Indicator: Total Suspended Solids Concentrations in the Great Bay Estuary

Question

How have total suspended solids (TSS) in the Great Bay Estuary changed over time?

Short Answer

Suspended solids at Adams Point show a statistically significant trend since 1989. At the Great Bay Station, there is no statistically significant trend in the data going back to 2002.

(See Table TSS-1 for more results from the other six trend stations.)

PREP Goal
No increasing trends for total suspended solids (from the PREP Comprehensive Conservation and Management Plan PREP 2010).

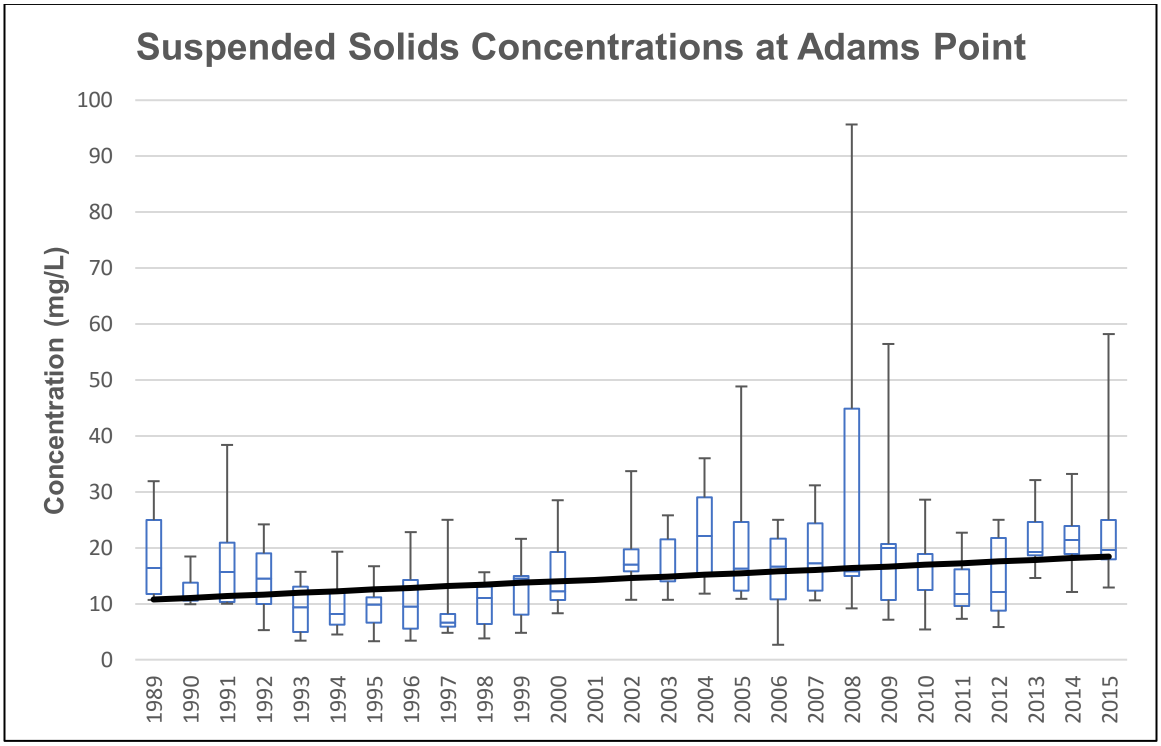

Figure TSS-1. Total Suspended Solids at Adams Point Station. Box and whisker chart of data collected at low tide only. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Year 2001 not included due to missing data. The black trendline indicates a statistically significant trend. Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

Why This Matters

Total suspended solids (TSS) are what is left over when a water sample is filtered and dried. While a small percentage of phytoplankton or pieces of plant matter remain, most of TSS is made up of sediment. Suspended solids come from resuspension within the estuary as well as erosion from streambanks, salt marshes and the upland portion of the watershed. This material is then delivered to the estuary via tributaries. Increasing suspended sediments reduce water clarity, and impact primary producers such as eelgrass, seaweeds and phytoplankton.

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Explanation (from 2018 State of Our Estuaries Report)

Total suspended solids have increased at Adams Point since 1989 (Figure TSS-1). The average median value for the first 13 years of the dataset (1989-2002) was 12.0 mg/L. For the second half of the data set (2003-2015), the average median value increased to 22.9 mg/L, an increase of 90%. In contrast, suspended solids have remained relatively stable at the Great Bay station since 2002. In 2015, the median concentration was 14.1 mg/L (Figure TSS-2).

