MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Martin O'Malley, Governor
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Upper Eastern Shore Basin
Water Quality and Habitat Assessment

Maryland Department of Natural Resources
Tidewater Ecosystem Assessment

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Information on the water and habitat quality of Maryland's rivers and bays is available due to the hard work of many dedicated staff including:

- staff who are in the field collecting the samples year-round, sometimes under less than desirable weather conditions
- laboratory staff who perform the chemical tests to determine what exactly is in those water samples
- data management staff who collect the resulting information, confirm the accuracy and quality of the data, and organize and maintain the databases and
- analytical staff who interpret the data to answer the question 'how is the river/Bay doing?'

There are too many individuals to directly name from more than 25 years of monitoring, so we simply wish to commend all of them for their commitment to collecting high quality information and making it available and useful to the citizens of Maryland.

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Upper Eastern Shore Basin
Overall Condition

Healthy rivers and bays support a diverse population of aquatic life as well as recreational uses, such as swimming and fishing. To be healthy, rivers and bays need to have good water and habitat quality. High levels of nutrients and sediments lead to poor water quality. Poor water quality reduces habitat quality, including water clarity (how much light can get to the bottom) and the amount of dissolved oxygen in the water. In turn, habitat quality affects where plants and animals can live. The Maryland Department of Natural Resources (DNR) is responsible for monitoring water and habitat quality in the Chesapeake Bay and rivers, as well as the health of aquatic plants and animals. DNR staff use this information to answer common questions like "How healthy is my river?", "How does my river compare to other rivers?", "What needs to be done to make my river healthy?" and "What has already been done to improve water and habitat quality in my river?"

The Upper Eastern Shore basin includes five major rivers and one embayment. Overall, this basin is dominated by agricultural land use and has a low to medium human population density in most areas. Negative impacts from urban land use, percent impervious surface and waste-water treatment plants are much lower than in the Western Shore rivers. Despite the similarities overall among the Upper Eastern Shore rivers, there are differences in water and habitat quality conditions due to localized land use and human impacts.

How healthy are the Upper Eastern Shore Rivers?
How do the Upper Eastern Shore Rivers compare to other Maryland rivers?

Northeast River: Water quality in the Northeast River is fair. Phosphorus and sediment levels have improved but nitrogen levels are too high (Table 1). Habitat quality for underwater grasses is poor due to poor water clarity and high algal densities. Even with reduced habitat quality, the area covered by underwater grass beds has been increasing since 2005 and is more than twice the restoration goal. Habitat quality is good for benthic animals but sampling of benthic populations has been too limited to consider in the assessment.

Compared with the larger Maryland tidal tributaries, the Northeast River is in the 'High Urban, High Agriculture' land use category (Figure 1). Total nitrogen and total phosphorus levels are high compared with other high urban systems (Figure 2). Algal levels are among the highest and total suspended solids levels are moderate, contributing to water clarity that is worse than in similar rivers. Summer dissolved oxygen levels are higher than in all other high urban rivers.

***Back Creek*:** Water quality in Back Creek is poor because nitrogen, phosphorus and sediment levels that are too high. Habitat quality is poor for underwater grasses due to poor water clarity but habitat quality is good for bottom dwelling animals.

Back Creek is in the 'Low Urban, High Agriculture' land use category. Total nitrogen, total phosphorus and total suspended solids levels are among the highest compared with all of the other rivers. Water clarity is low and algal densities are very low despite the high nutrient levels, suggesting that algae have limited light to grow. Summer bottom dissolved oxygen levels are high.

Table 1. Summary of tidal water quality and habitat quality indicators.
Algal densities, water clarity, inorganic phosphorus and sediments either 'Meet' or 'Fail' SAV habitat requirements (Appendix 5). Dissolved nitrogen levels below the level for nitrogen limitation 'Meet' criteria, otherwise 'Fail' criteria. Summer bottom dissolved oxygen levels above 3 mg/l 'Meet' criteria, otherwise 'Fail' criteria. Annual trends for 1999-2010 either 'Increase' or 'Decrease' if significant at $p \leq 0.01$ or 'Maybe Inc' or 'Maybe Dec' at $0.01 < p < 0.05$; blanks indicate no significant trend. Improving trends are in green, degrading trends are in red. Nitrogen trends are for total nitrogen, phosphorus trends are for total phosphorus, water clarity trends are for Secchi depth. Depth 'Shallow' is from the shallow water monitoring program, 'Open' is from the long-term monitoring program.

River/Bay	Depth	Water Quality			Habitat Quality		
		Nitrogen	Phosphorus	Sediments	Algal densities	Water Clarity	Summer Bottom Dissolved Oxygen
NORTHEAST	Shallow	FAIL	MEET	MEET	FAIL	FAIL	MEET
	Open	FAIL	MEET DECREASE	MEET DECREASE	FAIL	FAIL	MEET
BACK CREEK	Open	FAIL	FAIL	FAIL	MEET Maybe Inc	FAIL	MEET
BOHEMIA	Shallow	FAIL	MEET	FAIL	FAIL	FAIL	MEET
	Open	MEET	MEET	FAIL DECREASE	FAIL	FAIL	MEET
ELK	Shallow	FAIL	FAIL	FAIL	MEET	FAIL	MEET
	Open	FAIL	FAIL	MEET	MEET INCREASE	FAIL Maybe Dec	MEET
SASSAFRAS	Shallow	FAIL	MEET	MEET	FAIL	FAIL	MEET
	Open	MEET	MEET	FAIL	FAIL	FAIL	MEET
UPPER CHESTER	Shallow	FAIL	FAIL	FAIL	MEET	FAIL	MEET
	Open	FAIL Maybe Dec	FAIL DECREASE	FAIL DECREASE	MEET DECREASE	FAIL	MEET
MIDDLE CHESTER	Shallow	FAIL	FAIL	MEET	MEET	FAIL	MEET
LOWER CHESTER	Shallow	FAIL	MEET	MEET	MEET	FAIL	MEET
	Open	MEET	MEET	MEET	MEET	FAIL	FAIL
EASTERN BAY	Shallow	FAIL	MEET	MEET	MEET	FAIL	MEET
	Open	MEET	MEET	MEET Maybe Dec	MEET	MEET	FAIL

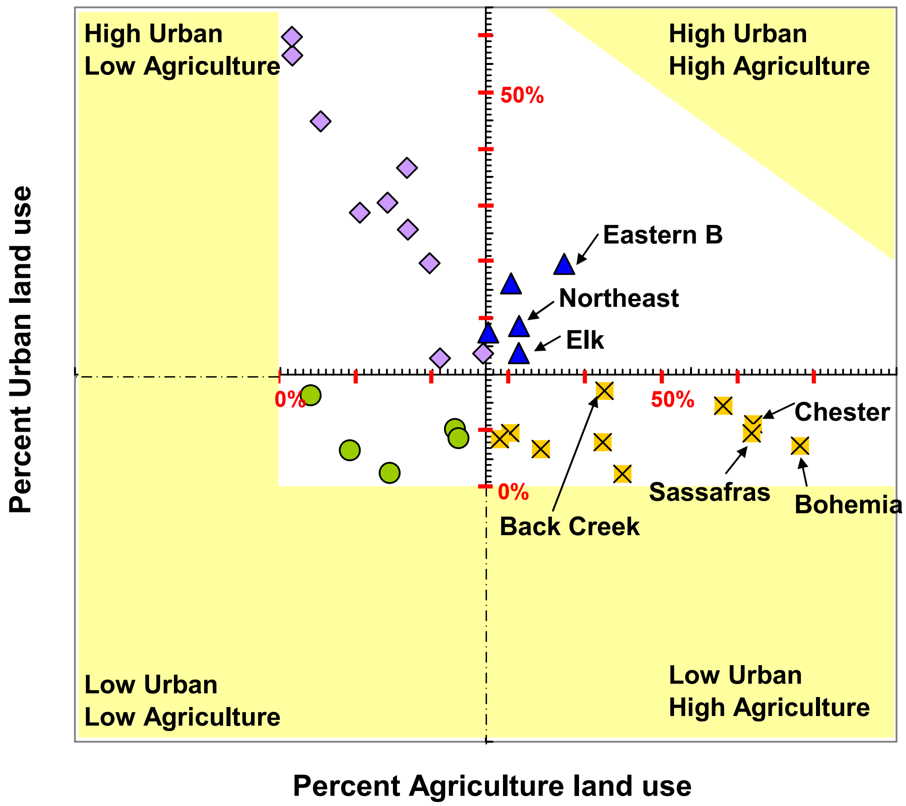

Figure 1. Classification of Maryland rivers and bays by land use.
The medians of all systems percent agriculture and percent urban land use are used to create a grid with four categories. Systems with percent urban less than the median are considered low urban. Systems with percent agriculture less than the median are considered low agriculture. Each system was categorized based on placement on the grid. Note that yellow areas are not mathematically possible (i.e. there is not a negative percent agriculture land use, and it is not possible for percent agriculture + percent urban to be greater than 100%). These groupings were used to evaluate each system relative to other rivers with similar land use characteristics.

***Elk River*:** Water quality in the Elk River is poor with dissolved nitrogen, phosphorus and sediment levels that are too high. Habitat quality is fair for underwater grasses and is good for benthic animals. The area covered by underwater grass beds has increased since 1996 and meets the restoration goal, but benthic animal populations are not healthy in the majority of locations sampled.

The Elk River is in the 'High Urban, High Agriculture' land use category. Total nitrogen and total suspended solids levels are among the highest compared with all of the other rivers, and total phosphorus levels are moderate compared to high agricultural rivers. Water clarity is low and algal levels are very low despite the high nutrient levels, suggesting that light conditions are determining algal levels. Summer bottom dissolved oxygen levels are high.

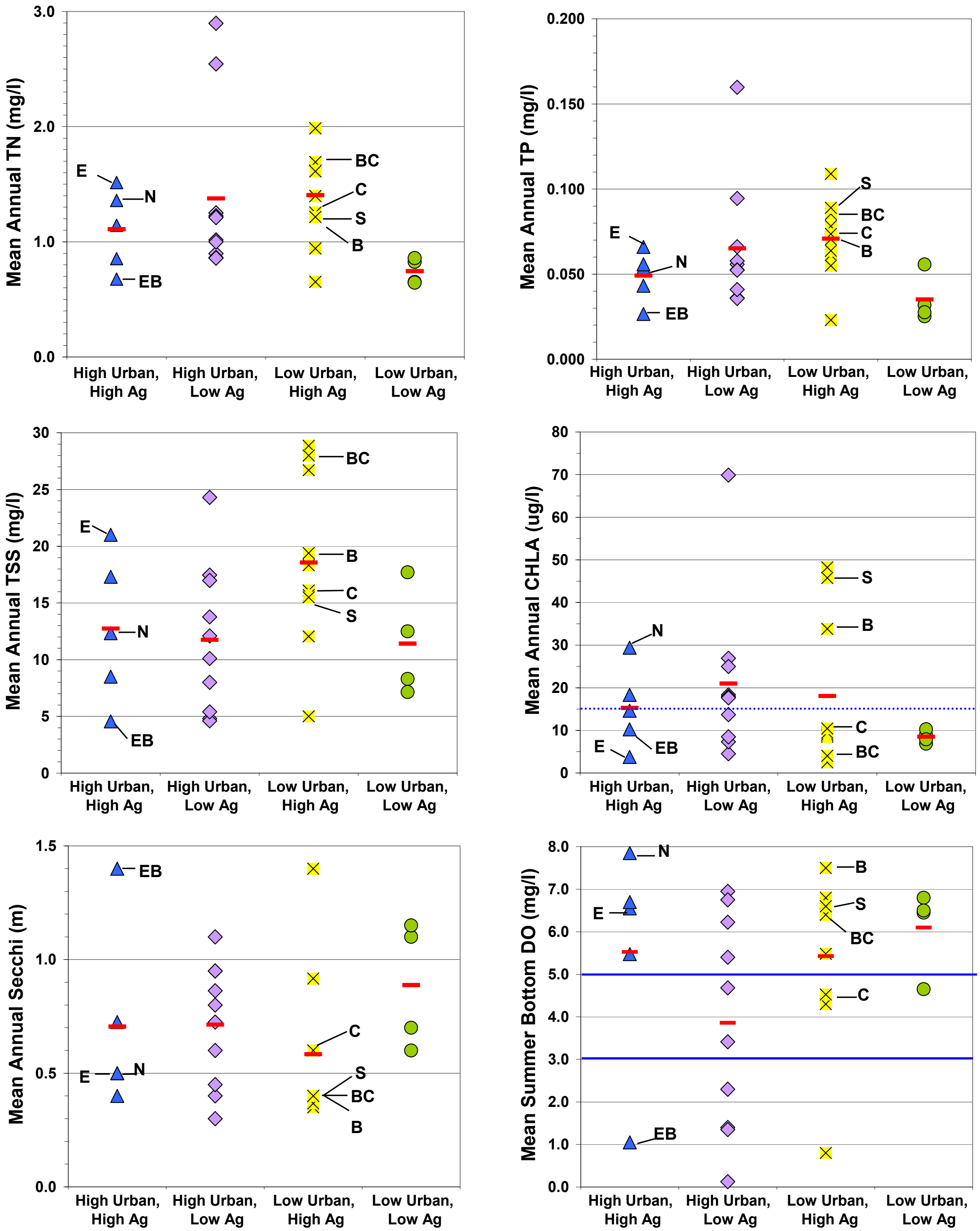

Figure 2. Comparison of the Upper Eastern Shore rivers to similar rivers.
The mean annual concentration or depth (bottom dissolved oxygen is only summer) for 2008-2010 data. Red bars indicate the mean of all systems within a category. Reference lines are included on the CHLA and BDO graphs. Abbreviations are E (Elk), N (Northeast), EB (Eastern Bay), B (Bohemia), BC (Back Creek), C (Chester) and S (Sassafras).

***Bohemia River*:** Water quality in the Bohemia River is fair in the open waters but poor in some of the shallow water areas. Sediment levels are too high but have improved. Nitrogen levels in shallow water areas are too high. Habitat quality is poor for underwater grasses due to poor water clarity and high algal densities but habitat quality is good for bottom dwelling animals. Bohemia River underwater grass beds have increased.

The Bohemia River is in the 'Low Urban, High Agriculture' land use category. Percent agricultural land use in this basin is among the highest of all systems in Maryland. Total nitrogen and total phosphorus levels are moderate compared to other high agricultural rivers. Total sediment and algal population levels are among the highest of all rivers. Water clarity is very low among all rivers but comparable to other high agriculture systems. Summer bottom dissolved oxygen levels are among the highest.

***Sassafras River*:** Water quality in the Sassafras River is fair due to high sediment levels in the open water areas and high nitrogen levels in some of the shallow water areas. Habitat quality for underwater grasses s poor due to poor water clarity and high algal densities. Algal blooms in the upstream areas of the river can lead to extremely high dissolved oxygen levels. Harmful algal blooms of blue-green algae occur in most years and have led to human health impacts and beach closures at Betterton Beach.

The area covered with underwater grass beds has been variable but improved in the last few years and are currently more than 75% of the restoration goal. Benthic animal populations were healthy in about 40% of the locations sampled and only very unhealthy in one location.
The Sassafras River is in the 'Low Urban, High Agriculture' land use category. Total nitrogen and total suspended solids levels are moderate and total phosphorus levels are higher than most rivers. Water clarity is low and algal levels are very high. Summer bottom dissolved oxygen levels are high.

***Chester River*:** Water and habitat quality differs between the upper, middle and lower Chester River. The upper Chester has poor but improving water quality. The middle Chester has poor water quality but sediment levels are lower than in the upper Chester. The lower Chester has fair water quality, but nitrogen levels are high in some shallow water areas.

The upper Chester has small underwater grass beds in some years. Underwater grass beds in the lower Chester were very large in 1998 but by 2010 have dropped to 3% of the restoration goal. Bottom dwelling animal populations are healthy in about 40% of the areas sampled (mostly sampled in the middle Chester).

The Chester River is in the 'Low Urban, High Agriculture' land use category. As a whole, the Chester has moderate nutrient, sediment and water clarity levels. Algal levels are low. However, harmful algal blooms occur often in the higher salinity portions of the Chester River and its tributaries (including the Corsica River). Summer bottom dissolved oxygen levels are also low on average, though in the upper Chester River summer bottom dissolved oxygen levels are good.

***Eastern Bay*:** Water quality in open water areas of Eastern Bay is good and sediment levels may be improving. Nitrogen levels are too high in some shallow water areas. Habitat quality is good for underwater grasses but poor for bottom dwelling animals in deeper areas of the bay. Underwater grass bed sizes have been variable and covered only 7% of restoration goals in 2010.

Bottom dissolved oxygen in the deeper areas is often below 3 mg/l. Benthic animal populations are unhealthy in all areas sampled.

Eastern Bay is in the ‘High Urban, High Agriculture’ land use category, due to the high population density on Kent Island. Total nitrogen, total phosphorus and total suspended solids levels are the lowest of all rivers. Water clarity is very high and algal levels are moderate. Summer bottom dissolved oxygen levels are extremely low and indicate impaired habitat.

What needs to be done to make the Upper Eastern Shore rivers and Eastern Bay healthy?

The biggest water quality issue, shared by most of the rivers, is poor water clarity. By lowering nutrients and sediments, water clarity should improve which will improve habitat quality for underwater grasses. Reductions in nutrients will also lead to lower algal densities and further improve habitat quality. In particular, lower nutrients will help reduce the frequency and duration of harmful algal blooms that occur in the Upper Eastern Shore rivers in most years.

As more areas of the Upper Eastern Shore basin are developed, controlling loadings from urban land use will become even more important. Alternatives to conventional building methods and materials should be used to reduce the amount of impervious surfaces and prevent additional degradation of water quality in the rivers. Reducing algal densities by reducing nutrients will improve dissolved oxygen conditions, which is especially important in the lower Chester and Eastern Bay.

In all of the rivers, reducing nutrient and sediment loadings from agricultural land use should be the focus of management actions. In the Northeast River, reductions in phosphorus and sediment loadings from urban runoff are also needed, especially with the increase in urban land use over the last ten years. In the Elk River, urban, point source and septic sources of nutrients and sediment are also important. A management strategy in the Elk River watershed needs to address all of these sources. Nitrogen and phosphorus loadings from the Elkton wastewater treatment plant have already been greatly reduced by upgrades implemented in 2009, but septic system loadings of nitrogen still need to be addressed.

What has already been done to improve water and habitat quality in the Upper Eastern Shore Rivers?

A variety of actions have already been taken to lower nitrogen, phosphorus and sediment loadings from agricultural lands. While specific goals have not been set for this basin, improvements are being made. In 2010 there were more than 48,400 acres of cover crops planted in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on almost 700 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. More than 280 containment structures had been built to store animal wastes to allow these nutrients to be applied to the land in the most effective manner at the appropriate time. More than 22,700 acres of stream buffers were also in place, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

To reduce nutrient inputs from urban lands, additional actions have been taken. These actions include upgrades to wastewater treatment plants, managing stormwater runoff and retrofitting septic systems. Upgrades to the largest wastewater treatment plant that discharges to the Northeast, Elk and Chester rivers have been implemented or are under construction. In all three rivers, these upgrades have reduced nitrogen and phosphorus levels to or below management goals. In the rest of the basin, nearly 300 septic system retrofits were completed between 2008-2010, and stormwater retrofits have reduced nitrogen loadings and prevented 2,500 pounds of nitrogen from entering the rivers since 2003.

Maryland also has a number of programs in place to reduce the impacts of continued development and increasing amounts of impervious surfaces. Program Open Space projects have conserved about 2000 acres of land for outdoor recreation opportunities. Rural Legacy Program projects have protected approximately 9,000 acres, with special focus on areas with important cultural sites and natural resources and to ensure large areas of habitat. Maryland Environmental Trust projects have helped individual land owners protect more than 13,000 acres. Maryland Agricultural Land Preservation Program projects have preserved more than 5,500 acres of agricultural land from development.

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Introduction

Water quality is measured as the level of nutrients and sediments in the water. Habitat quality is determined by how nutrients and sediments impact water clarity, algal populations and bottom dissolved oxygen levels. Habitat quality is also determined by salinity and water temperatures, but these measures are not changed by nutrients and sediments. Habitat quality determines if and where underwater grasses, fish and bottom dwelling animals can live. Reducing the levels of nutrients and sediments is a major focus of restoration efforts. The goal is to reduce nutrient and sediment levels so that habitat quality is improved and high quality habitat is expanded. Assessing water and habitat quality is an important first step in making decisions on what needs to be done to improve water and habitat quality.

Habitat quality can be assessed by looking at the health of the aquatic plants and animals that remain in the same location, such as underwater grasses and bottom dwelling animals. The health of these organisms depends on habitat that is suitable for growth and survival, so healthy organisms indicate healthy habitats. Changes in the populations of these plants and animals can often be linked to specific parts of habitat quality that are poor, such as water clarity or bottom dissolved oxygen. This additional information helps managers better pinpoint what needs to be changed to improve water and habitat quality.

Land use in a watershed is linked to the human population density. Rivers with high urban land uses have higher population densities and more impervious surfaces. Rivers with high agricultural land uses in rural areas have lower population densities and less impervious surfaces. Higher population densities are often linked to management of human wastes through wastewater treatment plants, while septic systems are more prevalent in areas with lower population density. Pollutant loadings from undeveloped lands such as forests are different from loadings from more developed areas. Information on human population and land use help managers decide the best methods for reducing nutrients and sediments going from the land into the water.

The Upper Eastern Shore Basin Water Quality and Habitat Assessment includes a variety of information. Land use data and census data are examined to understand how the watersheds are impacted by human uses. Loadings data is examined to identify how much nutrient and sediment is entering the non-tidal streams from the watershed. Data from the long-term tidal water quality monitoring program are examined for current water and habitat quality and changes over time. Data from monitoring in shallow water habitats are examined to determine water and habitat quality in the areas most important for underwater grasses and the organisms that live there. Data from monitoring of algal populations, underwater grasses and bottom dwelling organisms are examined to determine how well the resulting habitat quality supports healthy plant and animal populations.

Land use and Human population

Maryland's Upper Eastern Shore basin includes all of Kent County and portions of Cecil, Queen Anne's, and Talbot Counties (Figure 3). The basin drains 940 square miles in 21 sub-watersheds. Major water bodies include the Chester, Elk, Bohemia, Sassafras, and Northeast rivers. There are numerous tributary creeks and several large embayments (Eastern Bay, Prospect Bay, Crab

Alley Bay). Back Creek forms the western end of the Chesapeake and Delaware Canal. The Chesapeake and Delaware Canal generally transports water toward Delaware River, but can transport either way. The basin lies both in the Piedmont physiographic province and the Coastal Plain province. Major population centers in the basin include Elkton, Chestertown, Grasonville, Centreville, and North East.

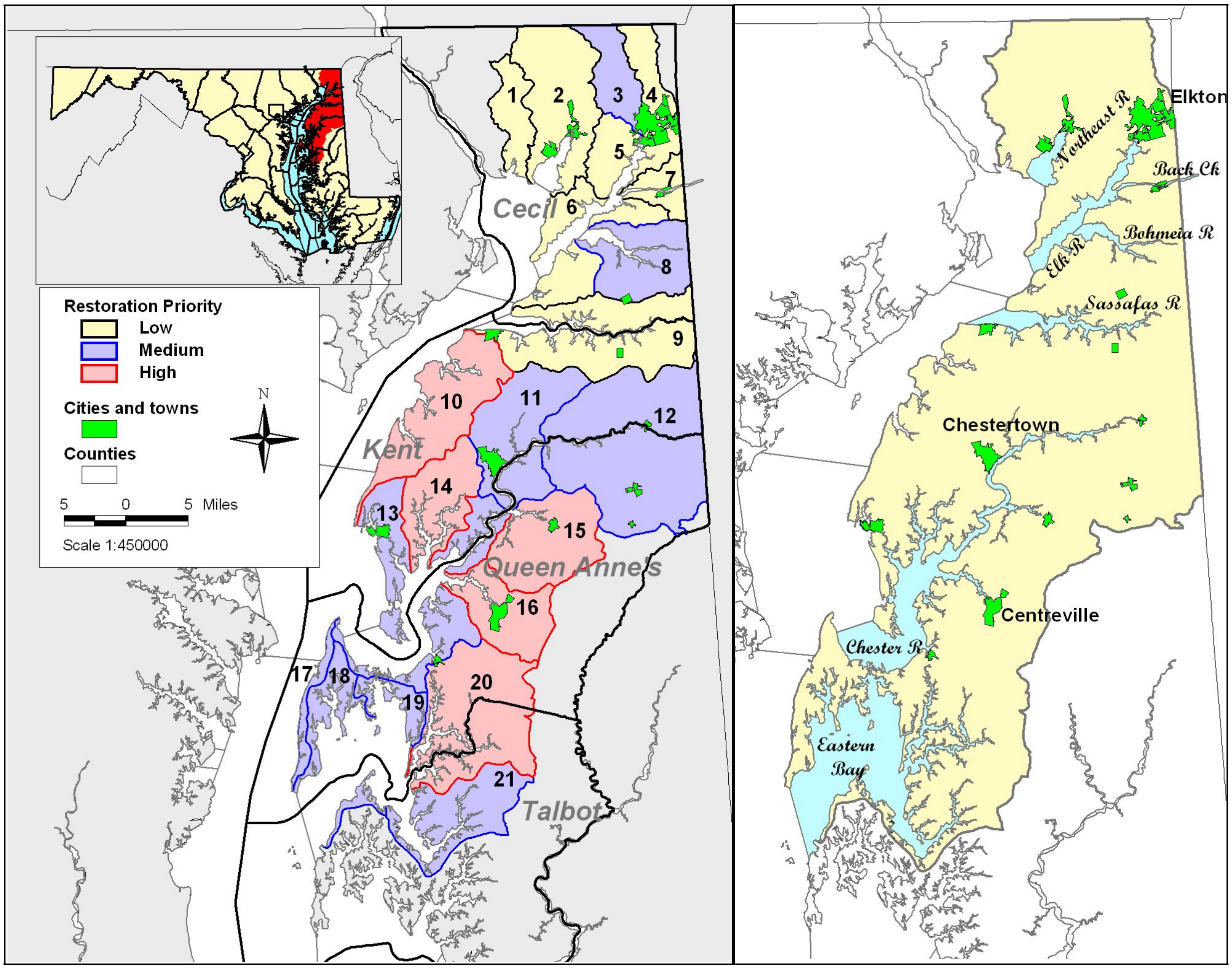

Figure 3. Upper Eastern Shore basin.
Left Panel- Trust Fund Priority Watershed Restoration Priority designation (high, medium, low), county lines and cities/towns are shown. Sub-watersheds (8-digit) are: 1: Furnace Bay, 2: Northeast River, 3:Little Elk Creek, 4: Big Elk Creek, 5: Upper Elk River, 6: Lower Elk River, 7: Back Creek, 8: Bohemia River, 9: Sassafras River, 10: Still Pond- Fairlee, 11: Middle Chester River, 12: Upper Chester River, 13: Lower Chester River, 14: Langford Creek, 15: Southeast Creek, 16: Corsica River, 17: Kent Island Bay, 18: Eastern Bay, 19: Kent Narrows, 20: Wye River, 21: Miles River. Right Panel- Rivers, bays and cities/towns are shown

As of 2010, there were approximately 150,000 people living in the basin in Maryland, 80,000 in Pennsylvania and 30,000 people living in Delaware (Figure 4).[1] Population density was mostly moderate (between 100-1,000 people mi^2) in the upper basin and low (10-100 people mi^2) in the lower basin, though there were several areas in the lower basin with moderate densities. In the area of the towns of Elkton, Northeast and Chestertown population density was high (1,000-10,000 people mi^2).

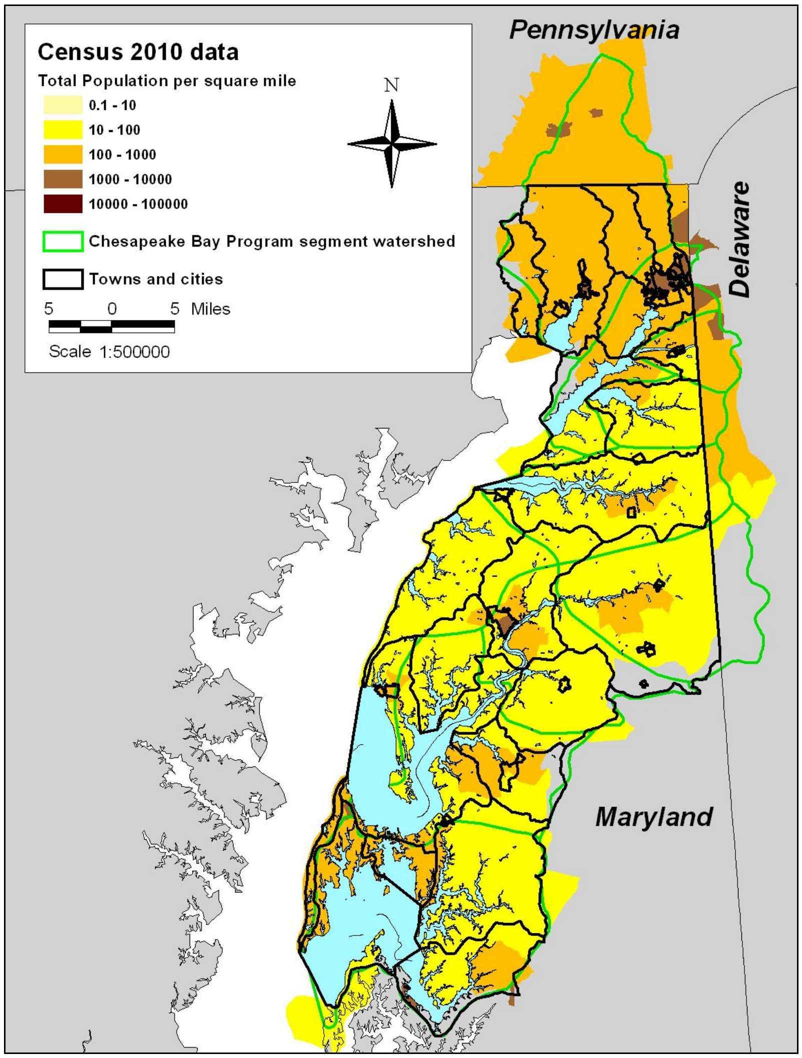

Figure 4. Upper Eastern Shore basin 2010 Census data for total population by block group. Total population per square mile is shown using a log scale. Delaware and Pennsylvania data is included for the corresponding watersheds that also drain to the Upper Eastern Shore basin (based on the Chesapeake Bay Program segment watersheds). Differences between the watershed boundaries and the Census bureau block group boundaries result in non-exact matching of the population data to the given watershed.

[1] 2010 data from the U.S. Census Bureau available online at http://www2.census.gov/census_2010/04-Summary_File_1/

In the most northern portion of the basin (Furnace Bay and Northeast River sub-watersheds), the dominant land use is forest (approximately 40%), followed by agriculture (approximately 30%) and urban land uses (approximately 25%, Figure 5)[2]. Between 2000 and 2010, urban land use increased by more than 9% (Figure 6, Appendix 1). Impervious surfaces in the Northeast River now account for 6% of the watershed. Both are low priority watersheds for Trust Fund Restoration activities.[3] Stream health in Furnace Bay sub-watershed is good, and stream health is fair in the Northeast River sub-watershed.[4]

In the Elk River watershed (Big Elk Creek, Little Elk Creek, Upper Elk River and Lower Elk River sub-watersheds), forest is the largest land use (42%) followed by agriculture and urban land use (31% and 24% respectively). Overall, urban land use increased by 7% from 2000-2010, and the increase was 5% or greater in all 4 sub-watersheds. Agriculture decreased by 6%, with the largest decrease in the Big Elk Creek sub-watershed (10%). Impervious surfaces throughout the watershed cover 5%, but are higher in the Little Elk Creek and Upper Elk Creek (7% and 8% respectively). The Lower Elk River is a medium priority watershed for Trust Fund Restoration. stream health is fair.

The region between the Elk and Chester rivers (Back Creek, Bohemia River, Sassafras River and Stillpond-Fairlee sub-watersheds) is dominated by agricultural land use (42%-68%) and forest (23%-33%). Impervious surfaces account for 2% or less of the sub-watersheds. The Stillpond-Fairlee watershed is a high priority for Trust Fund Restoration activities. Stream health in the Bohemia River sub-watershed is poor and fair in the Sassafras and Stillpond-Fairlee sub-watersheds.

The Chester River system (Upper Chester River, Middle Chester River, Langford Creek, Southeast Creek, Corsica River and Lower Chester River sub-watersheds) is also dominated by agriculture (64% overall) and forest (25%). Impervious surfaces cover 3% or less of the sub-watersheds. Upper and Middle Chester River sub-watersheds are medium priority watersheds, while the remaining are high priority Trust Fund Restoration watersheds. Stream health is fair in the upper watersheds but poor in the Lower Chester watershed. A Watershed Restoration Action Strategy (WRAS) was developed in 2001 for the middle Chester River, in 2003 for the Corsica River, and in 2004 for the Upper Chester River.[5]

Land use in the southern portion of the basin (Wye River, Miles River, Kent Narrows, Kent Island Bay and Eastern Bay sub-watersheds) is about half agricultural (53% overall) and about one-quarter forest and urban (23% and 22% respectively). Impervious surfaces cover 4% of the system overall. Urban land use is highest in the Kent Island and Eastern Bay sub-watersheds (though Kent Island is a very small sub-watershed) and increased by more than 9% from 2000 to 2010. Wye River sub-watershed is a medium priority watershed and the others are high priority Trust Fund Restoration watersheds. Steam health is poor in the Miles River sub-watershed and fair in the rest of this region.

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[2] Maryland Department of Planning data for 2010 available at http://www.planning.maryland.gov/OurWork/landUse.shtml

[3] Information on Maryland's Trust Fund is available at http://www.dnr.maryland.gov/ccp/funding/pdfs/TrustFundPriorities.pdf

[4] Maryland Department of Natural Resources data available at www.streamhealth.maryland.gov/stream_health.asp

[5] Detailed reports are available at http://dnr.maryland.gov/watersheds/surf/proj/wras.html.

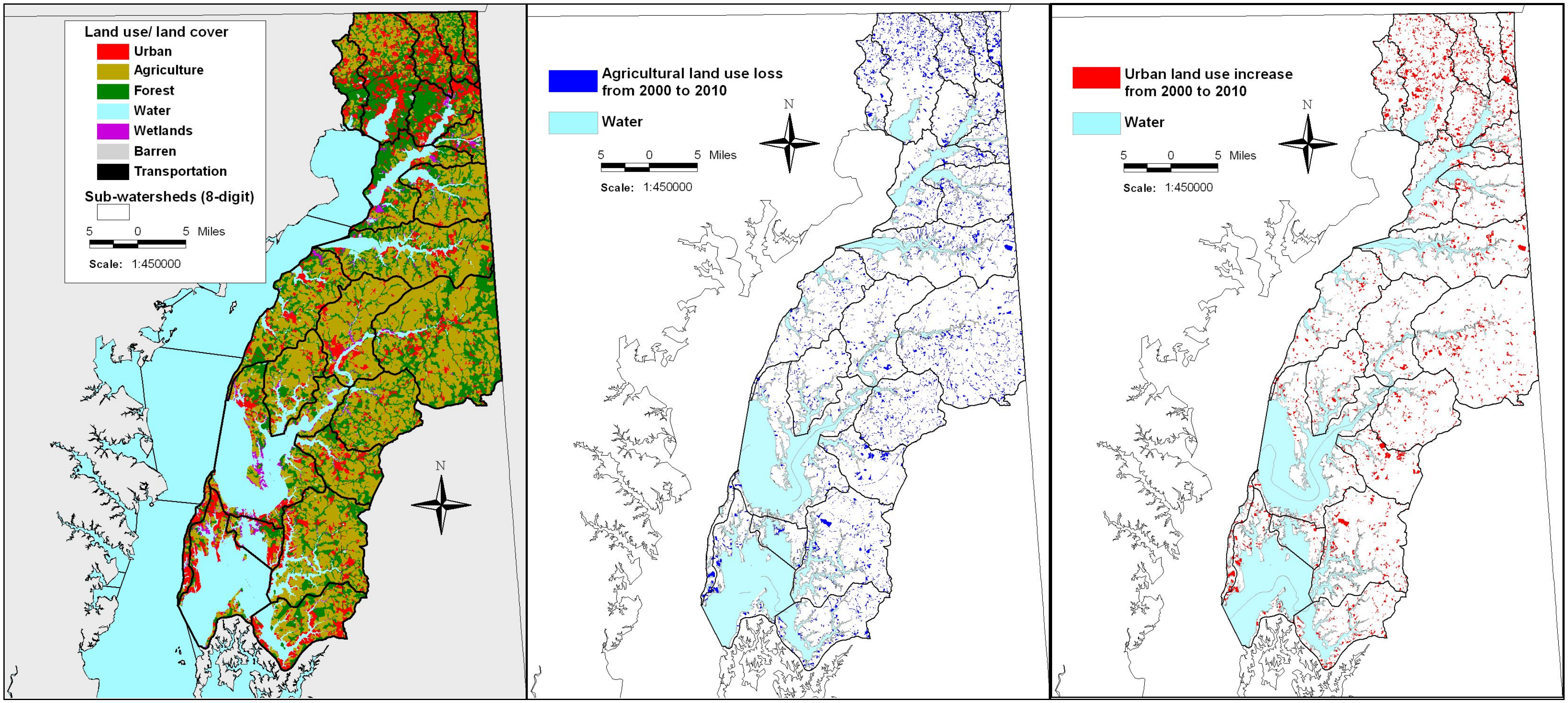

Figure 5. Upper Eastern Shore basin land use/land cover data for 2010.
Left panel shows all major land use types (See Appendix 1 for detailed land use/land cover information). Middle panel shows change in agricultural land use from 2000 to 2010. Right panel shows change in urban land use from 2000 to 2010.

