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DEPARTMENT OF
NATURAL RESOURCES

2012 Masonville Cove – Patapsco River Shallow Water Monitoring Data Report

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Executive summary

Masonville Cove, a small inlet of the upper tidal Patapsco River, figures in local Baltimore lore as a natural respite from the rigors of early twentieth century city life. However, as the Patapsco River was heavily impacted by pollution from centuries of being a center of commerce and population, so too was Masonville Cove. In 2007, the Maryland Port Administration received a permit to build a dredged material containment facility at the Masonville Marine Terminal, adjacent to Masonville Cove. As part of the mitigation agreement for this project, the Maryland Department of Natural Resources (DNR) first deployed a continuous water quality monitor in the summer of 2009, ahead of the construction of the dredged material containment facility. Since 2009, DNR has continued to deploy a monitor during most of the year, although it has been removed in the winter to prevent icing damage. In continuation of this project, two water quality monitors were deployed in Masonville Cove in the early spring of 2012.

In 2012, water quality conditions in Masonville Cove were heavily influenced by two severe algal blooms that impacted the upper Patapsco River. A mahogany tide in the late spring resulted in anoxic conditions and caused a fish kill of over 100,000 fish in the upper Patapsco. Excessive nutrients in a massive sanitary sewer overflow at the Patapsco Pumping Station may have been a factor in the formation of this bloom. Conditions improved following the fish kill, but the dissolved oxygen threshold failure rate was the highest since DNR began monitoring Masonville Cove. A second severe bloom occurred in mid-September, which was partially composed of a potentially harmful cyanobacteria species. Even with these blooms potentially clouding the water for significant periods of time, clearer conditions prevailed for much of the year due to relatively dry conditions, and the turbidity threshold failure rate in 2012 was the lowest since DNR began monitoring Masonville Cove. Hurricane Sandy impacted the region in late October, which led to a significant discharge event and several sanitary sewer overflows that affected salinity and turbidity. Long-term effects of this storm may not be readily apparent and DNR will, therefore, continue to actively monitor and report on the condition of Masonville Cove and the entire Patapsco River.

Introduction

In 2007, the Maryland Port Administration (MPA) submitted plans to the United States Army Corps of Engineers (USACE) to construct a dredged material containment facility (DMCF) in the vicinity of the Masonville Marine Terminal (Figure 1). The terminal, located on the upper Patapsco River in Baltimore, is a major port for the automotive industry. The design for the DMCF uses sand and clay dikes to contain material dredged from the navigation channels in Baltimore Harbor. The same year, an environmental impact study submitted to USACE suggested mitigation for the project. Mitigation was deemed necessary as the DMCF was to fill 130 acres of tidal open water, cover ten acres of upland habitat, and disturb one acre of vegetated wetland and 0.38 acres of submerged aquatic vegetation (SAV).

In 2012, as continuation of the mitigation plan implemented in 2009, the Resource Assessment Service of the Maryland Department of Natural Resources (DNR) monitored water quality in Masonville Cove adjacent to the DMCF site. In late March, DNR deployed two continuous water quality monitors that collected data every 15 minutes on a suite of water quality parameters, including dissolved oxygen, salinity, temperature, turbidity, pH, and chlorophyll. The two monitors were deployed at the same location, one near the water surface and the other near the bottom. Data from the surface monitor were telemetered to the DNR website "Eyes on the Bay" (www.eyesonthebay.net) and displayed in near real-time. DNR personnel visited the station every two to four weeks to replace the meters, and to collect water samples for analyses of total suspended solids, chlorophyll *a*, and phaeophytin concentrations. The continuous monitoring site at Masonville Cove was one of two continuous monitoring stations located in the upper Patapsco in 2012. The other monitor, deployed near Fort McHenry, was discontinued in 2013 due to funding restrictions.

Description of continuous monitoring

On March 21st, 2012, a data collection device known as a sonde was attached to a piling in Masonville Cove (39.2444°, -76.5957°) with its instrumentation deployed one meter below the water surface (see Figure 1 for station location). This 'surface' data sonde, a YSI™ 6600 V2 (Yellow Springs Instruments, Yellow Springs, OH), housed several water quality sensors (Figure 2). The water quality indicator data collected by each sensor are explained in greater detail in the following section. The sonde collected a reading from each sensor simultaneously every 15 minutes for the duration of its deployment. These readings were stored in the sonde's data memory and sent, by attached cellular telemetry equipment, to DNR headquarters in Annapolis. There, the data were posted on DNR's "Eyes on the Bay" website (www.eyesonthebay.net) for easy public access. This website enables the public to access near real-time water quality data for numerous locations throughout Maryland. The data are called "near real-time" since there is a lag of approximately 30-minutes to one hour between the time that the sonde collects the data and the time that the data are posted on the website.

A second YSI™ 6600 V2 sonde was also attached to the same piling on March 21st, and deployed 1.7m below the water surface. This 'bottom' monitor was part of research project conducted in conjunction with the Smithsonian Environmental Research Center to quantify the relationship between dissolved oxygen levels and the presence of shellfish. The portion of this project conducted at Masonville Cove was completed in 2012 and a manuscript based on this research is currently in preparation for the journal *Ecological Applications*.

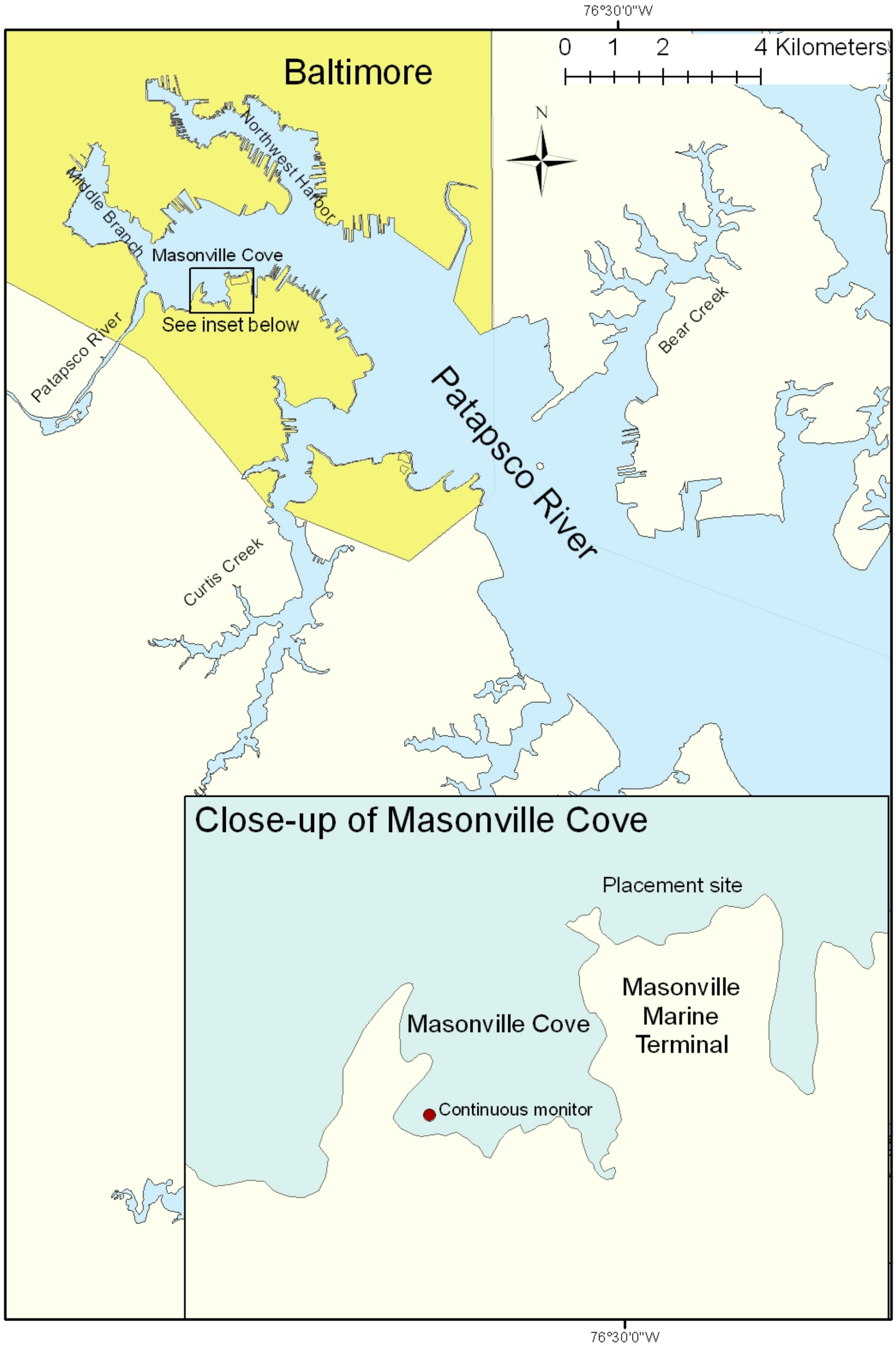


Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows where the continuous monitor is located within the cove as well as the approximate site for dredged material placement.