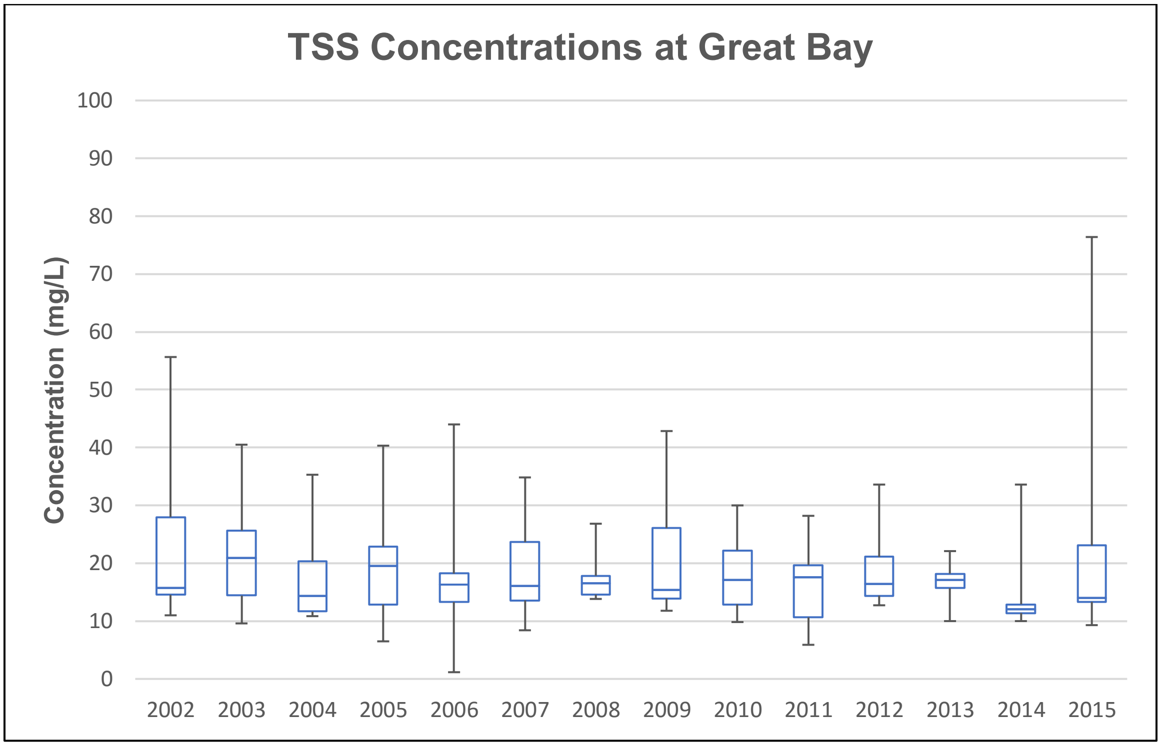

Figure TSS-2. Total Suspended Solids at Great Bay Station. Box and whisker chart of data collected at low tide only. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

Methods and Data Sources

Trend analysis for chlorophyll-a was performed at the following stations (Figure TSS-3):

- GRBAP (Adams Point between Great Bay and Little Bay)
- GRBGB (Great Bay)
- GRBCL (Chapmans Landing in the Squamscott River)
- GRBSQ (Squamscott River at the railroad trestle)
- GRBLR (Lamprey River)
- GRBOR (Oyster River)
- GRBUPR (Upper Piscataqua River)
- GRBCML (Portsmouth Harbor)

Samples collected at low-tide at the trend stations were identified. Low-tide samples were used for the trend analysis to control for the effects of tides. The data for each station were averaged by month (there was rarely more than one sample in the same month) and then the number of months with data in each year was counted. Only data from the months April through December were used. (The station at Adams Point is monitored 12 months per year.) If three consecutive

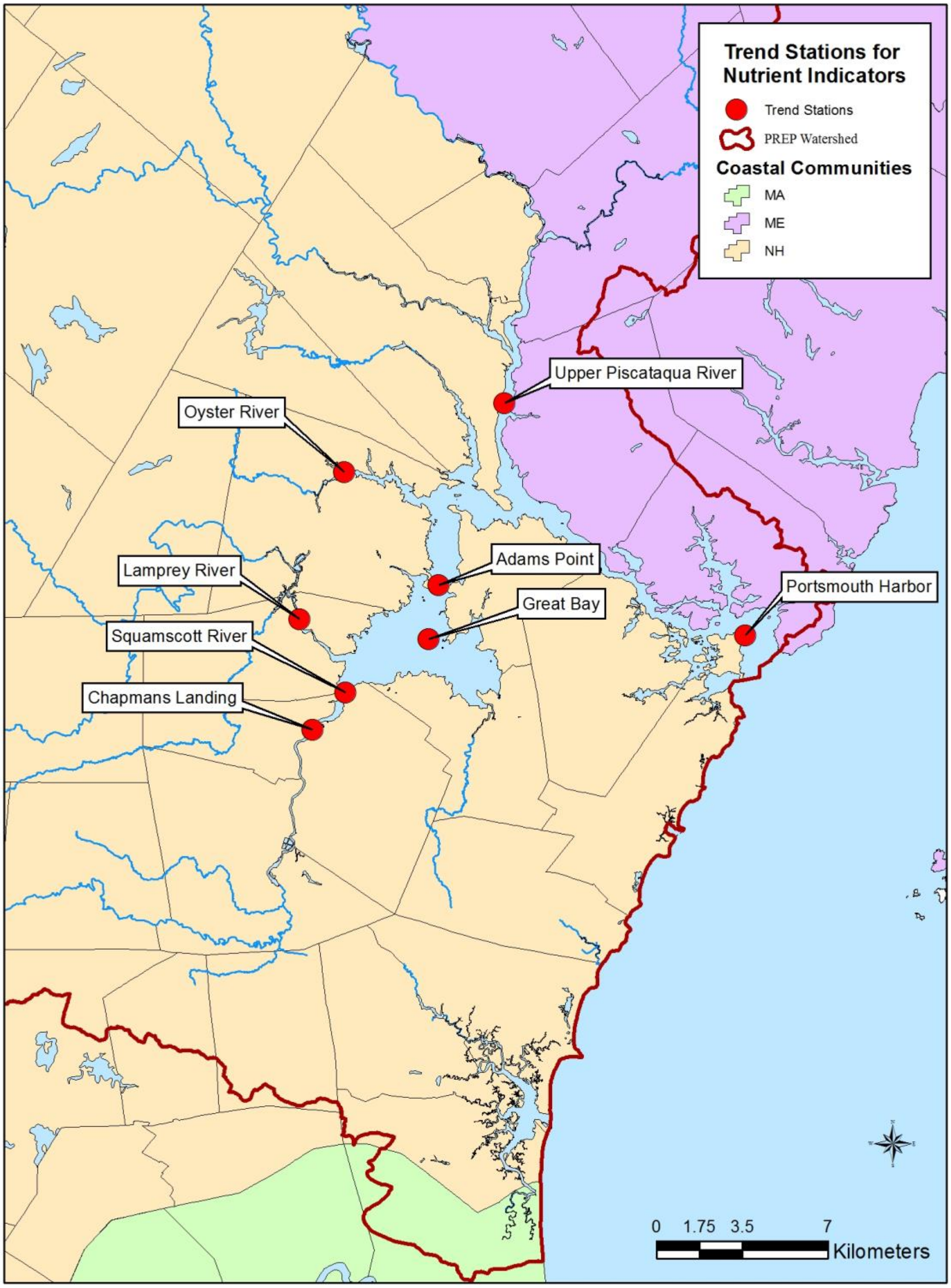

Figure TSS-3: Map of trend stations for total suspended solids.

months were missed in any year, that year was not included in the analysis. This was done in order to minimize bias from years for which the data do not reflect the full range of seasons.

