Vertical Profiler Water Quality Monitoring in the Tred Avon River – June 2016 to December 2016

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MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Executive Summary

During June-December 2016, the National Oceanic and Atmospheric Administration (NOAA) deployed a vertical profiler to monitor water quality conditions in the Tred Avon River, an important oyster restoration area in the Chesapeake Bay. The vertical profiler measured salinity, water temperature, pH, dissolved oxygen, chlorophyll, and turbidity at fixed intervals throughout the water column. Profiles were conducted once every hour.

During the 2016 monitoring period, the Maryland Department of Natural Resources (DNR) provided field support for the Tred Avon vertical profiler, monitored profiler operation, downloaded data files, and reviewed the data for quality assurance. In 2016, the Tred Avon vertical profiler was operated without the use of the optional depth sounder. Instead, the profiler was programmed to conduct water quality readings at fixed depths of 0.5m, 1.0m, 2.0m, 3.0m, 4.0m, and 4.5m. By not using the depth sounder, many of the operating issues of previous years were avoided and the profiler functioned mostly error-free during 2016. However, in 2016 a complete set of working data sondes was not available for deployment with the vertical profiler. DNR supplemented the equipment needs at the Tred Avon profiler when able to do so, but some sonde deployments did not collect pH or chlorophyll data due to missing or malfunctioning probes. Before the vertical profiler is redeployed, it is recommended that a complete inventory of data sondes and probes be performed and the necessary replacement equipment be purchased.

Vertical profiler data consists of two types: the readings collected during profile sequences (profile data); and the readings collected when the monitoring sonde was parked in a fixed position awaiting the next profile (hourly data). Salinity, pH, water temperature, chlorophyll, turbidity, and dissolved oxygen data from the vertical profiler show that water quality conditions in the Tred Avon River during 2016 were generally suitable for oyster growth and survival.

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Introduction

During June-December 2016, the National Oceanic and Atmospheric Administration (NOAA) deployed a vertical profiler to monitor water quality conditions in the Tred Avon River. The Tred Avon is a tributary of the Choptank River and part of the Choptank Complex that is targeted for oyster restoration activities. Water quality information from the profiler may be used to assess habitat suitability for oyster growth and survival. The 2016 monitoring was a continuation of vertical profile monitoring that NOAA conducted during the years 2014 and 2015. This report summarizes the monitoring activities and data results for 2016.

In partnership with NOAA, the Maryland Department of Natural Resources (DNR) provided equipment maintenance and data management support for the Tred Avon vertical profiler. Beginning in 2012, DNR has deployed a similar vertical profiler in nearby Harris Creek, and therefore has experience maintaining this type of monitoring equipment.

The vertical profiler system deployed in the Tred Avon River consists of a water quality monitoring sonde (YSI Inc., Model 6600 V2) attached by a cable to a CR1000 datalogger (Campbell Scientific, Inc.). The CR1000 is mounted on a floating platform along with a winch mechanism that raises and lowers the sonde in the water column. The Tred Avon profiler was programmed to conduct a profile every hour, with readings taken at 0.5m, 1m, 2m, 3m, 4m, and 4.5m depths through the water column. Profile sequences commenced at the top of the hour and took approximately 8 minutes to complete.

The water quality monitoring sonde measured the following parameters: specific conductance/salinity, temperature, pH, dissolved oxygen, turbidity, and chlorophyll. Readings were stored in electronic files on the CR1000. In addition to water quality data, the CR1000 can also store data files pertinent to instrument operation that are helpful when troubleshooting problems. Data are retrieved from the CR1000 either by connecting to the unit with a laptop computer, or by communicating remotely via telemetry connection.

Field Support

NOAA installed the vertical profiler platform in the Tred Avon River on June 1, 2016, and shortly thereafter DNR connected a YSI sonde to the unit to initiate profiler operation. To ensure data integrity, regular cleaning and maintenance of the sondes was necessary throughout the monitoring season. DNR conducted regular field visits to the site generally every two weeks during the monitoring period. During each field visit, a clean and freshly calibrated sonde was brought out to the site and exchanged with the sonde that was already deployed at the profiler. The sonde that was removed was then returned to the DNR field office for post-calibration to identify any drift in the measurements made by the sonde during deployment. Finally, the sonde was cleaned and recalibrated to ready it for redeployment.

DNR staff visited the Tred Avon site a total of ten times during the 2016 monitoring season. Dates of field visits are listed in Table 1.

Table 1. Field visits to the Tred Avon vertical profiler by DNR personnel during the 2016 monitoring season.

Date	Activity
June 14, 2016	Initial sonde deployment
June 28, 2016	Swapped sonde
July 11, 2016	Swapped sonde
July 21, 2016	Swapped sonde
August 11, 2016	Coupler broke during maintenance; no sonde deployed
August 16, 2016	Repaired coupler; deployed sonde. Noted problem with pontoon taking on water.
September 6, 2016	Swapped sonde
September 28, 2016	Swapped sonde
-- Profiler not deployed during October --	
November 15, 2016	Swapped sonde
December 8, 2016	Swapped sonde

Profile data collection began on June 14, 2016 with the initial sonde deployment. The monitoring season concluded on December 21, 2016, when NOAA removed the vertical profiling equipment from the Tred Avon River.

2016 Operating Experience

The Tred Avon vertical profiler is equipped with an optional depth sounder that can measure the water depth at the site prior to each profile sequence. The profiler can then conduct each vertical profile using the measured water depth to determine the bottom depth of the profile sequence. Although the depth sounder was used during previous years, its operation was often problematic. Erroneous readings by the depth sounder caused the vertical profiler to switch into "standby" mode and stop collecting data. Based on this experience, the use of the depth sounder during profiler operation was eliminated in 2016. As noted, the depth sounder is optional equipment. Alternatively, the vertical profiler can be programmed to collect data readings at pre-determined depths during each profile sequence. In 2016, the Tred Avon vertical profiler was programmed to take readings at 0.5m, 1.0m, 2.0m, 3.0m, 4.0m, and 4.5m depths. With the profiler operating at pre-programmed depths and not using the depth sounder, the recurring "standby" errors that plagued the previous monitoring seasons were eliminated.

