Chesapeake Update
Issue 1 Jan 05

Water Quality 2004

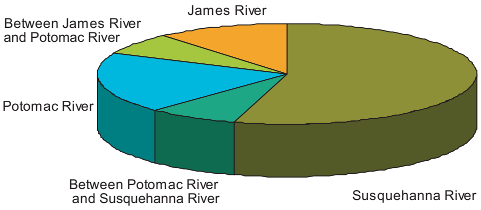
This is the first in a series of newsletters to be produced by the Monitoring and Analysis Subcommittee (MASC). MASC coordinates and supports the monitoring activities of the Chesapeake Bay Program (CBP). Newsletters produced by MASC will summarize current and significant issues relating to the health of Chesapeake Bay ecosystems, those factors that affect the health of the Bay, and the restoration effort.

This newsletter summarizes four important water quality events that affected Chesapeake Bay during 2004. These being: 1) a large turbidity plume in the Bay's mainstem due to the remnants of Hurricane Ivan; 2) The worst harmful algal bloom within the Potomac River for 20 years; 3) A large volume of anoxic water (no dissolved oxygen) in the Bay's mainstem and; 4) Unusually clear water and abundant aquatic plant occurrence in the upper Bay.

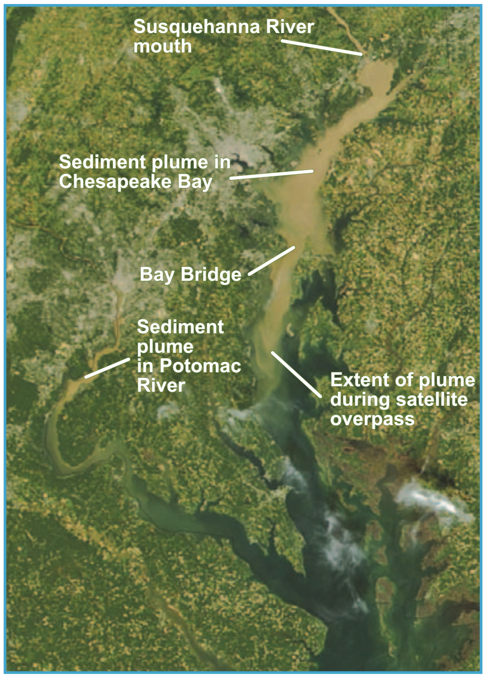
Hurricane Ivan leads to record September river flow

River discharge into Chesapeake Bay during the first six months of 2004 was consistent with the long-term average (1940s to 2002). However, in September, the remnants of Hurricane Ivan dumped up to 13 inches of rain onto the Chesapeake Bay watershed leading to record river discharge and subsequently very large loads of nutrients and sediments being delivered to the Bay. Ivan was a category four hurricane that made landfall early in the morning of September 16 between Mobile, Alabama and Pensacola, Florida. The remnants of the hurricane moved northwards to the Appalachian Mountains and merged with a cold front on September 17, resulting in the record rainfall.

Consistent with the long-term average, approximately half of the water flowing into the Bay came from the Susquehanna River (54%), with the Potomac and James Rivers being responsible for 19% and 11%, respectively.



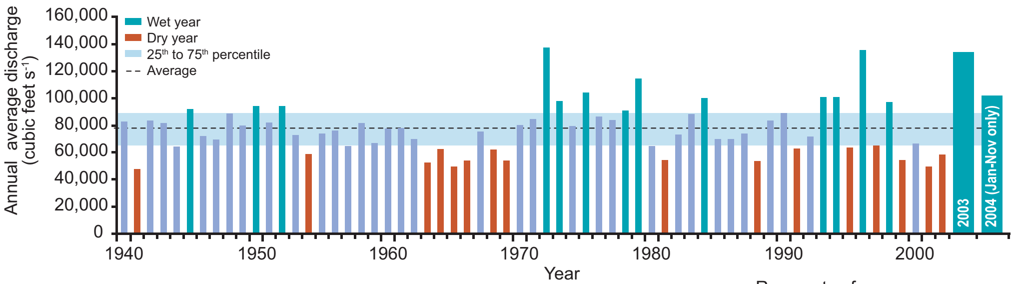
Relative inflow of water into Chesapeake Bay during 2004.

