



**Vertical Profiler Water Quality Monitoring
in the Tred Avon River –
April 2018 to November 2018**

February 7, 2019



Executive Summary

During April-November 2018, 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 was outfitted with a data sonde that measured salinity, water temperature, pH, dissolved oxygen, chlorophyll, and turbidity at fixed intervals throughout the water column. Profiles were conducted once every hour with readings taken at 0.5 m, 1 m, 2 m, 3 m, 4 m, and 4.5 m depths.

During the 2018 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 control. Additionally, in 2018 DNR created a web page for the Tred Avon vertical profiler to facilitate data download and dissemination. The web page allows for viewing of the most recent profiles and for downloading data records from the current year as well as all past years of monitoring. The web address for the Tred Avon vertical profiler page is:

<http://eyesonthebay.dnr.maryland.gov/contmon/NOAAProfiler.cfm>

The Tred Avon vertical profiler operated without incident for the entire monitoring period in 2018, and the data record is almost entirely complete. An exception is chlorophyll, which is missing data records for two-week intervals throughout the monitoring season due to a missing chlorophyll probe on one of the data sondes. This probe should be replaced prior to the next monitoring season to eliminate such data gaps. Another equipment issue may occur in the future as Verizon plans to discontinue its support of 3G modems at the end of 2019. If the profiler is not currently equipped with a modem that has 4G capability, it will be necessary to upgrade the modem prior to the start of 2020 to retain remote access to the instrument via telemetry.

Water quality conditions in the Tred Avon River show expected seasonal variability and are generally suitable for oyster growth and survival. During 2018, the data ranges for each of the water quality parameters were as follows: water temperature (6.4° C – 32.5° C); chlorophyll (0.1 µg/l – 81.2 µg/l); turbidity (0.2 NTU – 82.0 NTU); salinity (6.2 ppt – 11.7 ppt); pH (7.2 – 9.0); dissolved oxygen (4.0 mg/l – 13.9 mg/l).

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Introduction

During April-November 2018, the National Oceanic and Atmospheric Administration (NOAA) deployed a vertical profiler to monitor water quality conditions in the Tred Avon River. The Tred Avon, a tributary of the Choptank River, is designated as an oyster sanctuary and is targeted for oyster restoration activities. Water quality information from the profiler may be used to assess habitat suitability for oyster growth and survival in the Tred Avon River. Water quality monitoring during 2018 was a continuation of vertical profile monitoring that NOAA conducted during the years 2014-2017. This report summarizes the monitoring activities and data results for 2018.

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 0.5 m, 1 m, 2 m, 3 m, 4 m, and 4.5 m 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: salinity, water temperature, pH, dissolved oxygen, turbidity, and chlorophyll. Readings were stored in electronic files on the CR1000 datalogger. In addition to water quality data, the CR1000 can also store data files pertinent to instrument operation that are helpful for 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 anchored the vertical profiler platform in the Tred Avon River in late April 2018, and on April 25, 2018 DNR connected a YSI sonde to the unit to initiate profiler operation and data collection. The monitoring season concluded on November 26, 2018, when NOAA removed the vertical profiling equipment from the Tred Avon River.

Throughout the 2018 monitoring period, DNR conducted regular field visits to the site (generally every two weeks) to maintain the profiler equipment. During field visits, the data sonde at the profiler was exchanged with a clean and freshly calibrated sonde that was brought out to the site.

The sonde that was removed was then returned to the DNR field office laboratory for post-calibration and cleaning. In total, DNR staff visited the Tred Avon site thirteen times during the 2018 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 2018 monitoring season.

Date	Activity
April 25, 2018	Initial deployment -- installed sonde and battery
May 23, 2018	Swapped sonde
June 5, 2018	Swapped sonde
June 19, 2018	Swapped sonde
July 3, 2018	Swapped sonde
July 16, 2018	Swapped sonde
August 7, 2018	Swapped sonde
August 21, 2018	Swapped sonde
September 4, 2018	Swapped sonde
September 27, 2018	Swapped sonde
October 9, 2018	Swapped sonde
October 30, 2018	Swapped sonde
November 26, 2018	Swapped sonde (NOAA removed the vertical profiler shortly after the swap.)

Data Collection

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 1.0 m 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.

Equipment Operation

The vertical profiler instrument operated without incident during 2018, and as a result, the monitoring record is almost entirely complete. Two sondes were available for deployment at the site and allowed for efficient swapping of the sondes during field visits. One sonde did have a pH probe fail, and that probe was replaced using DNR equipment. Also, one sonde did not have a chlorophyll probe installed, but otherwise operated reliably all season without one. As with previous years, extensive biofouling of the equipment was an issue at the Tred Avon site, especially during the summer.

Missing Data Records

During the seven months of deployment during 2018, only two profile sequences were missed. On May 20, the vertical profiler skipped a profile sequence at 1:00am for unknown reasons. On August 21, field personnel were on site and performing maintenance to the instrument, causing the 8:00am profile to be missed. For hourly records, just five readings over the entire 2018 monitoring period were missed. Most often, the hourly reading was skipped due to field personnel swapping sondes at the time of the scheduled hourly reading. This happened on May 23, July 3, August 21, and September 4. On October 26, the vertical profiler skipped the 4:56am hourly reading for unknown reasons.

Two sondes were dedicated for use at the Tred Avon profiler, allowing one sonde to be deployed at the site while a second sonde was in the laboratory for cleaning and post-calibration. One of the sondes used at the Tred Avon profiler did not have a chlorophyll probe installed. Thus, data gaps for chlorophyll exist in the 2018 monitoring record when no chlorophyll probe was present.

Future Considerations

The telemetry unit at the Tred Avon monitoring site allows remote access to the instrument and downloading of data. DNR has been notified that the wireless carrier, Verizon, will no longer support 3G modems beginning in 2020. Thus, DNR is currently converting all 3G modems at their continuous monitoring sites to 4G capability. Similarly, if the vertical profiler in the Tred Avon River is not currently equipped with a modem that has 4G capability, it will be necessary for NOAA to upgrade the modem to continue remote access.

