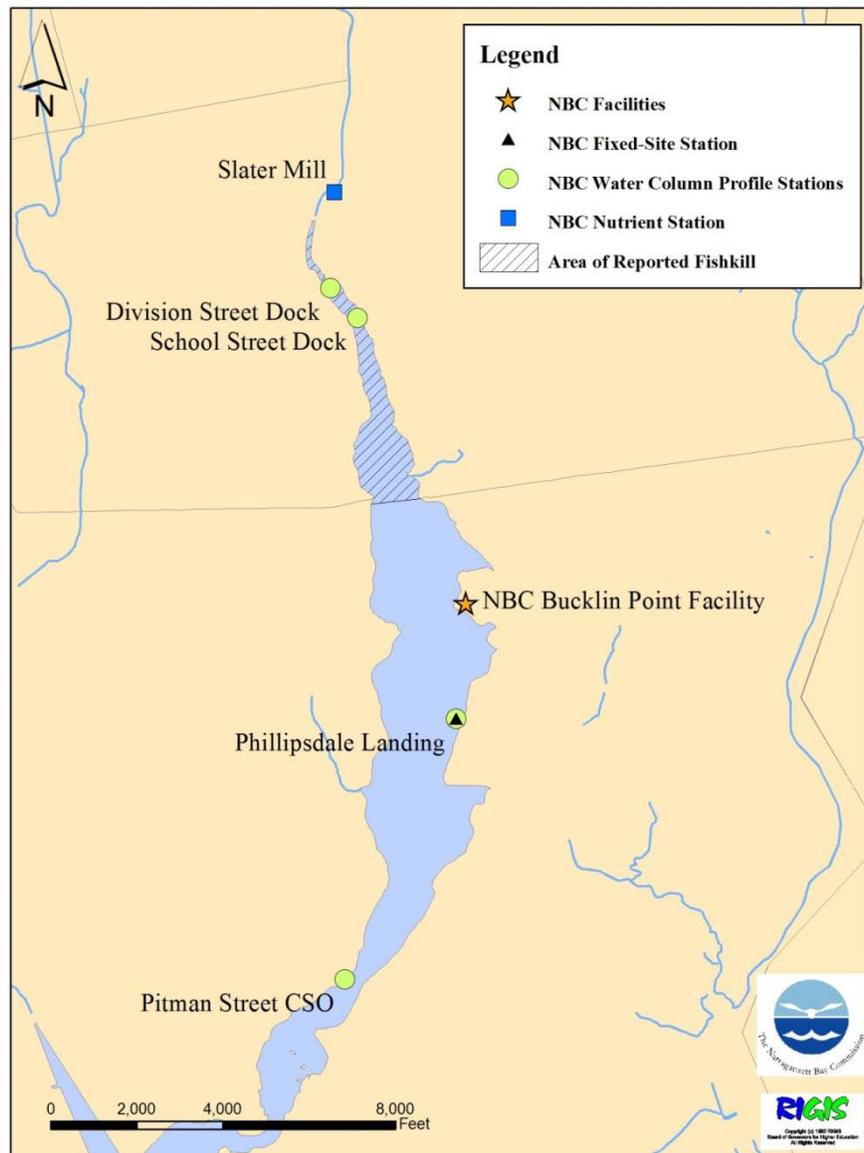


## Analysis of Seekonk River Water Quality Following the Fish Kill of May 2015

On May 25<sup>th</sup>, 2015, the Rhode Island DEM began to receive notifications of a moderate fish kill of Atlantic menhaden (*Brevoortia tyrannus*) in the Seekonk River. The kill appeared to be localized to the northern reach between Pawtucket Falls and Bishop Point (Figure 1). Minor-to-moderate fish kills, primarily of menhaden, occur periodically in the Seekonk River and other areas of Narragansett Bay, however they are more typical late in the summer. They may be caused by several factors including predator-prey interactions, limited dissolved oxygen due to recent phytoplankton or algae blooms, and

**Figure 1.** Map of Seekonk River showing extent of fish-kill area, water profile sampling sites, and NBC fixed site water quality monitoring station.