The vertical profiler operated mostly error-free for the 2016 monitoring season. Only two minor mechanical issues interrupted data collection in 2016. The first issue occurred during a routine field visit on August 11 when, during regular maintenance, a plastic coupler on the winch broke. A replacement part had to be ordered, and the profiler sat idle until August 16 when a new coupler was brought out to the site and installed. It was during this repair visit on August 16 that the field crew noticed a second issue: the profiler platform was listing to one side, suggesting

Figure 1. Vertical profiler platform taking on water in one of the platform pontoons (August 16, 2016).

that a leak had formed in one of the platform pontoons (Figure 1). NOAA removed the profiler platform from the Tred Avon River on August 18 to repair the leak. After the leak was repaired, the vertical profiler was redeployed and began collecting data again on August 30, 2016.

It is important to note that although the vertical profiler functioned well during 2016, some data were not collected due to a lack of working probes for the sondes. At the start of the monitoring season, NOAA provided DNR with only one complete working sonde for deployment with the Tred Avon profiler. Just two weeks into the monitoring season, the pH probe on the NOAA sonde failed. After several subsequent deployments of the NOAA sonde without a working pH probe, DNR used a replacement pH probe from their own supply to restore the NOAA sonde to full working order. Additionally, throughout 2016, DNR data sondes had to be deployed at the Tred Avon profiler during the two week intervals when the NOAA sonde was removed for maintenance. However, due to the equipment needs of other DNR monitoring programs, the only DNR sonde that was available for use with the Tred Avon profiler did not have a working chlorophyll probe. Future deployments of the vertical profiler will require an investment in additional data sondes and monitoring probes to obtain full monitoring capability.

Figure 2. Biofouling on the monitoring sonde at the Tred Avon vertical profiler (August 11, 2016).

As in previous years, biofouling was extensive at the Tred Avon monitoring site. Figure 2 illustrates the biofouling that occurred during a three-week deployment period in August 2016. Biofouling can impair profiler operation and compromise data results.

Data Management

Data Acquisition

In addition to field support and equipment maintenance, DNR also assumed data management responsibilities for the Tred Avon vertical profiler. DNR staff were able to connect to the profiler and perform regular data downloads using Campbell Loggernet software. Connecting remotely with the CR1000 also allowed DNR to troubleshoot potential issues with profiler operation.

DNR scheduled automatic data downloads to a DNR server daily at 12:00am and 12:00pm. In addition, periodic manual downloads of the data were also performed throughout the monitoring season. Utilizing both automatic and manual data downloads helped to minimize the risk of losing data records due to equipment malfunctions.

Missing Data Records

Table 2 summarizes the gaps that occurred in the 2016 profile data record. Some of these gaps occurred during repairs to the winch coupler and the leaking pontoon that were noted above. An equipment malfunction caused a sonde depth reading error on September 4, 2016 and temporarily halted profile operation. The error was corrected with the scheduled sonde exchange

on September 6, 2016. A small gap (a single missing profile sequence) occurred in the data record on September 8, 2016 for unknown reasons. The largest data gap occurred from October 5, 2016 to November 4, 2016. During this time, NOAA removed the vertical profiler from the Tred Avon River in advance of Hurricane Matthew. Finally, due to the shortage of fully functioning sondes and probes for use with the profiler, some data gaps for individual parameters exist in the 2016 monitoring record. Missing parameter data are summarized in Table 3.

Table 2. Time intervals of missing profile data records during the 2016 monitoring season.

Date of missing records		Time interval			Possible Cause
From	To	Days	Hours	Minutes	
8/11/16 07:07	8/16/16 07:27	5	0	20	Repair broken coupler on winch
8/18/16 06:07	8/30/16 13:01	12	6	54	Repair leaking pontoon
9/4/16 20:07	9/6/16 12:01	1	15	54	Sonde reading error: Invalid depth reading (-14.492m)
9/8/16 22:07	9/9/16 00:01	0	1	54	Skipped profile (reason unknown)
10/5/16 09:07	11/4/16 10:01	30	0	54	Profiler removed due to Hurricane Matthew

Table 3. Parameter data not collected due to missing or malfunctioning probes.

Missing parameter	Deployment dates		Number of data records affected
	From	To	
pH	6/28/16	7/11/16	1878
pH	7/21/16	8/11/16	3024
Chlorophyll	8/16/16	9/4/16	1056
Chlorophyll	9/28/16	11/15/16	2580
Chlorophyll	12/8/16	12/21/16	1872

Data Quality Assurance Procedures

DNR's data quality assurance (QA) procedures for the Tred Avon vertical profiler were modeled after the data management protocols for the Harris Creek profiler and the DNR Shallow Water Monitoring Program. DNR staff analyzed the Tred Avon data using the same Excel macro used to QA similar data collected from the Harris Creek profiler. The macro was run to detect any extreme parameter values that warranted closer examination. Post-calibration results, field notes, and plots of the data were reviewed to judge data validity. Data values determined to be of questionable quality were assigned an error code, but no data were deleted. The file was saved as a "Q-file" which contains parameter values, error codes, and a comment field for additional remarks. A more detailed description of the data quality assurance procedures is documented in the Quality Assurance Project Plan (QAPP) for the DNR Shallow Water Monitoring Program.

Water Quality Monitoring Results

Two types of water quality data were collected by the vertical profiler: profile readings and hourly readings. Profiles were conducted beginning at the top of each hour. During a profile sequence, the profiler took readings at fixed intervals as the sonde was lowered through the water column. A complete profile took less than 10 minutes to complete. Data collected during a profile sequence were stored as profile readings.

After conducting a profile, the sonde returned to a depth of 1.0m and remained parked there until the next profile sequence. Four minutes before the start of each hour, the profiler took an additional reading as the sonde was resting in the parked position. Data collected while the sonde was parked were stored as hourly readings.

Profile Readings

Data collected during profile sequences are shown in Figures 3-8. These plots show data values over time with the data at each depth represented by a different line. The plots show the entire data record from June through December 2016. Breaks in the line are due to gaps in the data record, either as a result of missing data collection or censoring the data through the QA process.

