Indicator: Nutrient Concentrations in the Great Bay Estuary

Question

How has the concentration of nitrogen and phosphorus in the waters of the Great Bay Estuary changed over time?

Short Answer

Nitrogen concentration varies by location and type of nitrogen. Total nitrogen (TN), which is less variable in space and time than dissolved inorganic nitrogen (DIN), shows a statistically significant decreasing trend at Adams Point. TN shows a statistically significant increasing trend at the Chapmans Landing and Lamprey River stations. No other stations indicate TN trends. For DIN, the Oyster River and Upper Piscataqua River stations indicate statistically significant decreasing trends while Chapmans Landing indicates a statistically significant increasing trend. (See "Additional Results" for discussion of phosphorus.)

PREP Goal
No increasing trends for any nitrogen or phosphorus species (from the PREP Comprehensive Conservation and Management Plan, PREP 2010).

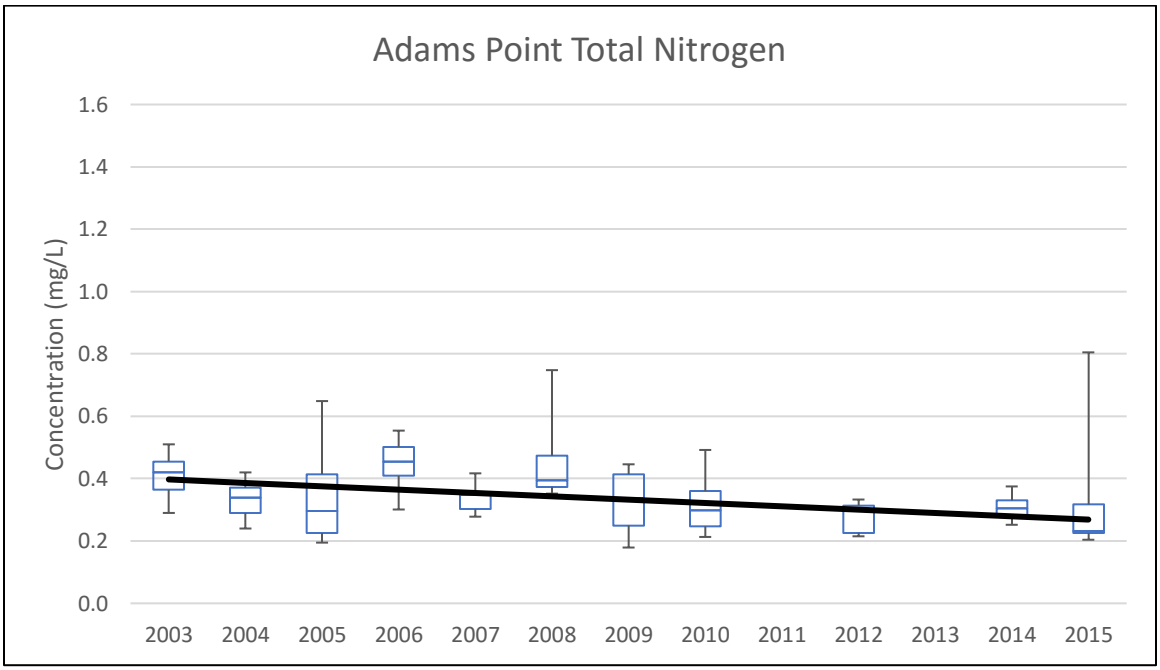


Figure NC-1. Total nitrogen at Adams Point. Box and whisker plots of Total Nitrogen concentrations (collected monthly, April through December, at low tide) between 2003 and 2015. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Years 2011 and 2013 not included due to missing data. Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

Why This Matters

Nitrogen is a critical nutrient for estuarine ecosystems; some is needed, but too much leads to problems. While nutrient loading measures how much nitrogen is being added to the system from the land and air, nutrient concentration measures the amount of nitrogen present in the water as a result of continual processing, at time of sampling. Measuring the concentration of nitrogen adds insight into the impact of nitrogen loading on the ecosystem. This report discusses two

forms of nitrogen: total nitrogen (TN) and dissolved inorganic nitrogen (DIN). It is important to note that both forms – but especially DIN – are taken up quickly by plants and algae, so the concentration of DIN does not necessarily reflect the potential effects of nitrogen on the estuarine ecosystem.

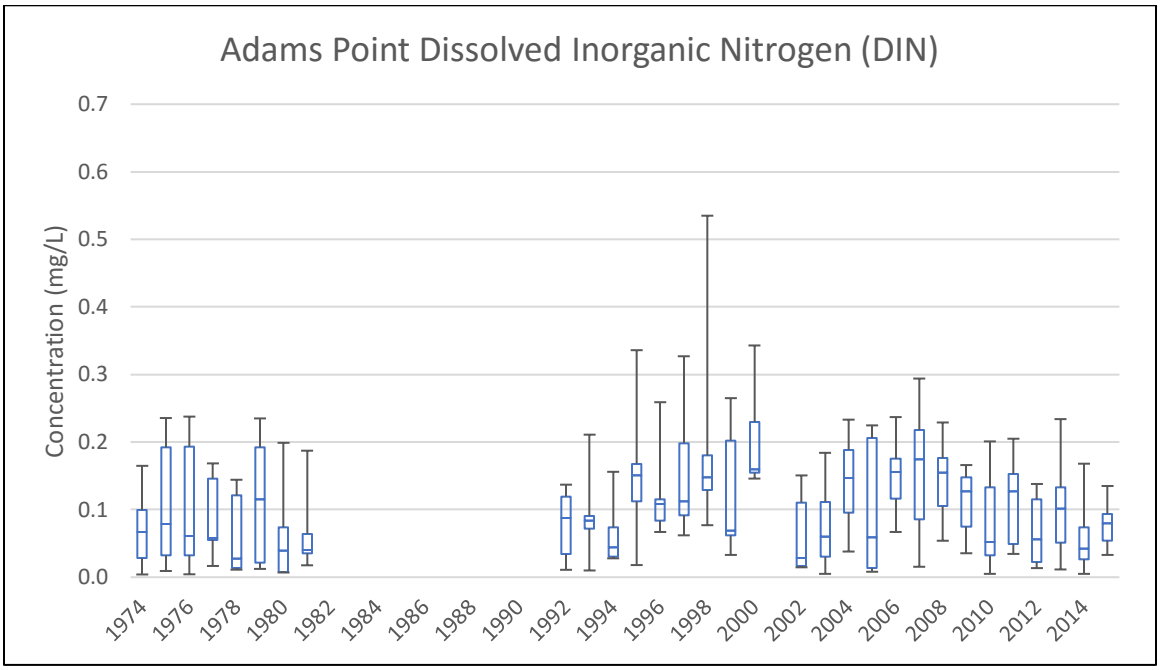


Figure NC-2. Dissolved inorganic nitrogen (DIN) at Adams Point. Box and whisker plots of concentrations (collected monthly, April through December, at low tide) between 1974 and 2015. The horizontal line in each box is the median. Boxes encompass the middle 50% of the data points. Upper and lower vertical lines show the complete range of data values. Some years omitted due to missing data. Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

Explanation (from 2018 State of Our Estuaries Report)

Total Nitrogen (TN): Includes both dissolved inorganic nitrogen (DIN) and nitrogen contained in particulate and dissolved organic matter, and is considered to be a more accurate measure of the nitrogen status of an estuary than DIN alone. TN at Adams Point shows a significant decreasing trend (Figure NC-1), but it is important to note that the time series begins relatively recently, in 2003. Since 2012, median values ranged from 0.23 mg/L to 0.30 mg/L over the sample season for TN at Adams Point. Figure NC-1 indicates that the years 2005, 2008 and 2015 experienced TN concentrations above 0.6 mg/L.

TN values at the Lamprey River and Chapmans Landing stations (Figure NC-3) show a significantly increasing trend, with average values over the last reporting period (2012 – 2015) of 0.52 and 0.90 mg/L, respectively. Average values for other stations were: 0.77 mg/L (Squamscott River), 0.35 mg/L (Great Bay), 0.52 mg/L (Oyster River), 0.44 mg/L (Upper Piscataqua) and 0.24 mg/L (the Coastal Marine Laboratory in Portsmouth Harbor).

Dissolved Inorganic Nitrogen (DIN): At Adams Point, median values for DIN for 2012 to 2015 ranged from 0.04 to 0.1 mg/L comparable to median values for the years 1974 to 1981 (Figure TC-2). For reference, the EPA National Coastal Assessment Condition Report categorizes values less than 0.1 as “Good.” Other categories include “Fair” (0.1 to 0.5 mg/L) and “Poor” (greater than 0.5 mg/L), (Bricker et al. 2003; US EPA 2012).

The Oyster River and Upper Piscataqua River stations both showed statistically significant decreasing trends for DIN, with average values since 2012 at 0.18 and 0.04 mg/L, respectively. In contrast, Chapmans Landing showed a statistically significant increasing trend with average values since 2012 at 0.48 mg/L. Average values for other stations were: 0.37 mg/L (Squamscott River), 0.21 mg/L (Lamprey River), 0.08 mg/L (Great Bay) and 0.09 mg/L (Coastal Marine Lab). Nutrient concentrations in the water are affected by nutrient loading from the watershed. As noted in the Nutrient Loading Indicator report, loadings since 2012 have been reduced in part due to reductions at municipal wastewater treatment facilities. Additionally, loading has been reduced due to consecutive years of low annual rainfall amounts and low occurrence of extreme rainfall events, which equates to less non-point source loading from run-off.

Methods and Data Sources

Trend analysis for nitrogen and phosphorus species was performed at the following stations (Figure NC-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)

With regard to nitrogen species, this report focuses on total nitrogen and dissolved inorganic nitrogen (Table NC-1 and Figures NC-4 and NC-5); data are also available for ammonia, nitrate+nitrite, total dissolved nitrogen and particulate nitrogen and can be obtained by querying the NH DES Environmental Monitoring Database or by contacting PREP staff.

The phosphorus parameter for trend analysis was orthophosphate and is included in this report (Table NC-1 and Figure NC-6.)

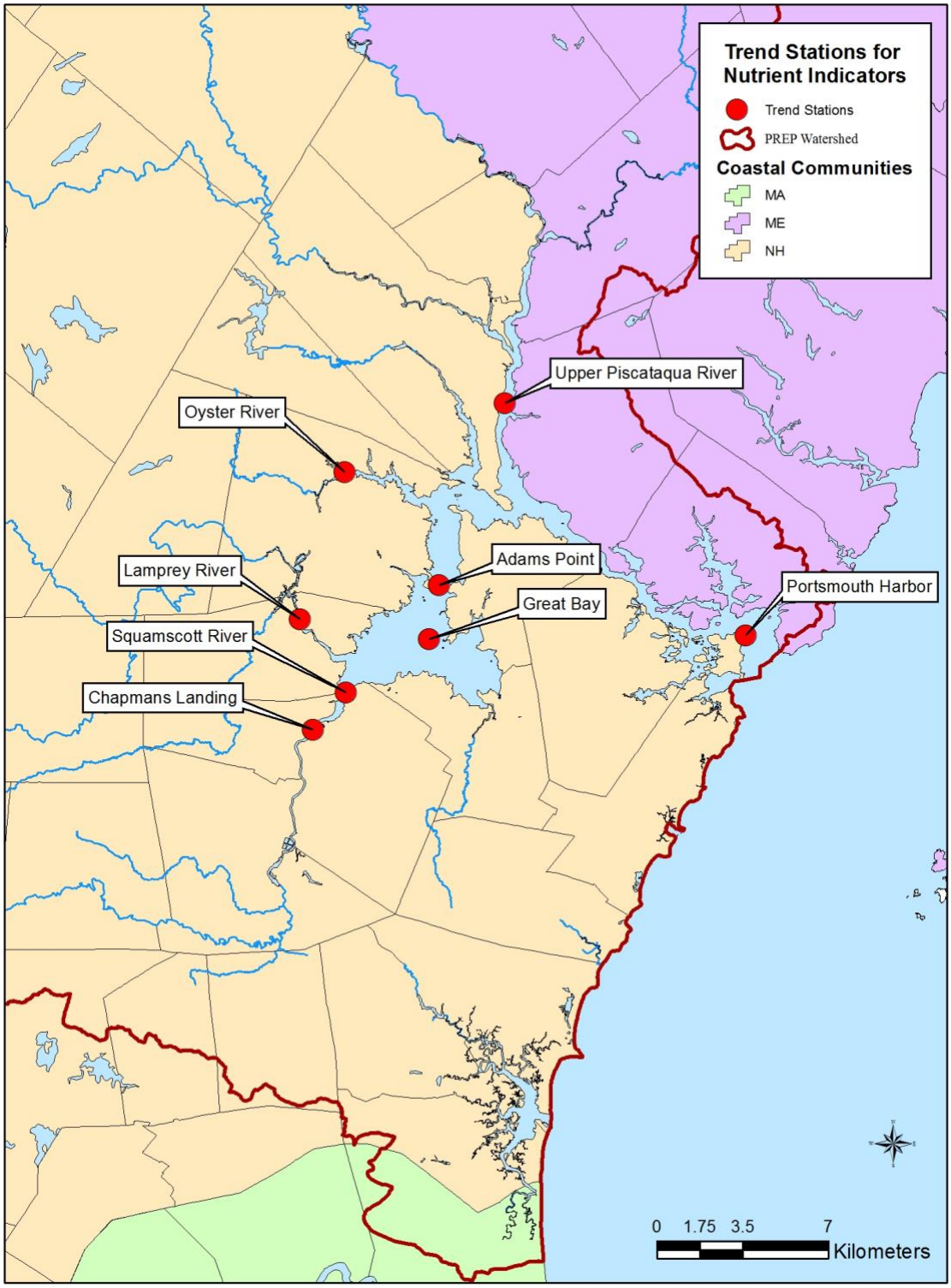
Samples collected at low-tide at the trend stations were identified. Low-tide samples were used for the trend analysis to control for the effects of tides and because historic datasets were collected exclusively at low tide. The data for each station were averaged by month (there was rarely more than 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 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 for years 1992 to present. Historic datasets from 1974 to 1981 (Norall et al. 1982; Loder et al. 1983) were also included in the trend analysis for station GRBAP.

Additional trend monitoring stations were added in 2017 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.

Figure NC-3. Map of trend stations for nutrient concentrations.



Additional Results (Beyond What Was Reported in the SOOE)

The results of the trend analysis for nitrogen and phosphorus compounds are summarized in Table NC-1. Plots of each nitrogen (TN and DIN) and phosphorus (orthophosphate) compound at each station are shown on Figures NC-4 through NC-6.