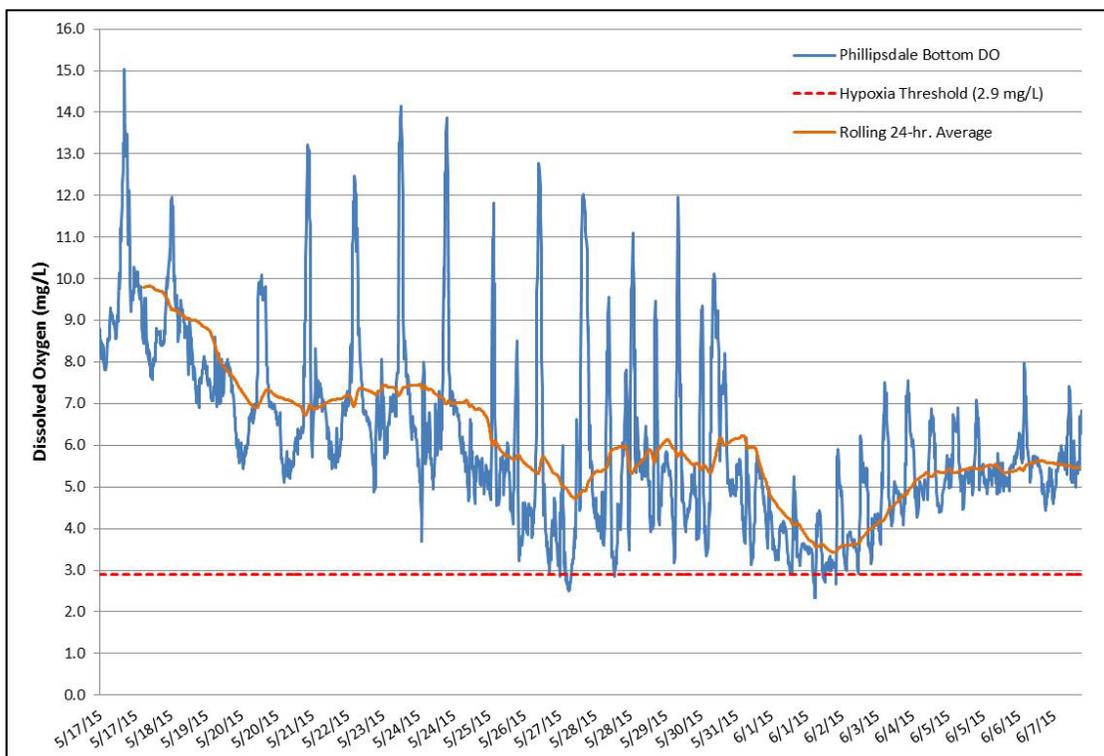


potentially by a parasite-induced whirling/spinning disease. The NBC was first notified of the fish kill late on Friday, May 29<sup>th</sup>. NBC monitoring staff had been north of the fish kill area at Slater Mill on May 27<sup>th</sup> and did not notice anything unusual coming down the river at that time that may have affected the fish downstream. On June 1<sup>st</sup>, NBC monitors visited the fish kill area and observed many dead menhaden lining the shorelines in the affected area, and 1 to 2 live menhaden behaving erratically. This erratic behavior was as described by DEM and other reporters of the fish kill as spinning near the surface, often with their head above water.

The NBC evaluated water quality data collected during this time period from NBC's fixed-site monitoring station at Phillipsdale Landing, as well as water column profiles taken throughout the affected area on June 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup>. Two water column profiles were taken in the morning on June 1<sup>st</sup>, the initial day that NBC staff were on the Seekonk River to investigate the reported fish kill. These profiles showed DO at the bottom to be around 4.9–5.0 mg/L at Phillipsdale and at a site near the rt. 195 bridge.

The Phillipsdale Landing water quality station consists of two sondes, one at the surface (average depth 0.72 m) and one near the bottom (average depth 1.92 m), located in the Seekonk River south of the fish kill area and the NBC Bucklin Point wastewater treatment plant. Dissolved oxygen (DO) measurements from the bottom sonde began to show a decline at Phillipsdale starting May 24<sup>th</sup> (Figure 2). Hypoxia (DO <2.9 mg/L) was not noted at the site until May 27<sup>th</sup>, two days after the fish kill was first reported upriver.

**Figure 2.** Bottom dissolved oxygen at Phillipsdale, May 17-June 7, 2015. Note that the rolling 24 hr. average (in orange) does not decline below 2.9 mg/l, though some intermittent periods of hypoxia were observed, particularly on 5/27 and 6/1 – 6/2.



