2015 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) 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 in prior years due to icing conditions. In continuation of this project, a water quality monitor was deployed off the Masonville Cove pier during the entirety of 2015.

Water quality conditions in Masonville Cove during 2015, as in the rest of the Chesapeake Bay watershed, were influenced by meteorological events. Heavy rains in June and several associated sanitary sewer overflows led to large discharge events that affected salinity and turbidity. Rains in September were also associated with reduced water clarity and the highest levels of Total Suspended Solids (TSS) measured in 2015. After two years of improvement, chlorophyll and dissolved oxygen concentrations degraded and a potentially toxic dinoflagellate species, *Prorocentrum minimum*, was measured at high concentrations in Masonville Cove in early December. All 2015 continuous monitoring data, as well as data from previous years, are available on the DNR "Eyes on the Bay" website (www.eyesonthebay.net). Data from grab samples are available through the Chesapeake Bay Program's Data Hub (www.chesapeakebay.net/data).

Please note that as of the publication date of this document, DNR's "Eyes on the Bay" website is not available to users due to ongoing, major technical revisions to the website. Masonville Cove data collection continues, however, and any parties interested in receiving data while the website is unavailable can send data requests to eyesonthebay.dnr@maryland.gov.

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 2015, 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. DNR deployed a continuous water quality monitor that collected data every 15 minutes on a suite of water quality parameters, including dissolved oxygen, salinity, temperature, turbidity, pH, and chlorophyll. Data from this 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 the only continuous monitoring station located in the upper Patapsco in 2015.

Description of continuous monitoring

For the entirety of 2015, a data collection device known as a sonde was attached to a piling on the Masonville Cove pier (39.2447°, -76.5972°) with its instrumentation deployed one meter below the water surface (see Figure 1 for station location). This location is approximately one-tenth of a mile west of the deployment location used prior to 2013 (Figure 1). The location change was made so that DNR field personnel would be able to access the site during winter months, which allows the monitor to be deployed year-round. Prior to 2013, the site was only accessible by boat so the monitor needed to be removed during the winter months when icing at the boat ramp precluded access. The data sonde deployed in Masonville Cove was a YSI™ 6600 V2 (Yellow Springs Instruments, Yellow Springs, OH), which 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. However, a major technical revision to the website began on October 1st, 2015. Therefore, as of the publication date of this document, the "Eyes on the Bay" website is unavailable to users. We expect the website to be back online in the near future and the public will then have access to 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.

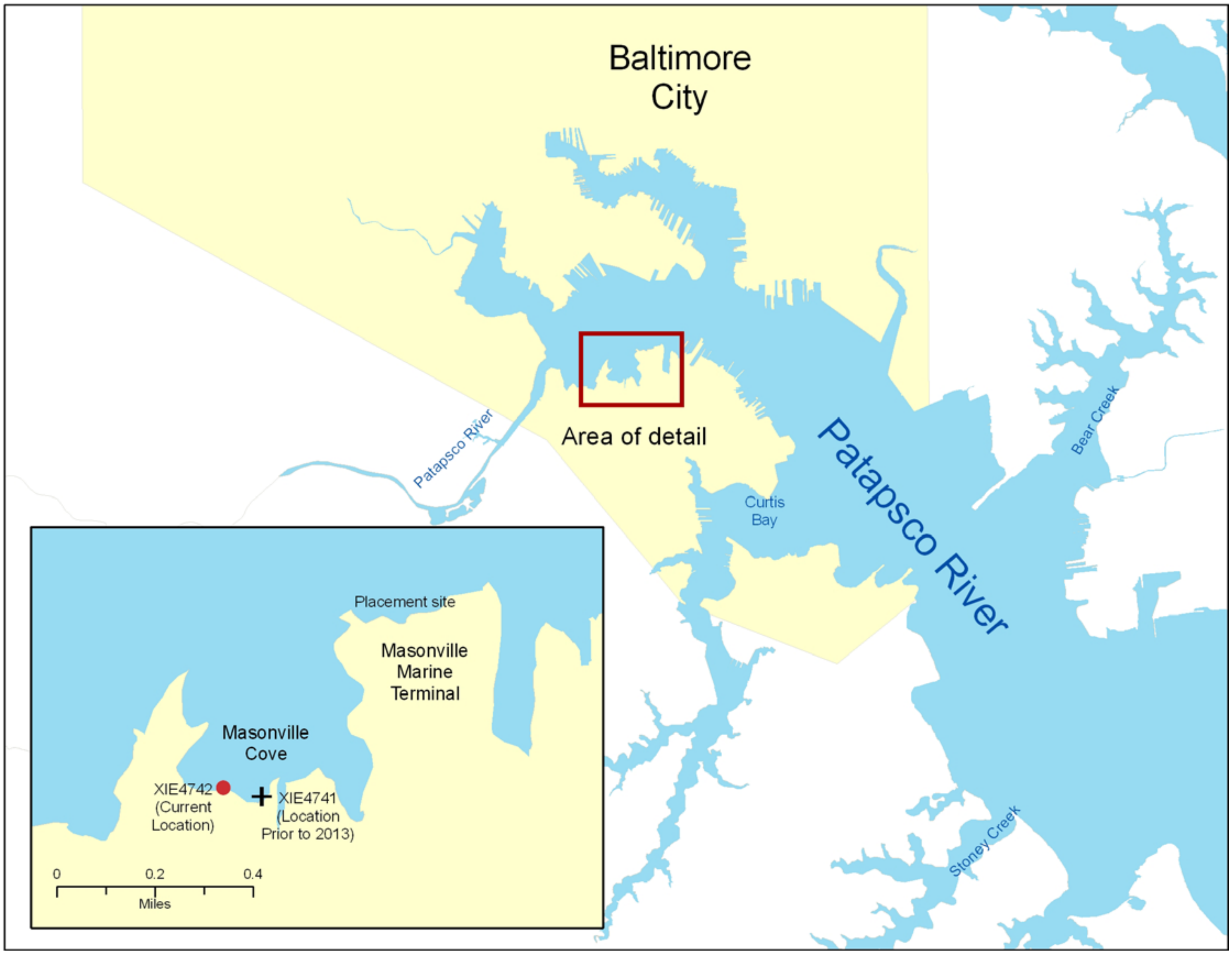

Figure 1. Map of the Patapsco River and Masonville Cove. The inset shows the 2015 continuous monitor location within the cove, the location of the monitor prior to 2013, and the approximate site for dredged material placement.

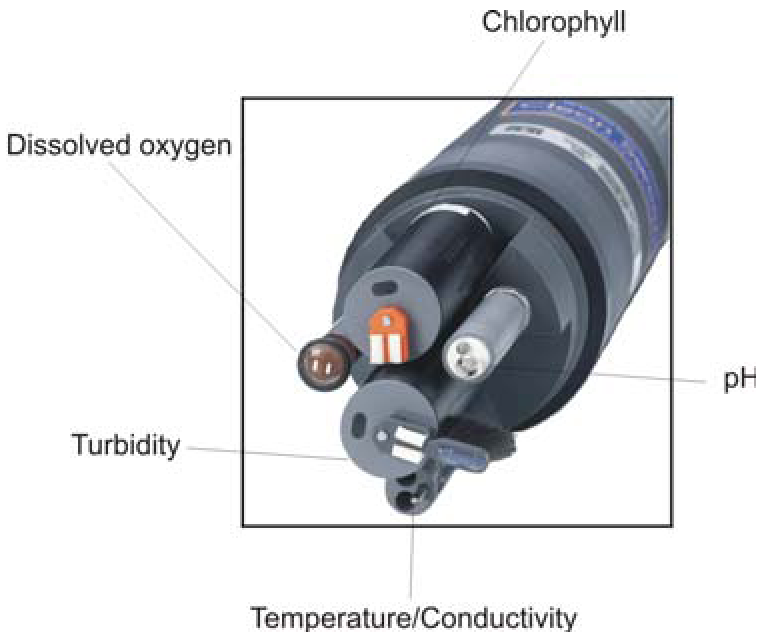

Figure 2. YSI 6600 continuous monitoring sonde showing individual sensors. Image courtesy of YSI, Inc.

Continuous monitoring parameters

The continuous monitor 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 between April and October, and once a month between November and March. At the time of each instrument replacement, Secchi disk depth was recorded for use in water clarity determination.

Masonville Cove continuous monitor deployment

In 2015, the continuous monitor at Masonville Cove was deployed the entire year. Data sondes collected 34,042 data records and 19 calibration samples were collected and analyzed in 2015. Automated telemetry generally operated throughout the deployment of the 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 data. Between June 14th and June 25th, a sonde malfunction did prevent data collection. Also, a failure of the temperature probe between February 11th and March 24th caused temperature data values and the other collected parameters, all of which are temperature dependent, to be flagged as suspect values. Additional gaps seen in the data are where questionable data were removed for quality assurance purposes.

2015 Precipitation and Discharge Events

Precipitation increases runoff into waterways, which can lead to a higher input of nutrients that fuel algal blooms, decrease water clarity, and suppress SAV growth. Although 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).