Water temperatures show expected seasonal variability throughout the monitoring season (Figure 3). Temperatures increased from around 25° C in June to peak values around 31° C in late July, and then declined steadily to values around 3° C in December. Chlorophyll values generally remained below 20 µg/l throughout the monitoring period, although a few brief spikes greater than 100 µg/l, indicative of a severe algal bloom, occurred during the month of September (Figure 4). Turbidity readings occasionally spiked during this same September period to values greater than 30 NTU (Figure 5). Otherwise, turbidity was typically less than 15 NTU, with frequent, smaller spikes between 15-30 NTU. Salinity values were between 12-13 ppt for most of the summer season, but began to increase in September and rose to values above 16 ppt in November and December (Figure 6). Values for pH in the Tred Avon River ranged between 7.4 and 8.5, with slightly higher values observed in late December (Figure 7). The values for salinity and pH were both within the ranges considered to be favorable for oyster habitat (https://chesapeakebay.noaa.gov/fish-facts/oysters). Dissolved oxygen, which generally ranged between 5-10 mg/l for June through October, increased to more than 10 mg/l in late November through December (Figure 8). During several weeks in September, dissolved oxygen in the bottom waters (4.5m depth) dropped below 5 mg/l.

Water quality conditions at the site show slight differences between surface and bottom values. Generally, temperature, chlorophyll, and pH values were slightly greater at the surface, and turbidity and salinity were slightly greater near the bottom. Dissolved oxygen values at the surface were about 1 mg/l greater than bottom water values, but when bottom dissolved oxygen dropped below 5 mg/l in September, the surface and bottom values differed by nearly 3 mg/l.

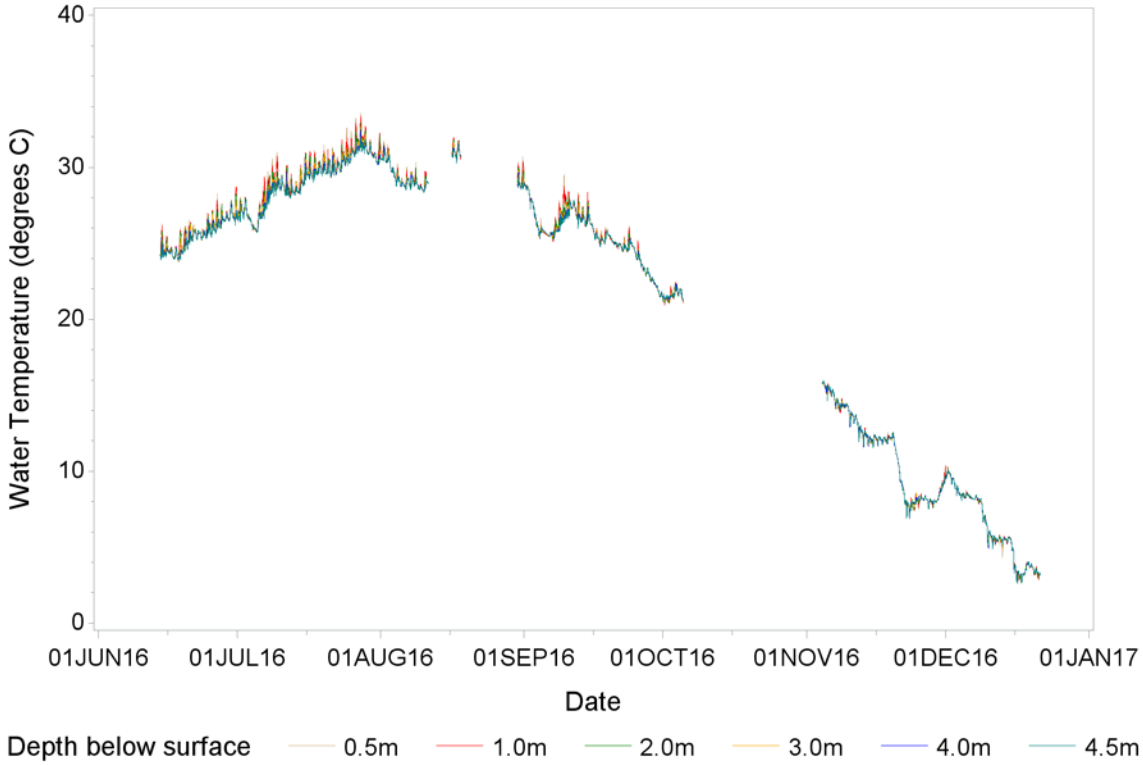

Figure 3. Water temperature in the Tred Avon River during 2016.