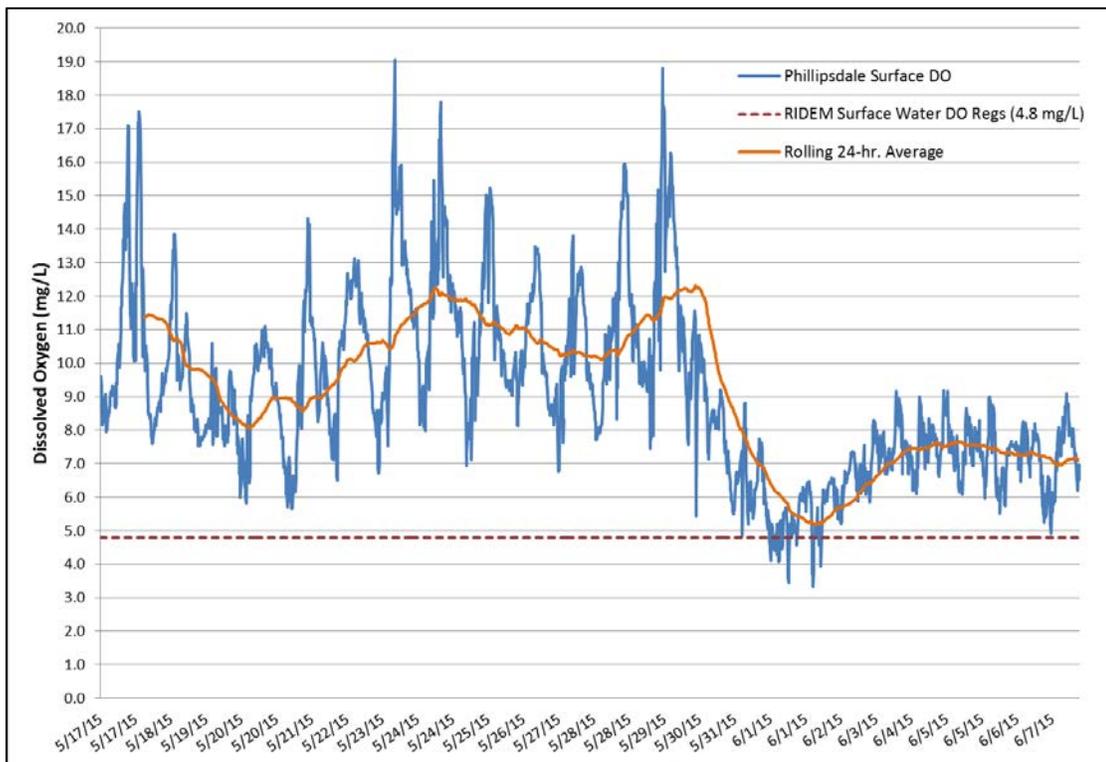
On May 27<sup>th</sup>, there were four consecutive hours of measured oxygen levels below 2.9 mg/L, with intermittent hypoxic conditions (shorter than four hours) continuing to occur at the site. A more significant decline in bottom DO began on May 31<sup>st</sup>, and continued through June 2<sup>nd</sup>; over this time, the DO daily average was 3.6 mg/L with a minimum reading of 2.3 mg/L. After reaching minimum levels on June 2<sup>nd</sup>, DO began to increase and return back to acceptable levels in the days following. During this time, DO levels did not decrease below 2.9 mg/L for any 24 hour period.

Surface DO followed a similar pattern, beginning to decline on May 29<sup>th</sup>, with a daily average low of 5.2 mg/L on June 1<sup>st</sup> and reaching a minimum of 3.3 mg/L on June 2<sup>nd</sup>. There were a few instances where surface DO declined below 4.8 mg/L, the RIDEM threshold criteria for DO in surface waters, but this was intermittent and not sustained for any length of time (Figure 3).