Annual precipitation for 2015 at Baltimore Washington International (BWI) Thurgood Marshall Airport was over 9-inches greater than the 30-year average (Figure 3). However, over 25% of the total precipitation in 2015 fell in the month of June, which broke the previous monthly precipitation record by over 3-inches. Preciptation totals over the remaining eleven months were roughly equivalent to the long-term average. June, March, April, and December all had monthly precipitation totals greater than 4-inches. The largest single event of 2015 occurred on June 27th as over 3-inches of rain fell in Central Maryland. The driest month in 2015 was May with a rainfall deficit of almost 50% below the long-term average.

Daily mean discharge at the USGS gaging station in the Gwynns Falls reflected the pattern of precipitation seen in 2015 (Figure 4). Gage data show numerous spikes throughout 2015, which are indicative of the precipitation events that affected the region during the year. The largest spikes occurred during the heavy rains in late June, and in early October when over 2-inches of rain fell on the region over a three day period. Both of these flow events were over 600-times greater than the daily median measured over 50-years, reflecting very high discharge levels into the Patapsco River and Chesapeake Bay. Flows in May and August, two of the driest months in 2015, were below the daily median for much of those months.

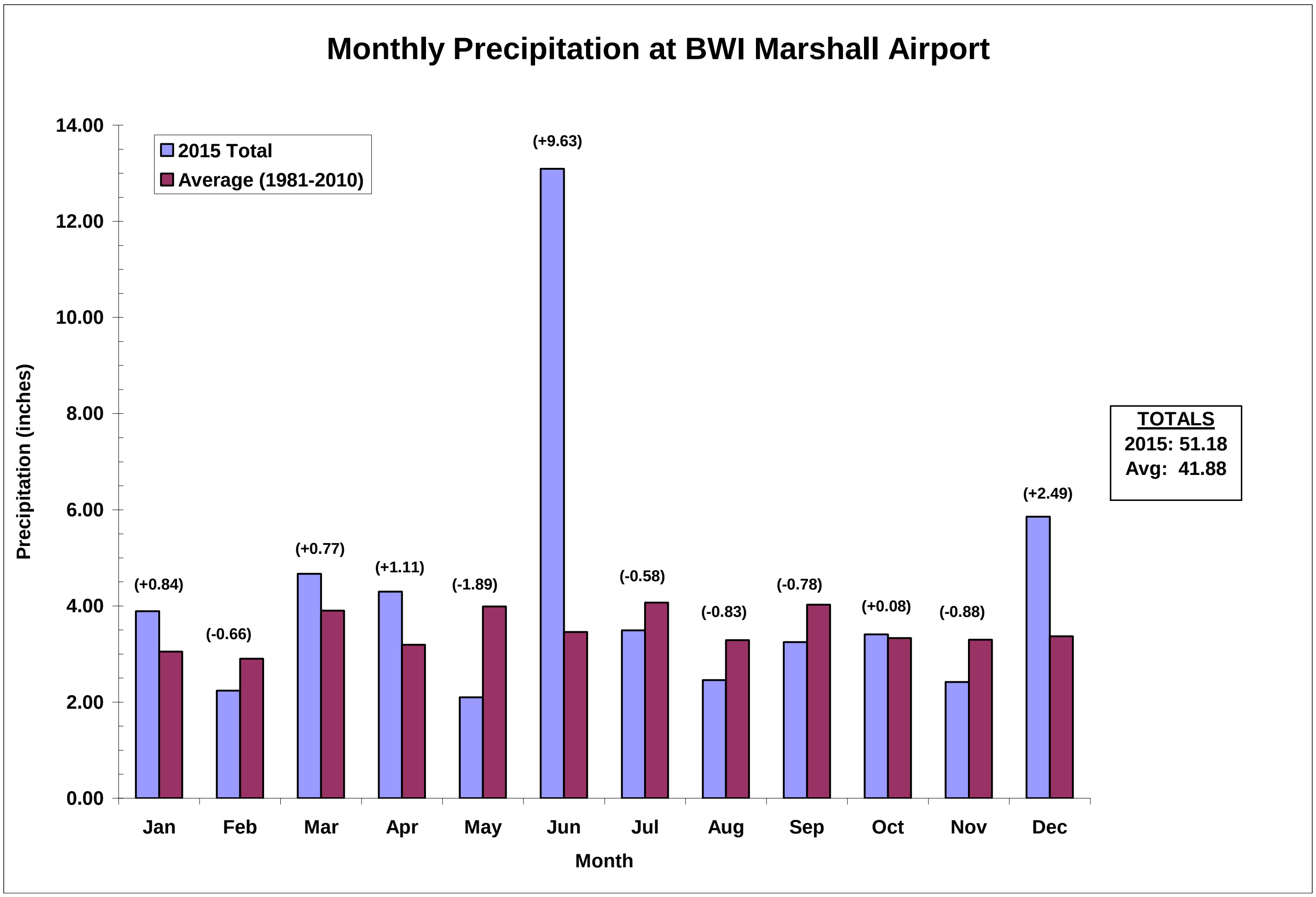

Figure 3. Total monthly precipitation at BWI Thurgood Marshall Airport compared to 30-year averages for 2015. Data source: National Oceanographic and Atmospheric Administration (http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/stations/GHCND:USW00093721/detail).

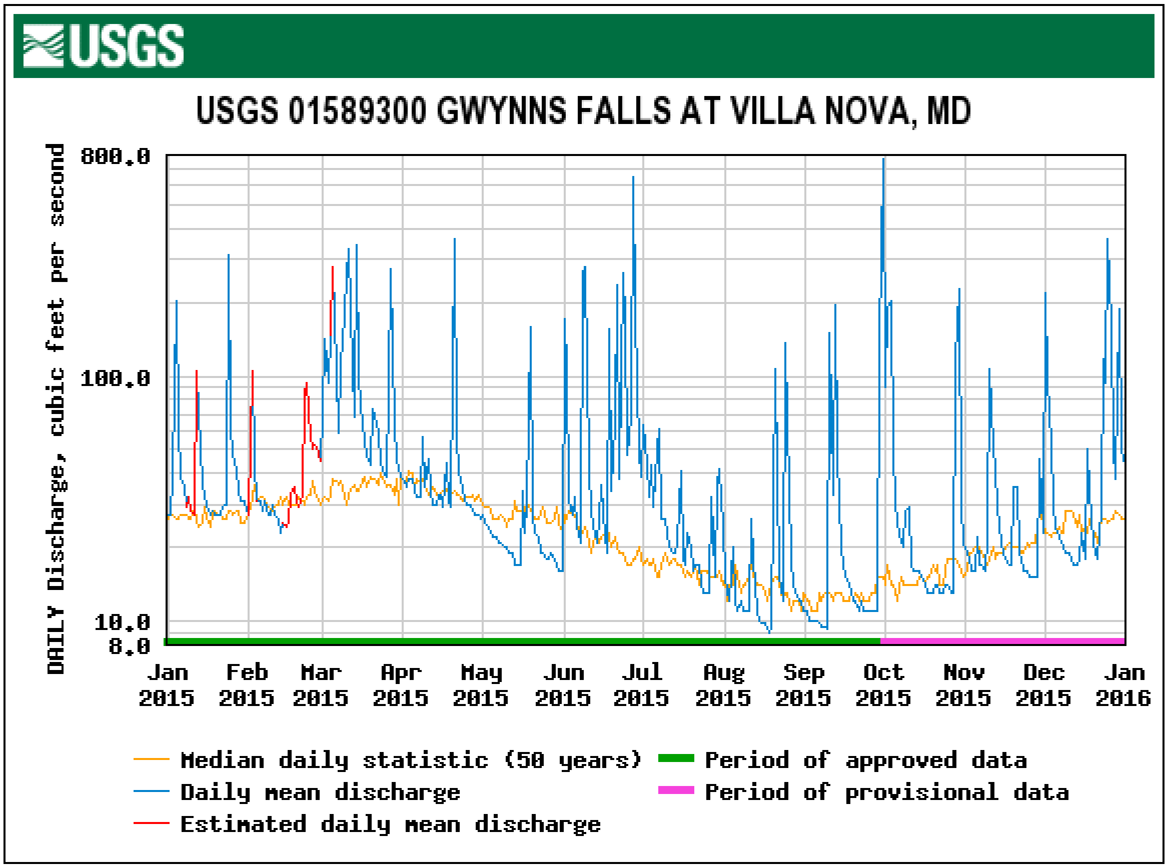

Figure 4. Daily discharge in cubic feet per second measured at a USGS gaging station west of Masonville Cove. The y-axis is in logarithmic scale. Graph courtesy of the United States Geological Survey (http://waterdata.usgs.gov/nwis/dv/?site_no=01589300).

2015 Continuous Monitoring Data

Water Temperature

Water temperature at Masonville Cove rose predictably as air temperatures increased during the summer months (Figure 5). Water temperature peaked at approximately 31°C (87º F) on July 20th, remained generally above 25-26°C (77-79º F) through early September, before gradually declining with air temperatures through much of 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).