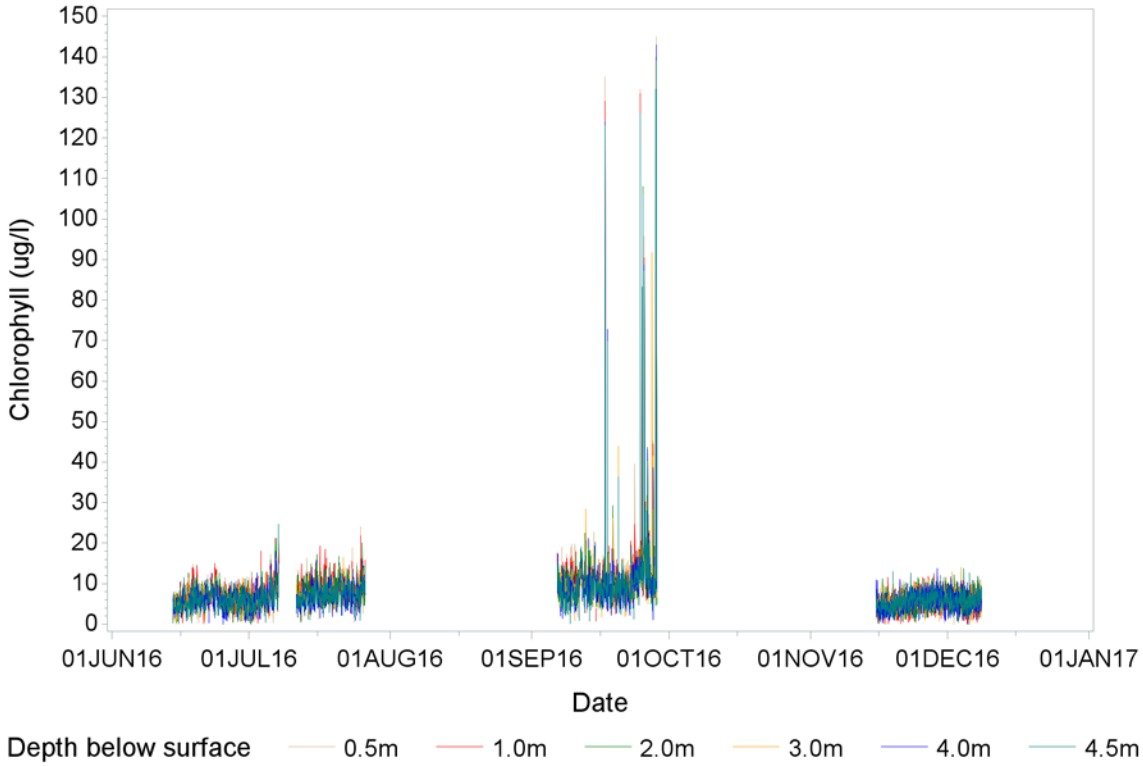

Figure 4. Chlorophyll in the Tred Avon River during 2016.

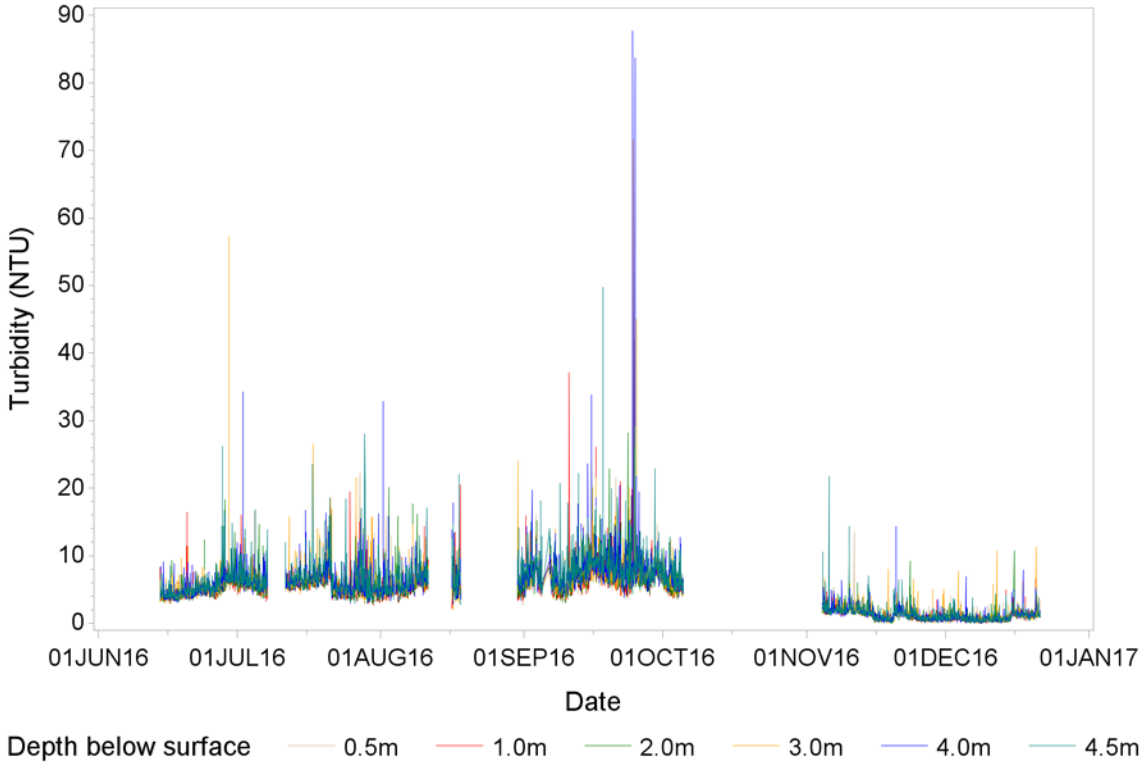

Figure 5. Turbidity in the Tred Avon River during 2016.

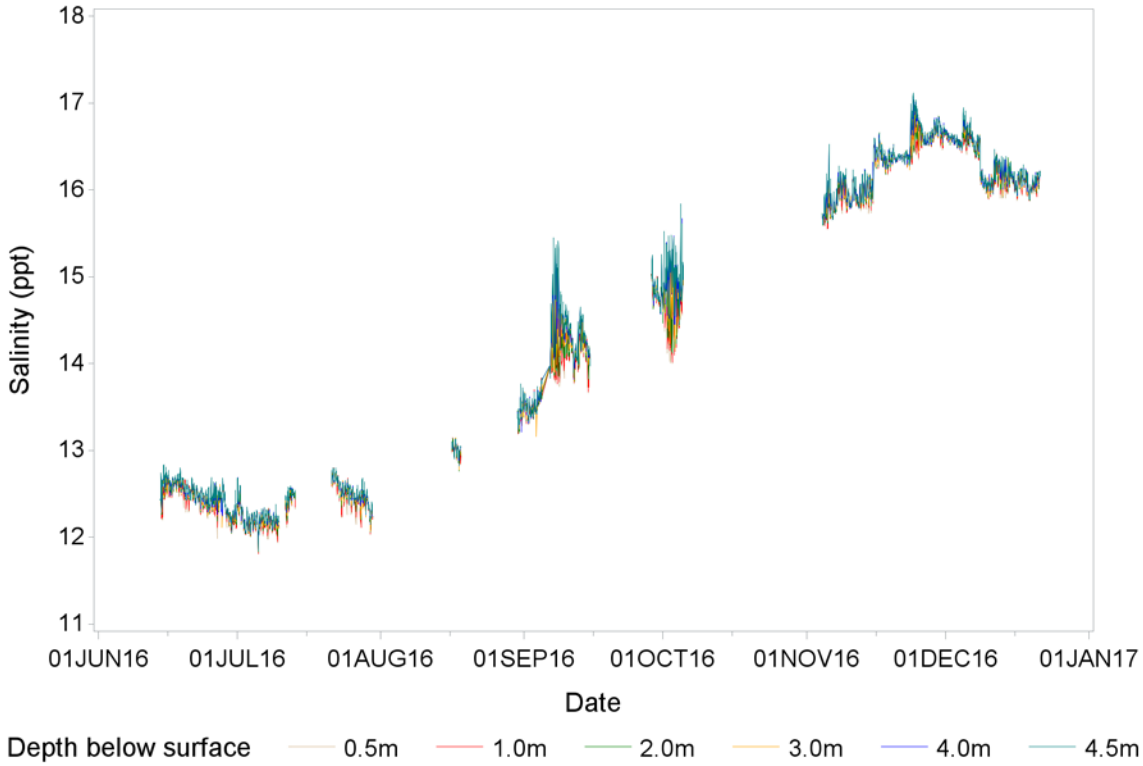

Figure 6. Salinity in the Tred Avon River during 2016.