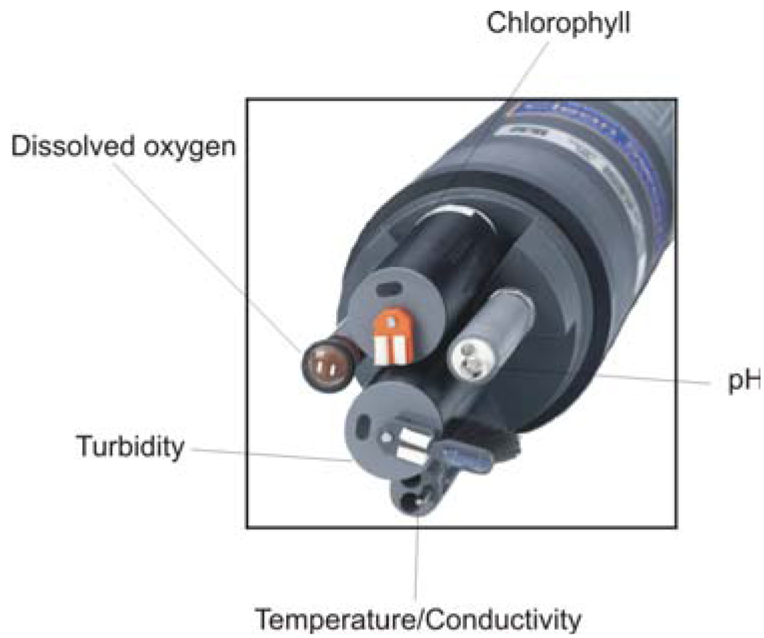


Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

Continuous monitoring parameters

The continuous monitors at Masonville Cove, like all continuous monitors in the DNR Shallow Water Monitoring Program, collected data on six water quality parameters:

1. Dissolved oxygen (DO): Fish and other aquatic life require DO to survive. Maryland state water quality criteria require a minimum DO concentration of 5 milligrams per liter (mg/L) (COMAR 1995). This threshold is necessary for the survival of many fish and shellfish species, including blue crabs (*Callinectes sapidus*) and striped bass (*Morone saxitilis*).
2. Salinity: Salinity, or salt concentration, in the Patapsco River comes from the Chesapeake Bay. Therefore, areas closer to the Bay have higher salinities, except perhaps during large freshwater releases from the Conowingo Dam on the Susquehanna River. During periods of low precipitation and river flow, salinity increases as salty water intrudes further up the river. During wetter periods, salinity decreases. Salinity also cycles in relation to tides, increasing during flood tides and decreasing during ebb tides. Salinity levels are important to aquatic organisms, as some organisms are adapted to live only in brackish or salt water, while others require fresh water.
3. Water temperature: Water temperature is another variable affecting suitability of waterways for aquatic organisms. Many aquatic organisms can tolerate gradual temperature changes associated with changing seasons, but sudden changes can cause stress. Higher water temperatures cause more dissolved oxygen to come out of solution and enter the air, decreasing the amount available to fish and other aquatic organisms.
4. pH: The acidity of water is indicated by pH. A neutral pH is 7; lower values indicate higher acidity, while higher numbers indicate more alkaline conditions. pH is affected by salinity (higher salinities

tend to buffer pH in the 7-8 range) and algae blooms (large algae blooms can raise the pH over 8 in low salinity waters).

5. Turbidity: Turbidity is a measure of water clarity. Events that stir up sediment or cause runoff, such as storms, will increase turbidity. Dense algae blooms will also cause higher turbidities. Relatively clear water (low turbidity) is required for growth and survival of submerged aquatic vegetation (SAV).
6. Chlorophyll: Chlorophyll concentration is a surrogate measure of the amount of algae in the water. Chlorophyll is the main photopigment responsible for photosynthesis, the process by which sunlight is converted into food energy. Chlorophyll concentrations are calculated from fluorescence values collected by the sensors. One downside to this method is that certain species of phytoplankton, such as cyanobacteria or blue-green algae, fluoresce outside the detection range of the chlorophyll fluorescence sensor.

Calibration of continuous monitors and collection of laboratory water samples

Pigments and suspended solids data were obtained by DNR staff during deployment of continuous monitoring data sondes. Discrete whole water samples were collected to measure chlorophyll *a*, phaeophytin, and total suspended solids. Data sondes were removed and replaced with freshly calibrated instruments on a biweekly basis. At the time of each instrument replacement, Secchi disk depth was recorded for use in water clarity determination.

Masonville Cove continuous monitor deployment

In 2012, both the surface and bottom continuous monitors at Masonville Cove were deployed on March 21st. The bottom sonde was removed on October 23rd, and collected 20,741 data records in 2012. The surface sonde remained deployed for the rest of the year and collected 26,126 data records in 2012. Fifteen calibration samples were also collected and analyzed in 2012. Automated telemetry generally operated throughout the deployment of the surface sonde, but there were times when telemetry did not work properly, which led to gaps in near real-time web presentation of the data. Telemetry issues did not, however, impede the sonde from collecting the data. The surface monitor did not, however, collect water quality data between December 18th and the end of the year due to a failure of the sonde. Winter months are generally a time of low biological activity and sondes are often removed during this time to preclude the potential threat of icing damaging the equipment.

2012 Precipitation and Discharge Events

Precipitation increases runoff into waterways, which can lead to a higher discharge of nutrients that fuel algal blooms, decrease water clarity, and suppress SAV growth. Though beyond the scope of sampling for this report, precipitation has also been tied to increased loads of contaminants from urban and industrial centers in and around Baltimore (Leffler and Greer 2001).

Monthly precipitation at Baltimore Washington International (BWI) Thurgood Marshall Airport was below normal for ten of the twelve months in 2012 and only August and October were wetter than normal (Figure 3). Precipitation levels in October were fueled by Hurricane Sandy as approximately 7-inches of rain fell at BWI Marshall Airport when the storm impacted the region October 28th-30th. The 12-month total for 2012, however, fell approximately 3.5-inches below the 20-year average.

Daily mean discharge at the USGS gaging station in the Gwynns Falls reflected a dry spring and a summer punctuated by several brief, high-flow events (Figure 4). Gage data indicate low flows in spring and early summer associated with a dryer than average March, April, and May. Flows during the summer generally reflected the 47-year mean with several brief spikes in flow associated with storm events that impacted the region. Flows associated with Hurricane Sandy were approximately 100 times greater than the 47-year mean, reflecting high discharge levels into the Chesapeake Bay from this storm event. Furthermore, there were twelve reported sanitary sewer overflows associated with Hurricane Sandy that discharged over 4.2-million gallons of diluted sewage into the Patapsco River and related waterways. Additional information on these overflows, and all reported sewer overflows in Maryland, can be found on the Maryland Reported Sewer Overflow Database webpage (http://www.mde.state.md.us/programs/Water/OverFlow/Pages/ReportedSewerOverflow.aspx).

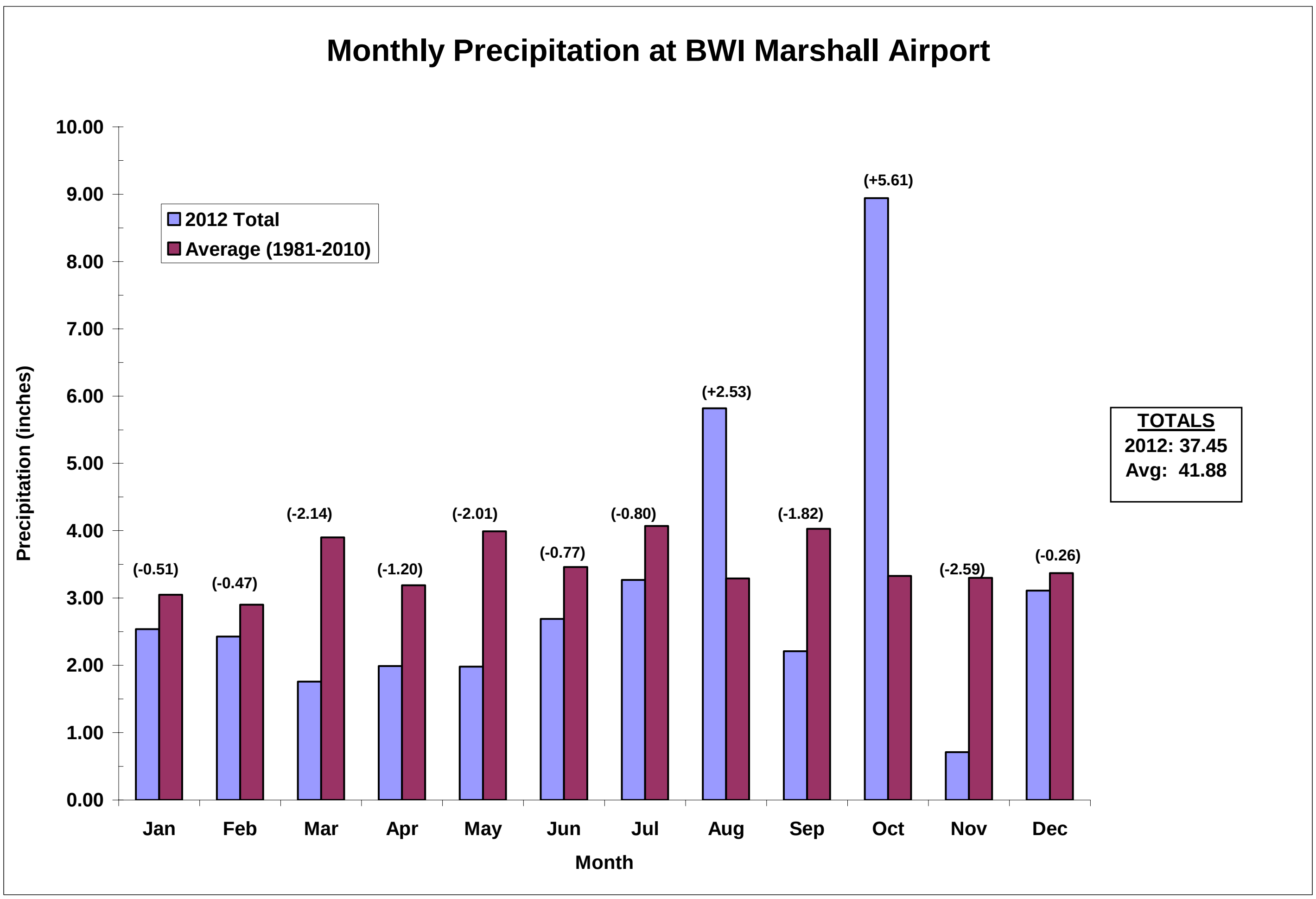


Figure 3. Total monthly precipitation at BWI Thurgood Marshall Airport compared to 20-year averages for 2012. Data source: National Oceanographic and Atmospheric Administration (http://www.erh.noaa.gov/lwx/climate/bwi/bwiprecip.txt).

