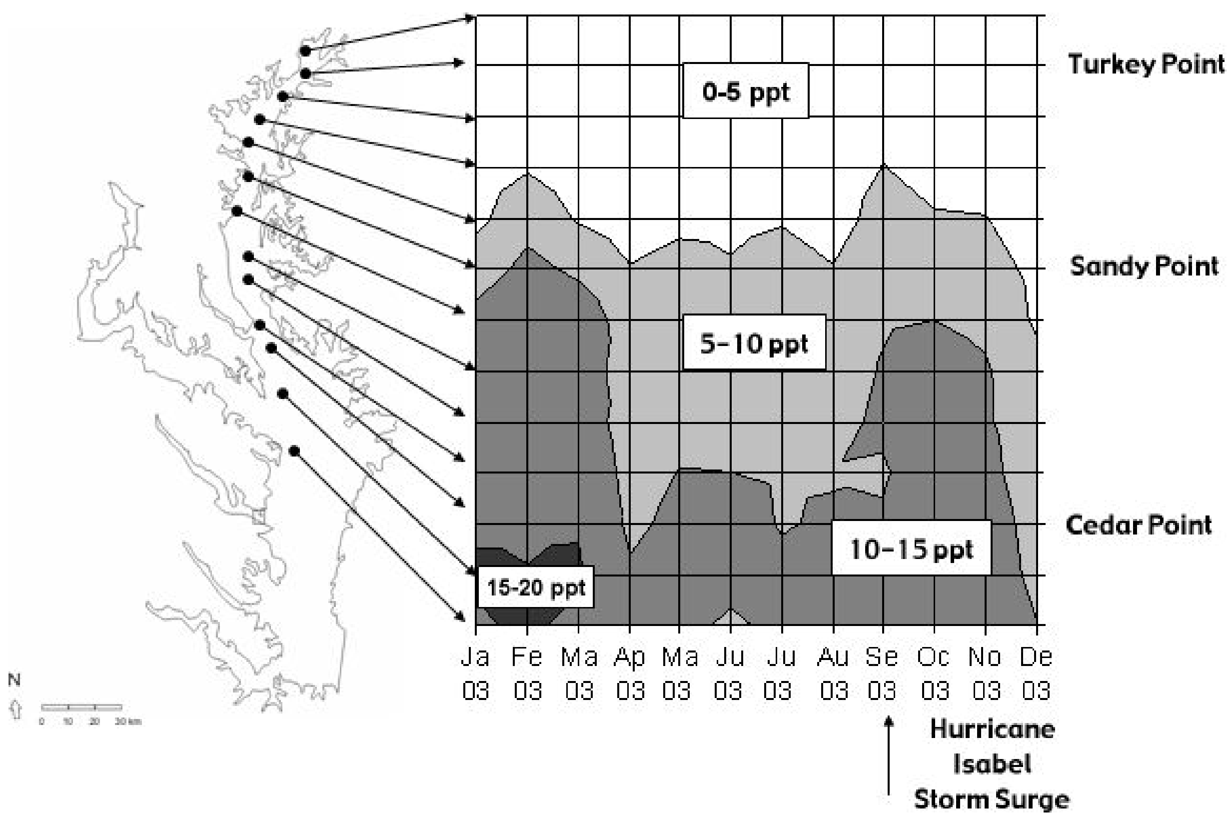


**Figure 4.** Surface plot of salinity distribution in the main stem of Maryland's tidal Chesapeake Bay in response to storm surge and resulting persistence of elevated salinity into November 2003 in the upper Chesapeake Bay.

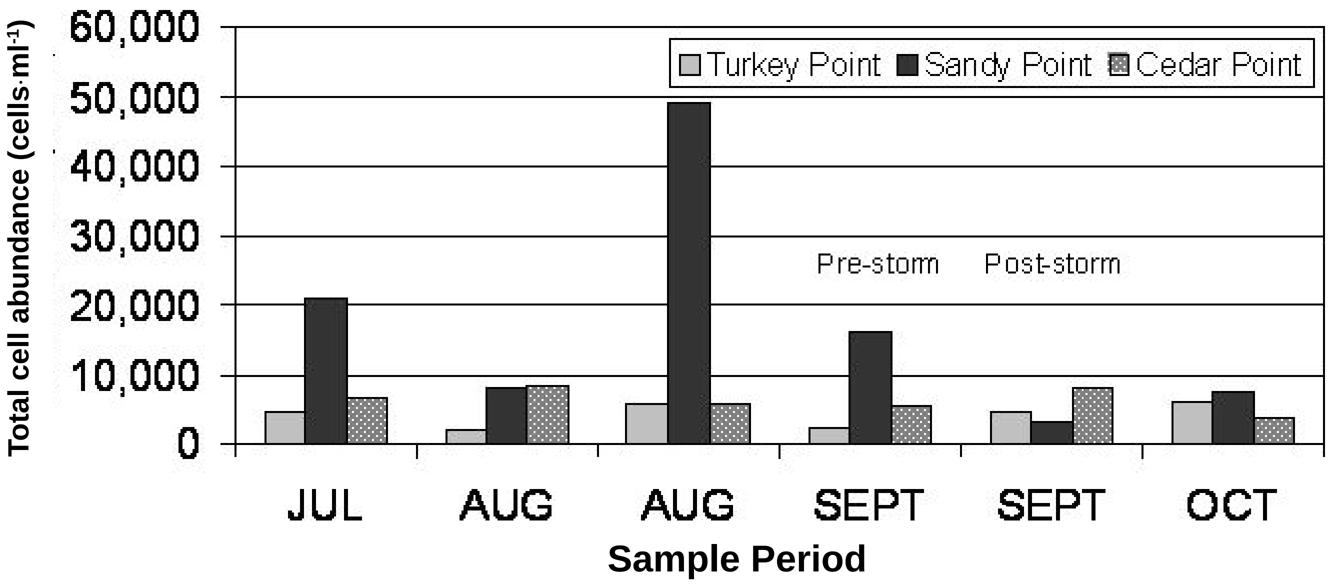


**Figure 5.** Phytoplankton abundance from July to October 2003 for mainstem Chesapeake Bay stations Turkey Point, Sandy Point, and Cedar Point.

