Chesapeake Update

Water quality & aquatic grass

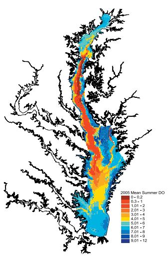
~Summer 2005~

Issue 4
Nov. 05

Summer wrap-up produced by the Monitoring and Analysis Subcommittee (MASC). MASC coordinates and supports the monitoring activities of the Chesapeake Bay Program.

This edition of Chesapeake Update provides an overview of water quality and aquatic grass conditions over the summer of 2005. An explanation as to why these conditions occurred is provided–largely a combination of a wet spring followed by a dry, calm and relatively warm summer. The observed conditions are compared to those forecast to occur before the summer, and explanations for any differences is provided. The main events this summer can be summarized as...

Severe dissolved oxygen conditions



Large spring nutrient loads combined with a calm and hot summer leads to one of the worst anoxic volumes on record (see page 2).

Mean summer mainstem dissolved oxygen

Localized harmful algal blooms

Localized harmful algal blooms occurred in many regions of the Bay, but not to the extent predicted in the Potomac River (see page 3).

Harmful algal bloom in Sassafras River

Aquatic grasses flourish in Northern Bay

Good summer water clarity at the Susquehanna Flats leads to increased cover of aquatic grasses (see page 4).

Aquatic grasses in the northern Bay

Bay responds to dry, calm and hot summer

Climate and weather play a critical role in affecting the health and ecology of Chesapeake Bay. A combination of low rainfall, warm water and calmer conditions impacted many aspects of the Bay's health this summer. These conditions combined with a wet spring, had an overriding influence on many aspects of the Bay's health.

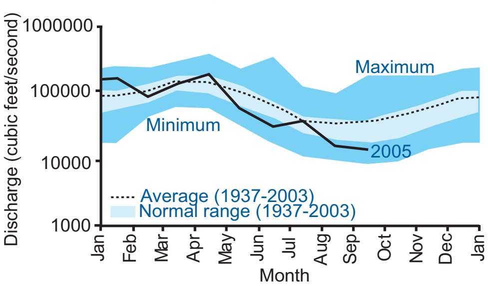


Figure 1. Mean monthly inflow into Chesapeake Bay. Flow was below the normal range for many months (USGS provisional data).

Exceptionally low rainfall in many Chesapeake Bay watersheds, especially during September, resulted in below-average river discharge (Fig. 1), with some streams recording the lowest flows in over 50 years. Low discharge generally means less nutrients and sediment delivered to the Bay, which in itself, can lead to improved water quality.

Wind speeds and event durations were also below average this summer. Duration of wind above 10 meters per second (~20 knots) are thought to have a significant effect on the Bay's dissolved oxygen levels because they mix low oxygen bottom waters with higher oxygen surface waters. Duration of these strong wind events was one of

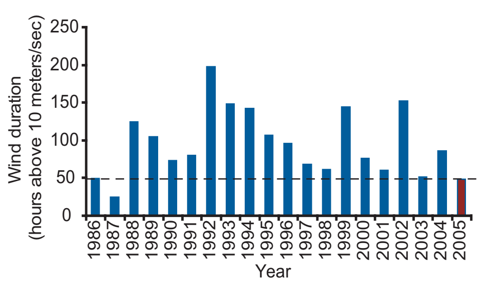


Figure 2. Wind speeds in summer of 2005 were lower than recent years.

the lowest in 20 years in 2005 (Fig. 2), and this likely contributed to the large anoxic (dissolved oxygen levels at/or below 0.2 mg/l) volume this summer. Wind is also the primary cause of sediment resuspension. This summer's calm conditions may also have contributed to some of the good water clarities and increased aquatic grass cover in the Northern bay.