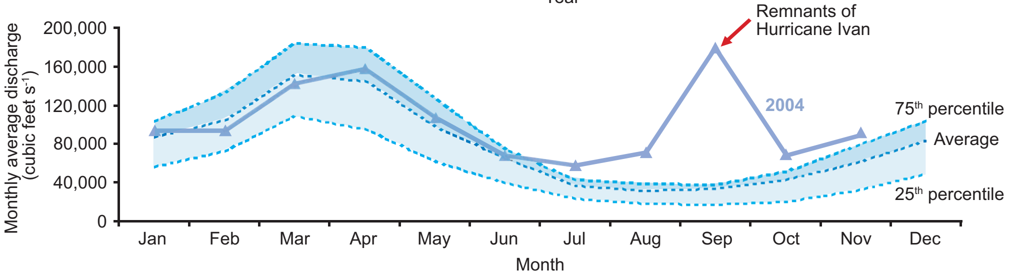


Chesapeake Bay on 22 September 2004 shortly after the heavy rains caused by the remnants of Hurricane Ivan. Image shows a large sediment plume from the Susquehanna River extending south into the central reaches of the Bay. (Source: NASA MODIS/Terra.)

The record September discharge also follows two years of extreme river flow, with very low flow in 2002 and high flow in 2003. River flow into Chesapeake Bay accounts for approximately 62% of the nitrogen and the majority of sediment delivered to the Bay. Consequently, the quality of the Bay's water and the health of the Bay's flora and fauna are strongly influenced by river flow.

Elevated river flow over the past two years has contributed to a large harmful algal bloom in the Potomac River and low dissolved oxygen levels in the Chesapeake Bay mainstem. Contrary to these negative impacts, water clarity in the northern region of the Bay reached record levels this summer, before the effects of Hurricane Ivan. This newsletter summarizes these three events.

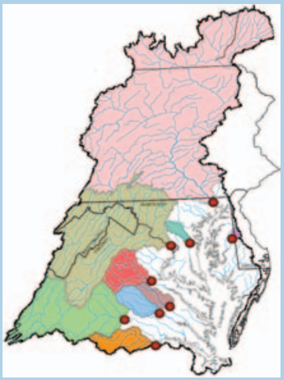




River discharge rates into Chesapeake Bay over the past 60 years (top) and during 2004 (bottom). The past six years are characterized by two years of higher than average discharge (highlighted by thicker bars) preceded by four years of lower than average discharge. The elevated discharge in 2004 was largely attributable to September rainfall from Hurricane Ivan. (Source: United States Geological Survey.)

River Input Monitoring stations

River flow, pollutant concentration and load monitoring is conducted by the River Input Monitoring (RIM) program, a collaboration between United States Geological Survey, Virginia Department of Environmental Quality and Maryland Department of Natural Resources. There are nine RIM stations in the Chesapeake watershed, measuring approximately 93% of river flow into the Bay. Over the next few years, the number of monitoring stations is expanding to obtain better estimates of loads entering the bay from coastal watersheds.



Location of River Input Monitoring stations.

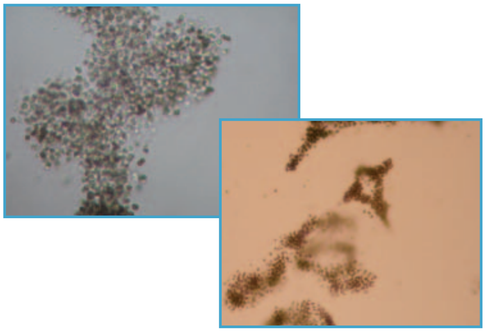
Further information on river flow can be found at the US Geological Survey website: *http://va.water.usgs.gov/chesbay/RIMP/index.html*