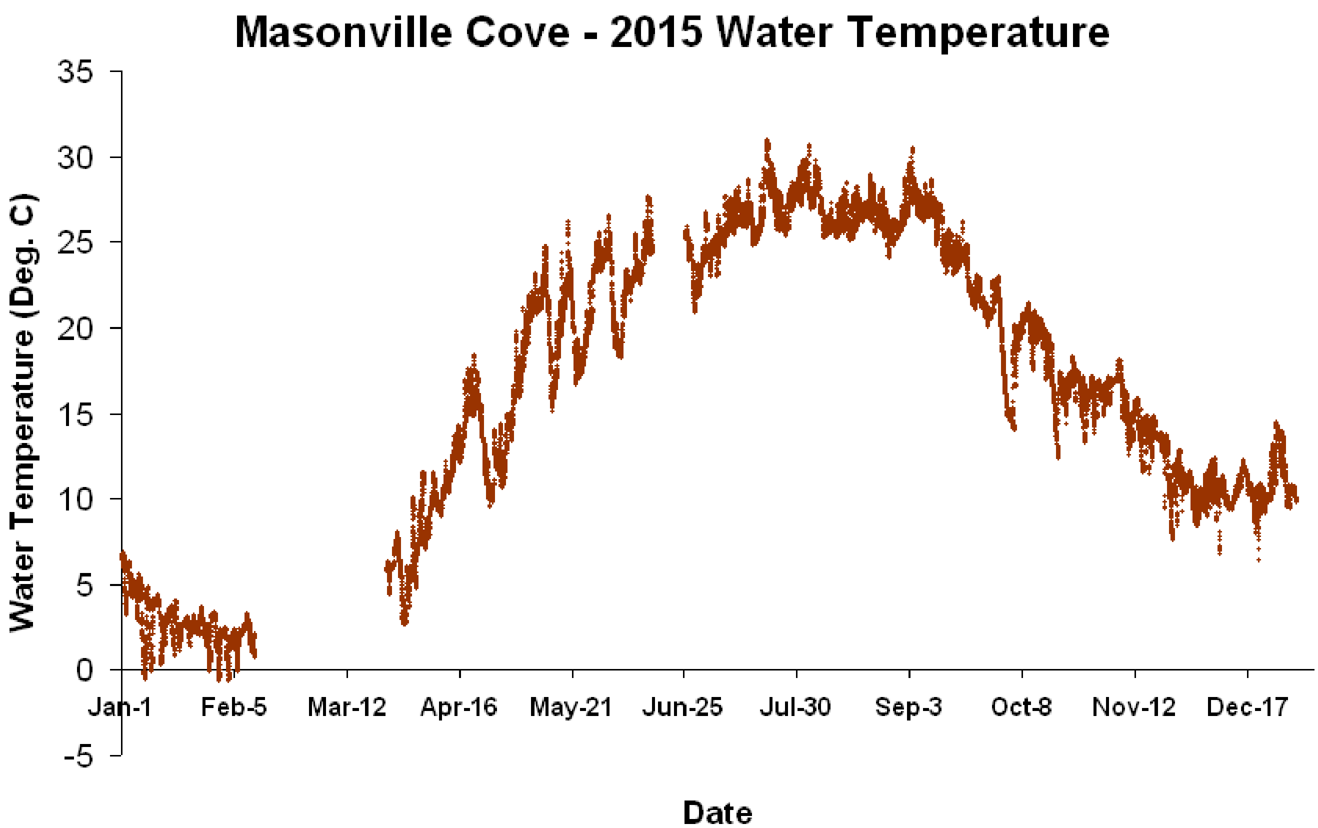

Figure 5. Water temperature at Masonville Cove Continuous Monitor during 2015.

Salinity

Salinity tends to vary with precipitation and stream flow. The overall salinity trend in 2015 (Figure 6) began with generally higher salinities in late winter. Salinity values then dropped considerably between late March and mid-April, coinciding with two of the wetter periods during 2015 (Figure 3). Fueled by an extremely wet June (Figure 3), salinity values remained comparably low for much of the summer, reaching the lowest levels of the year (0.61 parts per thousand – ppt) on June 28th. Salinity levels then rose for much of the rest of the year, reaching a peak of 15.64 ppt on November 15th, before dropping again to less than 1 ppt during a wetter than normal December (Figure 3).

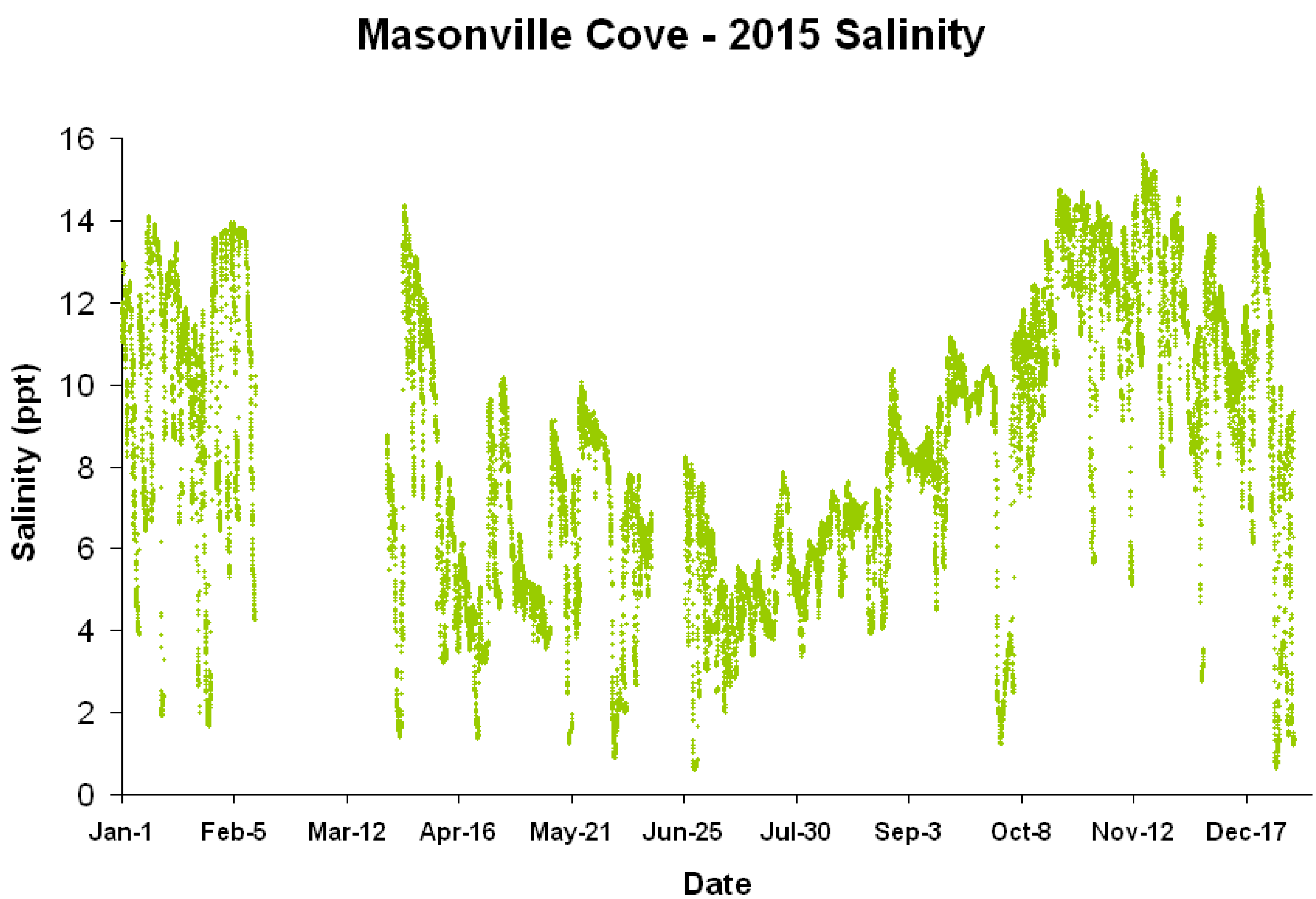

Figure 6. Salinity levels at Masonville Cove Continuous Monitor during 2015.

Dissolved Oxygen

Dissolved oxygen (DO) values remained high through the early spring of 2015. Levels then dropped in the late spring and early summer and exhibited a large number of low readings (< 5 mg/L) for much of the summer and early fall before gradually increasing again 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. However, the large daily swings seen in DO levels between late July and mid-September are indicative of algal bloom conditions that were present in Masonville Cove during this time period (Figure 8). During such blooms, DO levels peak during the day when algal cells are photosynthesizing and producing large amounts of oxygen. However, DO drops to very low levels at night when photosynthesis ceases and oxygen is consumed through cellular respiration. Prolonged periods of low DO concentrations can stress and be detrimental to the survival of juvenile fish and other aquatic animals (US EPA, 2003). The lowest DO reading of 2015 was 0.22 mg/L on September 15th.

Decreases in chlorophyll levels signal the death and decomposition of algal blooms and are often accompanied by a drop in DO levels. The decomposition process can consume significant amounts of oxygen in the water and can lead to conditions harmful to aquatic organisms. For example, decreases in DO levels to extremely low concentrations at the Masonville Cove water quality monitor coincided with drops in chlorophyll levels (Figure 8) on August 29th (0.55 mg/L), September 9th (0.93 mg/L), and October 8th (0.46 mg/L).

