Vertical Profiler Water Quality Monitoring in the Tred Avon River – June 2017 to December 2017

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MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Executive Summary

During June-December 2017, 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 2017 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.

Data sondes are normally changed out every two weeks to minimize the chances of fouling affecting the accuracy of data readings. However, the 2017 monitoring season began with just one data sonde available for deployment at the Tred Avon vertical profiler. Although a second sonde was made available in late August, the profiler operated through the summer months with extended (longer than two weeks) sonde deployments or with sondes that were not properly cleaned and calibrated. Due to the extensive biofouling that typically occurs at the Tred Avon site especially in the summer months, it is likely that these operating conditions impacted the data collected during 2017. With only two sondes available for deployment at the Tred Avon profiler, it is important that both sondes be in good working condition. Before the vertical profiler is redeployed, it is recommended that a complete inventory of sondes be performed and that any necessary replacement sensors be purchased.

Vertical profiler data consist 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). Data results for 2017 show that chlorophyll values greater than 50 µg/l and turbidity values greater than 50 NTU frequently occurred through the months of June, July, and August. However, data during this period should be viewed cautiously due to the issues noted previously with replacing the sondes. Salinity, pH, water temperature, and dissolved oxygen data from the vertical profiler indicate that water quality conditions in the Tred Avon River during 2017 were generally suitable for oyster growth and survival.

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Introduction

During June-December 2017, 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. The 2017 monitoring was a continuation of vertical profile monitoring that NOAA conducted during the years 2014-2016. This report summarizes the monitoring activities and data results for 2017.

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 late in May 2017, and in June 2017 DNR connected a YSI sonde to the unit to initiate profiler operation. Profile data collection began on June 1, 2017 with the initial sonde deployment. The monitoring season concluded on December 15, 2017, when NOAA removed the vertical profiling equipment from the Tred Avon River.

Throughout the 2017 monitoring period, DNR conducted regular field visits to the site (generally every two weeks) to maintain the profiler equipment. During field visits, standard maintenance procedures require exchanging the data sonde at the profiler with a clean and freshly calibrated

sonde that is brought out to the site. The sonde that is removed is then returned to the DNR field office laboratory for cleaning and post-calibration. However, early in the 2017 monitoring season, only a single sonde was available for deployment at the Tred Avon profiler. Without a replacement sonde on hand, maintenance of the profiler was limited to simply cleaning the sonde on-site during field visits and then redeploying the same sonde.

By late July 2017, the sonde that was deployed at the Tred Avon profiler was so heavily fouled (Figure 1) that on-site cleaning was no longer a viable option. Since a clean, calibrated sonde was still unavailable, DNR staff instead replaced the Tred Avon sonde with one that had just been removed from the DNR monitoring site in Harris Creek. Thus, the sonde installed on the Tred Avon profiler on July 27 was not properly cleaned and calibrated in the laboratory prior to deployment. On the next scheduled field visit (August 17), the same procedure was followed – replacing the sonde at the Tred Avon site with a sonde that had just been removed from the Harris Creek site. Replacing the sondes in this manner allowed data collection to continue uninterrupted at the Tred Avon site. If instead, field staff had removed the Tred Avon sonde and not installed any replacement sonde, at least two weeks of data collection would have been missed as the single sonde was in the laboratory being cleaned, calibrated, and readied for redeployment. However, recognizing that the sondes installed at the Tred Avon site in August were not calibrated prior to deployment, the data collected during this time period should be closely scrutinized.

A second, replacement sonde for the Tred Avon profiler became available in late August and was deployed at the site for the first time on August 30, 2017. The replacement sonde was missing a chlorophyll probe, therefore any data collected by the second sonde did not include chlorophyll readings.

As in previous years, biofouling continued to be an issue at the Tred Avon monitoring site in 2017. In fact, the extended deployment of the initial sonde resulted in such heavy fouling that when the instrument was finally returned to the field office at the end of July, it could not be post-calibrated. Figure 1 and Figure 2(a-b) show the growth that was present when the sonde was retrieved on July 27, 2017. Severe biofouling such as this can impair profiler operation and compromise data results. Since equipment at the Tred Avon monitoring site is prone to such extensive fouling, routine maintenance is especially important to ensure data quality.

Figure 1. Biofouling on data sonde after an extended deployment at the Tred Avon profiler (July 27, 2017).


Figure 2(a-b). Biofouling on data sonde after an extended deployment at the Tred Avon profiler (July 27, 2017).

In total, DNR staff visited the Tred Avon site eleven times during the 2017 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 2017 monitoring season.

Date	Activity
June 1, 2017	Initial sonde deployment
June 22, 2017	Cleaned sonde and redeployed (no swap)
July 13, 2017	Cleaned sonde and redeployed (no swap)
July 27, 2017	Sonde was too heavily fouled for on-site cleaning; sonde was removed and replaced with a non-calibrated DNR sonde
August 17, 2017	Swapped sonde with a non-calibrated DNR sonde
August 30, 2017	Swapped sonde
September 12, 2017	Swapped sonde
September 27, 2017	Swapped sonde
October 11, 2017	Swapped sonde
October 31, 2017	Swapped sonde
November 13, 2017	Swapped sonde

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.

Missing Data Records

Table 2 summarizes the gaps that occurred in the 2017 profile data record. Some of these gaps occurred following field maintenance of the equipment. During maintenance, the profiler switches to "standby" mode and must be restarted to continue conducting profiles. Gaps in the data record exist on July 13-19 and on August 17-21 when restarting the profiler was delayed following a field visit. On July 26, the profiler stopped conducting profiles, perhaps due in part to extreme fouling of the sonde. The sonde was replaced on July 27 and the profiler resumed collecting profile readings. On October 7, the profiler stopped collecting data and recorded the error message, "Sonde not responding correctly to wipe command". On October 11, field personnel visited the site to investigate and found the sonde lying in mud on the river bottom. Replacing the sonde and restarting the profiler corrected the problem. Finally, on December 1, data collection stopped after the power in the sonde battery dropped below the level needed for sonde operation.