For DIN, the Chapmans Landing and Squamscott River stations both showed significant increasing trends. The Oyster River and Upper Piscataqua River stations, on the other hand, demonstrated significant decreasing trends. No significant trends were found at the other stations.

For total nitrogen, only the Chapmans Landing station showed a significant increasing trend. Adams Point, Great Bay and Oyster River all demonstrated significant decreasing trends. The other stations did not have significant trends in either direction.

Finally, for orthophosphate, none of the stations indicated any trends.

Table NC-1 indicates the range of median values seen at each station between the years 2012 and 2015. It is also important to review Figures NC-4 through NC-6 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.

EPA (2012) provides general category ranges (poor, fair, good) for both DIN and dissolved phosphorus (orthophosphate), but not for total nitrogen. For DIN, less than 0.1 mg/L is “good;” between 0.1 mg/L and 0.5 mg/L is “fair;” and more than 0.5 mg/L is “poor.” Figures NC-2 (Adams Point) and NC-4 indicate that results at most stations tend to fall into the “fair” category, with Adams Point, Great Bay, Upper Piscataqua River and the Coastal Marine Laboratory also seeing results in the “good” category as well. Chapmans Landing and Squamscott River both show results in the “fair” and “poor” category.

For orthophosphate, the EPA (2012) categories are: less than 0.01 mg/L is “good;” between 0.01 and 0.05 is “fair;” and above 0.05 mg/L is “poor.” Figure NC-5 indicates that results at most stations can be categorized as “fair.” Great Bay, relative to other stations, shows more results in the “good” category. Chapmans Landing, Lamprey River and Oyster River show results in both the “fair” and “poor” category.

The above EPA thresholds are general values for the entire Northeast region of the country (EPA 2012). More data is required to set nutrient thresholds that are specific to various zones of the Great Bay Estuary (Bierman et al. 2014; Kenworthy et al. 2017).

For more on the relationship between nutrient concentrations and other indicators (e.g., nitrogen loading, eelgrass, seaweed, and phytoplankton, please see those indicator sections.)

For more on the relationship between nitrogen loading and overall ecosystem health and resilience, see the “Stress and Resilience” section of the State of Our Estuaries Report (PREP 2017b) and the “External Advisors Statement Regarding Eelgrass Stressors in Great Bay Estuary” (Kenworthy et al. 2014).

References Cited

Bierman VJ, Diaz RJ, Kenworthy WJ, Reckhow KH. 2014. Joint Report of Peer Review Panel for Numeric Nutrient Criteria for Great Bay Estuary. http://scholars.unh.edu/rtr/1/

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

Kenworthy WJ, Gobler CJ, Moore KA. 2017. Statement Regarding Eelgrass Stressors in the Great Bay Estuary. An appendix to the 2017 PREP Final Environmental Data Report. http://stateofourestuaries.org/2018-reports/data-report

Loder TC, Love JA, Kim JP, Wheat CG. 1983. Nutrient and hydrographic data for the Great Bay Estuarine System, New Hampshire-Maine: Part II, January 1976 – June 1978. UNH- MP-D/TR-SG-83-4. University of New Hampshire Marine Program, Durham, NH.

Norall TL, Mathieson AC, Penniman CE. 1982. Nutrient and hydrographic data for the Great Bay Estuarine System, New Hampshire-Maine: Part I, September 1973-December 1975. Jackson Estuarine Laboratory contribution #150, UNH-D/TR-83-1. University of New Hampshire Marine Program, Durham, NH.

PREP 2010. Piscataqua Region Comprehensive Conservation and Management Plan, Piscataqua Region Estuaries Partnership: D.B.Truslow Associates, Mettee Planning Consultants, 2010, Durham, NH. http://scholars.unh.edu/prep/22/.

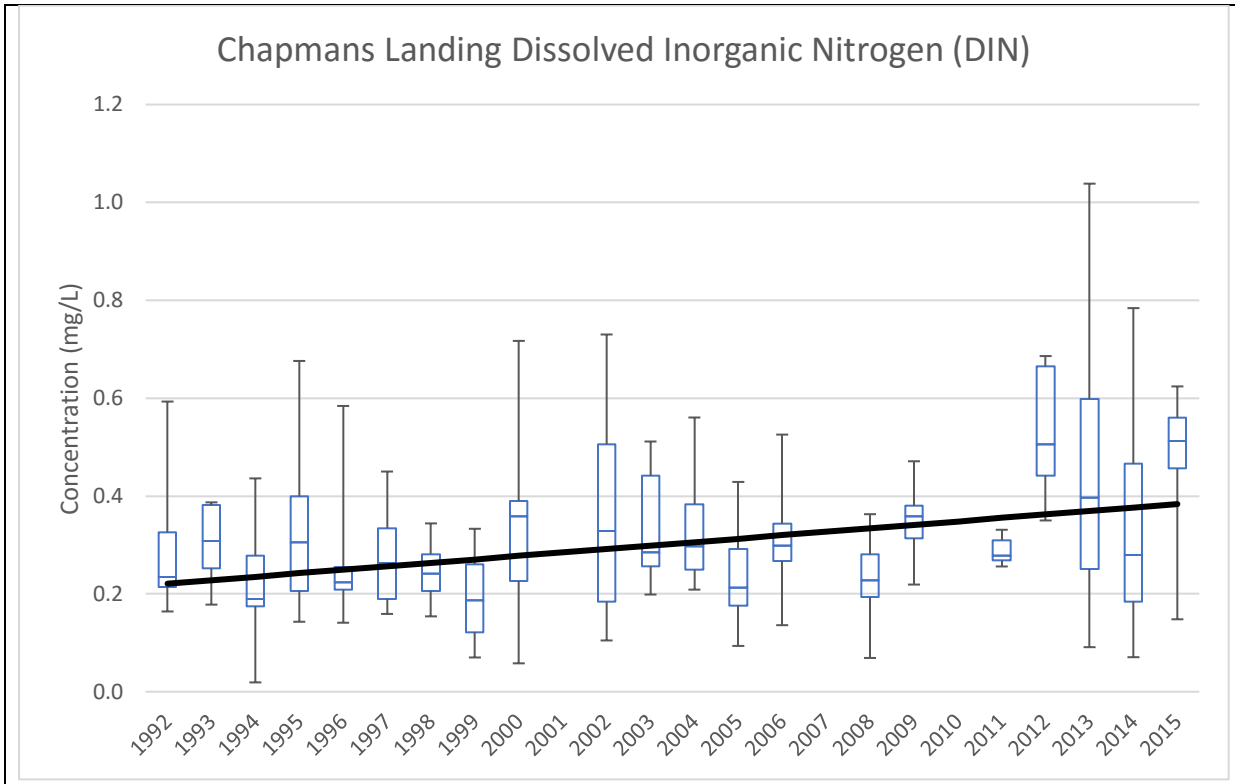
PREP. 2017b. State of Our Estuaries 2018" PREP. http://stateofourestuaries.org/2018-reports/sooe-full-report

US EPA. 2012. National Coastal Condition Report IV. https://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-report-iv-2012

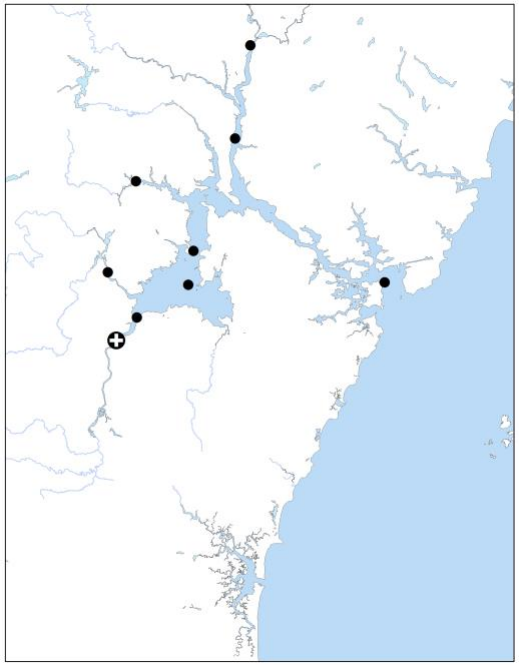
Table NC-1: Trends for nutrient compounds in the Great Bay Estuary

Station	Parameter	Period	Range of Recent Median Values (2012 -2015, mg/L)	Long Term Trend
GRBAP (Adams Point)	Dissolved Inorganic Nitrogen	1974-2015	0.04 to 0.1	No significant trend
	Total Nitrogen	2003-2015	0.23 to 0.30	Significant decreasing trend
	Orthophosphate	1992-2015	0.02 to 0.03	No significant trend
GRBCL (Chapmans Landing)	Dissolved Inorganic Nitrogen	1992-2015	0.28 to 0.51	Significant increasing trend
	Total Nitrogen	2003-2015	0.81 to 0.92	Significant increasing trend
	Orthophosphate	1992-2015	0.03 to 0.04	No significant trend
GRBSQ (Squamscott River)	Dissolved Inorganic Nitrogen	2002-2015	0.38 to 0.44	Significant increasing trend
	Total Nitrogen	2003-2015	0.71 to 0.77	No significant trend
	Orthophosphate	2002-2015	0.04 to 0.04	No significant trend
GRBLR (Lamprey River)	Dissolved Inorganic Nitrogen	1992-2015	0.14 to 0.22	No significant trend
	Total Nitrogen	2003-2015	0.41 to 0.49	No significant trend
	Orthophosphate	1992-2015	0.01 to 0.01	No significant trend
GRBGB (Great Bay)	Dissolved Inorganic Nitrogen	2002-2015	0.03 to 0.11	No significant trend
	Total Nitrogen	2003-2015	0.30 to 0.35	Significant decreasing trend
	Orthophosphate	2002-2015	0.02 to 0.02	No significant trend
GRBOR Oyster River	Dissolved Inorganic Nitrogen	2002-2015	0.11 to 0.23	Significant decreasing trend
	Total Nitrogen	2004-2015	0.40 to 0.53	Significant decreasing trend
	Orthophosphate	2002-2015	0.04 to 0.06	No significant trend
GRBUPR Upper Piscataqua River	Dissolved Inorganic Nitrogen	2007-2015	0.13 to 0.21	Significant decreasing trend
	Total Nitrogen	2009-2015	0.36 to 0.55	No significant trend
	Orthophosphate	2007-2015	0.02 to 0.02	No significant trend
GRBCML Coastal Marine Laboratory Portsmouth Harbor	Dissolved Inorganic Nitrogen	2001-2015	0.05 to 0.19	No significant trend
	Total Nitrogen	2003-2015	0.21 to 0.25	No significant trend
	Orthophosphate	2001-2015	0.02 to 0.02	No significant trend

Figure NC-4: Dissolved inorganic nitrogen (DIN) concentration trends at stations in the Great Bay Estuary



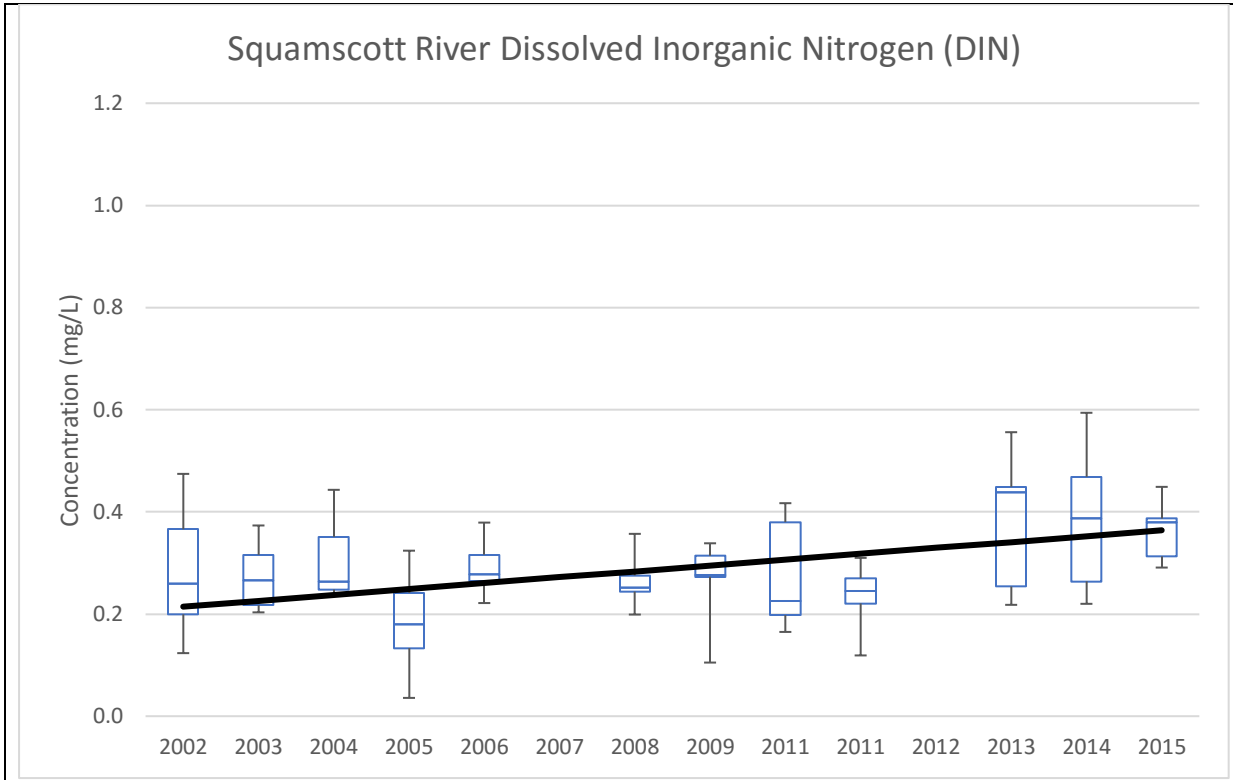
Monitoring Location (GRBCL)
Chapmans Landing
(black circle with white plus sign)



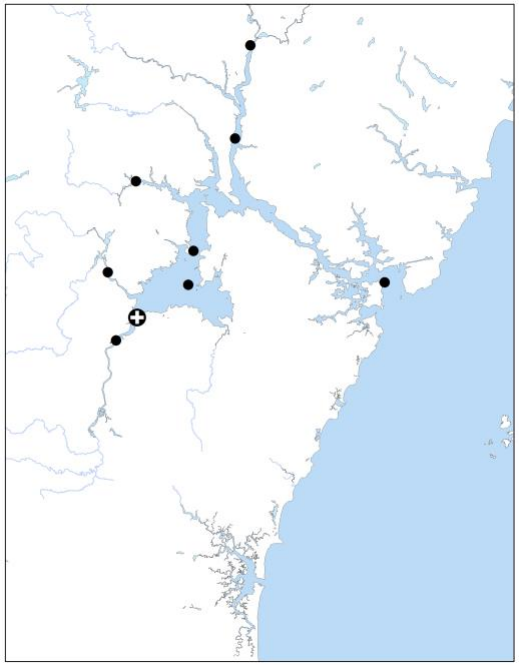
Station: GRBCL (Chapmans Landing in the Squamscott River)

Long Term Trend: 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. Some years omitted due to missing data.