As part 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 DO criteria are a 30-day average of 5 mg/L 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. 2015 DO failure rates increased to their highest levels in three years. The 3.2 mg/L failure rate was the second highest and the 5 mg/L failure rate was the third highest since monitoring began in Masonville Cove in 2009 (Table 1). Also, both the 3.2 mg/L and 5 mg/L failure rates exceeded the average failure rate over the prior 6-years of monitoring (10.2% for 3.2 mg/L; 24% for 5 mg/L). Most of these low DO readings in 2015 occurred between June and September, which were the four warmest months of the year. Chlorophyll data (Figure 8) also indicate that several algal blooms occurred during this time period.

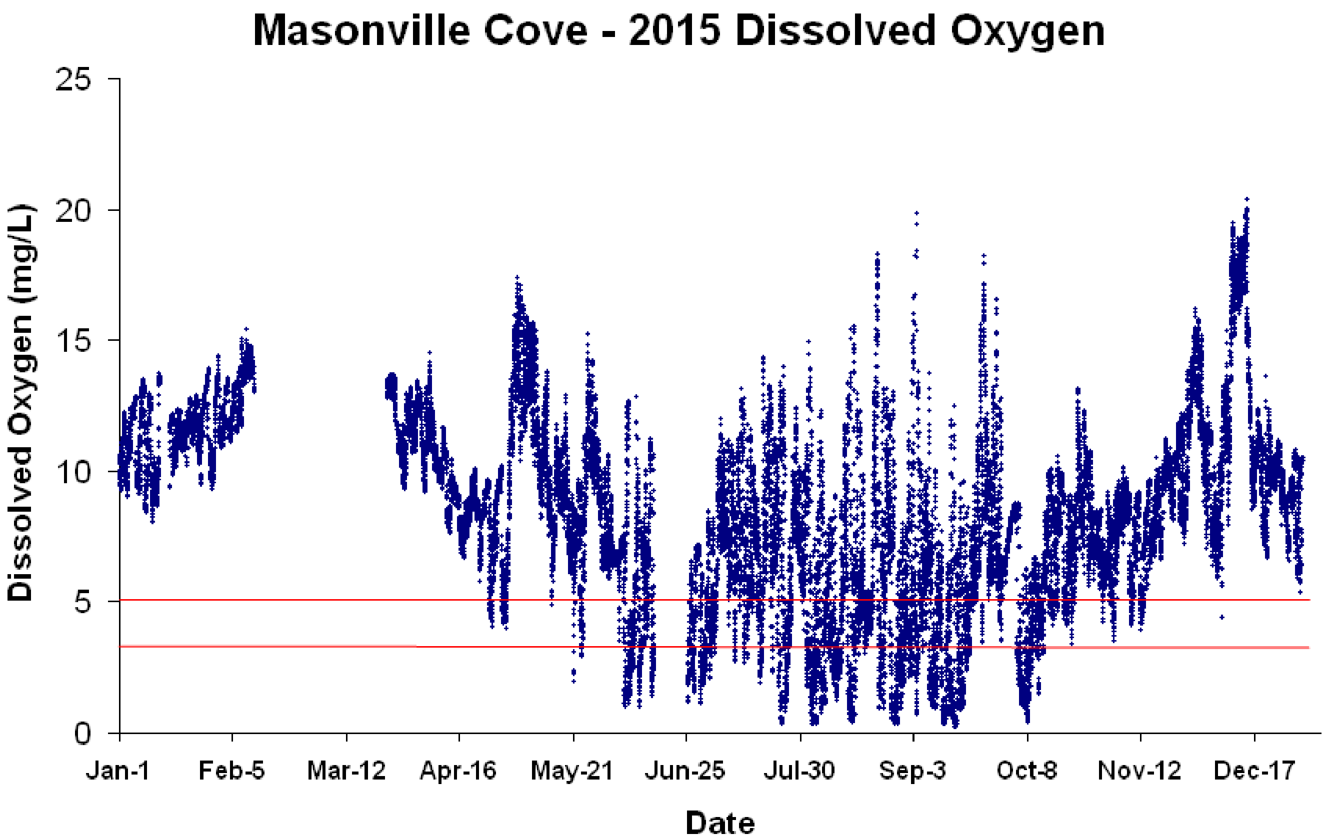

Figure 7. Dissolved oxygen levels at Masonville Cove Continuous Monitor during 2015. (*Red lines indicate 5 mg/L and 3.2 mg/L criteria.)*

Table 1. Dissolved oxygen criteria failure at Masonville Cove Continuous Monitor during June through November, 2009, March through October, 2010, and April through September, 2011 to 2015.

Continuous Monitor	2009	2010	2011	2012	2013	2014	**2015**
Surface							
Dissolved Oxygen less than 5 mg/L	28.29%	20.02%	14.32%	30.59%	26.01%	24.88%	**26.38%**
Dissolved Oxygen less than 3.2 mg/L	9.89%	8.61%	8.17%	14.20%	11.73%	8.81%	**13.49%**

Chlorophyll

Chlorophyll values 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 greater than 50 µg/L represent significant algal blooms, and concentrations above 100 µg/L represent severe blooms. At Masonville Cove in 2015, chlorophyll values indicated significant or severe algal blooms in mid-February, late March to early April, early and late May, late July, much of August and September, and early and late December (Figure 8). The highest chlorophyll value of the year (493 µg/L) occurred in late September during a severe bloom.

Water samples collected in Masonville Cove on December 10th were also used to measure the concentration of a dinoflagellate bloom in the Upper Patapsco River. A species of dinoflagellate, *Prorocentrum minimum*, was measured at high concentrations (>2 million cells/L) within the sample. *Prorocentrum minimum* is a potentially toxic dinoflagellate species that, in sufficient concentrations, can cause water to become discolored a reddish-brown and form "mahogany tides". The water quality monitor deployed around the time of the December bloom measured a chlorophyll peak of 403 µg/L on December 21st and pH levels, which can spike above 9 during an algal bloom, peaked at 9.26 on December 10th (Figure 9). Sonde data indicate that the bloom subsided on December 26th. Additional information on this bloom, and all potential toxic algal blooms throughout Maryland's waterways can be found by clicking the "Harmful Algae" tab on DNR's "Eyes on the Bay" website (www.eyesonthebay.net).

As stated previously, chlorophyll readings greater than 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 2015 deployment that coincided with SAV growing season (March – October). Algal blooms during this period may impede the ability of SAV to grow and reproduce. Chlorophyll levels exceeded the 15 µg/L threshold during approximately 43% of the readings in 2015 (Table 2), which was an increase from 36% in 2014. Chlorophyll levels exceeded the 50 µg/L during approximately 9% of the readings (Table 2), which was the third highest violation rate since DNR began monitoring Masonville Cove in 2009. The 15 µg/L violation rate was below the average vilolation rate over the prior 6-years (46.5%), while the 50 µg/L was above the average (7.2%).

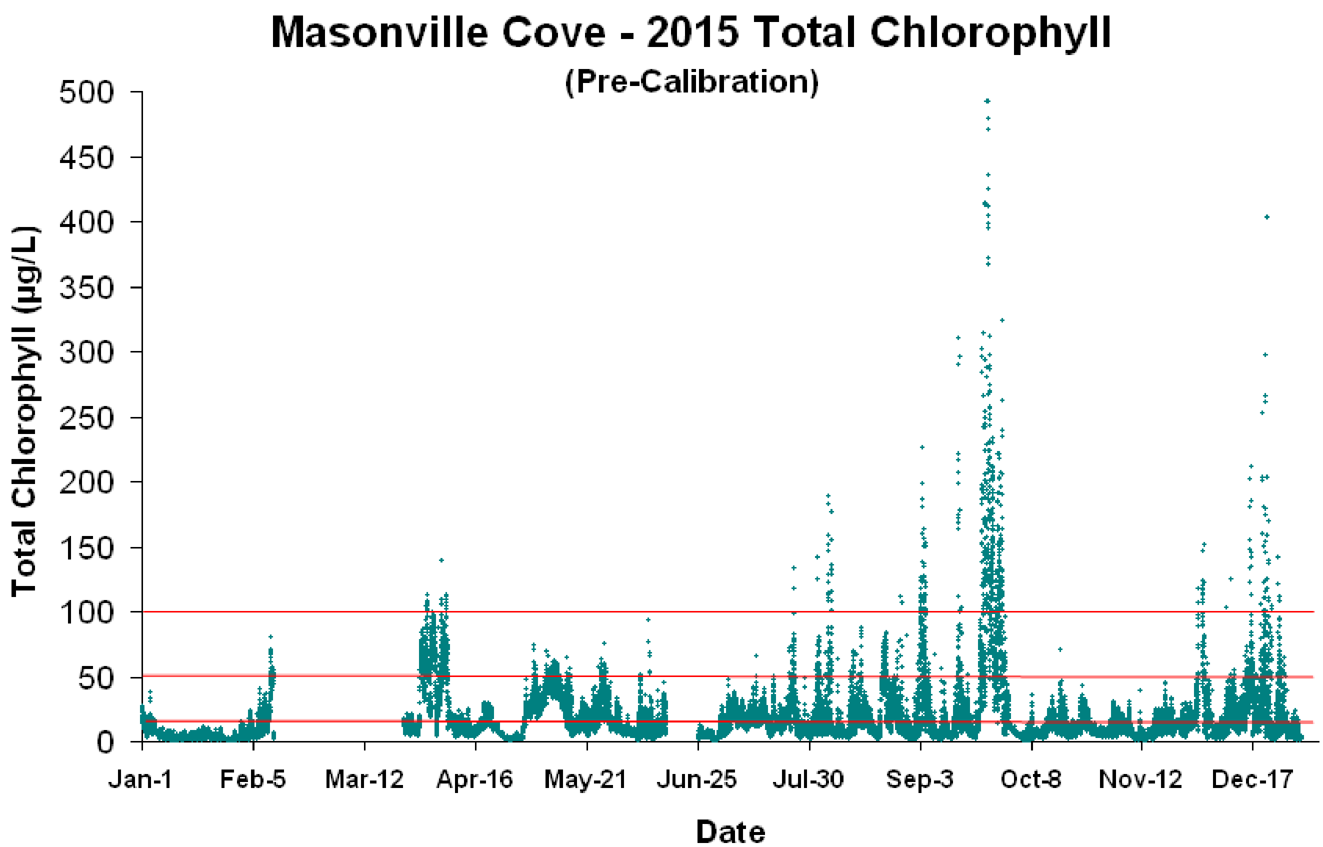

Figure 8. Total chlorophyll levels at Masonville Cove Continuous Monitor during 2015. *(Red lines indicate thresholds above which levels may have harmful effects on aquatic ecosystems—15 mg/L—are considered significant blooms—50 mg/L—or are considered severe blooms—100 mg/L.)*