in the oligohaline and mesohaline zones between September 15 and October 6 indicative of downstream shifts in habitat conditions (Figure 3); and surface water temperatures from a tidal-fresh average of 23.3°C on 15 September (n=3 pre-storm) to 19.8°C on 22 September (n=3 post- storm). By 6 October, mean water temperatures in the tidal-fresh zone were 16.2°C, well below favorable *M. aeruginosa* bloom conditions

### Maryland's Tidewaters of Chesapeake Bay

In the main Bay, surface salinity effects were most pronounced in the mid-Bay region and persisted into November (Figure 4). Salinity at three phytoplankton monitoring stations (Turkey Point, Sandy Point, and Cedar Point) showed little change in spite of the storm's impacts. Sandy Point experienced an algal bloom in late August and declined by 15 September—the pre-storm sampling date. Across all three stations, phytoplankton abundance showed low variability consistent with summer conditions for Turkey Point and Cedar Point; September pre-storm abundance remained low following the storm at Sandy Point into October (Figure 5). Diatoms showed an increase in their contribution to the community after the storm; however, 2002 and 2004 results also showed increases in diatom representation in the community progressing into the fall season for Turkey Point and Cedar Point (Figure 6).

## DISCUSSION AND CONCLUSIONS

Hurricane Isabel produced little short-term impact to the upper Chesapeake Bay phytoplankton community dynamics except in promoting the timing of seasonal changes. Low algal concentrations present before the storm persisted in the upper Bay region after Hurricane Isabel. An increase in the contribution of diatoms to the community after the summer was reflected in drought and wet years compared with 2003. The timing of this shift, however, was closely associated with the period of the storm suggesting a possible event linkage. An algal response was prominent in the lower Bay below the mouth of the Potomac River as measured by increases in chlorophyll *a* subject to wind-mixing effects and storm surge [3]. Isabel was a storm in which winds and runoff were considered comparatively weak but the surge was high, particularly in the upper portions of the estuary. The characteristic effects differed sharply from other hurricanes and tropical storms that affected the region, such as Agnes, which had high precipitation and runoff in the upper watershed, yet weak winds and a minor storm surge [8].

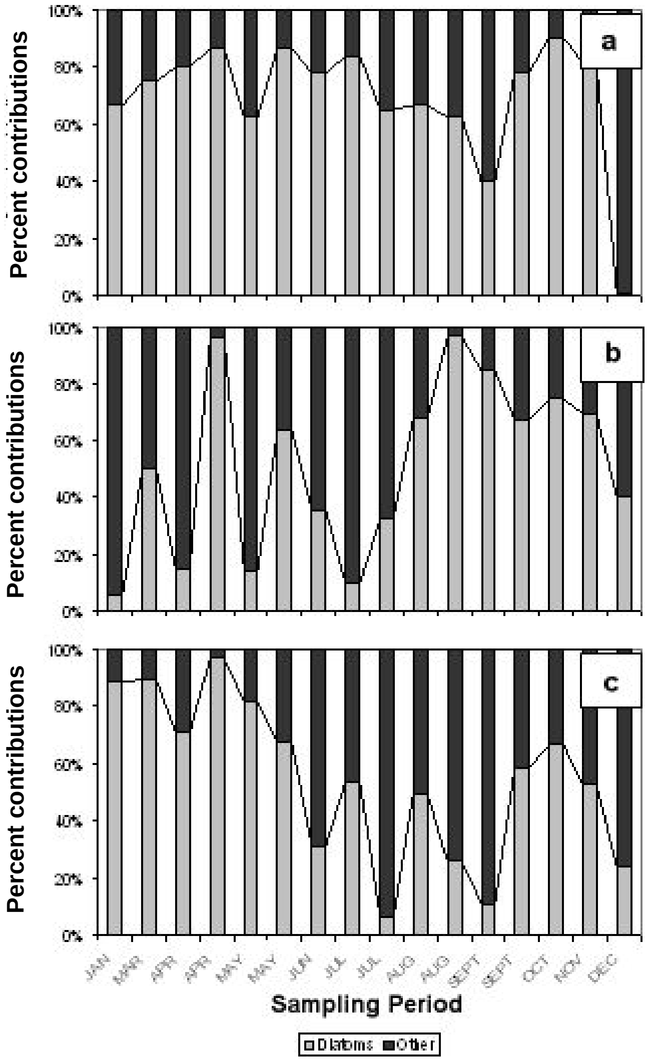


**Figure 6.** Phytoplankton community shifts during 2003 for mainstem Chesapeake Bay stations Turkey Point (5a), Sandy Point (5b), and Cedar Point (5c).

In contrast to the upper Chesapeake Bay and its tributaries, the cessation of the cyanobacteria blooms on the Potomac River were coincident with storm impacts. Strong winds were measured at National Airport and the surrounding region near the Potomac River, producing a major stress on the bloom. Flows into the region increased dramatically and salinity declines in the oligohaline and mesohaline indicate an advective mechanism to move the remaining bloom downstream. Coincident declines in water temperature below optimal growth conditions, reduced water clarity, and the shorter day lengths of autumn reduced any likelihood for bloom resurgence in the weeks after the storm.

## ACKNOWLEDGMENTS

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