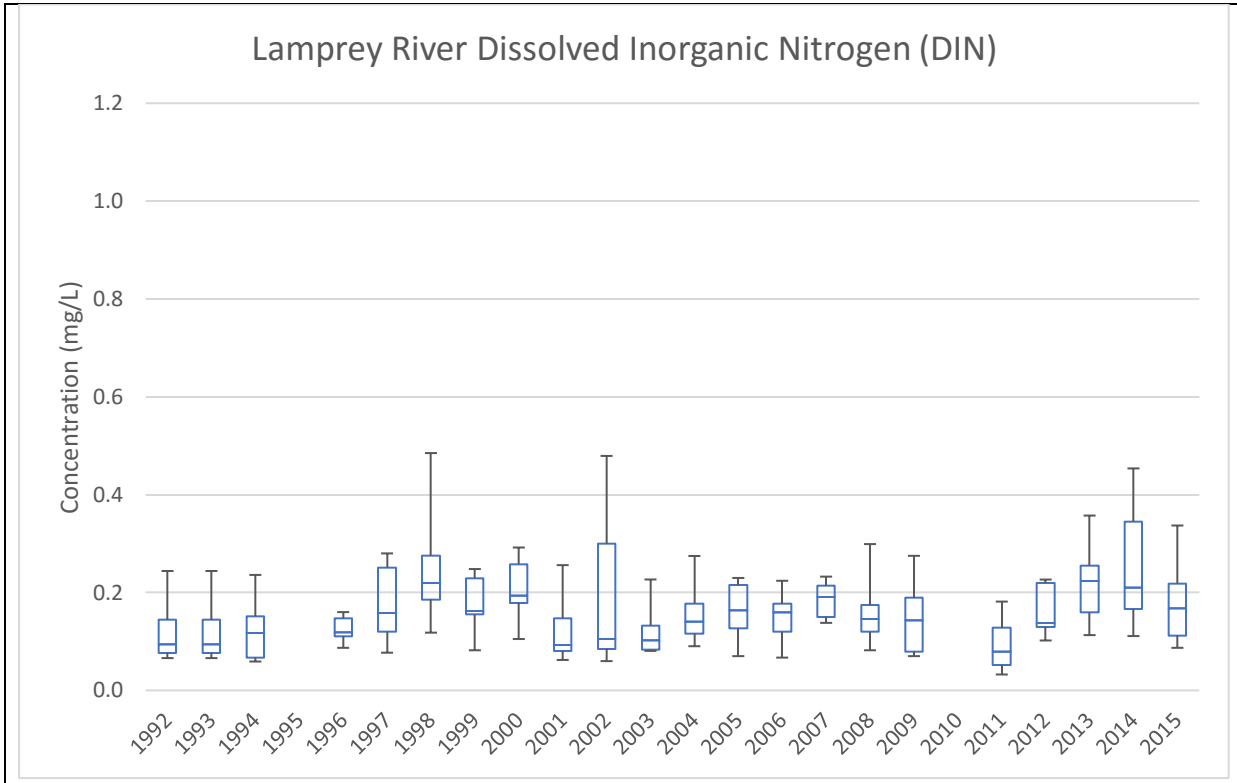
Monitoring Location (GRBSQ)
Squamscott River
(black circle with white plus sign)



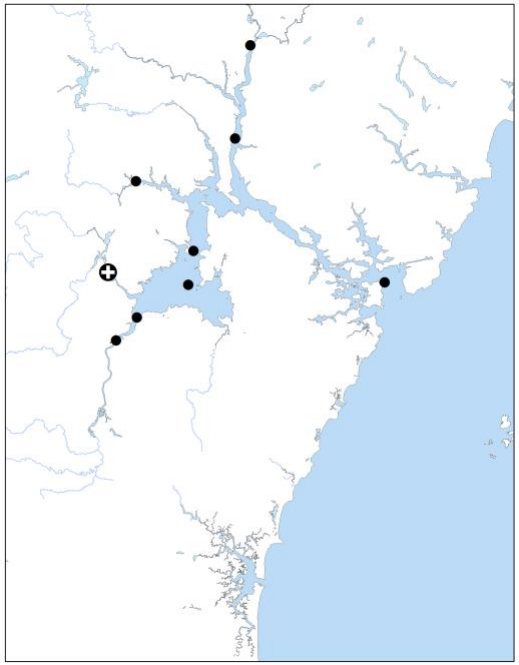
Station: GRBSQ (Squamscott River)

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. Some years omitted due to missing data.



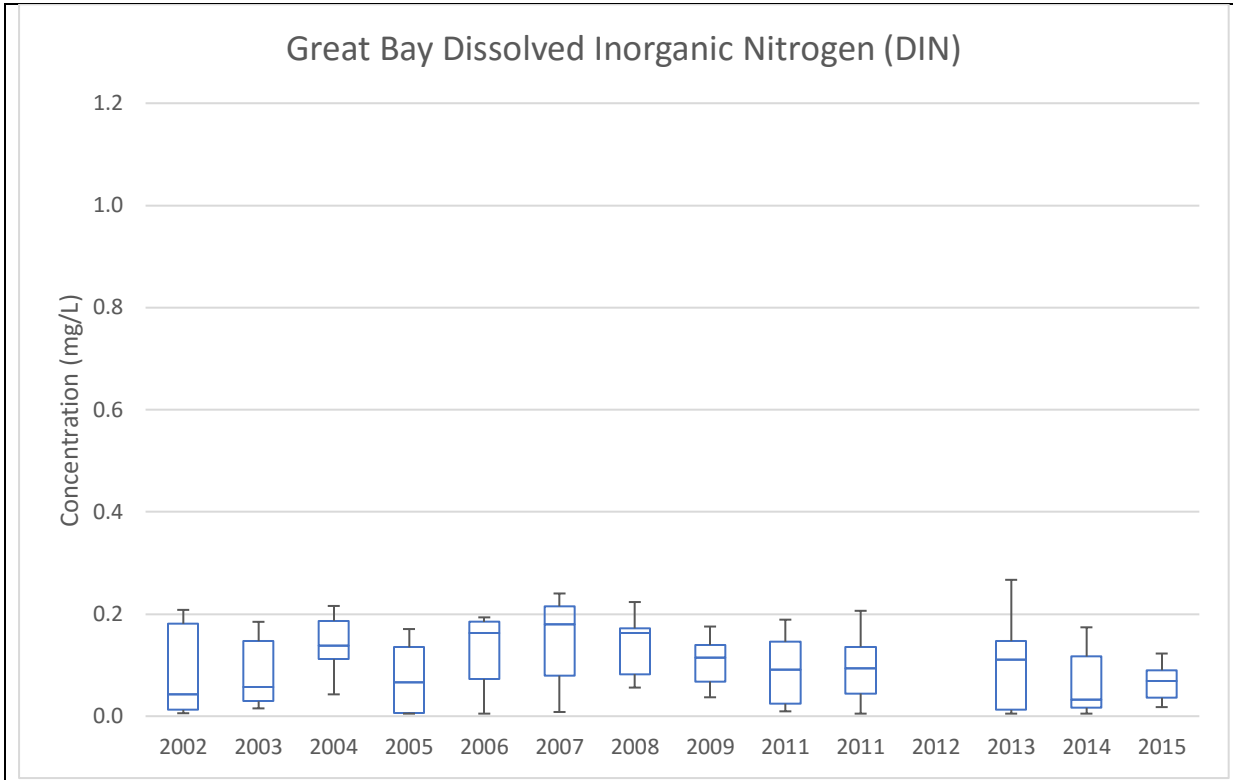
Monitoring Location (GRBLR)
Lamprey River
(black circle with white plus sign)



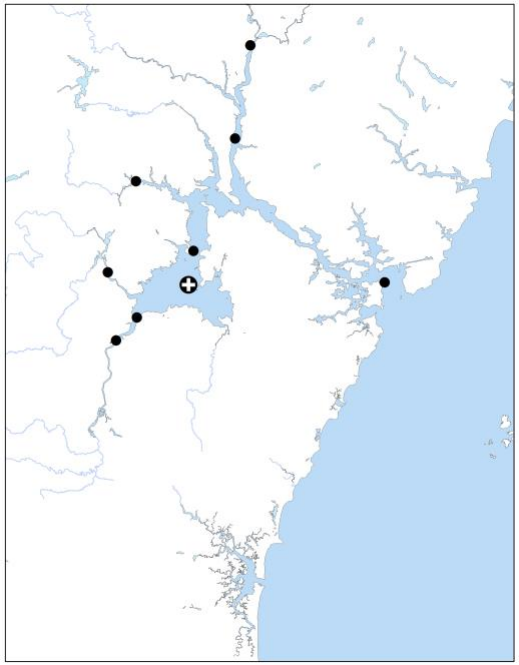
Station: GRBLR (Lamprey River)

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.



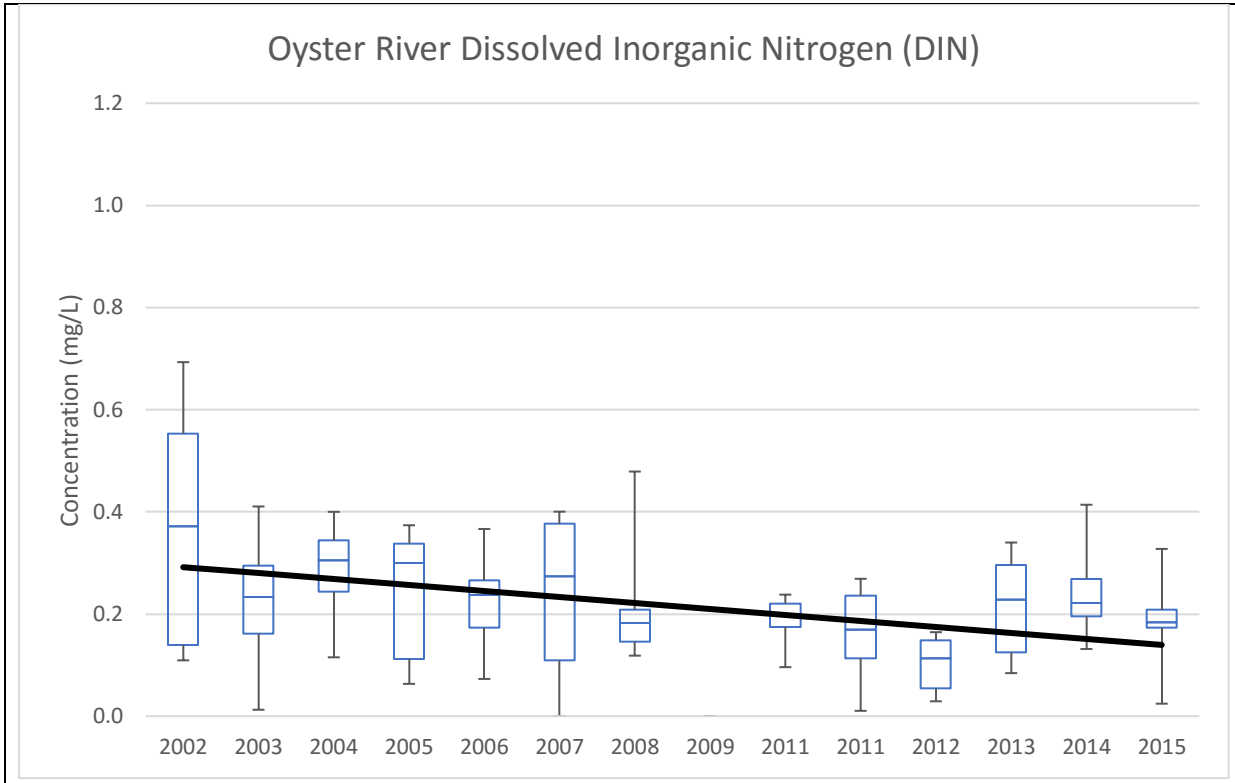
Monitoring Location (GRBGB)
Great Bay
(black circle with white plus sign)



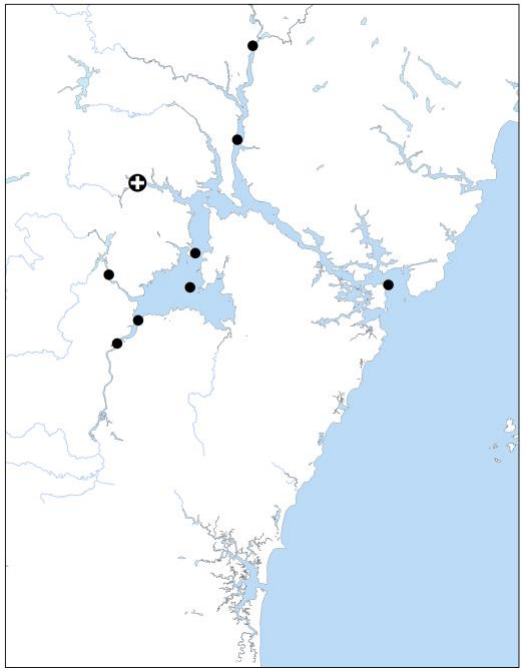
Station: GRBGB (Great Bay)

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. Some years omitted due to missing data.