Table 2. Chlorophyll threshold failure at Masonville Cove Continuous Monitor during June through November, 2009, and March through October, 2010 to 2015.

Continuous Monitor	2009	2010	2011	2012	2013	2014	**2015**
Surface							
Readings greater than 15 µg/L	37.37%	58.99%	38.78%	55.63%	52.12%	36.24%	**43.11%**
Readings greater than 50 µg/L	3.28%	6.58%	0.87%	14.52%	10.50%	5.24%	**8.89%**

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 2015, pH values exceeded 9 in early to mid-May, late August, late November, and early to mid-December. All but the late November readings coincided with significant algal blooms (chlorophyll concentrations greater than 50 µg/L), and the December readings coincided with an observed *Prorocentrum minimum* bloom in Masonville Cove. The highest pH value of the year (9.26) was recorded on December 10th.

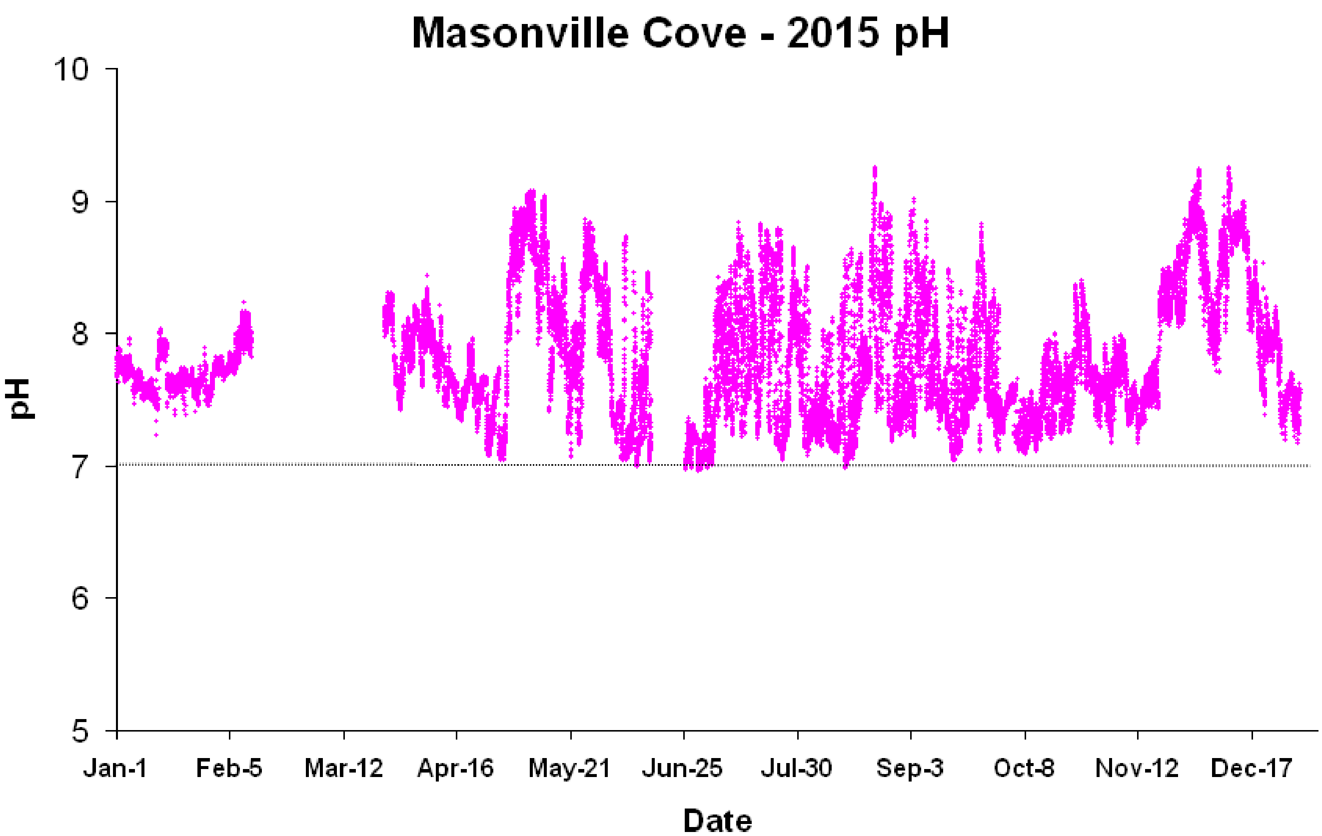

Figure 9. pH levels at Masonville Cove Continuous Monitor during 2015. *(Line indicates neutral pH.)*

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). During the year, there were only two time periods when turbidity levels spiked to above 100 NTU, and both of these occurred during and in the aftermath of heavy precipitation and discharge events. However values were generally high throughout the year (Figure 10). Masonville Cove turbidity levels were greater than 7 NTU for approximately 44% of all readings collected in 2015 (median value: 6.4 NTU).

Turbidity levels exceeded 100 NTU for the first time in 2015 on June 28th. The largest precipitation event of the year affected Central Maryland on June 27th, which led to a large discharge event (Figure 4). Due to heavy rains overwhelming sanitary lines, several sanitary sewer overflows into the Patapsco River and associated tributaries were also reported by the Baltimore City and County Departments of Public Works. An estimated 730,000 gallons of untreated, diluted wastewater were spilled into the watershed during these overflows. As a result of the storm and associated discharge event, turbidity levels spiked from approximately 5 NTU on June 25th to 142 NTU, the highest level of the year, on June 28th. Levels then remained below 100 NTU until late in the year. During this time, several very low turbidity readings were recorded in early through mid-September (Figure 10). Greater than usual water clarity was also measured in other parts of Maryland during the fall and may have been partly the result of below average rainfall (Figure 3) and low flows (Figure 4) during this time period.

In late December, more than 3-inches of rain fell on the region over three days between December 23rd and 25th. Sanitary sewer overflows associated with these rains spilled over 280,000 gallons of untreated, diluted wastewater in the watershed. Turbidity increased more than a thousand fold during this time as readings went from approximately 0.1 NTU on December 22nd to 106 NTU on December 25th. The high turbidity readings during both of these events indicate that water discharged into the river brought high concentrations of particles and sediment that clouded the water.

Turbidity concentrations above 7 NTU, as stated previously, are considered a threshold for detrimental effects on SAV. The water quality monitor at Masonville Cove was above this threshold for almost 54% of the readings (Table 3) during the 2015 SAV growing season (March through October), which was slightly above the average from the previous 5-years (51.4%).

Details of the sanitary sewer overflows described in this section can be found through the Maryland Reported Sewer Overflow Database (http://www.mde.state.md.us/programs/water/overflow/pages/reportedseweroverflow.aspx).