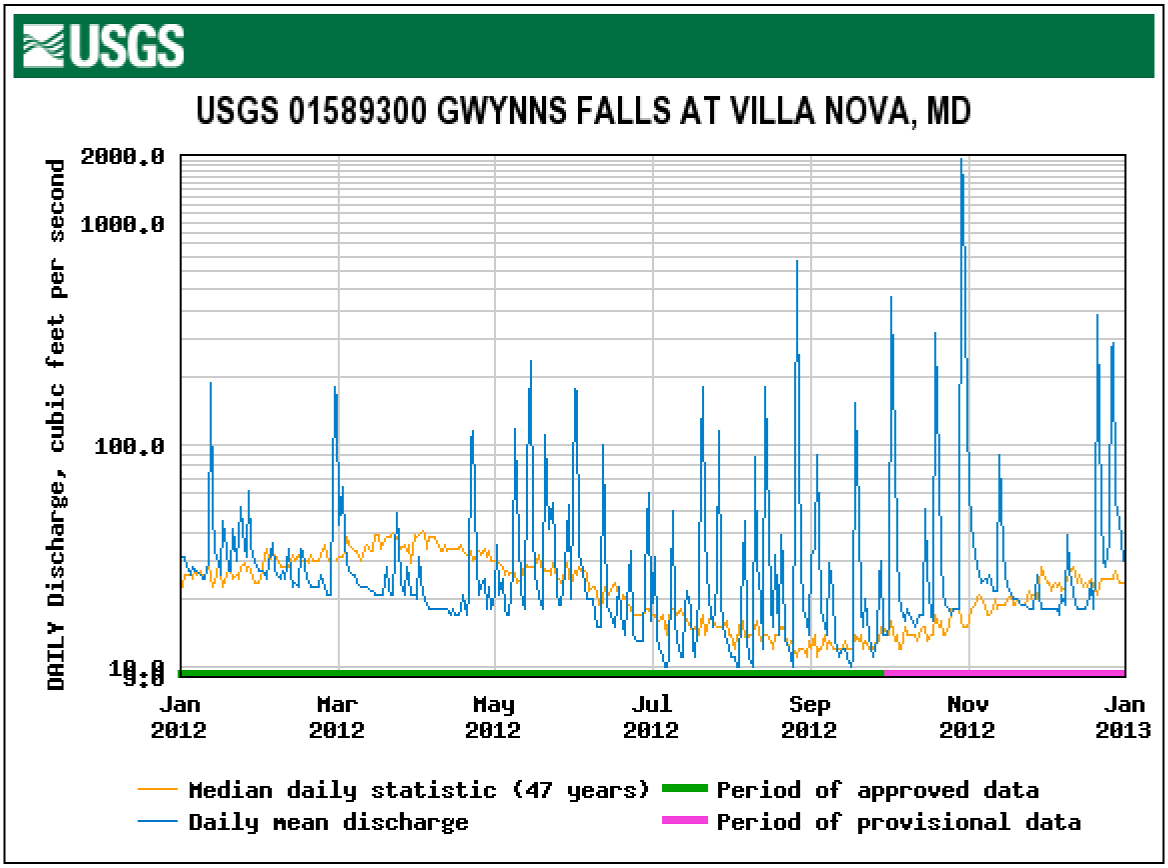
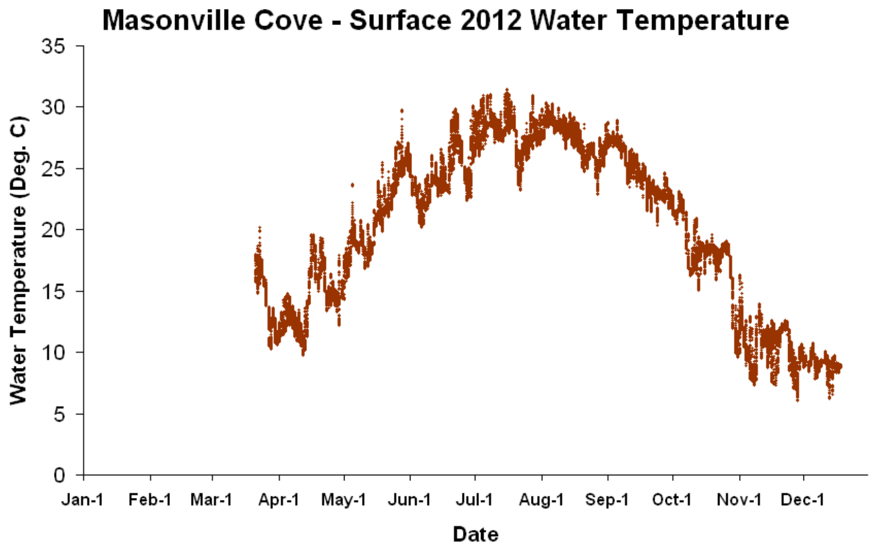


Figure 4. Daily discharge in cubic feet per second measured at a USGS gaging station west of Masonville Cove. The y-axis is in logarithmic scale. Graph courtesy of the United States Geological Survey (http://waterdata.usgs.gov/nwis/dv/?site_no=01589300).

Continuous Monitoring Data

Water Temperature

Water temperature at Masonville Cove rose predictably as air temperatures increased during the summer months and peaked in July (Figure 5). The surface monitor reached a peak of approximately 31°C (~88º F) on July 16th, while the bottom monitor peaked at approximately 30°C (~86º F) on July 28th. Following the July peak, temperature gradually declined through the rest of the year. Variability in the plots in Figure 5 was most likely a result of diel variation in temperature (warming temperatures during the day and cooling temperatures during the night).



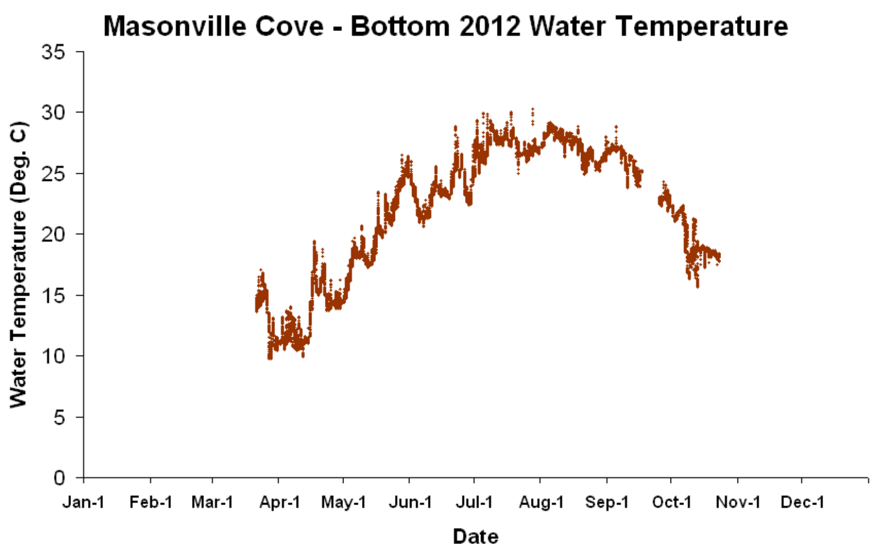


Figure 5. Water temperature at Masonville Cove Surface and Bottom Continuous Monitors during 2012.

Salinity

Salinity tends to vary with precipitation and stream flow. The overall salinity trend in 2012 (Figure 6) began with increasing salinities in spring, coinciding with a dryer than average March and April (Figure 3). Salinity then declined into June, and increased for much of the rest of the year as precipitation and flow declined. There were, however, brief, but steep drops in salinity that coincided with storm events in mid-July, late August, and late October.

The highest salinity of the year occurred in October, shortly before the impacts of Hurricane Sandy led to a brief drop. The surface monitor recorded a high of 15.05 part per thousand (ppt) on October 13th, while the bottom monitor peaked at 15.67 ppt on October 11th. The lowest salinity of the year occurred immediately after Hurricane Sandy, and the associated high run-off events and sewer overflows, affected the region. The surface monitor recorded a low of 0.37 ppt on October 31st. The bottom monitor was not deployed during Hurricane Sandy and, instead, recorded a low of 1.51 ppt on June 2nd.

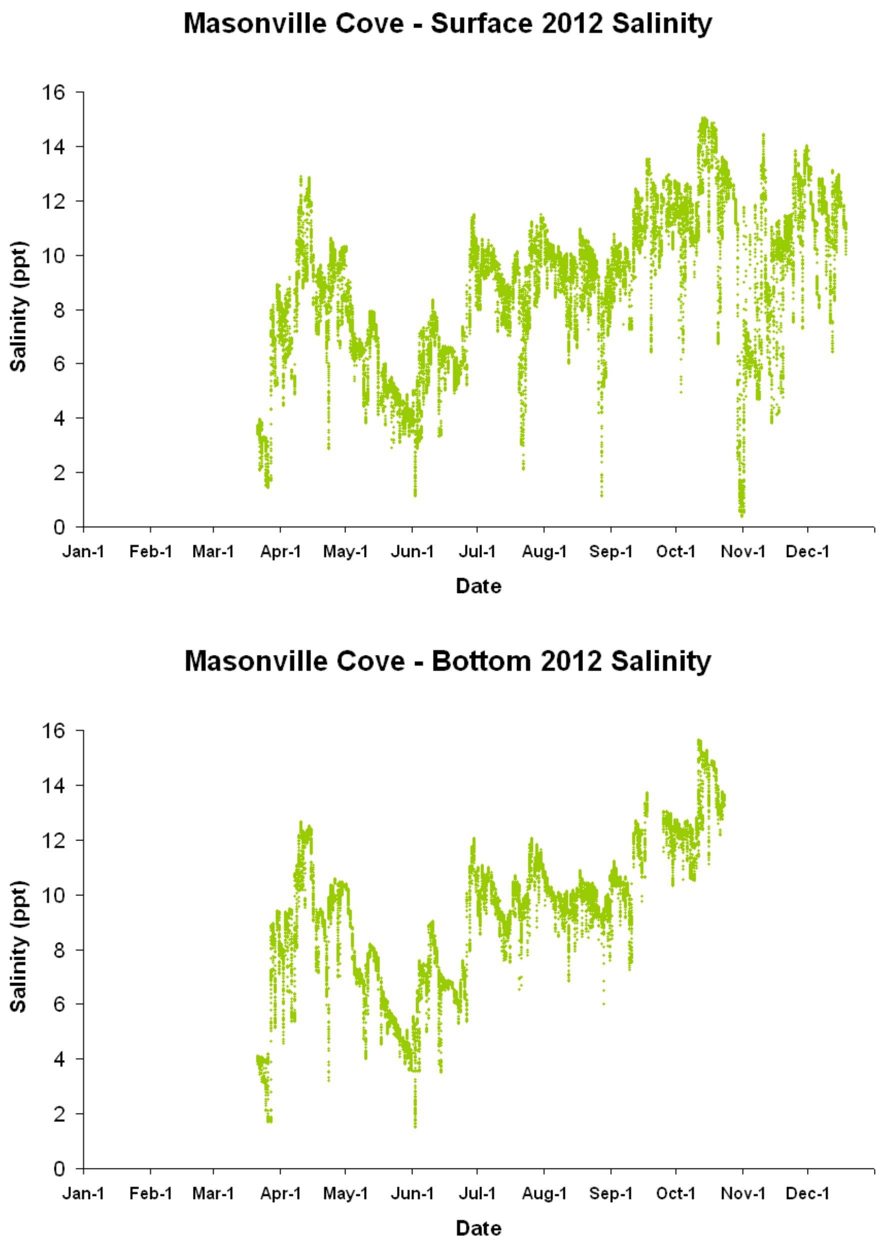


Figure 6. Salinity levels at Masonville Cove Surface and Bottom Continuous Monitors during 2012.