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 to the CR1000 also allowed DNR to troubleshoot potential issues with profiler operation.

DNR scheduled automatic data downloads to a DNR server daily at 4-hour intervals (12:30am, 4:30am, 8:30am, 12:30pm, 4:30pm, 8:30pm) for a total of 6 times per day. 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.

Data Visualization & Download

In 2018, DNR also developed and implemented a dedicated NOAA Profiler web page on DNR's water quality monitoring website, "Eyes On The Bay" (www.eyesonthebay.net). This web page allows for quick and easy online data visualization and download of Tred Avon NOAA Profiler data. During the sampling season, this page provides charts of the latest water quality profile for each parameter, which automatically update (every four hours) with the newest data record. A data download tool allows data to be queried and downloaded from the onset of data collection in June 2014 to the most recent data record available, with options to choose date range and select the parameters of interest. The NOAA Profiler web page also provides download access to all Tred Avon Vertical Profiler Water Quality Monitoring Reports from 2014 to present.

The NOAA Profiler web page is not linked to the "Eyes on the Bay" content, but is provided solely for use by NOAA for data acquisition and dissemination. The web page is accessed through the following link: <http://eyesonthebay.dnr.maryland.gov/contmon/NOAAPProfiler.cfm>

Data Quality Assurance and Quality Control Procedures

Following download, DNR staff thoroughly reviewed the Tred Avon vertical profiler data records. DNR's data quality assurance and quality control (QA/QC) 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. A detailed description of the data quality assurance procedure is documented in the Quality Assurance Project Plan (QAPP) for the DNR Shallow Water Monitoring Program:

(http://eyesonthebay.dnr.maryland.gov/eyesonthebay/documents/SWM_QAPP_2018_2019_Draft_v6.pdf)

DNR staff reviewed the Tred Avon data using the same Excel macro used to examine 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.

Water Quality Monitoring Results

Profile Readings

Data collected during profile sequences are shown in Figure 3 through Figure 8. These plots show data values over time with the data at each depth represented by a different colored line. The plots show the entire data record from April through November 2018. Breaks in the line are due to gaps in the data record. In the case of chlorophyll, this was the result of missing data collection due to a missing chlorophyll probe. For all other parameters, gaps in the data record

appear where the data values were censored as part of the data quality review process. The results for each water quality parameter are briefly discussed below.

Water temperatures in the Tred Avon River show expected seasonal variability throughout the monitoring season (Figure 3). Temperatures increased from around 15° C in April to peak values around 32° C in early July, and then decreased steadily to values around 7° C in late November. Surface temperatures were only slightly warmer than the bottom water temperatures, with less than a 2° C difference between the two.

Chlorophyll values at the Tred Avon site were generally between 30-50 µg/l at the start of the monitoring season. Chlorophyll values decreased through May and were generally below 30 µg/l for the remainder of the year, with occasional peaks between 30-80 µg/l (Figure 4). Peak values most often occurred in the months of August-October. As mentioned previously, large gaps in the chlorophyll record are due to a missing chlorophyll probe on one of the data sondes.

Turbidity values in the Tred Avon River were less than 10 NTU for most of 2018 (Figure 5). Turbidity frequently spiked between 10-30 NTU, and occasionally spiked between 30-80 NTU throughout the year. The highest measured turbidity occurred on May 5, with a value of 82 NTU.

While biofouling is always an issue at the Tred Avon site, salinity probes are especially susceptible to the effects of biofouling since they do not include a wiper to clear biological growth from the probe. Over the course of each sonde deployment period, salinity values at the Tred Avon site slowly declined as biofouling increased on the instrument. Due to this drift in data values, significant portions of the salinity data record were determined to be unreliable and were censored during data quality review. Of the non-censored values, salinity measured around 11.5 ppt at the start of the monitoring season (Figure 6). Salinity declined sharply through the month of May as the region experienced unusually heavy rainfall, totaling over 8 inches of rain for the month. Through the summer (June – September), salinity fluctuated between 7.5-9 ppt and then declined steadily through October and November. In late November, at the end of the monitoring season, salinity measured around 6.3 ppt – the lowest values for the year. Throughout 2018, surface salinity values were slightly less (<0.5 ppt) than the bottom values.

Values of pH ranged between 7.2 and 9.0 through the 2018 monitoring season (Figure 7). During the months of June through September, surface water pH values were greater than bottom pH values, sometimes by as much as 0.5 ppt.

Dissolved oxygen concentrations also differed between surface and bottom waters, especially during the summer months. While surface waters were often greater than 8 mg/l during June-September, bottom water dissolved oxygen values were usually below 8 mg/l during this same period and even dropped below 5 mg/l briefly on several dates (Figure 8). Dissolved oxygen values were higher at the beginning and at the end of the monitoring season (April and November, respectively), with surface and bottom concentrations both greater than 10 mg/l during the first and last weeks of monitoring.