Linear regression was used to test for long-term trends. The annual median values were regressed against the year variable. Trends were considered significant if the slope coefficient of the year variable was significant at the $p<0.05$ level.

Data Sources
Data for this indicator were provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Programs.

Additional trend monitoring stations have been added recently in the Bellamy, Cocheco, Salmon Falls, and Piscataqua Rivers and in Hampton-Seabrook Harbor; data from these stations will be included in the next Technical Report, scheduled for 2022.

<u>Additional Results (Beyond What Was Reported in the SOOE)</u>

The results of the trend analysis for TSS are summarized in Table TSS-1. Plots for each station are shown on Figure TSS-4. Two of the eight stations (Adams Point and Upper Piscataqua River) showed significant increasing trends for TSS. No other statistically significant temporal trends were evident at any of the other stations.

One of the primary reasons TSS is considered important is because it attenuates light and impacts primary producers such as eelgrass, seaweeds and phytoplankton. With regard to eelgrass, a range of thresholds at other estuaries have been established as being critical for the presence of eelgrass. For example, Kemp et al. (2004) noted that TSS levels less than 15 mg/L were required for eelgrass in Chesapeake Bay. Kenworthy et al. (2013), using a bio-optical model in Massachusetts coastal bays, asserted that TSS levels less than 6.4 mg/L were required for eelgrass to grow at a depth of 1.5 meters. These thresholds differ from system to system and are dependent on other light-attenuating substances such as colored dissolved organic matter (CDOM) and phytoplankton levels (measured via chlorophyll-a concentrations).

Table TSS-1 indicates the range of median and maximum values at each of the eight stations from 2012 to 2015. The highest median values were found at Squamscott River, Chapmans Landing, Oyster River and the Coastal Marine Laboratory. It is notable that the entire range of median values at these four sites was above 15 mg/L, the threshold noted by Kemp (2004). The lowest values were found at the Lamprey River and Upper Piscataqua River. Only the Lamprey River had median values (between 2012 and 2015) that were consistently below 15 mg/L. The highest maximum values were seen at the Squamscott River, Oyster River and Coastal Marine Laboratory stations.

It is also important to review Figure TSS-4 to understand the range of values seen at each station, since the ecosystem integrates the full range of values, not just the median or the mean. For example, TSS levels for single measurements frequently exceed 50 mg/L and, less frequently, are over 100 mg/L.

<u>Technical Advisory Committee (TAC) Discussion Highlights</u>
The Relationship Between TSS and Eelgrass
This topic was discussed as part of two consecutive TAC meetings on May 9-10, 2017; notes and presentations are available (PREP 2017). Of the 26 participants at the meeting, 23 rated TSS as a 3 or higher (on a scale of 1 to 5, 5 being highest) in terms of the probability that TSS is an important stressor on eelgrass habitat health. Of those 23 participants, 20 rated TSS 4 or higher.

At the meeting, there was little disagreement that turbidity is a very important factor for eelgrass health in the Great Bay Estuary. Turbidity is related to TSS; TSS is a measurement of the weight of particles larger than 2 microns while turbidity is measures how much light is scattered by particles in the water. Therefore, turbidity also includes particles that are smaller than 2 microns and are considered “dissolved,” such as CDOM.

At the May 9-10, 2017 meeting, the three external advisors to the TAC advocated that all light-attenuating components (e.g., seaweeds, TSS, colored dissolved organic matter (CDOM) and phytoplankton) be considered together, not separately, because these components act in an additive fashion. This approach to considering light attenuating substances and broader considerations relating to management options for increasing the resilience of the Great Bay Estuary are articulated more fully in the “Stress and Resilience” section of the 2018 State of Our Estuaries Report (PREP 2017b) as well as the “Statement Regarding Eelgrass Stressors” (Kenworthy et al. 2017).

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Bricker SB, Ferreira JG, Simas T. 2003. An integrated methodology for assessment of estuarine trophic status. *Ecological Modelling*. 169 (2003) 39 - 60.

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Kenworthy WJ, Gallegos CL, Costello C, Field D, di Carlo G. 2013. Dependence of eelgrass (Zostera marina) light requirements on sediment organic matter in Massachusetts coastal bays: Implications for remediation and restoration. *Marine Pollution Bull*etin. http://dx.doi.org/10.1016/j.marpolbul.2013.11.006

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Table TSS-1: Trends for Total Suspended Solids in the Great Bay Estuary.

Station	Period	Range of Recent (Median Values) & Maximum Values 2012 -2015, mg/L	Long Term Trend
GRBAP (Adams Point)	1989-2015	(12.1 to 21.4) 25.0 to 58.2	Significant increasing trend
GRBCL (Chapmans Landing)	1989-2015	(21.1 to 33.2) 26.7 to 62.5	No significant trend
GRBSQ (Squamscott River)	2002-2015	(29.6 to 33.2) 47.0 to 160.6	No significant trend
GRBLR (Lamprey River)	1992-2015	(4.0 to 6.7) 8.2 to 40.0	No significant trend
GRBGB (Great Bay)	2002-2015	(12.1 to 16.4) 10.0 to 12.7	No significant trend
GRBOR Oyster River	2002-2015	(18.6 to 24.1) 37.1 to 83.6	No significant trend
GRBUPR Upper Piscataqua River	2007-2015	(10.7 to 16.7) 17.9 to 60.0	Significant increasing trend
GRBCML Coastal Marine Laboratory Portsmouth Harbor	2002-2015	(16.1 to 19.3) 20.7 to 66.1	No significant trend