Maryland has a number of programs in place to reduce the impacts of continued development and increasing amounts of impervious surfaces. Program Open Space projects have conserved about 2000 acres of land for outdoor recreation opportunities. Rural Legacy Program projects have protected approximately 9,000 acres, with special focus on areas with important cultural sites and natural resources and to ensure large areas of habitat. Maryland Environmental Trust projects have helped individual land owners protect more than 13,000 acres. Maryland Agricultural Land Preservation Program projects have preserved more than 5,500 acres of agricultural land from development.

Nutrient and Sediment Loadings

In accordance with the Chesapeake Bay Total Maximum Daily Load (TMDL), Maryland has developed a Watershed Implementation Plan (WIP) for making reductions in nitrogen, phosphorus and sediment loads to the Chesapeake Bay.[6] Maryland is required to reduce loads to Final Target loads by 2025. Maryland's Interim Target loads are set at 60% of the Final Target loads by 2017. Progress toward these Interim and Final Target loads is further broken into 2-year milestone loads. The first of these 2-year milestones is set for July 1, 2011- June 30, 2013.[7]

The rivers in the Upper Eastern Shore basin are combined with the other eastern shore rivers into a single category- the Eastern Shore Basin. Final Target Loads for the Eastern Shore Basin are 11.82 million pounds per year of nitrogen, 1.02 million pounds per year of phosphorus and 189 million pounds (0.095 million tons) per year of sediments. The information below is for estimated loadings in 2009.

The Northeast River received 0.25 million lbs/yr of nitrogen, 0.013 million lbs/yr of phosphorus, and 16.5 million lbs/yr of sediment from the surrounding watershed (Appendix 2). Agricultural sources were the largest contributor of nitrogen (47%), phosphorus (41%) and sediments (63%) to the river (Figure 6). Urban runoff was an important source of phosphorus (31%) and sediments (28%). Forest sources were also important to nitrogen loadings (24%).

The Bohemia River received 0.18 million lbs/yr of nitrogen, 0.02 million lbs/yr of phosphorus, and 3.75 million lbs/yr of sediment from the surrounding watershed. Agricultural sources were the largest contributor of nitrogen (72%), phosphorus (73%) and sediments (91%) to the Bohemia River. No major WWTPs discharge to the river, though point sources contribute 16% of the phosphorus load.

Back Creek received 0.059 million lbs/yr of nitrogen, 0.0065 million lbs/yr of phosphorus, and 1.25 million lbs/yr of sediment from the surrounding watershed in Maryland. Agricultural sources were the largest contributor of nitrogen (50%), phosphorus (53%) and sediments (81%).

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[6] Maryland's Phase II Watershed Implementation Plan is online at www.mde.state.md.us/programs/Water/TMDL/TMDLImplementation/Pages/FINAL_PhaseII_WIPDocument_Main.aspx

[7] Progress toward meeting the 2011-2013 milestones is available on BayStat at www.baystat.maryland.gov/milestone_information.html

No major WWTPs discharge to the creek, though point sources contribute 28% of phosphorus loadings to Back Creek.

The Elk River received 0.47 million lbs/yr of nitrogen, 0.03 million lbs/yr of phosphorus, and 9.95 million lbs/yr of sediment from the surrounding watershed. Agricultural sources were the largest contributor of nitrogen (37%), phosphorus (46%) and sediments (67%) to the river. Urban runoff was an important source of phosphorus (20%) and forest sources were important to nitrogen loadings (21%).

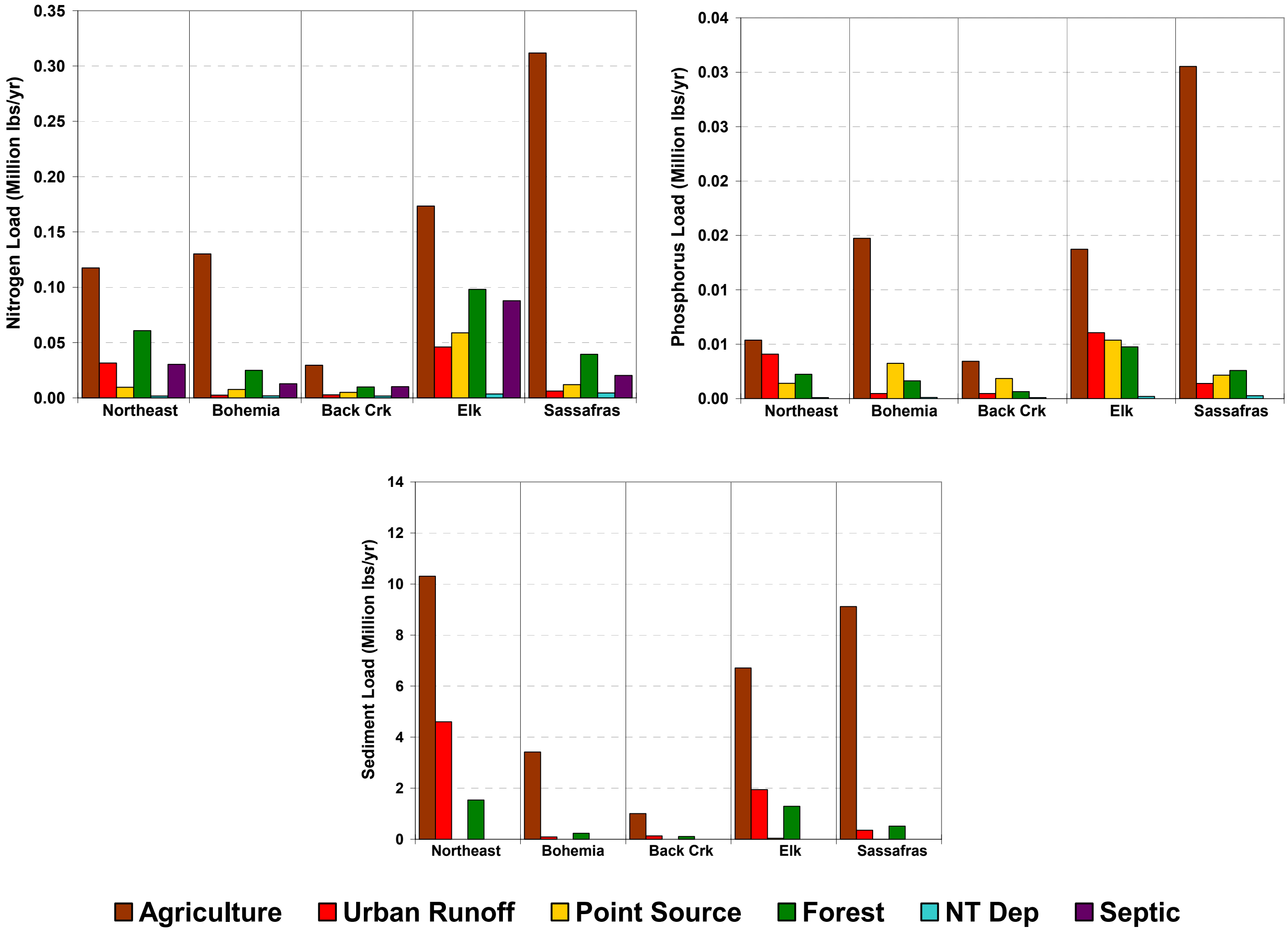

Figure 6. Nitrogen, phosphorus and sediment loadings per year to the upper basin rivers. Delivered loadings by category in million lbs/yr (see Appendix 2). Septic is not a source of phosphorus or sediment loadings and atmospheric deposition (NT Dep) is not a source of sediment loadings.

The Sassafras River received 0.39 million lbs/yr of nitrogen, 0.037 million lbs/yr of phosphorus, and 9.99 million lbs/yr of sediment from the surrounding watershed. Agricultural sources were the largest contributor of nitrogen (79%), phosphorus (83%) and sediments (91%) to the river.

Overall, the Chester River received 1.37 million lbs/yr of nitrogen, 0.12 million lbs/yr of phosphorus, and 24.1 million lbs/yr of sediment from the surrounding watershed (Figure 7). Agricultural sources were the largest contributor of nitrogen (80%), phosphorus (84%) and sediments (91%).

Eastern Bay received 0.79 million lbs/yr of nitrogen, 0.072 million lbs/yr of phosphorus, and 11.3 million lbs/yr of sediment from the surrounding watershed. Agricultural sources were the largest contributor of nitrogen (66%), phosphorus (76%) and sediments (75%).

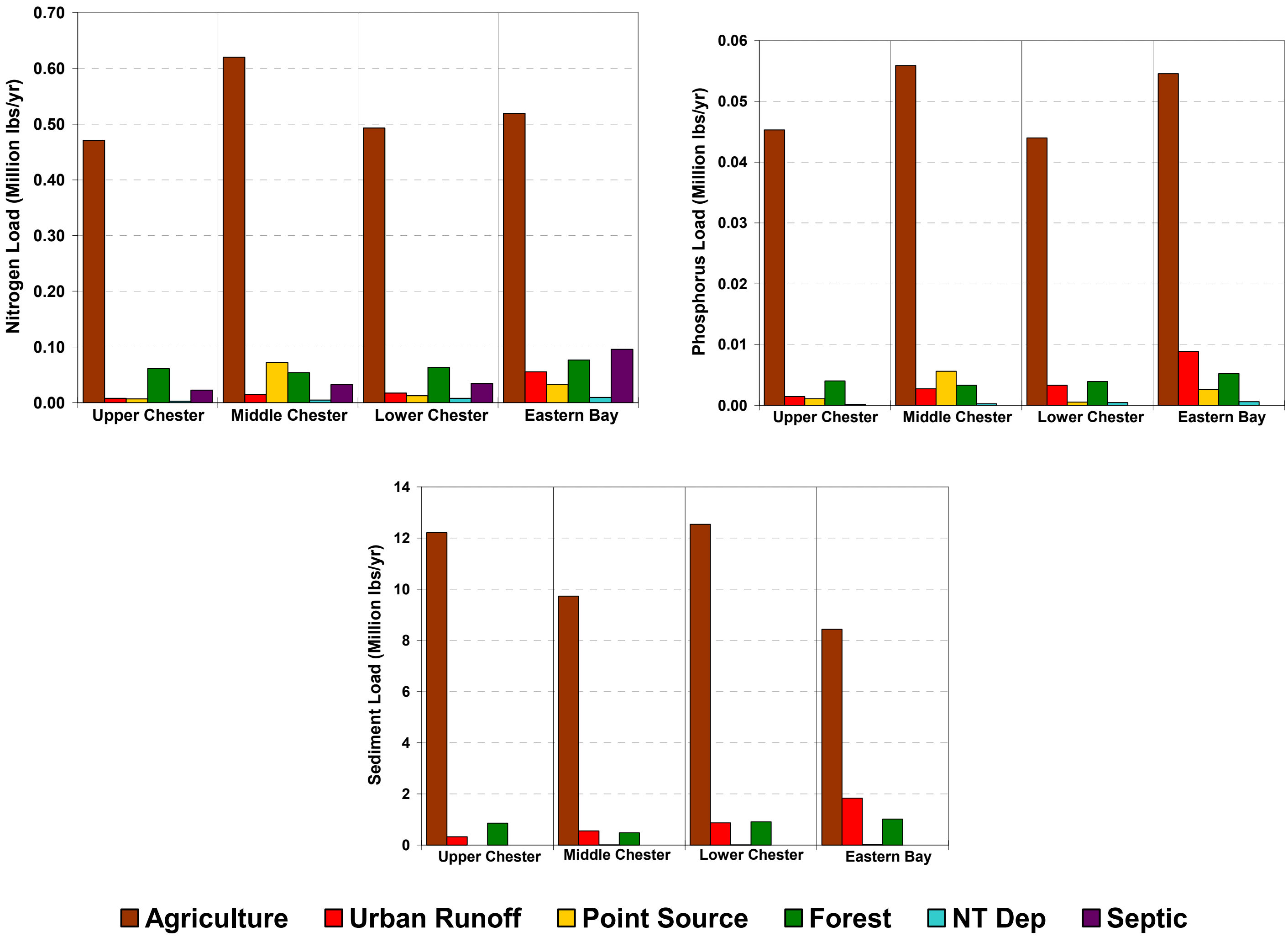

Figure 7. Nitrogen, phosphorus and sediment loadings per year to the Chester River and Eastern Bay.
Delivered loadings by category in million lbs/yr (see Appendix 2). Septic is not a source of phosphorus or sediment loadings and atmospheric deposition (NT Dep) is not a source of sediment loadings.

Point Source Loads

Nutrient loadings from point sources (including wastewater treatment plants, WWTPs) are the easiest to measure. Point source loads are often the most cost-effective to manage. A major focus of management actions to reduce nutrient loads has been upgrades to WWTPs. In 2004

Maryland passed legislation creating the Chesapeake Bay Restoration Fund specifically to fund WWTP upgrades to enhanced nutrient removal (ENR).[8] The program is working to complete ENR upgrades to 67 major WWTPs, including 7 facilities in the Upper Eastern Shore basin.[9] Upgrades to four Upper Eastern Shore basin facilities were complete by the end of 2010: Chestertown WWTP which discharges to the Chester River, St. Michaels WWTP which discharges to the Miles River and then to Eastern Bay, Elkton WWTP which discharges to Big Elk Creek then to the Elk River, and Perryville WWTP which discharges to Mill Creek and then to Furnace Bay. Upgrades to Kent Island WWTP, which discharges directly to the main Bay, were also completed by 2010.

Point sources were an important source of loadings to the Northeast, Bohemia, Back Creek, Elk and middle Chester rivers and less important in the other rivers.

Northeast River

Point sources contribute 11% of the total phosphorus load, but 4% of the total nitrogen (4% of load to the Northeast River. The Northeast WWTP, which discharges to the Northeast river, upgraded to biological nutrient removal (BNR) at the end of 2004.[10] Construction of ENR upgrades to Northeast River WWTP is expected to begin by the end of 2012 and be completed by the end of 2014. Following implementation of BNR, nitrogen loadings decreased to approximately one-fourth the loadings pre-BNR (Figure 8), despite continued increases in the total annual effluent flow. Nitrogen loadings were much higher in 2010 but still remained below the loading cap. Phosphorus loadings post-BNR dropped to less than half pre-BNR loadings, though 2010 phosphorus loadings also were higher. Phosphorus loadings since BNR was implemented are well below the loading cap.

Elk River

Point sources contribute 18% of the phosphorus load and 13% of the nitrogen load to the Elk River. Elkton WWTP upgraded to ENR at the end of 2009. Nitrogen loadings increased as effluent flow increased until ENR was in use. Post-ENR, nitrogen loadings dropped to one-sixth and phosphorus loadings to one-fourth pre-ENR loadings (Figure 9). Loadings were below loadings caps in 2009 and 2010.

Chester River

Point sources are not large contributors of phosphorus or nitrogen to the upper or lower Chester River system relative to other sources, but in the middle Chester, point sources contribute 9% of nitrogen loadings and 8% of phosphorus loadings. Chestertown WWTP discharges directly to the Chester River and Centreville WWTP discharges to Gravel Run (a tributary of the Corsica River). The Chestertown WWTP upgraded to ENR by mid-2008. Post-ENR nitrogen loadings dropped by more than half and phosphorous loadings dropped to approximately one-tenth pre-ENR loadings (Figure 10). Both nitrogen and phosphorus loadings were below loading caps.

[8] The Chesapeake Bay Restoration Fund collects fees from wastewater treatment plant users to pay for the upgrades. A similar fee is paid by septic system users to upgrade onsite systems and implement cover crops to reduce nitrogen loading to the Bay. For more information on the Chesapeake Bay Restoration Fund see http://www.mde.state.md.us/programs/Water/BayRestorationFund/Pages/index.aspx.

[9] Major wastewater treatment plants (WWTP) are those with greater than 0.5 million gallons per day (MGD) design flow.

[10] Biological nutrient removal (BNR) technology removes additional nitrogen than traditional methods, bringing nitrogen levels in effluent to below 8 mg/l. Enhanced nutrient removal (ENR) reduces nitrogen levels to below 3 mg/l and phosphorus levels to below 0.3 mg/l in effluent.

The Centreville WWTP upgraded to BNR in mid 2004. Post-BNR nitrogen loadings dropped to less than one-fourth and phosphorus loadings dropped to less than one-fifth pre-BNR loadings (Figure 11). Both nitrogen and phosphorus loadings were below loading caps following implementation of BNR. Upgrades to ENR are not yet scheduled for this facility.

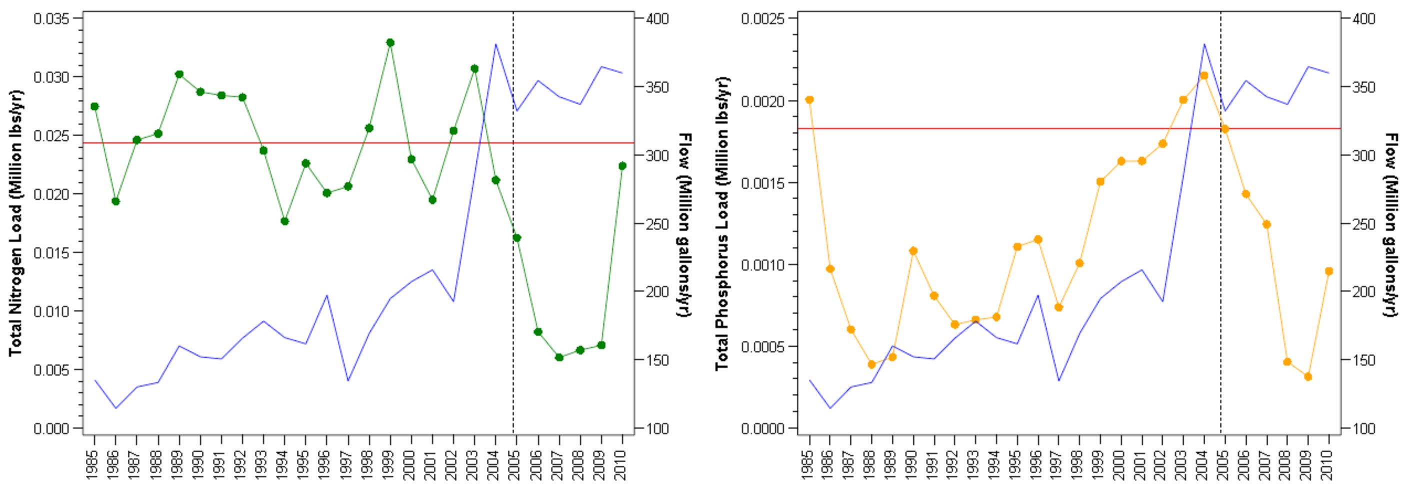

Figure 8. Wastewater treatment plant loadings to the Northeast River from Northeast WWTP. Blue line on graphs shows total annual effluent flow. Red horizontal line indicates the loading cap for the facility following implementation of ENR. The dotted vertical line indicates when BNR was implemented.

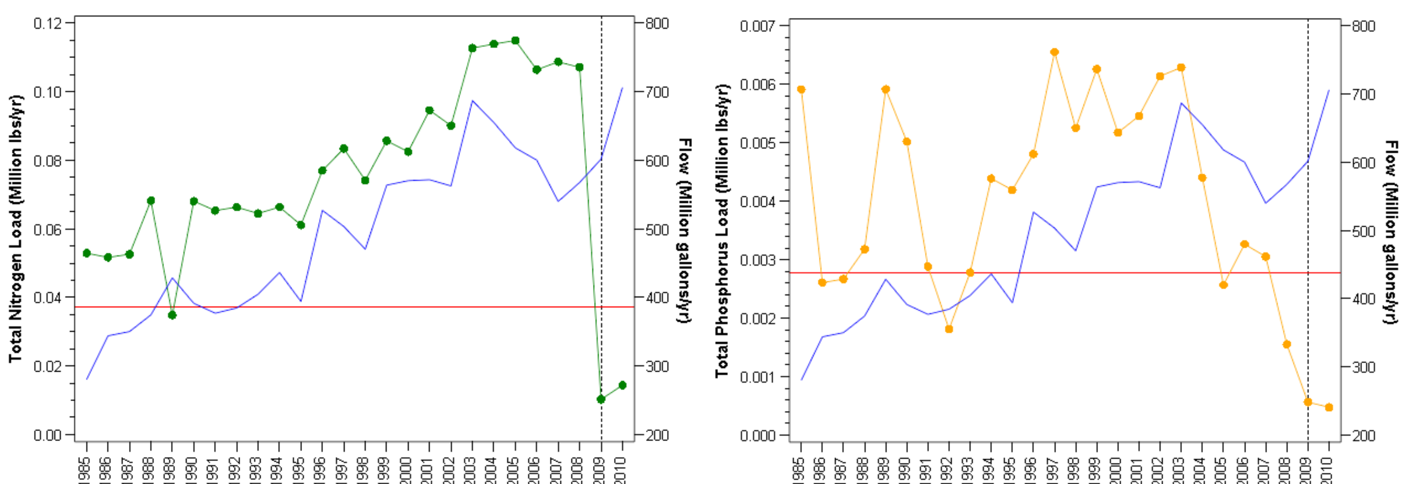

Figure 9. Wastewater treatment plant loadings to the Elk River from Elkton WWTP. Blue line on graphs shows total annual effluent flow. Red horizontal line indicates the loading cap for the facility following implementation of ENR. The dotted vertical line indicates when BNR was implemented.

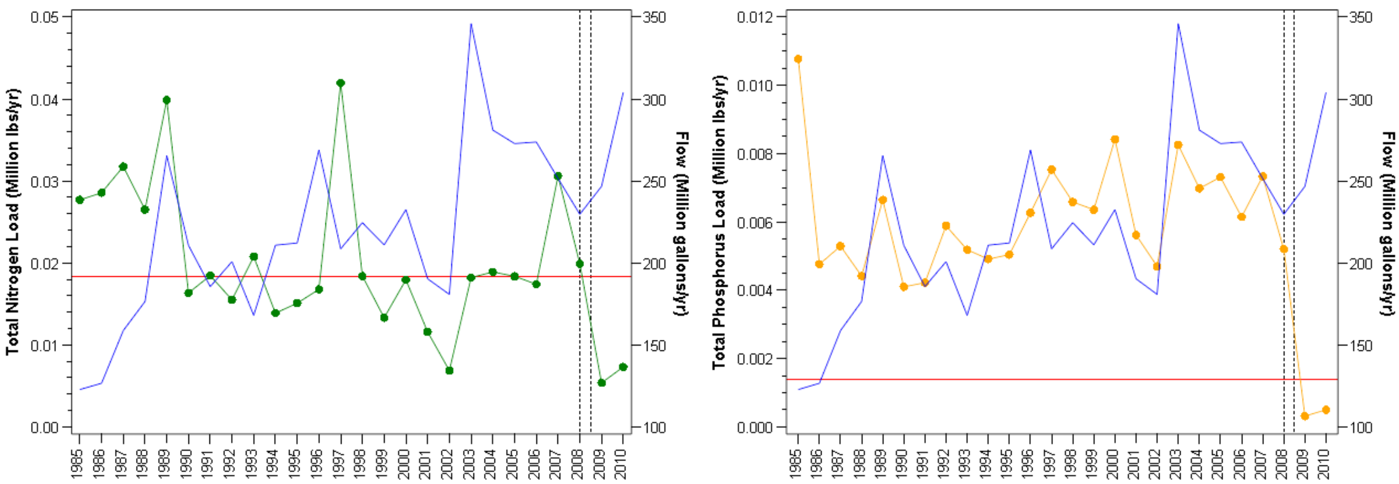

Figure 10. Wastewater treatment plant loadings to the Chester River from Chestertown WWTP. Blue line on graphs shows total annual effluent flow. Red horizontal line indicates the loading cap for the facility following implementation of ENR. The dotted vertical line indicates when BNR was implemented.

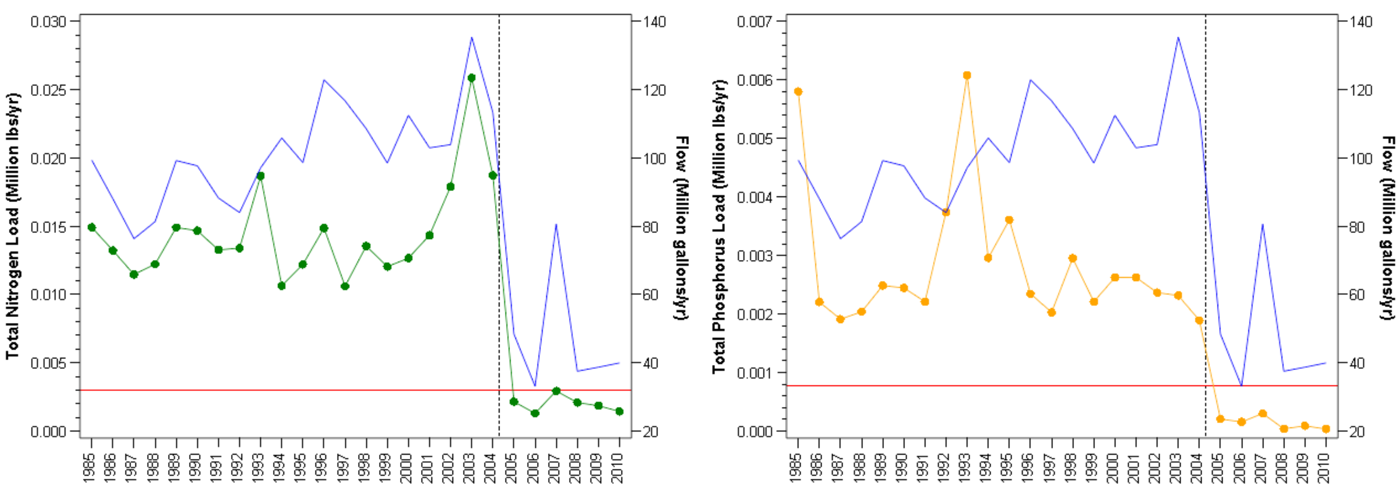

Figure 11. Wastewater treatment plant loadings to the Corsica River from Centreville WWTP. Blue line on graphs shows total annual effluent flow. Red horizontal line indicates the loading cap for the facility following implementation of ENR. The dotted vertical line indicates when BNR was implemented.

Non Point Source Loads

In 1998, Maryland passed the Water Quality Improvement Act, which requires farmers to reduce nitrogen and phosphorus loadings from agricultural lands.[11] Soil Conservation and Water Quality Plans (SCWQPs) are developed to determine what the appropriate actions, or best management plans (BMPs), are for a given area.[12] Each of Maryland's counties has a Soil Conservation District Office with staff to help farmers develop and implement SCWQPs. The total number of BMPs in place in the basin as a whole (not by individual farm) is used to measure progress.[13] In 2010 there were more than 48,400 acres of cover crops planted in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on almost 700 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. More than 280 containment structures had been built to store animal wastes to allow these nutrients to be applied to the land in the most effective manner at the appropriate time. More than 22,700 acres of stream buffers were also in place, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

Water and Habitat Quality

Tidal Rivers

Tidal water quality monitoring is done year-round at eight stations that have been monitored since 1985 (Figure 12, Appendix 3). Year-round tidal water sampling was started in the Corsica River in 2005 as part of an intensive monitoring effort to identify the impacts of restoration actions in a small watershed.

The following parameters were evaluated to assess water and habitat quality: total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (PO_4), algal abundance (as measured by chlorophyll *a*, CHLA), water clarity (as measured with a Secchi disc and by calculating the percent light through water, PLW), summer bottom dissolved oxygen (BDO), salinity and water temperature.

Assessment methods are described in Appendix 4. Selected graphical results are included with the text. Trends results discussed in the text refer to the 1999-2010 period. Seasons for 1999-2010 trends are: spring (March-May), summer (July-September)[14] and SAV growing season (Apr-October). Significant trends for 1985-2010 are noted in the footnotes. Figure and Appendix references are given only the first time referenced. Summary results are presented in Table 1 in the 'Overall Assessment' section. Detailed tabular results are included in the Appendices 6 and 7.

[11] For more information, please see the Maryland Department of Agriculture website http://mda2.maryland.gov/resource_conservation/Pages/nutrient_management.aspx
[12] For more information see http://mda.maryland.gov/pdf/scwqplan.pdf
[13] Progress on different BMPs is available at http://www.baystat.maryland.gov/milestone_information.html
[14] For summer bottom dissolved oxygen analysis, the months used are June-September.

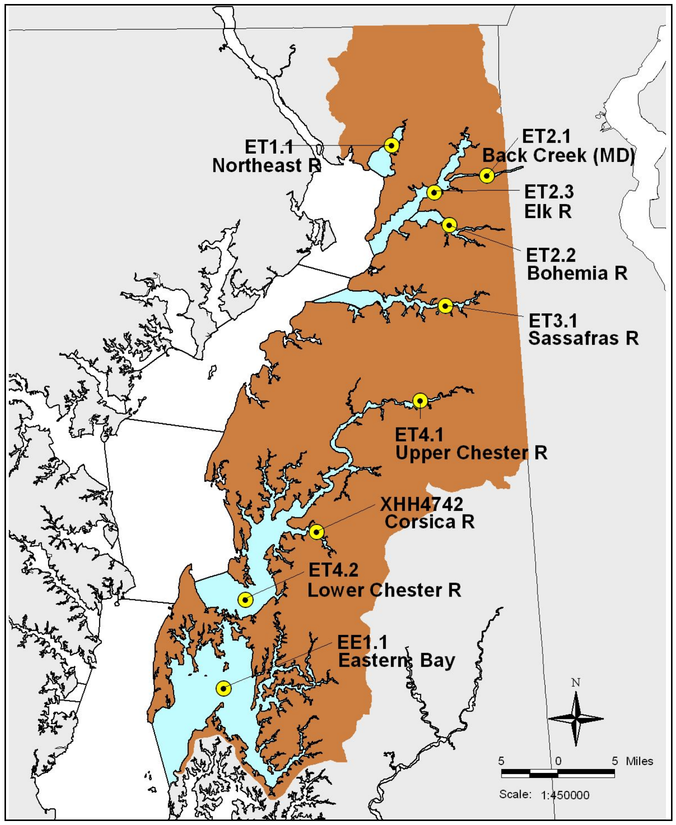

Figure 12. Long-term tidal water quality monitoring stations.

Northeast River

Nitrogen levels were relatively good in the Northeast River (Figure 13). Summer DIN levels were low enough to limit algal growth in some years (Figure 14).[15]

Phosphorus levels were relatively good and TP improved annually, in summer and in the SAV growing season. PO_4 levels in the SAV growing season met the habitat requirement (Figure 15). TSS levels were relatively good and improved annually, in the summer and in the SAV growing season. TSS levels met the habitat requirement in 2008-2010.

Algal abundance was relatively poor and did not meet the SAV habitat requirement (Figure 16). Water clarity was relatively poor but Secchi depths may have improved in the spring. Water clarity failed to meet the SAV habitat requirement. Summer BDO levels were good and were always above 5 mg/l (Figure 17).

Back Creek (C & D Canal)

Nitrogen levels were relatively poor in Back Creek but DIN may have improved annually and in the SAV growing season.[16] Summer DIN levels were not low enough to limit algal growth. TP levels were relatively good but PO_4 levels were relatively poor and PO_4 levels failed to meet the habitat requirement. TSS levels were relatively poor and failed to meet the SAV habitat requirement.

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[15] TN may have improved in the Northeast River from 1985-2010. DIN: PO_4 ratio may have increased but was 233:1 in 2010, well above the Redfield ratio of 16:1.

[16] TN may have improved in Back Creek from 1985-2010.

Algal densities were relatively good but may have degraded annually.[17] CHLA levels were low enough to meet the SAV habitat requirement. Water clarity was relatively poor and failed to meet the SAV habitat requirement. Summer BDO levels were good and were always above 5 mg/l.

Bohemia River
Nitrogen levels were relatively good in the Bohemia River and summer DIN levels were low enough to limit algal growth in some years.[18] TP and PO_4 levels were relatively good and PO_4 levels met the SAV habitat requirement. TSS levels were relatively good and improved annually, in the summer and in the SAV growing season. TSS levels only met the SAV habitat requirement in 2010.

Algal abundance was relatively poor.[19] Algal densities were not low enough to meet the SAV habitat requirement. Water clarity was relatively poor and failed to meet the SAV habitat requirement. Summer BDO levels were good and were always above 5 mg/l.

Elk River
Total nitrogen levels were relatively fair in the Elk River but DIN levels were relatively poor.[20] DIN levels in the SAV growing season may have improved annually, but were not low enough to limit algal growth. TP levels were relatively good but PO_4 levels were relatively poor and failed to meet the SAV habitat requirement. TSS levels were relatively good and met the SAV habitat requirement in 2008 and 2010.

Algal abundance was relatively good but degraded annually and may have degraded in the SAV growing season. Algal densities met the SAV habitat requirement. Water clarity was relatively good but may have degraded annually and failed to meet the SAV habitat requirement. Summer BDO levels were good and were always above 5 mg/l.

Sassafras River
TN levels were relatively poor in the Sassafras River but may have improved in the summer. DIN levels were relatively good and low enough to limit algal growth in the summer in most years. TP levels were relatively fair and PO_4 levels were relatively good. PO_4 levels met the SAV habitat requirement. TSS levels were relatively good and may have improved in the summer and SAV growing season. TSS levels only met the SAV habitat requirement in 2008.

Algal abundance and water clarity were relatively poor and neither met the SAV habitat requirement. Summer BDO levels were good and were always above 5 mg/l.

[17] CHLA in Back Creek may have improved from 1985-2010.
[18] TN in the Bohemia River improved from 1985-2010.
[19] CHLA in the Bohemia River may have improved from 1985-2010.
[20] TN in the Elk River may have improved from 1985-2010.

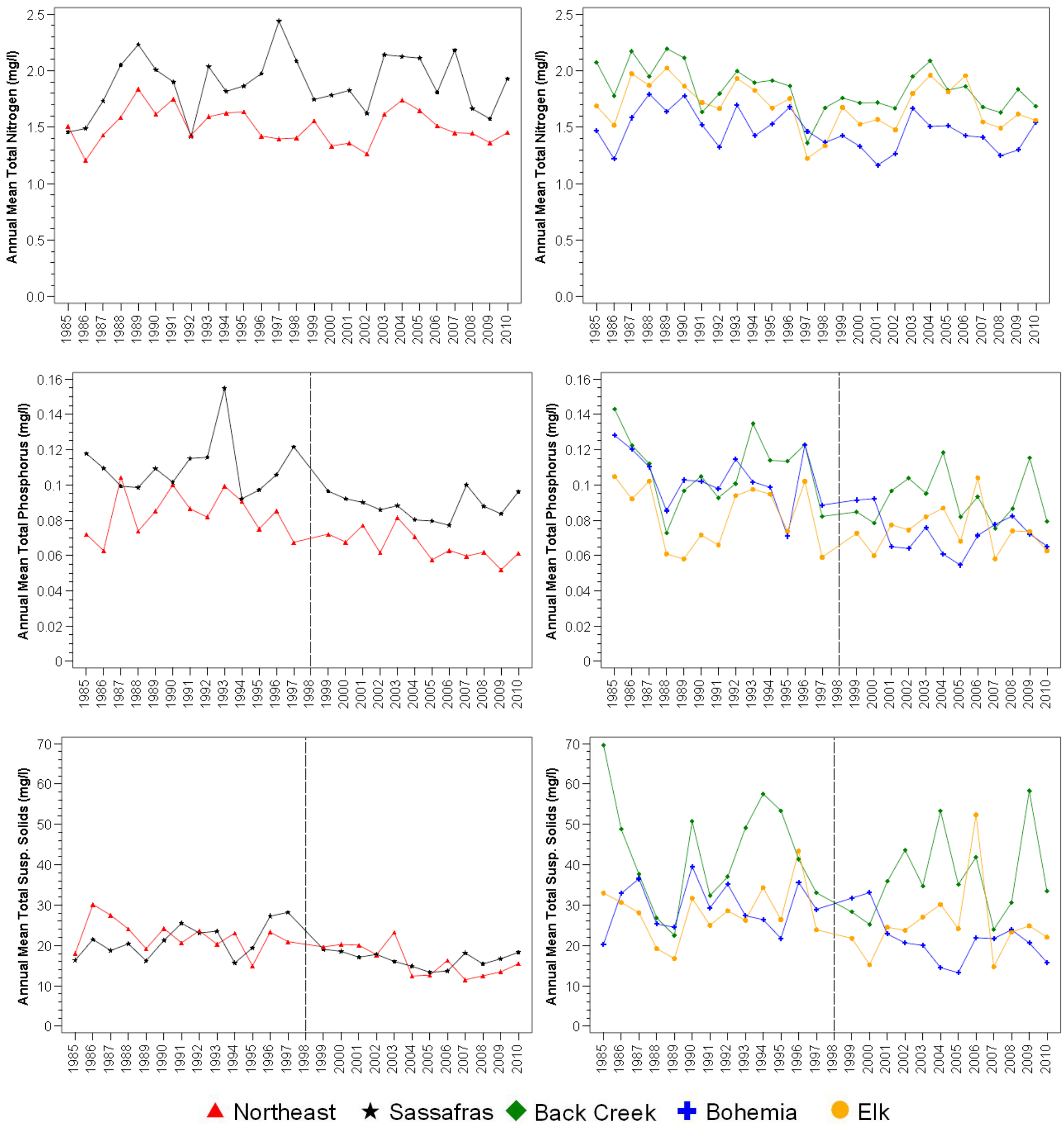

Figure 13. Annual means for total nitrogen, total phosphorus and total suspended solids in the upper basin rivers.
Left panels show data for the Northeast River and Sassafras River. The right panels show the data for Back Creek, Bohemia and Elk rivers. Dotted line (1998) indicates when the lab change occurred that may have impacted TP and TSS. Caution should be used in making comparisons for TP and TSS from before to after the lab change.