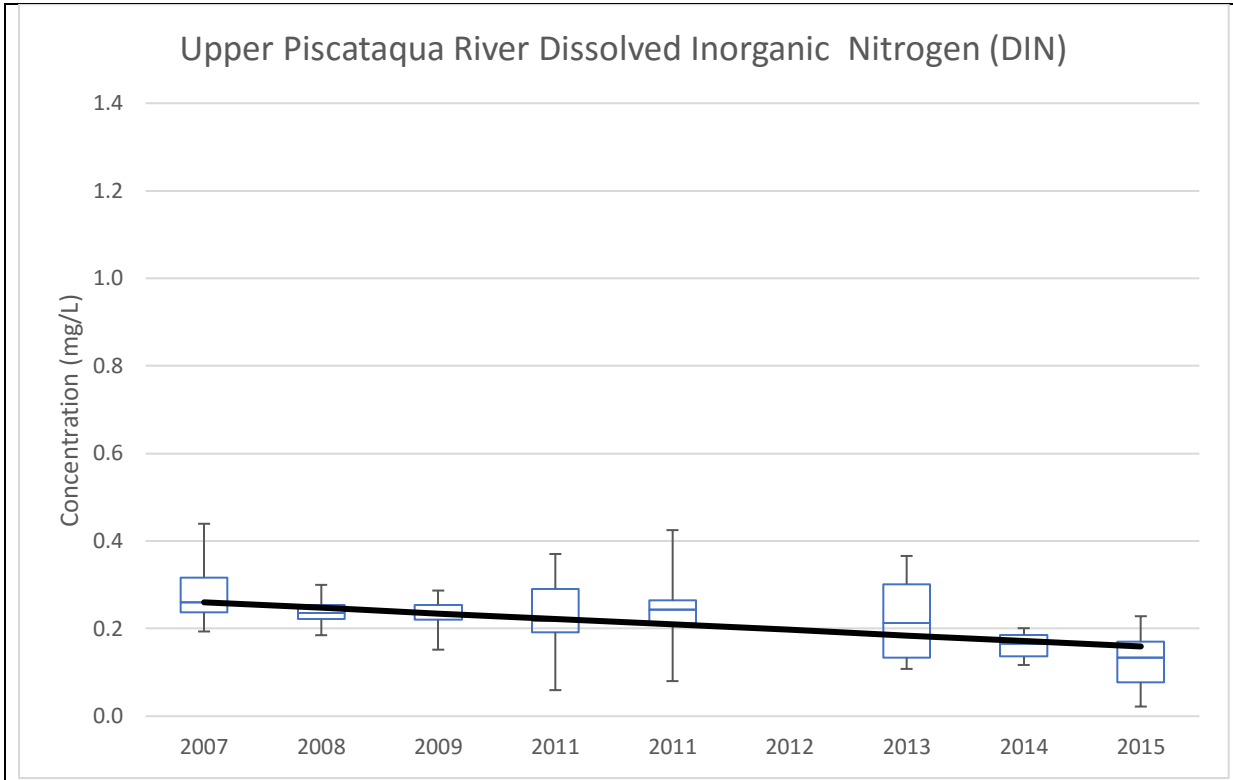
Monitoring Location (GRBOR)
Oyster River
(black circle with white plus sign)



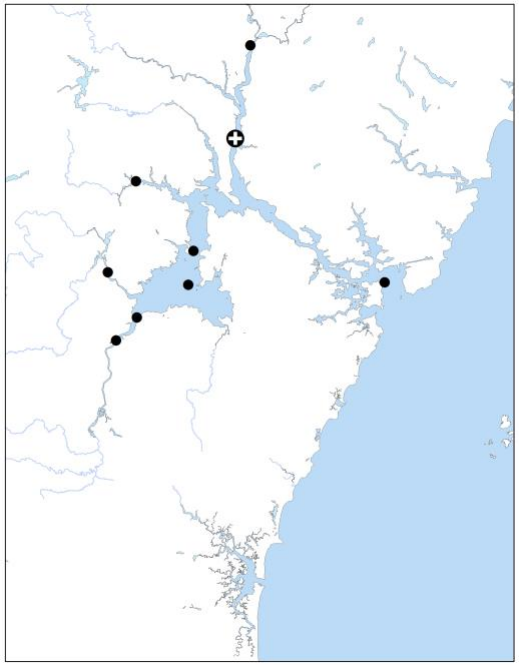
Station: GRBOR (Oyster River)

Long Term Trend: Significant decreasing 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.



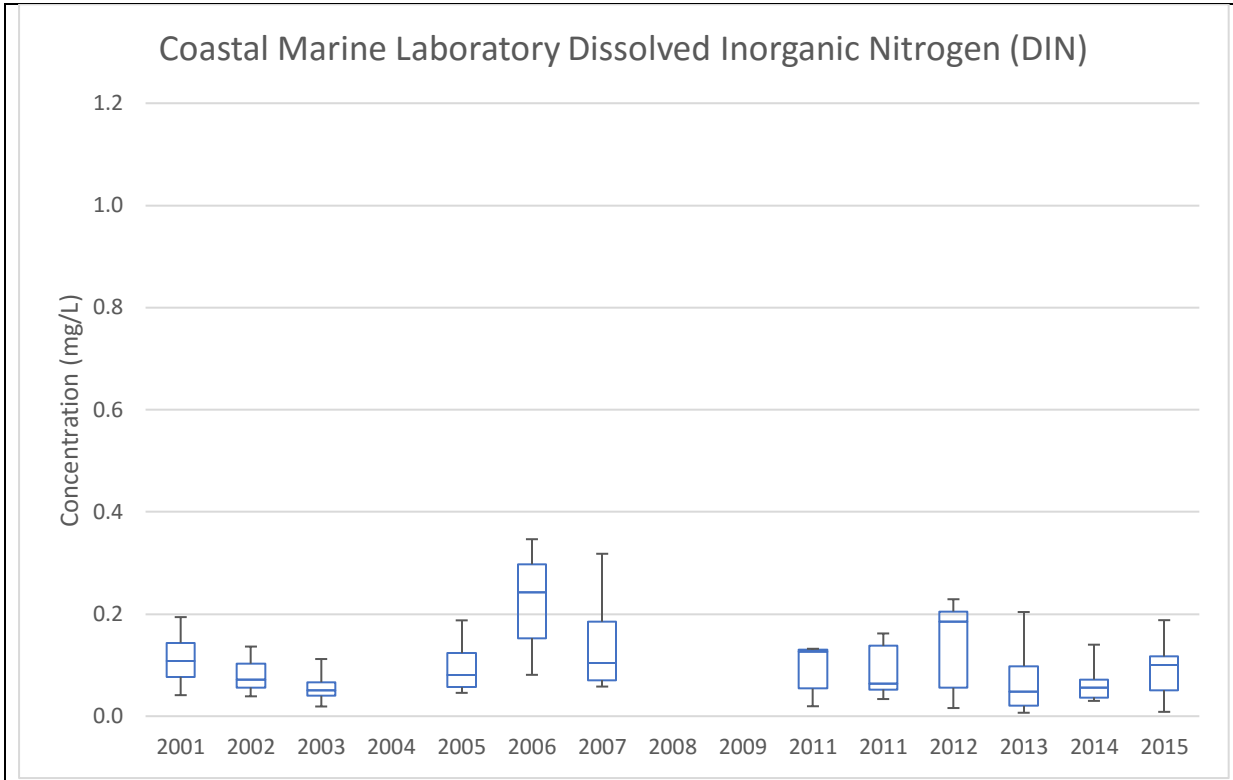
Monitoring Location (GRBUPR)
Upper Piscataqua River
(black circle with white plus sign)



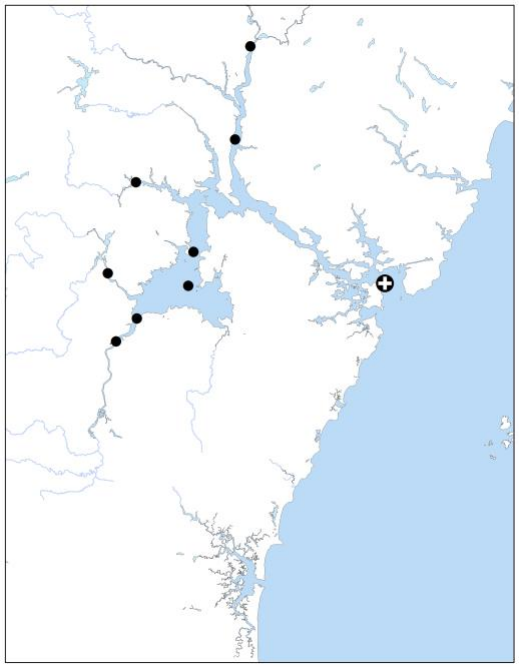
Station: GRBUPR (Upper Piscataqua River)

Long Term Trend: Significant decreasing 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 (GRBCML)
Coastal Marine Laboratory
Portsmouth Harbor
(black circle with white plus sign)

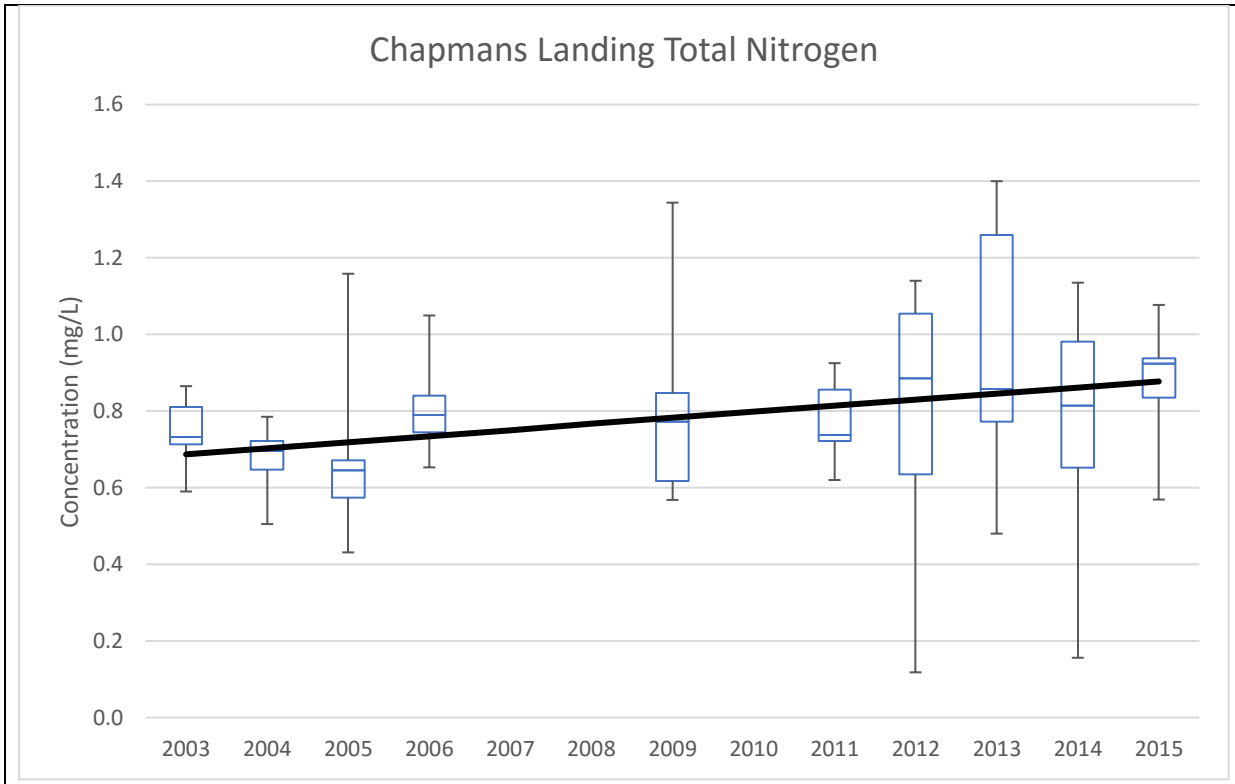


Station: GRBCML (Coastal Marine Laboratory in Portsmouth Harbor)

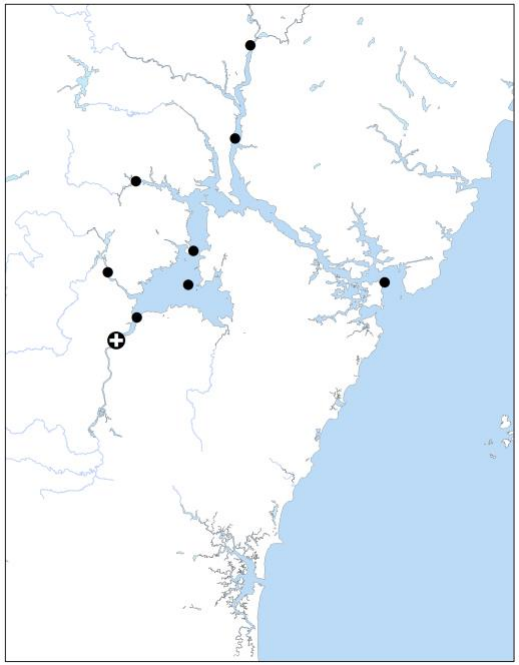
Long Term Trend: No significant trend

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. Some years omitted due to missing data.

Figure NC-5: Total nitrogen (TN) concentration trends at stations in the Great Bay Estuary.