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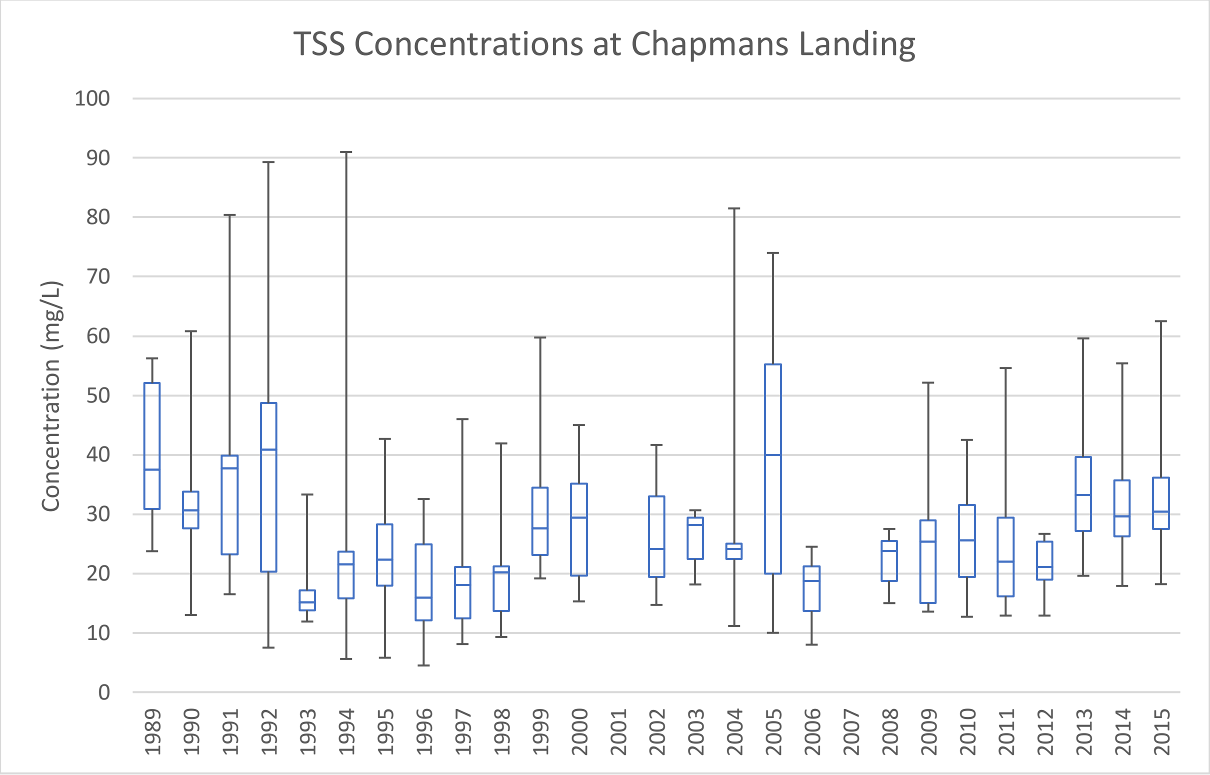
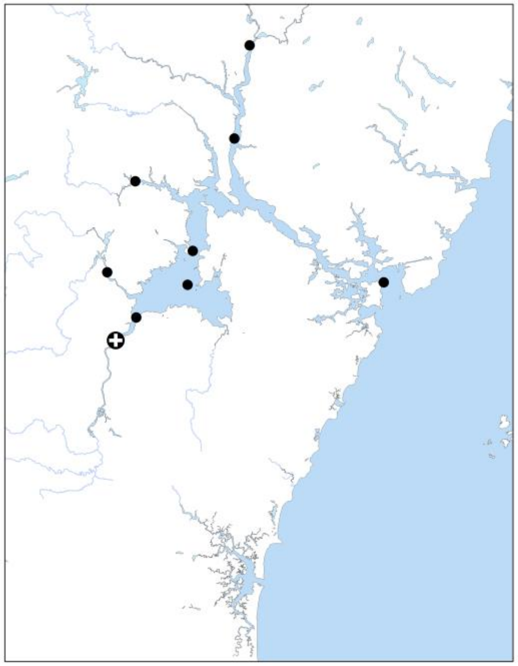
Figure TSS-4: Total Suspended Solids (TSS) Concentrations at Stations in the Great Bay Estuary



Monitoring Location (GRBCL)
Chapmans Landing
(black circle with white plus sign)



Station: GRBCL (Chapmans Landing in the Squamscott River)

Long Term Trend: No significant trend.

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Some years omitted due to missing data.

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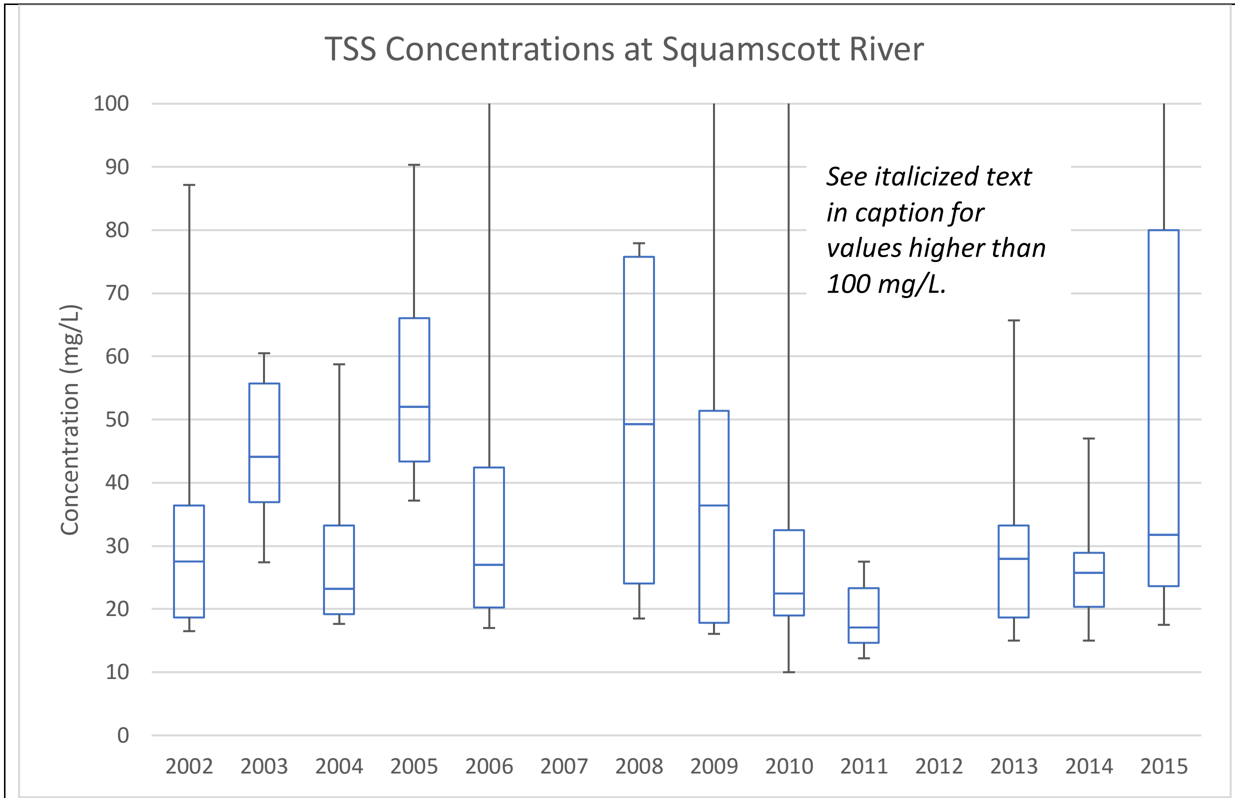
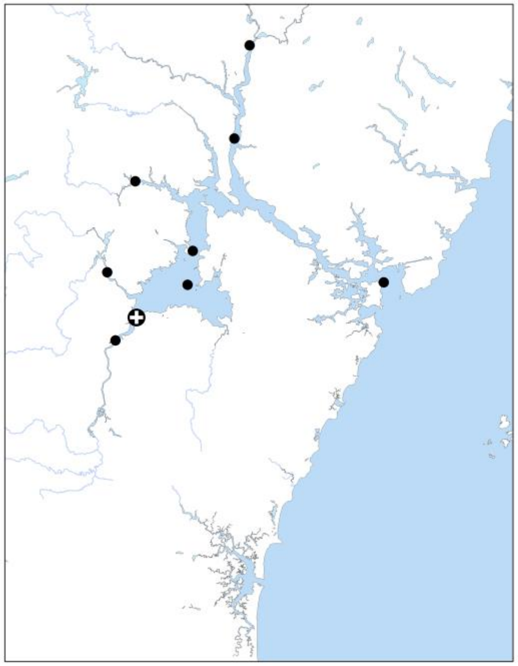