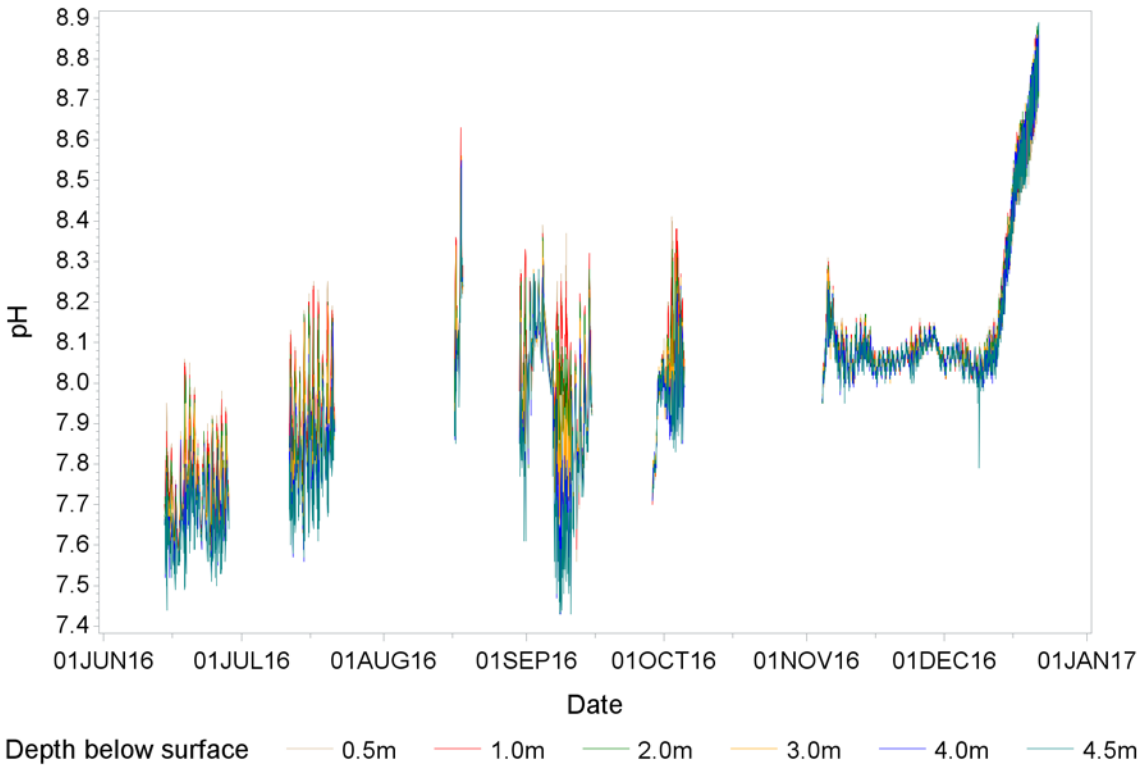

Figure 7. pH in the Tred Avon River during 2016.

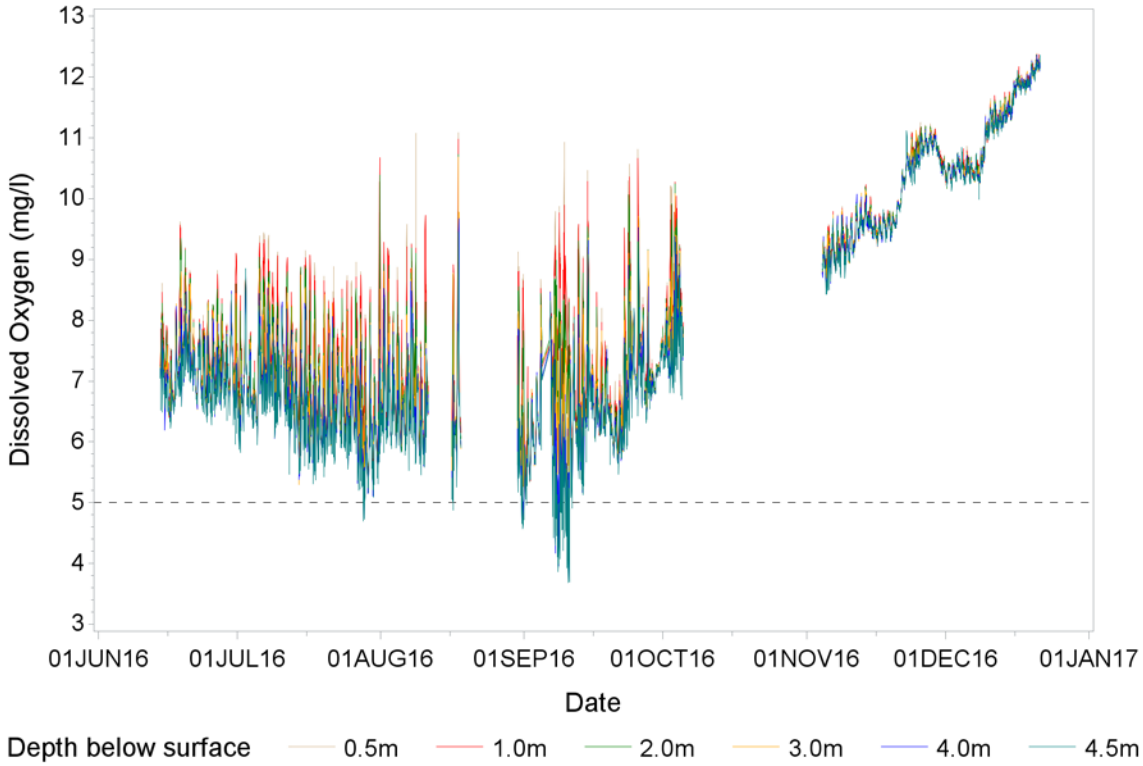

Figure 8. Dissolved oxygen in the Tred Avon River during 2016.