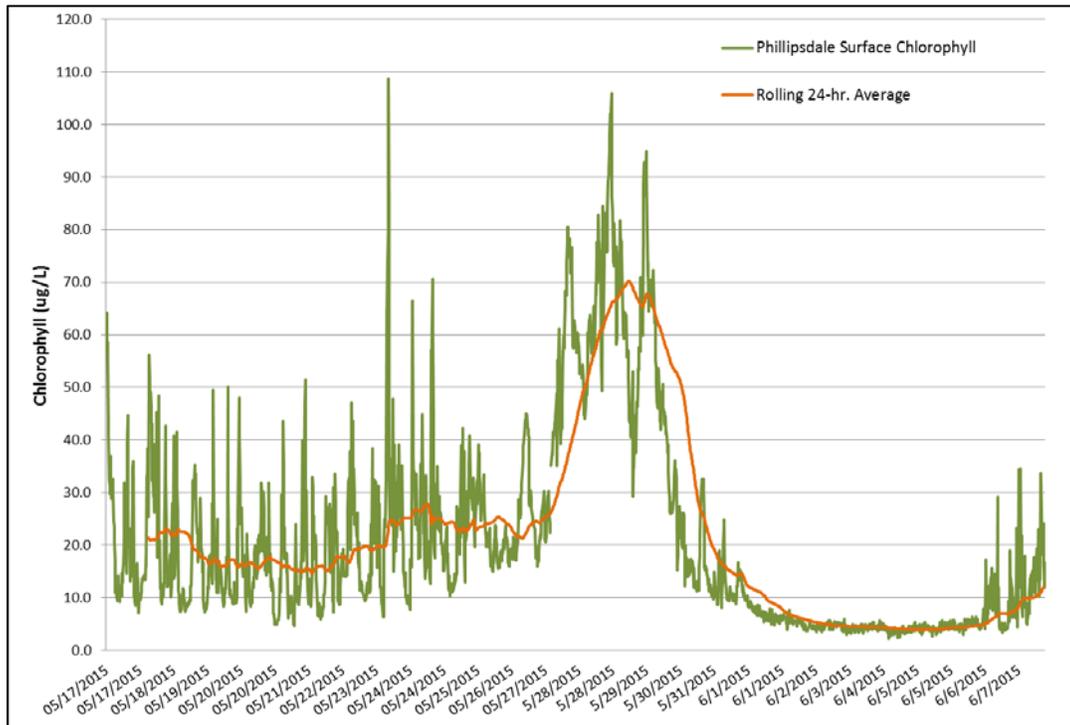
Surface chlorophyll measurements from the sondes indicated a phytoplankton bloom at the Phillipsdale Landing site beginning on May 27<sup>th</sup>, peaking on the 28<sup>th</sup> with chlorophyll measurements in the 85 - 110 ug/L range (Figure 4). Chlorophyll levels then sharply declined on May 29<sup>th</sup> and 30<sup>th</sup>.

In an effort to further investigate the spatial extent of low oxygen conditions in the Seekonk River, the NBC sampled vertical water column profiles at four locations on June 2<sup>nd</sup> (Figure 5) and resampled three of these locations on June 3<sup>rd</sup> (Figure 6). Profiles on June 2<sup>nd</sup> were collected in the afternoon just around low tide. The first profile was taken in the southern Seekonk River near the Pitman Street CSO. This

**Figure 3.** Surface dissolved oxygen at Phillipsdale, May 17-June 7, 2015. Note that the rolling average (in orange) does not decline below 4.8 mg/l, though intermittent periods of DO below 4.8 mg/l do occur, particularly on 6/1 – 6/2.



**Figure 4.** Surface chlorophyll at Phillipsdale, May 17-June 7, 2015. Note the evidence of a phytoplankton bloom between 5/27 and 5/30.