Monitoring Location (GRBSQ)
Squamscott River
(black circle with white plus sign)

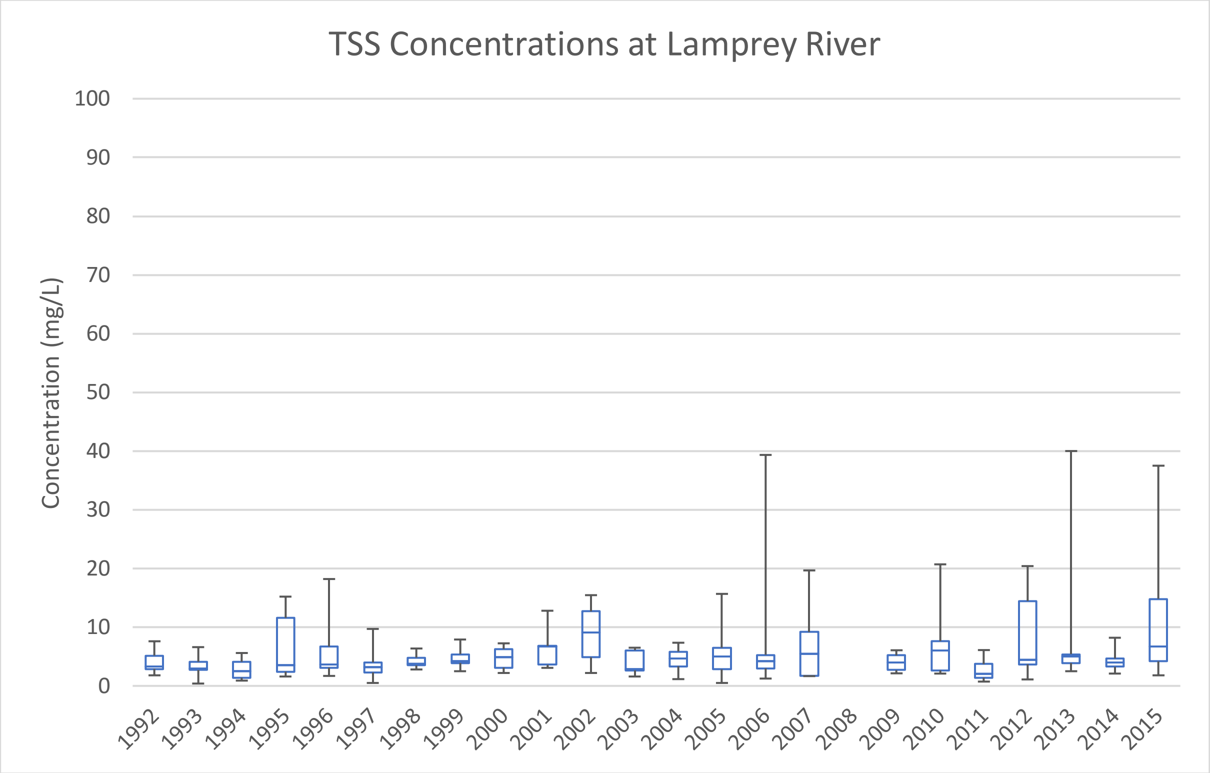


Station: GRBSQ (Squamscott River)

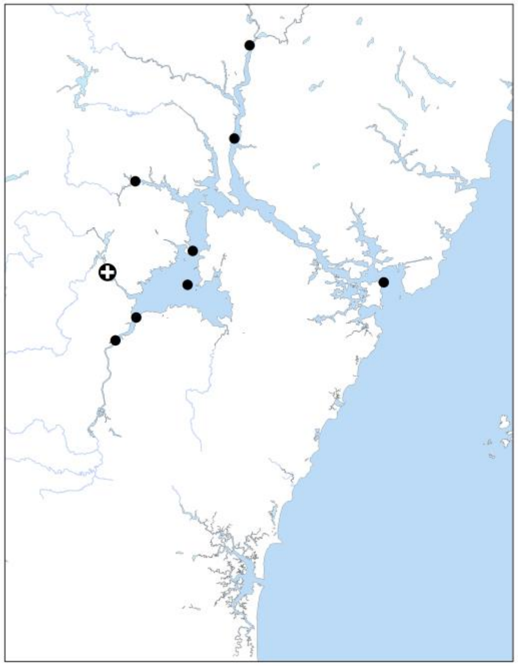
Long Term Trend: No significant trend

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Some years omitted due to missing data.