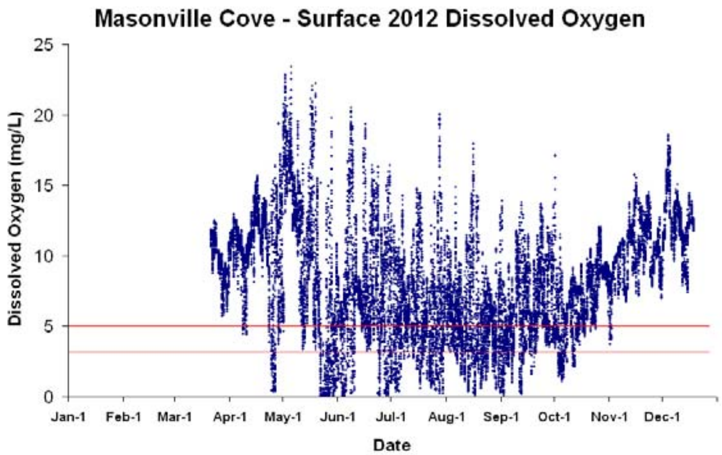
Dissolved Oxygen

After rising through the early spring of 2012, dissolved oxygen (DO) crashed a couple times in late spring following severe algal blooms, and showed a general downward trend throughout the summer before gradually increasing in the fall (Figure 7). The summer decrease and fall increase were expected since warmer water carries less dissolved oxygen, while cooler water can hold more. DO also generally fluctuated on a daily (diel) basis, possibly due to photosynthetic activity and tidal influence.

A large number of DO readings throughout the year were below 5 milligrams per liter (mg/L), which can be detrimental to the survival of juvenile fish (US EPA, 2003). The surface monitor recorded a low DO of 0.06 mg/L on May 22nd, while the bottom monitor recorded a low of 0.01 mg/L on June 10th. The extremely low DO levels in late May were responsible for a fish kill of over 100,000 fish in the upper Patapsco River (http://mddnr.chesapeakebay.net/eyesonthebay/stories/Our%20Bay%20patapsco2012b.pdf).

Algal blooms in waterways are identified by measuring chlorophyll concentrations. Decreases in chlorophyll levels signal the death and decomposition of algal blooms and are often accompanied by a drop in dissolved oxygen levels. The decomposition process can consume significant amounts of dissolved oxygen in the water and can lead to conditions harmful to aquatic organisms. For example, decreases in dissolved oxygen levels to extremely low concentrations at the Masonville Cove surface monitor coincided with drops in chlorophyll levels (Figure 8) on April 26th (0.36 mg/L), May 23rd (0.06 mg/L), June 29th (0.12 mg/L), July 17th (0.61 mg/L), August 20th (0.58 mg/L), September 12th (0.17 mg/L), and October 5th (1.06 mg/L).

As part of the goal of the 1987 Chesapeake Bay Agreement, the signatories agreed “to provide for the restoration and protection of living resources, their habitats and ecological relationships.” Further, the Chesapeake Executive Council (CEC) committed to “develop and adopt guidelines for the protection of water quality and habitat conditions necessary to support the living resources found in the Chesapeake Bay system, and to use these guidelines in the implementation of water quality and habitat protection programs.” A document was produced by the Chesapeake Bay Program outlining dissolved oxygen thresholds for various living resources (Jordan et al. 1992). The State of Maryland adopted these dissolved oxygen thresholds as standards in 1995 (COMAR 1995). For shallow water habitats, the criteria are a 30-day average of 5 mg/L DO and an instantaneous minimum of 3.2 mg/L. Table 1 shows the percentage of time the Masonville Cove DO data fell below these criteria values between April and September, which is generally the time of year that DO values are the lowest due to warmer waters. All of the 2012 values represent an increase in the DO criteria failure percentages from 2011, and the failure rate for the surface monitor was the highest since Maryland DNR began monitoring Masonville Cove in 2009 (Table 1). These results are in direct contrast to observed conditions in the main stem of the Chesapeake Bay. Dry conditions throughout the year (Figure 3) contributed to the smallest summer “Dead Zone” since 1985 (http://mddnr.chesapeakebay.net/eyesonthebay/stories/DeadZoneStatus_Summer2012_090512.pdf).



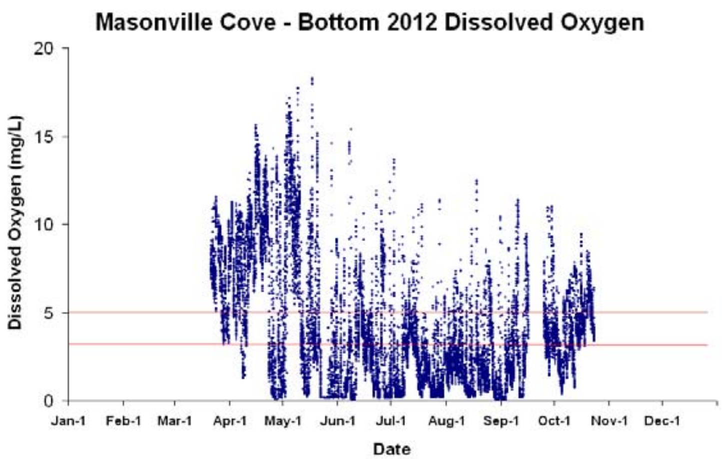


Figure 7. Dissolved oxygen levels at Masonville Cove surface and bottom Continuous Monitors during 2012. Gaps are where data were removed for quality assurance purposes. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove surface and bottom Continuous Monitors during March through October, 2010, and April through September, 2009, 2011, and 2012.

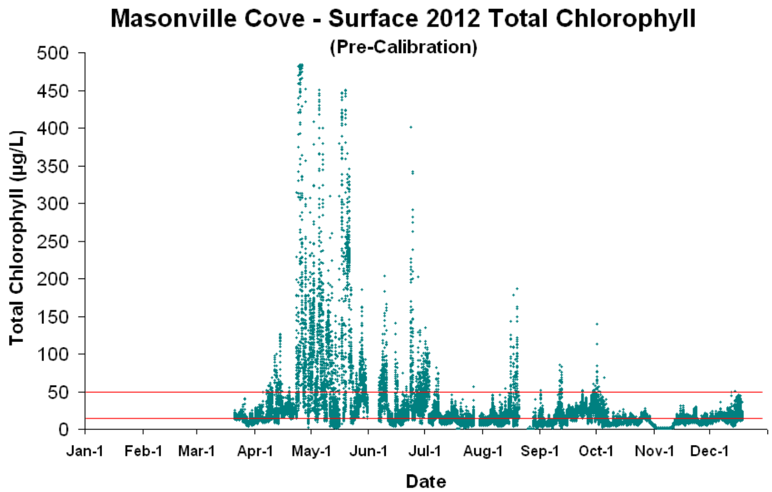
Continuous Monitor	2009	2010	2011	**2012**
Surface				
Dissolved Oxygen less than 5 mg/l	28.29%	20.02%	14.32%	**30.59%**
Dissolved Oxygen less than 3.2 mg/l	9.89%	8.61%	8.17%	**14.20%**
Bottom				
Dissolved Oxygen less than 5 mg/l	N/A	67.16%	54.03%	**71.59%**
Dissolved Oxygen less than 3.2 mg/l	N/A	41.34%	42.67%	**56.93%**

Chlorophyll

Chlorophyll data tend to vary with, and are an indicator of algal (phytoplankton) levels. Spikes above 15 micrograms per liter (µg/L) represent algal blooms that can negatively affect living resources. Chlorophyll concentrations above 50 µg/L represent significant algal blooms, and concentrations above 100 µg/L represent severe blooms. At Masonville Cove in 2012, the number chlorophyll readings above 50 µg/L were the most since DNR began monitoring activities in Masonville Cove (Figure 8; Table 2). Furthermore, a substantial proportion (6.5%) of readings between March and October indicated severe bloom conditions. Most of these elevated readings occurred between late-April and late-May when *Prorocentrum minimum* blooms were documented in the upper Patapsco. *Prorocentrum minimum* is a potentially toxic algal species that, in sufficient concentrations, can cause water to become discolored a reddish-brown and form mahogany tides. The highest chlorophyll concentrations during the 2012 deployment occurred during these late spring blooms. Surface chlorophyll concentrations peaked at 484.7 µg/L on April 25th, while bottom chlorophyll levels rose to 499.4 µg/L on May 2nd (Figure 8). These late-spring blooms may have been partially caused by a massive sanitary sewer overflow on March 25th into the Patapsco River upstream from Masonville Cove (see page 15 for details). Excessive nutrients, particularly nitrogen and phosphorus, flow into waterways with sewer overflows and have the potential to fuel algal blooms.

An additional *Prorocentrum minimum* bloom was documented in mid-September, along with the presence of another species of dinoflagellate (*Karlodinium veneficum*) capable of forming mahogany tides, as well as a potentially harmful cyanobacteria (*Synechococcus*). Additional information on these blooms, and all potential toxic algal blooms throughout Maryland's waterways can be found at DNR's Harmful Algal Bloom website (http://mddnr.chesapeakebay.net/eyesonthebay/habs.cfm).

As stated previously, chlorophyll readings of 15 µg/L and 50 µg/L indicate blooms with potential ecosystem effects and significant blooms, respectively. Table 2 lists the percentage of data readings that violated these thresholds for Masonville Cove during the portion of the 2012 deployment that coincided with SAV growing season (March – October). Algal blooms during this period may impede the ability of SAV to grow and reproduce. Over half of the chlorophyll measurements were greater than 15 µg/L and the failure rate for the 50 µg/L was 17-times greater than the rate in 2011 (Table 2).