Potomac River experiences worst harmful algal bloom in 20 years

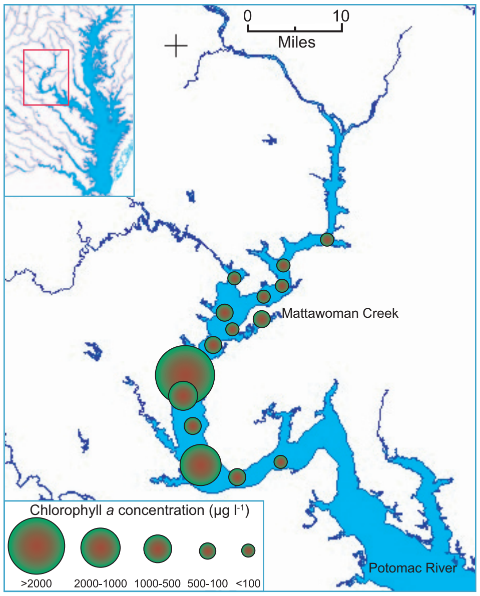
Last summer, the Potomac River experienced the worst harmful algal bloom (HAB) in 20 years. The bloom started at Mattawoman Creek and rapidly spread throughout the middle reaches of the estuary.

At the peak of the bloom in late July through early August, a 45-mile stretch of the estuary was affected. The bloom mostly consisted of the cyanobacterium (blue-green algae) *Microcystis aeruginosa*, a common species that typically blooms in summer within the fresh and low salinity portions of the Chesapeake Bay.

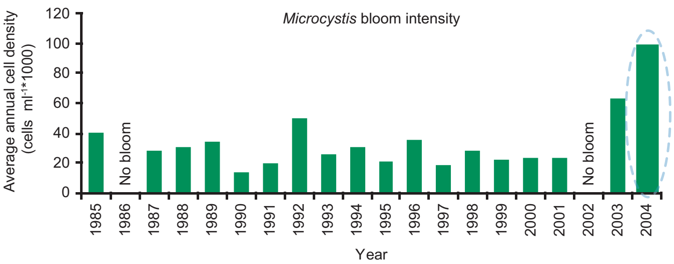
Analyses revealed that the bloom consisted of a toxic strain of the cyanobacterium. When high cell counts (>10,000 cells ml^{-1}) and toxin levels (microcystin levels >3 parts per billion) were recorded at Colonial Beach, the shoreline was closed for several days to water-related recreational activities. While the Potomac River has been experiencing harmful algal blooms in this region for many years (records of HABs in the Potomac date back to the 1960s), the blooms in the past two years have been the largest since 1984.

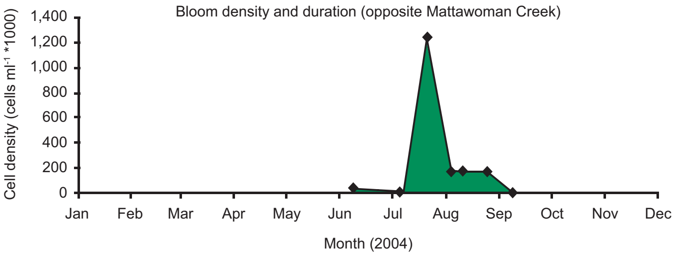


Microscopic views of* Microcystis aeruginosa. *Cells 3-4.5 µm diameter. (Source: Department of Biological Sciences, Old Dominion University.)



Surface water chlorophyll a concentrations in the upper reaches of the Potomac River illustrate the distribution and intensity of the bloom during its peak. Note: during blooms, surface water chlorophyll a concentrations can be significantly higher than the underlying water body. (Source: Morgan State University Estuarine Research Center.).





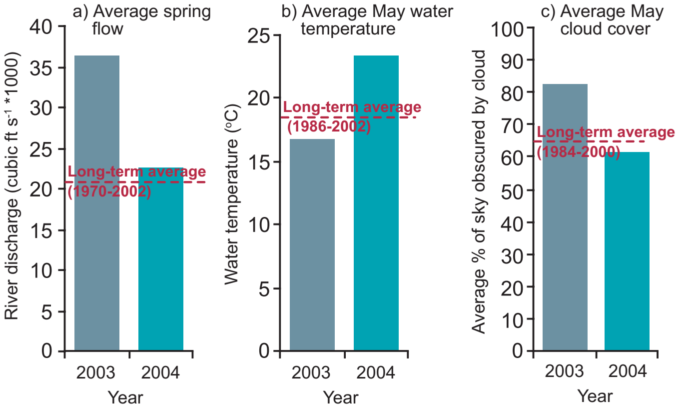
Bloom intensity over the past 20 years (above) and during 2004 (right). Bloom intensity expressed as the number of cells recorded in a milliliter of surface sample water. Note: no blooms were recorded in 1986 and 2002. (Source: Maryland Department of Natural Resources.)