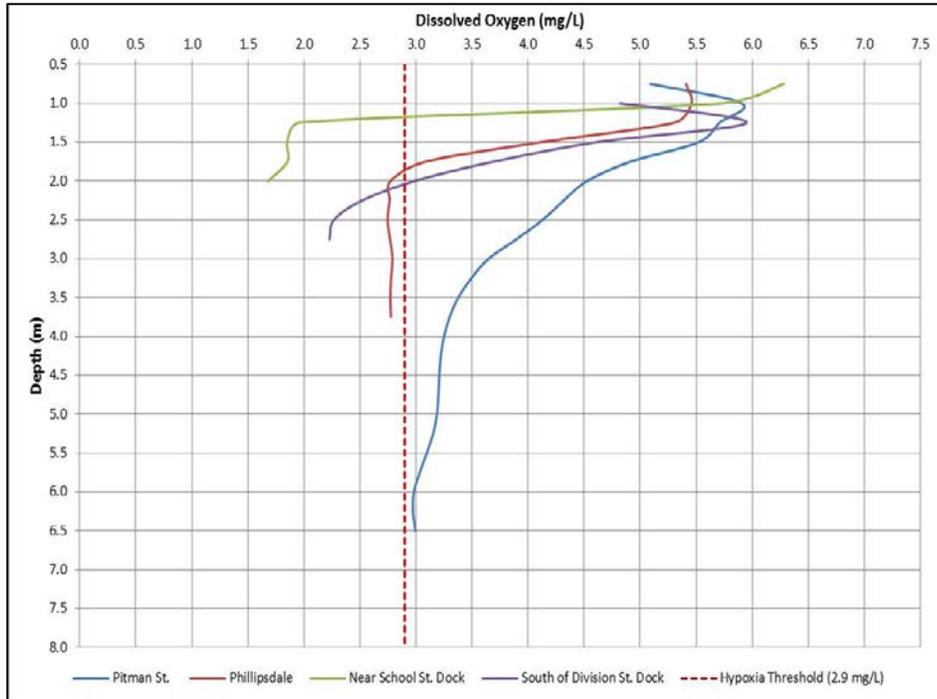


location exhibited fair DO concentrations, averaging 3.78 mg/L. The water column was slightly stratified, with a moderate density change below 2.75 m; the lowest DO, 2.97 mg/L, was measured at the bottom, near 6.25 m. A profile collected at Phillipsdale showed a stratified water column with a large density change between 1.5 – 2.0 m indicating the presence of a freshwater surface layer. Hypoxic conditions were noted below 2.0 m, where DO averaged 2.77 mg/L and reached a minimum of 2.75 mg/L. Further up in the northern stretches of the Seekonk River, profiles were also taken near the School St. Dock and the Division St. Dock in Pawtucket. Conditions were hypoxic below 1.5 m and 2.25 m at each location, respectively, averaging 1.8 mg/L and 2.4 mg/L and reaching minima of 1.68 mg/L and 2.23 mg/L.

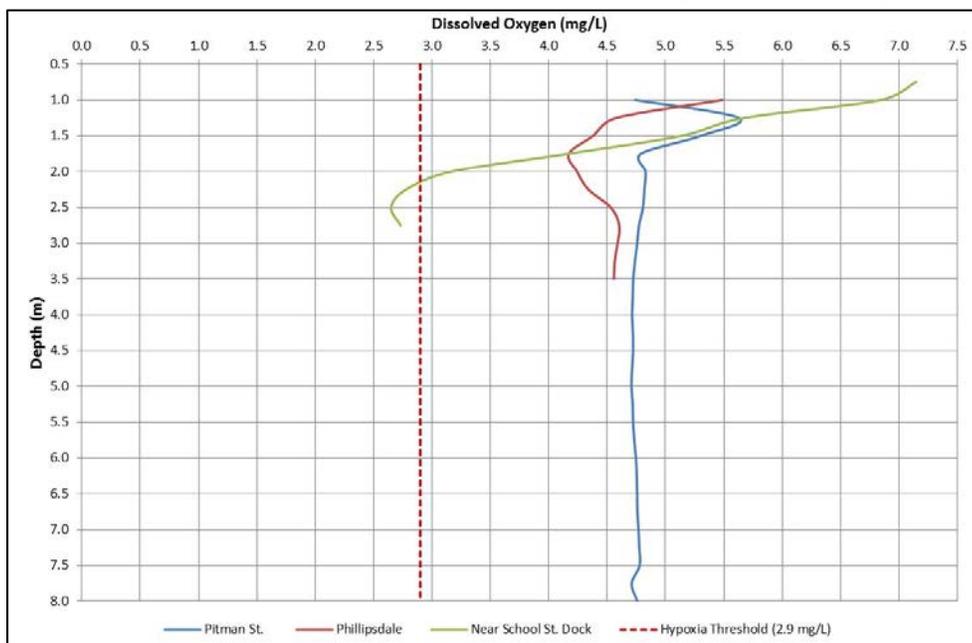
Water column profiles collected on June 3rd at three of the locations showed some improvement in DO levels; the Division St. Dock location was not resampled. In the upper reaches of the Seekonk River near the School St. Dock, profiles showed a somewhat stratified water column and hypoxic conditions below 2.25 m, where DO averaged 2.7 mg/L and reached a minimum of 2.5 mg/L. Conditions further south at Phillipsdale and the Pitman St. CSO were greatly improved, with DO above 4 mg/L in the entire water column.