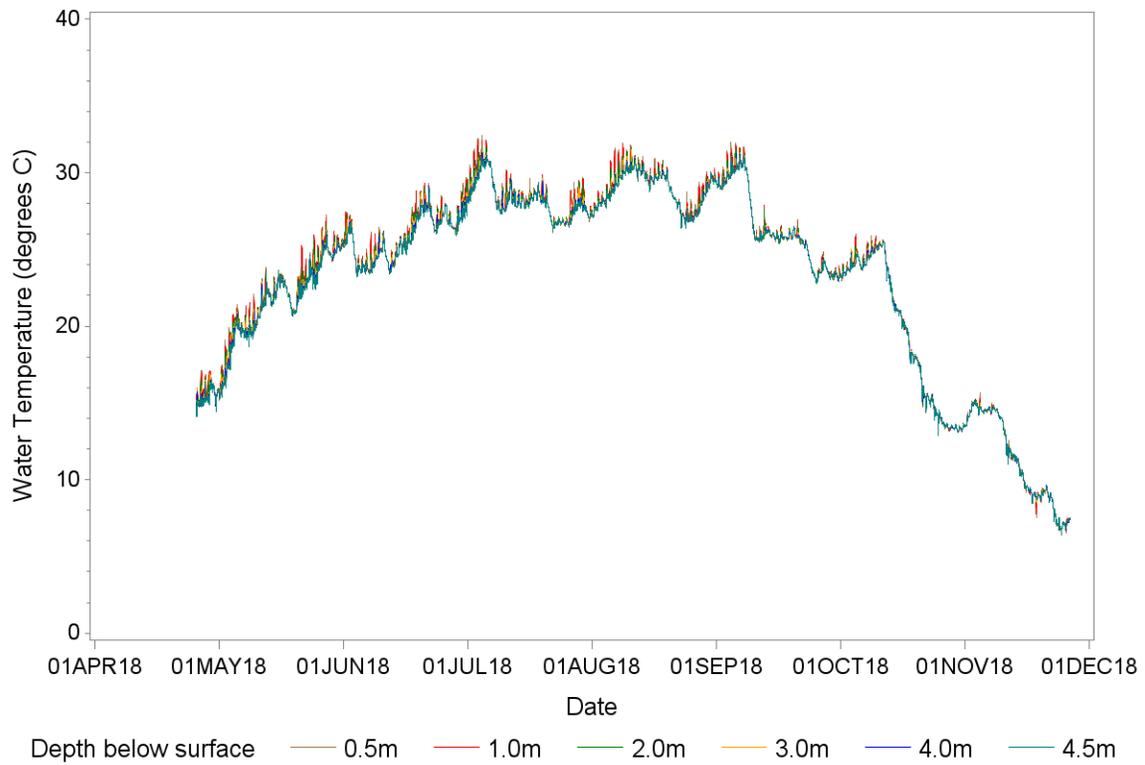


Figure 3. Water temperature in the Tred Avon River during 2018.

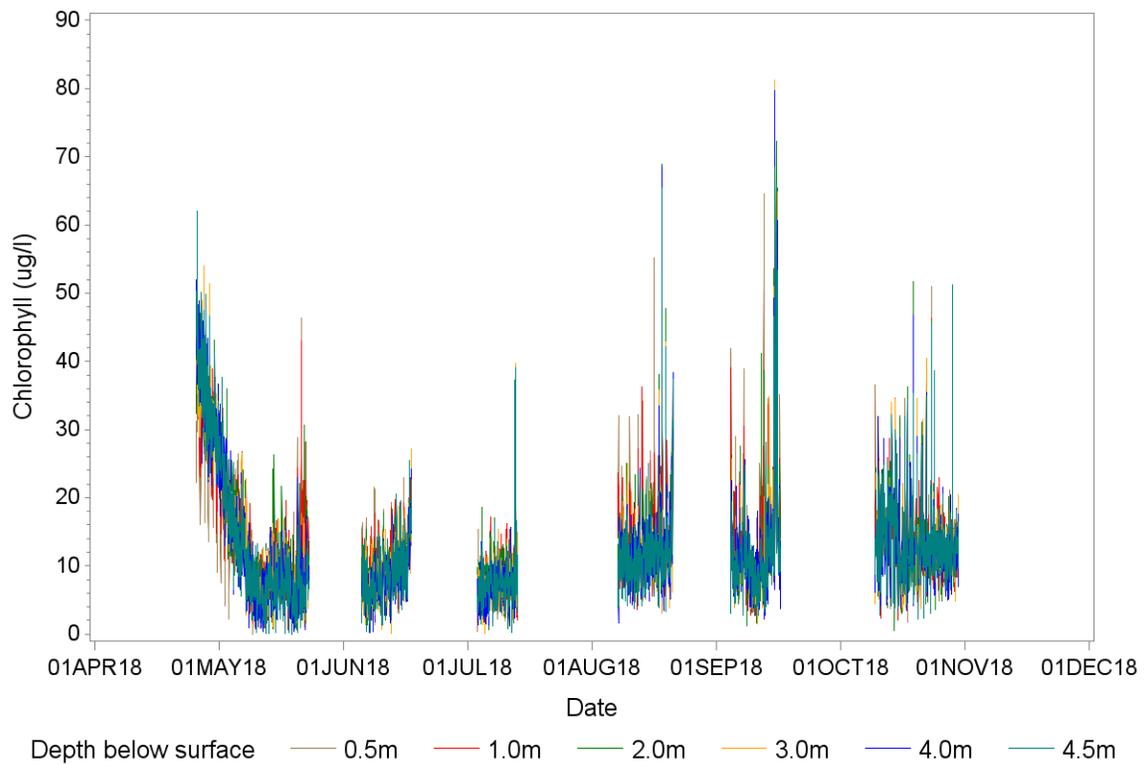


Figure 4. Chlorophyll in the Tred Avon River during 2018.