As mentioned previously, one of the sondes used at the Tred Avon profiler did not have a chlorophyll probe installed. Thus, some data gaps for chlorophyll exist in the 2017 monitoring record. Missing chlorophyll data are documented in Table 3.

Table 2. Time intervals of missing profile data records during the 2017 monitoring season.

Date of missing records		Time interval			Possible Cause
From	To	Days	Hours	Minutes	
7/13/17 10:07	7/19/17 10:01	5	23	54	Sonde cleaned on site; profiler left in standby mode
7/26/17 00:01	7/27/17 09:47	1	9	46	Instrument malfunction, possibly related to biofouling
8/17/17 12:07	8/21/17 08:01	3	19	54	Profiler left in standby mode following sonde swap
10/7/17 21:06	10/11/17 10:15	3	13	8	Sonde lying on river bottom
12/1/17 02:06	12/15/17 (end deployment)	~15	--	--	Power failure; low battery on sonde

Table 3. Chlorophyll data not collected due to a missing probe.

Missing parameter	Deployment dates		Number of data records affected
	From	To	
Chlorophyll	8/30/17	9/12/17	1890
Chlorophyll	9/27/17	10/7/17	1504
Chlorophyll	10/31/17	11/13/17	1902

Data Quality Assurance and Quality Control Procedures

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_2017_2018_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

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.

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 June through December 2017. 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 data quality review process.

Water temperatures show expected seasonal variability throughout the monitoring season (Figure 3). Temperatures increased from around 24° C in June to peak values around 32° C in late July, and then declined steadily to values around 9° C in late November. Surface temperatures were only slightly warmer than the bottom water temperatures, with less than a 1° C difference between the two.

Chlorophyll and turbidity values for 2017 show especially high values during the months of June through August. Chlorophyll values greater than 100 µg/l were recorded in late June and in late July (Figure 4). Turbidity values greater than 50 NTU were often recorded during June, July and August 2017 (Figure 5). However, these high values for chlorophyll and turbidity may not represent conditions in the water column, but may instead reflect the heavy fouling of the equipment that occurred through the summer months. While biofouling is always an issue at the Tred Avon site, in 2017 the problem was exacerbated by the lack of a replacement sonde for the vertical profiler. As previously noted, the sonde that was initially deployed at the profiler on June 1 remained in the field until July 27 with only occasional on-site cleaning. Then, throughout August, the sondes that were deployed at the Tred Avon site were DNR instruments that were moved to the Tred Avon site without first being cleaned and calibrated. It is important to consider these operating conditions when interpreting the high readings for chlorophyll and turbidity during June-August. During September through December, less biofouling typically occurs, and the sondes were regularly cleaned and calibrated. Chlorophyll and turbidity values during this time remained consistently low. Generally, chlorophyll values were less than 20 µg/l and turbidity values were less than 10 NTU during September-December 2017.

As with chlorophyll and turbidity, salinity and pH values may have been impacted by biofouling of the monitoring sondes. 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. Generally, however, 2017 salinity values were between 9.5 ppt and 11 ppt for June through mid-September, rose quickly from late September through early October, and then remained between 14.5 ppt and 15.5 ppt for the rest of the year (Figure 6). Surface salinity values were slightly (<0.5 ppt) less than the bottom values. Values of pH ranged between 7.3 and 8.3 through the 2017 monitoring season, with surface water pH values slightly higher than bottom pH values (Figure 7).

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 July-September, bottom water dissolved oxygen values were consistently below 8 mg/l during this period and briefly dropped below 5 mg/l in late August and again in late September (Figure 8). Dissolved oxygen values (surface and bottom) gradually increased from mid October through the end of November and were both greater than 10 mg/l at the end of the monitoring period.