Chesapeake Bay water temperatures were exceptionally warm this summer, with above-average and record high temperatures measured at most monitoring stations (Fig. 3). Warmer temperatures contribute to oxygen depletion by reducing the amount of oxygen that water can hold and by

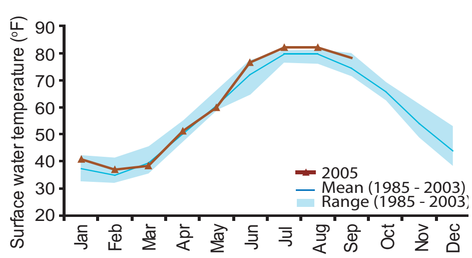


Figure 3. Surface water temperatures at a mainstem Bay water quality monitoring station (CB 4.3c)

accelerating oxygen consumption by microbes.

Water temperature also affects the rate at which phytoplankton and harmful algae grow. There were harmful algal blooms in many regions of the Bay this summer, with water temperature likely playing an important part in the occurrence of the blooms.

Large volume of anoxic water in Bay mainstem

In the spring of 2005, the Chesapeake Bay Program released its first ever forecast of anoxic conditions in the Bay for the following summer. The forecast indicated that the summer of 2005 had the potential to be the fourth worst since monitoring began in 1985. When the final summer cruise was completed and the data analyzed in September, it turned out that the anoxic conditions during the summer 2005 would be one of the worst on record.

The Bay Program assesses anoxic conditions by determining the total volume of anoxic water in the mainstem of Chesapeake Bay. Anoxic water has a dissolved oxygen concentration of ≤0.2 mg/l. Anoxic volume was below average at the beginning of June then moved and stayed above average for the durations of the summer. A record anoxic volume for August was set during the monitoring cruise at the beginning of August (Fig. 4). 2005 was unusual in that the peak in anoxic volume wasn't seen until August. Cooler temperatures at the beginning of the summer may have delayed the peak in anoxic volume until August. The summer mean value is used to compare one summer to the rest and was used to determine that the summer of 2005 was one of the worst on record (Fig. 5). Volumes recorded this summer were only slightly less than those recorded in 1993, 1996 and 1998.

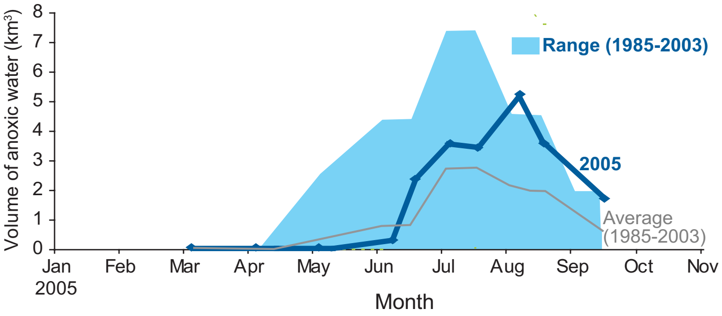


Figure 4. Volume of anoxic water in Chesapeake Bay mainstem during the 2005 summer months.

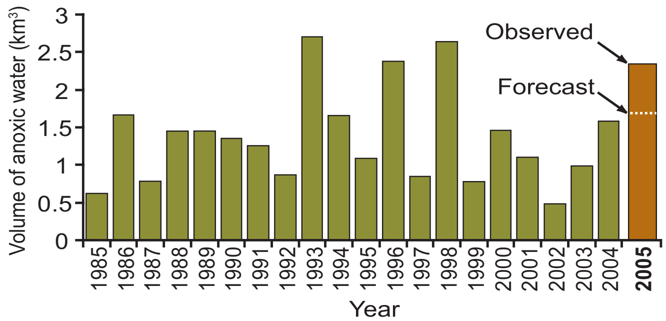


Figure 5: Mean volume of anoxic water in Chesapeake Bay mainstem in 2005 compared to previous 19 years and the spring forecast.