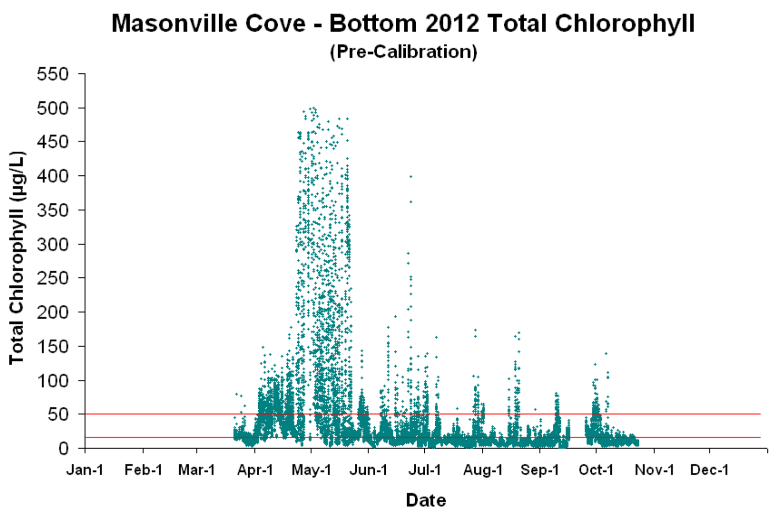


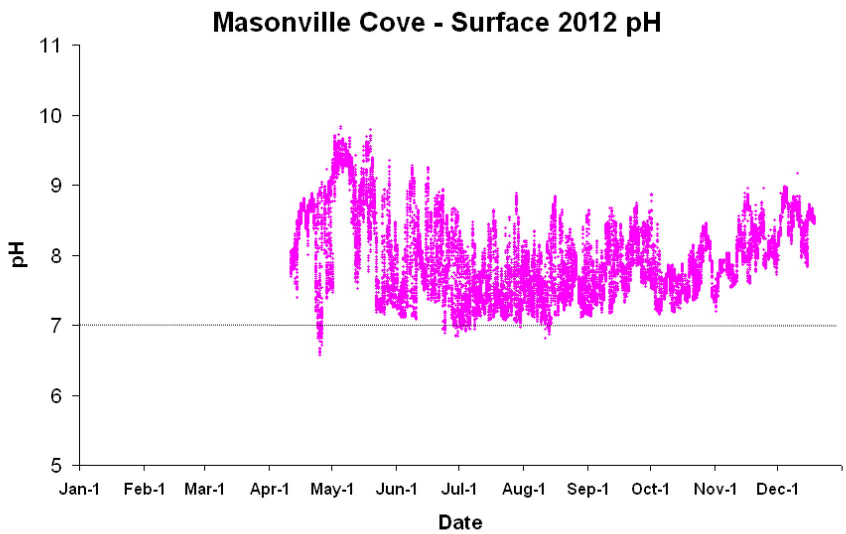
Figure 8. Total chlorophyll levels at Masonville Cove surface and bottom Continuous Monitors during 2012. Gaps are where data were removed for quality assurance purposes. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems---15mg/L-- or are considered significant blooms—50mg/L.)*

Table 2. Chlorophyll threshold failures at Masonville Cove surface and bottom monitors during June through November, 2009, and March through October, 2010 to 2012.

Continuous Monitor	2009	2010	2011	**2012**
Surface				
Readings greater than 15 µg/L	37.37%	58.99%	38.78%	**55.63%**
Readings greater than 50 µg/L	3.28%	6.58%	0.87%	**14.52%**
Bottom				
Readings greater than 15 µg/L	N/A	30.67%	40.57%	**46.87%**
Readings greater than 50 µg/L	N/A	2.30%	4.24%	**15.93%**

pH

pH readings tend to fluctuate between 7 and 9 in most Chesapeake Bay tidal waters, with spikes above 9 indicating potential algal blooms. High pH in the absence of high chlorophyll can also give some indication that a blue-green algal bloom may have occurred (the chlorophyll sensors on the continuous monitors deployed at Masonville Cove were not designed to detect the wavelengths emitted by cyanobacteria). At Masonville Cove in 2012, pH reached its maximum during the late spring algal blooms (Figure 9). Surface pH peaked at 9.84 on May 5th, while bottom pH peaked at 9.53 on May 9th. Additional pH spikes in mid-June and late July also corresponded with documented blue-green algal booms in the upper Patapsco.



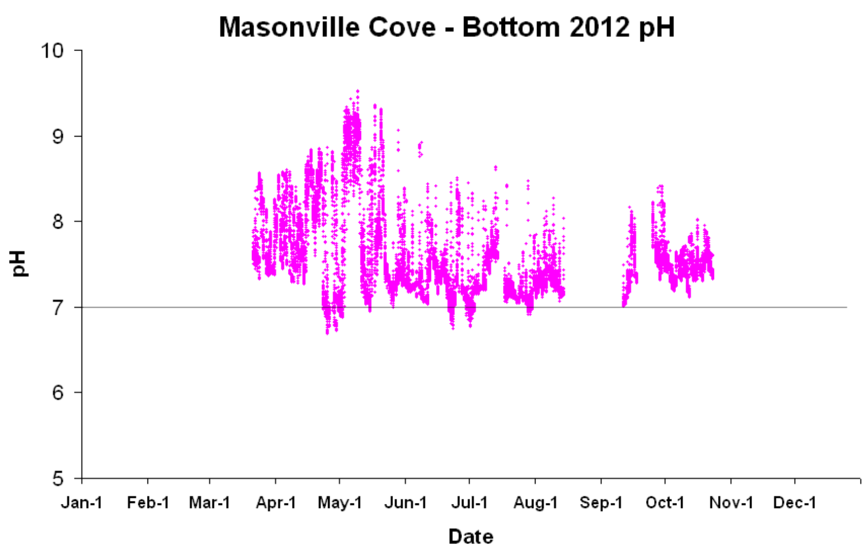


Figure 9. pH levels at Masonville Cove Surface and Bottom Continuous Monitors during 2012. Gaps are where data were removed for quality assurance purposes. *(Line indicates neutral pH.)*

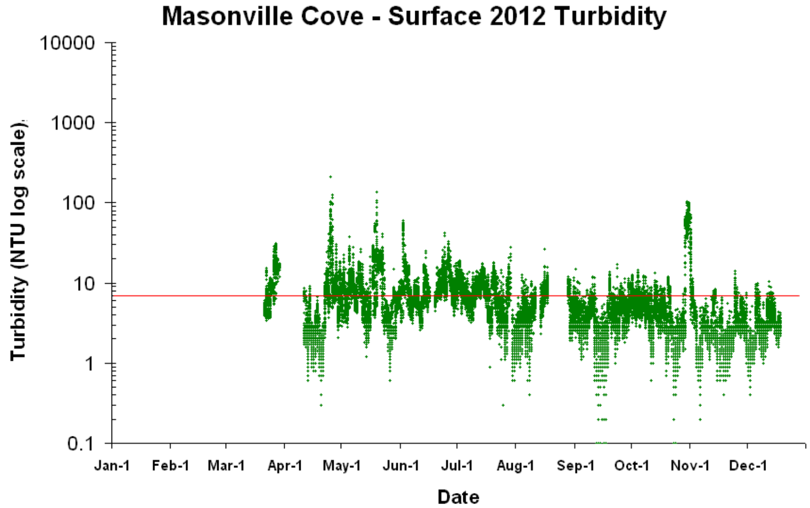
Turbidity

Turbidity is quantified by measuring how much light is reflected from suspended particles in the water and is used to determine water clarity. Lower turbidity values indicate less reflection and, therefore, clearer water, while values above 7 Nephelometric Turbidity Units (NTU) are generally thought to be detrimental to SAV growth based on the effects of elevated turbidity in other systems (M. Trice, MD DNR, personal communication). Masonville Cove turbidity levels at the surface were generally below 7 NTU for much of the year (median value: 4.8 NTU), while turbidity levels near the bottom were significantly higher (median value: 12.1 NTU).

During the year, there were three large spikes when turbidity levels surpassed 100 NTU at the surface, and one spike at the bottom when turbidity approached 500 NTU (Figure 10). Two of the surface spikes (209.4 NTU: April 25th; 137.8 NTU: May 19th) and the bottom spike (479.9 NTU: May 1st) occurred in the late spring when the dense algal bloom (Figure 8) in the upper Patapsco may have negatively impacted water clarity. The third surface spike (105.1 NTU: October 30th) coincided with Hurricane Sandy and the associated discharge events and reported sewer overflows (Figure 4). Storm runoff and sewer overflows carry excess nutrients and sediment that have the potential to cloud waterways for long periods of time.

Additional turbidity spikes on June 2nd (surface: 56.2 NTU; bottom 54.5 NTU) and July 28th (bottom: 97.4 NTU) coincided with significant discharge events at the Gwynns Falls gaging station west of Masonville Cove (Figure 4).

As stated previously, turbidity concentrations above 7 NTU are considered a threshold for detrimental effects on SAV. The surface monitor at Masonville Cove was above this threshold over one-third of the time during 2012 SAV growing season (March through October), and the bottom monitor exceeded this threshold almost 80% of the season (Table 3). However, the turbidity failure rate at the surface was the lowest since DNR began monitoring Masonville Cove in 2009.



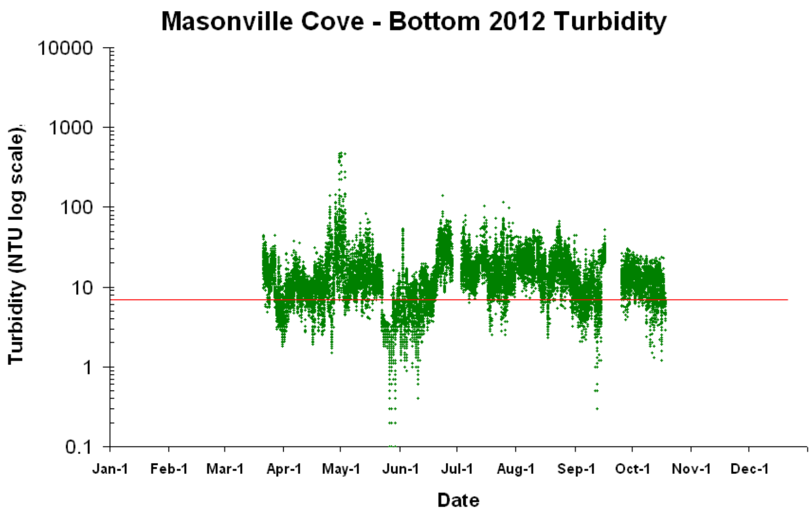


Figure 10. Turbidity levels at Masonville Cove surface and bottom Continuous Monitors during 2012. Gaps are where data were removed for quality assurance purposes. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failures at Masonville Cove surface and bottom monitors during June through September, 2009, and March through October, 2010 to 2012.