Why was the bloom so severe?

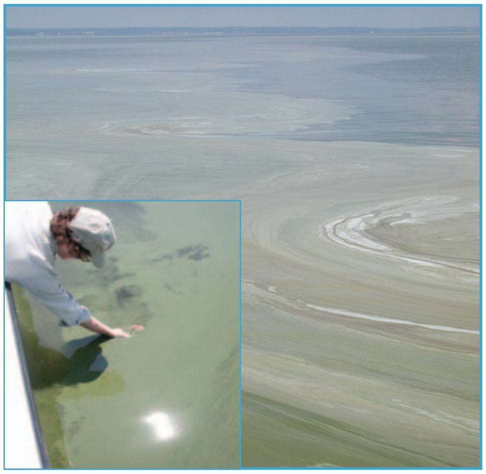
This year's record harmful algal bloom in the Potomac River is attributable to a combination of three factors leading to ideal bloom conditions:

a) Elevated nutrient availability due to high river flow rates in 2003,
b) Warmer than average May 2004 surface water temperatures,
c) Less than average cloud cover in May 2004 leading to greater light availability.

That an equally large HAB did not occur in 2003, despite elevated nutrient availability from increased flow conditions, may be attributable to less favorable water temperatures and light availability. Average water temperature in May 2003 was 2°C less than the long-term average and cloud cover was 18% greater.



Sources: a) River flow: United States Geological Survey Potomac River monitoring station; b) Surface water temperature at Maryland Department of Natural Resources monitoring site TF2.4; c) Cloud cover at Baltimore-Washington International airport: NOAA National Weather Service.



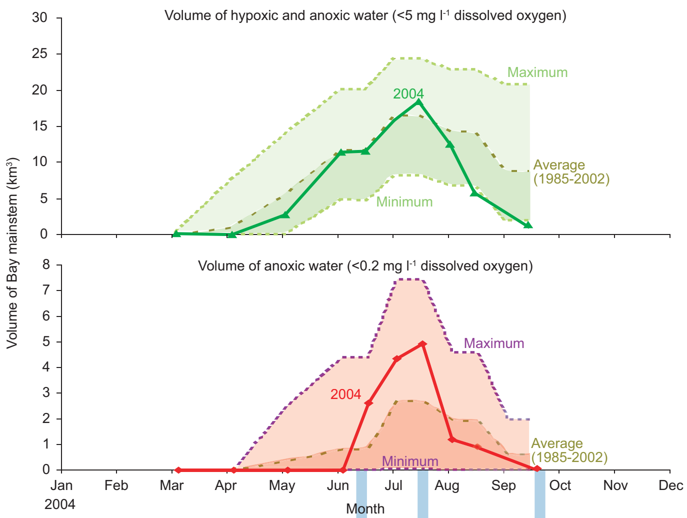
Surface bloom of the cyanobacterium* Microcystis aeruginosa *in the Potomac River in August 2004. (Source: Morgan State University Estuarine Research Center.)

Further information on Potomac River harmful algal blooms can be found at found at the Maryland Department of Natural Resources website: *http://www.dnr.state.md.us/bay/hab/index.html*

Dissolved oxygen: Large anoxic zone during summer

Once again, large areas of Chesapeake Bay experienced low dissolved oxygen levels in 2004. Lowest oxygen levels occurred in the deep waters of the central Bay region where strong stratification limited exchange between oxygen depleted bottom waters and oxygen rich surface waters. The volume of anoxic water (less than 0.2 mg l^{-1}) was worse than normal during June and July 2004, with the volumes recorded being significantly larger than the long-term average. During August and September, anoxic conditions rapidly diminished, with volumes below the long-term average recorded. The volume of Chesapeake Bay experiencing hypoxic and anoxic conditions (dissolved oxygen levels below 5 mg l^{-1}, levels which are stressful or lethal for many fish species) was close to average between March and July, then dropped below the long-term average in August and September. The rapid decrease in the volume of hypoxic and anoxic waters in August may be attributable to a wind-driven mixing event three days before the sampling cruise.