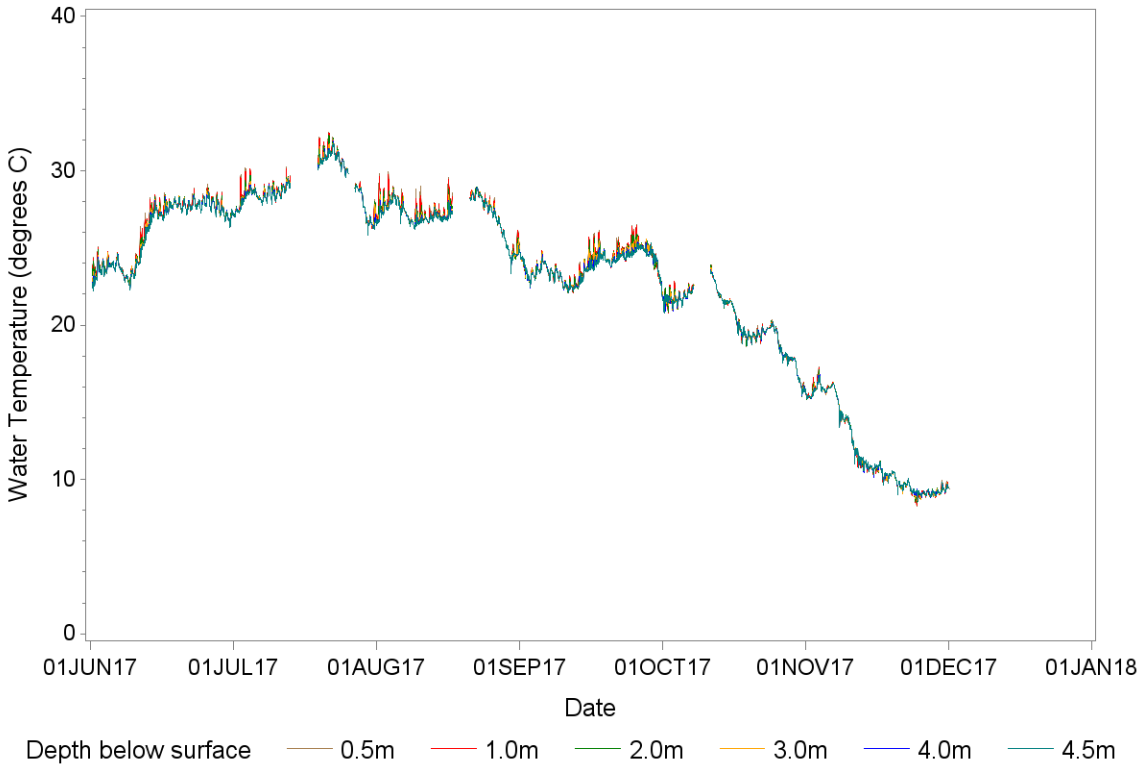

Figure 3. Water temperature in the Tred Avon River during 2017.

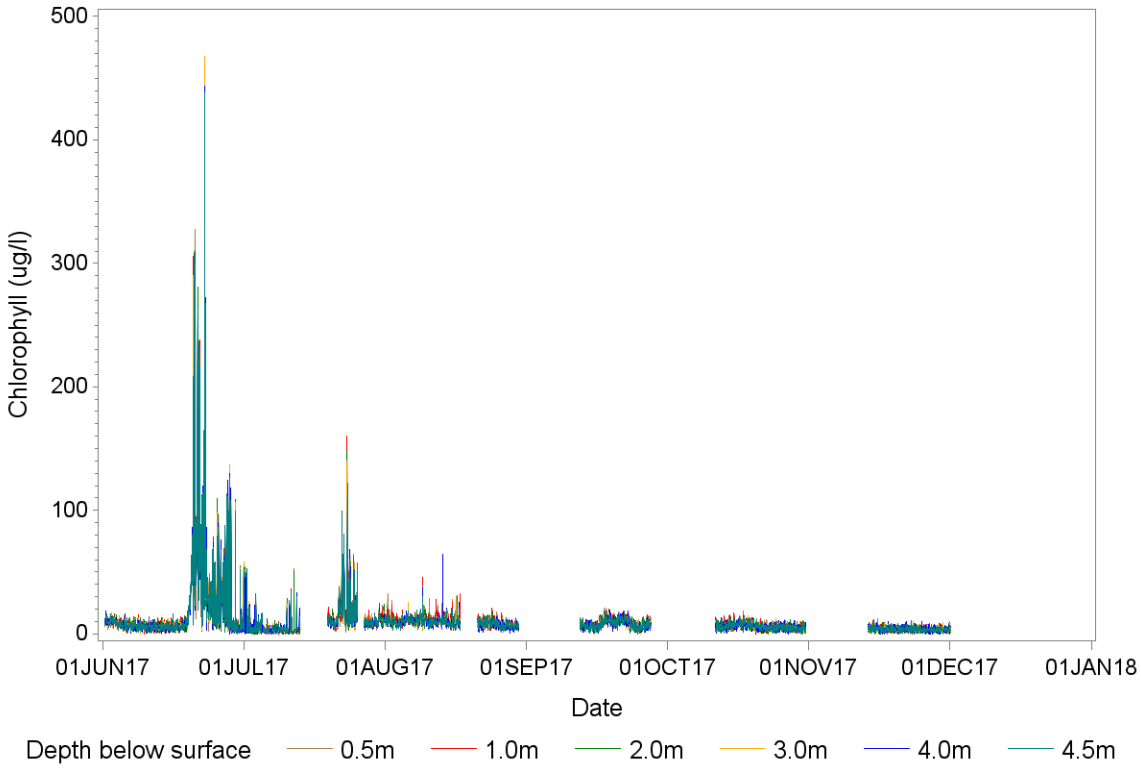

Figure 4. Chlorophyll in the Tred Avon River during 2017.