Values Higher Than 100 mg/L: 2006 = 159 mg/L; 2009 = 233 & 276 mg/L; 2010 = 121 mg/L; 2015 = 104 & 160 mg/L.



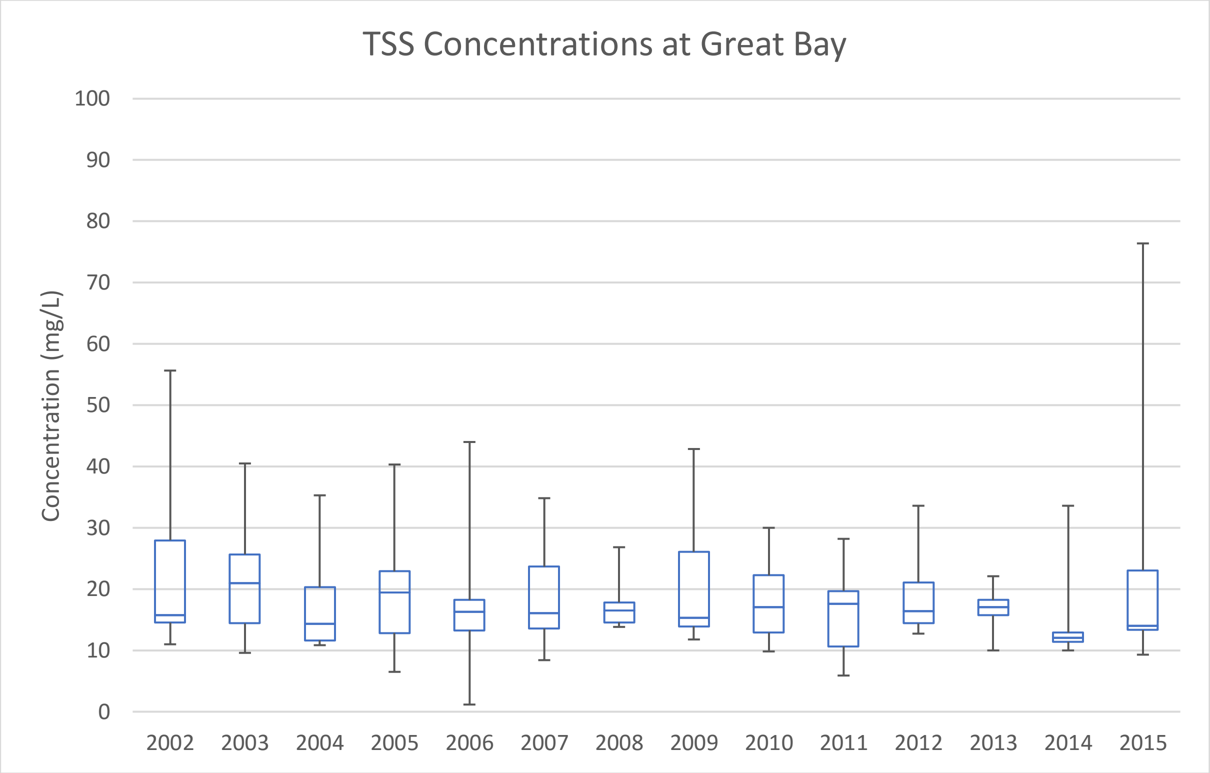
Monitoring Location (GRBLR)
Lamprey River
(black circle with white plus sign)



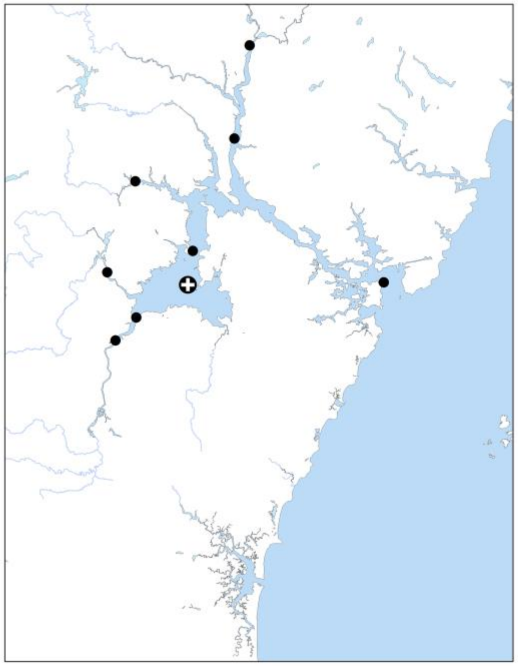
Station: GRBLR (Lamprey River)

Long Term Trend: No significant trend.

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Some years omitted due to missing data.