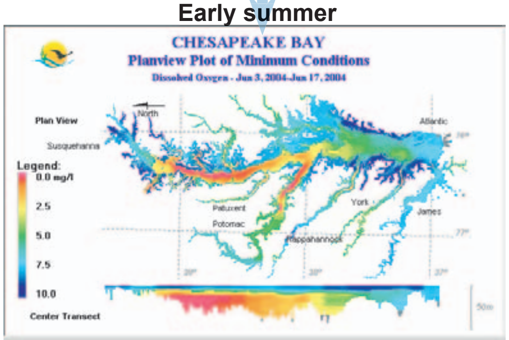
Volume of Bay mainstem waters experiencing hypoxic and anoxic conditions this summer. Anoxia was above average during June and July. Hypoxia and anoxia were below average during August and September. (Source: Chesapeake Bay Program.)



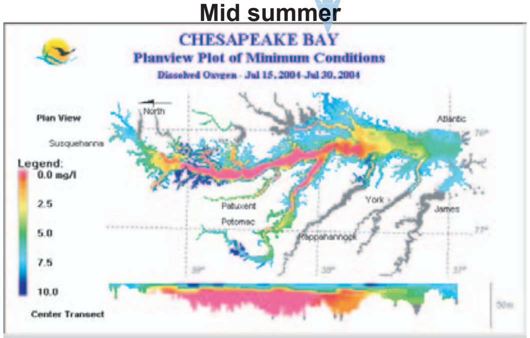
Despite large amounts of nutrients and organic matter entering the Bay during high flow conditions in 2003, the volume of hypoxic water remained at or below the long-term average. Why the volume of hypoxic water did not increase, but the volume of anoxic water increased, is still being investigated.

Further information on dissolved oxygen levels in the Bay can be found at the following websites:
http://www.chesapeakebay.net/wquality.htm
http://eyesonthebay.net