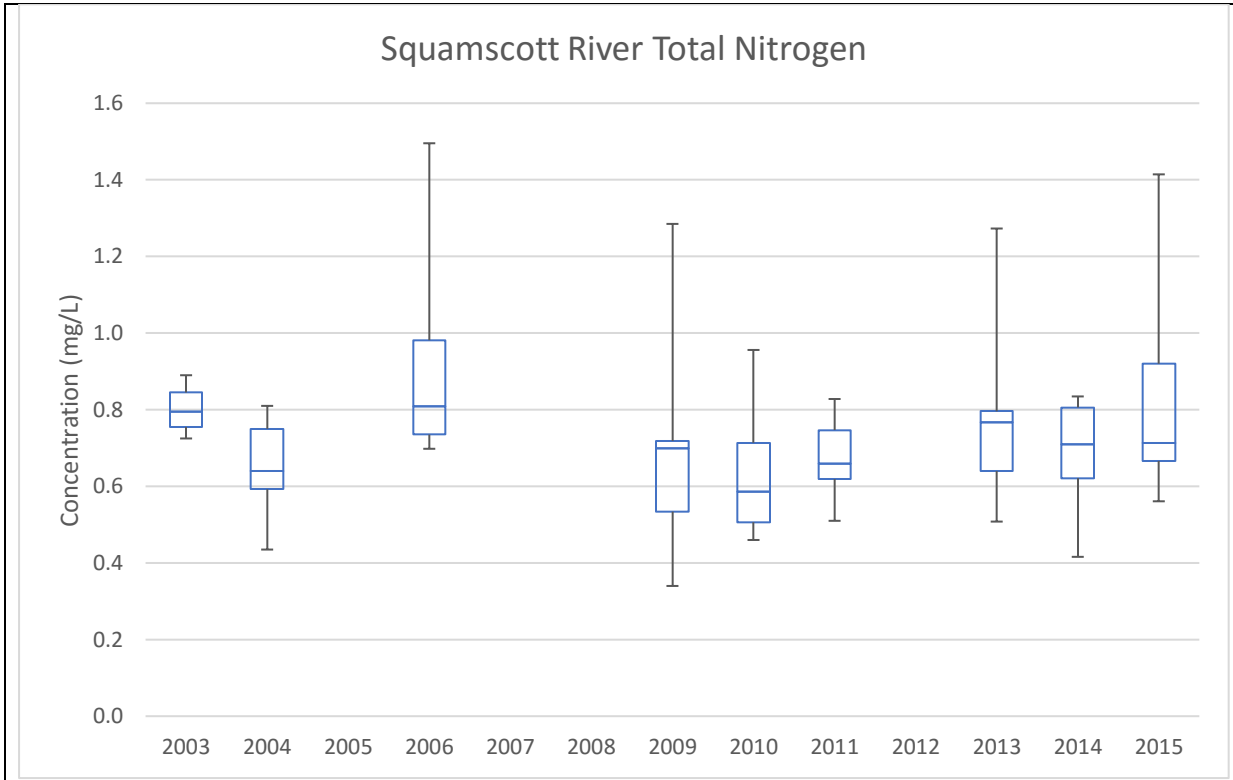
Monitoring Location (GRBCL)
Chapmans Landing
(black circle with white plus sign)



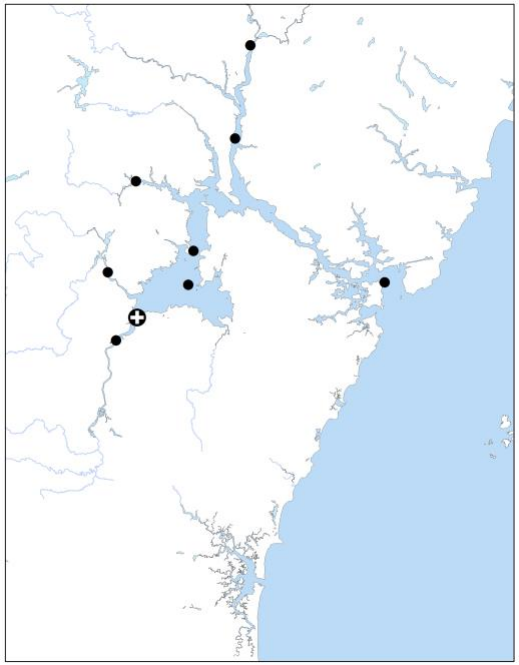
Station: GRBCL (Chapmans Landing in the Squamscott River)

Long Term Trend: 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. Some years omitted due to missing data.



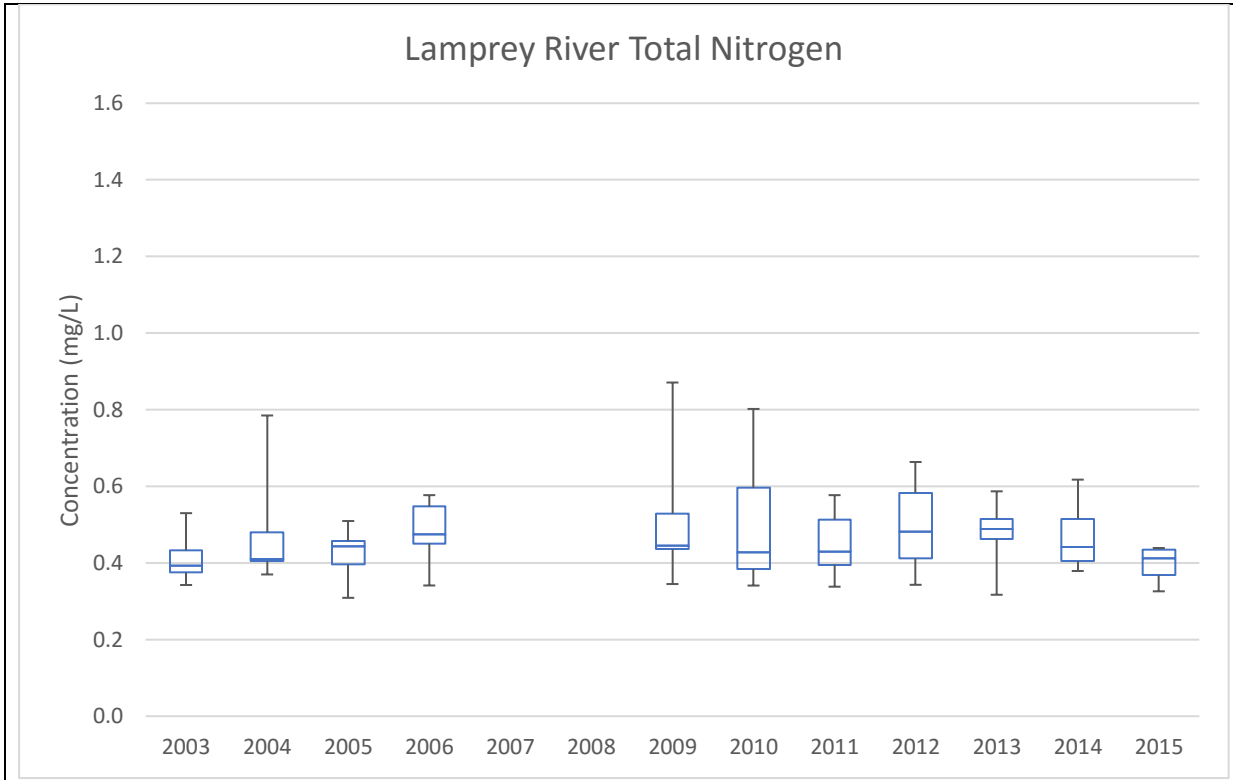
Monitoring Location (GRBSQ)
Squamscott River
(black circle with white plus sign)



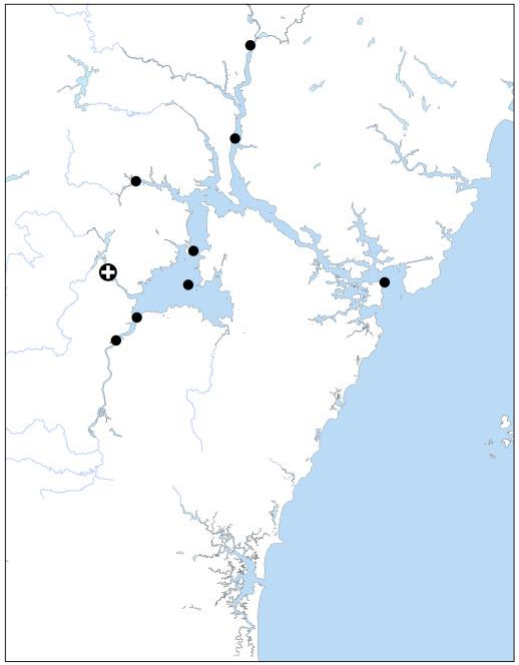
Station: GRBSQ (Squamscott River)

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.



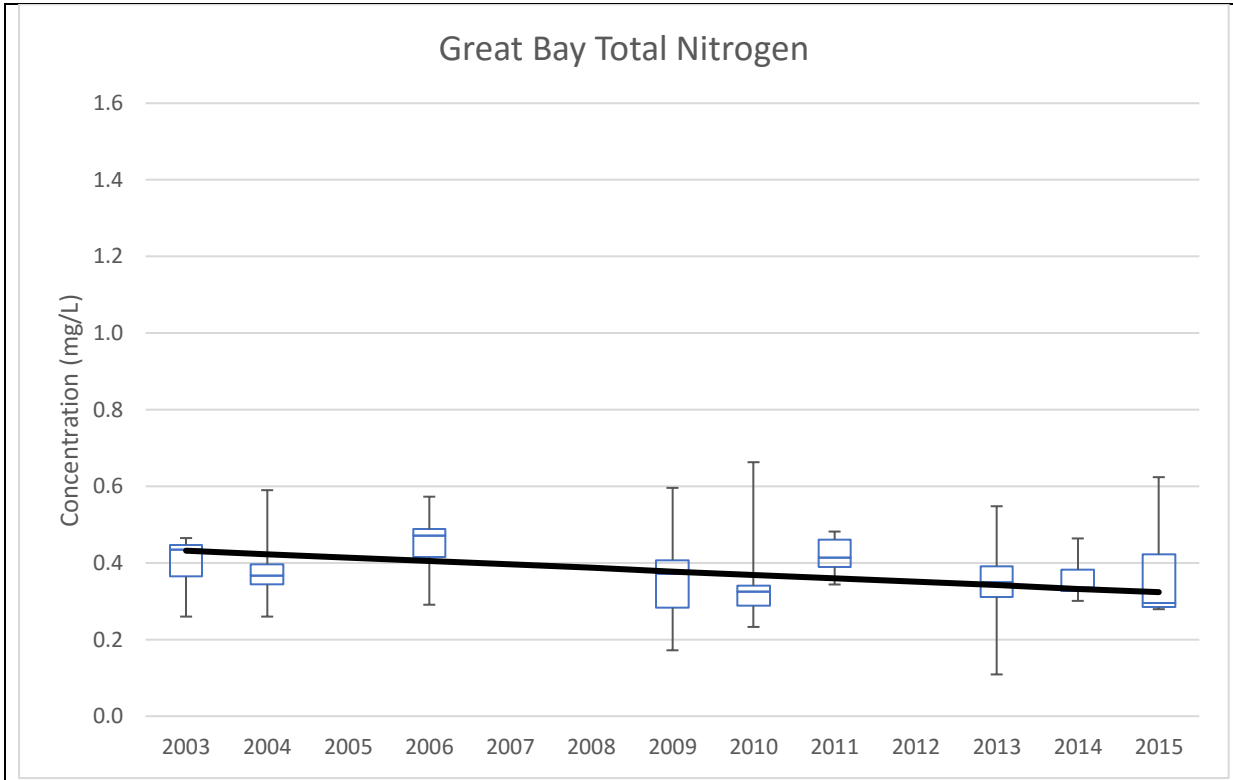
Monitoring Location (GRBLR)
Lamprey River
(black circle with white plus sign)



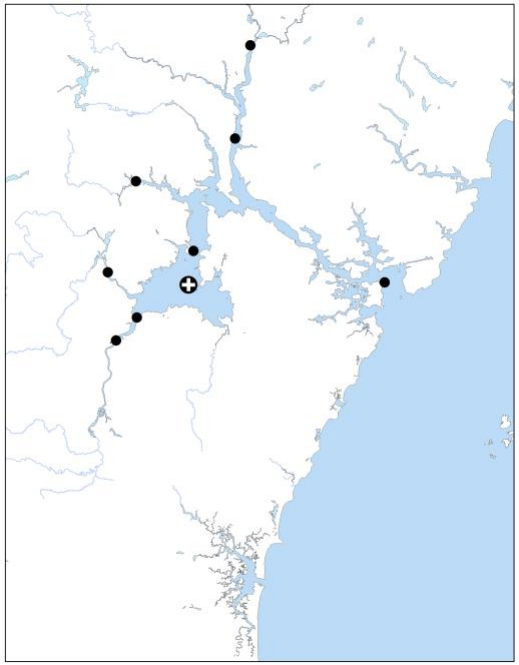
Station: GRBLR (Lamprey River)

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.



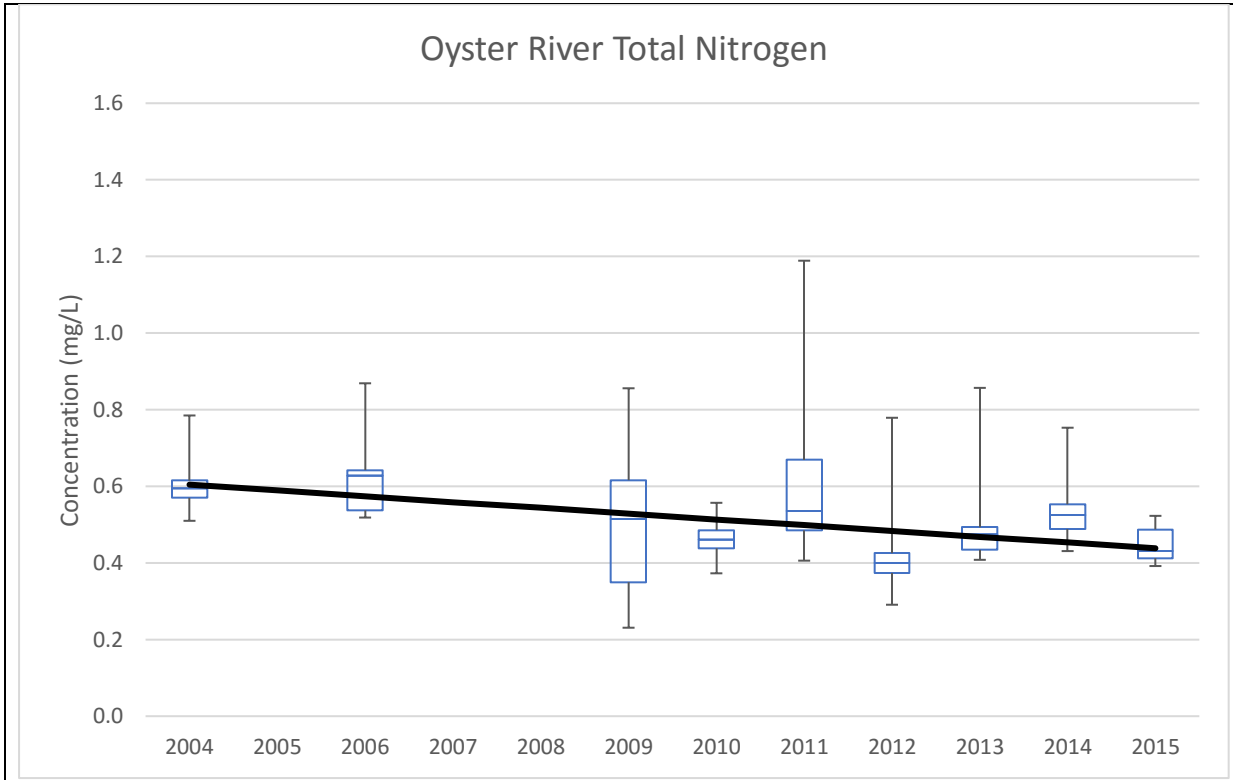
Monitoring Location (GRBGB)
Great Bay
(black circle with white plus sign)



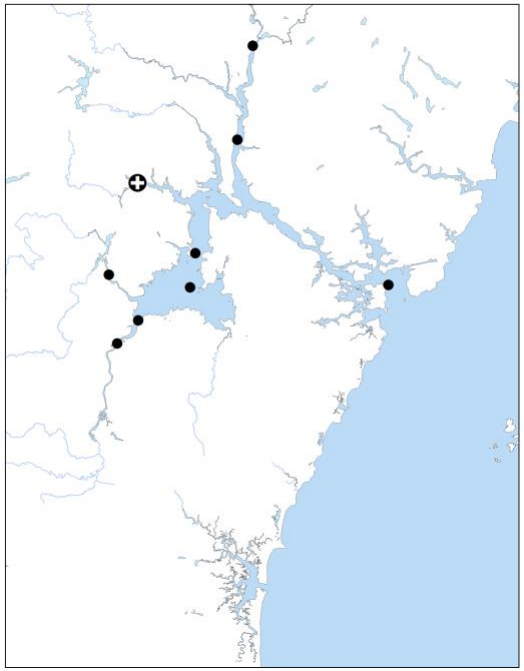
Station: GRBGB (Great Bay)

Long Term Trend: Significant decreasing 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.