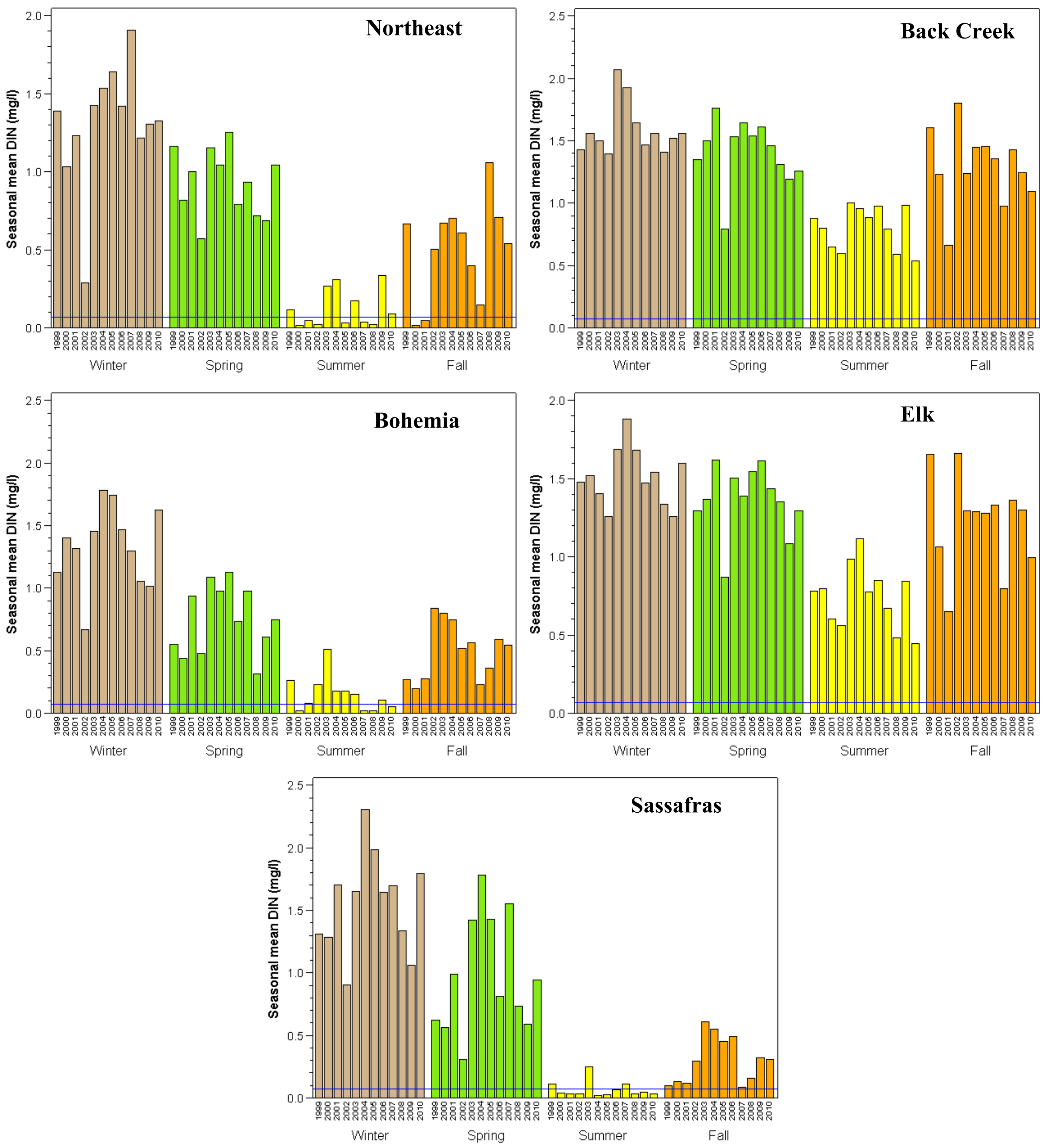

Figure 14. Mean dissolved inorganic nitrogen by season for the upper basin rivers. The blue line at 0.07 mg/l indicates the DIN level below which nitrogen limitation likely occurs. Winter season includes December (of the previous year), January and February. Spring season includes March-May. Summer season includes July-August (June is a transition month and not included). Fall season includes October and November. Biological nutrient removal of nitrogen at WWTPs is most effective in warmer months, and seasonal changes in phytoplankton populations (blooms in spring and fall) reduce DIN.

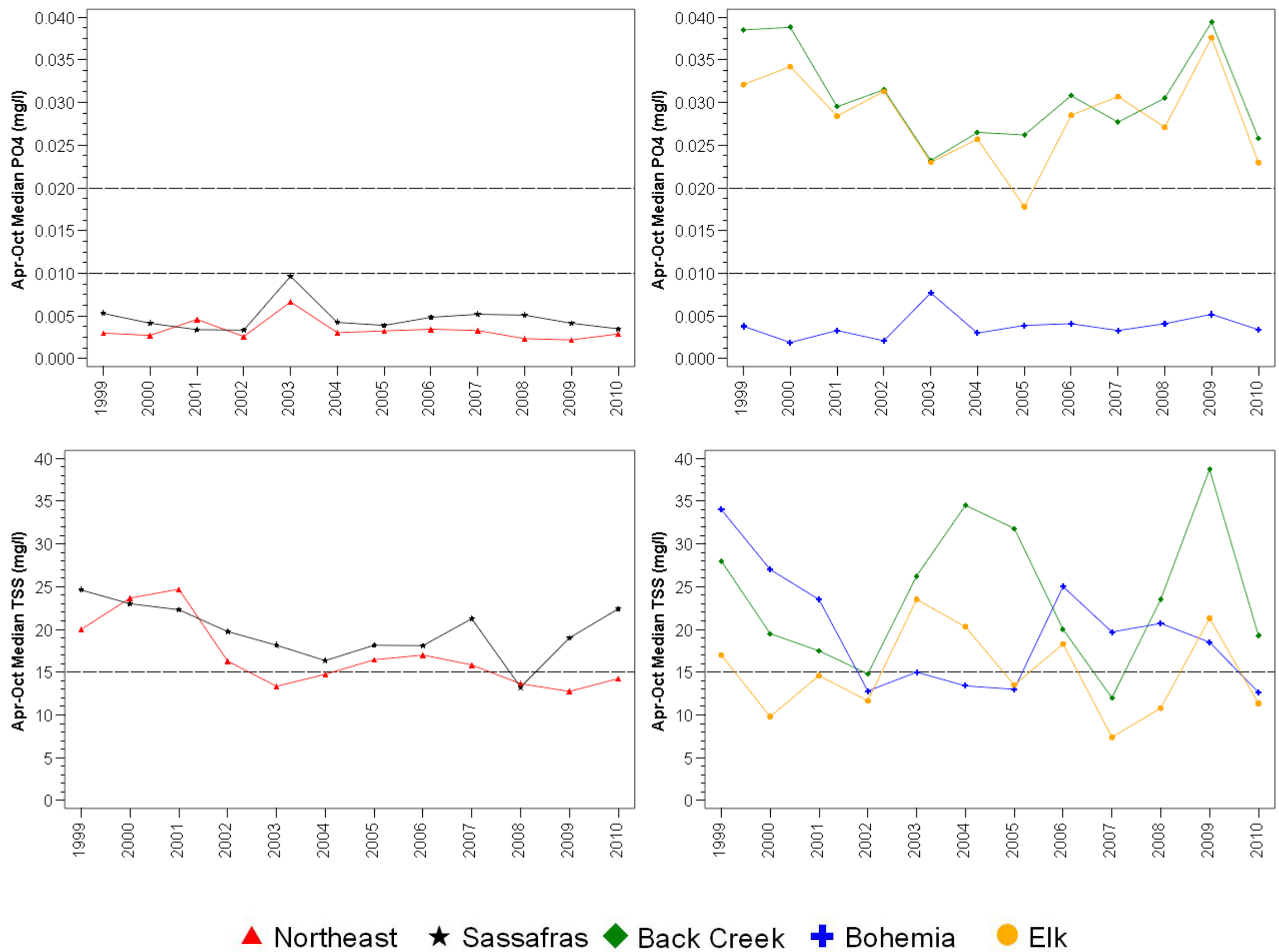

Figure 15. SAV Habitat Requirement parameters.
SAV growing season (April-October) median values for PO_4 and TSS. Left panels show data for the Northeast River and Sassafras River. The right panels show the data for Back Creek, Bohemia River and Elk River. Threshold values are shown with dashed lines (Appendix 5). To meet or pass the habitat requirements, levels of PO_4 and TSS need to be lower than the threshold. All rivers are compared the Tidal Fresh/Oligohaline thresholds.

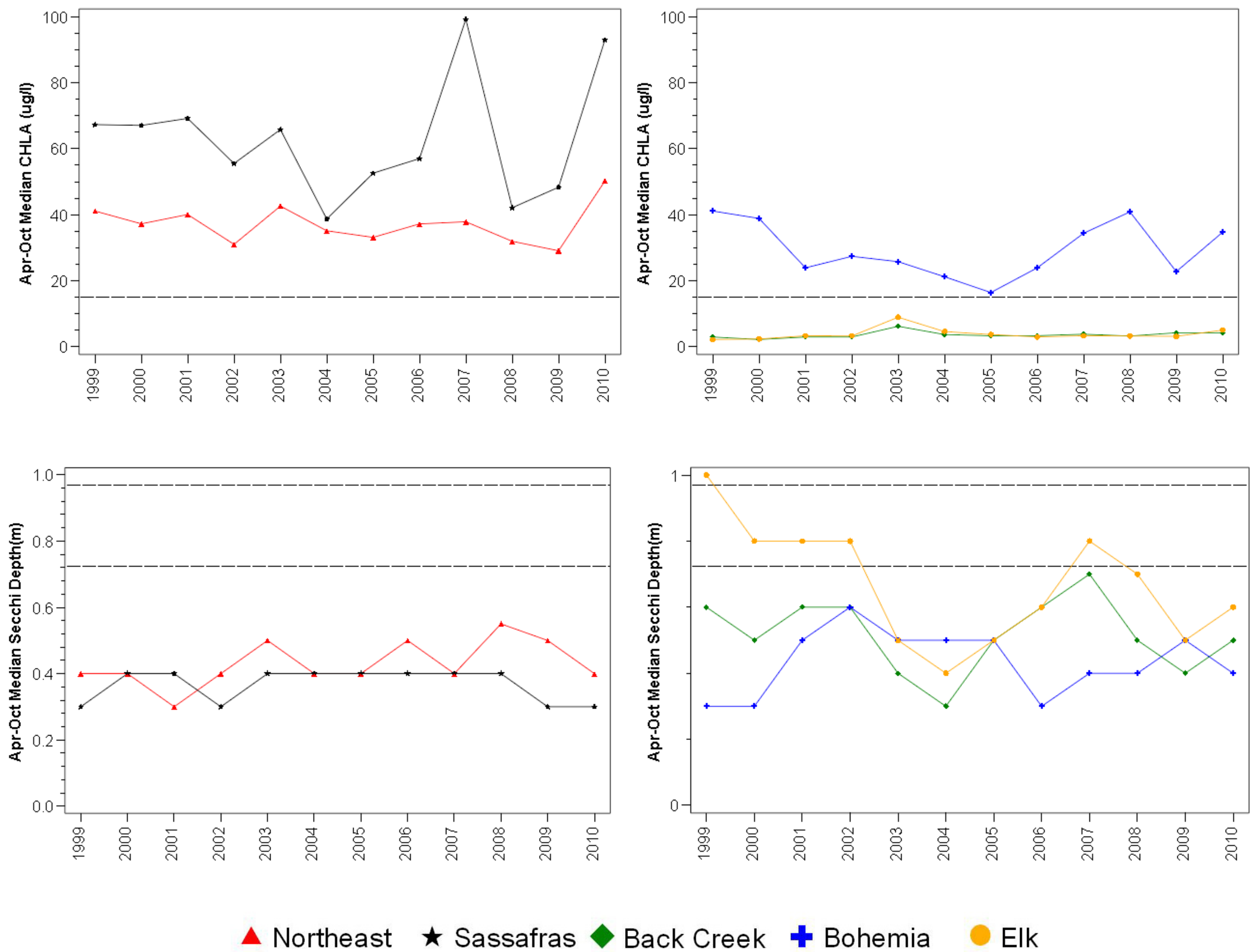

Figure 16. SAV habitat requirement parameters.
SAV growing season (April-October) median values for CHLA and Secchi depth. Left panels show data for the Northeast River and Sassafras River. The right panels show the data for Back Creek, Bohemia River and Elk River. Threshold values are shown with dashed lines (Appendix 5). To meet or pass the habitat requirements, levels of CHLA need to be lower than the threshold and Secchi depth needs to be above the threshold. All rivers need to meet the tidal fresh/oligohaline thresholds.

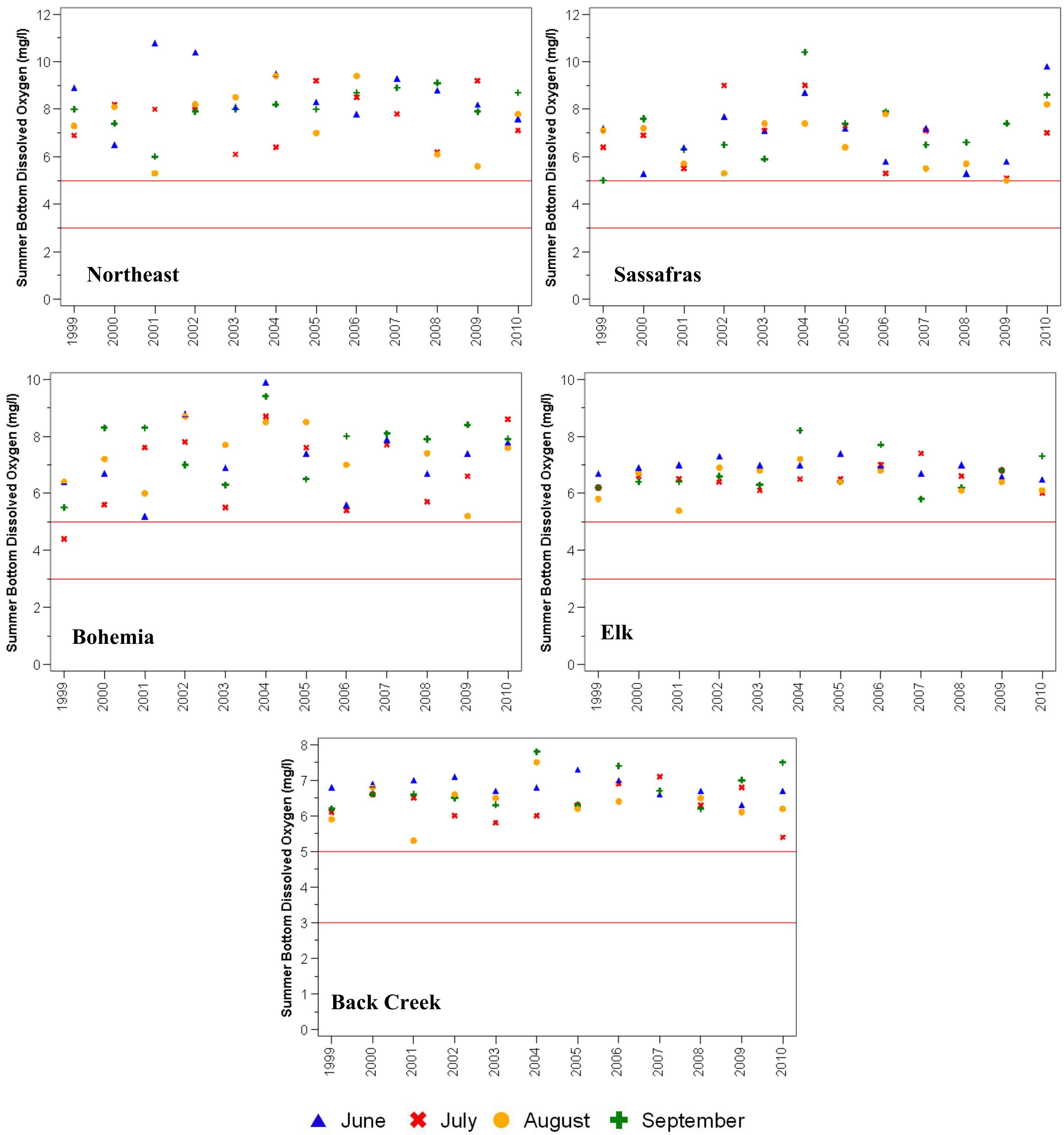

Figure 17. Summer bottom dissolved oxygen levels in the upper basin rivers.
Monthly bottom dissolved oxygen levels with threshold values of 5 mg/l and 3 mg/l shown with red reference lines. Note that the y-axes differ between graphs.

Upper Chester River

Nitrogen levels were relatively poor in the upper Chester River (Figure 18). TN may have improved annually but DIN levels were not low enough to limit algal growth (Figure 19).[21] Phosphorus levels were relatively poor but TP improved annually, in summer and in the SAV growing season.[22] PO_4 levels in the SAV growing season only met the SAV habitat requirement in 2008 (Figure 20). TSS levels were relatively fair and improved annually and in all seasons. Despite a large decrease since 1999, TSS levels were still too high to meet the SAV habitat requirement.

Algal abundance was relatively good and improved annually, in summer and the SAV growing season and may have improved in the spring.[23] There has also been a large decrease in algal densities since 1999, and algal abundance met the SAV habitat requirement in 2008-2010. Water clarity was relatively poor and failed to meet the SAV habitat requirement.[24] Summer bottom dissolved oxygen levels were good and only rarely were less than 5 mg/l (Figure 21).

Lower Chester River

TN levels were relatively poor in the lower Chester River but DIN levels were relatively good. DIN levels were low enough to limit algal growth in most years in summer, and also in the fall and winter in some years. Phosphorus levels were relatively good. PO_4 levels may have improved in the spring and met the SAV habitat requirement.[25] TSS levels were relatively good and met the SAV habitat requirement.

Algal abundance and water clarity were relatively poor.[26] Algal abundance did not meet the SAV habitat requirement in 2009 and was borderline in 2008 and 2010. Water clarity failed to meet the SAV habitat requirement. Summer bottom dissolved oxygen levels were fair and above 5 mg/l in the month of June in each year but fell to less than 3 mg/l in most of the other months from 2008-2010. Salinity may have decreased in the spring in the lower Chester River.[27] There were no trends in water temperature.

Corsica River

Nitrogen levels were relatively good in the Corsica River. DIN levels were low enough to limit algal growth in most years in summer and fall. TP levels were relatively poor but PO_4 levels were relatively good. PO_4 met the habitat requirement. TSS levels were relatively good, met the SAV habitat requirement in 2010 and were borderline in 2008. Algal abundance and water clarity were relatively poor, and did not meet the SAV habitat requirements. Summer bottom dissolved oxygen levels were fair but were below 5 mg/l about half the time.

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[21] TN and DIN in the Upper Chester degraded from 1985-1997.
[22] TP in the Upper Chester improved from 1985-1997.
[23] CHLA in the Upper Chester improved from 1985-2010.
[24] Secchi depth in the Upper Chester improved from 1985-2010.
[25] TP and TSS in the lower Chester degraded from 1985-1997.
[26] CHLA and Secchi depth in the lower Chester degraded from 1985-2010, though a non-linear trend for Secchi depth indicates Secchi depth improved after 2004.
[27] Non-linear trends in salinity indicate that salinity decreased until the early 2000s and has since increased in the Chester River and Eastern Bay.

Eastern Bay

Nitrogen levels were relatively good in Eastern Bay but may have degraded in the summer. DIN levels were low enough to limit algal growth in summer, and also in most years in the fall. Phosphorus levels were relatively good. TSS levels were relatively good and may have improved annually. PO_4 and TSS levels met the SAV habitat requirements.

Algal abundance was relatively poor.[28] Algal abundance met the SAV habitat requirement but was close to the 15 µg/l threshold. Water clarity was relatively good and met the SAV habitat requirements in 2009 and 2010 and was very close in 2008. Summer bottom dissolved oxygen levels were poor and below 3 mg/l most of the time.

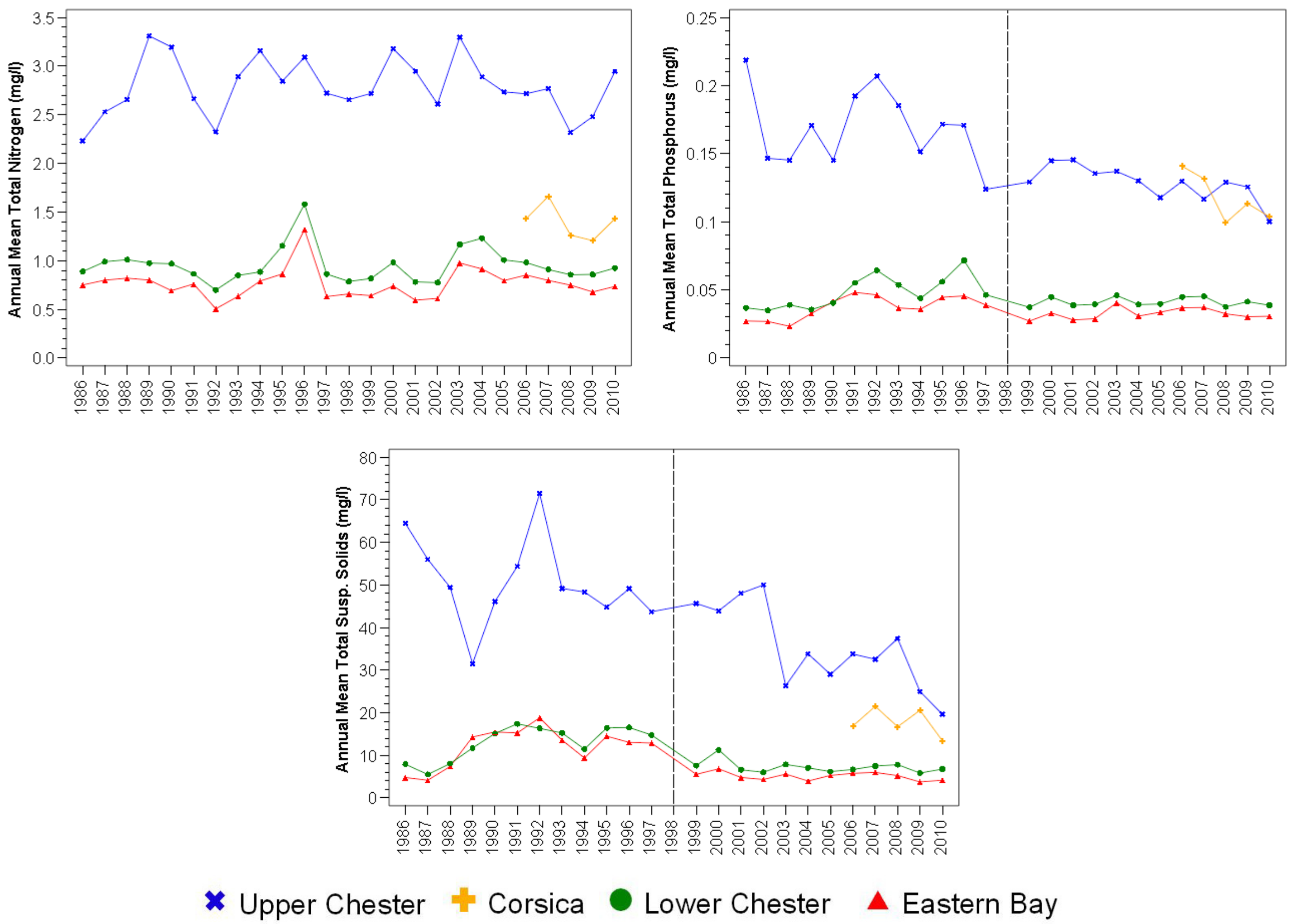


Figure 18. Annual means for total nitrogen, total phosphorus and total suspended solids in the Eastern Bay, Chester River and Corsica River.

Dotted line (1998) indicates when the lab change occurred that may have impacted TP and TSS. Caution should be used in making comparisons for TP and TSS from before to after the lab change.

[28] CHLA, Secchi depth and bottom dissolved oxygen in Eastern Bay degraded from 1985-2010.

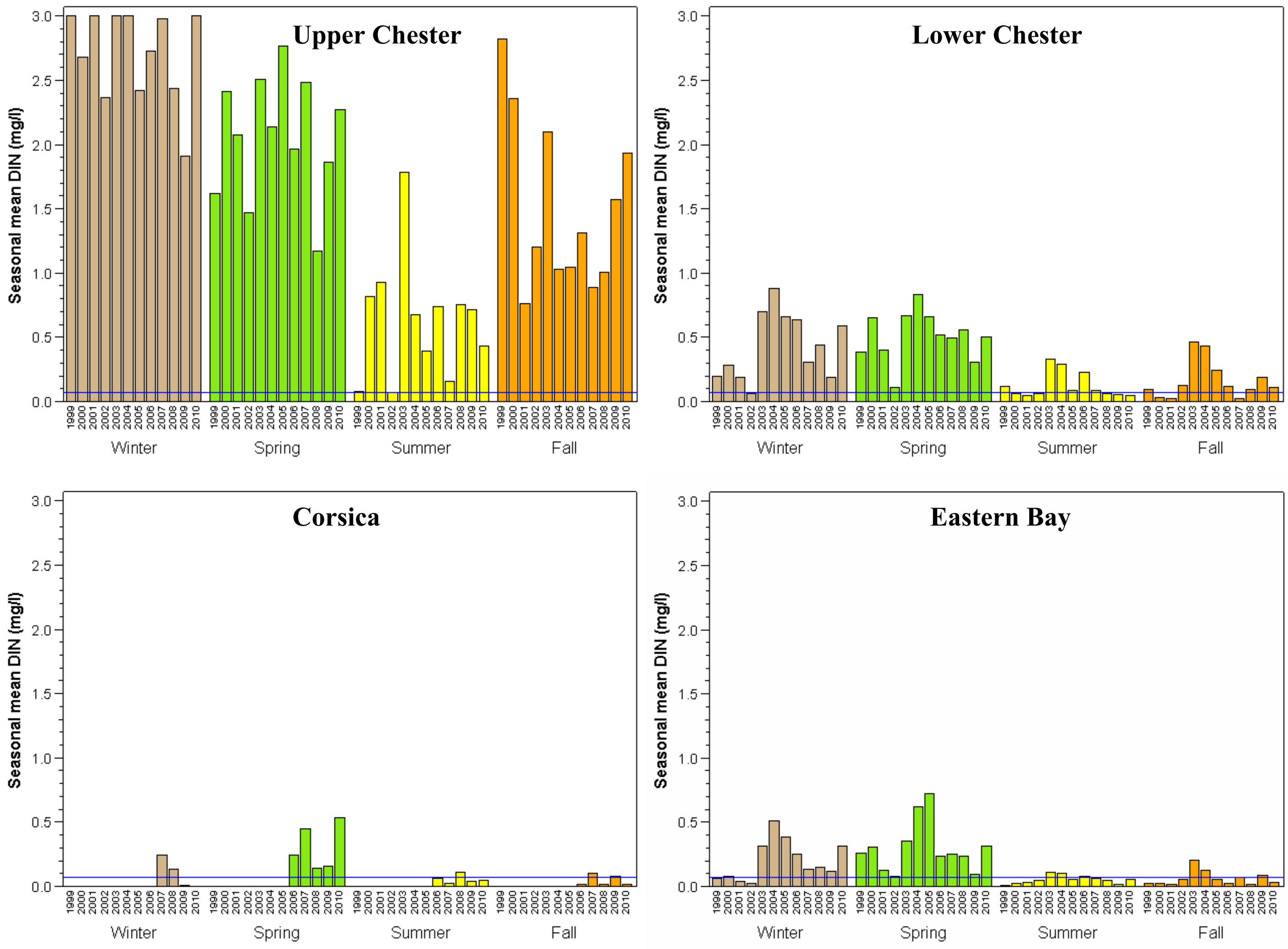


Figure 19. Mean dissolved inorganic nitrogen by season for the Chester River, Corsica River and Eastern Bay.
The blue line at 0.07 mg/l indicates the DIN level below which nitrogen limitation likely occurs. Winter season includes December (of the previous year), January and February. Spring season includes March-May. Summer season includes July-August (June is a transition month and not included). Fall season includes October and November. Biological nutrient removal of nitrogen at WWTPs is most effective in warmer months, and seasonal changes in phytoplankton populations (blooms in spring and fall) reduce DIN. Winter concentrations for the upper Chester are off scale for several years, with concentrations greater than 3 mg/l but less than 4 mg/l.

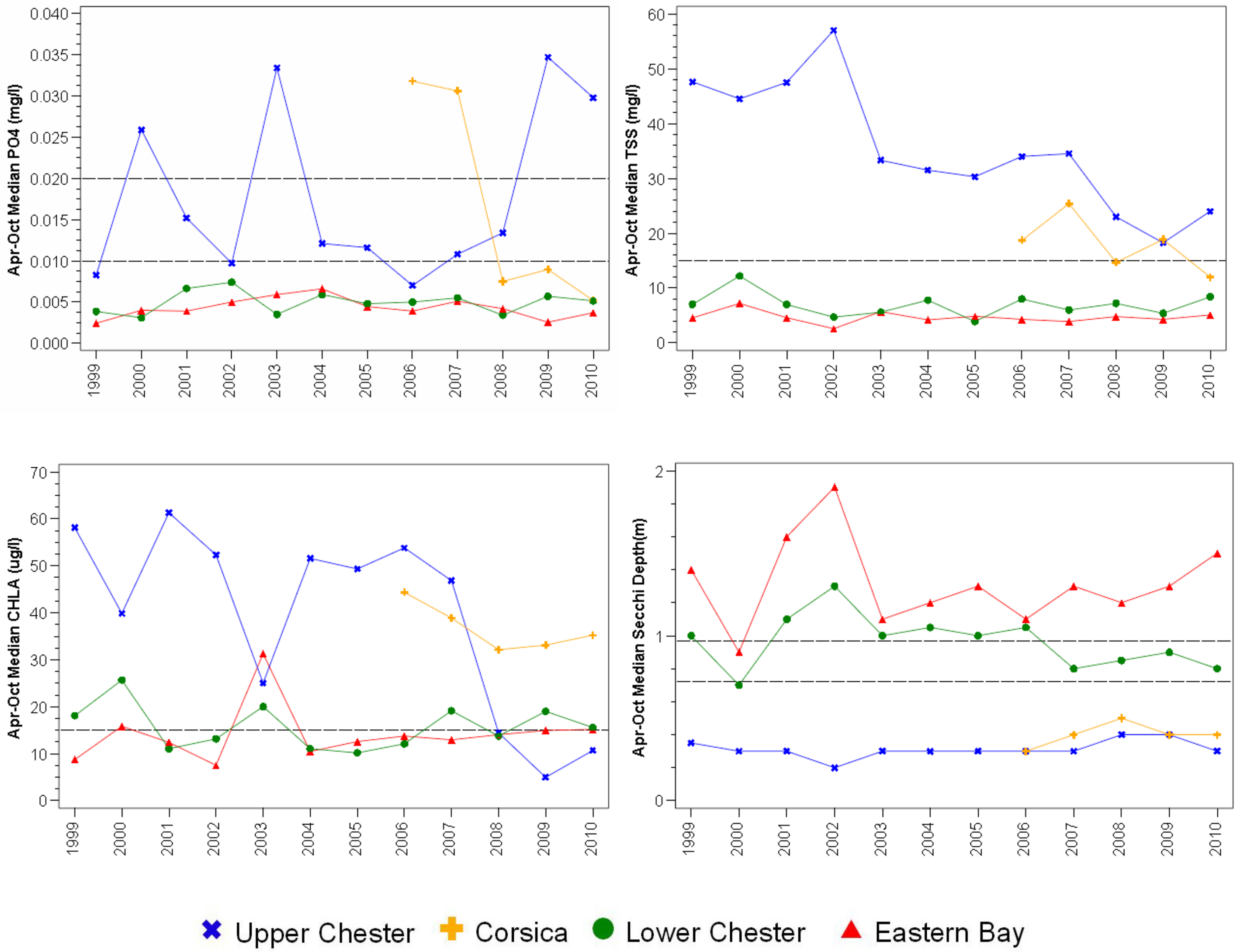


Figure 20. SAV habitat requirement parameters in Chester River, Corsica River and Eastern Bay. SAV growing season (April-October) median values for PO_4, TSS, CHLA and Secchi depth. Threshold values are shown with dashed lines (Appendix 5). To meet or pass the habitat requirements, levels of PO_4, TSS and CHLA need to be lower than the threshold and Secchi depth needs to be above the threshold. Upper Chester needs to meet the tidal fresh/oligohaline thresholds and the other stations need to meet the mesohaline thresholds.

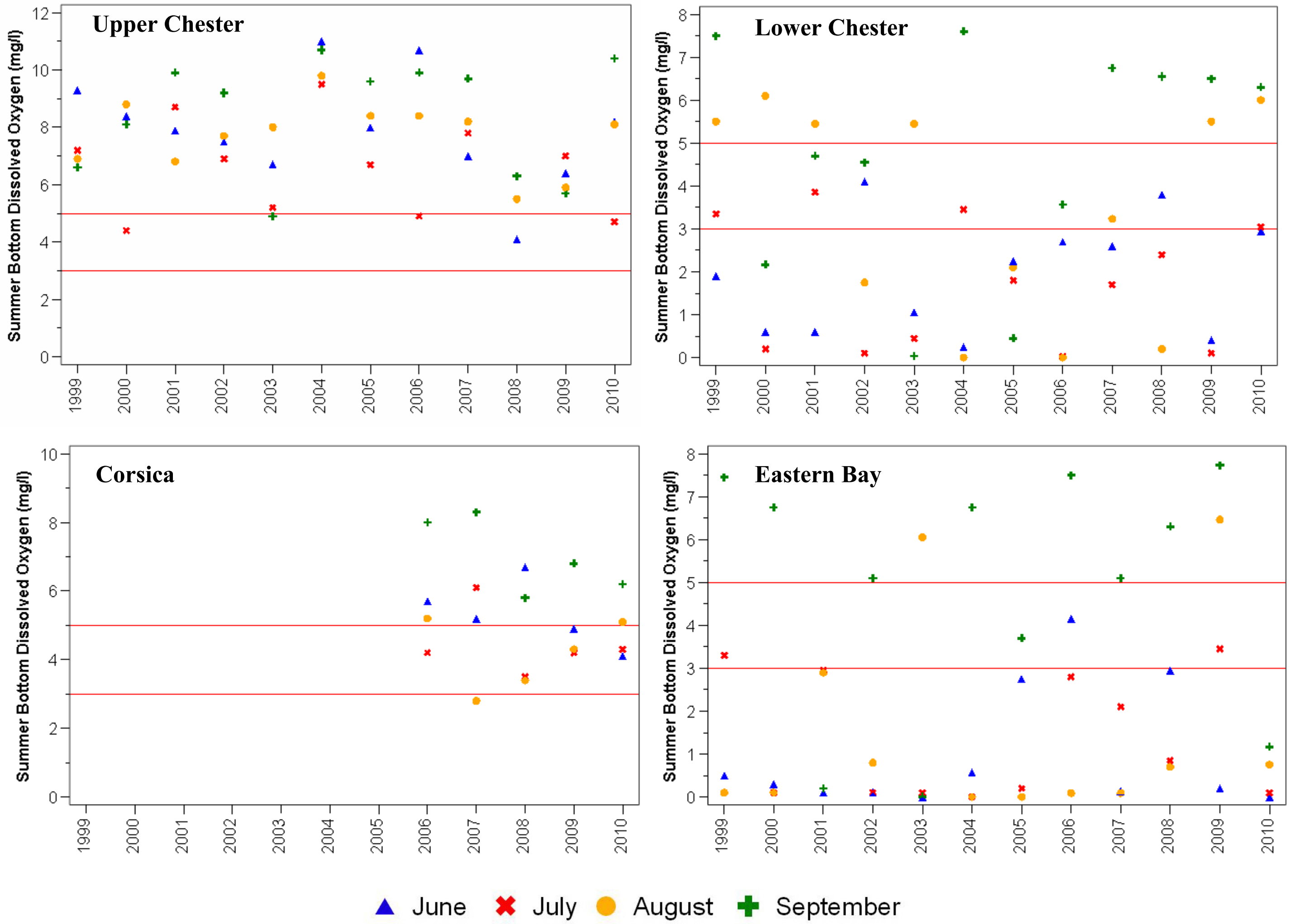


Figure 21. Summer bottom dissolved oxygen levels in the Chester River, Corsica River and Eastern Bay.
Monthly bottom dissolved oxygen levels with threshold values of 5 mg/l and 3 mg/l shown with red reference lines. Note that the y-axes differ between graphs.