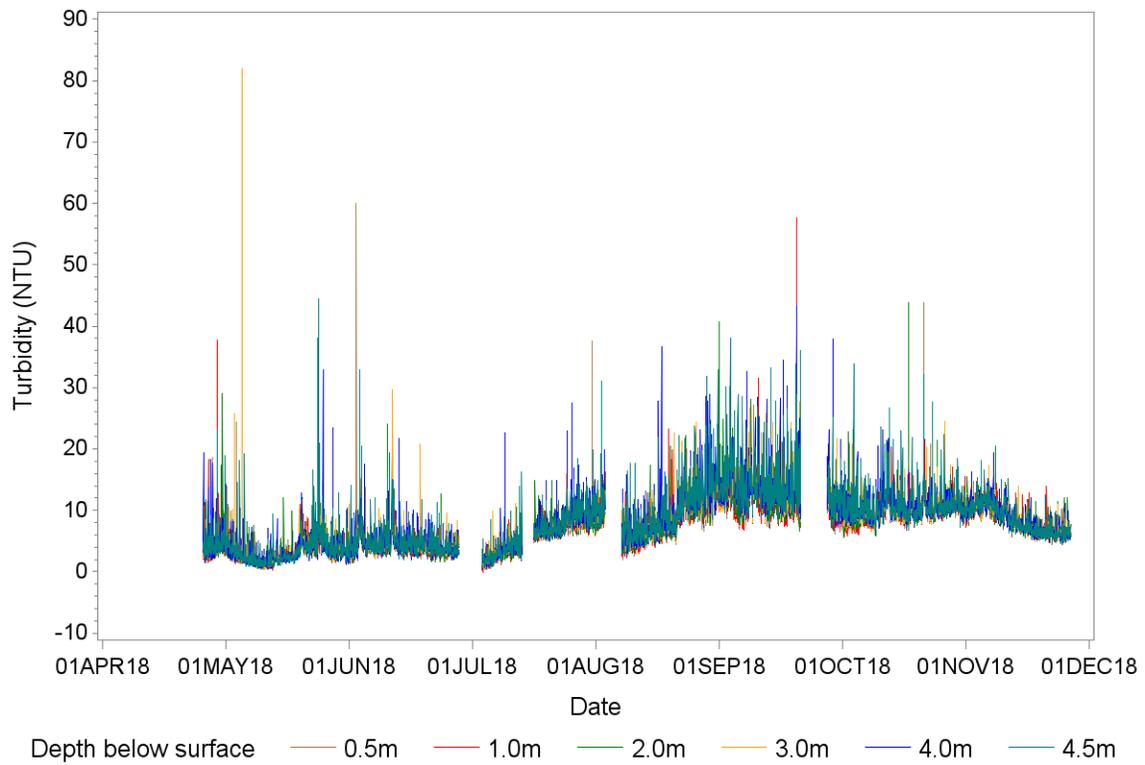


Figure 5. Turbidity in the Tred Avon River during 2018.

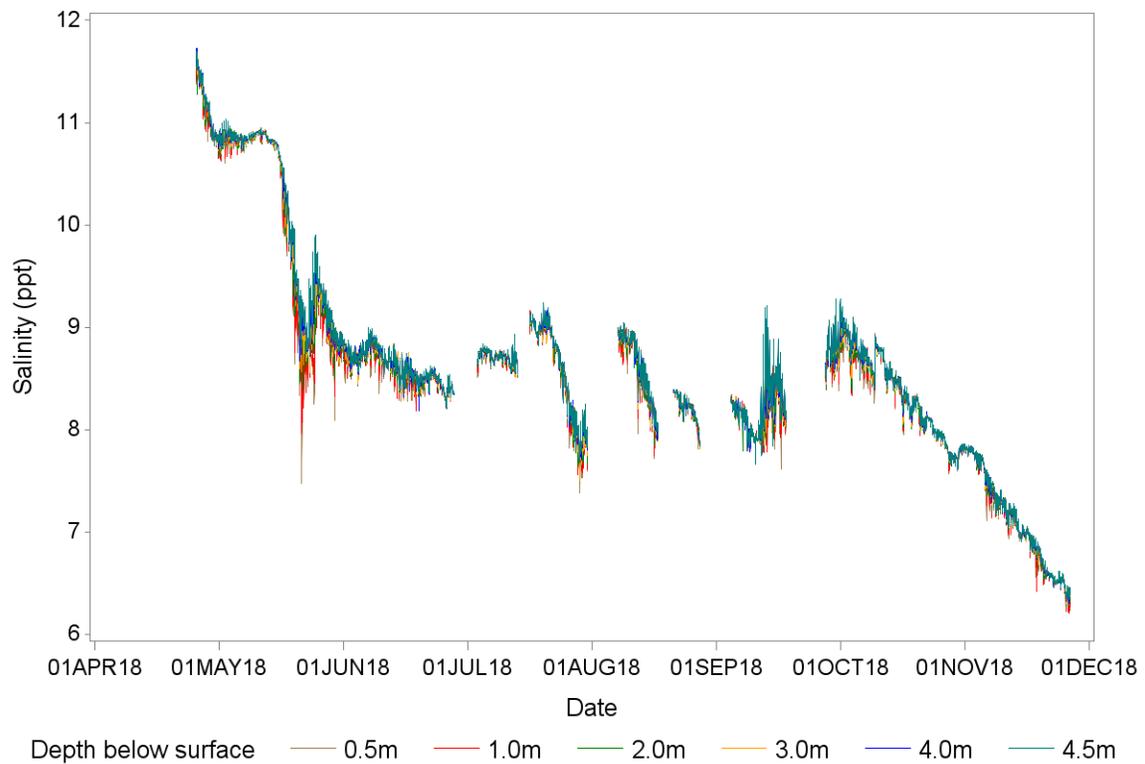


Figure 6. Salinity in the Tred Avon River during 2018.