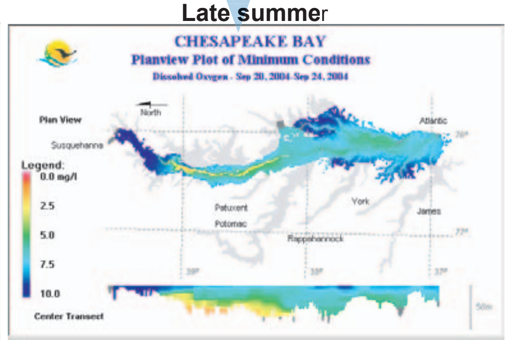
Early summer



Mid summer

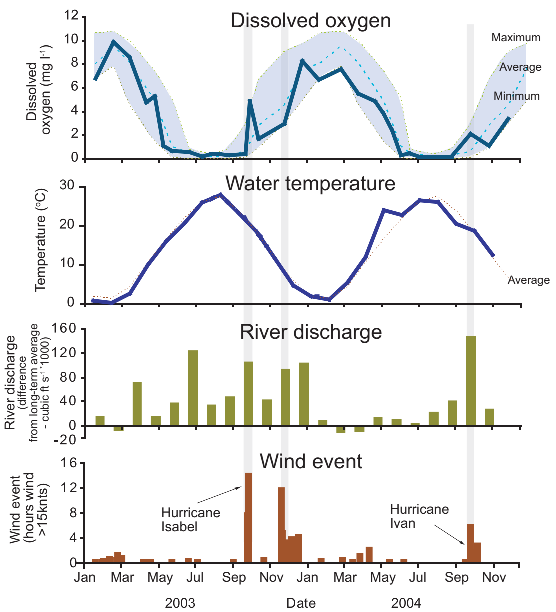


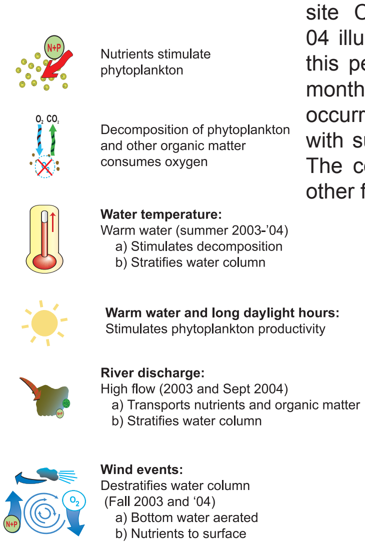
Late summer



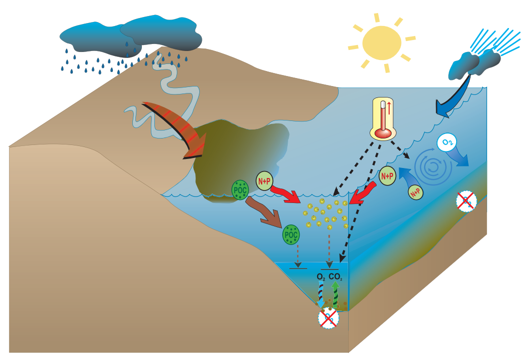
Spatial interpolation of dissolved oxygen levels in Chesapeake Bay mainstem during the summer of 2004. Mainstem and tributary interpolation based on ~144 sites, mainstem only interpolation based on 44 sites. There are at least five depths per site. Sample cruises conducted over 4 to 15 day periods. (Source: Chesapeake Bay Program.)

What causes dissolved oxygen levels to change?





Dissolved oxygen (DO) levels in the bottom waters at monitoring site CB3.3 (opposite Chesapeake Bay bridge) during 2003-04 illustrate the highly variable nature of Bay DO levels. During this period DO levels ranged between 0.2 and 10 mg l^{-1}. Many months were below the long-term average and rapid fluctuations occurred. This figure illustrates how water temperature (coupled with sunlight), river discharge and wind events affect DO levels. The conceptual diagram illustrates the interaction of these and other factors on DO levels.



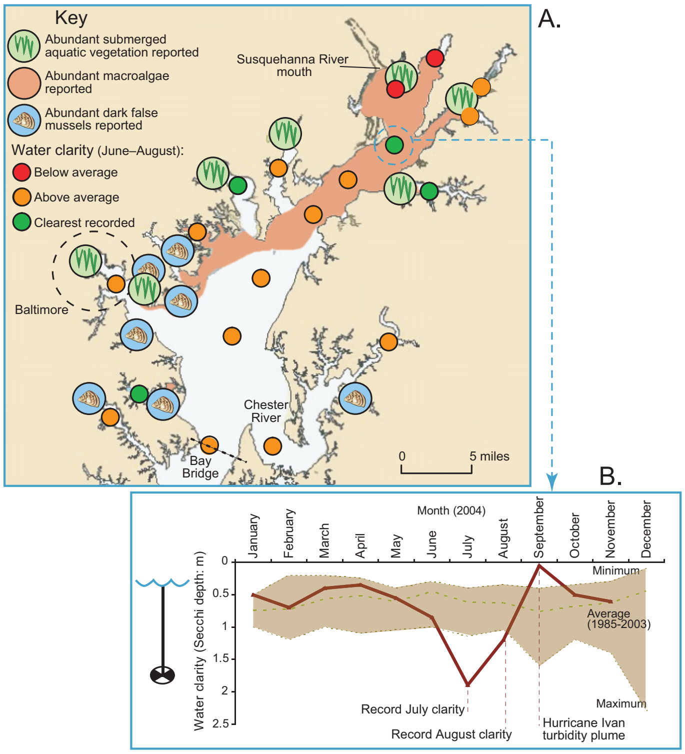
Sources: Dissolved oxygen and water temperature data from Maryland Department of Natural Resources monitoring site CB3.3. River discharge data from United States Geological Survey River Input Monitoring Program. Wind data from National Oceanographic and Atmospheric Administration – Thomas Point Lighthouse.

Unusual summer conditions in upper Bay

Last summer, upper Chesapeake Bay had unusually clear water, abundant submerged aquatic vegetation (SAV) cover, elevated macroalgae distribution and localized occurrence of dark false mussels. Here we summarize the observations and pose an explanation as to why the conditions occurred.

Water clarity

From June to August 2004, many monitoring stations in the upper Chesapeake Bay had water clarities at or above the 20-year average for this time of year, with many stations recording record clarities. This is particularly unusual given that river flow during the summer was consistent with the long-term average and that high flow rates occurred in the previous year.