Moderate fish kills like the recent menhaden die-off in the Seekonk River may be caused by several factors. Typically, the direct cause is low dissolved oxygen, which can be related to nutrient inputs from various sources, such as wastewater, septic systems and stormwater, as well as natural upstream

**Figure 5.** Dissolved oxygen water column profiles taken on June 2<sup>nd</sup>, 2015. Note that three of the four sites sampled had dissolved oxygen below 2.9 mg/L.



**Figure 6.** Dissolved oxygen water column profiles taken on June 3<sup>rd</sup>, 2015. Note that only one site of the three that were resampled had low dissolved oxygen below 2.9 mg/L.

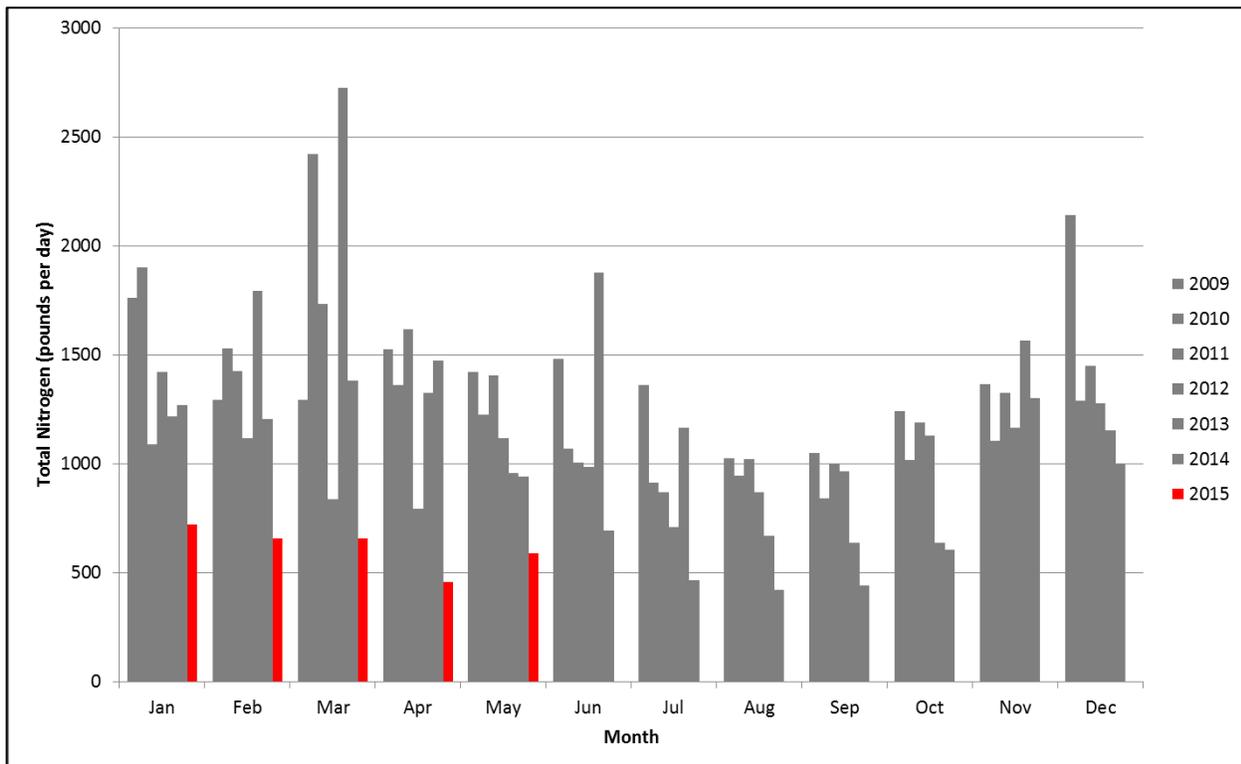


sources, which all may contribute to phytoplankton or algae blooms and other organic enrichment which subsequently reduce DO. Based upon the available data, it is difficult to conclude whether existing low dissolved oxygen conditions caused the recent fish kill or whether an abundance of menhaden in the narrow northern portion of the Seekonk River depleted the oxygen themselves. This is a relatively common occurrence when large schools of these bait fish are corralled by predators into a small area which may already have below-optimal DO levels (Benson 2015, Juliano 2015, NHR 2015, Stewart 2015).