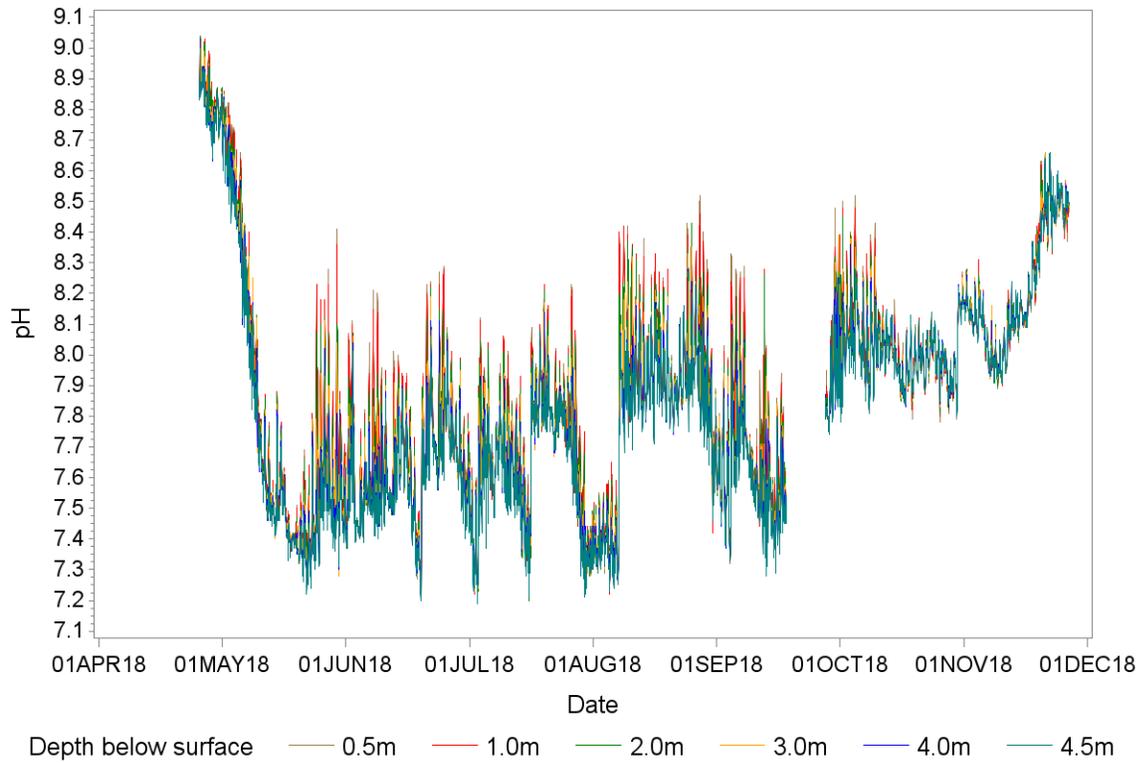


Figure 7. pH in the Tred Avon River during 2018.

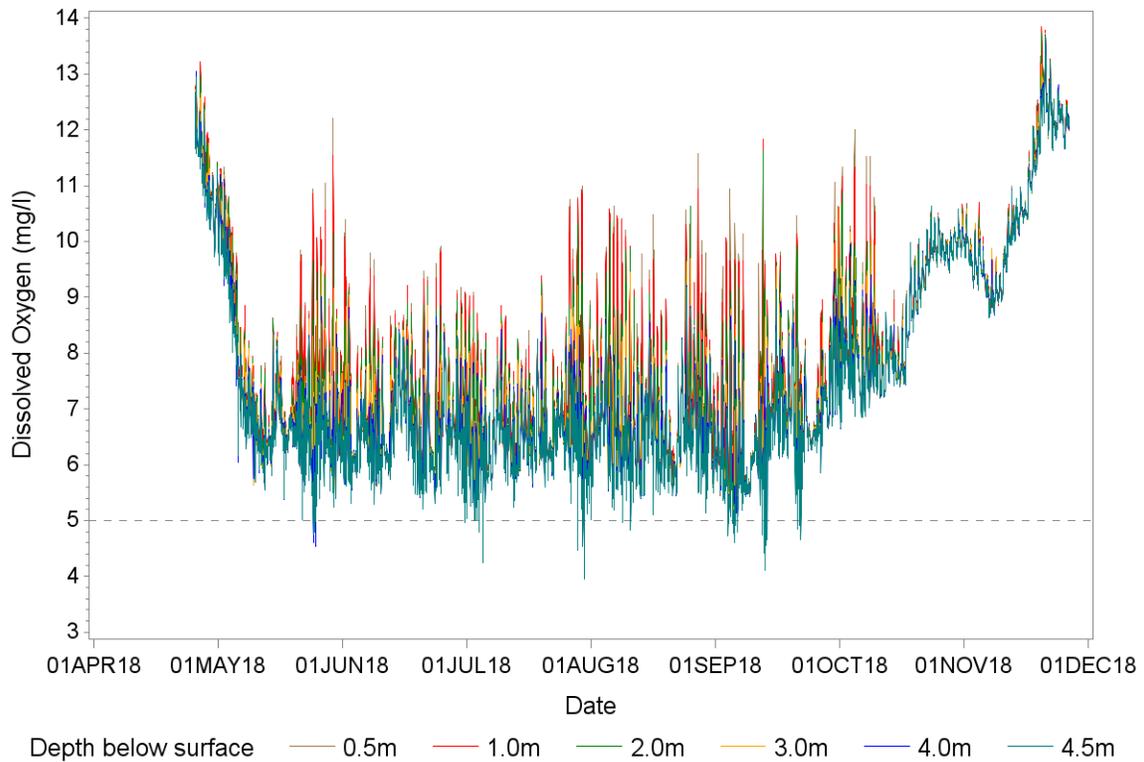


Figure 8. Dissolved oxygen in the Tred Avon River during 2018. (Dashed line indicates 5 mg/l criteria, values below which can be detrimental to living resources.)

Hourly Readings

The results of the hourly readings are presented in Figure 9 through Figure 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 at the 1 m depth in a parked position.

If errors cause the vertical profiler to stop conducting profile sequences, 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. However, since no significant instrument errors occurred in 2018, the number of hourly readings and the number of profile sequences are similar for this year.