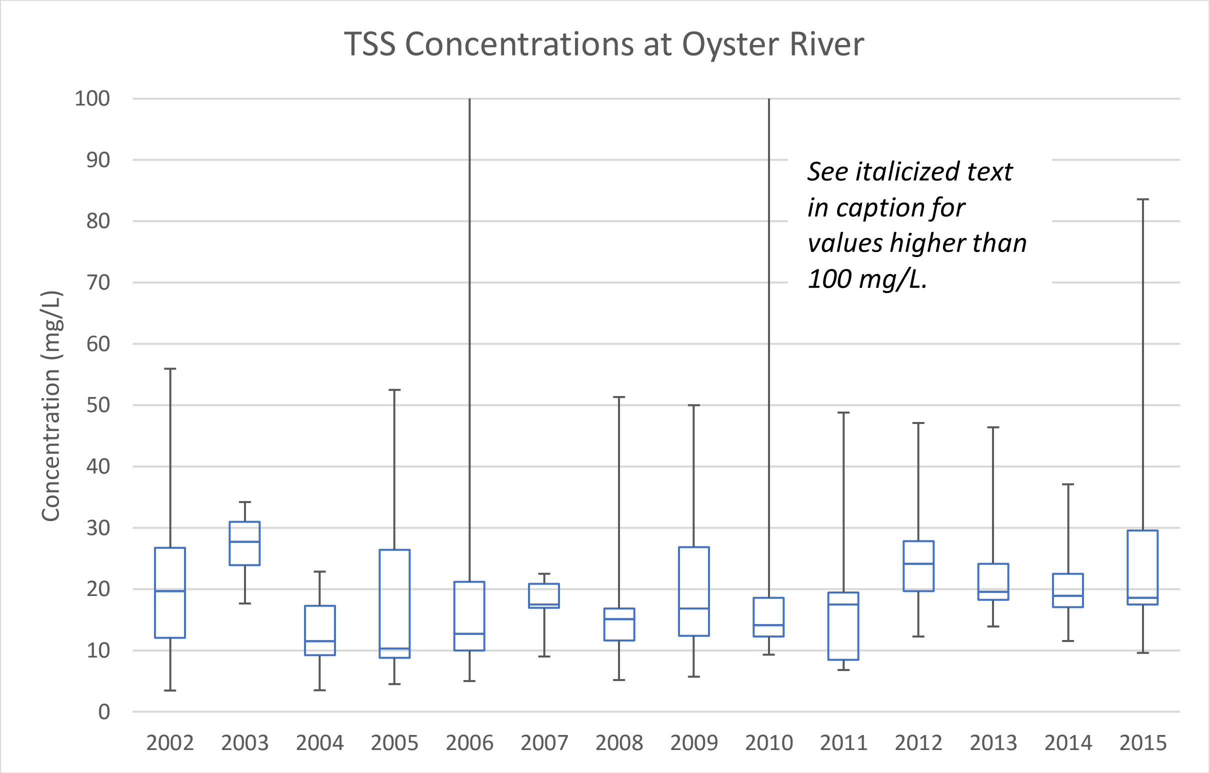
Monitoring Location (GRBGB)
Great Bay
(black circle with white plus sign)



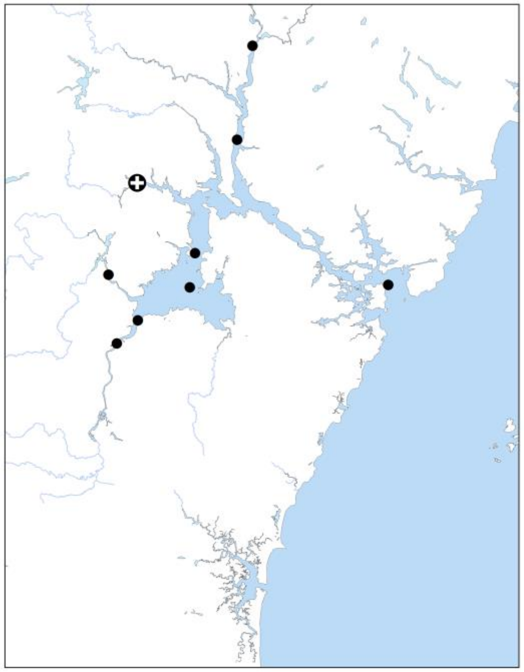
Station: GRBGB (Great Bay)

Long Term Trend: No significant trend.

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values.



Monitoring Location (GRBOR)
Oyster River
(black circle with white plus sign)

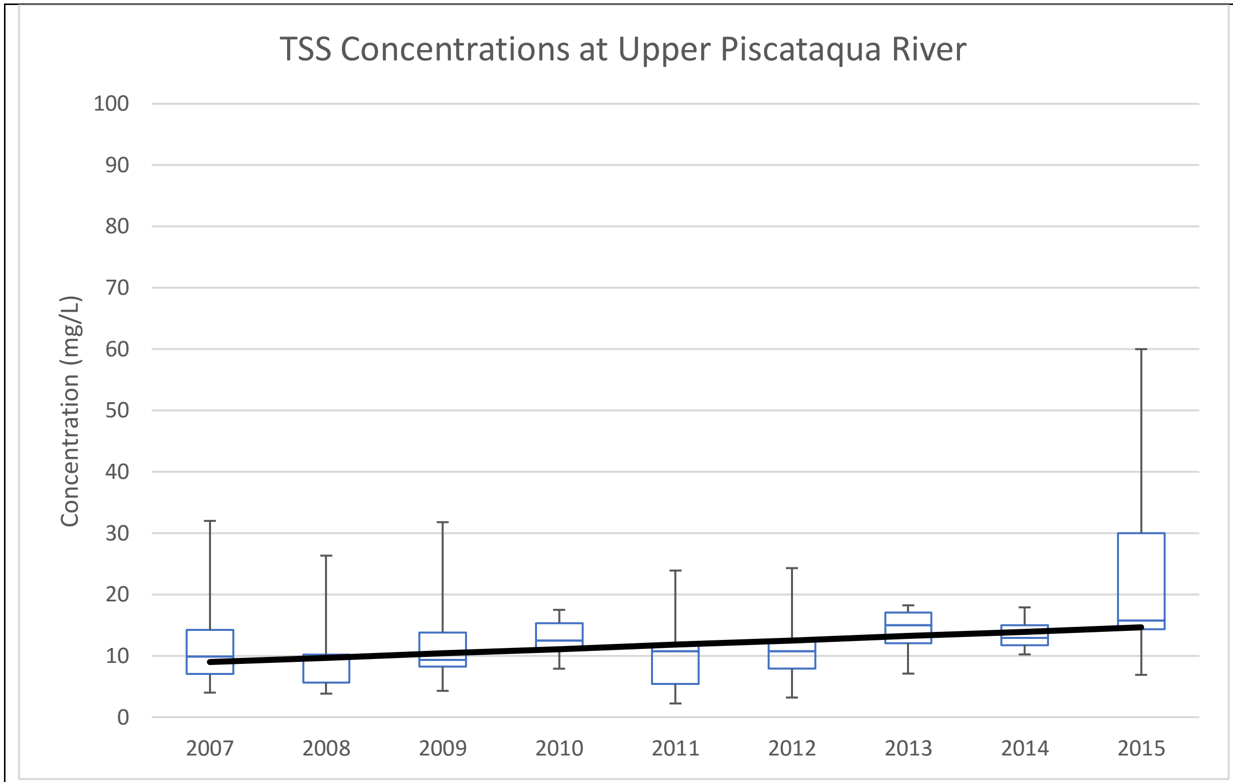


Station: GRBOR (Oyster River)