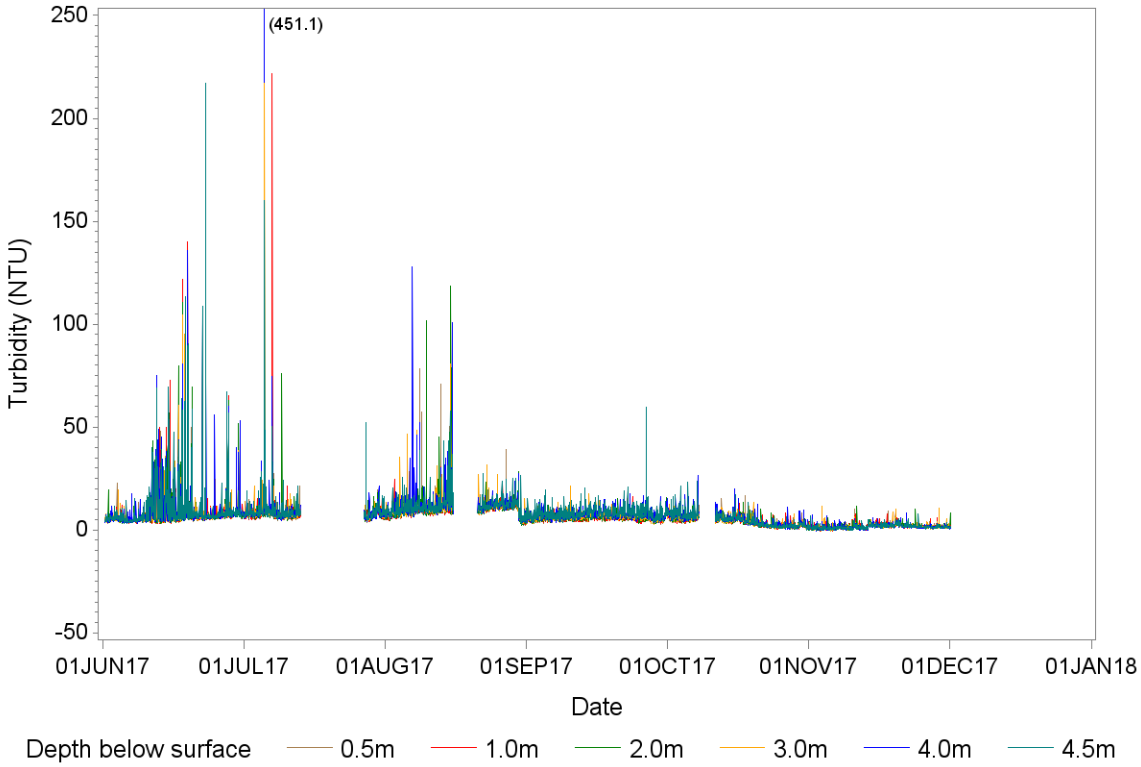

Figure 5. Turbidity in the Tred Avon River during 2017.

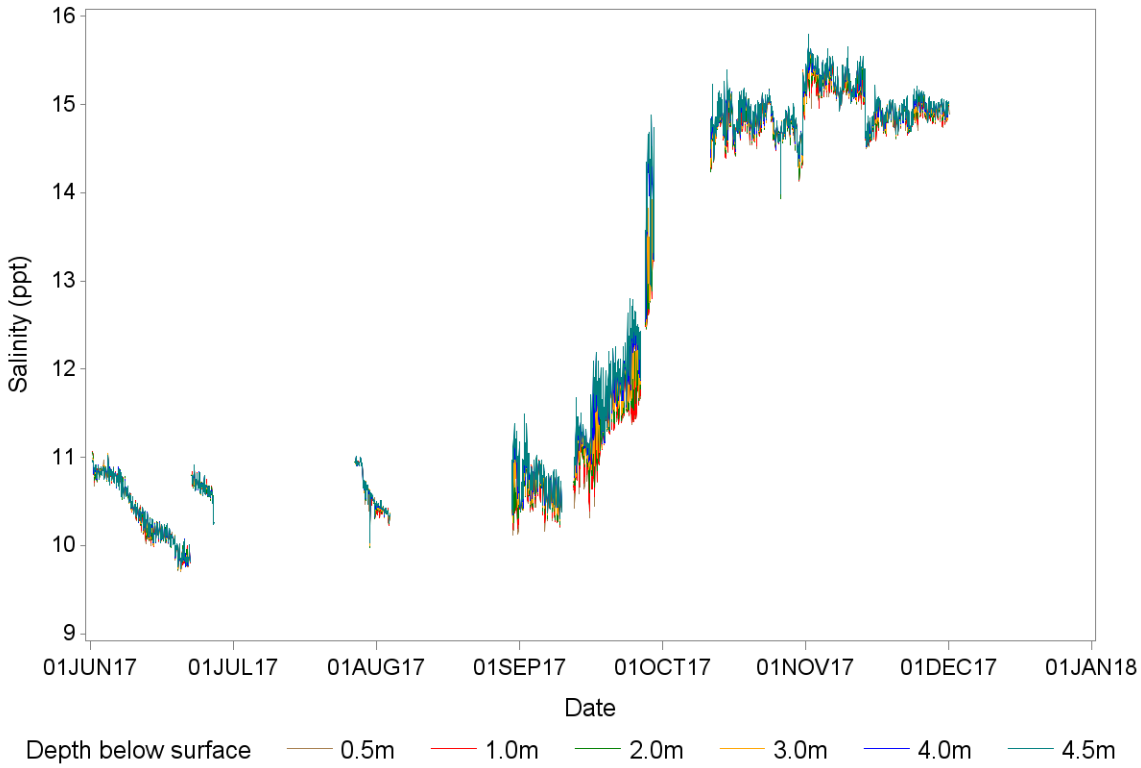

Figure 6. Salinity in the Tred Avon River during 2017.