Shallow water

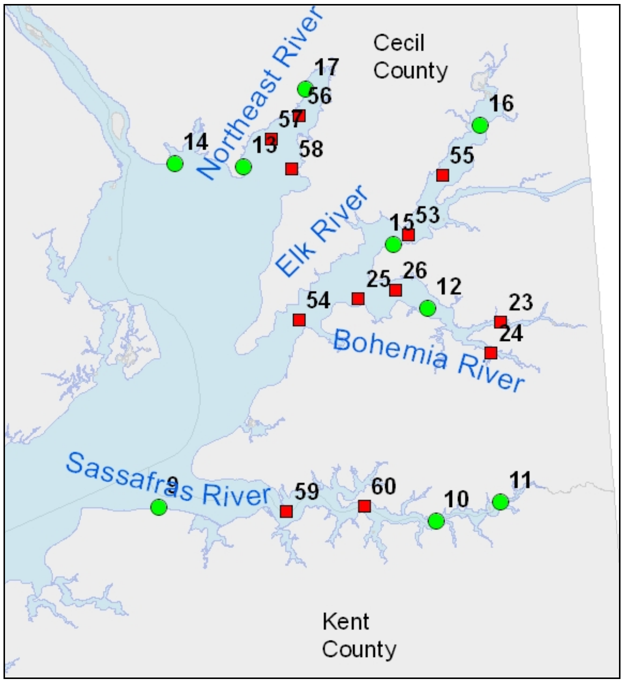
The long-term water quality monitoring program samples at a fixed point that is generally in the center channel and deeper waters of a river. Sampling is done once or twice a month. The strength of this type of monitoring is that the repetition of sampling over many years (more than two decades) measures how water quality has changed over time and in response to management actions, land use changes, etc. However, conditions at the long-term monitoring station may not adequately capture water quality conditions in shallow waters, the river as a whole or on short time scales. The shallow water monitoring program is designed to measure conditions in the areas closest to land that are critical habitat areas, especially in the areas with underwater grass beds. Sampling in a river is done for a 3-year period to determine short-term changes in water quality that occur due to weather, such as between a year with very high rainfall and a year with low rainfall. Some shallow water stations have been monitored for longer periods.

The first part of the shallow water monitoring program uses instruments that stay in the water for extended periods (usually April-October) and collect information every 15 minutes; this is called the continuous monitoring program. Instead of the one or two samples a month typical of the long-term monitoring program, the continuous monitoring program can collect more than 2,800 samples a month.[29] This type of monitoring 1) measures water quality changes that occur between night and day, between days and at longer times spans; 2) determines how long water quality problems persist, such as algal blooms or low oxygen water; and 3) measures water quality changes that occur related to weather events such as storms.

The second part of the monitoring program samples all of the shallow waters of a river (or river segment in larger rivers) once a month from April-October; this is the water quality mapping program. Data is collected nearly constantly as a boat moves along the entire shoreline, so changes in water quality can be measured from one part of the river to another. This data captures water quality in very localized areas and can identify places with better or worse water quality than the river overall. This monitoring is also able to capture changes in water quality related to events that occur in only part of the river such as algal blooms or in response to localized nutrient sources.

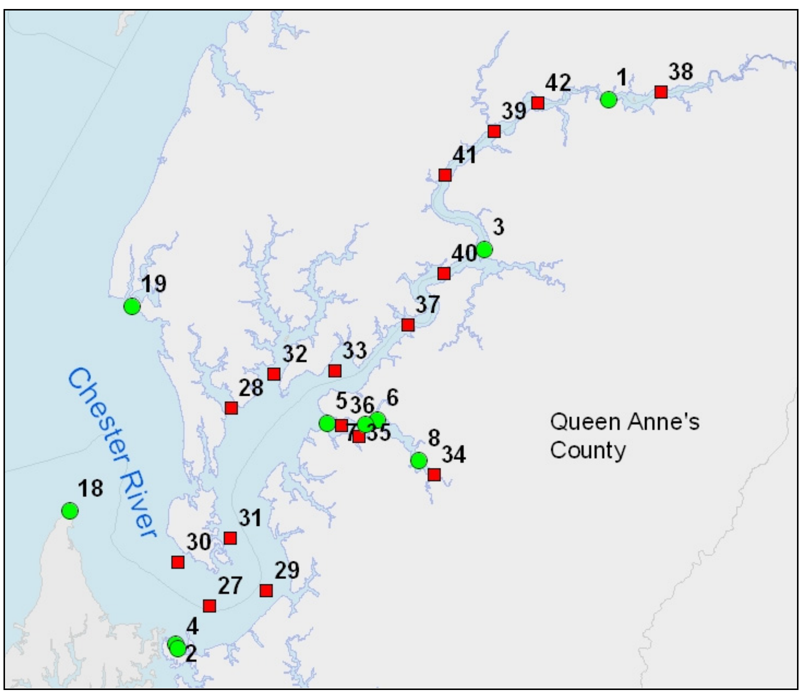
Many of the Upper Eastern Shore Rivers were monitored from 2007-2009 including the Northeast, Bohemia, Elk and Sassafras rivers (Figure 28) and the Corsica River (Figure 29).[30] Only the Sassafras River and Corsica River were measured in 2010. Monitoring in the Corsica River began in 2005. The Chester River was monitored from 2003-2006 (Figure 29). Eastern Bay was monitored from2004-2006 (Figure 30).

[29] Nutrient samples are collected twice a month instead of continuously.
[30] An interactive map of all continuous monitoring stations and complete archived data are available at http://mddnr.chesapeakebay.net/newmontech/contmon/archived_results.cfm.



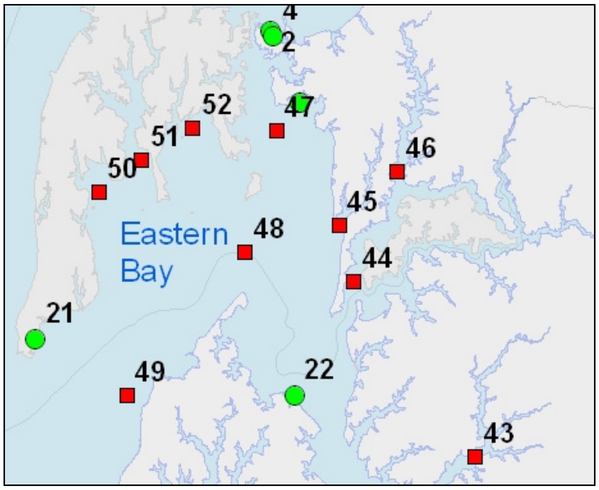
	STATION		map#
NORTHEAST RIVER	Charlestown	XKI5022	17
	long-term	ET1.1	56
		XKH3508	57
		XKI2616	58
	Carpenters Point	XKH2797	13
BOHEMIA RIVER		GBO0013	23
		LBO0010	24
	long-term	ET2.2	near 12
	Long Point	XJI8369	12
		XJI8856	26
		XJI8641	25
ELK RIVER	Locust Point	XKI3890	16
		XKI2475	55
	Hollywood Beach	XKI0256	15
	long-term mid	ET2.3	53
		XJI8018	54
SASSFRAS RIVER	Budds Landing	XJI2396	11
	Georgetown Yacht	XJI1871	10
	long-term	ET3.1	near 10
		XJI2342	60
		XJI2112	59
	Betterton Beach	XJH2362	9

Figure 22. Shallow water calibration stations in the upper rivers.
Green circles indicate where the continuous monitors were located. Red squares are additional calibrations stations that were collected on water quality mapping cruises.



	STATION		map#
UPPER CHESTER RIVER		ET4.1	38
	Deep Landing	CHE0348	1
		XIH4495	42
		XIH3581	39
		XIH1458	41
MIDDLE CHESTER RIVER	Rolphs Wharf	XIH0077	3
		XHH9362	40
		XHH7848	37
		XHH6419	33
		XHG6496	32
		GYI0001	28
LOWER CHESTER RIVER		XHG1579	31
		XGG9992	29
		ET4.2	27
	Inside SAV bed	XGG8359	4
	Outside SAV bed	XGG8458	2
		XGG9992	29
		XHG0859	30
CORSICA RIVER		COR0056	34
	Sycamore Point	XHH3851	8
	Possum Point	XHH4931	7
		XHH4916	5
	Emory Creek	XHH5046	6
		XHH4822	36
	long-term	XHH4742	near 35
		XHH4528	35

Figure 23. Shallow water calibration stations in the Chester River and Corsica River.
Green circles indicate where the continuous monitors were located.
Red squares are additional calibrations stations that were collected on water quality mapping cruises.



	STATION		map#
EASTERN BAY	long-term	EE1.1	48
		XGG4301	50
		XGG5115	51
		XGG5932	52
	CBEC	XGG6667	20
		XGG5959	47
		XGG3479	45
	Hambleton Point	XFG9164	22
		XFG9210	49
	Kent Point	XGF0681	21
MILES		XFH7523	43
WYE RIVER		XGG4898	46
		XGG2084	44

Figure 24. Shallow water calibration stations in Eastern Bay, Wye River and Miles River. Green circles indicate where the continuous monitors were located. Red squares are additional calibrations stations that were collected on water quality mapping cruises.

Current Conditions

Several continuous monitors were operating in the Upper Eastern Shore basin in 2010. In the Sassafras River, stations were located at Budds Landing and Betterton Beach. In the Corsica River, monitors were located at Sycamore Point, Possum Point, and The Sill. Possum Point and the Sill each had two monitors, one suspended 1 meter below the surface, and the other situated 0.3 meters above the bottom. Monitors in Chesapeake Bay Segment 3 were located at the mouth of the Chester River, at Gratitude Marina and Love Point. The 2010 monitoring results for each of these locations are discussed below.

Sassafras River

The upstream station at Budds Landing showed higher chlorophyll concentrations than downstream at Betterton Beach (Figure 25). Chlorophyll concentrations in excess of 50 µg/l are considered indicative of a significant algal bloom while values above 100 µg/l suggest severe algal bloom conditions. A severe bloom was evident at Budds Landing in late July when chlorophyll values peaked at 142 µg/l on July 30, 2010. Due to algal photosynthetic activity, dissolved oxygen values at Budds Landing occasionally exceeded 20 mg/l in the summer months, while summer dissolved oxygen values remained below 15 mg/l at Betterton Beach. In 2010, dissolved oxygen values never dropped below 5 mg/l at Budds Landing and did so only rarely at Betterton Beach.

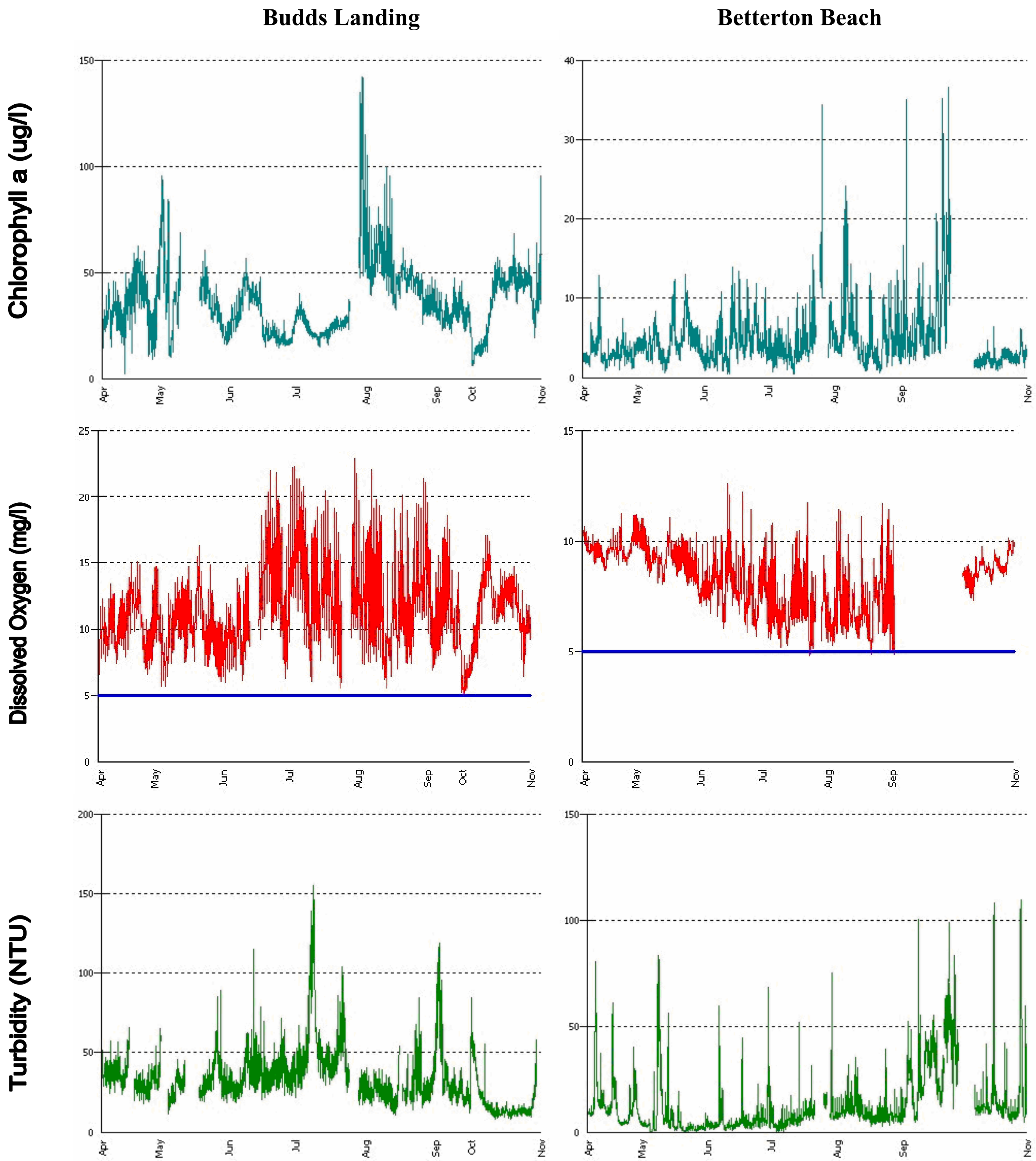


Figure 25. High frequency CHLA, DO and turbidity data from Budds Landing and Betterton Beach, Sassafras River, in 2010.
Data from April thorough November 2010. Blue reference line on the DO graphs at 5 mg/l. Note that the y-axis scales are different between Budds Landing and Betterton Beach graphs.

Corsica River
In the Corsica River in 2010, chlorophyll concentrations were highest at the upstream station at Sycamore Point and decreased with distance downstream. March chlorophyll values at Sycamore Point were close to 400µg/l over several weeks, indicating a severe algal bloom (Figure 26). Additionally, an extended period of chlorophyll values greater than 100 µg/l occurred at Sycamore Point in July and August. In the surface waters at Possum Point, chlorophyll values briefly rose above 50 µg/l several times during the months of March through September (Figure 27). The bottom water monitor at Possum Point detected occasional spikes of chlorophyll values greater than 100µg/l during this same period. Surface waters at the most downstream station, The Sill, recorded chlorophyll values above 50µg/l in March, which then declined and generally remained below 50µg/l for the rest of the year (Figure 28). Bottom waters at The Sill showed a similar pattern and range of values for chlorophyll. Algal concentrations contributed to the wide daily range of dissolved oxygen values observed at all Corsica stations. All stations had dissolved oxygen values that dropped below 5 mg/l, but the most frequent occurrences were at Sycamore Point and in the bottom waters of Possum Point and The Sill. Turbidity values were generally below 50 NTU at all Corsica River stations during 2010, although all turbidity graphs were punctuated by occasional spikes of much higher values. Some of the more significant turbidity spikes occurred at Sycamore Point and at Possum Point (bottom) during the months of May through July.

C*hesapeake Bay – Segment 3 (mid-bay)*
Both Gratitude Marina and Love Point showed similar water quality conditions in 2010 (Figure 29). Dissolved oxygen decreased in the summer months, but values below 5 mg/l were infrequent at both stations. At Gratitude Marina, a brief spike in chlorophyll (> 150 µg/l) occurred in May. Overall, turbidity values appeared slightly higher at Gratitude Marina, with the exception of a spike of 184 NTU at Love Point on August 7, 2010.

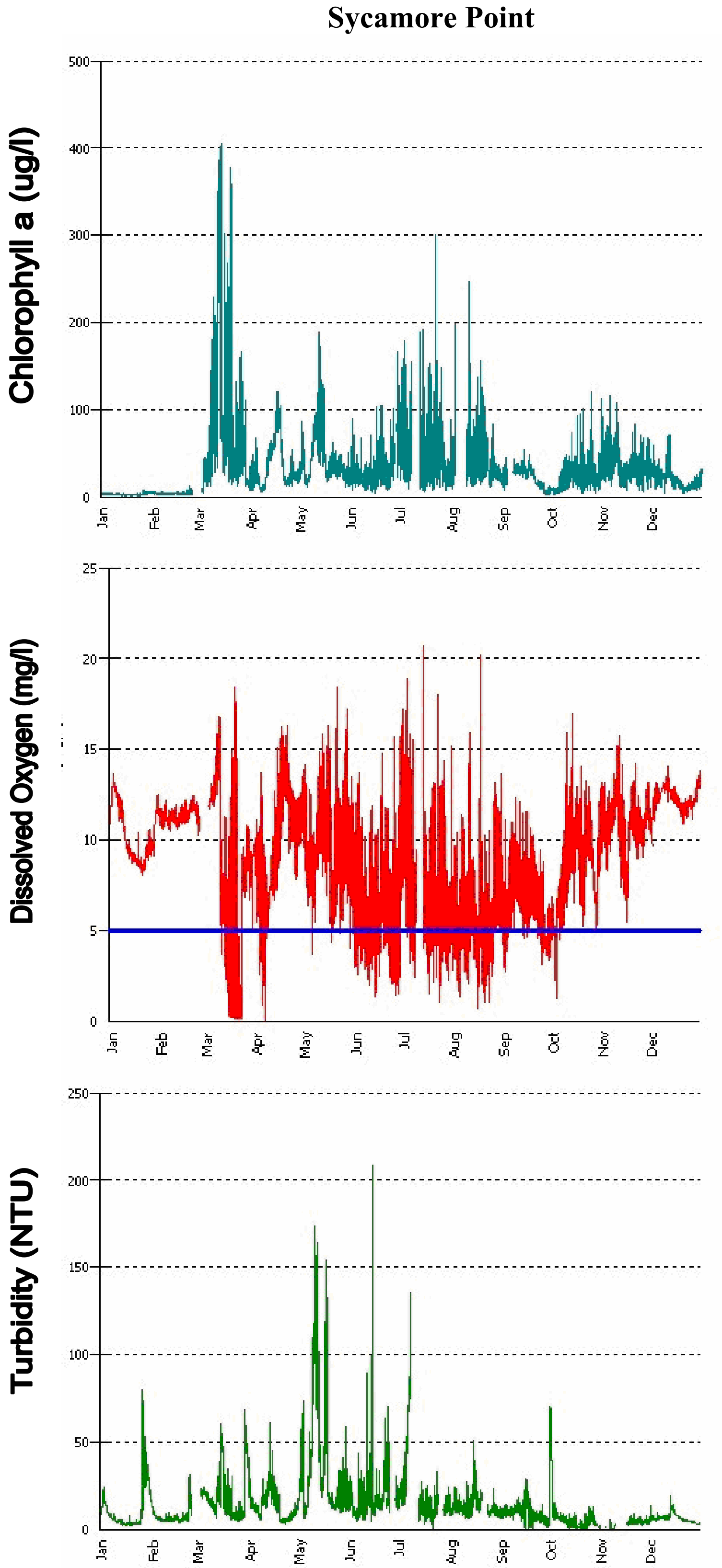


Figure 26. High frequency CHLA, DO and turbidity data from Sycamore Point, Corsica River, in 2010.
Data from January thorough December 2010. Blue reference line on the DO graphs at 5 mg/l.

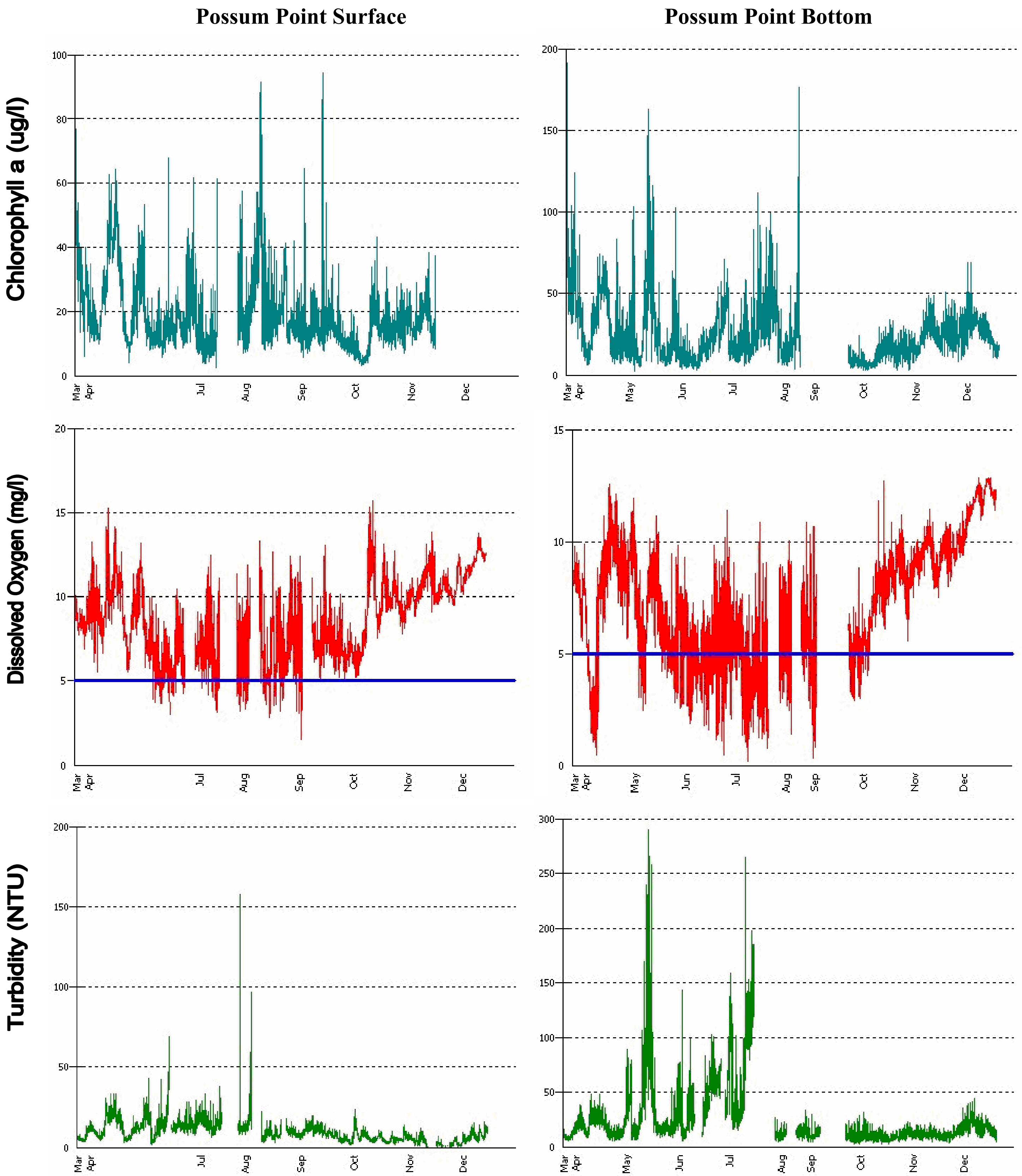


Figure 27. High frequency CHLA, DO and turbidity data from Possum Point (surface and bottom), Corsica River, in 2010.

Data from March thorough December 2010. Blue reference line on the DO graphs at 5 mg/l. Note that the y-axis scales are different between surface and bottom graphs.

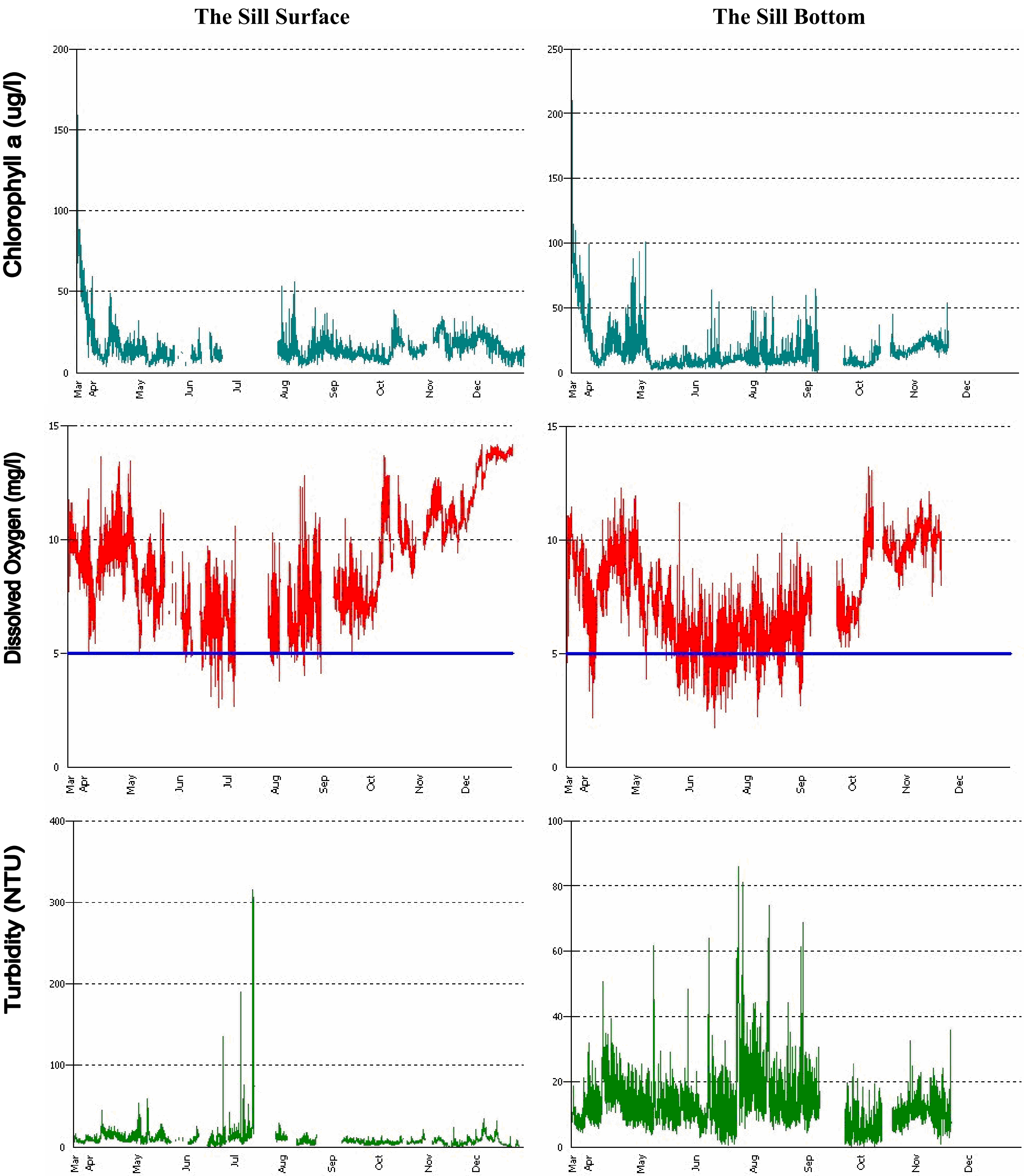


Figure 28. High frequency CHLA, DO and turbidity data from The Sill (surface and bottom), Corsica River in 2010.
Data from March thorough December 2010. Blue reference line on the DO graphs at 5 mg/l. Note that the y-axis scales are different between surface and bottom graphs.

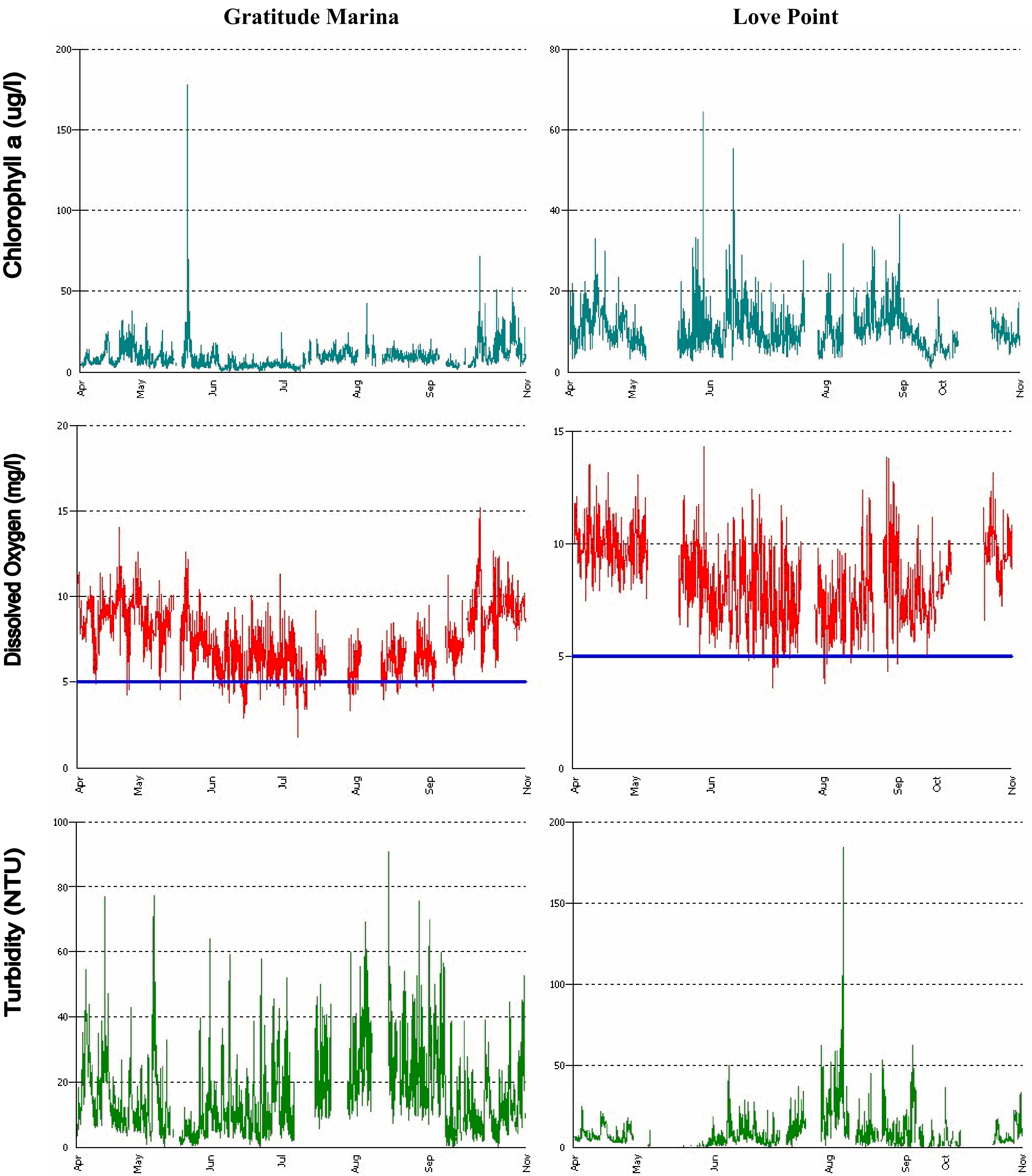


Figure 29. High frequency CHLA, DO and turbidity data from Gratitude Marin and Love Point, main Bay in 2010.

Data from April thorough November 2010. Blue reference line on the DO graphs at 5 mg/l. Note that the y-axis scales are different between Gratitude Marine and Love Point graphs.

Temporal and Spatial conditions

Water and habitat quality in the shallow water was evaluated in two ways. The first was a temporal assessment. High temporal frequency data from the continuous monitoring program were used to determine how often water quality met conditions needed for healthy habitats. Percent failures are defined as the percent of values in each year that did not meet the water quality thresholds (see Appendix 4 for methods). Data for the years 2003-2010 were used. Chlorophyll and turbidity measurements collected during the SAV growing season (April through October) and summer dissolved oxygen values (June through September) were included in the analysis. Percent failures for 2008-2010 data are shown in Table 2. The percent failures for all years are shown in Appendix 8.

The second method was a spatial assessment. The nutrient data collected at continuous monitoring and water quality mapping calibration stations for April-October were compared to the SAV habitat requirements. Results for 2008-2010 data are shown in Table 3. The results for all years are shown in Appendix 8. Water quality and habitat conditions were also compared between the shallow water stations and the long-term station.

Northeast River

At the continuous monitoring stations in the Northeast River, dissolved oxygen levels never dropped below 3.2 mg/l (Table 2). Chlorophyll levels at Carpenters Point exceeded the 15 µg/l threshold 16 - 47% of the time. At Charlestown, between 57% and 87% of chlorophyll values were greater than 15 µg/. Turbidity values at both stations exceeded the 7 NTU threshold more than 70% of the time.

Shallow water locations failed to meet the SAV habitat requirements for water clarity and algal densities, but met the requirement for PO_4 (Table 3). DIN levels were too high at all locations in 2009 but the two upper river stations (Charlestown and long-term stations) were below the threshold in 2008. Only the long-term station and the next station downstream (XKH3508) met the TSS habitat requirement in both 2008 and 2009, but DIN levels at the stations that failed were close to the threshold.

Algal densities in the upper river at Charlestown and the long-term station were significantly higher than in the rest of the river. TSS levels at Charlestown were also higher than at the other shallow water areas and the long-term station.[31] DIN levels in the lower river at Carpenter's Point and XKI2616 were higher than in the other areas, but PO_4 levels and water clarity were similar at all stations.

Bohemia River

At Long Point in the Bohemia River, dissolved oxygen levels never dropped below 3.2 mg/l. Chlorophyll levels exceeded the 15 µg/l threshold less than 35% of the time. Turbidity values generally exceeded the 7 NTU threshold more than 90% of the time.

Algal densities and TSS levels in the upper river were significantly higher than in the lower river. CHLA and TSS levels in the lower river met the SAV habitat requirements, but the levels in the upper river did not meet the requirements. Conversely, DIN and PO4 levels were

[31] TP levels at Charlestown on the Northeast River were also higher than the other locations, but there were no differences in TN levels.

significantly higher in the lower river and failed to meet the SAV habitat requirements. Middle river stations (Long Point and the long-term station) were similar to each other, and both locations only met the PO_4 habitat requirement. Water clarity failed to meet the SAV habitat requirement at all stations except the furthest downstream station in 2008, but Secchi depths in the lower river were significantly higher than in the upper river.

Table 2. Shallow water dissolved oxygen, chlorophyll and turbidity levels in the Upper Eastern Shore rivers in 2008-2009

The percent of instantaneous values in each year that did not meet the thresholds:
dissolved oxygen > 3.2 mg/l, chlorophyll *a* < 15 µg/l, turbidity < 7 NTU.