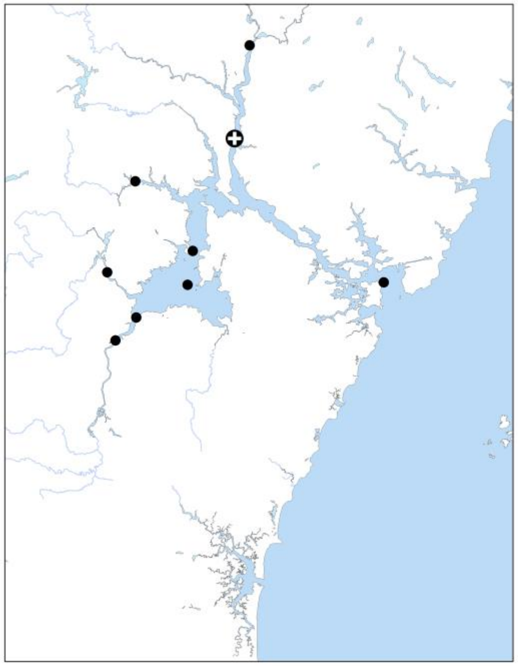
Long Term Trend: No significant trend.

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values.

Values Higher Than 100 mg/L: 2006 = 130 mg/L; 2010 = 128 mg/L.



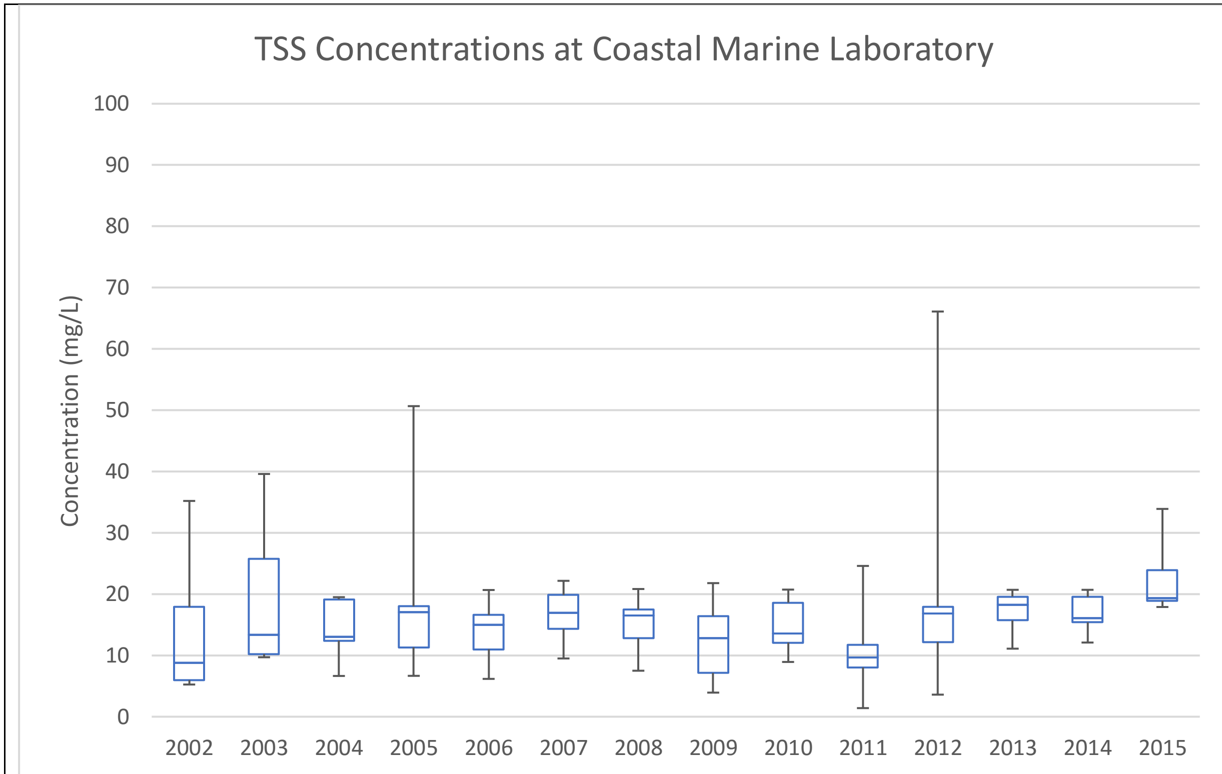
Monitoring Location (GRBUPR)
Upper Piscataqua River
(black circle with white plus sign)



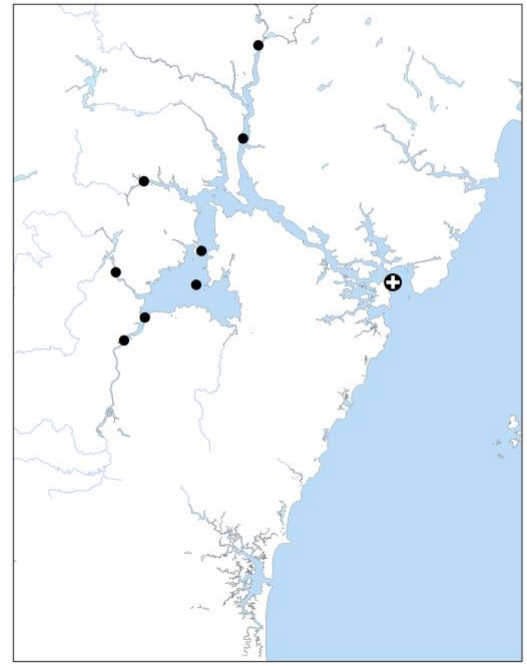
Station: GRBUPR (Upper Piscataqua River)

Long Term Trend: Significant increasing trend

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values.



Monitoring Location (GRBCML)
Coastal Marine Laboratory
Portsmouth Harbor
(black circle with white plus sign)



Station: GRBCML (Coastal Marine Laboratory in Portsmouth Harbor)

Long Term Trend: No significant trend

Box and whisker plots of data collected at low tide. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values.