Continuous Monitor	2009	2010	2011	**2012**
Surface				
Readings greater than 7 NTU	54.58%	60.09%	51.58%	**35.0%**
Bottom				
Readings greater than 7 NTU	N/A	96.46%	98.25%	**78.44%**

Spring Sanitary Sewer Overflow into the Upper Patapsco River

On March 25th, 2012, the Baltimore County Department of Public Works reported a major sewage overflow at the Patapsco Pumping Station on the 4600 block of Annapolis Road (Figure 11). The overflow, which was caused by a ruptured line, lasted for over three days and spilled an estimated 55-million gallons of diluted sewage into the upper Patapsco River. Additional information on this overflow, and all reported sewer overflows in Maryland, can be found on the Maryland Reported Sewer Overflow Database webpage (http://www.mde.state.md.us/programs/Water/OverFlow/Pages/ReportedSewerOverflow.aspx).

Figure 11. Map of the Patapsco River showing the locations of the reported sanitary sewer overflow on March 25th, 2012, and Maryland DNR's Continuous Monitor at Masonville Cove.

The overflow occurred upstream from Masonville Cove and the deployed continuous monitor captured the immediate and possible longer-term effects of this event. Turbidity at the surface increased from 3.8 NTU on March 24th to 30 NTU on March 27th (Figure 12a), while turbidity at the bottom increased from 5.5 NTU on March 24th to 44.2 NTU on March 27th (Figure 12b). These data indicate an influx of particles and sediment into the system that clouded the water. Furthermore, the surface monitor recorded the steady increase of chlorophyll concentrations in early and mid-April (Figure 12c) as a mahogany tide developed in the upper

Patapsco. This algal bloom may have been fueled by excess nutrients, particularly nitrogen and phosphorus, which entered the system with the sewer overflow.

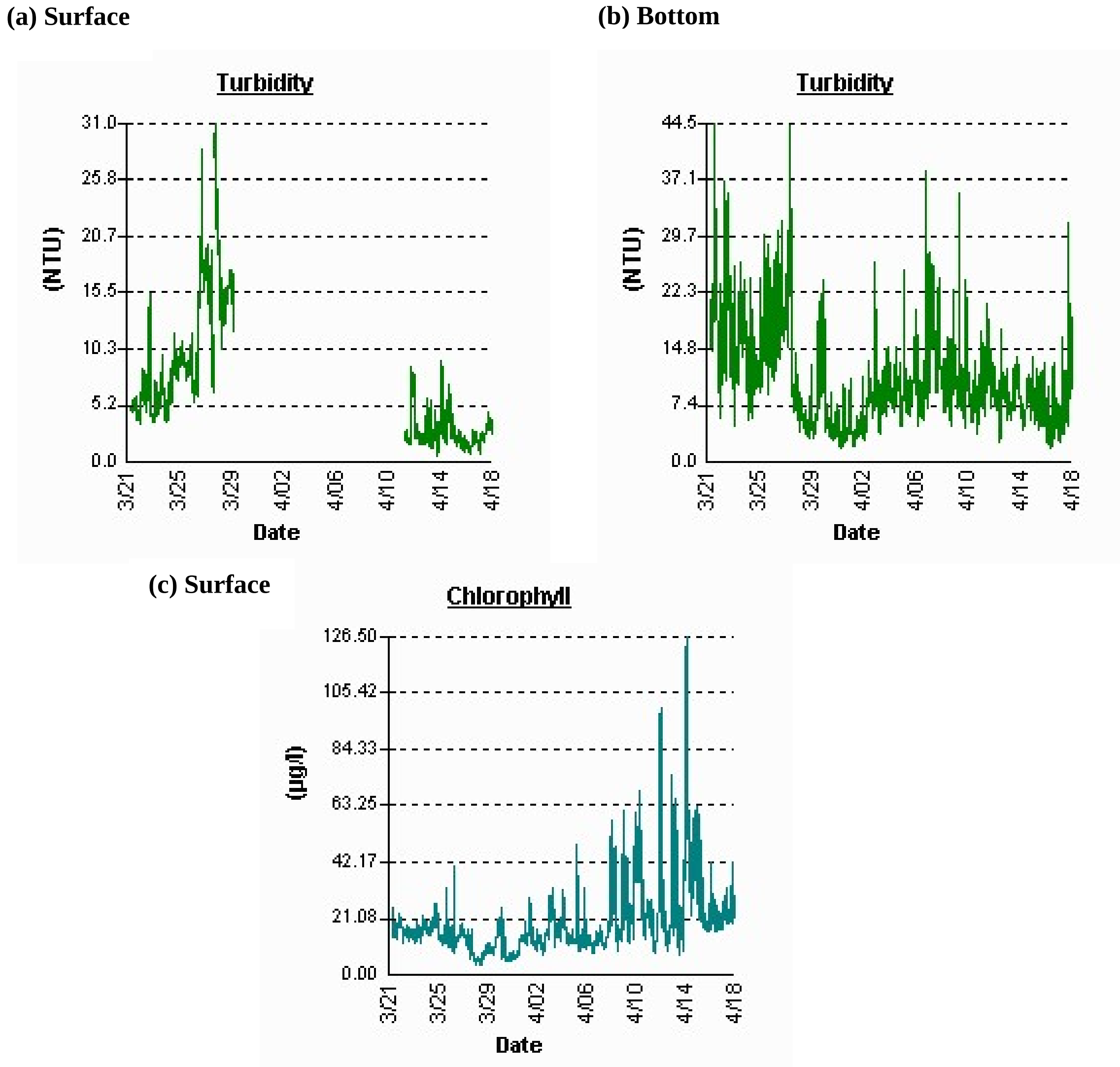


Figure 12. Turbidity levels at the surface (a) and bottom (b), and chlorophyll concentrations at the surface (c) recorded between March 21st and April 18th, 2012 at the Maryland DNR Continuous Monitoring site at Masonville Cove. Gaps are where data were removed for quality assurance purposes.

Anti-virus software updated on internet kiosk at Masonville Cove Environmental Education Center

DNR personnel updated anti-virus software installed on the interactive kiosk in the Masonville Cove Environmental Education Center (MCEEC) on July 23rd, 2012. The kiosk allows MCEEC staff to display real time water quality data from Masonville Cove, and throughout the Chesapeake Bay, through DNR's "Eyes on the Bay" website. The kiosk features a touch-screen as well as a track ball for easy web navigation. The kiosk is protected by software that prevents users from navigating away from the "Eyes on the Bay" or MCEEC websites. MCEEC staff use the kiosk in their education programs, and it is available to MCEEC visitors. Anti-virus software installed on the kiosk is next scheduled to be updated in 2014.

Submerged Aquatic Vegetation (SAV) in the Patapsco River

SAV, or underwater grasses, are an important component of estuarine ecosystems. They provide habitat for juvenile fish and shellfish, supply food for waterfowl, oxygenate the water, and help stabilize bottom sediments. Since 1984, SAV within the Chesapeake Bay and associated tributaries has been assessed annually (with the exception of 1988) by the Virginia Institute of Marine Science (VIMS). Figure 13 shows total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2012.

Total area of SAV within the Patapsco River remains well below the restoration goal of 389 acres. 2005 was the single best year with 72% of the restoration goal achieved, including SAV beds within Masonville Cove. 2004 and 2005 were generally very good years for SAV throughout the Chesapeake Bay region and the increases in coverage have been attributed to an accompanying population explosion and range expansion of dark false mussels (*Mytilopsis leucophaeata*). These filter feeders may have increased water clarity and allowed SAV coverage to significantly expand (L. Karrh, MD DNR, personal communication). In 2006, the mussels died back, SAV beds disappeared in Masonville Cove, and total area of SAV within the Patapsco decreased 83%. In 2010, there was no SAV in the entire Patapsco River. As of 2012, there continued to be no SAV within Masonville Cove, as well as no SAV within the entire Patapsco River.

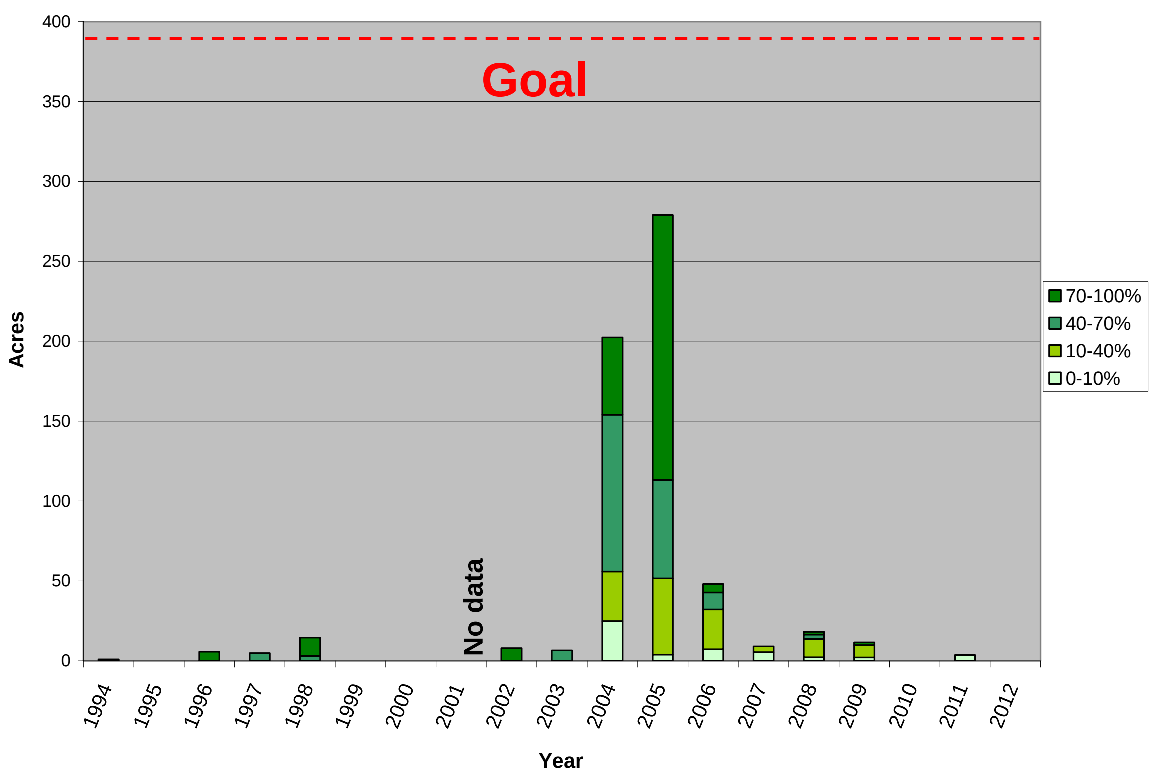


Figure 13. Total area and density of SAV in the Patapsco River. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids, and Secchi Data

Bi-weekly grab samples of water were collected at the Masonville Cove station when the YSI meters were exchanged during Continuous Monitoring cruises. A few samples were collected monthly instead of bi-weekly (Table 4) due to adverse weather conditions that prevented field crews from launching a boat on the scheduled cruise dates. Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected.