River	Location		Year	Diss. Oxygen % < 3.2 mg/l	Chlorophyll % > 15 ug/l	Turbidity % > 7 NTU
Chesapeake Bay	Bay Stump Point	XKH2870	2008	0.0	5.1	31.5
			2009	0.0	1.5	22.8
Northeast River	Charlestown	XKI5022	2008	0.0	78.7	87.7
			2009	0.0	86.7	91.2
	Carpenters Point	XKH2797	2008	0.0	46.8	79.8
			2009	0.0	24.0	68.4
Elk River	Locust Point Marina	XKI3890	2008	0.0	38.6	98.9
			2009	0.0	37.5	99.3
	Hollywood Beach	XKI0256	2008	0.0	0.0	93.9
			2009	0.0	0.1	90.3
Bohemia River	Long Point	XJI8369	2008	0.0	35.4	99.4
			2009	0.0	31.0	89.2
Sassafras River	Budds Landing	XJI2396	2008	0.0	98.7	99.0
			2009	0.0	98.4	99.7
			2010	0.0	96.5	100.0
	Betterton Beach	XJH2362	2008	0.0	1.3	63.1
			2009	0.0	5.6	31.0
			2010	0.0	2.3	57.3
Chester River	Kent Narrows (inside)	XGG8359	2008	2.3	6.0	19.1
			2009	0.8	12.9	22.2
	Kent Narrows (outside)	XGG8458	2008	0.0	20.3	47.0
			2009	0.9	24.6	32.1
Chesapeake Bay	Gratitude Marina	XHG8442	2009	3.2	19.1	50.2
			2010	0.3	10.4	72.9
	Love Point	XHG2318	2009	0.4	29.2	32.1
			2010	0.1	12.4	40.1
Corsica River	Sycamore Point	XHH3851	2008	17.0	83.3	84.5
			2009	10.9	83.0	94.0
			2010	6.8	80.9	76.7
	Possum Point (surface)	XHH4931	2008	0.8	77.2	79.8
			2009	0.6	53.1	68.6
			2010	0.3	50.9	71.4
	Possum Point (bottom)	XHH4931	2008	18.0	55.2	82.3
			2009	8.3	36.2	77.9
			2010	14.3	58.6	92.0
	The Sill (surface)	XHH4916	2008	0.0	37.8	60.5
			2009	0.0	32.7	59.3
			2010	0.3	26.0	55.3
	The Sill (bottom)	XHH4916	2008	3.0	39.6	93.2
			2009	1.7	33.0	85.1
			2010	1.5	29.1	81.2
Eastern Bay	Ches.Bay Environ. Center	XGG6667	2008	3.6	33.3	63.6

< 10 % failure **40 - 70 % failure** **10 - 40 % failure** **> 70 % failure**

Table 3. Shallow water monitoring data compared to SAV habitat requirements in the Northeast, Bohemia, Elk and Sassafras rivers for 2008-2009.
All calibration data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping calibration sampling.

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth	
NORTHEAST RIVER	Charlestown	XKI5022	17	2008	35.9	FAIL	16.0	FAIL	0.060	MEET	0.0033	MEET	0.40	FAIL
				2009	45.4	FAIL	22.0	FAIL	0.152	FAIL	0.0034	MEET	0.40	FAIL
	long-term	ET1.1	56	2008	33.1	FAIL	13.7	MEET	0.054	MEET	0.0027	MEET	0.40	FAIL
				2009	37.0	FAIL	14.2	MEET	0.334	FAIL	0.0023	MEET	0.50	FAIL
		XKH3508	57	2008	27.9	FAIL	14.7	MEET	0.463	FAIL	0.0029	MEET	0.40	FAIL
				2009	31.3	FAIL	12.5	MEET	0.679	FAIL	0.0023	MEET	0.50	FAIL
		XKI2616	58	2008	12.7	MEET	15.3	FAIL	0.595	FAIL	0.0036	MEET	0.40	FAIL
				2009	26.7	FAIL	16.5	FAIL	0.546	FAIL	0.0032	MEET	0.50	FAIL
	Carpenters Point	XKH2797	13	2008	16.4	FAIL	14.7	MEET	0.499	FAIL	0.0025	MEET	0.50	FAIL
				2009	20.8	FAIL	15.4	FAIL	0.788	FAIL	0.0026	MEET	0.55	FAIL
BOHEMIA RIVER		GBO0013	23	2008	76.8	FAIL	29.5	FAIL	0.026	MEET	0.0061	MEET	0.20	FAIL
				2009	40.6	FAIL	32.0	FAIL	0.014	MEET	0.0047	MEET	0.20	FAIL
		LBO0010	24	2008	48.8	FAIL	27.0	FAIL	0.024	MEET	0.0071	MEET	0.30	FAIL
				2009	38.1	FAIL	35.3	FAIL	0.017	MEET	0.0064	MEET	0.30	FAIL
	long-term	ET2.2	near 12	2008	45.1	FAIL	21.4	FAIL	0.014	MEET	0.0041	MEET	0.40	FAIL
				2009	22.8	FAIL	24.6	FAIL	0.203	FAIL	0.0054	MEET	0.45	FAIL
				2010	34.7	FAIL	12.7	MEET	0.071	FAIL	0.0034	MEET	0.40	FAIL
	Long Point	XJI8369	12	2008	24.7	FAIL	28.3	FAIL	0.146	FAIL	0.0069	MEET	0.40	FAIL
				2009	20.6	FAIL	28.8	FAIL	0.210	FAIL	0.0072	MEET	0.40	FAIL
		XJI8856	26	2008	12.8	MEET	8.0	MEET	0.460	FAIL	0.0218	FAIL	0.80	MEET
				2009	7.5	MEET	16.0	FAIL	0.864	FAIL	0.0309	FAIL	0.50	FAIL
		XJI8641	25	2008	5.0	MEET	13.8	MEET	0.506	FAIL	0.0218	FAIL	0.70	FAIL
				2009	4.3	MEET	12.7	MEET	0.826	FAIL	0.0313	FAIL	0.70	FAIL
ELK RIVER	Locust Point	XKI3890	16	2008	38.1	FAIL	46.0	FAIL	0.601	FAIL	0.0053	MEET	0.30	FAIL
				2009	12.0	MEET	46.0	FAIL	0.668	FAIL	0.0130	MEET	0.30	FAIL
		XKI2475	55	2008	2.4	MEET	16.5	FAIL	0.514	FAIL	0.0318	FAIL	0.80	MEET
				2009	4.6	MEET	19.0	FAIL	0.997	FAIL	0.0372	FAIL	0.50	FAIL
	Hollywood Beach	XKI0256	15	2008	5.1	MEET	30.0	FAIL	0.712	FAIL	0.0248	FAIL	0.40	FAIL
				2009	4.3	MEET	33.3	FAIL	0.990	FAIL	0.0377	FAIL	0.40	FAIL
	long-term mid	ET2.3	53	2008	3.6	MEET	11.8	MEET	0.762	FAIL	0.0256	FAIL	0.75	MEET
				2009	3.7	MEET	21.3	FAIL	1.071	FAIL	0.0367	FAIL	0.50	FAIL
		XJI8018	54	2008	5.4	MEET	6.8	MEET	0.724	FAIL	0.0209	FAIL	0.80	MEET
				2009	6.8	MEET	10.0	MEET	0.876	FAIL	0.0154	MEET	0.70	FAIL
SASSFRAS RIVER	Budds Landing	XJI2396	11	2008	73.3	FAIL	27.4	FAIL	0.018	MEET	0.0039	MEET	0.30	FAIL
				2009	73.7	FAIL	35.0	FAIL	0.030	MEET	0.0061	MEET	0.30	FAIL
				2010	103.6	FAIL	46.8	FAIL				MEET	0.20	FAIL
	Georgetown Yacht	XJI1871	10	2008	56.1	FAIL	14.8	MEET	0.015	MEET	0.0036	MEET	0.40	FAIL
				2009	54.5	FAIL	24.0	FAIL	0.022	MEET	0.0036	MEET	0.30	FAIL
		XJI2342	60	2008	28.8	FAIL	10.0	MEET	0.017	MEET	0.0030	MEET	0.55	FAIL
				2009	27.0	FAIL	16.5	FAIL	0.095	FAIL	0.0036	MEET	0.40	FAIL
		XJI2112	59	2008	17.7	FAIL	14.1	MEET	0.097	FAIL	0.0033	MEET	0.55	FAIL
				2009	10.0	MEET	14.0	MEET	0.348	FAIL	0.0052	MEET	0.50	FAIL
	Betterton Beach	XJH2362	9	2008	10.2	MEET	13.6	MEET	0.524	FAIL	0.0099	MEET	0.75	MEET
				2009	6.3	MEET	6.4	MEET	0.813	FAIL	0.0211	FAIL	1.10	MEET
				2010	6.2	MEET	10.4	MEET					0.70	FAIL

Elk River
At the continuous monitoring stations in the Elk River, dissolved oxygen levels never dropped below 3.2 mg/l. Chlorophyll levels at Hollywood Beach exceeded the 15 µg/l threshold less than 1% of the time, but at Locust Point Marina the failure rate for chlorophyll was 35-47%. Turbidity values exceeded the 7 NTU threshold more than 90% of the time.

Algal densities in the Elk River met the SAV habitat requirement at all stations except for Locust Point (uppermost station) in 2008. All stations failed to meet the DIN threshold. Water clarity at all stations failed to meet the SAV habitat requirement in 2009, but several met the requirement in 2008. Algal densities at Locust Point were significantly higher than at the other stations.[32] Locust Point and Hollywood Beach had significantly lower Secchi depths than the rest of the river (likely because of better conditions in 2008 at the other stations). DIN levels were similar throughout the river.

TSS levels at Locust Point failed to meet the SAV habitat requirement, but PO_4 levels met the requirement. The other upper river station and Hollywood Beach (middle river) failed to meet both the TSS and PO_4 habitat requirements. The long-term station (middle river) and lower river met the TSS habitat requirement but failed to meet the PO_4 habitat requirement with the exception of the lower river in 2009. TSS levels were similar at Locust Point and Hollywood Beach and significantly higher than the other stations. PO_4 levels were significantly higher in the middle Elk River than in the lower river or farthest upstream. The Bohemia River joins the Elk River in this middle portion of the Elk River, and PO_4 levels at the mouth of the Bohemia River were similar to those in the middle Elk River.

Sassafras River
At the continuous monitoring stations in the Sassafras River, dissolved oxygen levels almost never dropped below 3.2 mg/l. Budds Landing and the Georgetown Yacht Basin had the most failures of the 15 µg/l chlorophyll threshold in the Upper Eastern Shore basin. Budds Landing and Georgetown Yacht Basin exceeded the chlorophyll threshold more than 95% of the time in all years. Turbidity values at Budds Landing and Georgetown Yacht Basin generally exceeded the 7 NTU threshold more than 90% of the time. Betterton Beach appeared to show improvement over the period 2006-2010 with 86% of observations failing the 7 NTU turbidity threshold in 2006 and 57% of observations failing in 2010.

DIN levels failed to meet the threshold in the lower Sassafras River. PO_4 levels met the SAV habitat requirement with the exception of Budds Landing (lower river) in 2009. Water clarity failed to meet the SAV habitat requirement at all stations except Budds Landing. Algal densities and TSS levels in the upper and middle river failed to meet the SAV habitat requirement. CHLA and TSS levels were significantly higher at Budds Landing than the other stations.[33] DIN and PO_4 levels and Secchi depths were significantly higher at Betterton Beach. Secchi depths were also significantly higher in the middle river than in the upper river.

[32] TN levels in the Elk River were significantly higher at Locust Point than the other stations, and TP levels at both upper river stations were significantly higher than the rest of the river.
[33] TN and TP levels were significantly higher at Budds Landing than any other stations in the Sassafras River. TP levels at Georgetown Yacht Club were also significantly higher than stations in the lower river.

Corsica River
Corsica River, and in particular Sycamore Point, had the greatest percent failures of the dissolved oxygen threshold. Less than 1% of observations in surface waters at The Sill were below the 3.2 mg/l dissolved oxygen threshold, less than 3% of observations were below 3.2 mg/l in the surface waters at Possum Point, and generally 10-30% of observations were below 3.2 mg/l at Sycamore Point. Bottom water dissolved oxygen levels at Possum Point and The Sill failed the 3.2 mg/l threshold more frequently than the surface waters at these locations.

In the Corsica River, more than 75% of observations at Sycamore Point exceeded the chlorophyll threshold in all years, while Possum Point and Emory Creek had a 36-86% failure rate. The Sill exceeded the 15 µg/l chlorophyll threshold less than 50% of the time.

Algal densities and water clarity failed to meet the SAV habitat requirements in the entire Corsica River. DIN levels met the threshold everywhere except the station furthest upstream; DIN levels at this station were an order of magnitude higher than the rest of the river. Upper and middle river TSS levels also failed to meet the SAV habitat requirement. PO_4 levels varied between years and each station met the SAV habitat requirement at least one of the three years.

CHLA and TSS levels at the uppermost station (COR0056) were significantly higher than the rest of the river.[34] CHLA and TSS levels at Sycamore Point were also higher than the middle and lower river levels. PO_4 levels at The Sill were significantly lower than the upper two stations, but otherwise PO_4 levels in the river were similar. Secchi depths were significantly higher at The Sill and Possum Point than in the upper river, but similar to the other stations.

Chester River
Shallow water monitoring was completed in the Chester River in 2003-2006. While the data does not represent current conditions, it is useful for evaluating differences in water quality between locations. Two continuous monitoring stations in the mouth of the Chester River collected data in 2009-2010, but because this is not the same time period as the rest of the Chester River direct comparisons are not made between these stations and the other Chester River stations.

In the upper and middle Chester River in 2003-2006, less than 1% of dissolved oxygen values were below 3.2 mg/l. At Deep Landing and Rolph's Wharf, chlorophyll levels exceeded the 15 µg/l threshold 16-38% and 1-8% of the time, respectively. Both of these stations exceeded the 7 NTU turbidity threshold more than 70% of the time.

In the upper Chester River, the long-term station (farthest upstream station) only met the SAV habitat requirement for PO_4 levels. At the other upper Chester River stations, (from Deep Landing down to XIH3581), water quality only met the habitat requirement for algal densities. The station off Chestertown (XIH1458) was only monitored in 2003, and water quality at this station only met the habitat requirements for CHLA and TSS.

In the middle Chester River, the station at Rolph's Wharf only met the SAV habitat requirement for CHLA in all years and for TSS in 2004. All of the other stations in the middle Chester River

[34] TN and TP levels were significantly higher at the uppermost station in the Corsica River than the rest of the river. TN levels at Sycamore Point were also higher than the middle and lower river.

met the TSS and failed the water clarity habitat requirements. Algal densities met the habitat requirement at all stations in most years, but DIN and PO_4 levels only met the habitat requirements at the lower two stations in some years.

In the lower Chester River, DIN levels and water clarity failed but PO_4 and TSS levels met the habitat requirements in most years. CHLA levels met the requirement in most years at the long-term station and the upper station but algal densities failed in most years at the other stations.

At the mouth of the Chester River (Gratitude Marina and Love Point) in 2009-2010, generally less than 1% of dissolved oxygen values were below 3.2 mg/l. Chlorophyll levels exceeded the 15 µg/l threshold less than 30% of the time. For turbidity, 32-73% of values at the mouth of the Chester River were above 7 NTU.

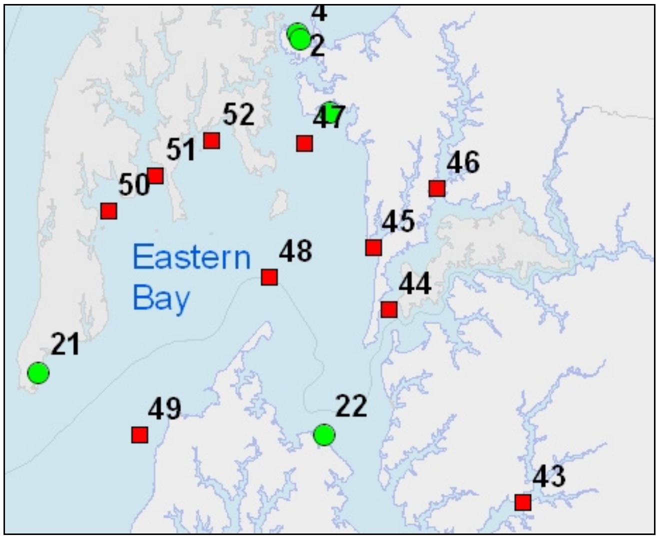
At the mouth of the Chester River, nutrient levels were only measured in 2009 but CHLA and TSS were measured in both 2009-2010. In 2009 both stations met SAV habitat requirements for TSS and PO_4 and failed to meet the DIN threshold. Water clarity failed in both years at the northern station and failed in 2010 at the southern station. Algal densities only failed to meet the habitat requirements at the southern station in 2009.

Eastern Bay

Shallow water monitoring was completed in Eastern Bay, the Miles River and the Wye River in 2004-2006 (Figure 30). While the data does not represent current conditions, it is useful for evaluating differences in water quality between locations. In Eastern Bay, less than 5% (and often less than 1%) of dissolved oxygen values were below 3.2 mg/l. Chlorophyll levels exceeded the 15 µg/l threshold less than 40% of the time. Turbidity levels were above the 7 NTU threshold 50-65% of the time at both the Chesapeake Bay Environmental Center (CBEC) and Kent Point, and only 10-25% of the time at Hambleton Point.

Algal densities, TSS levels and PO_4 levels met the SAV habitat requirements in Eastern Bay. The southern most stations (Hambleton Point, XFG9210 and Kent Point) did not meet the DIN threshold in any years, nor did the station in Prospect Bay (XGG5959). The remaining stations met the DIN threshold at least one of the three years. Water clarity failed to meet the SAV habitat requirement all three years at CBEC, Kent Point and XGG4301, but met the requirement at the long-term station and mouth of the river (XFG9210) in all three years.

The remaining stations failed to meet the water clarity SAV habitat requirement one of the three years, though which year varied between sites. The Miles River station failed to meet the water clarity habitat requirement in all three years and failed to meet CHLA and PO_4 requirements in 2005 and 2006. Miles River met the DIN threshold in all three years and met the TSS habitat requirement in 2005 and 2006. In the Wye River, the upstream station met TSS and DIN habitat requirements in all three years, while the downstream station met all the requirements except water clarity in two of the three years.



	STATION		map#
EASTERN BAY	long-term	EE1.1	48
		XGG4301	50
		XGG5115	51
		XGG5932	52
	CBEC	XGG6667	20
		XGG5959	47
		XGG3479	45
	Hambleton Point	XFG9164	22
		XFG9210	49
	Kent Point	XGF0681	21
MILES		XFH7523	43
WYE RIVER		XGG4898	46
		XGG2084	44

Figure 30. Shallow water calibration stations in Eastern Bay, Wye River and Miles River. Green circles indicate where the continuous monitors were located. Red squares are additional calibrations stations that were collected on water quality mapping cruises.

Inside/Outside SAV bed

Two continuous monitoring stations were located at Kent Narrows in the Chester River from 2007-2009 to monitor the water quality conditions that exist within an underwater grass bed. The station labeled "inside" was situated in the middle of an established SAV bed, while the station labeled "outside" was located just beyond the perimeter of the bed. Turbidity and chlorophyll thresholds were exceeded more frequently at the station located outside of the SAV bed, but more dissolved oxygen observations dropped below the 5 mg/l threshold at the station inside of the SAV bed. There was no apparent difference between the two stations when the percent failures for the 3.2 mg/l dissolved oxygen threshold were compared.

The SAV habitat requirement was met for PO_4 and not met for water clarity both inside and outside the grass bed. DIN levels were met inside the bed and failed outside the bed. CHLA and TSS levels both met and failed the SAV habitat requirements at both locations.

Duration of low oxygen conditions

The percent failure analysis determines how often dissolved oxygen levels were below healthy levels, but not how long at any one time dissolved oxygen levels were dangerously low. This is important because most benthic animals and fish can survive in low dissolved oxygen for short periods but not extended periods. A special study of the continuous monitoring data from Maryland rivers, including the data for the Corsica River (Sycamore Point data for 2005-2008) and the Sassafras River (Betterton Beach data for 2006-2008), found that periods of dissolved oxygen levels below 3.2 mg/l at different locations lasted from as little as 15 minutes to as long as 2.5 days.[35] The longest continuous period of extremely low dissolved oxygen at Sycamore Point was 37 hours. Also, the percentage of time in a sample year with extremely low dissolved oxygen levels ranged from 6% (in 2008) to 12% (in 2007). At Betterton Beach, dissolved

[35] Boynton et al (2011) available online at http://www.gonzo.cbl.umces.edu/documents/water_quality/Level1Report28.pdf

oxygen levels never were below 3.2 mg/l and out of 14,432 hours of data over three years, dissolved oxygen was below 5 mg/l for a total of 5 hours (0.03%).

Health of Key Plants and Animals

Phytoplankton

Phytoplankton (generally algae) are the primary producers in the Chesapeake Bay and rivers and the base of the food chain. Routine samples collected in the long-term tidal and shallow water monitoring programs estimate the abundance of algae but can not determine the health of the population overall. As part of a supplemental program, the overall phytoplankton community was sampled at the Sassafras River and lower Chester River long-term tidal water quality stations in spring and summer from 2007-2010. The phytoplankton index of biotic integrity (PIBI) assesses the health of the community. [36] A PIBI score of greater than 3 is considered meeting the goal for phytoplankton community health. Both spring and summer PIBI scores in the Sassafras River were below the goal in all years (Figure 23).[37] Lower Chester River PIBI scores were also below the goal except for Spring 2007.

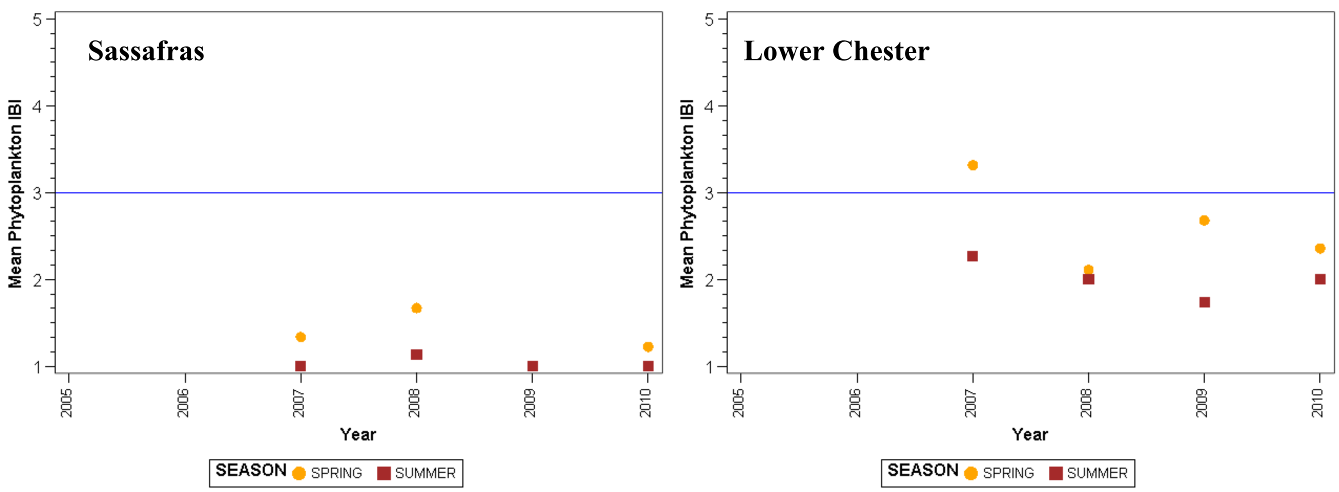


Figure 31. Spring and summer Phytoplankton Index of Biotic Integrity (PIBI) scores 2007-2010.

Harmful Algal Blooms (HABs)

High algal density (algal blooms) can degrade habitat quality. Blooms of certain species of phytoplankton (harmful algae) can also degrade habitat quality. Routine samples collected in the long-term tidal and shallow water monitoring programs can not distinguish between good and harmful algae. Additional samples are taken at some locations to determine what algal species are present and in what densities. When a bloom occurs, samples are taken to test for the presence and levels of toxins, which can be released by some types of harmful algae.

[36] Methods for calculation of the PIBI are available at www.chesapeakebay.net/.../indicator_survey_phyto_ibi_2011_final.docx

[37] PIBI scores calculated by J. Johnson, Interstate Commission on the Potomac River Basin/Chesapeake Bay Program.

Fortunately, of the more than 700 species of algae in Chesapeake Bay, less than 2% of them are believed to have the ability to produce toxic substances.[38]

Blue-green algae are generally smaller cells and not as nutritious and edible to small animals (zooplankton). Blooms of blue-green algae look like blue-green paint floating at or near the water surface (Figure 32). Blue-green algae can only live in low salinity waters. Some species of blue-green algae (*Microcystis* and *Anabaena*) can produce a toxin that is released into the water. Contact with or ingestion of water containing high toxin levels can cause human health impacts (skin irritation, gastrointestinal discomfort), and can be harmful or even fatal to livestock and pets.

Blooms of some species of dinoflagellates are known as 'mahogany tides' because the color of the algae and the density of algae in the bloom make the water appear brown or reddish-brown (Figure 32). These conditions are most often caused by blooms of *Prorocentrum minimum*. While *Prorocentrum* frequently blooms in the spring, blooms have been observed in Maryland waters in all seasons. These algae do not produce a toxin, but the magnitude of the bloom can harm fish and shellfish by replacing more nutritious algae, depleting oxygen in the water column or clogging gills. The darkened waters can also reduce the light reaching underwater grasses.

Other harmful algal species can lead to fish kills. *Karlodinium venificum* can release a toxin that harms fish, and densities above 20,000 cells/milliliter can be acutely toxic to fish. Extremely low dissolved oxygen is often the result of the abrupt die off of a bloom, when the process of decomposing the large amount of plant material uses up the oxygen in the water. The combination of the toxin and low dissolved oxygen can lead to fish kills.

Figure 32. Harmful algal blooms.
Left panel: Blue-green algae bloom. Right panel: 'Mahogany tide' bloom.

HABs are a recurring issue in the Upper Eastern Shore rivers, especially the Sassafras, Corsica and Elk rivers. The upper basin rivers (Sassafras, Elk, Northeast and Bohemia) have low salinities, which are suitable habitat for blue-green algae. In the Sassafras, blooms of blue-green algae start as early as May and persist until late September in most years (Figure 33). In some years, toxins produced by the blue-green algae *Microcystis* were found at sufficient levels to cause human health impacts, leading to beach closures at Betterton Beach. The Northeast and Bohemia rivers also have had significant blooms of blue-green algae.

[38] Information on Harmful Algal Blooms is available at http://mddnr.chesapeakebay.net/eyesonthebay/habs.cfm

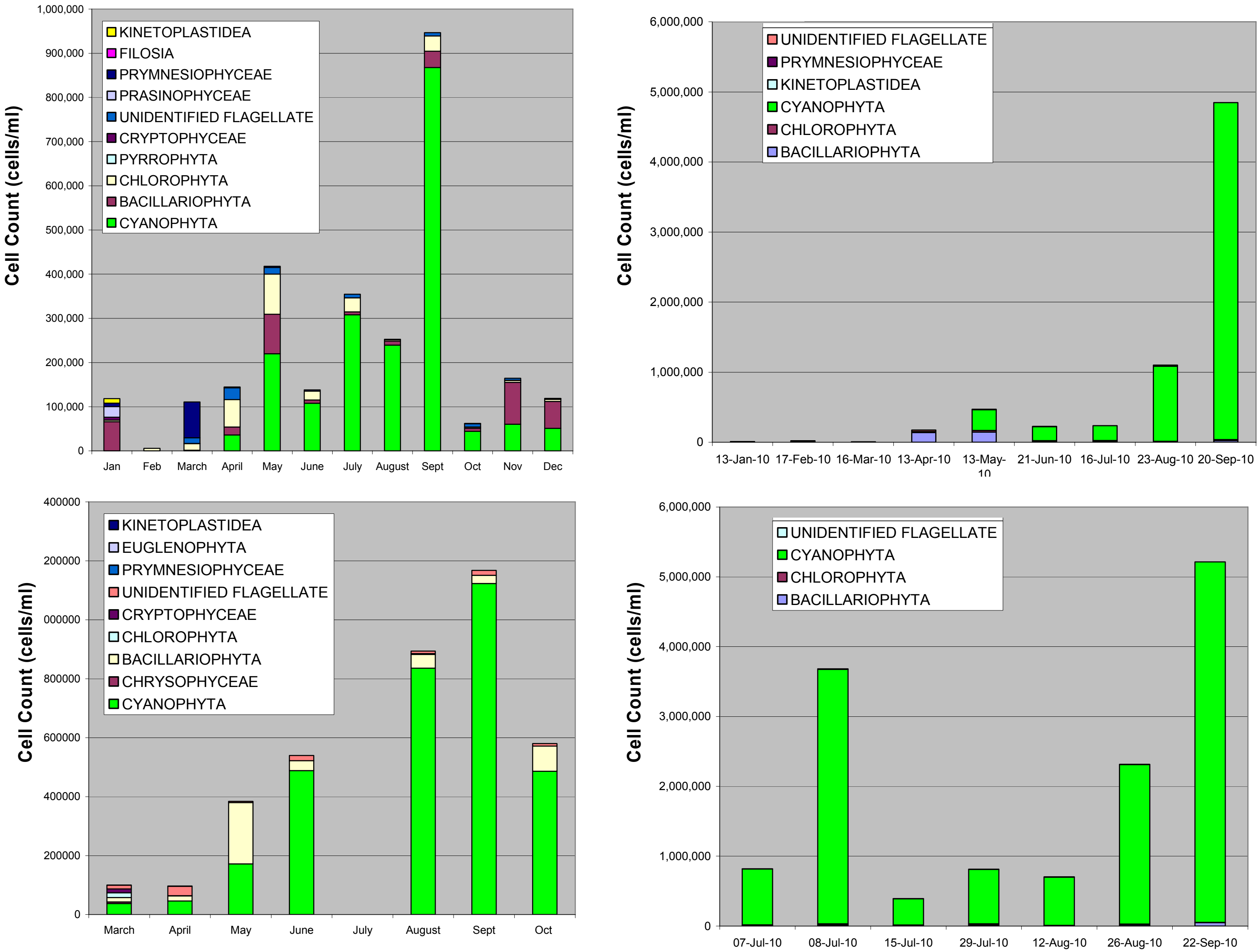


Figure 33: Phytoplankton levels and species in the Sassafras River.
Upper graphs show data from ET3.1. Lower graphs show data from XJI2396. Left-hand graphs show data from 2009. Right hand graphs show data from 2010. Note that Legend and y-axis differs between graphs.

In order to better determine the presence of blue-green algae on a continuous basis, a special probe was installed on the continuous monitoring sonde at Sycamore Point in the Corsica River in 2010.[39] The data collected by the special probe are recorded as raw fluorescence units (RFU, Figure 34). The data suggest the presence of phycoerythrin-containing algae at Sycamore Point. Peaks of around 10 RFU occurred regularly throughout 2010. Also, brief spikes of approximately 20 RFU were evident in June and July, and a spike greater than 30 RFU occurred in December.

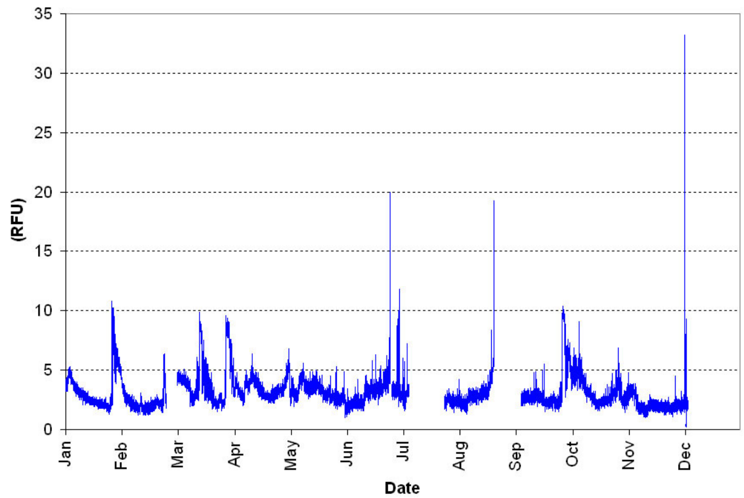


Figure 34. Phycoerythrin levels at Sycamore Point in the Corsica River in 2010.
Results are preliminary and have not undergone full QA/QC procedures.

The higher salinity waters of the Chester River and its tributaries (including the Corsica River) are subject to recurring 'mahogany tides'. In late September 2005, a fish kill in the upper and middle Corsica River was associated with a bloom of *K. veneficum*. The water contained sufficient levels of the toxin, and at the same time dissolved oxygen levels were extremely low (less than 2 mg/l and in some places 0 mg/l). Extremely low dissolved oxygen is often the result of the abrupt die off of a bloom, when the process of decomposing the large amount of plant material uses up the oxygen in the water. The combination of the toxin and low dissolved oxygen led to the death of more than 50,000 fish in the area of Sycamore Point and Cedar Point. The fish killed involved mostly menhaden but included fourteen other species.

[39] Blue-green algal species fluoresce outside of the range of the standard chlorophyll probe deployed with the monitoring instrument. As the result, continuous monitoring measurements do not adequately describe the abundance of blue-green algae in the water column. A special probe that specifically detects phycoerythrin-containing algae was installed in 2010.

Underwater grasses

Water quality determines the distribution and abundance of underwater grasses (submerged aquatic vegetation, SAV). For this reason, SAV communities are good barometers of the health of the tidal rivers and bays. SAV beds are also a critical nursery habitat for many bay animals. Similarly, several species of waterfowl are dependant on SAV as food when they over-winter in the Chesapeake region. SAV distribution is determined through the compilation of aerial photography directed by the Virginia Institute of Marine Science (VIMS).[40]

Northeast River

The tidal fresh Northeast River has had only small amounts of SAV since 1999 (Figure 35). SAV coverage has been highly variable, though steadily increasing. In 2005, 78 acres of SAV, or 88% of the restoration goal, were mapped. In 2006, SAV coverage increased to 133 acres (149% of the restoration goal). SAV beds were mapped in the vicinity of Carpenter Point, Cara Cove and Sandy Cove. In 2008- 2010, roughly 200 acres SAV were mapped each year. The 2010 coverage (228 acres) represents more than two and half times the SAV restoration goal (Figure 36).

Elk River

The low salinity Elk River has had highly variable SAV coverage since 1999. In 2001 2,035 acres of SAV were identified. In 2002 and 2003, coverage receded and then rebounded in 2004 and 2005 when 1,964 acres were mapped. In 2006, 1,989 acres were mapped, representing 98% of the restoration goal. Patchy to dense SAV beds fringed much of the shoreline of the Elk River, with dense coverage in Paddy Biddle and Piney Creek coves. Since 2006, SAV in the Elk River has surpassed its restoration goal repeatedly, with the highest acreage being mapped in 2009 (2,532 acres, 124% of goal). The extent of the SAV beds declined only slightly in 2010, when 2,376 acres were mapped, representing 117% of the SAV restoration goal.

Back Creek

Back Creek has a modest SAV restoration goal of 7 acres. In 2004, SAV was identified in this creek for the first time since 1978 (8 acres). Since 2005, acreage has fluctuated but increased to 16 acres in 2010. This represents 225% of the restoration goal.

Bohemia River

In 1993 there was less than one acre of SAV mapped in the Bohemia River. Since that time, there has been a relatively steady increase in SAV. Dense SAV fringed most of the shoreline from the Route 213 bridge to the mouth of the river. The largest areas of SAV occurred in Veazey Cove and from Battery Point to Long Point on the south shore and from Rich Point to Parlor Point on the north shore. Ground-truthing by citizens found eight species of SAV in the Bohemia River, with milfoil and wild celery being the most frequently observed. SAV acreage exceeded the restoration goal in 2008 and 2009, with more than 500 acres mapped, but in 2010 only 209 acres mapped (59% of the restoration goal).