Why dissolved oxygen conditions were so bad

The oxygen conditions in the bay were even worse than predicted, with the volume of anoxia in August the worst since intensive monitoring began in 1985. Most of the severity of anoxia this summer can be explained by the magnitude of the nutrient load this spring. However, it appears that lack of wind and above-average deep water temperatures were also contributing factors.

The average wind speed for the summer of 2005 was one of the lowest in the 1986-2005 period (Fig 3). The number of intense wind events was also much lower in 2005. Deep water temperatures were above average for most of the summer and continued to increase into September. Lack of wind means that deep, anoxic waters were not replenished with oxygen-rich surface waters by the mixing energy that wind provides. Warmer temperatures contribute to oxygen depletion by reducing the amount of oxygen that water can hold and by accelerating oxygen consumption by microbes (Fig. 6).

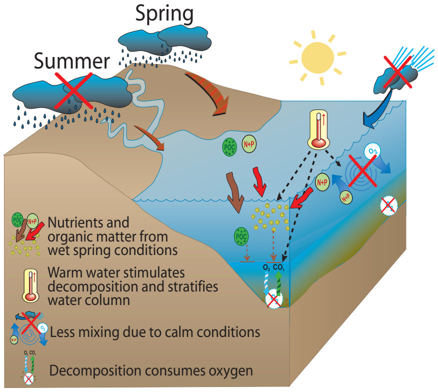
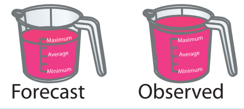


Figure 6. Conceptual diagram illustrating factors leading to large anoxic volume in the Bay's mainstem this summer.

Forecast predicted better dissolved oxygen conditions

Based on nitrogen and phosphorus inputs to the northern Chesapeake Bay during the January through May time period, it was forecast that the mean anoxic volume during the summer of 2005 would be 1.98 +/- 0.59 km³ (Fig. 7). The actual mean anoxic volume was 2.35 km³; well within the range forecasted. The forecast volume and historic volumes used to generate the forecast were revised over the summer. This revision involved incorporating a threshold of ≤0.2 mg/l dissolved oxygen (rather than < 0.2 mg/l) and expanding the interpolator output precision to 2 decimal places. These improvements in the analysis resulted in slightly different historic and forecast volumes.



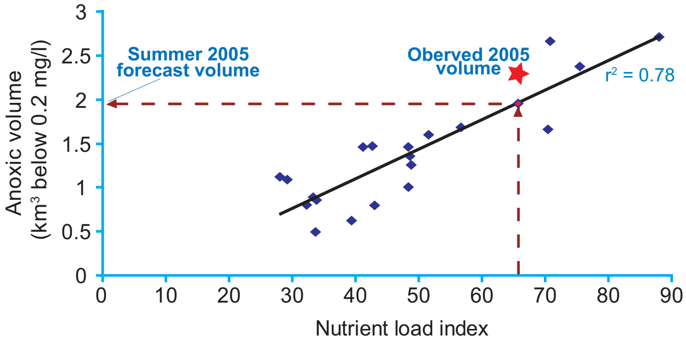


Figure 7. Relationship used to generate forecast, showing anoxic volume predicted and that observed.

Harmful algal blooms throughout the Bay

Harmful algal blooms (HABs) have been a common occurrence in many regions of the Chesapeake Bay in recent year, and this year was no exception. Harmful algal blooms were recorded in many of the Bay's tributaries and even in the mainstem this summer. Although there were many HABs, the long (2.5 month) bloom that was forecast to occur in the Potomac River did not persist for as long as predicted.

Harmful algal blooms (HABs) occurred in many regions of Chesapeake Bay this summer, including the Potomac River where blooms have occurred 18 times in the past 20 years (Fig. 8). Different harmful algae species bloomed in different regions of the Bay, and at varying times of the summer (Fig. 9).