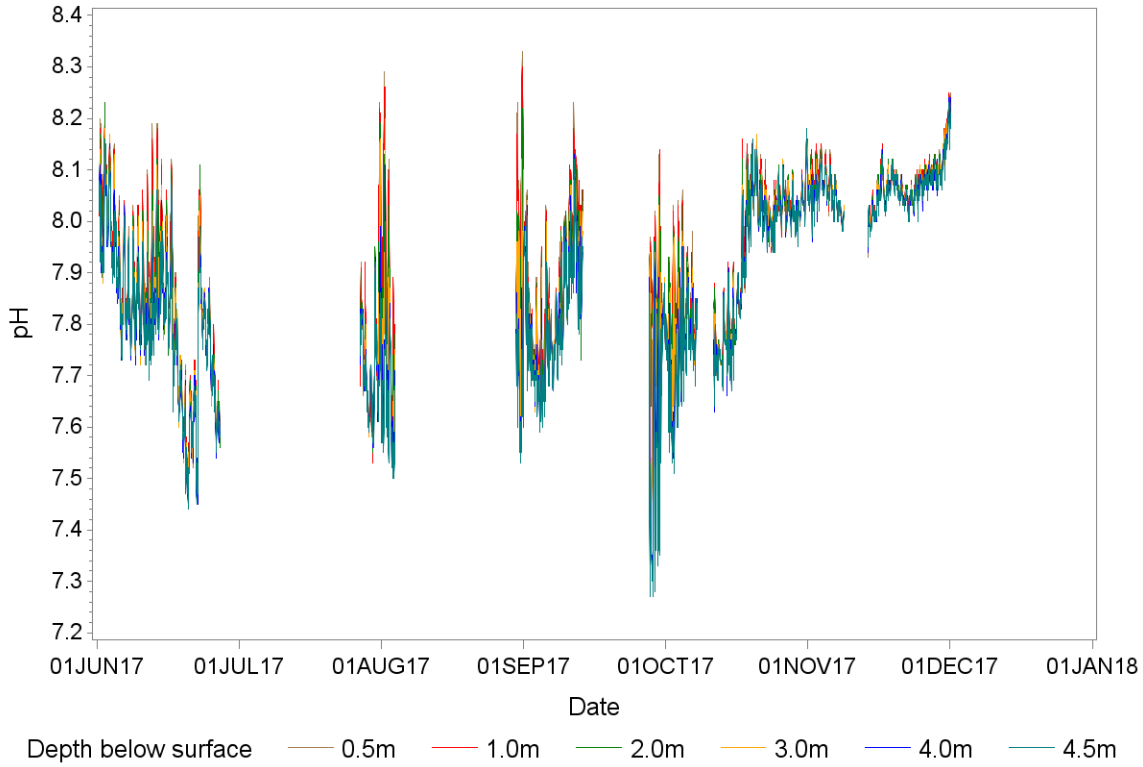

Figure 7. pH in the Tred Avon River during 2017.

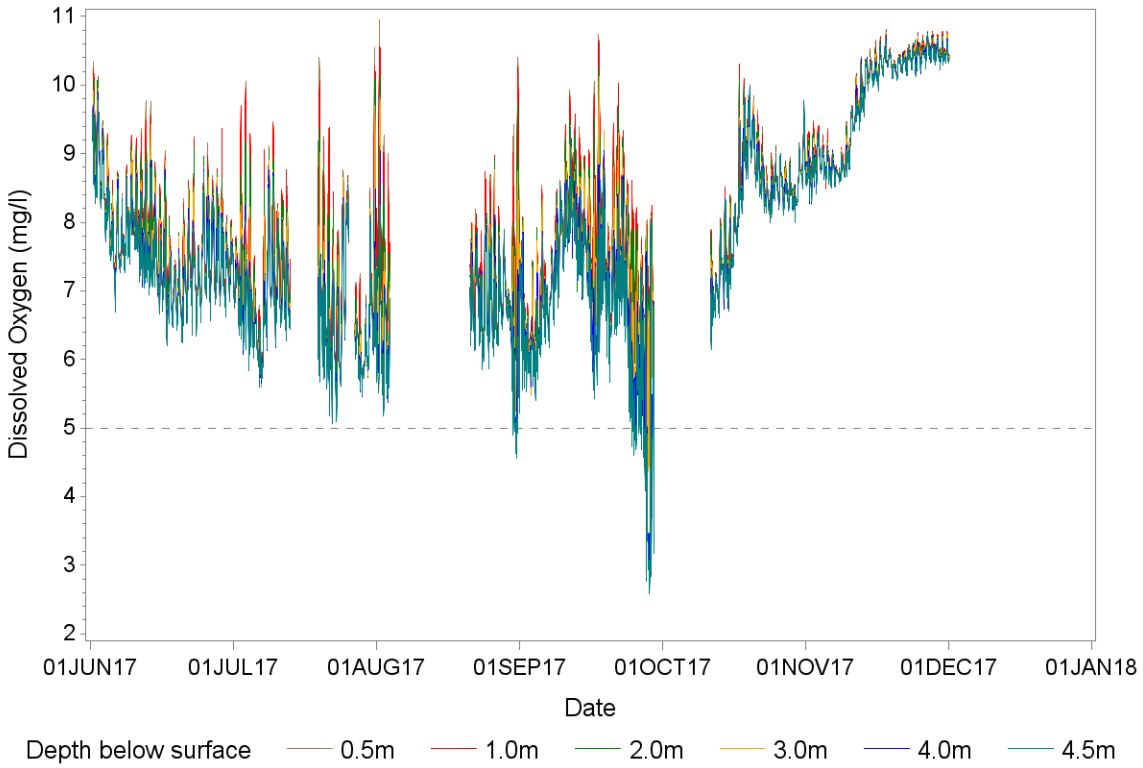

Figure 8. Dissolved oxygen in the Tred Avon River during 2017.

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. 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.

Note that for a brief period in 2017, the hourly readings were collected at a depth of 2 m instead of at 1 m. During a field visit on July 13, the sonde was cleaned on-site and then reattached to the profiler cable. During this process, the depth at which the sonde was suspended in the water column changed from 1 m to 2 m. The sonde remained parked at the 2 m depth, collecting hourly readings, until the profiler was restarted several days later on July 19. Once the profiler was restarted and began executing profiles, the sonde once again returned to the regular 1 m parked position.