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[40] Reports detailing methodology and annual SAV coverage are available at www.vims.edu/bio/sav . Details on species of SAV discussed in this report can be found at www.dnr.maryland.gov/bay/sav/key

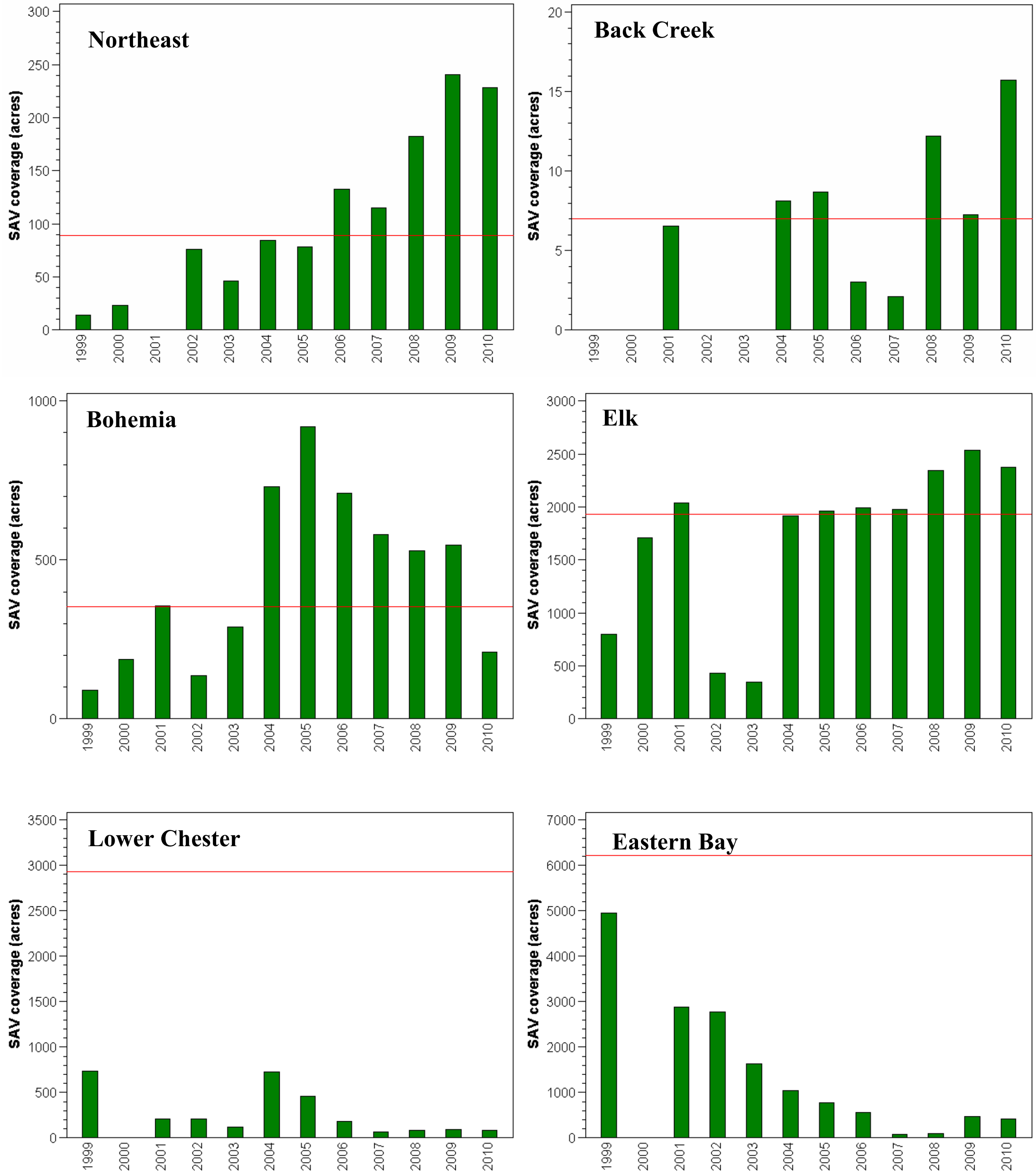

Figure 35. SAV coverages in the Upper Eastern Shore rivers 1999-2010.
SAV data provided by the Virginia Institute of Marine Science. Red line shows the restoration goal for each river or river segment.

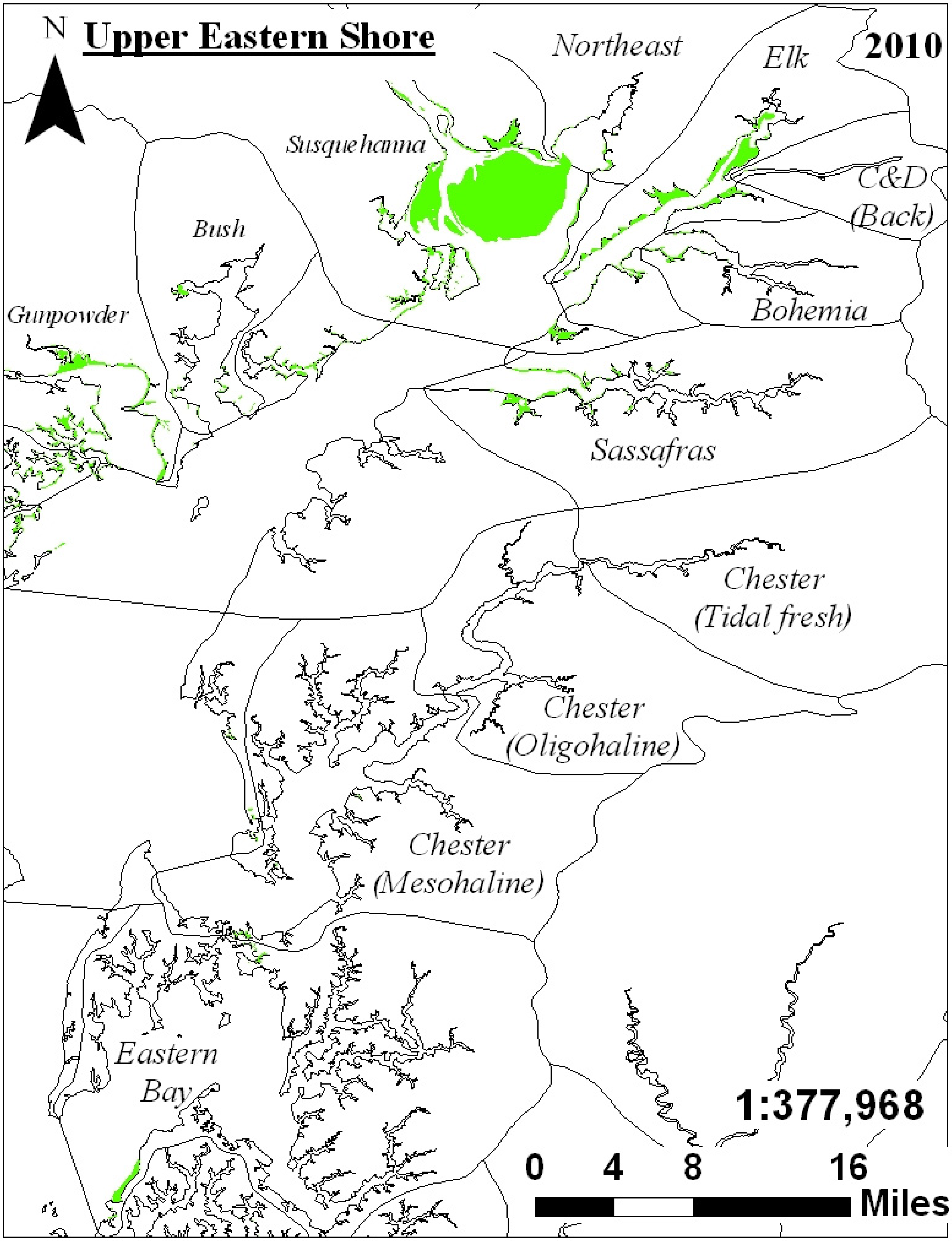

Figure 36. SAV beds (in green) in the Upper Eastern Shore basin in 2010.
SAV data provided by the Virginia Institute of Marine Science.

Sassafras River

The Sassafras River has had highly variable SAV coverage, from a low of 34 acres in 1992 to 1,476 acres in 2005 (126% of the goal). SAV increased from 605 to 861 acres between 2008 and 2009, and to 911 acres in 2010 (78% of the SAV goal).

Chester River

In 2004, SAV was mapped in the upper Chester River for the first time since 1978. In 2005, SAV was found north of Chestertown for the first time (approximately one acre of milfoil) and 228 acres of SAV were mapped near Roundtop Wharf. SAV was not mapped in the upper Chester in 2006. No SAV was identified in 2008-2010 in the upper Chester River, despite the 307 acre SAV restoration goal.

In the lower Chester River, SAV coverage has been highly variable. By 2004, SAV was down to 731 acres and declined again in 2005 and 2006. The majority of the SAV was located in Robin and Middle Quarter Coves near Corsica Neck, Macum and Piney Creeks and Muddy Creek and adjacent coves near the Kent Narrows. Ground-truthing by citizens found redhead grass, widgeon grass, milfoil and horned pondweed. Between 2008 and 2010, SAV acreage hovered around 3% of the restoration goal, with 84 acres mapped in 2010.

Eastern Bay

In Eastern Bay, SAV coverage has fluctuated since 1991, ranging from 168 acres in 1991 to 4,955 acres in 1999, which represented 80% of the SAV restoration goal. By 2008 acreage was down to 90 acres, although the SAV beds rebounded somewhat in 2009 and 2010, with 473 and 422 acres of SAV identified for each year, respectively. 2010 acreage represents 7% of the SAV restoration goal. Dense SAV beds were mapped in Marshy Creek and along the eastern side of Crab Alley Bay. Smaller beds were scattered in Warehouse and Kirwan Creeks. Ground-truthing by the U. S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration has found widgeon grass, horned pondweed, redhead grass, milfoil, sago pondweed and elodea.

Benthic animals

Benthic animals are the animals that live in or on the bottom of the bay. To determine the health of benthic communities, samples are collected in the summer at one long-term benthic monitoring station in the Elk River and another station in the upper Chester River near the long-term tidal water quality monitoring stations. These stations have been monitored since 1984. Trends are calculated for these long-term monitoring stations. Starting in 1994, samples were also collected from all of the rivers and mainstem Bay each year from randomly selected locations. Within the eastern shore rivers, there are not a fixed number of samples each year in any particular river and each river is not sampled in every year. Larger rivers end up with more samples collected over time. The benthic index of biotic integrity (BIBI) assesses the health of the benthic community.[41] A BIBI score of greater than 3 is considered meeting the goal for benthic community health.

[41] Methods for calculation of the BIBI are available at http://www.baybenthos.versar.com/DsgnMeth/Analysis.htm#BIBI.

In 2008-2010, benthic animal community health was degraded in the Elk River and met goals in the upper Chester, but no trends were detected. During this time period, 39 random samples were collected in the Upper Eastern Shore basin (Figure 37). Very few samples were collected in the Northeast (1 sample), Bohemia (2 samples) or Elk (4 samples) rivers. Half of the locations in the Sassafras met the goal, while only 39% of samples in the Chester passed the goal. In Eastern Bay, no samples met the goal. By year, 2008 sample locations were split about half pass/half fail. In 2009, sample locations more often met the goal, and in 2010 sample locations more often failed to meet the goal. The results indicated that about 70-80% of the total benthic habitat was degraded in 2008-2010.[42] Poor benthic community health in the eastern shore rivers results from low dissolved oxygen levels and high nutrient and sediment loadings.[43] Severely degraded conditions are likely due to prolonged low oxygen conditions that decrease the number of benthic animals. Degraded conditions are more often due to high nutrients, high levels of organic matter in the sediments and the absence of low dissolved oxygen conditions.

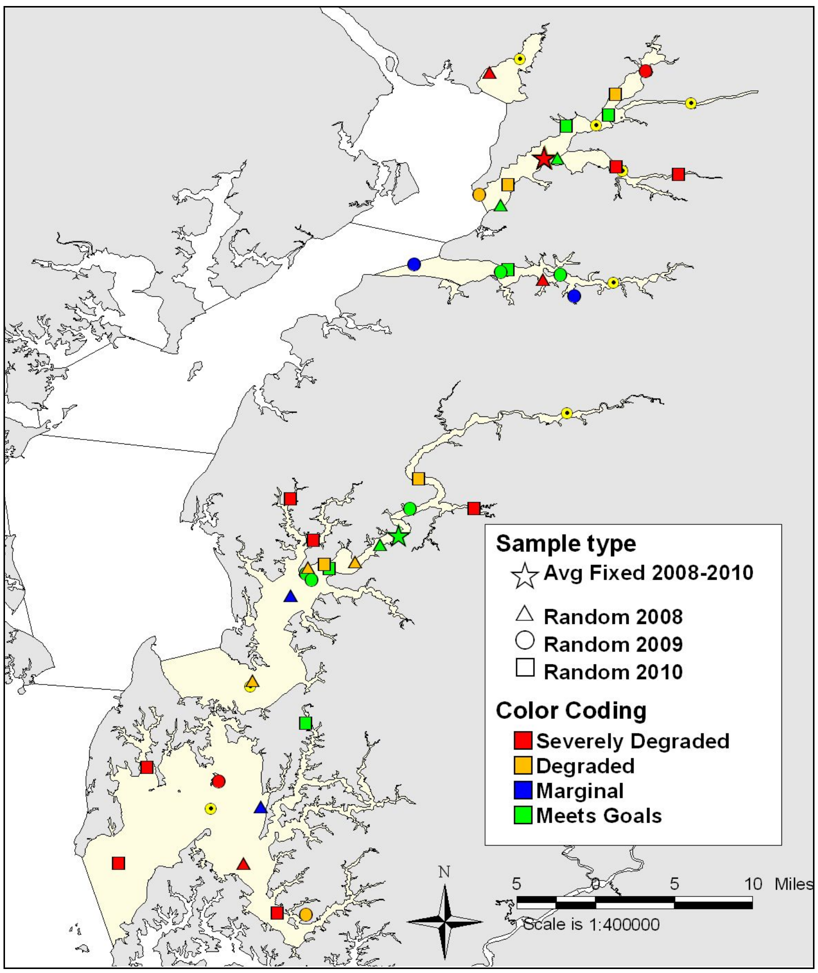

Figure 37. Benthic Index of Biotic Integrity results for 2008-2010.
There is one long-term benthic station in the Chester River and one in the Elk River. Random samples were collected in 39 locations in these years. Yellow dots show locations of the long-term tidal water quality monitoring stations.

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[42] Annual reports for 2008, 2009 and 2010 are available online at http://www.baybenthos.versar.com/referenc.htm.

[43] See Annual reports, section 4.

Summary of Water and Habitat Quality Conditions

Information on current water and habitat quality and the changes through time is needed to assess the health of a river. Many types of information are needed to most completely understand the current conditions. In some instances the assessment is straight forward and all of the information indicates both good water quality and healthy habitats. Most often, some aspects of the overall picture indicate good conditions and other aspects indicate poor conditions. The summary presented here is intended to best represent an overall condition. This is a simplified version and can not capture all the detail presented in the previous sections of this report. Informing the public about the overall health of a river is often best done with a summary of all of the data. Management decisions can benefit from both the summarized and the detailed information.

For this summary assessment, the Upper Eastern Shore basin is divided into two regions. The upper basin includes the areas north of the Sassafras River, and includes six major tributaries- Furnace Bay, Northeast River, Elk River, Bohemia River, Back Creek and Sassafras River. The lower basin includes the Chester River and Eastern Bay. Overall, the Upper Eastern Shore basin is dominated by agricultural land use and has a low to medium human population density in most areas. Urban land use and percent impervious surface is much lower than in the Western shore basins, though there is a greater impact of human population density/urban land use in the upper basin around the town of Elkton. Point sources are also not as much of an influence in the Upper Eastern Shore rivers as in the Western shore rivers. Despite the similarities overall among the Upper Eastern Shore rivers, there are differences in water and habitat quality conditions due to localized land use and human impacts.

Upper Basin

Land use in the Furnace Bay, Northeast River and Elk River sub-watersheds is about 40% forested and about 25% urban. The sub-watersheds of the Bohemia River, Back Creek and Sassafras Rivers are dominated by agricultural land uses. Agricultural land uses are the largest sources of nitrogen, phosphorus and sediment loadings in the entire upper basin. Stream health is generally fair, but in the Bohemia watershed stream health is poor. Two of the nine sub-watersheds are medium priority for Trust Fund restoration efforts.

Water quality in the Northeast, Bohemia and Sassafras rivers is generally fair, but water quality is poor in Back Creek and Elk River. All of the rivers have poor water clarity and sediments are too high. SAV habitat requirements are not entirely met in any of the rivers as the result of the high sediments and poor water clarity, but the area covered with SAV beds has been increasing and is above restoration goals in the Northeast River and Elk River, and more than 75% of goals in the Sassafras River. Bottom dissolved oxygen levels are good but benthic populations are healthy in less than half of the locations sampled. Harmful algal blooms are a recurrent problem and have led to human health impacts and beach closures on the Sassafras River.

Lower Basin

More than half of the area of the Chester River and Eastern Bay watersheds is used for agricultural uses, and about a quarter of the area is forested. Eight of the eleven sub-watersheds are high priority watersheds for the Trust Fund Restoration program, and the remaining sub-watersheds are medium priority. Stream health is fair to poor. Nitrogen, phosphorus and sediment loadings come mostly from agricultural sources, but point sources of nitrogen and phosphorus are also important in the middle Chester. A WRAS project is underway for the upper and middle Chester River and the Corsica River.

Water quality differs between the upper and lower Chester River. The upper Chester has poor but improving water quality. The lower Chester has good water quality. Both areas have poor water clarity. Dissolved oxygen levels are good in the upper Chester and fair in the lower Chester and benthic animal populations are healthy in about 40% of the areas sampled (mostly sampled in the middle Chester). The upper Chester has small SAV beds in some years but no areas were mapped in 2010. SAV beds in the lower Chester only cover 3% of restoration goal in 2010.

Water quality in Eastern Bay is good and meets most of the SAV habitat requirements. SAV bed area has been variable and only 7% of the restoration goal in 2010. Bottom dissolved oxygen in the deeper areas is poor and often below 2 mg/l. Benthic animal populations are unhealthy in all areas sampled.

Corsica River water quality is good but algal levels and water clarity is poor. Dissolved oxygen levels are good. Fish kills associated with harmful algal blooms have occurred in the upper and middle portions of the river and in the Chester River.

Appendix 1

Land use/Land cover for 2000 and 2010 and Amount of Impervious Surface

Land-use/Land-cover 2000 and 2010 from the Maryland Department of Planning. 2010 data available at www.planning.maryland.gov/OurWork/landUse.shtml. 2000 data available from Maryland Department of Planning, Planning Data Services, (410) 767-4450. Use codes from the Maryland Department of Planning Land Use/ Land Cover Classification Definitions (http://www.planning.maryland.gov/PDF/OurWork/LandUse/AppendixA_LandUseCategories.pdf). Impervious surface calculated from definitions in Cappiella and Brown, Urban Cover and Land Use in the Chesapeake Bay watershed, Center for Watershed Protection, 2001, as referenced in Table 4.1 of a User's Guide to Watershed Planning in Maryland, http://dnr.maryland.gov/watersheds/pubs/userguide.html

	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Furnace Bay	AGRICULTURE	8.93	**42%**	7.33	**34%**	1.60	8%
	BARREN LAND	0.06	0%	0.24	1%	-0.18	-1%
	FOREST	9.14	**43%**	8.47	**40%**	0.67	3%
	TRANSPORTATION	0.00	0%	0.16	1%	-0.16	-1%
	URBAN	3.14	15%	5.07	**24%**	-1.94	-9%
	WETLANDS	0.06	0%	0.06	0%	0.00	0%
	IMPERVIOUS SURFACE	0.37	2%	0.75	4%	-0.38	-2%
Northeast River	AGRICULTURE	23.22	**37%**	19.63	**31%**	3.58	6%
	BARREN LAND	0.27	0%	0.39	1%	-0.12	0%
	FOREST	27.57	**44%**	24.48	**39%**	3.08	5%
	TRANSPORTATION	0.00	0%	0.43	1%	-0.43	-1%
	URBAN	12.22	19%	18.26	**29%**	-6.04	**-10%**
	WETLANDS	0.04	0%	0.07	0%	-0.03	0%
	IMPERVIOUS SURFACE	2.65	4%	3.60	6%	-0.94	-1%
Back Creek	AGRICULTURE	6.55	**48%**	5.81	**42%**	0.74	5%
	BARREN LAND	0.37	3%	0.35	3%	0.02	0%
	FOREST	5.06	**37%**	4.52	**33%**	0.54	4%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	1.32	10%	2.39	17%	-1.08	-8%
	WETLANDS	0.44	3%	0.68	5%	-0.24	-2%
	IMPERVIOUS SURFACE	0.28	2%	0.34	2%	-0.06	0%
Bohemia River	AGRICULTURE	29.79	**72%**	28.30	**68%**	1.49	4%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	9.80	**24%**	9.52	**23%**	0.28	1%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	1.49	4%	3.19	8%	-1.70	-4%
	WETLANDS	0.57	1%	0.61	1%	-0.04	0%
	IMPERVIOUS SURFACE	0.33	1%	0.45	1%	-0.12	0%
Sassafras River	AGRICULTURE	49.95	**66%**	48.64	**64%**	1.32	2%
	BARREN LAND	0.06	0%	0.02	0%	0.04	0%
	FOREST	20.97	**28%**	19.65	**26%**	1.32	2%
	TRANSPORTATION	0.00	0%	0.26	0%	-0.26	0%
	URBAN	3.81	5%	6.33	8%	-2.52	-3%
	WETLANDS	1.10	1%	0.98	1%	0.12	0%
	IMPERVIOUS SURFACE	0.76	1%	1.08	1%	-0.32	0%
Stillpond-Fairlee	AGRICULTURE	35.13	**59%**	34.57	**58%**	0.57	1%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	17.95	**30%**	16.59	**28%**	1.36	2%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	5.09	9%	6.96	12%	-1.87	-3%
	WETLANDS	0.98	2%	1.01	2%	-0.03	0%
	IMPERVIOUS SURFACE	1.00	2%	1.12	2%	-0.11	0%

	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Big Elk Creek	AGRICULTURE	8.16	**48%**	6.39	**37%**	1.77	**10%**
	BARREN LAND	0.00	0%	0.05	0%	-0.05	0%
	FOREST	6.77	**39%**	6.88	**40%**	-0.11	-1%
	TRANSPORTATION	0.00	0%	0.17	1%	-0.17	-1%
	URBAN	2.19	13%	3.63	**21%**	-1.44	-8%
	WETLANDS	0.06	0%	0.06	0%	0.00	0%
	IMPERVIOUS SURFACE	0.54	3%	0.89	5%	-0.36	-2%
Little Elk Creek	AGRICULTURE	10.78	**44%**	8.96	**36%**	1.82	7%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	8.02	**33%**	7.60	**31%**	0.42	2%
	TRANSPORTATION	0.00	0%	0.19	1%	-0.19	-1%
	URBAN	5.69	**23%**	7.75	**31%**	-2.06	-8%
	WETLANDS	0.12	0%	0.12	0%	0.00	0%
	IMPERVIOUS SURFACE	1.38	6%	1.60	7%	-0.22	-1%
Upper Elk River	AGRICULTURE	5.49	18%	4.48	14%	1.01	3%
	BARREN LAND	0.11	0%	0.21	1%	-0.10	0%
	FOREST	16.08	**52%**	14.87	**48%**	1.21	4%
	TRANSPORTATION	0.00	0%	0.11	0%	-0.11	0%
	URBAN	8.77	**28%**	10.79	**35%**	-2.01	-6%
	WETLANDS	0.75	2%	0.74	2%	0.00	0%
	IMPERVIOUS SURFACE	2.39	8%	2.58	8%	-0.19	-1%
Lower Elk River	AGRICULTURE	16.87	**42%**	15.18	**38%**	1.69	4%
	BARREN LAND	0.56	1%	0.02	0%	0.54	1%
	FOREST	18.25	**46%**	17.76	**45%**	0.49	1%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	2.92	7%	4.99	13%	-2.07	-5%
	WETLANDS	1.29	3%	1.93	5%	-0.64	-2%
	IMPERVIOUS SURFACE	0.63	2%	0.71	2%	-0.09	0%
Entire System	AGRICULTURE	41.29	**37%**	35.00	**31%**	6.29	6%
	BARREN LAND	0.67	1%	0.28	0%	0.40	0%
	FOREST	49.12	**44%**	47.11	**42%**	2.01	2%
	TRANSPORTATION	0.00	0%	0.48	0%	-0.48	0%
	URBAN	19.56	17%	27.15	**24%**	-7.58	-7%
	WETLANDS	2.23	2%	2.85	3%	-0.62	-1%
	IMPERVIOUS SURFACE	4.93	4%	5.80	5%	-0.86	-1%

	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Upper Chester River	AGRICULTURE	87.91	**65%**	85.07	**63%**	2.84	2%
	BARREN LAND	0.01	0%	0.00	0%	0.01	0%
	FOREST	42.62	**31%**	41.32	**30%**	1.30	1%
	TRANSPORTATION	0.00	0%	0.32	0%	-0.32	0%
	URBAN	4.51	3%	8.47	6%	-3.95	-3%
	WETLANDS	0.73	1%	0.64	0%	0.09	0%
	IMPERVIOUS SURFACE	0.97	1%	1.46	1%	-0.48	0%
Middle Chester River	AGRICULTURE	44.81	**76%**	44.51	**76%**	0.29	0%
	BARREN LAND	0.04	0%	0.03	0%	0.01	0%
	FOREST	7.45	13%	6.49	11%	0.96	2%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	5.20	9%	6.74	11%	-1.54	-3%
	WETLANDS	1.27	2%	0.99	2%	0.28	0%
	IMPERVIOUS SURFACE	1.58	3%	1.70	3%	-0.12	0%
Langford Creek	AGRICULTURE	28.47	**72%**	26.22	**70%**	2.25	2%
	BARREN LAND	0.00	0%	0.01	0%	-0.01	0%
	FOREST	8.86	**23%**	7.57	**20%**	1.29	2%
	TRANSPORTATION	0.00	0%	0.00	0%	0.00	0%
	URBAN	1.46	4%	2.97	8%	-1.51	-4%
	WETLANDS	0.54	1%	0.55	1%	-0.02	0%
	IMPERVIOUS SURFACE	0.25	1%	0.32	1%	-0.07	0%
Southeast Creek	AGRICULTURE	37.03	**68%**	35.87	**66%**	1.16	2%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	15.29	**28%**	14.57	**27%**	0.72	1%
	TRANSPORTATION	0.00	0%	0.21	0%	-0.21	0%
	URBAN	1.52	3%	3.38	6%	-1.86	-3%
	WETLANDS	0.60	1%	0.47	1%	0.14	0%
	IMPERVIOUS SURFACE	0.29	1%	0.59	1%	-0.29	-1%
Corsica River	AGRICULTURE	23.95	**64%**	22.62	**60%**	1.34	4%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	10.61	**28%**	9.59	**26%**	1.03	3%
	TRANSPORTATION	0.00	0%	0.21	1%	-0.21	-1%
	URBAN	2.75	7%	4.94	13%	-2.19	-6%
	WETLANDS	0.16	0%	0.15	0%	0.02	0%
	IMPERVIOUS SURFACE	0.72	2%	1.18	3%	-0.45	-1%
Lower Chester River	AGRICULTURE	33.77	**55%**	33.37	**54%**	0.40	1%
	BARREN LAND	0.01	0%	0.02	0%	-0.01	0%
	FOREST	16.55	**27%**	15.69	**25%**	0.86	1%
	TRANSPORTATION	0.27	0%	0.24	0%	0.03	0%
	URBAN	6.35	10%	7.76	13%	-1.42	-2%
	WETLANDS	4.80	8%	4.73	8%	0.06	0%
	IMPERVIOUS SURFACE	1.68	3%	1.77	3%	-0.09	0%
Entire System	AGRICULTURE	255.94	**66%**	247.66	**64%**	8.27	2%
	BARREN LAND	0.06	0%	0.06	0%	0.00	0%
	FOREST	101.38	**26%**	95.23	**25%**	6.15	2%
	TRANSPORTATION	0.27	0%	0.97	0%	-0.70	0%
	URBAN	21.80	6%	34.26	9%	-12.46	-3%
	WETLANDS	8.10	2%	7.54	2%	0.56	0%
	IMPERVIOUS SURFACE	5.50	1%	7.01	2%	-1.51	0%

	Land use/ Land cover	Area in 2000 (sqr miles)	%Total in 2000	Area in 2010 (sqr miles)	%Total in 2010	Area Change (sqr miles)	%Total Area change
Wye River	AGRICULTURE	53.09	**67%**	51.38	**65%**	1.71	2%
	BARREN LAND	0.04	0%	0.11	0%	-0.07	0%
	FOREST	19.30	**24%**	18.18	**23%**	1.13	1%
	TRANSPORTATION	0.03	0%	0.32	0%	-0.29	0%
	URBAN	6.16	8%	8.58	11%	-2.42	-3%
	WETLANDS	0.47	1%	0.50	1%	-0.02	0%
	IMPERVIOUS SURFACE	1.15	1%	1.44	2%	-0.29	0%
Miles River	AGRICULTURE	23.15	**54%**	21.07	**49%**	2.08	5%
	BARREN LAND	0.02	0%	0.10	0%	-0.08	0%
	FOREST	11.70	**27%**	11.46	**27%**	0.24	1%
	TRANSPORTATION	0.00	0%	0.11	0%	-0.11	0%
	URBAN	7.56	18%	9.83	**23%**	-2.27	-5%
	WETLANDS	0.47	1%	0.35	1%	0.12	0%
	IMPERVIOUS SURFACE	1.75	4%	2.06	5%	-0.31	-1%
Kent Narrows	AGRICULTURE	4.02	**37%**	3.59	**33%**	0.43	4%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	2.98	**27%**	2.60	**24%**	0.39	4%
	TRANSPORTATION	0.05	0%	0.03	0%	0.02	0%
	URBAN	2.96	**27%**	3.49	**32%**	-0.53	-5%
	WETLANDS	0.92	8%	1.23	11%	-0.31	-3%
	IMPERVIOUS SURFACE	0.62	6%	0.57	5%	0.05	0%
Kent Island Bay	AGRICULTURE	2.33	**30%**	1.82	**23%**	0.51	7%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	1.51	19%	1.45	18%	0.06	1%
	TRANSPORTATION	0.11	1%	0.07	1%	0.04	1%
	URBAN	3.43	**43%**	4.23	**53%**	-0.81	**-10%**
	WETLANDS	0.51	6%	0.36	5%	0.15	2%
	IMPERVIOUS SURFACE	0.92	12%	0.94	12%	-0.02	0%
Eastern Bay	AGRICULTURE	9.78	**43%**	8.43	**37%**	1.35	6%
	BARREN LAND	0.00	0%	0.00	0%	0.00	0%
	FOREST	4.19	18%	3.74	16%	0.45	2%
	TRANSPORTATION	0.11	0%	0.07	0%	0.04	0%
	URBAN	7.04	**31%**	9.08	**40%**	-2.04	-9%
	WETLANDS	1.65	7%	1.48	7%	0.17	1%
	IMPERVIOUS SURFACE	1.62	7%	1.74	8%	-0.11	0%
Entire System	AGRICULTURE	92.36	**56%**	86.28	**53%**	1.35	1%
	BARREN LAND	0.06	0%	0.21	0%	0.00	0%
	FOREST	39.69	**24%**	37.42	**23%**	0.45	0%
	TRANSPORTATION	0.31	0%	0.60	0%	0.04	0%
	URBAN	27.15	17%	35.21	**22%**	-2.04	-1%
	WETLANDS	4.02	2%	3.93	2%	0.17	0%
	IMPERVIOUS SURFACE	6.07	4%	6.74	4%	-0.67	0%

Appendix 2

Delivered Loads to the Upper Eastern Shore Rivers
Phase 5.3 2009 Progress Run 8/25/2010

Chesapeake Bay Program. Accessed January 10, 2012 from http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044 File (ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase53_Loads-Acres-BMPs/MD/ Load_Acres_MDWIP_08252010.xls)

River	Category	N load (Million lbs per yr)	% Total N Load	P load (Million lbs per yr)	% Total P Load	Sed load (Million lbs per yr)	% Total Sed Load
Northeast NORTF	Agriculture	0.117	**47%**	0.0054	**41%**	10.31	**63%**
	Forest	0.061	**24%**	0.0022	17%	1.54	9%
	Non-tidal Water Depo	0.002	1%	0.0001	1%		
	Septic	0.030	12%				
	Urban Runoff	0.031	13%	0.0041	**31%**	4.60	**28%**
	Point source	0.010	4%	0.0014	11%		0%
	TOTAL	**0.251**		**0.0132**		**16.45**	
Bohemia BOHOH	Agriculture	0.130	**72%**	0.0147	**73%**	3.42	**91%**
	Forest	0.025	14%	0.0016	8%	0.24	6%
	Non-tidal Water Depo	0.002	1%	0.0001	1%		
	Septic	0.013	7%				
	Urban Runoff	0.002	1%	0.0005	2%	0.09	3%
	Point source	0.008	4%	0.0032	16%		
	TOTAL	**0.180**		**0.0202**		**3.75**	
Back Creek* C&DOH MD	Agriculture	0.030	**50%**	0.0034	**53%**	1.01	**81%**
	Forest	0.010	17%	0.0006	10%	0.11	9%
	Non-tidal Water Depo	0.002	3%	0.0001	2%		
	Septic	0.010	17%				
	Urban Runoff	0.003	5%	0.0005	7%	0.13	11%
	Point source	0.005	9%	0.0018	**28%**		0%
	TOTAL	**0.059**		**0.0065**		**1.25**	
Elk ELKOH	Agriculture	0.173	**37%**	0.0137	**46%**	6.71	**67%**
	Forest	0.098	**21%**	0.0048	16%	1.29	13%
	Non-tidal Water Depo	0.004	1%	0.0002	1%		
	Septic	0.088	19%				
	Urban Runoff	0.046	10%	0.0061	**20%**	1.94	19%
	Point source	0.059	13%	0.0054	18%		0%
	TOTAL	**0.468**		**0.0301**		**9.95**	
Sassafras SASOH	Agriculture	0.312	**79%**	0.0305	**83%**	9.12	**91%**
	Forest	0.039	10%	0.0026	7%	0.51	5%
	Non-tidal Water Depo	0.004	1%	0.0003	1%		
	Septic	0.020	5%				
	Urban Runoff	0.006	2%	0.0014	4%	0.36	4%
	Point source	0.012	3%	0.0022	6%	0.01	0%
	TOTAL	**0.394**		**0.0369**		**9.99**	

River		Category	N load (Million lbs per yr)	% Total N Load	P load (Million lbs per yr)	% Total P Load	Sed load (Million lbs per yr)	% Total Sed Load
Upper Chester	CHSTF	Agriculture	0.471	**82%**	0.0453	**87%**	12.21	**91%**
		Forest	0.061	11%	0.0040	8%	0.86	6%
		Non-tidal Water Dep	0.003	0%	0.0002	0%		
		Septic	0.023	4%				
		Urban Runoff	0.008	1%	0.0015	3%	0.33	2%
		Point source	0.007	1%	0.0011	2%	0.00	0%
		TOTAL	**0.572**		**0.0521**		**13.40**	
Middle Chester	CHSOH	Agriculture	0.620	**78%**	0.0559	**82%**	9.73	**90%**
		Forest	0.054	7%	0.0033	5%	0.48	4%
		Non-tidal Water Dep	0.005	1%	0.0003	0%		
		Septic	0.032	4%				
		Urban Runoff	0.015	2%	0.0027	4%	0.55	5%
		Point source	0.072	9%	0.0056	8%	0.01	0%
		TOTAL	**0.797**		**0.0678**		**10.77**	
Lower Chester	CHSMH	Agriculture	0.493	**78%**	0.0440	**84%**	12.54	**88%**
		Forest	0.063	10%	0.0039	8%	0.91	6%
		Non-tidal Water Dep	0.008	1%	0.0005	1%		
		Septic	0.035	6%				
		Urban Runoff	0.017	3%	0.0033	6%	0.87	6%
		Point source	0.013	2%	0.0005	1%	0.01	0%
		TOTAL	**0.628**		**0.0522**		**14.32**	
Entire Chester	Overall total	Agriculture	1.091	**80%**	0.1012	**84%**	21.94	**91%**
		Forest	0.115	8%	0.0073	6%	1.34	6%
		Non-tidal Water Dep	0.007	1%	0.0004	0%		
		Septic	0.055	4%				
		Urban Runoff	0.023	2%	0.0042	3%	0.88	4%
		Point source	0.079	6%	0.0067	6%	0.01	0%
		OVERALL TOTAL	**1.369**		**0.1198**		**24.17**	
Eastern Bay	EASMH	Agriculture	0.519	**66%**	0.0546	**76%**	8.43	**75%**
		Forest	0.076	10%	0.0052	7%	1.02	9%
		Non-tidal Water Dep	0.010	1%	0.0006	1%		
		Septic	0.096	12%				
		Urban Runoff	0.055	7%	0.0089	12%	1.83	16%
		Point source	0.033	4%	0.0026	4%	0.03	0%
		TOTAL	**0.789**		**0.0719**		**11.32**	

Appendix 3

Station locations and descriptions

.