Hourly Readings

The results of the hourly readings are presented in Figures 9-14 and are consistent with the profile results presented above. Hourly readings were collected once per hour at a time when the sonde was resting in the 1 meter parked position. When errors cause the vertical profiler to stop collecting profile readings, the instrument usually continues to collect hourly readings. Thus, the data record for the hourly readings can be slightly more complete than the record for profile readings. As mentioned previously, the Tred Avon vertical profiler experienced relatively few instrument malfunctions in 2016, and so the data record of hourly readings closely matches that of profile readings.

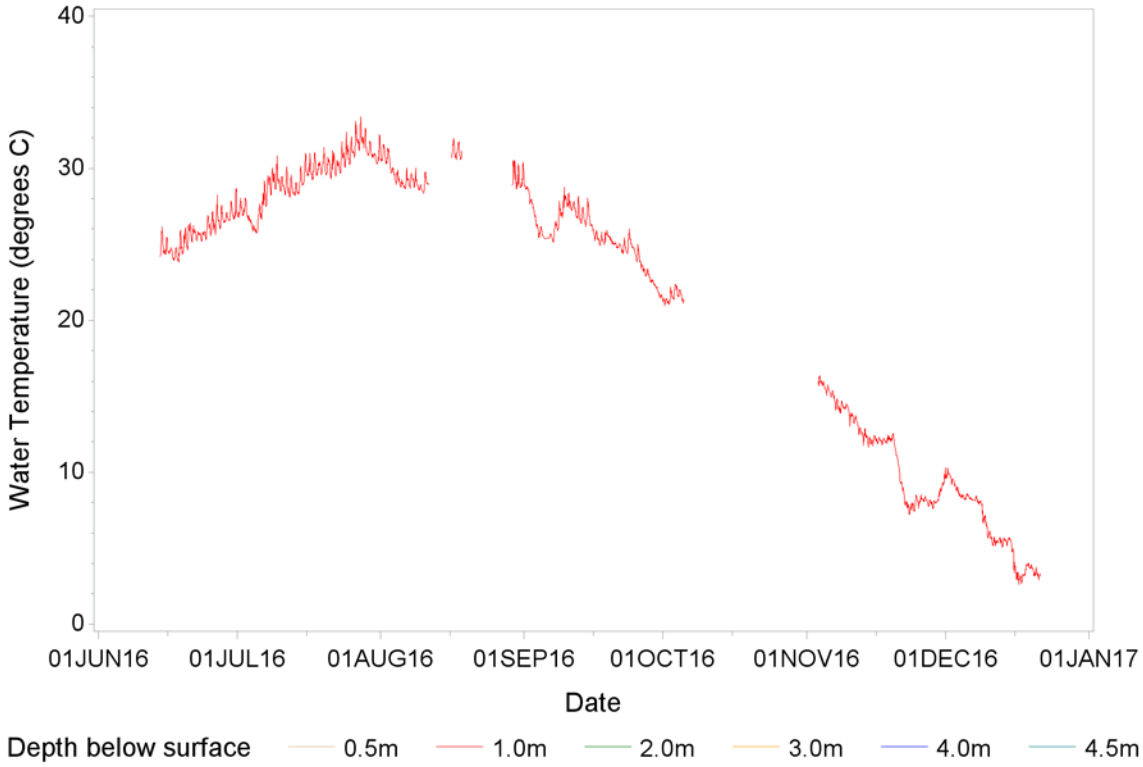

Figure 9. Hourly readings for water temperature in the Tred Avon River during 2016.

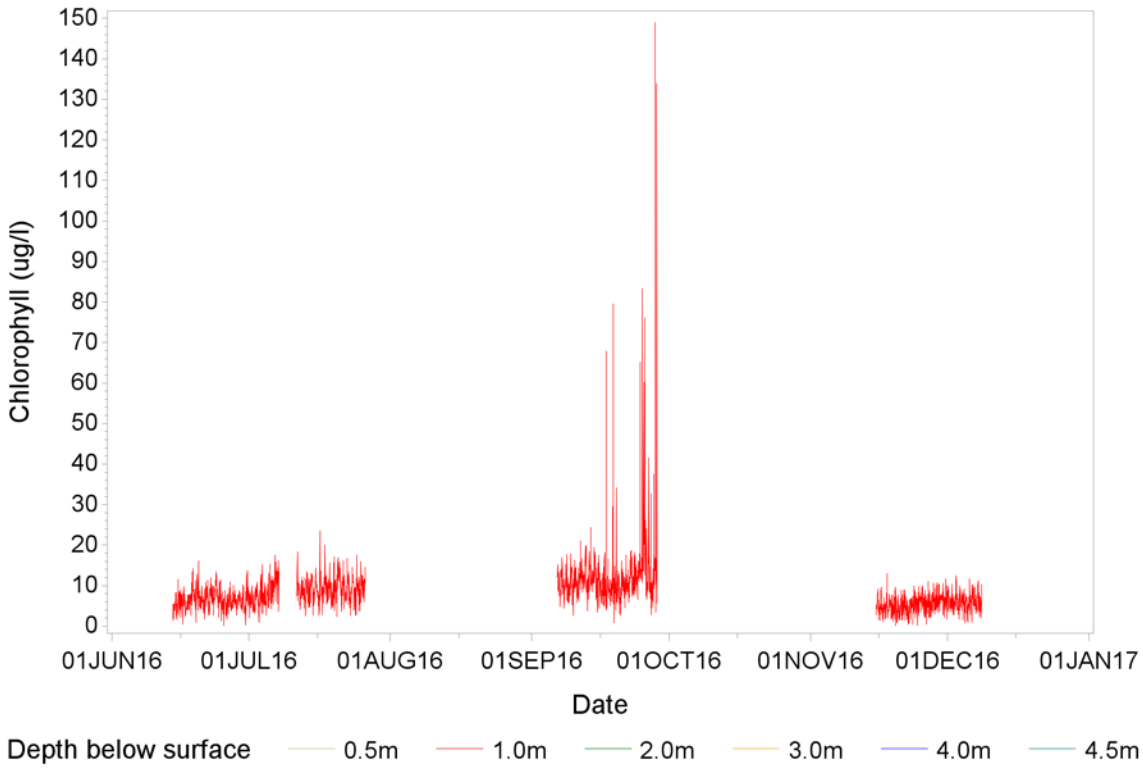

Figure 10. Hourly readings for chlorophyll in the Tred Avon River during 2016.