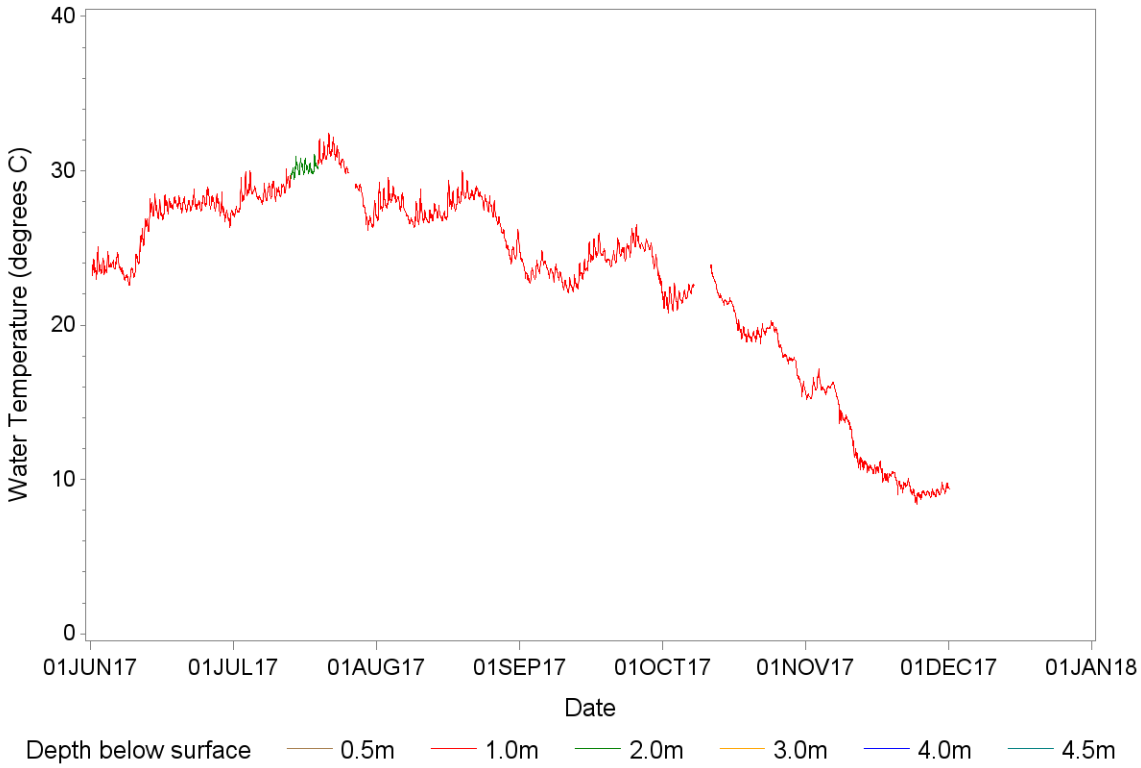

Figure 9. Hourly readings for water temperature in the Tred Avon River during 2017.

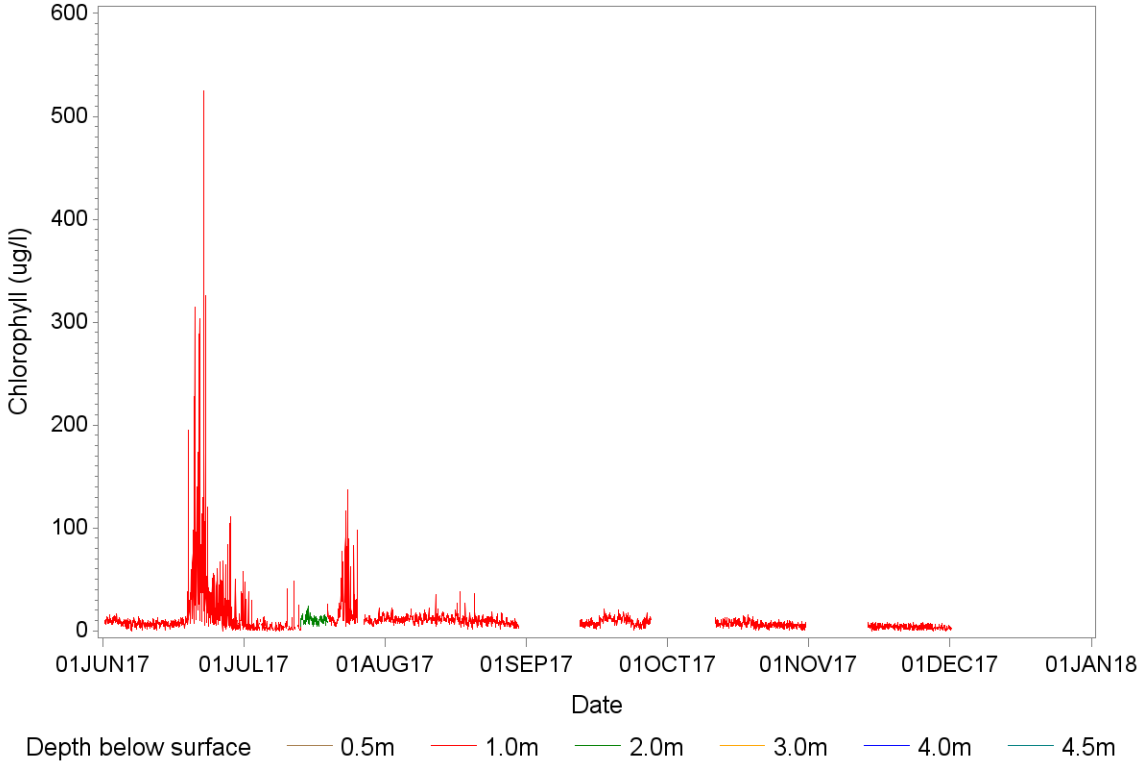

Figure 10. Hourly readings for chlorophyll in the Tred Avon River during 2017.