Long-term tidal water quality monitoring

Station Name	Location/Depth	Latitude/ Longitude (NAD83 DMS)	Characterizes
ET1.1	Northeast River at Daymarker 12 off Hance Pt, mid-channel; 3.0 m.	39° 34.186'N 75° 58.069'W	Tidal freshwater
ET2.1	C&D Canal E of Rt 213 Bridge at Chesapeake City; 13.0 m.	39° 31.758'N 75° 48.681'W	Tidal freshwater
ET2.2	Bohemia River off Hack Pt, 75 yds ENE of daymarker R 4, midchannel; 3.0 m.	39° 28.022'N 75° 52.421'W	Tidal freshwater
ET2.3	Elk River SE of Old Cornfield Pt at G 21, mid-channel; 12.0 m.	39° 30.524'N 75° 53.869'W	Tidal freshwater
ET3.1	Sassafras R from end of pier at Georgetown Yacht Basin, NW side of MD. Rt. 213 bridge; 5.0 m.	39° 21.849'N 75° 52.922'W	Tidal freshwater
ET4.1	Chester River at Rt 290 bridge near Crumpton; 6.0 m.	39° 14.624'N 75° 55.493'W	Tidal freshwater
ET4.2	Lower Chester River South of Easter Neck Island 200 yds SW of buoy FL G 9; 16.0 m.	38° 59.540'N 76° 12.906'W	Lower estuarine
EE1.1	Eastern Bay between Tilghman Pt and Parsons Island, N of buoy R4; 13.0 m.	38° 52.800'N 76° 15.0873'W	Embayment
XHH4742	Corsica River 0.6 km ESE of Rocky Point	39° 4.6840'N 76° 5.8320'W	Lower estuarine

Shallow water monitoring stations and dates

Waterbody	Segment	Station Name	Map #	Station	Years deployed	LAT (NAD83)	LONG (NAD83)
Northeast River	NORTF	Charlestown	17	XKI5022	2007 – 2009	39° 34.987' N	75° 57.826' W
		Carpenters Point	13	XKH2797	2007 – 2009	39° 32.660' N	76° 00.294' W
		Additional water quality mapping calibration stations	56	ET1.1	2007 – 2009	39° 34.188' N	75° 58.068' W
			5	XKH3508	2007 – 2009	39° 33.498' N	75° 59.202' W
			58	XKI2616	2007 – 2009	39° 32.574' N	75° 58.410' W
Elk River	ELKOH	Locust Point Marina	16	XKI3890	2007 – 2009	39° 33.841' N	75° 51.007' W
		Hollywood Beach	15	XKI0256	2007 – 2009	39° 30.234' N	75° 54.447' W
		Additional water quality mapping calibration stations	53	ET2.3	2007 – 2009	39° 30.522' N	75° 53.868' W
			54	XJI8018	2007 – 2009	39° 27.978' N	75° 58.182' W
			55	XKI2475	2007 – 2009	39° 32.322' N	75° 52.500' W
Bohemia River	BOHOH	Long Point	12	XJI8369	2007 – 2009	39° 28.275' N	75° 53.144' W
		Additional water quality mapping calibration stations	23	GBO0013	2007 – 2009	39° 27.822' N	75° 50.298' W
			24	LBO0010	2007 – 2009	39° 26.904' N	75° 50.694' W
			25	XJI8641	2007 – 2009	39° 28.584' N	75° 55.860' W
			26	XJI8856	2007 – 2009	39° 28.830' N	75° 54.408' W
Sassafras River	SASOH	Budds Landing	11	XJI2396	2007 – present	39° 22.335' N	75° 50.392' W
		Georgetown Yacht	10	XJI1871	2006 – 2007	39° 21.793’ N	75° 52.940’ W
		Betterton Beach	9	XJH2362	2006 – present	39° 22.302’ N	76° 03.751’ W
		Additional water quality mapping calibration stations	59	XJI2112	2007 – 2009	39° 22.134' N	75° 58.752' W
			60	XJI2342	2007 – 2009	39° 22.272' N	75° 55.716' W
Corsica River	CHSMH	Sycamore Point	8	XHH3851	2005 – present	39° 03.770' N	76° 04.897' W
		Emory Creek	6	XHH5046	2005 – 2006	39° 04.994' N	76° 06.439' W
		Possum Point (surface and bottom)	7	XHH4931	2006 – present	39° 04.872' N	76° 06.894' W
		The Sill (surface and bottom)	5	XHH4916	2006 – present	39° 04.908' N	76° 08.352' W
		Additional water quality mapping calibration stations	34	COR0056	2006 – present	39° 03.348' N	76° 04.308' W
			35	XHH4528	2006 – present	39° 04.494' N	76° 07.188' W

Shallow water monitoring stations and dates (continued)

Waterbody	Segment	Station Name	Map #	Station	Years deployed	LAT (NAD83)	LONG (NAD83)
Chester River	CHSTF	Deep Landing	1	CHE0348	2003 – 2006	39° 14.415' N	75° 57.513' W
	CHSOH	Rolphs Wharf	3	XIH0077	2003 – 2006	39° 09.998' N	76° 02.319' W
		Additional water quality mapping calibration stations	38	ET4.1	2003 – 2006	39° 14.622' N	75° 55.494' W
			39	XIH3581	2003 – 2006	39° 13.512' N	76° 01.884' W
			40	XHH9362	2003	39° 09.324' N	76° 03.846' W
			41	XIH1458	2003	39° 12.240' N	76° 03.768' W
			42	XIH4495	2003	39° 14.322' N	76° 00.204' W
	CHSMH	Kent Narrows (inside)	4	XGG8359	2007 – 2009	38° 58.277' N	76° 14.144' W
		Kent Narrows (outside)	2	XGG8458	2007 – 2009	38° 58.404' N	76° 14.201' W
		Additional water quality mapping calibration stations	27	ET4.2	2003 – 2006	38° 59.538' N	76° 12.906' W
			28	GYI0001	2003 – 2006	39° 05.400' N	76° 12.018' W
			29	XGG9992	2003 – 2006	38° 59.970' N	76° 10.746' W
			30	XHG0859	2003 – 2006	39° 00.834' N	76° 14.094' W
			31	XHG1579	2003 – 2006	39° 01.542' N	76° 12.102' W
			32	XHG6496	2003 – 2006	39° 06.378' N	76° 10.380' W
			33	XHH6419	2003 – 2006	39° 06.456' N	76° 08.070' W
			36	XHH4822	2003 – 2005	39° 04.824' N	76° 07.818' W
			37	XHH7848	2003	39° 07.788' N	76° 05.262' W
Chesapeake Bay	CB1TF	Stump Point	14	XKH2870	2007 – 2009	39° 32.761' N	76° 02.961' W
	CB3MH	Gratitude Marina	19	XHG8442	2009 – present	39° 08.428' N	76° 15.777' W
		Love Point	18	XHG2318	2009 – present	39° 02.363' N	76° 18.228' W
Eastern Bay	EASMH	Hambleton Point	22	XFG9164	2004 – 2006	38° 49.165' N	76° 13.552' W
		Chesapeake Bay Environmental Center	20	XGG6667	2005 – 2008	38° 56.568' N	76° 13.297' W
		Kent Point	21	XGF0681	2004 – 2006	38° 50.640' N	76° 21.920' W
		Additional water quality mapping calibration stations	43	XFH7523	2004 – 2006	38° 47.556' N	76° 07.692' W
			44	XGG2084	2004 – 2006	38° 52.020' N	76° 11.574' W
			45	XGG3479	2004 – 2006	38° 53.454' N	76° 12.042' W
			46	XGG4898	2004 – 2006	38° 54.810' N	76° 10.134' W
			47	XGG5959	2004 – 2006	38° 55.872' N	76° 14.040' W
			48	EE1.1	2004 – 2006	38° 52.800' N	76° 15.090' W
			49	XFG9210	2004 – 2006	38° 49.200' N	76° 18.960' W
			50	XGG4301	2004 – 2006	38° 54.342' N	76° 19.836' W
			51	XGG5115	2004 – 2006	38° 55.146' N	76° 18.438' W
			52	XGG5932	2004 – 2006	38° 55.956' N	76° 16.764' W

Appendix 4

Water and Habitat Quality Data Assessment Methods

Loadings
For USGS methods see http://md.water.usgs.gov/publications/sir-2006-5178/index.html

Current condition- Status
Tidal station nutrient concentrations and physical properties were evaluated to determine the current health of the rivers (status). Relative status was determined for total nitrogen (TN), dissolved inorganic nitrogen (DIN), total phosphorus (TP), dissolved inorganic phosphorus (PO_4), total suspended solids (TSS), algal abundance (as measured by chlorophyll *a*, CHLA) and water clarity (as measured with a Secchi disc) for the 2008-2010 period. For status calculation methods see
http://mddnr.chesapeakebay.net/eyesonthebay/documents/ICPRB09-4_StatusMethodPaperMolson2009.pdf.

Results for some parameters are compared with established threshold values to evaluate habitat quality. Summer bottom dissolved oxygen (BDO) is compared to US EPA Chesapeake Bay dissolved oxygen criteria for deep-water seasonal (June- September). Summer dissolved oxygen is considered healthy if levels are 5 mg/l or greater and impaired if levels are less than 3 mg/l. For more details see www.chesapeakebay.net/content/publications/cbp_13142.pdf. DIN is compared to a nitrogen limitation threshold value of less than 0.07 mg/l (Fisher and Gustafson 2002, available online at
http://www.hpl.umces.edu/gis_group/Resource%20Limitation/2002_report_27Oct03.htm#es).
Submerged aquatic vegetation (SAV) growing season median levels for 2008-2010 for PO_4, TSS, CHLA and Secchi depth are compared to SAV habitat requirements (Appendix 5) using the methods of Kemp et al. (2004) available online at
http://archive.chesapeakebay.net/pubs/sav/savreport.pdf).

Change over time- Trends
Nutrient levels and physical properties were evaluated to determine progress toward improved water quality (trends). For trends calculation methods see
http://mddnr.chesapeakebay.net/eyesonthebay/documents/stat_trend_hist.pdf. The following parameters were evaluated: TN, DIN, TP, PO_4, TSS, algal abundance (as measured by chlorophyll *a*, CHLA), water clarity (as measured with a Secchi disc), summer BDO, salinity and water temperature. In order to understand results in the primary parameters, additional parameters were examined including nitrate-nitrite (NO_{23}), ammonium (NH_4) and ratios of nutrient levels (TN:TP, DIN:PO_4) that may explain more about nutrient use by aquatic plants and limitations of available nutrients.

Tidal water quality data were tested for linear trends for 1985-1997, 1999-2010 and 1985-2010. Tests for non-linear trends were also done for 1985-2010 with the tidal water quality data. Trends are significant if $p \leq 0.01$; the text also includes discussion of trends that 'may be' significant when $0.01 < p < 0.05$. Due to a laboratory change in 1998 that affects the tidal water quality data, a step trend may occur for TP, PO_4 and TSS. For these parameters, trends are determined for 1985-1997 and 1999-2010 only.

In addition to annual trends for the various time ranges above, tidal water quality data was tested for seasonal trends for 1999-2010. Seasons tested were spring (March-May), summer (July-September) and SAV growing season (April-October).

Shallow water Temporal Assessment (Percent failure analysis)
Continuous monitoring data were compared to water quality thresholds. Measurements of dissolved oxygen taken during the months of June through September were compared to the USEPA threshold value of 3.2 mg/l for shallow water bay grass use (instantaneous minimum). This time period was used because the summer months typically experience the lowest dissolved oxygen levels and are the most critical for living resources. Chlorophyll and turbidity measurements collected during the SAV growing season of April through October were compared to threshold levels of 15 µg/l and 7 NTU, respectively. Values above these levels can inhibit light penetration through the water column and impact growth of underwater grasses. Percent failures are defined as the percent of values in each year that did not meet the water quality thresholds.

Shallow water Spatial Assessment

Algal density, sediment and nutrient samples were collected from calibration sites on water quality mapping cruises, some of which were also at continuous monitoring sites. In addition, samples were collected at the continuous monitoring sites when the equipment was serviced (approximately every two weeks). All data for a station (water quality mapping calibration and continuous monitoring calibration) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median. Note that the long-term stations include data from long-term and water quality mapping sampling. The median CHLA, TSS, PO_4 and DIN levels and Secchi depths for the April-October SAV growing season were compared to the habitat requirements in the same manner as the long-term tidal data (Appendix 5).

Non-parametric one-way ANOVAs were used to determine if there were differences between stations (SAS Institute software). Where a significant difference was present, a Tukey's Studentized Range (HSD) test was performed to determine which stations were different from each other. Tests were considered significant at $p < 0.05$.
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Appendix 5

Submerged Aquatic Vegetation Habitat Requirements

Submerged Aquatic Vegetation (SAV) habitat requirements by salinity regime (from Habitat Requirements for Submerged Aquatic Vegetation in Chesapeake Bay: Water Quality, Light Regime, and Physical-Chemical Factors. W. M. Kemp, R. Batiuk, R. Bartleson, P. Bergstrom, V. Carter, C. L. Gallegos, W. Hunley, L. Karrh, E. W. Koch, J. M. Landwehr, K. A. Moore, L. Murray, M. Naylor, N. B. Rybicki, J. C. Stevenson and D. J. Wilcox. Estuaries. 2004. 27:363–377 available online at http://archive.chesapeakebay.net/pubs/sav/savreport.pdf.).

SAV growing season for all three regimes in Maryland is from April-October. Median seasonal values are compared to the listed habitat requirement to determine if water quality is suitable for SAV growth and survival. Note that the dissolved inorganic nitrogen (DIN) requirement for mesohaline waters exceeds the 0.07 mg/l level where nitrogen limitation of algal growth likely occurs. The more stringent nitrogen limitation DIN level is used for interpretation of habitat quality instead. Due to issues with the model calibration, instead of Percent light at leaf (PLL) water clarity is assessed with percent light through water (PLW) at 1.0 meter depth (L. Karrh, personal communication). PLW can be calculated for the long-term stations that were sampled from 1985-2010. For all stations, Secchi depth can also be used to estimate PLW (L. Karrh, personal communication).

Salinity Regime (ppt)	**Water Column Light Requirement (PLW) (%) or Secchi Depth (m)**	**Total Suspended Solids (mg/l)**	**Plankton Chlorophyll-*a* (µg/l)**	**Dissolved Inorganic Nitrogen (mg/l)**	**Dissolved Inorganic Phosphorus (mg/l)**
Tidal Fresh <0.5 ppt	>13% or 0.725 m	< 15	< 15	Not applicable	< 0.02
Oligohaline 0.5-5 ppt	>13% or 0.725 m	< 15	< 15	Not applicable	< 0.02
Mesohaline 5-18 ppt	>22% or 0.97 m	< 15	< 15	< 0.15 (Nitrogen Limitation < 0.07)	< 0.01

Appendix 6

Current status and long-term tidal water quality trends
Status results for 2008-2010
Trend results from 1985-1997, 1999-2010 and 1985-2010

Data is from the surface layer with the exception of dissolved oxygen, which is from the bottom. Trends for dissolved oxygen are for summer only (June-September). Red colored status and trends results indicate poor or degrading conditions. Green colored status and trends results indicate good or improving conditions. Blue colored status indicates fair status. Blue colored trends indicate decreasing trends where a qualitative assessment (improving or degrading) is not applicable; purple colored trends indicate increasing trends in the same parameters. Grey shading of the 1985-2010 Linear Trend results indicates the non-linear trend is significant and the linear trend results should not be reported. For trends significant at $p \leq 0.01$, results are abbreviated as IMP (improving), DEG (degrading), INC (increasing), DEC (decreasing), U (u-shaped non-linear trend) and INV-U (inverse u-shaped non-linear trend). For trends significant at $0.01 < p < 0.05$, NT (no trend) precedes the abbreviation. NT alone indicates trend is not significant at $p < 0.05$.

Param	River	Initial 2-yr Median	2008-2010 Median	2008-2010 Status	1985-1997 Linear Trend	1999-2010 Linear Trend	1985-2010 Linear Trend	1985-2010 Non-Lin Trend	Non-linear inflection
TN	**Northeast**	1.253	1.359	GOOD	NT	NT	NTIMP		
	Back Creek	2.050	1.693	POOR	NT IMP	NT	NTIMP		
	Bohemia	1.243	1.216	GOOD	NT	NT	IMP		
	Elk	1.590	1.514	FAIR	NT IMP	NT	NTIMP		
	Sassafras	1.545	1.613	POOR	DEG	NT	NT		
	Upper Chester	1.843	2.375	POOR	DEG	NTIMP	NT	INV-U	Nov-98
	Lower Chester	0.921	0.864	POOR	NT	NT	NT		
	Eastern Bay	0.755	0.677	GOOD	NT	NT	NT		
DIN	**Northeast**	0.338	0.605	GOOD	NT	NT			
	Back Creek	1.474	1.179	POOR	NTIMP	NTIMP			
	Bohemia	0.123	0.430	GOOD	NT	NT			
	Elk	1.020	1.090	POOR	NT	NTIMP	Not evaluated due to lab change		
	Sassafras	0.122	0.281	GOOD	NT	NT			
	Upper Chester	0.493	1.515	POOR	DEG	NT			
	Lower Chester	0.237	0.133	GOOD	NT	NT			
	Eastern Bay	0.162	0.087	GOOD	NT	NT			
TP	**Northeast**	0.066	0.054	GOOD	NT	IMP			
	Back Creek	0.101	0.085	GOOD	NT	NT			
	Bohemia	0.117	0.070	GOOD	NT	NT			
	Elk	0.097	0.066	GOOD	NT	NT	Not evaluated due to lab change		
	Sassafras	0.104	0.089	FAIR	NT	NT			
	Upper Chester	0.235	0.112	POOR	IMP	IMP			
	Lower Chester	0.045	0.033	GOOD	DEG	NT			
	Eastern Bay	0.032	0.027	GOOD	DEG	NT			
PO4	**Northeast**	0.005	0.003	GOOD	*	NT			
	Back Creek	0.026	0.027	POOR	NT	NT			
	Bohemia	0.005	0.004	GOOD	*	NT			
	Elk	0.018	0.023	POOR	NT	NT	Not evaluated due to lab change		
	Sassafras	0.005	0.004	GOOD	*	NT			
	Upper Chester	0.019	0.021	POOR	NT	NT			
	Lower Chester	0.005	0.003	GOOD	*	NT			
	Eastern Bay	0.005	0.003	GOOD	*	NT			
TSS	**Northeast**	21.5	12.3	GOOD	NT	IMP			
	Back Creek	40.5	28.0	POOR	NT	NT			
	Bohemia	29.8	19.4	GOOD	NT	IMP			
	Elk	31.5	21.0	GOOD	NT	NT	Not evaluated due to lab change		
	Sassafras	18.5	15.5	GOOD	NTDEG	NT			
	Upper Chester	61.0	23.5	FAIR	NTIMP	IMP			
	Lower Chester	6.6	7.0	GOOD	DEG	NT			
	Eastern Bay	5.0	4.6	GOOD	DEG	NTIMP			
CHLA	**Northeast**	27.2	29.4	POOR	NT	NT	NT		
	Back Creek	6.8	4.0	GOOD	NT	NTDEG	NTIMP		
	Bohemia	33.2	33.8	POOR	NT IMP	NT	NTIMP		
	Elk	8.6	3.7	GOOD	NT	DEG	NT		
	Sassafras	39.1	45.8	POOR	NT	NT	NT		
	Upper Chester	46.0	6.2	GOOD	IMP	IMP	IMP		
	Lower Chester	9.5	15.0	POOR	NT	NT	DEG		
	Eastern Bay	5.5	10.2	POOR	DEG	NT	DEG		
SECCHI	**Northeast**	0.5	0.5	POOR	NT		NT		
	Back Creek	0.4	0.4	POOR	NT	NT	NT		
	Bohemia	0.3	0.4	POOR	NT	NT	NT		
	Elk	0.4	0.5	GOOD	NT	NTDEG	NT		
	Sassafras	0.5	0.4	POOR	NT	NT	NT		
	Upper Chester	0.2	0.3	POOR	SLOPE = 0	NT	IMP		
	Lower Chester	1.2	0.9	POOR	DEG	NT	DEG	U	Mar-04
	Eastern Bay	2.0	1.4	GOOD	DEG	NT	DEG		

Param		Initial 2-yr Median	2008-2010 Median	2008-2010 Status	1985-1997 Linear Trend	1999-2010 Linear Trend	1985-2010 Linear Trend	1985-2010 Non-Lin Trend	Non-linear inflection
DO	Northeast	8.0	7.9	GOOD	NT	NT	NT		
	Back Creek	6.0	6.4	GOOD	NTIMP	NT	NT		
	Bohemia	6.4	7.5	GOOD	NT	NT	NT		
	Elk	6.6	6.6	GOOD	NT	NT	NT		
	Sassafras	5.9	6.6	GOOD	NT	NT	NT		
	Upper Chester	6.5	6.3	GOOD	NTIMP	NT	NT		
	Lower Chester	4.1	2.8	FAIR	NT	NT	NT		
	Eastern Bay	3.3	1.1	POOR	DEG	NT	DEG		
WTEMP	Northeast	16.0	14.7	INC	NT	NT	NT		
	Back Creek	17.6	15.4	INC	NT	NT	NT		
	Bohemia	17.6	14.9	INC	NT	NT	NT		
	Elk	17.5	15.4	INC	NT	NT	NT		
	Sassafras	17.0	15.1	INC	NT	NT	NT		
	Upper Chester	16.9	12.7	NOD	NTDEC	NT	NT		
	Lower Chester	16.0	13.8	INC	NT	NT	NT		
	Eastern Bay	18.2	14.4	INC	NT	NT	NT		
SALINITY	Northeast	0.1	0.0	INC	NT	NT	NT		
	Back Creek	2.7	1.1	NOD	NT	NT	NT		
	Bohemia	1.0	0.5	DEC	NT	NT	NT		
	Elk	1.7	0.8	NOD	NT	NT	NT		
	Sassafras	0.4	0.3	DEC	NT DEC	NTDEC	NT		
	Upper Chester	1.1	0.0	DEC	SLOPE = 0	NT	SLOPE=0	U	Sep-02
	Lower Chester	10.8	8.9	DEC	DEC	NT	NTDEC	U	Mar-02
	Eastern Bay	13.4	12.3	INC	DEC	NT	NTDEC	U	Sep-00
NH4	Northeast	0.010	0.012	GOOD	NT	NT			
	Back Creek	0.082	0.056	FAIR	NT	NT			
	Bohemia	0.010	0.011	GOOD	NT	NT			
	Elk	0.075	0.054	FAIR	NT	NT	Not evaluated due to lab change		
	Sassafras	0.010	0.023	GOOD		NT			
	Upper Chester	0.028	0.101	POOR	NT	NT			
	Lower Chester	0.055	0.013	GOOD	IMP	NT			
	Eastern Bay	0.040	0.010	GOOD	NT	NT			
NO23	Northeast	0.300	0.592	GOOD	NT	NT			
	Back Creek	1.400	1.075	POOR	NTIMP	NT			
	Bohemia	0.075	0.427	FAIR	NT	NT			
	Elk	0.940	1.010	POOR	NT	NTIMP	Not evaluated due to lab change		
	Sassafras	0.050	0.239	GOOD	SLOPE = 0	NT			
	Upper Chester	0.456	1.380	POOR	DEG	NT			
	Lower Chester	0.132	0.124	POOR	NT	NT			
	Eastern Bay	0.101	0.041	GOOD	NT	NT			
TN:TP	Northeast	48	54	INC	NT	NTINC			
	Back Creek	36	43	INC	NT	NT			
	Bohemia	20	40	NOD	NT	NT			
	Elk	40	51	INC	NT	NT	Not evaluated due to lab change		
	Sassafras	32	35	DEC	NT	NT			
	Upper Chester	19	43	INC	NTINC	NT			
	Lower Chester	46	52	INC	NT	NT			
	Eastern Bay	49	51	NOD	NT	NT			
DIN:PO4	Northeast	139	355	DEC	NT	NTINC			
	Back Creek	90	79	DEC	NT	NT			
	Bohemia	46	203	DEC	NT DEC	NT			
	Elk	95	85	DEC	NT	NT			
	Sassafras	54	123	DEC	NT	NT	Not evaluated due to lab change		
	Upper Chester	73	130	DEC	NTINC	NT			
	Lower Chester	84	90	DEC	NT	NT			
	Eastern Bay	71	42	DEC	NT	NT			

Appendix 7

Seasonal trends results for long-term tidal water quality data from 1999-2010

Seasonal trends results for surface data from 1999-2010. Color codes and abbreviations are the same as used in Appendix 6.

param	station	ANNUAL Jan-Dec	SPRING Mar-May	SUMMER Jun-Sep	SAV Apr-Oct
TN	Northeast	NT	NT	NT	NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NTIMP	NT
	Upper Chester	NTIMP	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NTDEG	NT
DIN	Northeast	NT	NT	NT	NT
	Back Creek	NTIMP	NT	NT	NTIMP
	Bohemia	NT	NT	NT	NT
	Elk	NTIMP	NT	NT	**IMP**
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
TP	Northeast	**IMP**	NT	**IMP**	**IMP**
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NT	NT
	Upper Chester	**IMP**	NT	**IMP**	**IMP**
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
PO4	Northeast	NT	NT	NT	NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NTIMP	NT	NT
	Eastern Bay	NT	NT	NT	NT
TSS	Northeast	**IMP**	NT	**IMP**	**IMP**
	Back Creek	NT	NT	NT	NT
	Bohemia	**IMP**	NT	**IMP**	**IMP**
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NTIMP	NTIMP
	Upper Chester	**IMP**	**IMP**	**IMP**	**IMP**
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NTIMP	NT	NT	NT

param	station	ANNUAL Jan-Dec	SPRING Mar-May	SUMMER Jun-Sep	SAV Apr-Oct
CHLA	Northeast	NT	NT	NT	NT
	Back Creek	NTDEG	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	**DEG**	NT	NT	NTDEG
	Sassafras	NT	NT	NT	NT
	Upper Chester	**IMP**	NTIMP	**IMP**	**IMP**
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
SECCHI	Northeast		NTIMP	NT	NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NTDEG	NT	NT	NT
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
WTEMP	Northeast	NT	NT	NT	NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
SALINITY	Northeast	NT			NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NTDEC	NTDEC	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NTDEC	NT	NT
	Eastern Bay	NT	NTDEC	NT	NT
NH4	Northeast	NT	NTIMP	NT	NT
	Back Creek	NT	NT	NT	NT
	Bohemia	NT	NT	NT	NT
	Elk	NT	NT	NT	NT
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT
NO23	Northeast	NT	NT	NT	NT
	Back Creek	NT	NT	NT	NTIMP
	Bohemia	NT	NT	NT	NT
	Elk	NTIMP	NT	NT	NTIMP
	Sassafras	NT	NT	NT	NT
	Upper Chester	NT	NT	NT	NT
	Lower Chester	NT	NT	NT	NT
	Eastern Bay	NT	NT	NT	NT

Appendix 8

Shallow water monitoring water and habitat quality

Temporal Assessment- Percent failures

Continuous monitoring data for the years 2000-2010. Instantaneous measurements of dissolved oxygen taken during June through September were compared to threshold value 3.2 mg/l. Chlorophyll and turbidity measurements collected during the SAV growing were compared to threshold levels of 15µg/l and 7 NTU, respectively. The percent of values in each year that did not meet the water quality thresholds are presented as "percent failures".

Station	Location	Year	Dissolved Oxygen Thresholds		Chlorophyll Thresholds	Turbidity Thresholds
			% < 3 mg/l	% < 5 mg/l	% > 30 ug/l	% > 7 NTU
XKH2870	*Chesapeake Bay* Stump Point	2007	0.00	0.36	0.00	26.25
		2008	0.00	0.47	0.03	31.54
		2009	0.00	0.01	0.01	22.76
XKI5022	*Northeast River* Charlestown	2007	0.00	0.03	1.38	97.59
		2008	0.00	0.08	28.54	87.65
		2009	0.00	0.08	11.33	91.23
XKH2797	*Northeast River* Carpenters Point	2007	0.00	0.00	0.16	89.31
		2008	0.00	0.20	11.85	79.76
		2009	0.00	0.00	0.57	68.40
XKI3890	*Elk River* Locust Point Marina	2007	0.00	0.01	11.71	99.95
		2008	0.00	0.47	11.00	98.91
		2009	0.00	0.04	10.45	99.27
XKI0256	*Elk River* Hollywood Beach	2007	0.00	0.00	0.00	99.21
		2008	0.00	0.00	0.00	93.87
		2009	0.00	0.00	0.00	90.31
XJI8369	*Bohemia River* Long Point	2007	0.00	2.06	0.62	99.85
		2008	0.00	0.92	7.47	99.36
		2009	0.00	0.20	5.29	89.22
XJI2396	*Sassafras River* Budds Landing	2007	0.00	0.14	57.03	100.00
		2008	0.00	0.50	72.18	99.04
		2009	0.00	2.02	78.26	99.65
		2010	0.00	0.00	56.82	100.00
XJI1871	*Sassafras River* Georgetown Yacht	2006	0.00	7.71	40.97	88.91
		2007	0.00	0.00	59.26	95.36
XJH2362	*Sassafras River* Betterton Beach	2006	0.00	0.00	0.05	85.71
		2007	0.00	0.06	1.50	87.66
		2008	0.00	0.11	0.20	63.12
		2009	0.00	0.08	3.52	30.98
		2010	0.00	0.34	0.12	57.34

< 10 % failure
40 - 70 % failure
10 - 40 % failure
> 70 % failure

Station	Location	Year	Dissolved Oxygen Thresholds		Chlorophyll Thresholds	Turbidity Thresholds
			% < 3 mg/l	% < 5 mg/l	% > 30 ug/l	% > 7 NTU
CHE0348	*Chester River* Deep Landing	2003	0.00	8.04	2.30	100.00
		2004	0.00	1.59	2.93	99.99
		2005	0.00	4.13	1.39	99.66
		2006	0.19	24.25	11.21	99.49
XIH0077	*Chester River* Rolphs Wharf	2003	0.36	25.62	0.05	94.78
		2004	0.15	1.07	0.54	90.56
		2005	0.00	15.25	1.42	71.73
		2006	0.05	21.16	1.86	87.31
XGG8359	*Chester River* Kent Narrows (inside)	2007	1.43	17.43	0.29	14.01
		2008	1.54	19.44	0.17	19.05
		2009	0.64	12.65	1.73	22.22
XGG8458	*Chester River* Kent Narrows (outside)	2007	1.06	5.63	4.69	66.06
		2008	0.00	1.92	0.74	46.96
		2009	0.80	6.05	4.39	32.11
XHG8442	*Chesapeake Bay* Gratitude Marina	2009	2.56	23.11	8.39	50.18
		2010	0.23	10.39	1.35	72.93
XHG2318	*Chesapeake Bay* Love Point	2009	0.30	1.63	6.24	32.11
		2010	0.05	2.12	0.43	40.09
XHH3851	*Corsica River* Sycamore Point	2005	17.87	43.12	50.21	92.71
		2006	19.35	49.42	69.68	92.54
		2007	29.13	50.42	62.68	88.15
		2008	14.76	40.77	58.19	84.49
		2009	9.23	32.98	52.61	93.99
		2010	5.54	29.44	42.61	76.71
XHH5046	*Corsica River* Emory Creek	2005	6.64	26.74	16.86	54.98
		2006	0.34	17.08	47.84	78.08
XHH4931	*Corsica River* Possum Point (surface)	2006	0.10	10.26	22.88	63.76
		2007	2.52	15.80	13.83	74.75
		2008	0.52	12.84	27.83	79.83
		2009	0.43	11.10	15.58	68.56
		2010	0.18	11.53	10.50	71.36
XHH4931	*Corsica River* Possum Point (bottom)	2006	6.51	36.92	18.28	88.10
		2007	6.01	37.94	11.87	86.42
		2008	15.76	49.68	21.73	82.28
		2009	6.56	44.74	9.73	77.93
		2010	11.84	48.86	23.33	91.98
XHH4916	*Corsica River* The Sill (surface)	2006	0.04	3.75	13.29	53.10
		2007	0.09	4.09	4.65	72.36
		2008	0.02	2.93	5.82	60.54
		2009	0.00	2.17	6.44	59.35
		2010	0.22	4.22	1.84	55.26
XHH4916	*Corsica River* The Sill (bottom)	2006	6.70	32.10	8.33	82.93
		2007	2.20	24.05	6.48	89.15
		2008	2.37	28.39	9.29	93.23
		2009	1.17	22.35	10.90	85.14
		2010	0.85	21.84	6.02	81.24
XFG9164	*Eastern Bay* Hambleton Point	2004	0.00	3.00	2.49	14.68
		2005	0.70	12.15	4.00	23.13
		2006	0.12	6.70	5.33	24.71
XGG6667	*Eastern Bay* Chesapeake Bay Environmental Center	2005	3.55	23.29	2.48	64.61
		2006	1.58	13.22	1.66	60.36
		2007	2.62	17.49	12.21	61.28
		2008	2.56	21.46	6.87	63.55
XGF0681	*Eastern Bay* Kent Point	2004	0.00	1.92	1.65	52.57
		2005	0.03	2.29	1.49	62.20
		2006	0.80	3.10	1.64	58.92

< 10 % failure

10 - 40 % failure

40 - 70 % failure

> 70 % failure

Spatial Assessment

Shallow water monitoring data for 2008-2010 compared to SAV habitat requirements in the Upper Eastern Shore Rivers.
All data for a station (water quality mapping and continuous monitoring) were used to calculate a monthly median. Monthly medians for April-October were used to calculate the SAV growing season median, which was compared to habitat requirements (Appendix 5). Note that the long-term stations include data from long-term and water quality mapping sampling. In 2010, DIN and PO_4 was not measured at some stations.

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Dissolved Oxygen		Salinity		TN	TP	wtemp
NORTHEAST RIVER	Charlestown	XKI5022	17	2008	35.9	FAIL	16.0	FAIL	0.060	MEET	0.0033	MEET	0.40	FAIL	10.5	MEET	0.0	TF	1.22	0.065	22.8
				2009	45.4	FAIL	22.0	FAIL	0.152	FAIL	0.0034	MEET	0.40	FAIL	9.5	MEET	0.0	TF	1.20	0.075	22.5
	long-term	ET1.1	56	2008	33.1	FAIL	13.7	MEET	0.054	MEET	0.0027	MEET	0.40	FAIL	8.8	MEET	0.0	TF	1.14	0.062	25.4
				2009	37.0	FAIL	14.2	MEET	0.334	FAIL	0.0023	MEET	0.50	FAIL	9.5	MEET	0.0	TF	1.17	0.055	23.3
		XKH3508	57	2008	27.9	FAIL	14.7	MEET	0.463	FAIL	0.0029	MEET	0.40	FAIL	8.4	MEET	0.0	TF	1.22	0.056	24.9
				2009	31.3	FAIL	12.5	MEET	0.679	FAIL	0.0023	MEET	0.50	FAIL	9.5	MEET	0.0	TF	1.17	0.047	22.9
		XKI2616	58	2008	12.7	MEET	15.3	FAIL	0.595	FAIL	0.0036	MEET	0.40	FAIL	8.1	MEET	0.0	TF	1.05	0.050	25.0
				2009	26.7	FAIL	16.5	FAIL	0.546	FAIL	0.0032	MEET	0.50	FAIL	8.8	MEET	0.0	TF	1.16	0.047	22.2
	Carpenters Point	XKH2797	13	2008	16.4	FAIL	14.7	MEET	0.499	FAIL	0.0025	MEET	0.50	FAIL	10.1	MEET	0.0	TF	1.23	0.040	21.7
				2009	20.8	FAIL	15.4	FAIL	0.788	FAIL	0.0026	MEET	0.55	FAIL	9.5	MEET	0.0	TF	1.27	0.048	21.8
BOHEMIA RIVER		GBO0013	23	2008	76.8	FAIL	29.5	FAIL	0.026	MEET	0.0061	MEET	0.20	FAIL	8.3	MEET	0.2	OH	1.33	0.139	25.4
				2009	40.6	FAIL	32.0	FAIL	0.014	MEET	0.0047	MEET	0.20	FAIL	8.9	MEET	0.3	OH	1.39	0.130	23.8
		LBO0010	24	2008	48.8	FAIL	27.0	FAIL	0.024	MEET	0.0071	MEET	0.30	FAIL	8.8	MEET	0.0	TF	1.24	0.135	25.4
				2009	38.1	FAIL	35.3	FAIL	0.017	MEET	0.0064	MEET	0.30	FAIL	8.3	MEET	0.3	OH	1.36	0.142	23.5
	long-term	ET2.2	near 12	2008	45.1	FAIL	21.4	FAIL	0.014	MEET	0.0041	MEET	0.40	FAIL	9.4	MEET	0.1	OH	1.00	0.092	19.4
				2009	22.8	FAIL	24.6	FAIL	0.203	FAIL	0.0054	MEET	0.45	FAIL	8.5	MEET	0.4	OH	0.97	0.076	23.8
				2010	34.7	FAIL	12.7	MEET	0.071	FAIL	0.0034	MEET	0.40	FAIL	10.2	MEET	0.3	OH	1.11	0.064	23.5
	Long Point	XJI8369	12	2008	24.7	FAIL	28.3	FAIL	0.146	FAIL	0.0069	MEET	0.40	FAIL	7.8	MEET	0.3	OH	1.00	0.080	23.7
				2009	20.6	FAIL	28.8	FAIL	0.210	FAIL	0.0072	MEET	0.40	FAIL	8.3	MEET	0.5	OH	1.04	0.087	21.3
		XJI8856	26	2008	12.8	MEET	8.0	MEET	0.460	FAIL	0.0218	FAIL	0.80	MEET	6.7	MEET	0.6	OH	1.10	0.055	25.3
				2009	7.5	MEET	16.0	FAIL	0.864	FAIL	0.0309	FAIL	0.50	FAIL	7.5	MEET	0.4	OH	1.28	0.062	22.6
		XJI8641	25	2008	5.0	MEET	13.8	MEET	0.506	FAIL	0.0218	FAIL	0.70	FAIL	6.8	MEET	1.0	OH	1.01	0.054	25.2
				2009	4.3	MEET	12.7	MEET	0.826	FAIL	0.0313	FAIL	0.70	FAIL	7.2	MEET	0.4	OH	1.35	0.060	22.5
ELK RIVER	Locust Point	XKI3890	16	2008	38.1	FAIL	46.0	FAIL	0.601	FAIL	0.0053	MEET	0.30	FAIL	9.2	MEET	0.2	OH	1.43	0.109	23.5
				2009	12.0	MEET	46.0	FAIL	0.668	FAIL	0.0130	MEET	0.30	FAIL	7.2	MEET	0.4	OH	1.57	0.119	21.4
		XKI2475	55	2008	2.4	MEET	16.5	FAIL	0.514	FAIL	0.0318	FAIL	0.80	MEET	8.0	MEET	0.7	OH	0.98	0.062	24.9
				2009	4.6	MEET	19.0	FAIL	0.997	FAIL	0.0372	FAIL	0.50	FAIL	8.3	MEET	0.8	OH	1.66	0.076	23.5
	Hollywood Beach	XKI0256	15	2008	5.1	MEET	30.0	FAIL	0.712	FAIL	0.0248	FAIL	0.40	FAIL	7.8	MEET	0.5	OH	1.21	0.076	23.6
				2009	4.3	MEET	33.3	FAIL	0.990	FAIL	0.0377	FAIL	0.40	FAIL	7.4	MEET	0.8	OH	1.56	0.085	21.0
	long-term mid	ET2.3	53	2008	3.6	MEET	11.8	MEET	0.762	FAIL	0.0256	FAIL	0.75	MEET	7.3	MEET	0.5	OH	1.13	0.051	25.2
				2009	3.7	MEET	21.3	FAIL	1.071	FAIL	0.0367	FAIL	0.50	FAIL	7.2	MEET	0.6	OH	1.53	0.071	22.7
		XJI8018	54	2008	5.4	MEET	6.8	MEET	0.724	FAIL	0.0209	FAIL	0.80	MEET	6.9	MEET	0.0	TF	1.15	0.039	25.2
				2009	6.8	MEET	10.0	MEET	0.876	FAIL	0.0154	MEET	0.70	FAIL	7.6	MEET	0.0	TF	1.45	0.043	22.4

Shallow water monitoring data for 2008-2010 compared to SAV habitat requirements in the Upper Eastern Shore Rivers (continued).