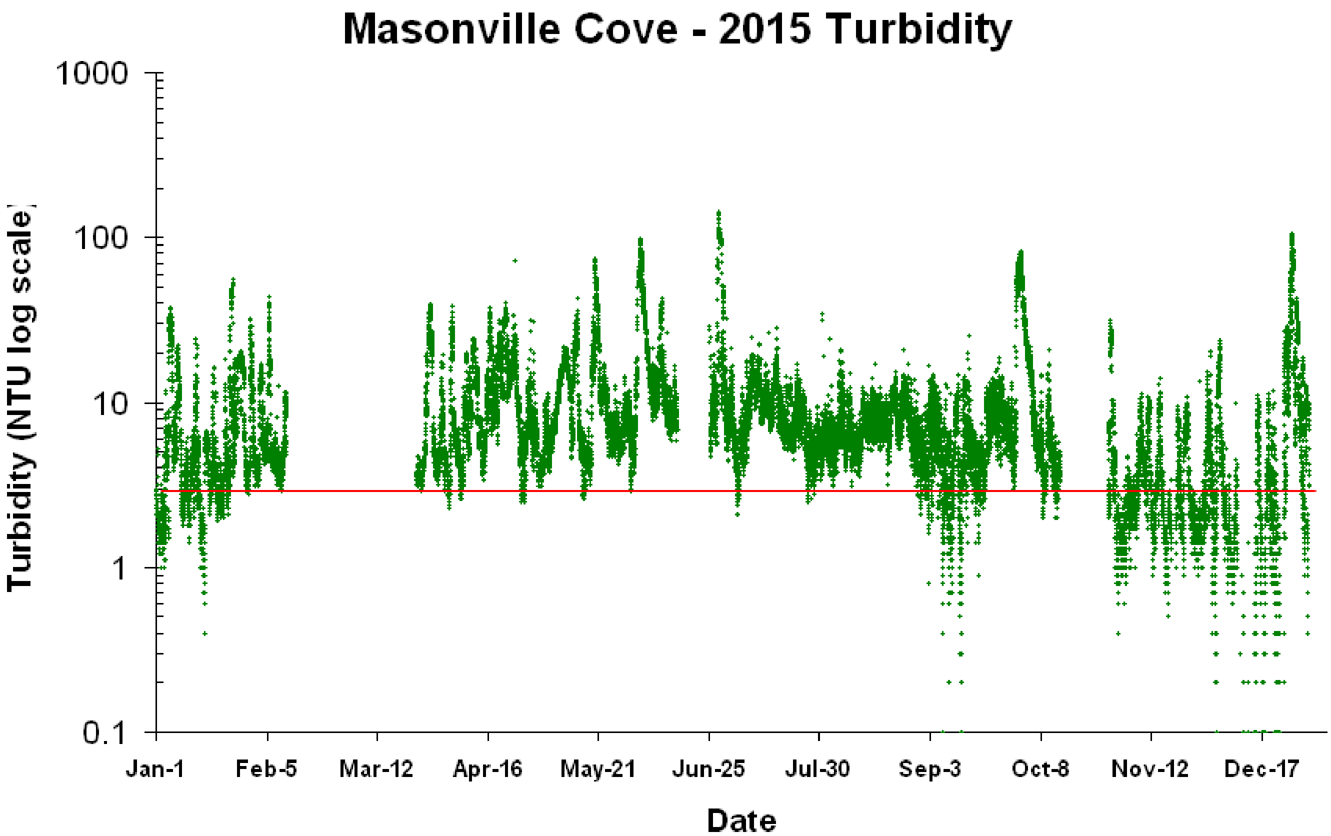

Figure 10. Turbidity levels at Masonville Cove Continuous Monitor during 2015. *(Red line indicates threshold above which levels are considered detrimental to bay grass growth.)*

Table 3. Turbidity threshold failure at Masonville Cove Continuous Monitor during June through December, 2009, and March through October, 2010 to 2015.

Continuous Monitor	2009	2010	2011	2012	2013	2014	**2015**
Surface							
Readings greater than 7 NTU	54.58%	60.09%	51.58%	35.0%	53.91%	52.92%	**53.82%**

Submerged Aquatic Vegetation (SAV) in the Patapsco River

SAV, or underwater grasses, are an important component of estuarine ecosystems. SAV provides 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 11 shows total area and density of SAV within the Patapsco beginning in 1994 (the first year SAV was found in the river) through 2015.

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 2015, approximately 38.7 acres of SAV were observed in the Patapsco River, which is the most since 2006, and is approximately 10% of the river's restoration goal. However, there continued to be no SAV within Masonville Cove.

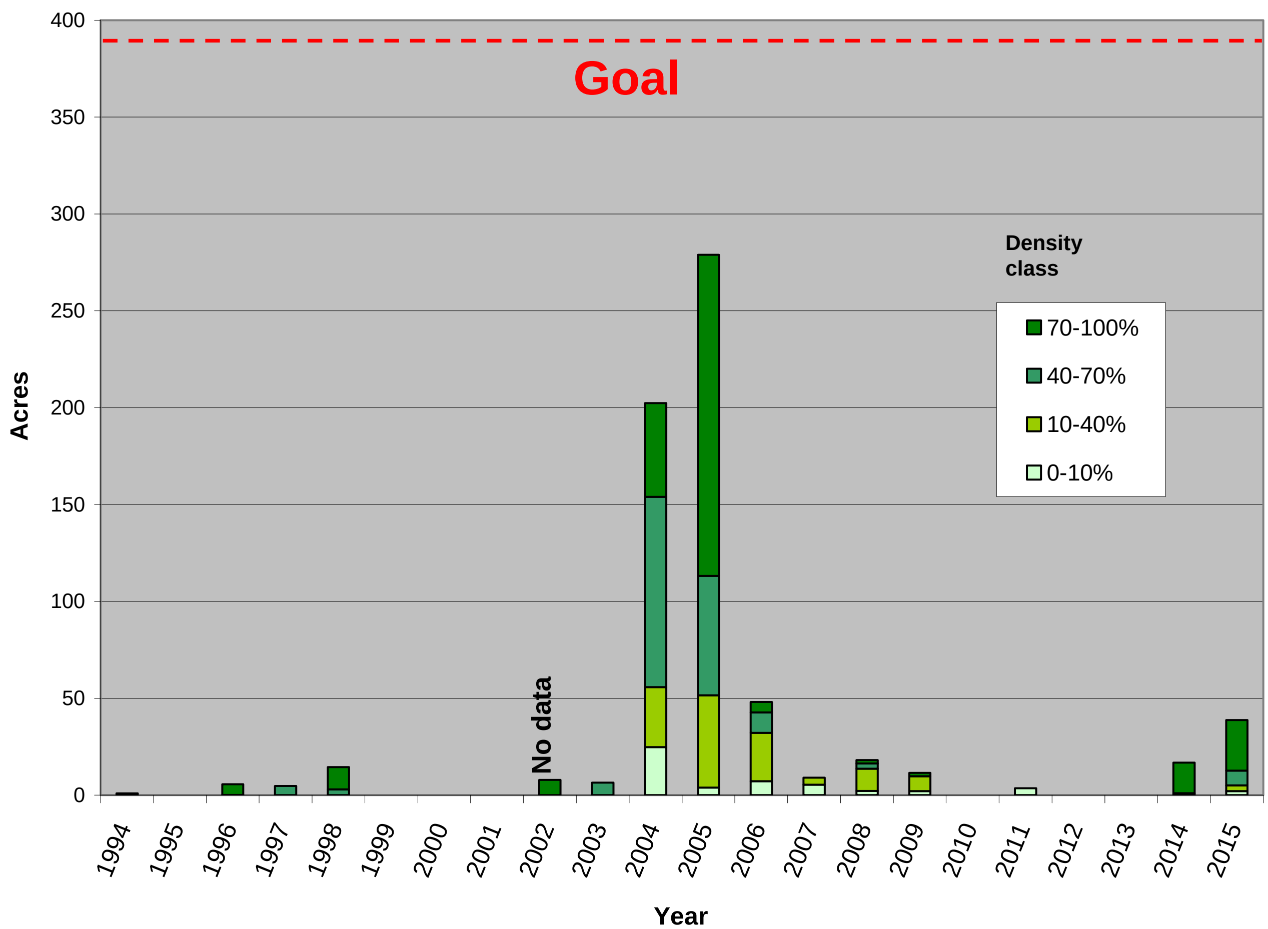

Figure 11. Total area and density of SAV in the Patapsco River between 1994 and 2015. (*Restoration goal is 389 acres)*

Pigments, Suspended Solids, and Secchi Data

Biweekly grab samples of water were taken at the Masonville Cove station when the YSI meters were exchanged during Continuous Monitoring service visits. Samples collected during November through March were collected monthly instead of biweekly (Table 4). Secchi depth, a measure of water clarity, was also recorded at the Masonville Cove station each time a grab sample was collected.

For the grab samples, the water was processed in the field using vacuum filtration, and the resulting particulate samples were delivered to the laboratory for analysis. Samples collected during Continuous Monitoring service visits 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 using publication type 'QAPP' to search the monitoring stories and publications page of DNR's "Eyes on the Bay" website (www.eyesonthebay.net). 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. Note that on February 11, 2015, the field crew did not have a Hydrolab instrument on site, thus a data profile is not available for this date (Table 4). All data values for dissolved oxygen, pH, salinity, and water temperature are provided in Table A-2 of Appendix A.

At Masonville Cove in 2015, peak values of chlorophyll *a* occurred on May 12 (42.5 µg/L), July 23 (47.3 µg/L), and September 1 (51.3 µg/L). Peak phaeophytin values occurred on or near these same dates: May 12 (10.9 µg/L), July 23 (11.7 µg/L), and September 15 (13.2 µg/L). All other chlorophyll and phaeophytin values at Masonville Cove were generally below 30 µg/L and 10 µg/L, respectively, for 2015.

Elevated values of total suspended solids occurred at Masonville Cove late in the months of June and September 2015, peaking at 18.7 mg/L on June 25 and 28.0 mg/L on September 30. Corresponding low values of 0.2 m for Secchi depth (a measure of water clarity) were observed at the station on both of these dates. Furthermore, salinity measurements for these two dates showed a large range in values, a difference of more than 5 ppt from surface to bottom, suggesting an input of freshwater to the system. Weather data confirm that storms likely contributed to the observed turbid conditions and reduced salinities, with significant rain events occurring in the days preceding the sampling dates. In the Baltimore region, June 2015 was the wettest June on record with a precipitation total of 13.09 inches for the month recorded at BWI airport (Figure 3). This total included 1.92 inches of rainfall on June 20 and 1.30 inches on June 23, just a few days before the June 25 sampling date at Masonville Cove. On September 29, one day before the September 30 sampling date, heavy rains resulted in 2.58 inches of precipitation for the day at BWI.