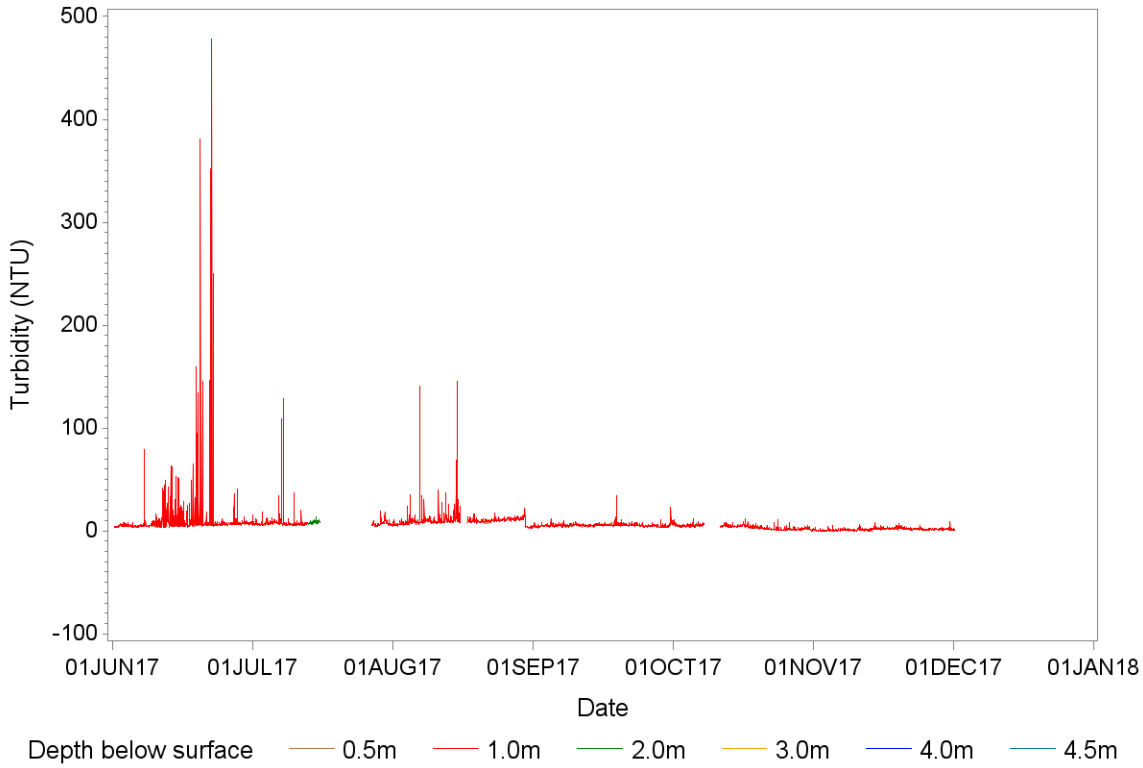

Figure 11. Hourly readings for turbidity in the Tred Avon River during 2017.

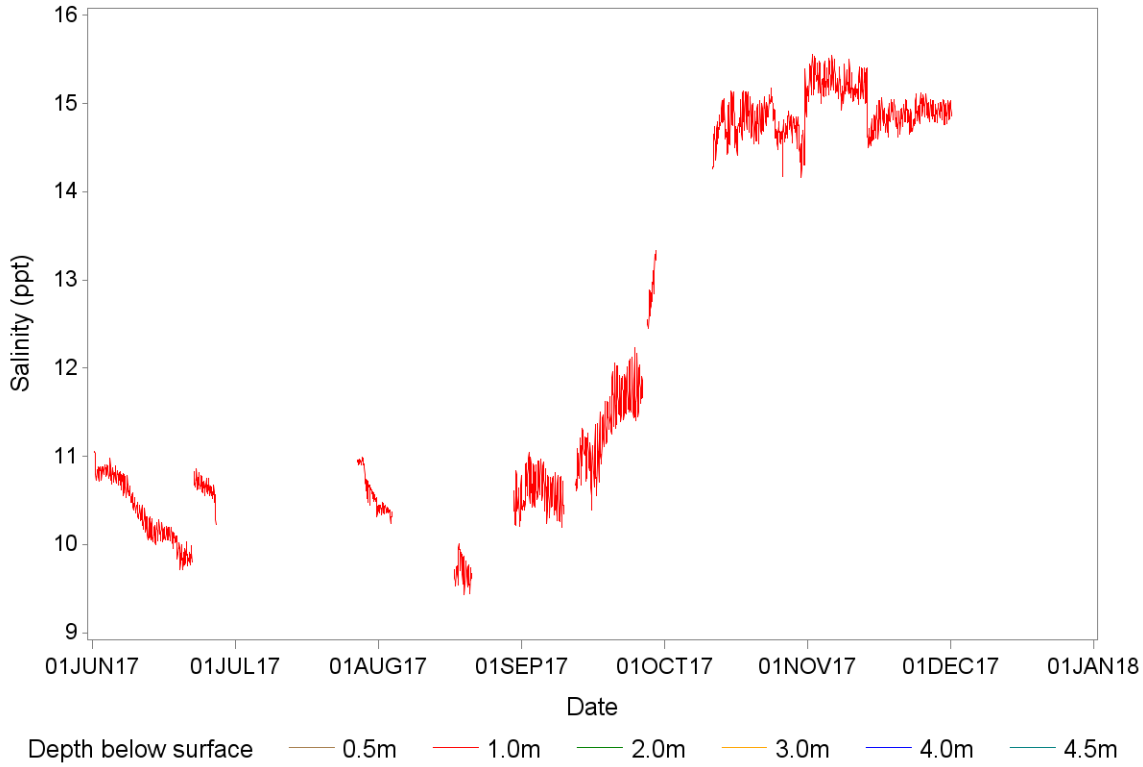

Figure 12. Hourly readings for salinity in the Tred Avon River during 2017.