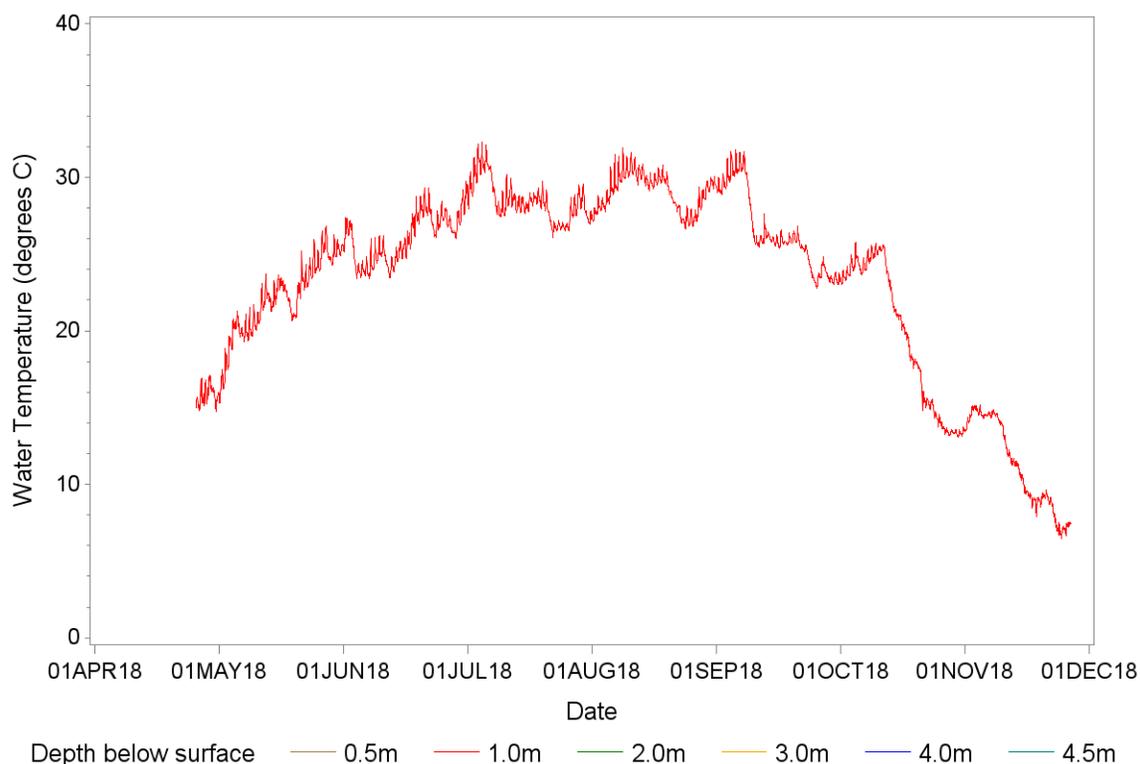


Figure 9. Hourly readings for water temperature in the Tred Avon River during 2018.

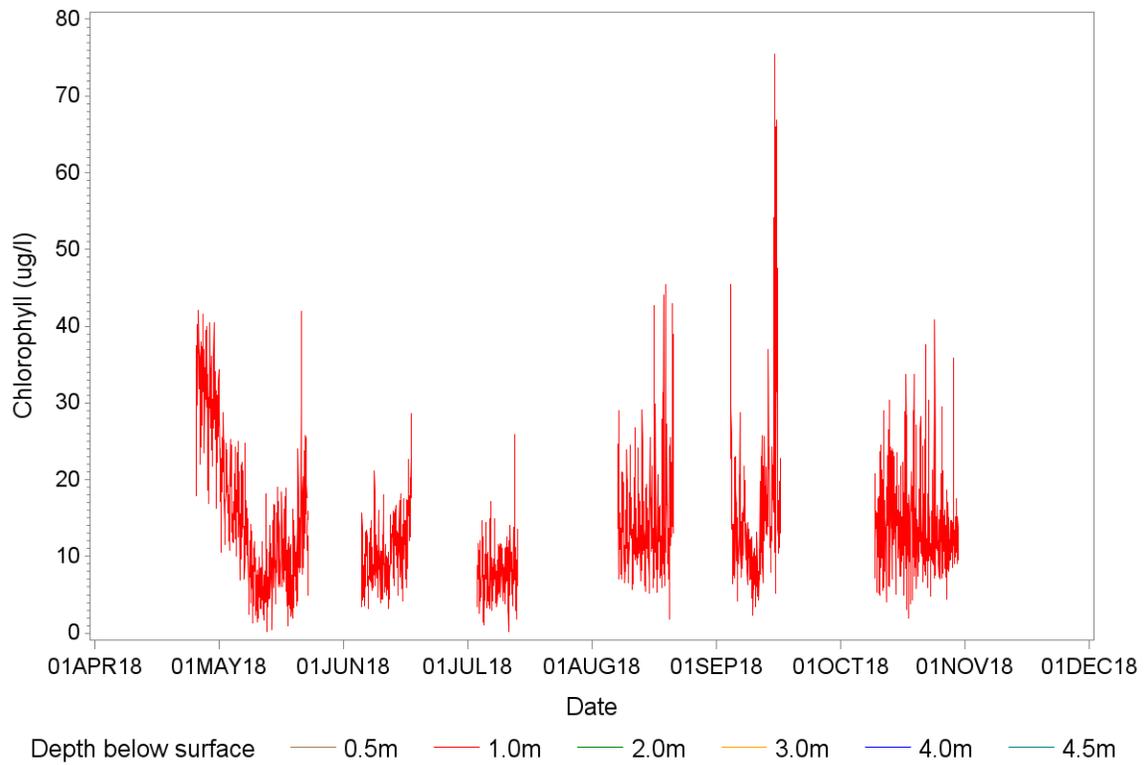


Figure 10. Hourly readings for chlorophyll in the Tred Avon River during 2018.