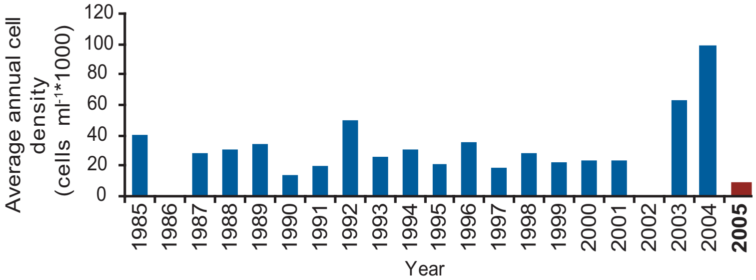


Figure 8. Historic levels of the HAB Microcystis aeruginosa in Potomac River in relation to the low levels recorded this summer.

A spring Mahogany Tide (caused by the dinoflagellate *Prorocentrum minimum*) was one of the most extensive in the 20-year history of the long-term water quality monitoring program. The phenomenon was detected in the mainstem Chesapeake Bay and the lower tributaries, including the Potomac, Patuxent and Choptank Rivers. Most other HAB events were in local regions and were relatively short-lived. Exceptions were a highly varied species composition bloom in the upper reaches of the Sassafras River which turned the water electric green for nearly two months. Toxic blooms of algae were noted on a five-mile stretch of the upper Transquaking River however no fish kill effects were observed.

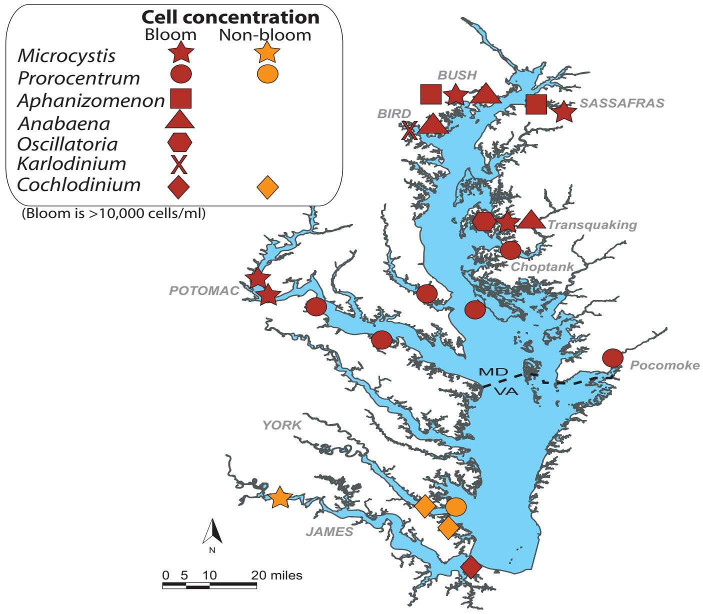


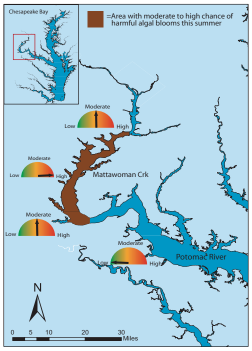
Figure 9. Location of documented harmful algae events this year.

Early this autumn, low dissolved oxygen events were coincident with a toxic bloom of the dinoflagellate *Karlodinium micrum* combining to cause a kill of an estimated 50,000 fish on the Corsica River (See below for more details).

Bloom duration shorter than forecast

A high intensity, moderate sized bloom (> 10 miles) persisting for over 2 months was predicted to occur on the Potomac River this summer (Fig. 10). The largest *Microcystis* bloom distribution was detected on July 11th of 15 miles of moderate intensity with the last bloom sample collected 1 month later. The slight inconsistency between the observed and forecasted bloom conditions can, in part, be attributed to an over estimate of spring river flow rates used to generate the forecast. Near- and long-term shifts in wastewater treatment plant nutrient delivery patterns likely also affected bloom behavior.

Figure 10. High to moderate probabilities of harmful algal blooms were forecasted to occur in the upper reaches of the estuary.