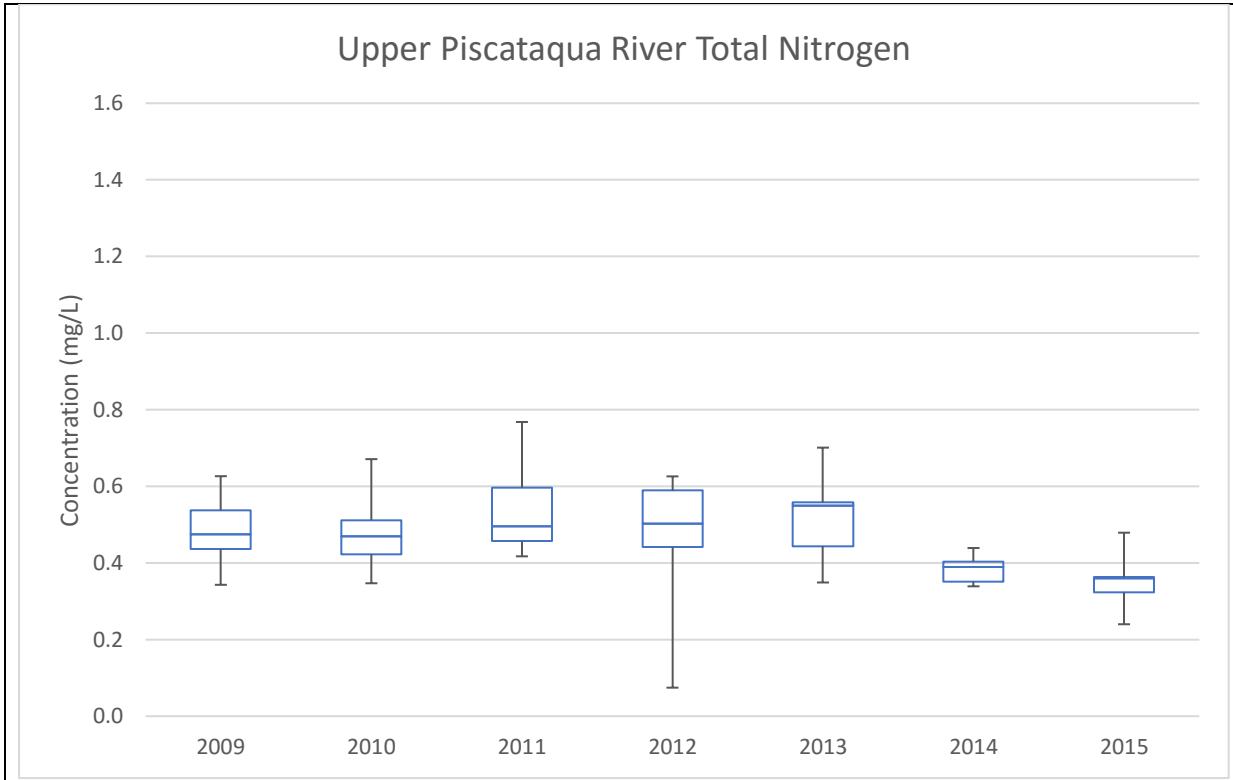
Monitoring Location (GRBOR)
Oyster River
(black circle with white plus sign)



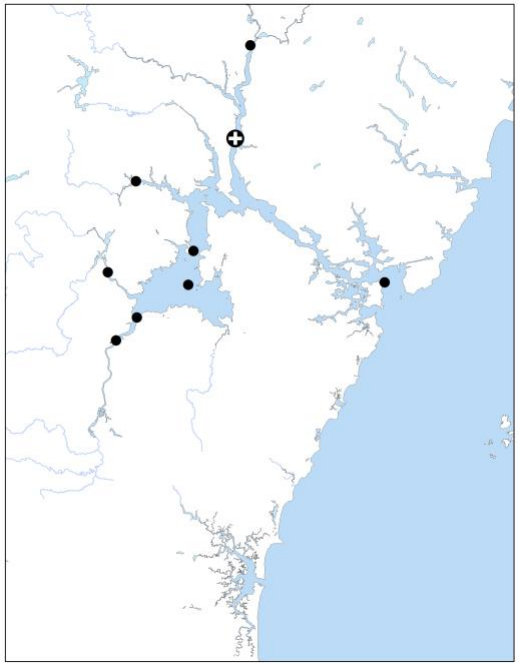
Station: GRBOR (Oyster River)

Long Term Trend: Significant decreasing 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.



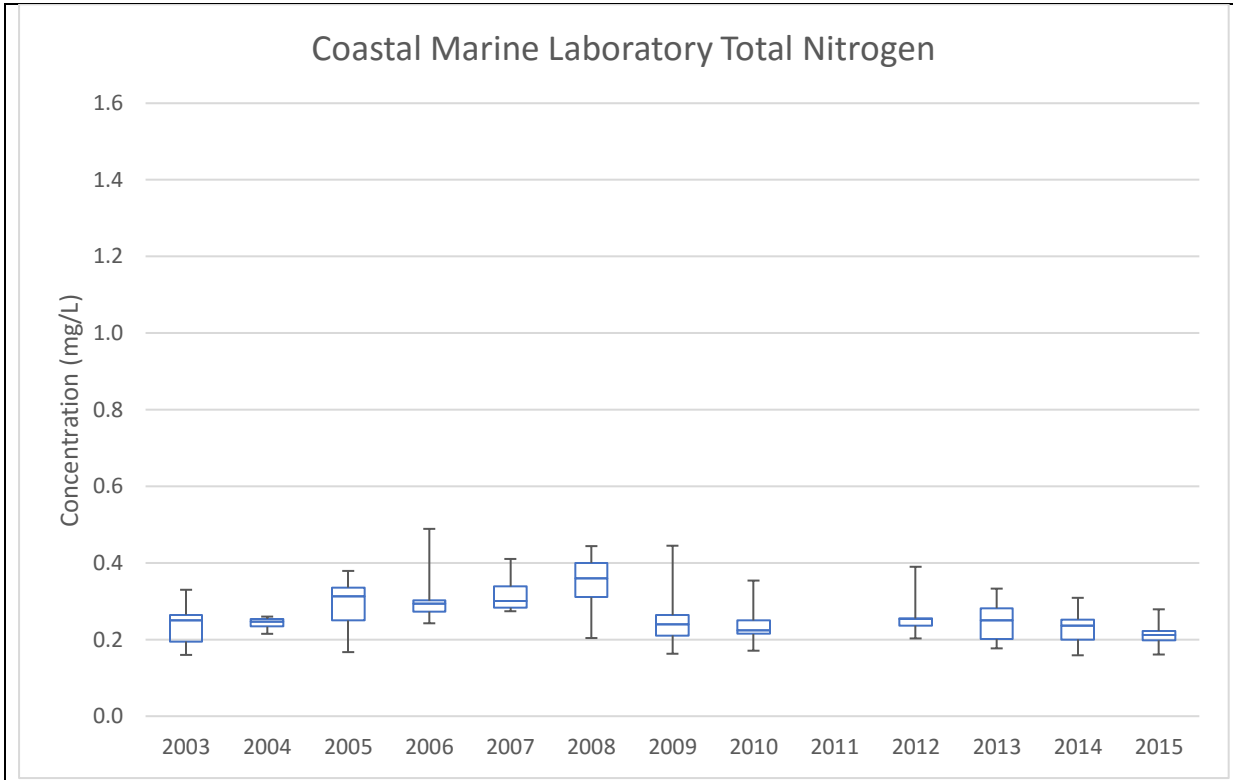
Monitoring Location (GRBUPR)
Upper Piscataqua River
(black circle with white plus sign)



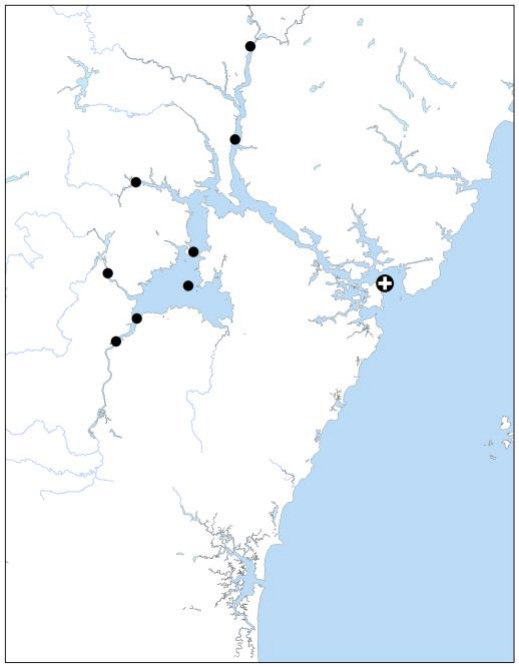
Station: GRBUPR (Upper Piscataqua River)

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.



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

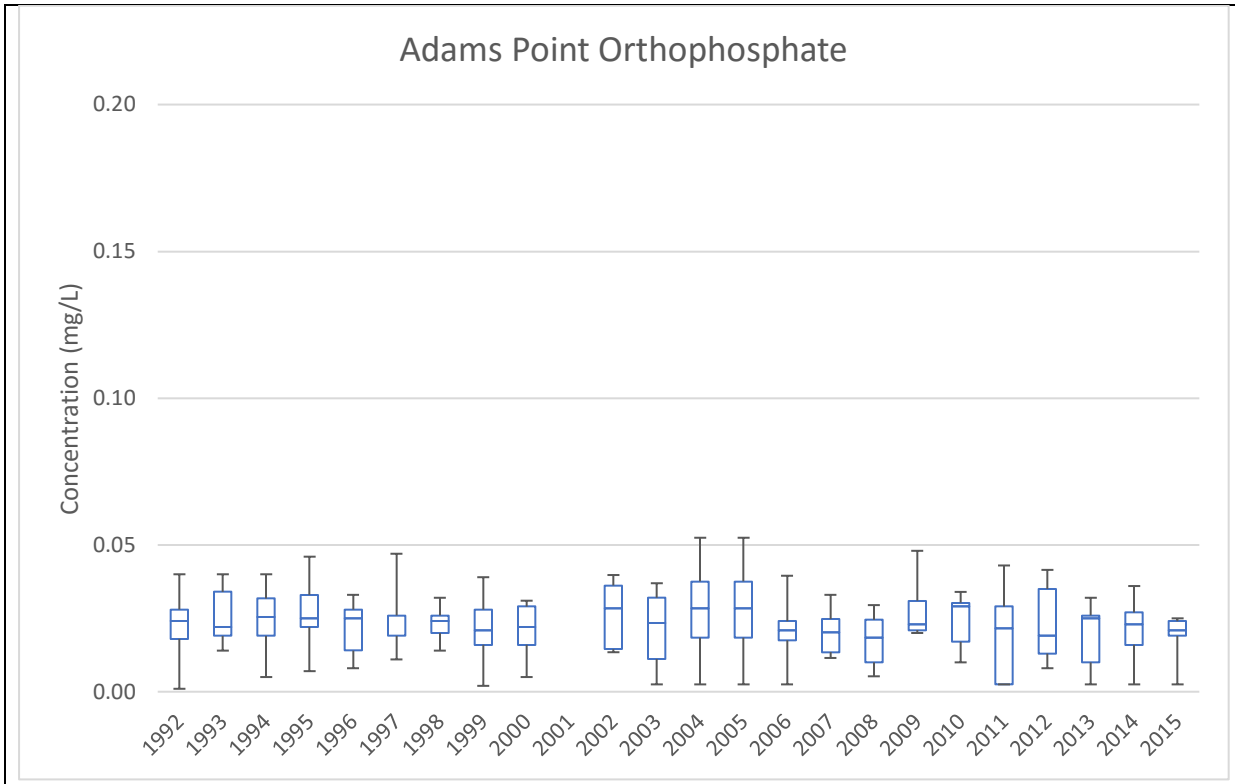


Station: GRBCML (Coastal Marine Laboratory in Portsmouth Harbor)

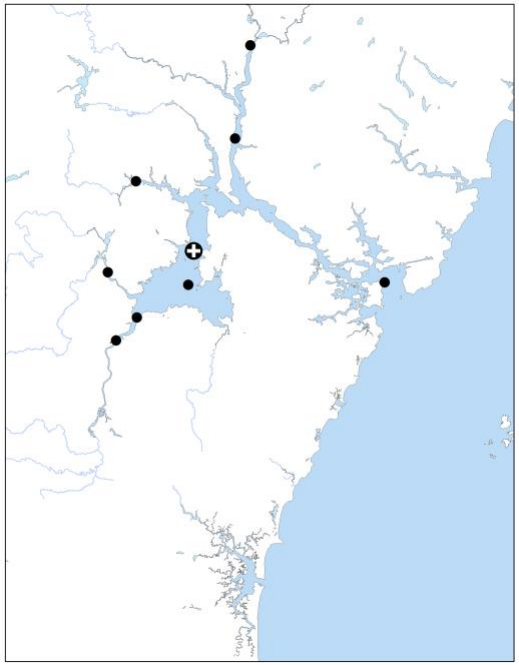
Long Term Trend: No significant trend

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. Some years omitted due to missing data.

Figure NC-6: Orthophosphate concentration trends at stations in the Great Bay Estuary.