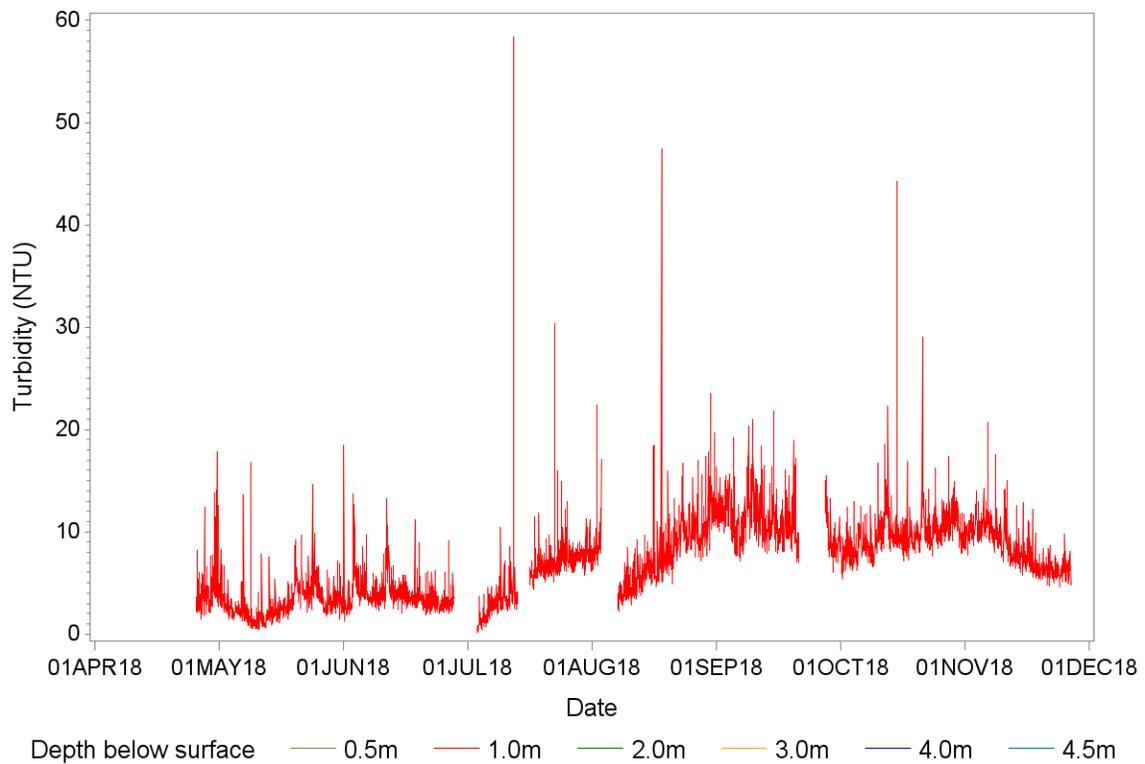


Figure 11. Hourly readings for turbidity in the Tred Avon River during 2018.

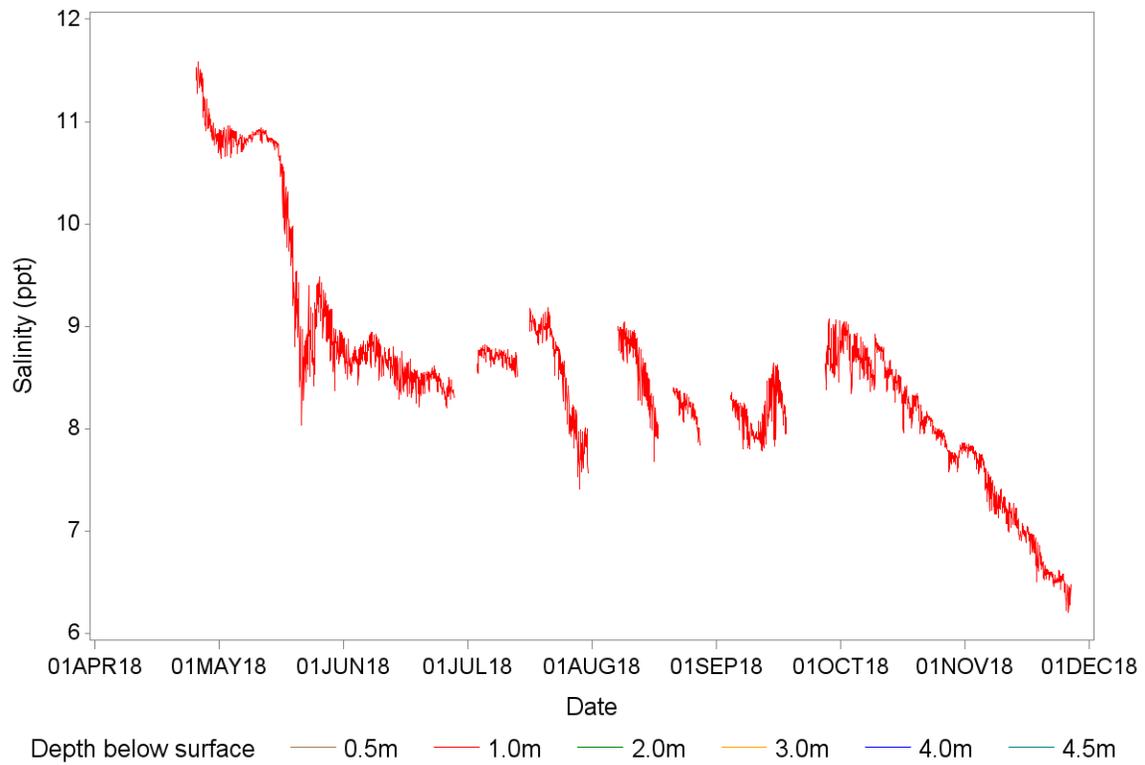


Figure 12. Hourly readings for salinity in the Tred Avon River during 2018.