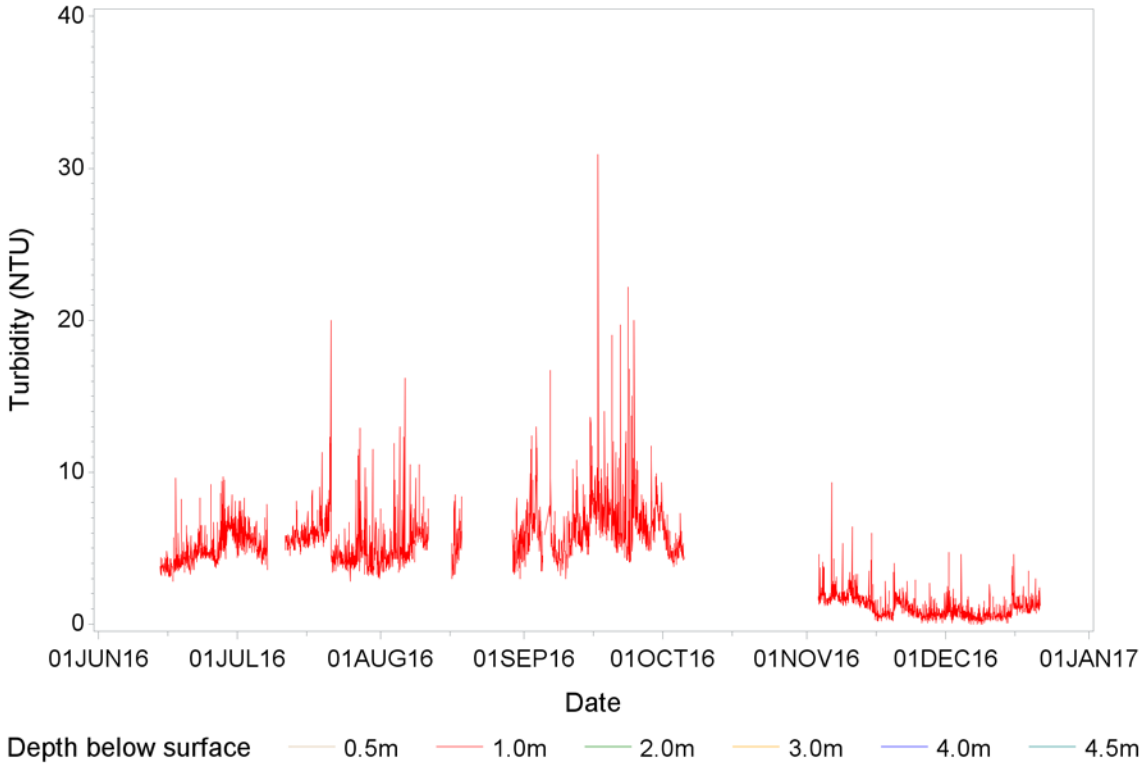

Figure 11. Hourly readings for turbidity in the Tred Avon River during 2016.

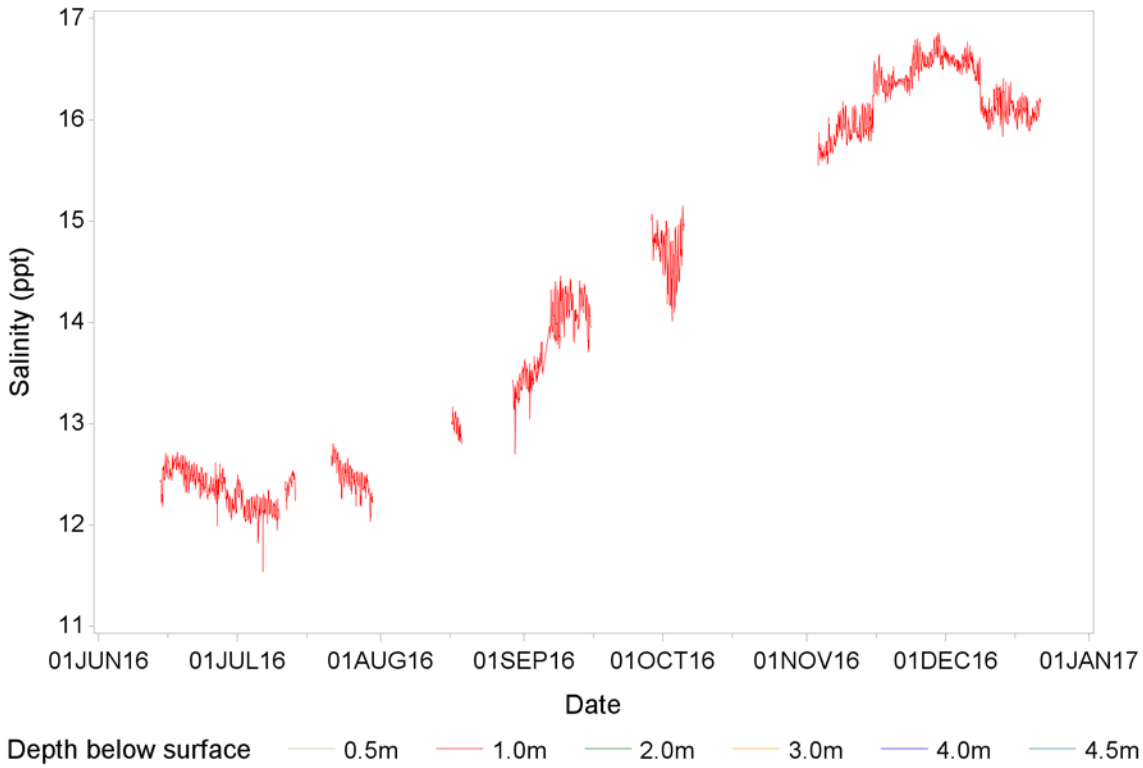

Figure 12. Hourly readings for salinity in the Tred Avon River during 2016.