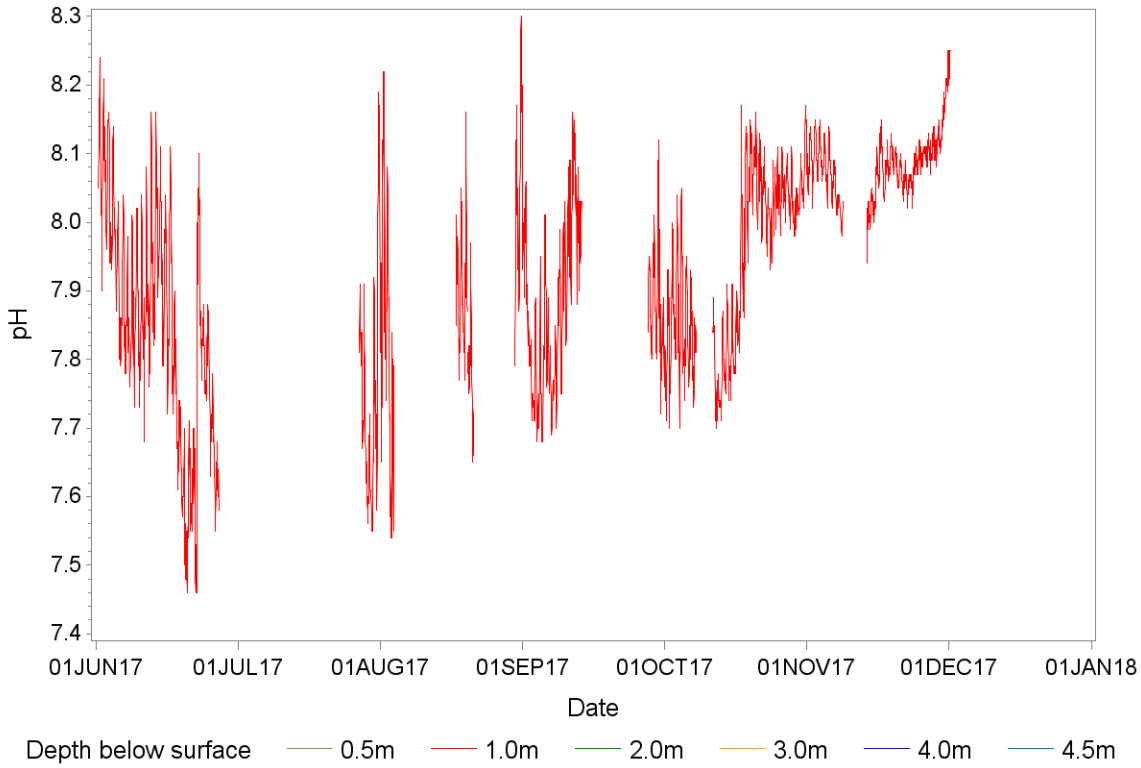

Figure 13. Hourly readings for pH in the Tred Avon River during 2017.

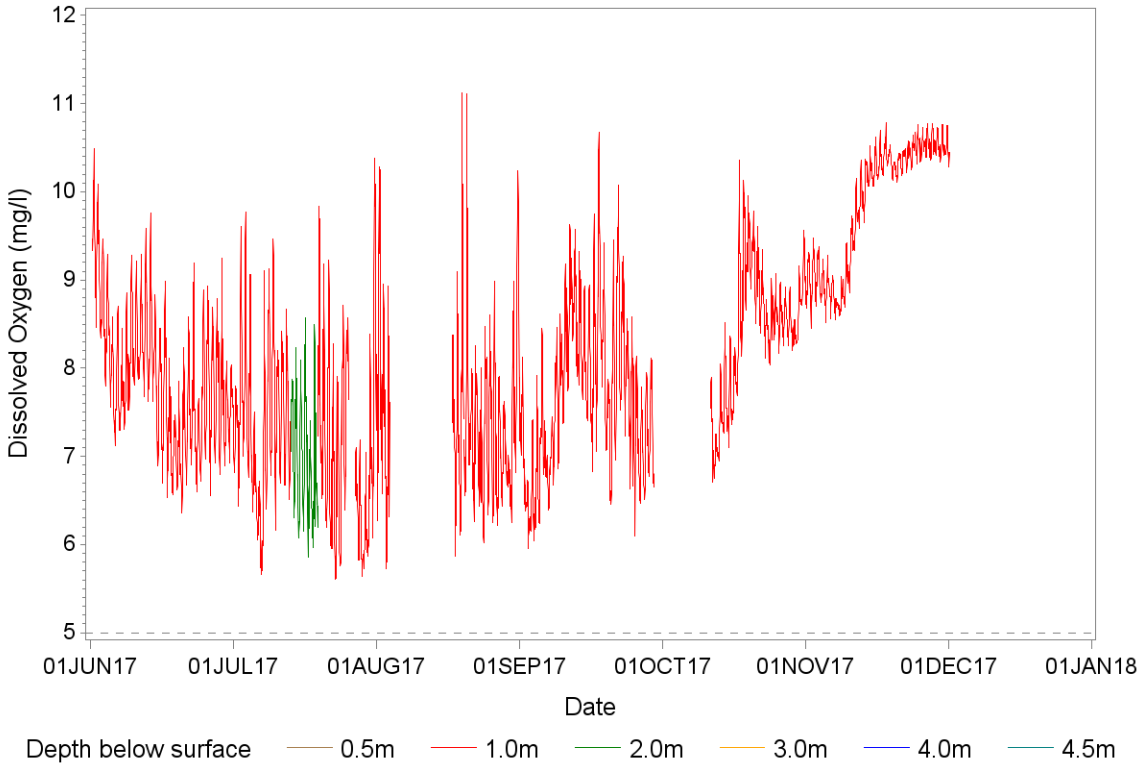

Figure 14. Hourly readings for dissolved oxygen in the Tred Avon River during 2017.