Dissolved oxygen values at Masonville Cove were generally lower during the summer months, with at least one value below 5 mg/L measured during all surveys from June through August 2015. The lowest dissolved oxygen levels were observed at the bottom of the depth profile, and bottom dissolved oxygen concentrations below 3 mg/L were measured on June 25 (2.0 mg/L), July 23 (1.1 mg/L), and September 15 (0.7 mg/L). Water temperature varied seasonally at Masonville Cove, beginning with a measurement of 0.7°C on February 11, gradually rising to a peak of 27.6°C on September 1, and then falling slowly to around 10°C on December 10. For 2015, pH values at Masonville Cove generally fluctuated between 7 and 9 throughout the year.

Table 4. Deployment and calibration record for Masonville Cove continuous monitor 2015.

Scheduled calibration date	Samples collected	Comment
January 13, 2015	No	Ice precluded collection of samples..
January 16, 2015	No	Ice precluded collection of samples.
February 11, 2015	Yes	Data profile not conducted
March 24, 2015	Yes	
April 15, 2015	Yes	
April 28, 2015	Yes	
May 12, 2015	Yes	
May 27, 2015	Yes	
June 11, 2015	Yes	
June 25, 2015	Yes	
July 9, 2015	Yes	
July 23, 2015	Yes	
August 6, 2015	Yes	
August 18, 2015	Yes	
September 1, 2015	Yes	
September 15, 2015	Yes	
September 30, 2015	Yes	
October 14, 2015	Yes	
October 29, 2015	Yes	
November 18, 2015	Yes	
December 10, 2015	Yes	

Conclusion

Shallow water monitoring was conducted in Masonville Cove in the upper Patapsco River during 2015. 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 Masonville Cove and the Patapsco River as a whole. In 2015, heavy rains in June and September led to massive discharge events that affected salinity, water clarity, and TSS. Significant to severe algal bloom conditions occurred during much of the spring, summer, and early fall, and a potentially toxic dinoflagellate species, *Prorocentrum minimum*, was measured at high concentrations in Masonville Cove in early December. Dissolved oxygen concentrations were low for much of the summer and early fall and, after two years of improvement, both dissolved oxygen and chlorophyll conditions degraded in 2015. Finally, as of 2015, no submerged aquatic vegetation was found in Masonville Cove. Therefore, conditions remain relatively 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.

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Appendix A

Results of laboratory and ambient water quality analyses for:
Masonville Cove Pier (Station XIE4742)

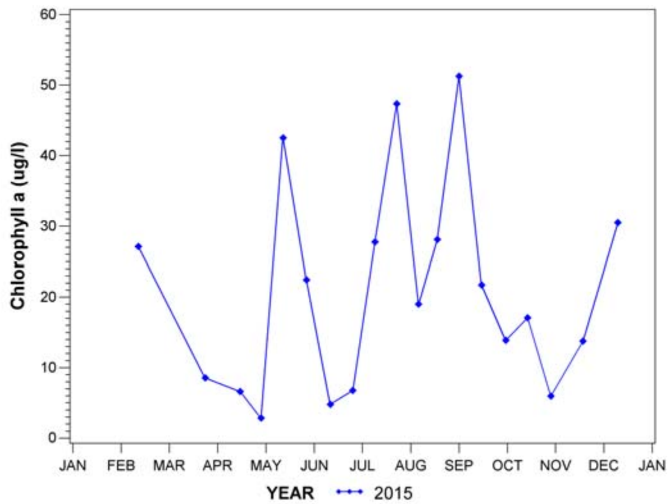

Figure A-1. Chlorophyll *a* concentrations at Masonville Cove in 2015.

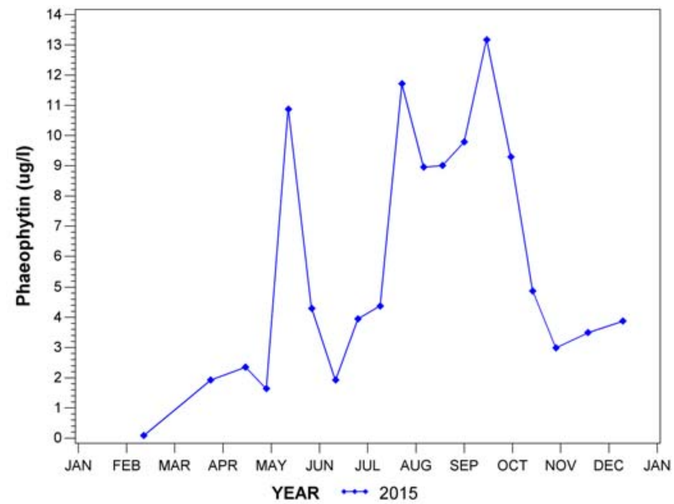

Figure A-2. Phaeophytin concentrations at Masonville Cove in 2015.

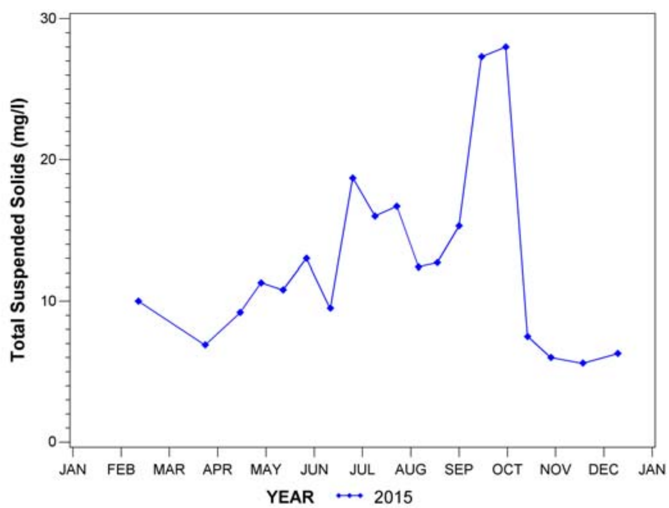

Figure A-3. Total suspended solids concentrations at Masonville Cove in 2015.

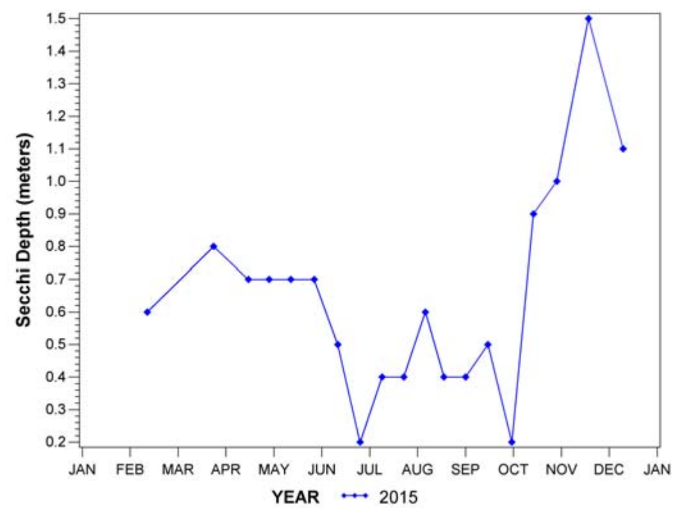

Figure A-4. Secchi depth at Masonville Cove in 2015.

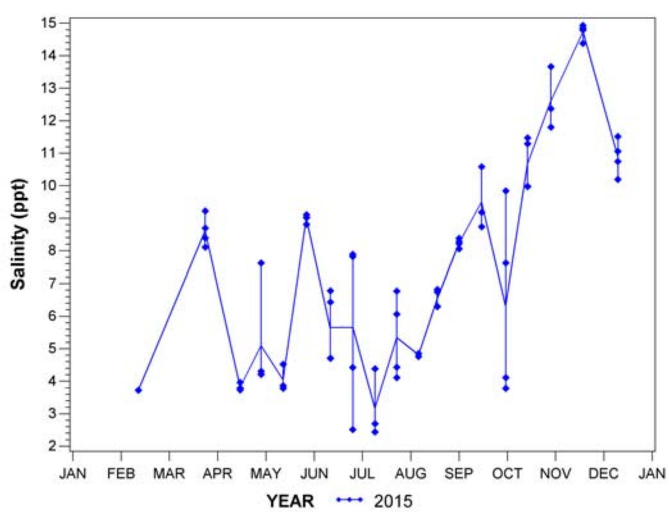

Figure A-5. Salinity concentrations at Masonville Cove in 2015.