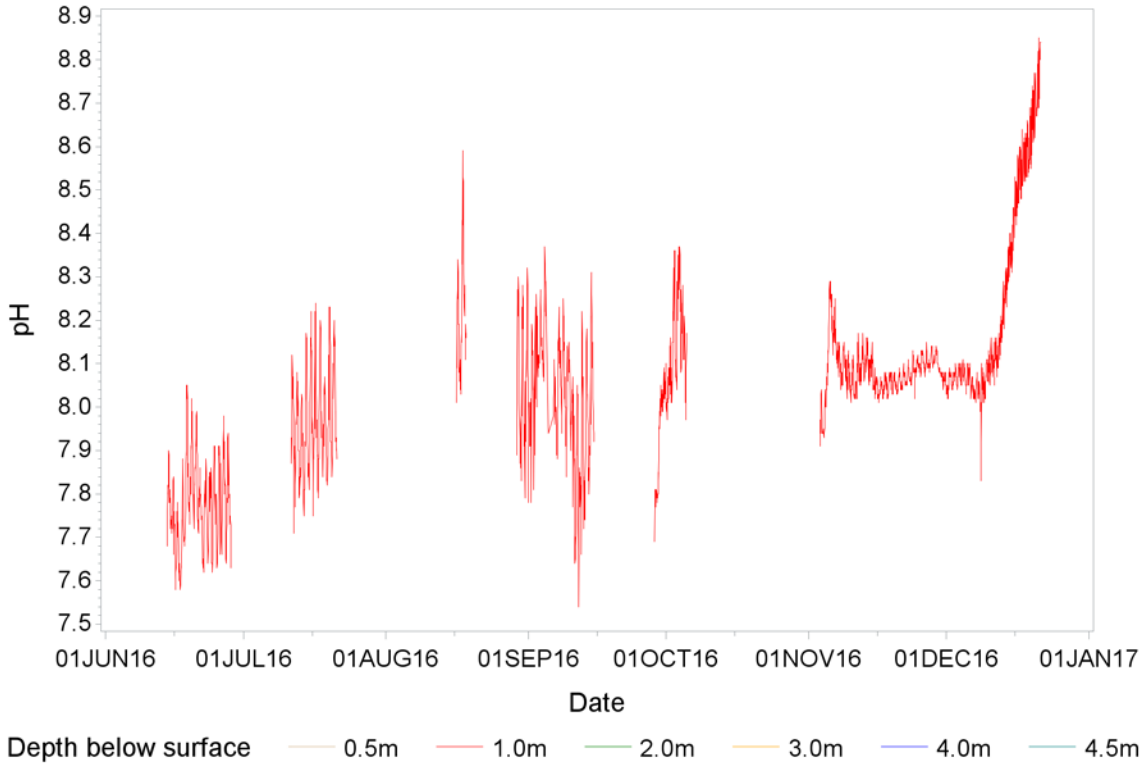

Figure 13. Hourly readings for pH in the Tred Avon River during 2016.

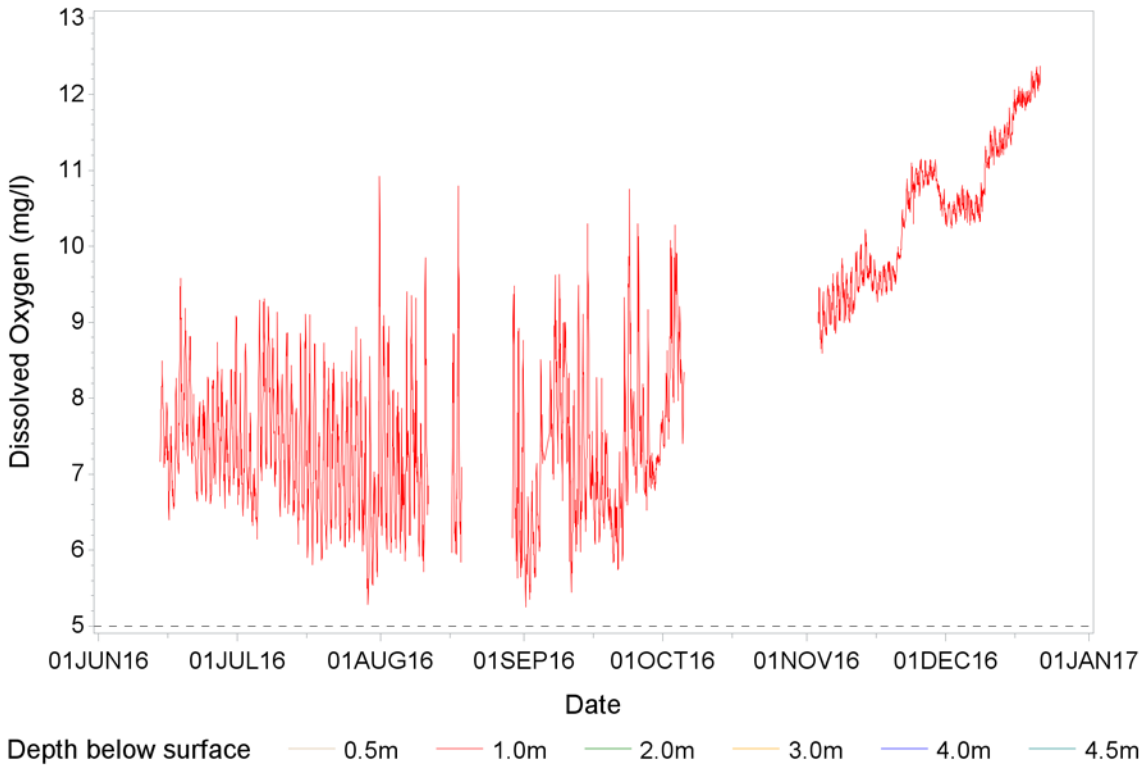

Figure 14. Hourly readings for dissolved oxygen in the Tred Avon River during 2016.