The grab samples of water were processed in the field using vacuum filtration, and the resulting particulate samples were delivered to the laboratory for analysis. Samples collected during Continuous Monitoring cruises were analyzed for pigments and suspended solids. All analyses were performed by the University of Maryland's Chesapeake Biological Laboratory (CBL) Nutrient Analytical Services Laboratory (NASL). For details on methods, procedures, analysis, and detection limits, refer to the Quality Assurance Project Plan (QAPP) for the Shallow Water Monitoring Program. This document can be found at http://mddnr.chesapeakebay.net/eyesonthebay/documents/SWM_QAPP_2012_2013_Draft_v2.1.pdf.

Results of the laboratory analyses are presented graphically in Appendix A (Figures A-1 through A-3). Secchi depth measurements are presented in Figure A-4. The suspended sediments, pigments, and Secchi depth data are also presented in Table A-1 of Appendix A.

Ambient water quality data (dissolved oxygen, pH, salinity, and water temperature) were collected concurrently with the grab samples. The data values are presented graphically in Figures A-5 to A-8 in Appendix A. These water quality parameters are measured as a profile, with readings recorded at 0.5m depth intervals at the station. In the graphs, the data range for each profile is represented by a vertical bar for each sample date. The vertical bars are connected by a line that intersects each bar at the mean value for the station on that date. All data values for dissolved oxygen, pH, salinity, and water temperature are provided in Table A-2 of Appendix A.

Table 4: Deployment and calibration record for Masonville Cove continuous monitor 2012.

Scheduled calibration date	Samples collected	Comment
March 21, 2012	No	Initial deployment of surface and bottom sondes.
April 11, 2012	Yes	
April 26, 2012	Yes	Sample collected for measuring *Prorocentrum* bloom.
May 9, 2012	No	Site not visited due to illness of field personnel.
May 22, 2012	Yes	
June 6, 2012	Yes	
June 19, 2012	Yes	
July 3, 2012	Yes	
July 17, 2012	Yes	
July 30, 2012	Yes	
August 14, 2012	Yes	
August 28, 2012	Yes	
September 11, 2012	Yes	Sample collected for measuring algal bloom.
September 25, 2012	Yes	
October 10, 2012	Yes	
October 23, 2012	Yes	Bottom sonde removed for 2012 season.
November 7, 2012	Yes	
November 19, 2012	No	Site not visited due to inclement weather.
December 17, 2012	No	Site not visited due to inclement weather.
December 18, 2012	No	Make-up visit postponed due to inclement weather.

The Patapsco River experienced a large bloom of the algal species *Prorocentrum minimum* during May 2012. Pigmentation in this algal species causes the water to appear reddish-brown in color and creates what is called a “mahogany tide”. The chlorophyll concentrations for Masonville Cove were greater than 150 µg/l during May (Figure A-1) and reflect the presence of this large algal bloom. Also during May, Secchi depth readings were low (Figure A-4), indicating poor water clarity. High chlorophyll concentrations (>100 µg/l) at Masonville Cove were measured once again in September during a large algal bloom, with similar low values of Secchi depth also recorded. Dissolved oxygen values during the May algal bloom showed very low oxygen levels throughout the water column (Figure A-5). A large fish kill that occurred during this time may have been the result of such low oxygen levels. Bottom water dissolved oxygen values remained below 5 mg/l at Masonville Cove throughout the summer months and into September.

Although the weather during 2012 was generally characterized by below-average rainfall, Hurricane Sandy brought significant rain and wind to the region in late October. While the storm resulted in lower salinity values at Masonville Cove due to the increased freshwater input (Figure A-6), the data did not show a prolonged decrease in water clarity as suspended solids concentrations remained low and secchi disk depth actually increased following the storm (Figures A-3 and A-4).

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2012. Continuous monitoring data provide a critical function for assessing the health of Maryland’s tidal waters in areas historically lacking water quality information. Shallow water data provide information about the effects of nutrient pollution and weather events on the Patapsco River and in Masonville Cove. In 2012, a late spring mahogany tide led to severely low dissolved oxygen conditions and a massive fish kill in the upper Patapsco River. A second severe bloom occurred in late summer, which contained a potentially toxic species, but overall water clarity was good due to the dry conditions for much of the year. However, no submerged aquatic vegetation was found in Masonville Cove and total acreage is well below the goal for the river as a whole. Therefore, conditions remain poor for living resources in the upper Patapsco River.

Shallow water monitoring information is not only used for characterizing the health of shallow water habitats, but it is also useful for: 1) assessing Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow water habitats; 2) determining attainment or non-attainment of shallow water habitats for their designated uses; 3) assessing SAV habitats and identifying potential SAV restoration sites; 4) providing information to better understand ecosystem processes and the impact of extreme events (e.g. hurricanes, high flows, sanitary sewer overflows) in shallow water and open water environments; 5) providing data for calibrating the Bay Eutrophication and Watershed Model; and 6) assessing mitigation efforts in relation to the dredged material containment facility at the Masonville Marine Terminal.

References

COMAR (Code of Maryland Regulations). 1995. Code of Maryland Regulations: 26.08.02.03 – Water Quality Criteria Specific to Designated Uses. Maryland Department of the Environment. Baltimore, Maryland.

Jordan, S., C. Stegner, M. Olson, R. Batiuk, and K. Mountford. 1992. Chesapeake Bay dissolved oxygen goal for restoration of living resources habitats. Chesapeake Bay Program, Reevaluation Report #7c. CBP/TRS88/93. Annapolis, Maryland.

Leffler, M. and J. Greer. 2001. Taking on toxics in Baltimore Harbor. Maryland Marine Notes 19(2). http://www.mdsg.umd.edu/MarineNotes/Mar-Apr01/

Appendix A

Results of laboratory and ambient water quality analyses for:
Masonville Cove (Station XIE4741)

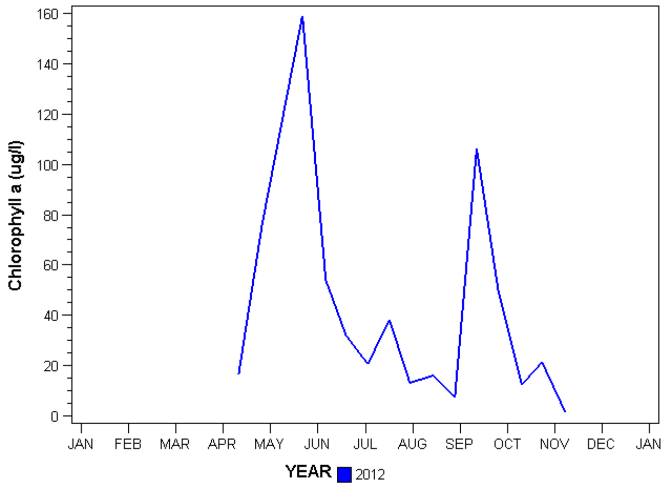


Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2012.

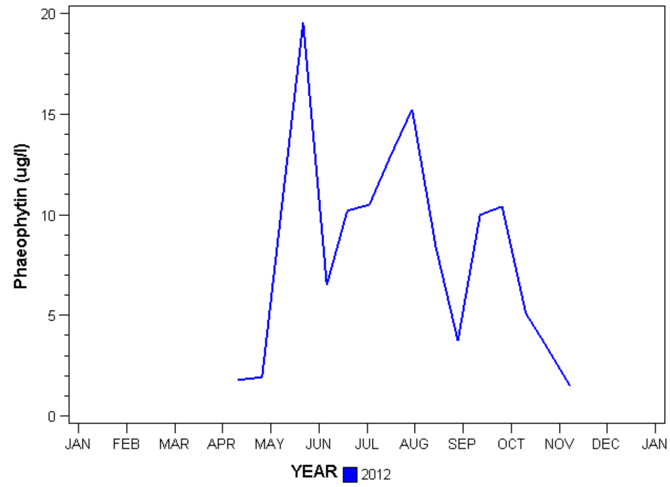


Figure A-2. Phaeophytin concentrations at Masonville Cove in 2012.

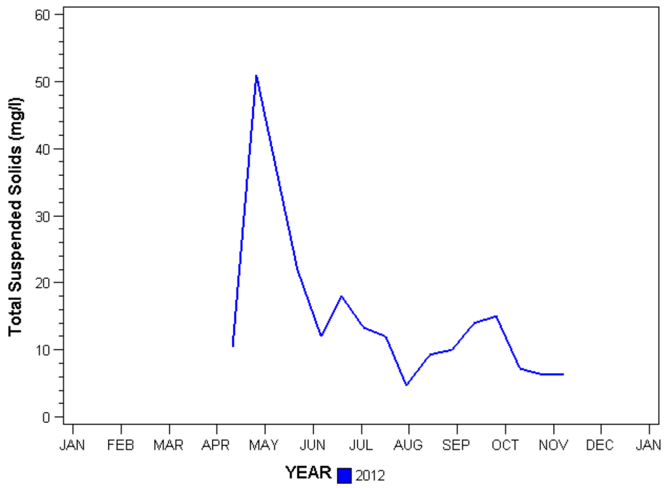


Figure A-3. Total suspended solids concentrations at Masonville Cove in 2012.

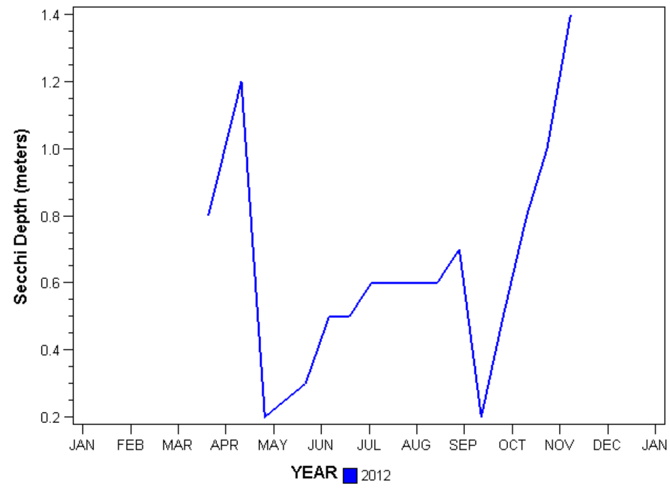


Figure A-4. Secchi depth at Masonville Cove in 2012.