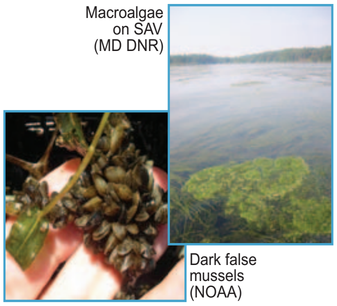
A) Upper Chesapeake Bay summer water clarity and occurrences of macroalgae, dark false mussels and submerged aquatic vegetation. B) Secchi depth at upper Chesapeake mainstem site (Turkey Point: CB2.1). (Source: Maryland Department of Natural Resources.)

Submerged aquatic vegetation

An abundance of submerged aquatic vegetation beds was reported in the upper Bay this year by the local community. In some instances it was reported in areas where little or none had been observed in the recent past (e.g., Baltimore Harbor basin on the Patapsco River). Species and density shifts within existing beds may be producing greater coverage and increased diversity of native species.

Macroalgae

This summer extensive blooms of macroalgae were reported in the upper Bay, covering a 20-mile region. Large blooms of macroalgae are not typically observed in Chesapeake Bay, with any occurrence normally restricted to small, localized patches. The predominant macroalgae present were *Cladophora* and *Rhizoclonium,* both green macroalgae. The cyanobacterium *Lyngbya* was also locally abundant. The bloom fouled crab pots and gill nets, forcing watermen to reduce fishing effort or move farther south to unimpacted areas.



Macroalgae on SAV (MD DNR)

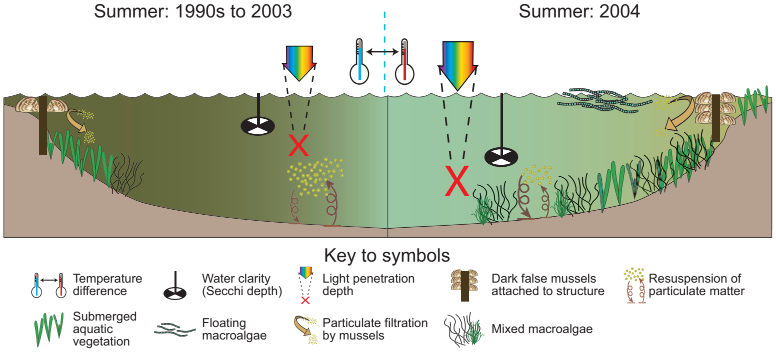
Dark false mussels (NOAA)

Mussels

The dark false mussel (*Mytilopsis leucophaeta*) is one of several mussel species native to the Chesapeake Bay, though not typically considered common or abundant. The mussel is small (typically less than one inch or 2.5 cm), attaches itself to rocks or other hard substrate, and prefers lower salinity waters. During summer 2004, greater than normal abundances of this mussel were observed in the South River, Bear Creek (Patapsco River) and upper Severn River. However, the Magothy River was the primary area for a large population of the mussel extending from the headwater creeks to the mouth.

Why are we seeing these conditions?

There has been a slow increase in upper Bay SAV populations over the past 10–12 years. This has probably been the result of gradually decreasing amounts of suspended sediments in this portion of the Bay. Then, during the spring of 2004, upper Bay water temperatures rose to a 20-year high due to an unusually hot May. This warm water may have allowed SAV and macroalgae populations to get an early start on the growing season enabling the beds to not only survive, but to trap sediments and nutrients, maintaining high water clarity during the early summer. Filtration by the dark false mussels may also have increased water clarity in localized areas.



Conceptual diagram comparing the upper Bay during the summer of 2004 to that of more recent summers.

Further information on the unusual conditions in the upper Bay can be found at: *http://www.dnr.state.md.us/bay/index.html*

This newsletter was the initiative of the **Tidal Monitoring and Analysis Workgroup** (TMAW). TMAW is responsible for the Chesapeake Bay Program's (CBP) tidal water quality and biomonitoring programs. The Workgroup coordinates and integrates the State- and Federally-funded monitoring programs within the tidal monitoring network, promoting consistency in sample collection and analysis, data management and reporting. The data collection programs provide quantitative information on a suite of physical and chemical water quality parameters, as well as certain biological parameters.

Chesapeake Bay Program
A Watershed Partnership

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