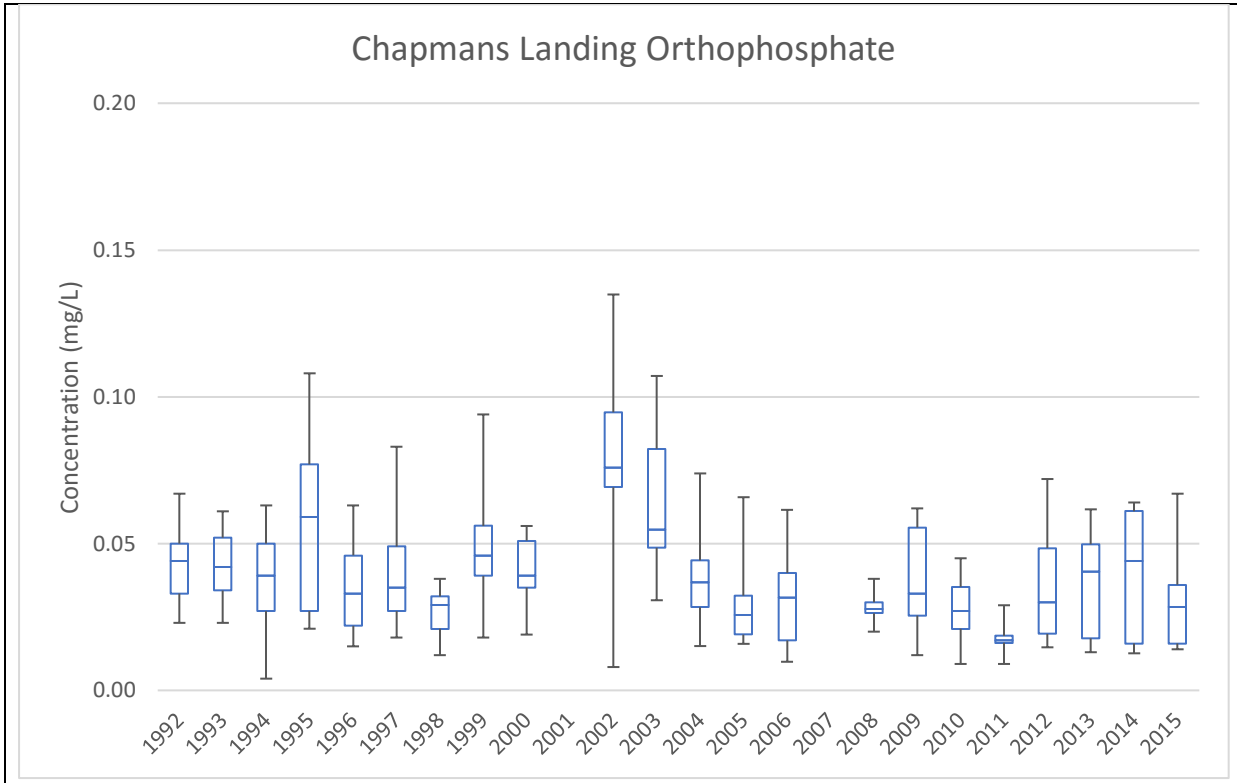
Monitoring Location (GRBAP)
Adams Point
(black circle with white plus sign)



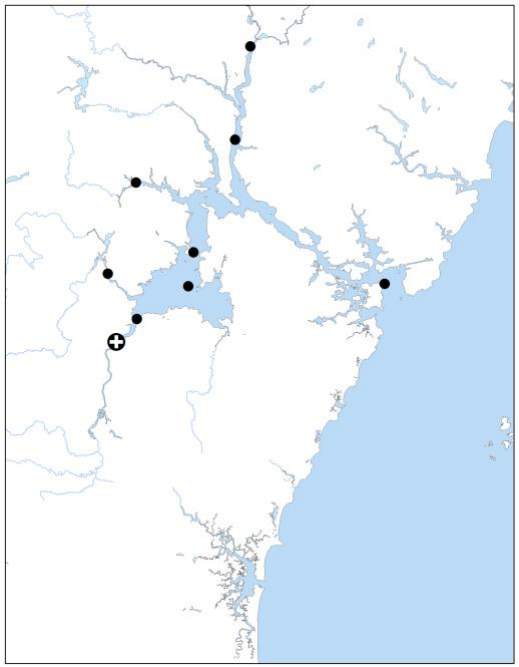
Station: GRBAP (Adams Point)

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.



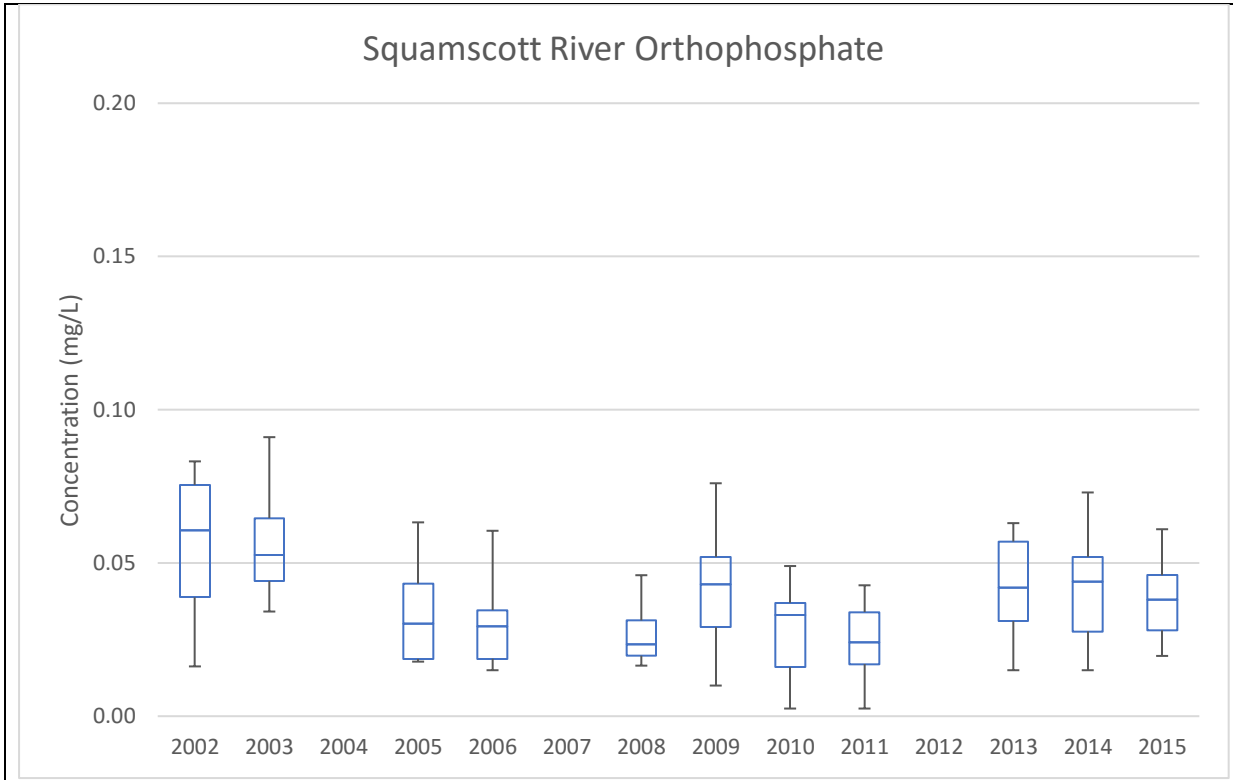
Monitoring Location (GRBCL)
Chapmans Landing
(black circle with white plus sign)



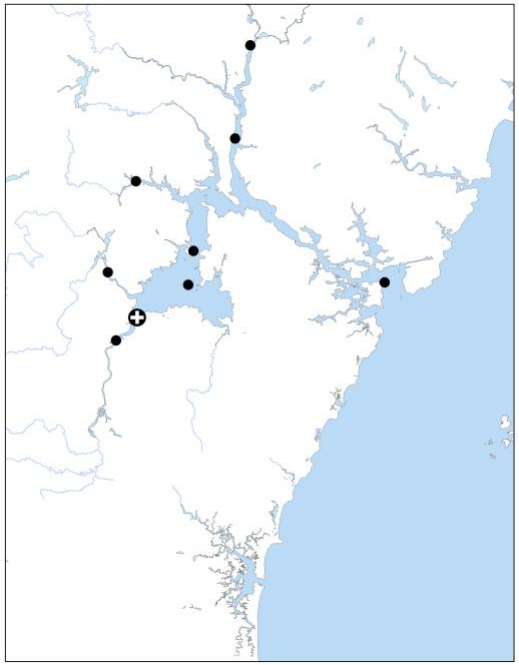
Station: GRBCL (Chapmans Landing in the Squamscott River)

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.



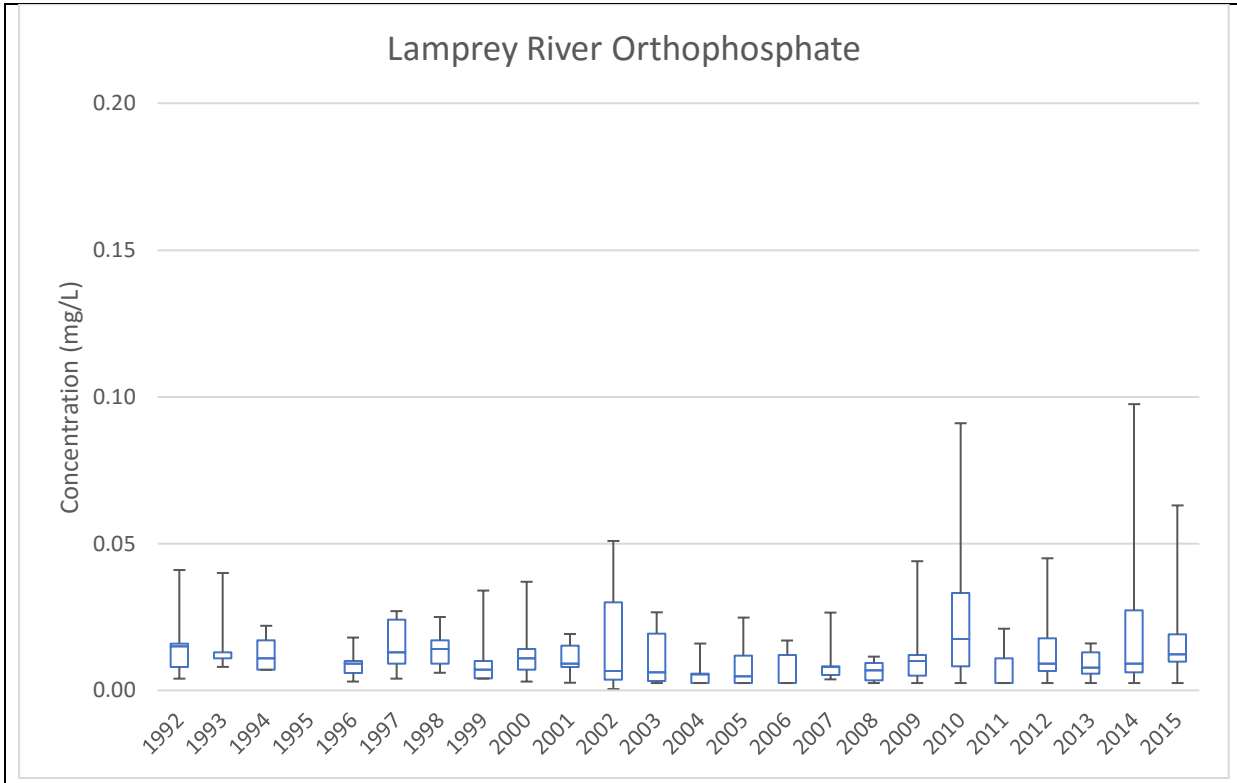
Monitoring Location (GRBSQ)
Squamscott River
(black circle with white plus sign)



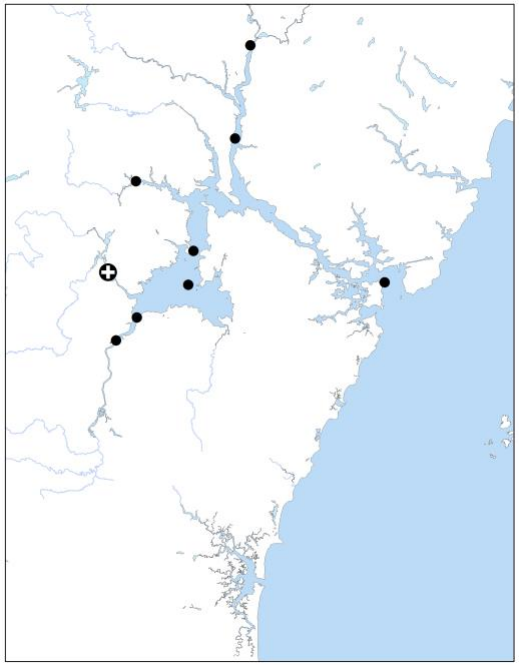
Station: GRBSQ (Squamscott River)

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.