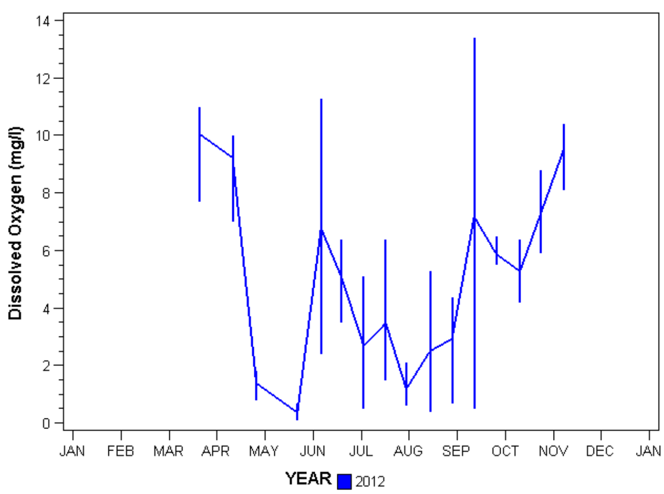


Figure A-5. Dissolved oxygen concentrations at Masonville Cove in 2012.

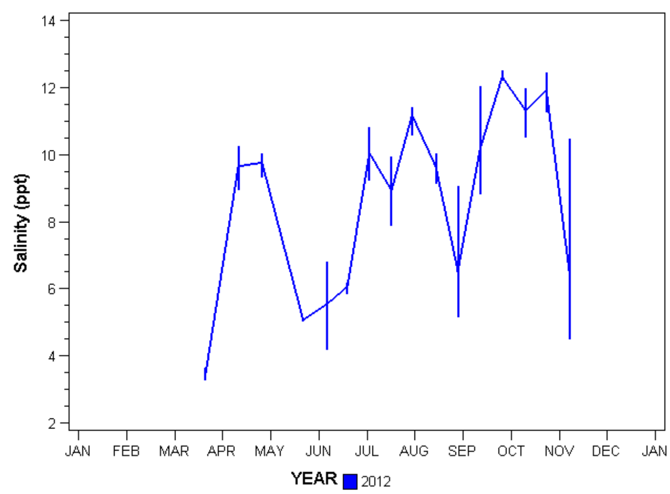


Figure A-6. Salinity concentrations at Masonville Cove in 2012.

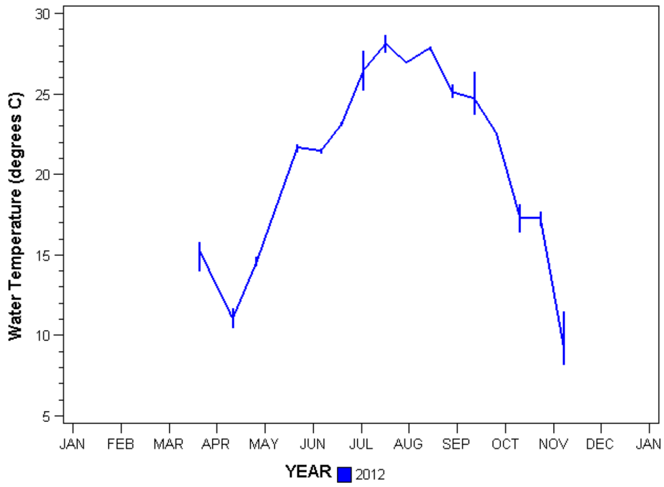


Figure A-7. Water temperature at Masonville Cove in 2012.

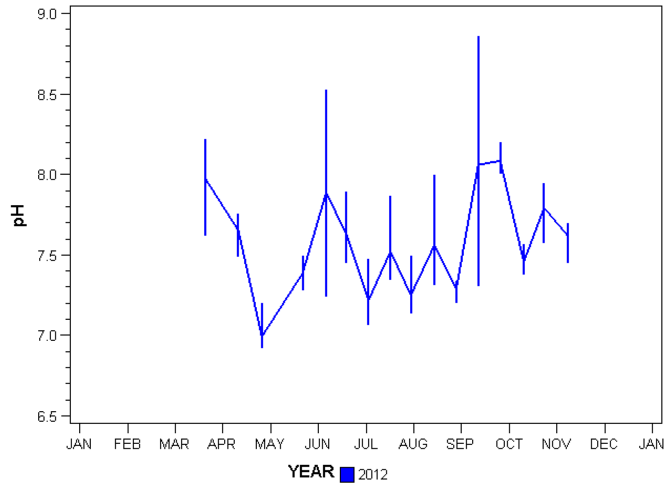


Figure A-8. Values of pH at Masonville Cove in 2012.

Vertical bars within a graph represent the data range for each profile and are intersected at the mean value.

Table A-1. Discrete Continuous Monitoring Data for Chlorophyll-a, Phaeophytin, Total Suspended Solids, and Secchi Disk Depth for Masonville Cove (XIE4741) in 2012.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Phaeophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
03/21/12	1.0				0.8
04/11/12	1.0	16.447	1.794	10.5	1.2
04/26/12	1.0	75.828	1.922	51.0	0.2
05/22/12	1.0	159.132	19.544	22.0	0.3
06/06/12	1.0	54.041	6.515	12.0	0.5
06/19/12	1.0	32.040	10.199	18.0	0.5
07/03/12	1.0	20.648	10.502	13.3	0.6
07/17/12	1.0	38.181	13.030	12.0	0.6
07/30/12	1.0	13.172	15.237	4.7	0.6
08/14/12	1.0	16.020	8.402	9.3	0.6
08/28/12	1.0	7.476	3.738	10.0	0.7
09/11/12	1.0	106.266	9.986	14.0	0.2
09/25/12	1.0	49.395	10.413	15.0	0.5
10/10/12	1.0	12.389	5.105	7.2	0.8
10/23/12	1.0	21.360	3.460	6.4	1.0
11/07/12	1.0	1.495	1.495	6.4	1.4

Table A-2. Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity, and Water Temperature for Masonville Cove (XIE4741) in 2012 (continued on next page).

Date	Sample Depth (m)	D.O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
03/21/12	0.5	11.0	8.22	3.26	15.7
03/21/12	1.0	10.9		3.40	15.8
03/21/12	1.5	10.6	8.08	3.27	15.6
03/21/12	2.0	7.7	7.62	3.65	14.0
04/11/12	0.5	10.0	7.76	8.96	10.5
04/11/12	1.0	10.0	7.63	9.58	10.9
04/11/12	1.5	9.9	7.73	9.78	11.1
04/11/12	1.8	7.0	7.49	10.28	11.7
04/26/12	0.5	1.3	6.94	9.31	14.9
04/26/12	1.0	1.8	7.20	9.65	14.8
04/26/12	1.5	1.7	6.96	9.91	14.3
04/26/12	2.0	0.8	6.92	9.91	14.3
04/26/12	2.4	1.3	6.94	10.04	14.3
05/22/12	0.5	0.2	7.34	5.03	21.9
05/22/12	1.0	0.7	7.28	5.12	21.8
05/22/12	1.5	0.1	7.38	5.08	21.7
05/22/12	2.0	0.2	7.43	5.08	21.6
05/22/12	2.5	0.6	7.50	5.06	21.4
06/06/12	0.5	11.3	8.50	4.19	21.4
06/06/12	1.0	10.9	8.53	4.38	21.3
06/06/12	2.0	2.4	7.24	6.77	21.6
06/06/12	2.8	2.5	7.28	6.82	21.6
06/19/12	0.5	6.4	7.82	5.85	23.3
06/19/12	1.0	6.4	7.90	6.06	23.2
06/19/12	1.5	5.0	7.46	6.06	23.0
06/19/12	2.0	3.5	7.45	6.16	23.0
06/19/12	2.4	4.0	7.50	6.19	23.1
07/03/12	0.5	5.1	7.35	9.23	27.7
07/03/12	1.0	5.1	7.48	9.35	27.5
07/03/12	1.5	2.1	7.11	10.07	26.6
07/03/12	2.0	0.6	7.07	10.75	25.4
07/03/12	2.3	0.5	7.07	10.82	25.2
07/17/12	0.5	6.4	7.87	7.89	28.7
07/17/12	1.0	3.9	7.45	8.47	28.3
07/17/12	1.5	1.5	7.35	9.40	27.9
07/17/12	2.2	2.1	7.42	9.97	27.6
07/30/12	0.5	2.1	7.27	10.56	26.9
07/30/12	1.0	1.3	7.50	11.43	27.0
07/30/12	1.5	1.3	7.19	11.28	27.0
07/30/12	2.0	0.6	7.14	11.28	26.9
07/30/12	2.3	0.6	7.15	11.34	26.9

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity, and Water Temperature for Masonville Cove (XIE4741) in 2012.

Date	Sample Depth (m)	D.O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
08/14/12	0.5	5.3	8.00	9.14	27.7
08/14/12	1.0	4.3	7.83	9.45	27.7
08/14/12	1.5	1.5	7.35	9.72	27.9
08/14/12	2.0	1.0	7.31	9.85	28.0
08/14/12	2.3	0.4	7.31	10.04	28.0
08/28/12	0.5	3.9	7.34	5.18	24.8
08/28/12	1.0	4.4	7.32	5.23	24.9
08/28/12	1.5	2.7	7.30	6.62	25.2
08/28/12	2.0	0.7	7.20	9.08	25.6
09/11/12	0.5	13.4	8.66	8.84	23.7
09/11/12	1.0	12.4	8.86	8.88	23.8
09/11/12	1.5	2.4	7.41	10.87	25.0
09/11/12	2.2	0.5	7.31	12.06	26.4
09/25/12	0.5	5.8	8.08	12.26	22.6
09/25/12	1.0	6.5	8.20	12.54	22.6
09/25/12	1.5	5.7	8.05	12.26	22.5
09/25/12	2.2	5.5	8.01	12.21	22.6
10/10/12	0.5	6.4	7.57	10.51	16.4
10/10/12	1.0	6.0	7.38	11.24	17.1
10/10/12	1.5	4.5	7.45	11.48	17.6
10/10/12	2.2	4.2	7.43	11.98	18.2
10/23/12	0.5	7.8	7.92	11.28	16.8
10/23/12	1.0	8.8	7.95	11.87	17.0
10/23/12	1.5	6.5	7.72	12.06	17.7
10/23/12	2.1	5.9	7.58	12.47	17.6
11/07/12	0.5	10.3	7.68	4.49	8.2
11/07/12	1.0	10.4	7.65	5.15	8.4
11/07/12	1.5	9.4	7.70	5.18	8.5
11/07/12	2.0	8.1	7.45	10.50	11.5