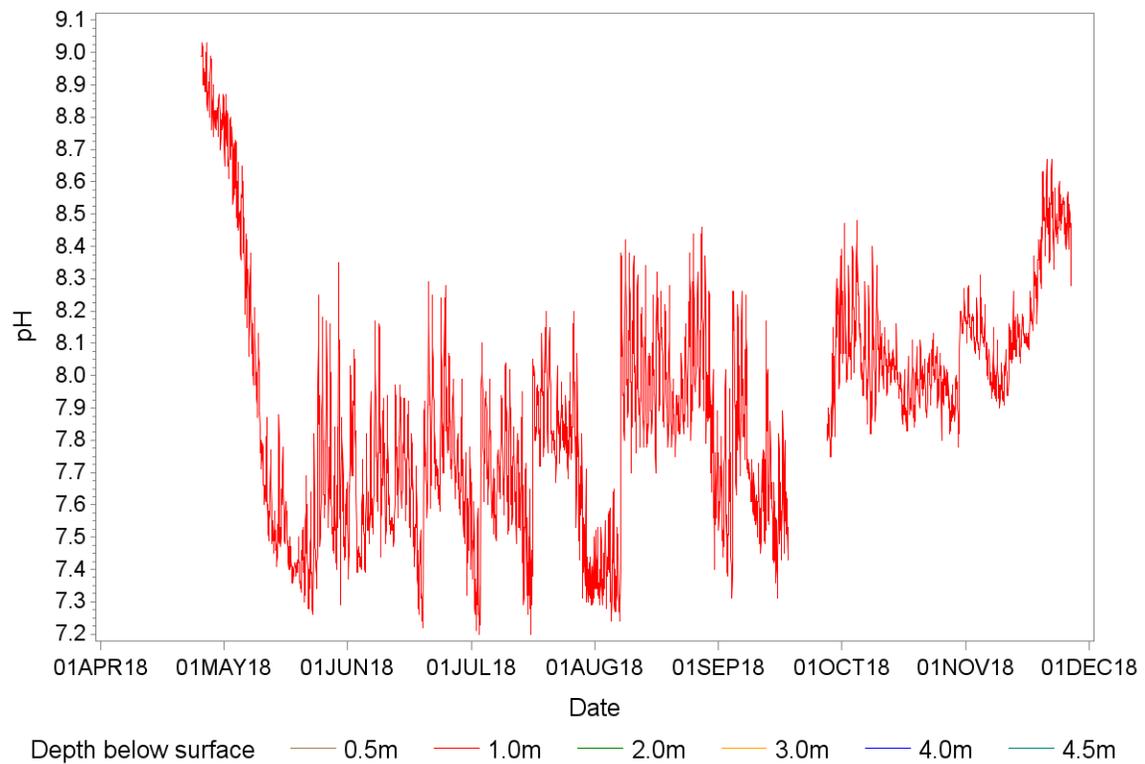


Figure 13. Hourly readings for pH in the Tred Avon River during 2018.

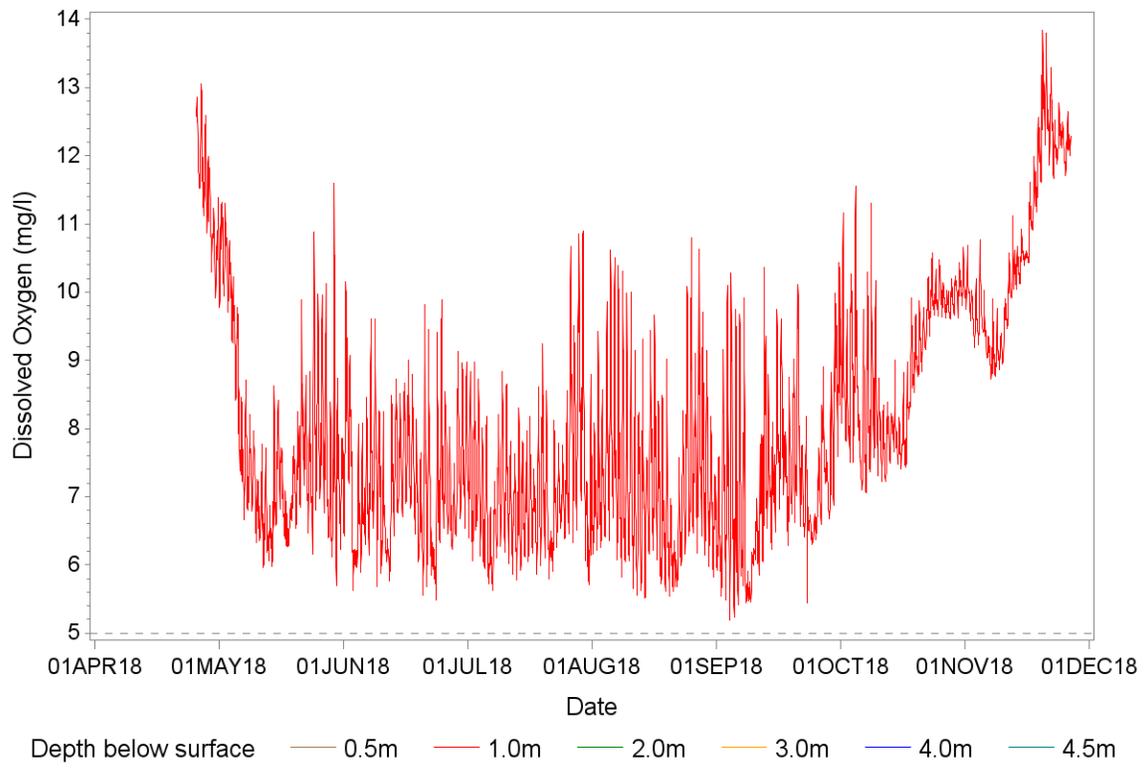


Figure 14. Hourly readings for dissolved oxygen in the Tred Avon River during 2018.