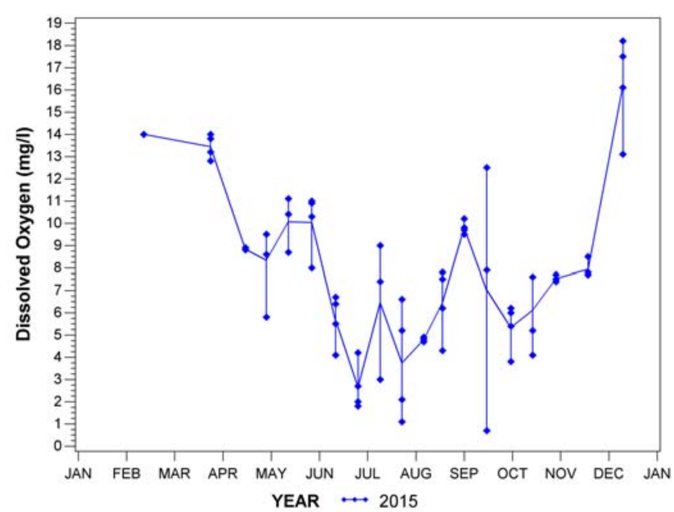

Figure A-6. Dissolved oxygen concentrations at Masonville Cove in 2015.

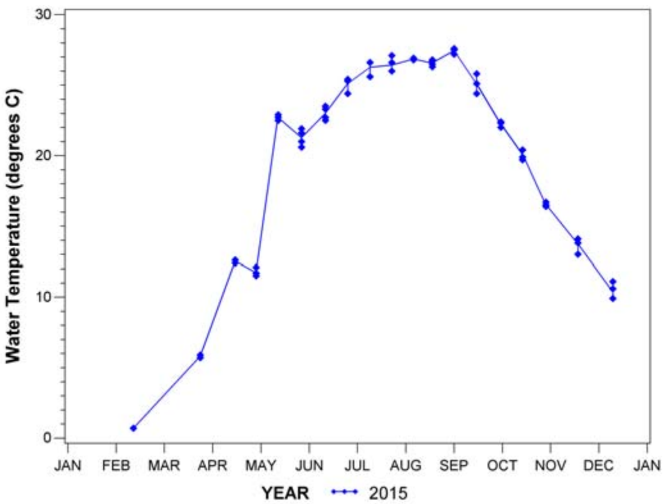

Figure A-7. Water temperature at Masonville Cove in 2015.

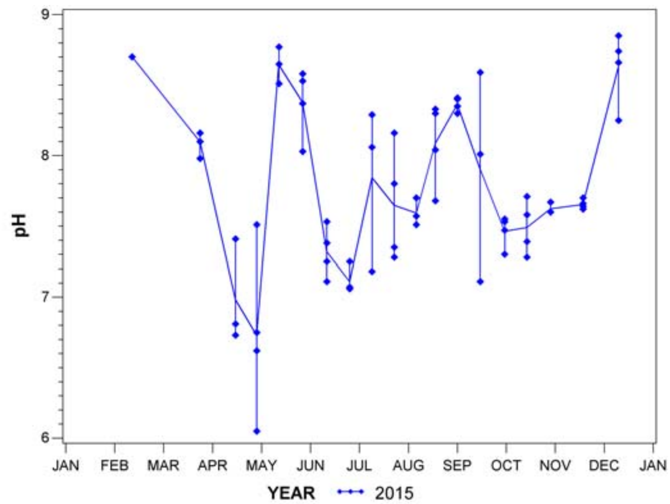

Figure A-8. Values of pH at Masonville Cove in 2015.

Vertical bars within a graph represent the data range for each profile, with readings recorded at 0.5m depth intervals, 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 (XIE4742) in 2015.

Date	Sample Depth (m)	Chlorophyll-a (ug/L)	Phaeophytin (ug/L)	Total Suspended Solids (mg/L)	Secchi Depth (m)
02/11/15	1	27.127	0.085	10.0	0.6
03/24/15	1	8.544	1.922	6.9	0.8
04/15/15	1	6.622	2.350	9.2	0.7
04/28/15	1	2.848	1.638	11.3	0.7
05/12/15	1	42.506 (1)	10.872 (1)	10.8	0.7
05/27/15	1	22.428	4.299	13.0	0.7
06/11/15	1	4.806	1.922	9.5	0.5
06/25/15	1	6.764	3.952	18.7	0.2
07/09/15	1	27.768	4.379	16.0	0.4
07/23/15	1	47.348	11.712	16.7	0.4
08/06/15	1	19.010	8.950	12.4	0.6
08/18/15	1	28.124	9.007	12.7	0.4
09/01/15	1	51.264	9.790	15.3	0.4
09/15/15	1	21.716	13.172	27.3	0.5
09/30/15	1	13.884	9.292	28.0	0.2
10/14/15	1	17.088	4.873	7.5	0.9
10/29/15	1	5.981	2.990	6.0	1.0
11/18/15	1	13.777	3.492	5.6	1.5
12/10/15	1	30.514	3.875	6.3	1.1

(1) Data value has an associated error code: "High optical density (750 nm); actual value recorded".

Table A-2. Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2015 (continued on next page).

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
02/11/15	1.0	14.0	8.70	3.72	0.7
03/24/15	0.5	13.2	8.10	8.11	5.9
03/24/15	1.0	12.8	7.98	8.39	5.9
03/24/15	1.5	13.8	8.16	8.69	5.7
03/24/15	1.8	14.0	8.16	9.22	5.7
04/15/15	0.5	8.9	6.81	3.73	12.6
04/15/15	1.0	8.8	7.41	3.96	12.4
04/15/15	1.7	8.8	6.73	3.79	12.6
04/28/15	0.5	9.5	6.75	4.21	11.7
04/28/15	1.0	9.5	7.51	4.31	11.5
04/28/15	1.5	8.6	6.62	4.22	11.7
04/28/15	1.8	5.8	6.05	7.62	12.1
05/12/15	0.5	11.1	8.77	3.78	22.9
05/12/15	1.0	10.4	8.65	3.86	22.7
05/12/15	1.6	8.7	8.51	4.52	22.5
05/27/15	0.5	11.0	8.53	8.81	21.9
05/27/15	1.0	10.9	8.58	9.02	21.6
05/27/15	1.5	10.3	8.37	9.01	21.0
05/27/15	2.0	8.0	8.03	9.10	20.6
06/11/15	0.5	6.4	7.38	4.70	22.7
06/11/15	1.0	6.7	7.53	4.71	22.5
06/11/15	1.5	5.5	7.25	6.43	23.5
06/11/15	1.8	4.1	7.11	6.78	23.3
06/25/15	0.5	4.2	7.25	2.51	24.4
06/25/15	1.0	2.7	7.06	4.42	25.3
06/25/15	1.5	1.8	7.07	7.82	25.4
06/25/15	1.9	2.0	7.06	7.88	25.4
07/09/15	0.5	7.4	8.06	2.44	26.6
07/09/15	1.0	9.0	8.29	2.69	26.6
07/09/15	1.7	3.0	7.18	4.38	25.6
07/23/15	0.5	6.6	8.16	4.11	26.0
07/23/15	1.0	5.2	7.80	4.43	26.0
07/23/15	1.5	2.1	7.35	6.06	27.1
07/23/15	2.1	1.1	7.28	6.77	26.6

Table A-2 (continued). Ambient Water Quality Data for Dissolved Oxygen (D.O.), pH, Salinity, and Water Temperature for Masonville Cove (XIE4742) in 2015.

Date	Sample Depth (m)	D. O. (mg/L)	pH	Salinity (ppt)	Water Temperature (°C)
08/06/15	0.5	4.9	7.57	4.76	26.9
08/06/15	1.0	4.7	7.70	4.85	26.8
08/06/15	1.7	4.8	7.51	4.85	26.9
08/18/15	0.5	7.8	8.30	6.30	26.8
08/18/15	1.0	7.5	8.33	6.29	26.7
08/18/15	1.5	6.2	8.04	6.75	26.5
08/18/15	2.2	4.3	7.68	6.82	26.3
09/01/15	0.5	9.8	8.35	8.21	27.6
09/01/15	1.0	9.5	8.41	8.06	27.5
09/01/15	1.5	10.2	8.40	8.28	27.5
09/01/15	2.0	9.7	8.30	8.38	27.2
09/15/15	0.5	12.5	8.59	8.73	25.1
09/15/15	1.0	7.9	8.01	9.18	24.4
09/15/15	1.7	0.7	7.11	10.58	25.8
09/30/15	0.5	6.0	7.53	4.11	22.4
09/30/15	1.0	6.2	7.55	3.78	22.3
09/30/15	1.5	5.4	7.47	7.62	22.4
09/30/15	2.1	3.8	7.30	9.84	22.0
10/14/15	0.5	7.6	7.71	9.98	19.9
10/14/15	1.0	7.6	7.58	9.97	19.7
10/14/15	1.5	5.2	7.39	11.29	20.4
10/14/15	2.0	4.1	7.28	11.47	20.4
10/29/15	0.5	7.5	7.60	11.80	16.5
10/29/15	1.0	7.7	7.67	12.37	16.4
10/29/15	1.5	7.4	7.60	13.66	16.7
11/18/15	0.5	8.5	7.70	14.38	13.0
11/18/15	1.0	7.8	7.64	14.85	14.1
11/18/15	1.5	7.7	7.62	14.93	14.1
11/18/15	2.2	7.8	7.66	14.79	13.8
12/10/15	0.5	18.2	8.85	10.19	9.9
12/10/15	1.0	17.5	8.74	10.74	9.9
12/10/15	1.5	16.1	8.66	11.06	10.6
12/10/15	2.0	13.1	8.25	11.51	11.1