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Dissolved Oxygen		Salinity		TN	TP	wtemp
SASSFRAS RIVER	Budds Landing	XJI2396	11	2008	73.3	FAIL	27.4	FAIL	0.018	MEET	0.0039	MEET	0.30	FAIL	10.0	MEET	0.0	TF	1.71	0.154	23.5
				2009	73.7	FAIL	35.0	FAIL	0.030	MEET	0.0061	MEET	0.30	FAIL	9.5	MEET	0.1	OH	1.67	0.156	23.0
				2010	103.6	FAIL	46.8	FAIL				MEET	0.20	FAIL	9.3	MEET	0.0	TF			25.3
	Georgetown Yacht	XJI1871	10	2008	56.1	FAIL	14.8	MEET	0.015	MEET	0.0036	MEET	0.40	FAIL	7.8	MEET	0.0	TF	1.27	0.089	23.3
				2009	54.5	FAIL	24.0	FAIL	0.022	MEET	0.0036	MEET	0.30	FAIL	8.5	MEET	0.4	OH	1.33	0.116	24.1
		XJI2342	60	2008	28.8	FAIL	10.0	MEET	0.017	MEET	0.0030	MEET	0.55	FAIL	7.8	MEET	0.3	OH	1.01	0.063	22.9
				2009	27.0	FAIL	16.5	FAIL	0.095	FAIL	0.0036	MEET	0.40	FAIL	9.7	MEET	0.5	OH	0.99	0.061	24.0
		XJI2112	59	2008	17.7	FAIL	14.1	MEET	0.097	FAIL	0.0033	MEET	0.55	FAIL	8.0	MEET	0.8	OH	0.89	0.051	22.5
				2009	10.0	MEET	14.0	MEET	0.348	FAIL	0.0052	MEET	0.50	FAIL	7.8	MEET	0.7	OH	1.00	0.044	23.2
	Betterton Beach	XJH2362	9	2008	10.2	MEET	13.6	MEET	0.524	FAIL	0.0099	MEET	0.75	MEET	8.9	MEET	0.4	OH	1.13	0.049	23.4
				2009	6.3	MEET	6.4	MEET	0.813	FAIL	0.0211	FAIL	1.10	MEET	8.4	MEET	0.3	OH	1.35	0.042	22.4
				2010	6.2	MEET	10.4	MEET					0.70	FAIL	7.7	MEET	0.5	OH			24.9
CORSICA RIVER		COR0056	34	2008	102.7	FAIL	36.0	FAIL	0.186	FAIL	0.0118	MEET	0.30	FAIL	9.3	MEET	3.8	OH	2.85	0.234	22.5
				2009	79.3	FAIL	36.6	FAIL	0.303	FAIL	0.0170	MEET	0.20	FAIL	6.3	MEET	5.0	OH	2.32	0.236	22.7
				2010	52.2	FAIL	30.0	FAIL	0.760	FAIL	0.0456	FAIL	0.20	FAIL	7.5	MEET	2.7	OH	2.60	0.204	23.4
	Sycamore Point	XHH3851	8	2008	61.3	FAIL	28.4	FAIL	0.027	MEET	0.0121	FAIL	0.35	FAIL	8.1	MEET	5.2	MH	1.50	0.167	23.7
				2009	49.1	FAIL	32.8	FAIL	0.025	MEET	0.0070	MEET	0.30	FAIL	7.9	MEET	7.7	MH	1.47	0.154	23.7
				2010	54.8	FAIL	20.7	FAIL	0.038	MEET	0.0229	FAIL	0.40	FAIL	7.4	MEET	5.6	MH	1.48	0.160	26.0
	Possom Point	XHH4931	7	2008	27.7	FAIL	18.7	FAIL	0.027	MEET	0.0087	MEET	0.50	FAIL	7.3	MEET	6.1	MH	1.09	0.091	22.9
				2009	36.0	FAIL	20.4	FAIL	0.027	MEET	0.0141	FAIL	0.45	FAIL	7.0	MEET	8.9	MH	1.05	0.099	25.4
				2010	26.7	FAIL	15.3	FAIL	0.029	MEET	0.0120	FAIL	0.50	FAIL	7.1	MEET	7.4	MH	1.07	0.104	24.2
	The Sill	XHH4916	5	2008	18.7	FAIL	14.0	MEET	0.037	MEET	0.0079	MEET	0.60	FAIL	7.8	MEET	6.6	MH	0.86	0.066	22.6
				2009	19.8	FAIL	17.4	FAIL	0.020	MEET	0.0060	MEET	0.60	FAIL	7.8	MEET	9.5	MH	0.86	0.069	24.9
				2010	20.3	FAIL	12.0	MEET	0.066	MEET	0.0067	MEET	0.50	FAIL	7.4	MEET	8.3	MH	0.96	0.062	25.5
	long-term	XHH4742	near 35	2008	32.2	FAIL	14.7	MEET	0.028	MEET	0.0075	MEET	0.50	FAIL	8.3	MEET	5.9	MH	1.18	0.105	22.0
				2009	33.1	FAIL	18.9	FAIL	0.048	MEET	0.0090	MEET	0.40	FAIL	7.6	MEET	8.4	MH	1.15	0.096	23.2
				2010	35.2	FAIL	12.0	MEET	0.018	MEET	0.0052	MEET	0.40	FAIL	7.2	MEET	7.2	MH	1.18	0.127	23.4
		XHH4528	35	2008	25.4	FAIL	16.0	FAIL	0.025	MEET	0.0119	FAIL	0.50	FAIL	7.9	MEET	6.1	MH	1.18	0.088	22.5
				2009	51.3	FAIL	20.7	FAIL	0.020	MEET	0.0048	MEET	0.40	FAIL	7.9	MEET	9.1	MH	1.79	0.100	24.7
				2010	23.5	FAIL	14.7	MEET	0.038	MEET	0.0142	FAIL	0.40	FAIL	7.3	MEET	7.6	MH	1.10	0.112	26.9
CHESTER RIVER	Inside SAV bed	XGG8359	4	2008	9.5	MEET	8.0	MEET	0.039	MEET	0.0054	MEET	0.90	FAIL	7.0	MEET	8.2	MH	0.76	0.047	22.1
				2009	13.5	MEET	17.2	FAIL	0.044	MEET	0.0035	MEET	0.65	FAIL	6.6	MEET	10.8	MH	0.77	0.047	23.9
	Outside SAV bed	XGG8458	2	2008	15.7	FAIL	13.0	MEET	0.079	FAIL	0.0029	MEET	0.70	FAIL	7.7	MEET	8.3	MH	0.81	0.042	20.5
				2009	14.3	MEET	16.2	FAIL	0.091	FAIL	0.0032	MEET	0.80	FAIL	7.1	MEET	10.8	MH	0.74	0.046	22.2
MOUTH OF CHESTER RIVER		XHG8442	19	2009	11.4	MEET	14.0	MEET	0.158	FAIL	0.0045	MEET	0.65	FAIL	7.3	MEET	8.9	MH	0.88	0.047	22.9
				2010	9.6	MEET	19.2	FAIL					0.50	FAIL	7.2	MEET	8.6	MH			23.5
		XHG2318	18	2009	16.4	FAIL	9.8	MEET	0.145	FAIL	0.0038	MEET	1.00	MEET	7.8	MEET	9.3	MH	0.80	0.048	21.9
				2010	11.6	MEET	9.2	MEET					0.90	FAIL	8.5	MEET	9.1	MH			23.6

Shallow water monitoring data prior to 2008 compared to SAV habitat requirements in the Upper Eastern Shore Rivers.

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Diss Oxygen		Salinity		TN	TP	wtemp
NORTHEAST RIVER	Charlestown	XKI5022	17	2007	40.4	FAIL	19.0	FAIL	0.043	MEET	0.0029	MEET	0.30	FAIL	10.2	MEET	0.0	TF	1.45	0.078	23.3
	long-term	ET1.1	56	2007	28.6	FAIL	15.0	FAIL	0.032	MEET	0.0029	MEET	0.40	FAIL	9.9	MEET	0.0	TF	1.26	0.063	21.5
		XKH3508	57	2007	17.9	FAIL	10.5	MEET	0.095	FAIL	0.0030	MEET	0.50	FAIL	10.4	MEET	0.0	TF	1.24	0.051	23.2
		XKI2616	58	2007	11.5	MEET	11.0	MEET	0.598	FAIL	0.0032	MEET	0.50	FAIL	9.4	MEET	0.0	TF	1.22	0.041	23.4
	Carpenters Point	XKH2797	13	2007	13.4	MEET	14.0	MEET	0.786	FAIL	0.0029	MEET	0.40	FAIL	9.3	MEET	0.0	TF	1.31	0.043	23.5
BOHEMIA RIVER		GBO0013	23	2007	43.4	FAIL	31.3	FAIL	0.021	MEET	0.0038	MEET	0.30	FAIL	9.0	MEET	0.2	OH	1.27	0.108	24.9
		LBO0010	24	2007	41.9	FAIL	24.7	FAIL	0.032	MEET	0.0038	MEET	0.30	FAIL	8.7	MEET	0.3	OH	1.14	0.105	24.7
	Long Point	XJI8369	12	2007	16.9	FAIL	25.9	FAIL	0.141	FAIL	0.0062	MEET	0.40	FAIL	8.1	MEET	0.6	OH	0.97	0.075	24.0
		XJI8856	26	2007	5.6	MEET	12.0	MEET	0.517	FAIL	0.0244	FAIL	0.60	FAIL	7.5	MEET	0.9	OH	1.04	0.051	23.8
ELK RIVER	Locust Point Marina	XKI3890	16	2007	7.7	MEET	32.0	FAIL	0.594	FAIL	0.0149	MEET	0.40	FAIL	7.5	MEET	2.2	OH	1.23	0.075	23.2
		XKI2475	55	2007	3.0	MEET	13.0	MEET	0.588	FAIL	0.0262	FAIL	0.70	FAIL	7.6	MEET	2.6	OH	1.11	0.056	25.2
	Hollywood Beach	XKI0256	15	2007	6.9	MEET	24.5	FAIL	0.715	FAIL	0.0229	FAIL	0.40	FAIL	7.6	MEET	2.0	OH	1.16	0.067	24.3
	long-term	ET2.3	53	2007	4.0	MEET	8.6	MEET	0.601	FAIL	0.0225	FAIL	0.70	FAIL	7.6	MEET	2.4	OH	1.03	0.046	24.2
		XJI8018	54	2007	8.1	MEET	7.5	MEET	0.572	FAIL	0.0112	MEET	0.80	MEET	8.4	MEET	2.1	OH	1.10	0.042	25.7
SASSAFRAS RIVER	Budds Landing	XJI2396	11	2007	138.3	FAIL	43.9	FAIL	0.031	MEET	0.0053	MEET	0.20	FAIL	12.0	MEET	0.1	OH	2.64	0.213	25.7
	Georgetown Yacht Club	XJI1871	10	2006	47.8	FAIL	22.0	FAIL	0.130	FAIL	0.0051	MEET	0.40	FAIL	7.8	MEET	0.3	OH	1.38	0.105	22.4
				2007	75.1	FAIL	22.4	FAIL	0.211	FAIL	0.0040	MEET	0.30	FAIL	9.5	MEET	0.2	OH	1.84	0.097	25.7
		XJI2112	59	2007	26.4	FAIL	15.6	FAIL	0.090	FAIL	0.0039	MEET	0.50	FAIL	8.1	MEET	3.3	OH	0.99	0.068	26.5
		XJI2342	60	2007	49.9	FAIL	17.0	FAIL	0.037	MEET	0.0034	MEET	0.45	FAIL	9.1	MEET	2.0	OH	1.28	0.088	26.9
	Betterton Beach	XJH2362	9	2006	5.6	MEET	16.7	FAIL	0.770	FAIL	0.0122	MEET	0.70	FAIL	7.9	MEET	0.6	OH	1.28	0.056	21.3
				2007	9.5	MEET	13.3	MEET	0.410	FAIL	0.0041	MEET	0.50	FAIL	8.3	MEET	2.4	OH	1.11	0.048	23.7
		XJI2342	60	2007	49.9	FAIL	17.0	FAIL	0.037	MEET	0.0034	MEET	0.45	FAIL	9.1	MEET	2.0	OH	1.28	0.088	26.9

Shallow water monitoring data prior to 2008 compared to SAV habitat requirements in the Upper Eastern Shore Rivers (continued).

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Diss Oxygen		Salinity		TN	TP	wtemp
UPPER CHESTER RIVER		ET4.1	38	2003	32.5	FAIL	31.0	FAIL	1.665	FAIL	0.0277	FAIL	0.20	FAIL	8.2	MEET	0.0	TF	2.88	0.141	22.7
				2004	47.9	FAIL	35.3	FAIL	0.952	FAIL	0.0131	MEET	0.20	FAIL	9.5	MEET	0.0	TF	2.37	0.127	25.4
				2005	44.9	FAIL	30.3	FAIL	0.970	FAIL	0.0106	MEET	0.30	FAIL	8.9	MEET	0.0	TF	2.06	0.115	25.8
				2006	37.9	FAIL	32.5	FAIL	0.809	FAIL	0.0124	MEET	0.30	FAIL	9.0	MEET	0.2	OH	1.88	0.153	21.0
				2007	46.9	FAIL	34.5	FAIL	0.406	FAIL	0.0108	MEET	0.30	FAIL	10.6	MEET	0.8	OH	1.74	0.132	21.3
	Deep Landing	CHE0348	1	2003	14.0	MEET	21.7	FAIL	1.563	FAIL	0.0436	FAIL	0.30	FAIL	6.5	MEET	0.0	TF	2.38	0.157	24.6
				2004	13.1	MEET	26.5	FAIL	1.016	FAIL	0.0256	FAIL	0.30	FAIL	7.0	MEET	0.1	OH	1.77	0.118	24.8
				2005	6.2	MEET	25.0	FAIL	0.841	FAIL	0.0280	FAIL	0.40	FAIL	6.5	MEET	0.5	OH	1.74	0.104	25.1
				2006	15.3	FAIL	31.5	FAIL	0.757	FAIL	0.0209	FAIL	0.30	FAIL	7.5	MEET	0.8	OH	1.64	0.114	21.6
		XIH4495	42	2003	2.6	MEET	25.3	FAIL	1.612	FAIL	0.0475	FAIL	0.35	FAIL	5.8	MEET	0.0	TF	2.30	0.147	23.0
		XIH3581	39	2003	2.6	MEET	15.9	FAIL	1.486	FAIL	0.0570	FAIL	0.40	FAIL	5.9	MEET	0.2	OH	2.04	0.142	23.5
				2004	4.1	MEET	20.0	FAIL	0.780	FAIL	0.0414	FAIL	0.40	FAIL	6.5	MEET	0.9	OH	1.72	0.095	25.7
				2005	3.7	MEET	16.5	FAIL	0.801	FAIL	0.0533	FAIL	0.50	FAIL	6.6	MEET	1.4	OH	1.31	0.103	26.4
				2006	6.5	MEET	15.9	FAIL	0.834	FAIL	0.0467	FAIL	0.40	FAIL	6.8	MEET	3.0	OH	1.47	0.100	22.3
		XIH1458	41	2003	3.7	MEET	14.1	MEET	1.257	FAIL	0.0618	FAIL	0.45	FAIL	5.9	MEET	0.9	OH	1.98	0.133	23.4
MIDDLE CHESTER RIVER	Rolphs Wharf	XIH0077	3	2003	6.5	MEET	15.3	FAIL	0.860	FAIL	0.0594	FAIL	0.60	FAIL	6.0	MEET	3.1	OH	1.48	0.121	24.2
				2004	4.6	MEET	13.0	MEET	0.530	FAIL	0.0505	FAIL	0.70	FAIL	7.1	MEET	3.7	OH	1.16	0.093	25.2
				2005	4.5	MEET	15.3	FAIL	0.538	FAIL	0.0500	FAIL	0.55	FAIL	6.3	MEET	5.8	MH	1.13	0.097	24.5
				2006	6.3	MEET	17.2	FAIL	0.496	FAIL	0.0585	FAIL	0.55	FAIL	7.0	MEET	6.5	MH	1.13	0.116	22.1
		XHH9362	40	2003	6.1	MEET	11.3	MEET	0.670	FAIL	0.0551	FAIL	0.55	FAIL	5.7	MEET	3.7	OH	1.28	0.100	23.0
		XHH7848	37	2003	10.5	MEET	10.2	MEET	0.436	FAIL	0.0422	FAIL	0.55	FAIL	5.9	MEET	5.2	MH	1.12	0.091	22.5
		XHH6419	33	2003	23.8	FAIL	10.9	MEET	0.268	FAIL	0.0247	FAIL	0.50	FAIL	7.4	MEET	6.5	MH	1.12	0.079	22.7
				2004	5.0	MEET	6.8	MEET	0.285	FAIL	0.0244	FAIL	1.00	MEET	6.6	MEET	6.1	MH	0.89	0.058	24.9
				2005	14.8	MEET	10.3	MEET	0.170	FAIL	0.0107	FAIL	0.60	FAIL	7.3	MEET	7.9	MH	0.94	0.075	24.9
				2006	11.2	MEET	8.3	MEET	0.172	FAIL	0.0440	FAIL	0.80	FAIL	7.6	MEET	8.5	MH	0.86	0.085	21.6
		XHG6496	32	2003	26.0	FAIL	14.0	MEET	0.049	MEET	0.0061	MEET	0.45	FAIL	7.9	MEET	6.1	MH	1.00	0.064	22.4
				2004	7.1	MEET	9.5	MEET	0.205	FAIL	0.0161	FAIL	0.60	FAIL	7.0	MEET	6.4	MH	0.75	0.049	25.7
				2005	12.9	MEET	8.4	MEET	0.106	FAIL	0.0078	MEET	0.60	FAIL	8.4	MEET	7.8	MH	0.84	0.051	25.9
				2006	12.6	MEET	10.0	MEET	0.065	MEET	0.0135	FAIL	0.60	FAIL	7.5	MEET	9.5	MH	0.84	0.081	21.3
		GYI0001	28	2003	25.9	FAIL	14.7	MEET	0.046	MEET	0.0090	MEET	0.40	FAIL	9.3	MEET	6.3	MH	1.03	0.068	22.5
				2004	10.2	MEET	10.5	MEET	0.071	FAIL	0.0033	MEET	0.50	FAIL	8.2	MEET	6.6	MH	0.79	0.043	25.9
				2005	13.8	MEET	10.8	MEET	0.061	MEET	0.0052	MEET	0.70	FAIL	8.5	MEET	8.1	MH	0.82	0.055	25.9
				2006	16.8	FAIL	11.2	MEET	0.044	MEET	0.0202	FAIL	0.60	FAIL	8.0	MEET	9.0	MH	0.74	0.084	20.9

Shallow water monitoring data prior to 2008 compared to SAV habitat requirements in the Upper Eastern Shore Rivers (continued).

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Diss Oxygen		Salinity		TN	TP	wtemp
LOWER CHESTER RIVER		XHG1579	31	2003	22.1	FAIL	11.5	MEET	0.152	FAIL	0.0058	MEET	0.65	FAIL	9.2	MEET	7.7	MH	0.94	0.045	20.8
				2004	9.0	MEET	6.4	MEET	0.220	FAIL	0.0059	MEET	0.80	FAIL	6.9	MEET	7.6	MH	0.75	0.038	24.4
				2005	12.6	MEET	7.6	MEET	0.152	FAIL	0.0049	MEET	0.70	FAIL	7.8	MEET	9.1	MH	0.82	0.043	24.5
				2006	11.6	MEET	6.0	MEET	0.158	FAIL	0.0160	FAIL	0.90	FAIL	7.5	MEET	10.5	MH	0.81	0.058	21.0
		XGG9992	29	2003	29.1	FAIL	8.5	MEET	0.155	FAIL	0.0055	MEET	0.55	FAIL	10.4	MEET	7.1	MH	0.94	0.055	23.2
				2004	12.0	MEET	6.0	MEET	0.137	FAIL	0.0054	MEET	0.80	FAIL	7.9	MEET	7.4	MH	0.76	0.035	25.3
				2005	16.4	FAIL	4.8	MEET	0.162	FAIL	0.0077	MEET	0.80	FAIL	9.3	MEET	9.1	MH	0.88	0.046	26.1
				2006	24.2	FAIL	6.8	MEET	0.132	FAIL	0.0165	FAIL	0.90	FAIL	9.3	MEET	10.4	MH	0.95	0.067	21.3
		ET4.2	27	2003	21.3	FAIL	8.4	MEET	0.265	FAIL	0.0052	MEET	0.80	FAIL	7.7	MEET	7.2	MH	0.99	0.051	21.9
				2004	11.2	MEET	5.6	MEET	0.302	FAIL	0.0050	MEET	0.90	FAIL	8.6	MEET	7.4	MH	1.09	0.035	23.1
				2005	11.1	MEET	5.2	MEET	0.200	FAIL	0.0053	MEET	1.00	MEET	8.9	MEET	8.7	MH	0.84	0.042	23.4
				2006	12.6	MEET	5.6	MEET	0.211	FAIL	0.0054	MEET	1.00	MEET	8.0	MEET	10.6	MH	0.86	0.046	21.4
				2007	19.1	FAIL	6.0	MEET	0.058	MEET	0.0055	MEET	0.80	FAIL	9.3	MEET	10.3	MH	0.89	0.059	22.0
	Inside SAV bed	XGG8359	4	2007	13.5	MEET	12.3	MEET	0.032	MEET	0.0035	MEET	0.50	FAIL	5.9	MEET	12.3	MH	0.89	0.054	23.4
	Outside SAV bed	XGG8458	2	2007	15.1	FAIL	17.9	FAIL	0.048	MEET	0.0041	MEET	0.45	FAIL	7.1	MEET	11.2	MH	0.93	0.059	23.6
		XGG9992	29	2003	29.1	FAIL	8.5	MEET	0.155	FAIL	0.0055	MEET	0.55	FAIL	10.4	MEET	7.1	MH	0.94	0.055	23.2
		XHG0859	30	2003	16.6	FAIL	5.0	MEET	0.284	FAIL	0.0047	MEET	0.90	FAIL	8.6	MEET	7.6	MH	0.93	0.037	22.0
				2004	15.5	FAIL	6.0	MEET	0.310	FAIL	0.0047	MEET	0.80	FAIL	8.2	MEET	7.2	MH	0.96	0.029	24.6
				2005	20.6	FAIL	9.2	MEET	0.133	FAIL	0.0042	MEET	0.90	FAIL	7.9	MEET	9.4	MH	0.84	0.045	24.1
				2006	12.7	MEET	7.2	MEET	0.178	FAIL	0.0088	MEET	1.00	MEET	8.2	MEET	10.0	MH	0.93	0.050	20.5
CORSICA RIVER		COR0056	34	2006	112.6	FAIL	41.3	FAIL	0.308	FAIL	0.0150	MEET	0.30	FAIL	7.5	MEET	4.0	OH	2.52	0.302	23.1
				2007	72.5	FAIL	34.0	FAIL	0.050	MEET	0.0324	FAIL	0.30	FAIL	8.4	MEET	5.4	MH	2.51	0.289	25.2
	Sycamore Point	XHH3851	8	2005	37.8	FAIL	24.3	FAIL	0.291	FAIL	0.0073	MEET	0.50	FAIL	8.5	MEET	5.8	MH	1.85	0.124	24.9
				2006	49.8	FAIL	27.0	FAIL	0.031	MEET	0.0339	FAIL	0.30	FAIL	7.3	MEET	7.1	MH	1.57	0.181	22.8
				2007	58.7	FAIL	30.4	FAIL	0.028	MEET	0.0402	FAIL	0.30	FAIL	8.1	MEET	6.9	MH	1.84	0.196	25.5
	Possum Point	XHH4931	7	2006	27.8	FAIL	12.7	MEET	0.053	MEET	0.0405	FAIL	0.40	FAIL	7.0	MEET	8.5	MH	1.21	0.115	24.5
				2007	26.2	FAIL	16.5	FAIL	0.046	MEET	0.0262	FAIL	0.40	FAIL	6.4	MEET	9.0	MH	1.13	0.109	25.1
		XHH4916	5	2006	14.1	MEET	12.3	MEET	0.092	FAIL	0.0268	FAIL	0.50	FAIL	7.1	MEET	9.2	MH	1.00	0.081	23.4
				2007	20.0	FAIL	14.7	MEET	0.056	MEET	0.0133	FAIL	0.40	FAIL	7.1	MEET	10.0	MH	0.98	0.069	24.5
	Emory Creek	XHH5046	6	2005	23.2	FAIL	15.8	FAIL	0.105	FAIL	0.0115	FAIL	0.60	FAIL	7.5	MEET	7.8	MH	1.22	0.092	26.7
				2006	46.9	FAIL	20.0	FAIL	0.041	MEET	0.0042	MEET	0.40	FAIL	9.6	MEET	8.6	MH	1.30	0.098	19.3
		XHH4822	36	2003	34.4	FAIL	13.1	MEET	0.048	MEET	0.0090	MEET	0.35	FAIL	8.6	MEET	5.9	MH	1.32	0.076	23.4
				2004	15.5	FAIL	7.2	MEET	0.125	FAIL	0.0060	MEET	0.80	FAIL	7.6	MEET	5.9	MH	0.86	0.042	25.3
				2005	25.9	FAIL	12.8	MEET	0.104	FAIL	0.0074	MEET	0.60	FAIL	8.4	MEET	7.6	MH	1.34	0.094	25.7
	long-term	XHH4742	near 35	2006	44.4	FAIL	18.7	FAIL	0.023	MEET	0.0318	FAIL	0.30	FAIL	8.0	MEET	7.8	MH	1.29	0.131	23.2
				2007	38.9	FAIL	25.4	FAIL	0.026	MEET	0.0306	FAIL	0.40	FAIL	9.0	MEET	8.1	MH	1.23	0.134	24.2
		XHH4528	35	2006	28.2	FAIL	19.3	FAIL	0.081	FAIL	0.0450	FAIL	0.40	FAIL	7.5	MEET	8.6	MH	1.47	0.115	22.8
				2007	26.9	FAIL	15.3	FAIL	0.110	FAIL	0.0272	FAIL	0.40	FAIL	7.5	MEET	8.0	MH	1.24	0.088	25.4

Shallow water monitoring data prior to 2008 compared to SAV habitat requirements in the Upper Eastern Shore Rivers (continued).

	STATION		map#	year	Chla mg/l		TSS mg/l		DIN mg/l		PO4 mg/l		Secchi Depth		Diss Oxygen		Salinity	salzone	TN	TP	wtemp
EASTERN BAY	long-term	EE1.1	48	2004	10.5	MEET	4.6	MEET	0.117	FAIL	0.0059	MEET	1.30	MEET	8.4	MEET	9.6	MH	0.82	0.031	23.6
				2005	12.5	MEET	4.5	MEET	0.071	FAIL	0.0045	MEET	1.30	MEET	7.7	MEET	11.5	MH	0.80	0.037	24.5
				2006	13.8	MEET	4.0	MEET	0.041	MEET	0.0039	MEET	1.10	MEET	8.5	MEET	12.5	MH	0.80	0.037	21.7
		XGG4301	50	2004	6.3	MEET	6.0	MEET	0.173	FAIL	0.0032	MEET	0.90	FAIL	8.1	MEET	9.5	MH	0.83	0.026	24.1
				2005	8.7	MEET	6.0	MEET	0.087	FAIL	0.0036	MEET	0.90	FAIL	7.1	MEET	11.5	MH	0.90	0.032	23.2
				2006	11.6	MEET	9.5	MEET	0.048	MEET	0.0039	MEET	0.80	FAIL	7.5	MEET	11.9	MH	0.74	0.034	21.5
		XGG5115	51	2004	6.1	MEET	6.4	MEET	0.128	FAIL	0.0033	MEET	1.00	MEET	8.6	MEET	9.5	MH	0.76	0.024	25.4
				2005	9.7	MEET	9.0	MEET	0.018	MEET	0.0024	MEET	0.70	FAIL	7.6	MEET	11.3	MH	0.79	0.033	23.9
				2006	12.0	MEET	8.0	MEET	0.052	MEET	0.0041	MEET	0.60	FAIL	8.0	MEET	11.5	MH	0.84	0.039	22.0
		XGG5932	52	2004	4.3	MEET	4.4	MEET	0.141	FAIL	0.0021	MEET	1.20	MEET	7.2	MEET	9.5	MH	0.73	0.025	25.0
				2005	10.5	MEET	5.6	MEET	0.015	MEET	0.0025	MEET	0.70	FAIL	8.0	MEET	11.4	MH	0.78	0.037	24.2
				2006	12.6	MEET	6.0	MEET	0.029	MEET	0.0030	MEET	0.80	FAIL	8.8	MEET	12.1	MH	0.80	0.036	21.7
	CBEC	XGG6667	20	2005	10.0	MEET	12.9	MEET	0.060	MEET	0.0039	MEET	0.70	FAIL	7.6	MEET	11.4	MH	0.86	0.041	25.3
				2006	11.8	MEET	11.1	MEET	0.087	FAIL	0.0044	MEET	0.80	FAIL	7.5	MEET	12.4	MH	0.86	0.050	23.0
		XGG5959	47	2004	6.6	MEET	6.8	MEET	0.307	FAIL	0.0030	MEET	0.90	FAIL	7.7	MEET	8.9	MH	0.85	0.027	23.7
				2005	10.1	MEET	5.0	MEET	0.156	FAIL	0.0066	MEET	0.80	FAIL	7.4	MEET	11.3	MH	0.96	0.050	22.6
				2006	13.1	MEET	5.2	MEET	0.081	FAIL	0.0061	MEET	1.00	MEET	8.3	MEET	12.0	MH	0.82	0.033	21.2
		XGG3479	45	2004	5.3	MEET	6.2	MEET	0.087	FAIL	0.0035	MEET	1.15	MEET	7.2	MEET	9.7	MH	0.71	0.026	23.9
				2005	10.1	MEET	6.0	MEET	0.052	MEET	0.0031	MEET	0.65	FAIL	7.9	MEET	10.5	MH	0.88	0.035	23.5
				2006	12.9	MEET	9.5	MEET	0.025	MEET	0.0035	MEET	0.50	FAIL	8.9	MEET	12.1	MH	0.78	0.044	22.4
	Hambleton Point	XFG9164	22	2004	8.7	MEET	6.5	MEET	0.134	FAIL	0.0075	MEET	0.80	FAIL	7.7	MEET	9.6	MH	0.91	0.043	23.1
				2005	8.6	MEET	8.8	MEET	0.113	FAIL	0.0036	MEET	1.05	MEET	7.4	MEET	11.3	MH	0.83	0.039	23.8
				2006	10.8	MEET	10.0	MEET	0.078	FAIL	0.0056	MEET	0.95	FAIL	7.8	MEET	12.9	MH	0.87	0.046	21.7
		XFG9210	49	2004	10.5	MEET	3.6	MEET	0.233	FAIL	0.0041	MEET	1.20	MEET	8.8	MEET	9.0	MH	0.97	0.024	23.1
				2005	7.6	MEET	4.4	MEET	0.133	FAIL	0.0033	MEET	1.20	MEET	9.1	MEET	11.6	MH	0.69	0.030	23.7
				2006	12.9	MEET	4.0	MEET	0.084	FAIL	0.0050	MEET	1.50	MEET	8.4	MEET	12.2	MH	0.80	0.033	21.4
	Kent Point	XGF0681	21	2004	7.9	MEET	13.0	MEET	0.272	FAIL	0.0058	MEET	0.60	FAIL	8.5	MEET	9.0	MH	0.91	0.044	22.7
				2005	11.1	MEET	17.3	FAIL	0.122	FAIL	0.0038	MEET	0.60	FAIL	8.1	MEET	11.4	MH	0.95	0.043	22.9
				2006	13.3	MEET	13.6	MEET	0.105	FAIL	0.0038	MEET	0.70	FAIL	8.8	MEET	12.4	MH	0.87	0.038	21.8
MILES RIVER		XFH7523	43	2004	14.5	MEET	17.0	FAIL	0.039	MEET	0.0080	MEET	0.50	FAIL	5.7	MEET	8.8	MH	0.98	0.072	25.2
				2005	15.4	FAIL	13.5	MEET	0.038	MEET	0.0428	FAIL	0.50	FAIL	6.2	MEET	10.0	MH	1.03	0.107	23.7
				2006	35.0	FAIL	14.3	MEET	0.031	MEET	0.0499	FAIL	0.50	FAIL	7.0	MEET	10.0	MH	1.45	0.131	22.1
WYE RIVER		XGG4898	46	2004	15.6	FAIL	11.3	MEET	0.013	MEET	0.0133	FAIL	0.65	FAIL	7.6	MEET	9.0	MH	0.73	0.057	24.3
				2005	17.0	FAIL	11.0	MEET	0.025	MEET	0.0259	FAIL	0.60	FAIL	9.7	MEET	10.1	MH	0.86	0.094	24.1
				2006	13.8	MEET	6.4	MEET	0.022	MEET	0.0545	FAIL	0.70	FAIL	9.3	MEET	11.1	MH	0.92	0.118	22.4
		XGG2084	44	2004	12.0	MEET	7.2	MEET	0.067	MEET	0.0049	MEET	1.05	MEET	7.5	MEET	9.8	MH	0.78	0.038	23.9
				2005	10.5	MEET	6.5	MEET	0.089	FAIL	0.0065	MEET	0.80	FAIL	7.9	MEET	11.3	MH	0.92	0.046	23.7
				2006	23.9	FAIL	5.2	MEET	0.044	MEET	0.0096	MEET	0.90	FAIL	8.1	MEET	12.0	MH	0.87	0.075	21.7