Harmful algal bloom and low dissolved oxygen leads to fish kill

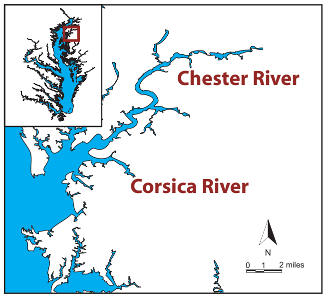


Figure 11. Corsica River is a small tributary of the Chester River, located on the Eastern Shore of Maryland

On and around September 29, the Corsica River (Fig. 11) experienced a large fish kill as a result of algal toxins and low (hypoxic) to no (anoxic) dissolved oxygen. Approximately 50,000 fish representing 15 species were observed, with menhaden being the most prevalent (Fig. 12). Water quality mapping and continuous monitoring by Maryland DNR observed that intense algal blooms of *Karlodinium micrum* began to die off on September 26, resulting in anoxic conditions down-river on September 27, and hypoxic conditions upriver on September 28. Testing for algal karlotoxins indicated nearly twice the lethal level necessary to kill fish in a one-hour period. For more information visit: *www.dnr.state.md.us/bay/hab/index.html*

Figure 12. Dead fish (mostly menhaden) floating in the Corsica River at the end of September (photo: MD DNR).

Susquehanna Flats aquatic grasses promote water clarity

This summer, aquatic grasses growing in the low salinity waters of the northern Bay increased in both cover and density. *"This year's' abundance is nothing short of phenomenal! When we first started the annual mapping program in 1984, we were hard pressed to observe the small patches present back then. The bed today is large and dense, consisting of multiple species."* Robert Orth (Virginia Institute of Marine Science; lead scientist of aquatic grass surveys) describing preliminary survey results from the Susquehanna Flats.

Flourishing northern Bay aquatic grasses may, in part, be due to exceptionally good water clarity, especially over the Susquehanna Flats where visibilities through the water column of up to 12 feet (4 meters) were recorded. This exceptional clarity is likely attributable to a combination of: (a) abundant aquatic grasses improving clarity by slowing water movement, allowing smaller sediment particles to settle to the bottom; (b) lower than average summer Susquehanna River discharge flows; and (c) a trend of fewer nutrients and sediments in the Susquehanna River over recent years. The last two reasons result in less sediment and nutrients being delivered to the northern Bay (Fig. 13). The low flow events also give a glimpse of what Bay water quality could be if sediment and nutrient controls were fully implemented throughout the watershed.

Data from upper Bay long-term fixed monitoring sites (CB 1.1) in deeper channel waters show above-average to average water clarities. Clarity at these deeper water sites are more indicative of sediments and nutrient delivery to the Bay than the exceptional clarities observed in the shallow aquatic grass beds of the Susquehanna Flats.