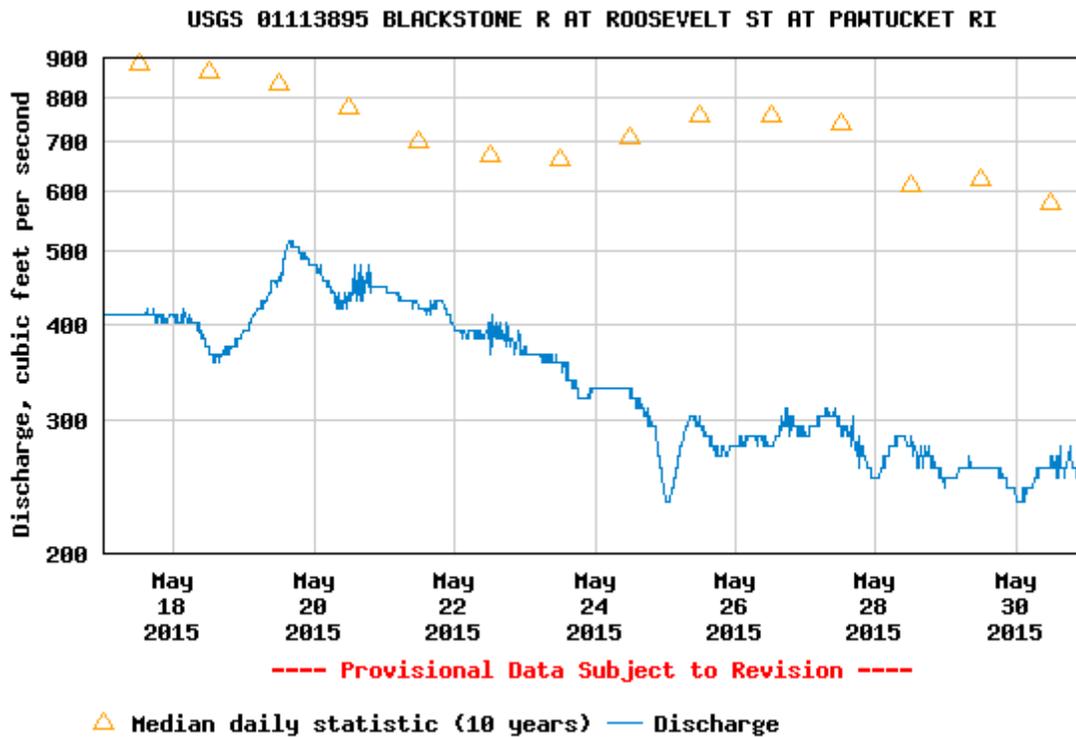
While there was evidence of a phytoplankton bloom in the Phillipsdale area in the days following the initial reports of the fish kill, the bloom may have begun earlier upstream and contributed to the low DO conditions affecting the menhaden. Phytoplankton blooms are a natural occurrence in estuaries, which historically have been exacerbated by anthropogenic nutrient inputs.

In recent years, the NBC has made great investments in plant improvements to reduce the nutrient loadings from the Bucklin Point wastewater treatment plant, and loadings in 2015 have been far below levels seen in the past (Figure 7). Other factors were likely involved in the recent menhaden fish kill, including exceptionally-low flow from the Blackstone River into the Seekonk in the hours before the first reports of dead fish; in fact, flows from the Blackstone River have been below average for much of this dry spring (USGS 2015; Figure 8). This lack of freshwater inflow likely contributed to the low oxygen

**Figure 7.** Monthly average total nitrogen loading (pounds per day) to the Seekonk River from the NBC Bucklin Point wastewater treatment facility from 2009 to present. Note that loadings in 2015 have been substantially lower than in several recent years.



**Figure 8.** USGS flow graph for the Blackstone River in the days surrounding the fish kill. Note the sudden drop in flow which occurred around midnight on May 25<sup>th</sup>, the hours preceding the first reports of the fish kill (USGS 2015).



conditions observed during the fish kill by increasing water residence time and stagnation. Lastly, the Connecticut DEEP is investigating a whirling/spinning disease as a potential contributor to similar fish kills they have observed in estuaries throughout the state (Benson 2015, Juliano 2015, NHR 2015, Stewart 2015). While periodic fish kills such as this are expected to continue to occur in the future, a large collaboration of environmental groups, state and local agencies, and organizations like the NBC are working hard to continue collecting the data to better understand the causes of these occurrences.

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