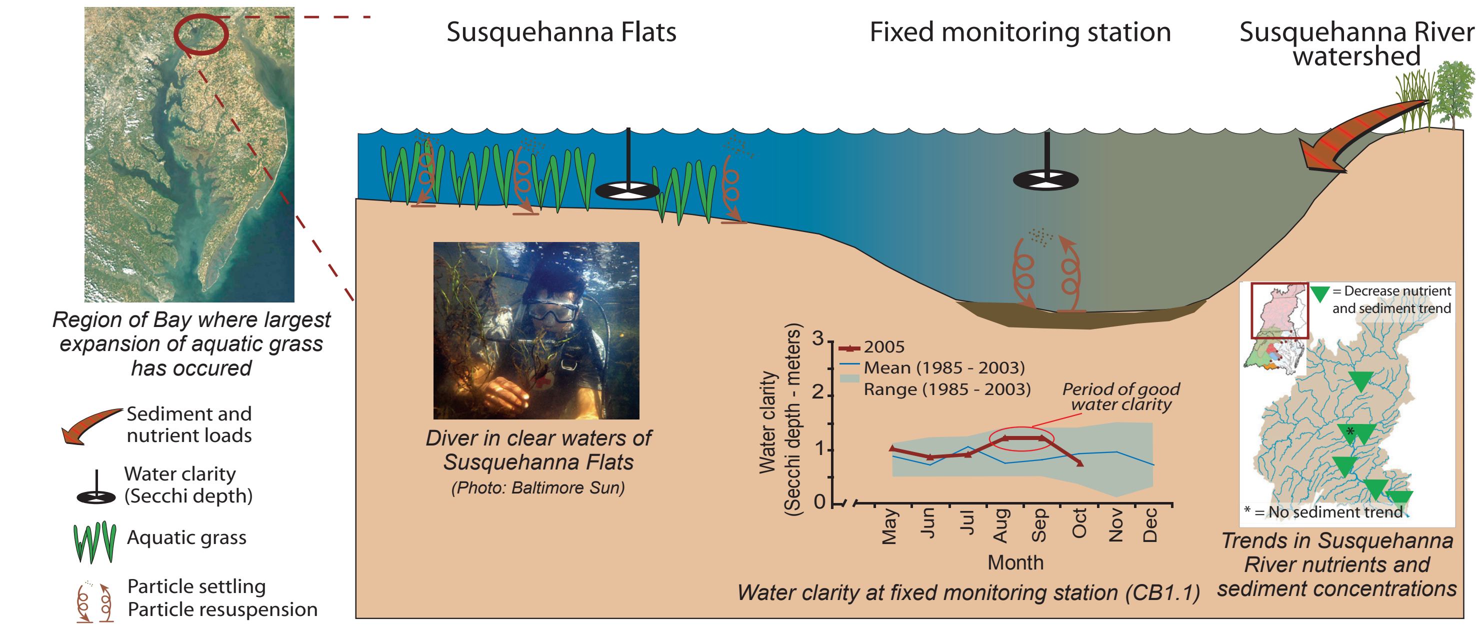


Figure 13. Conceptual diagram, with supporting figures and photos, illustrating the processes that may be leading to the expansion of aquatic grasses in the north of Chesapeake Bay.

Forecast predicted increase of low salinity grasses

This spring, the Chesapeake Bay Program forecast changes in the cover of high, medium and low salinity aquatic grass communities. Based on previous years' growth and spring conditions, it was forecast that the low salinity aquatic grass would increase (Fig. 14). "As was forecast, a small increase in cover of the high salinity aquatic grass community occurred this summer. However, during August there was a severe defoliation event, so that by September eelgrass was lost from some areas. This unusual late season defoliation event is thought to have been caused by the warm, still and low light summer conditions."

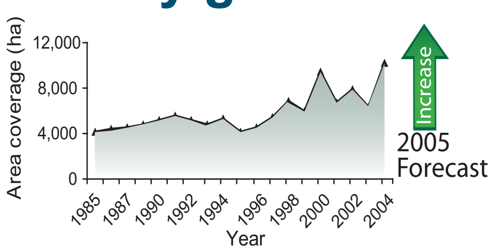


Figure 14. Cover of the low salinity grass community over the past 20 years, and the predicted increase in cover during the past summer.

Newsletter produced by the Chesapeake Bay Program's Monitoring and Analysis Workgroup (MASC). Dissolved oxygen forecast and analysis conducted by David Jasinski. HAB forecast and analysis conducted by Dr. Peter Tango. Aquatic grass forecast and analysis directed by the Tidal Monitoring and Analysis Workgroup (TMAW) in collaboration with Dr. Robert Orth. Nutrient load data used in forecasts and summer wrap-up provided by the USGS, with specific help provided by Jeff Raffensperger.

Chesapeake Bay Program
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Further information located at *www.chesapeakebay.net/bayforecast.htm and www.eyesonthebay.net*
Photos: Photo courtesy of John Vail, Sassafras River Association, Mark Trice and Baltimore Sun.