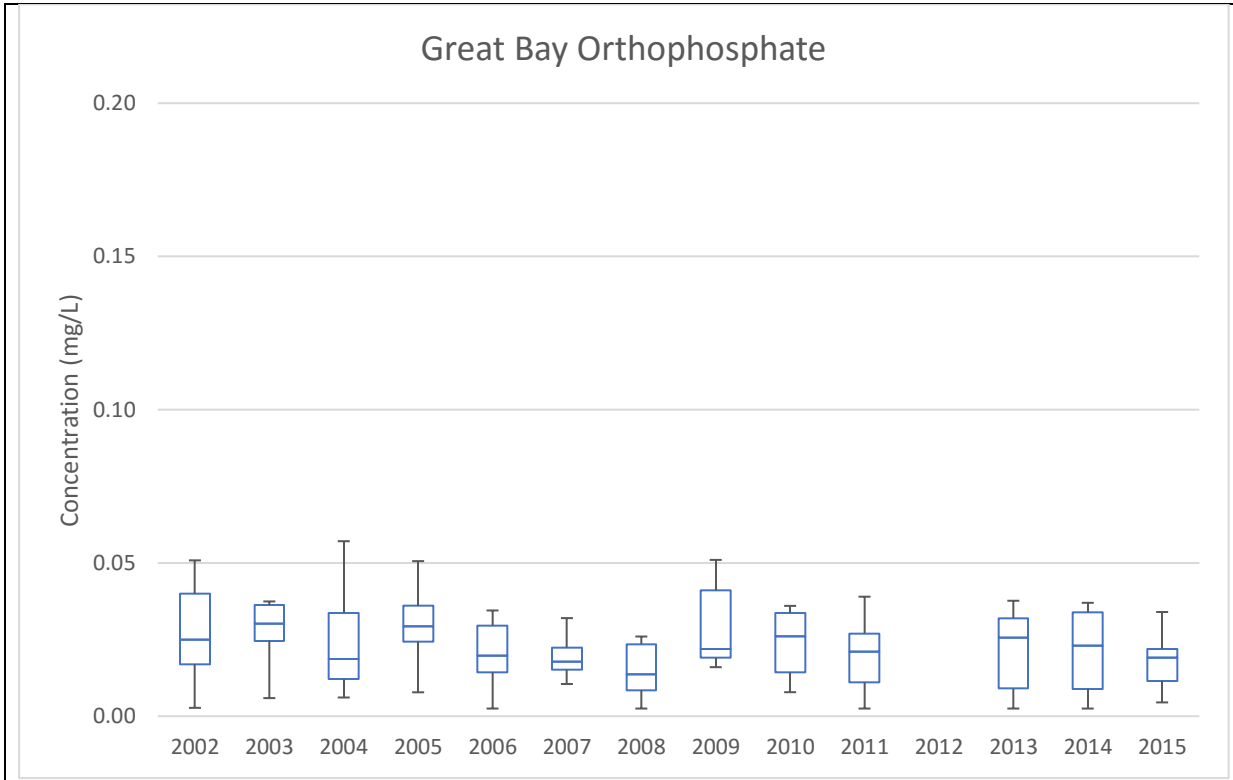
Monitoring Location (GRBLR)
Lamprey River
(black circle with white plus sign)



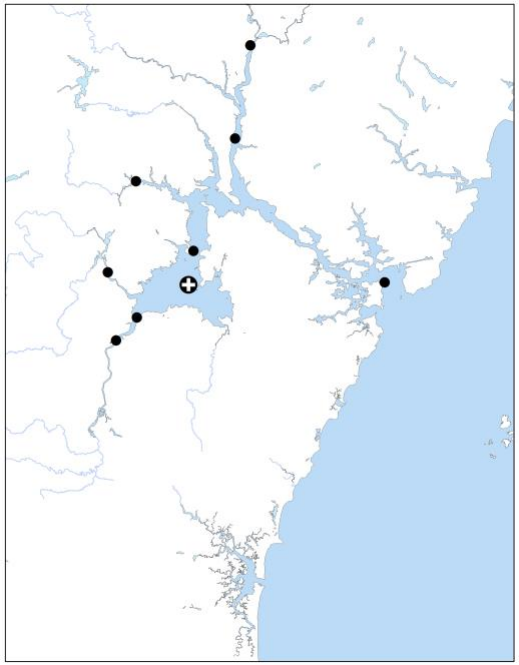
Station: GRBLR (Lamprey River)

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.



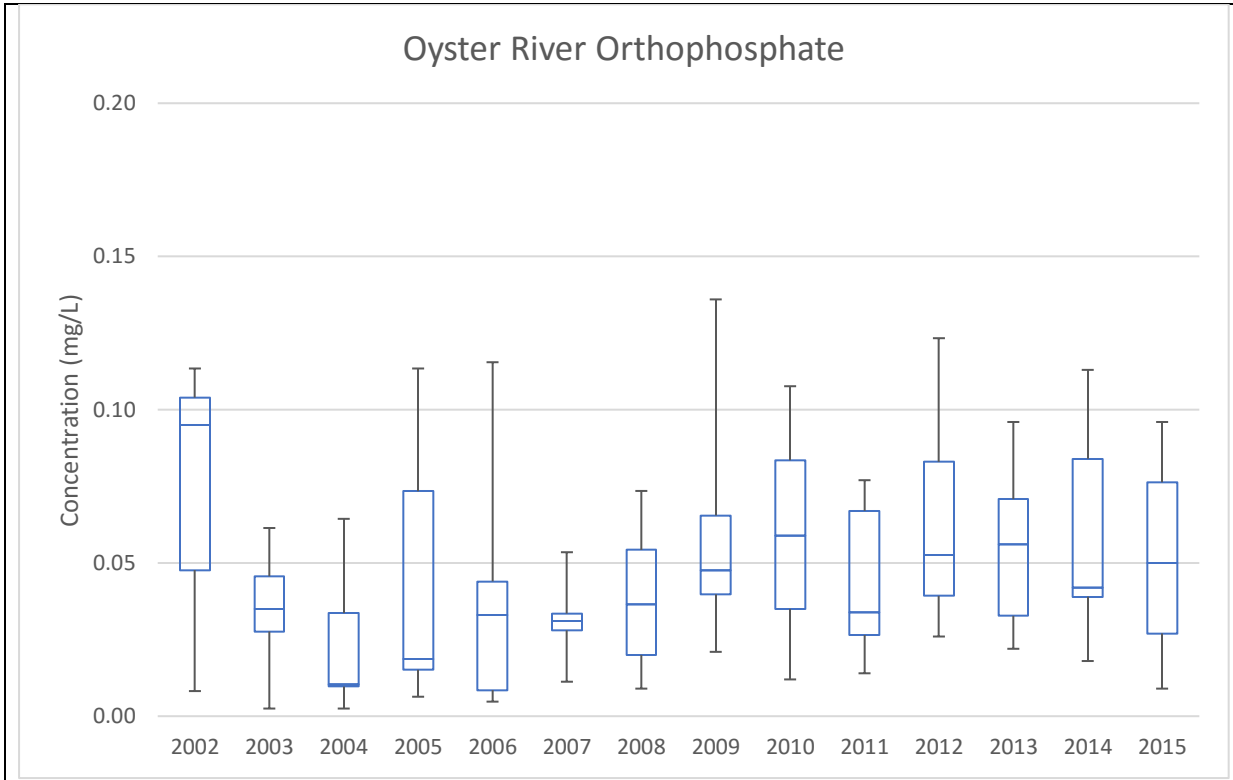
Monitoring Location (GRBGB)
Great Bay
(black circle with white plus sign)



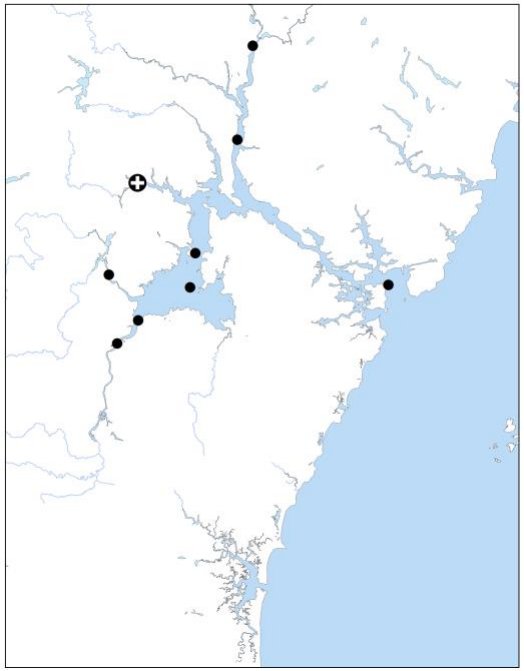
Station: GRBGB (Great Bay)

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. Some years omitted due to missing data.



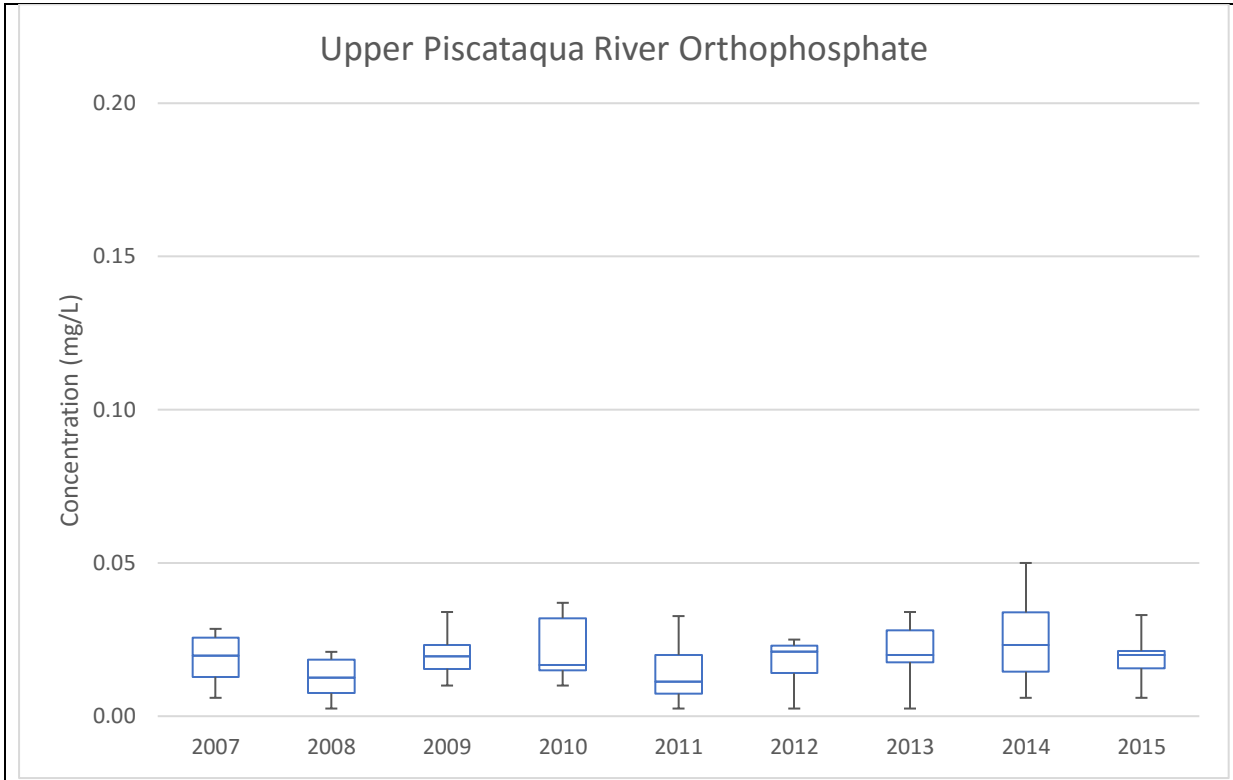
Monitoring Location (GRBOR)
Oyster River
(black circle with white plus sign)



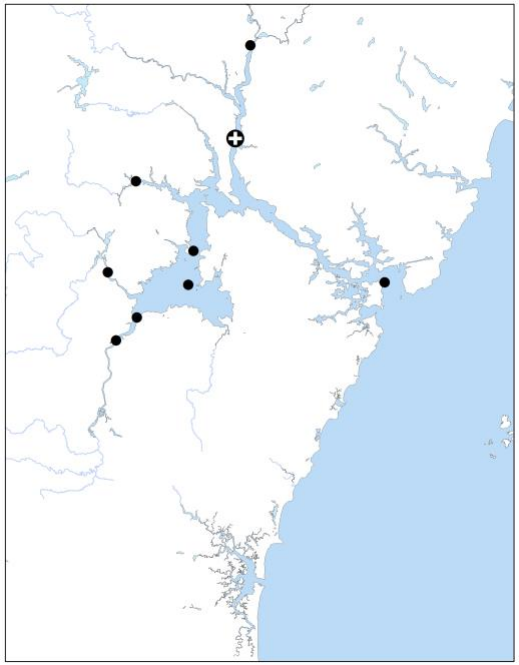
Station: GRBOR (Oyster River)

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.



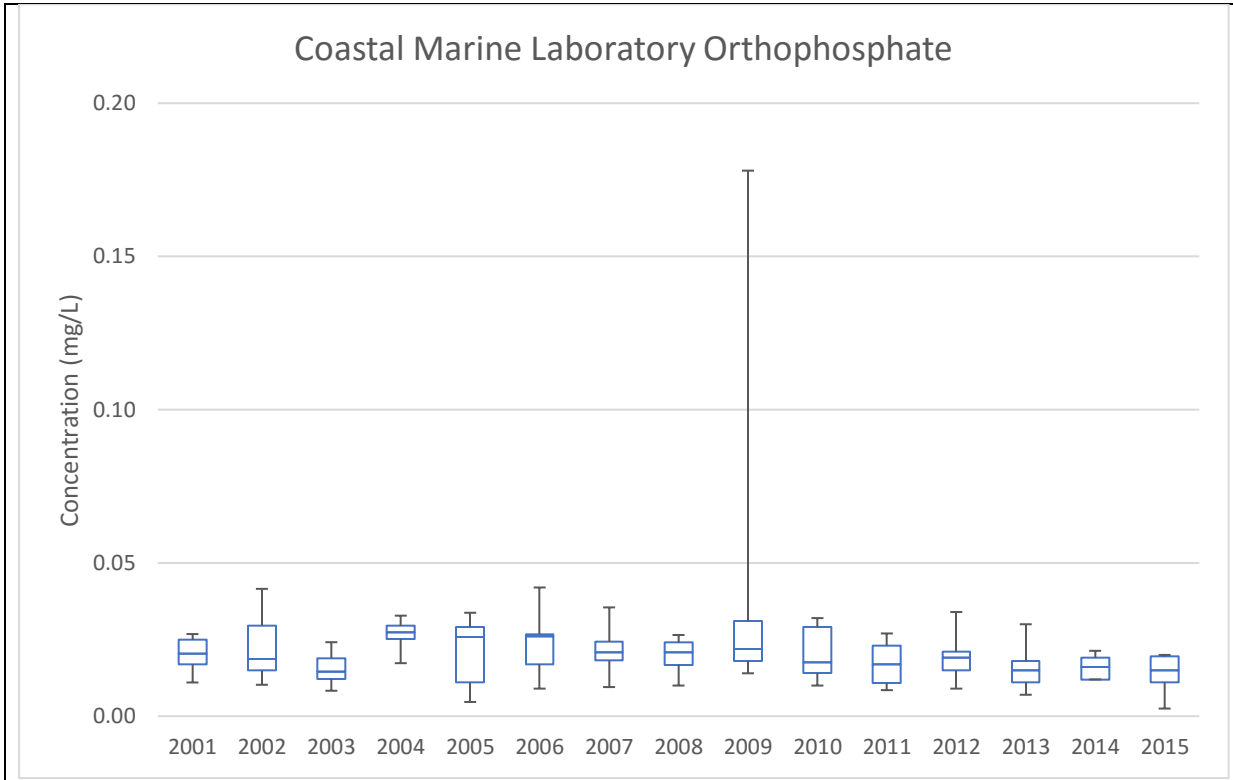
Monitoring Location (GRBUPR)
Upper Piscataqua River
(black circle with white plus sign)



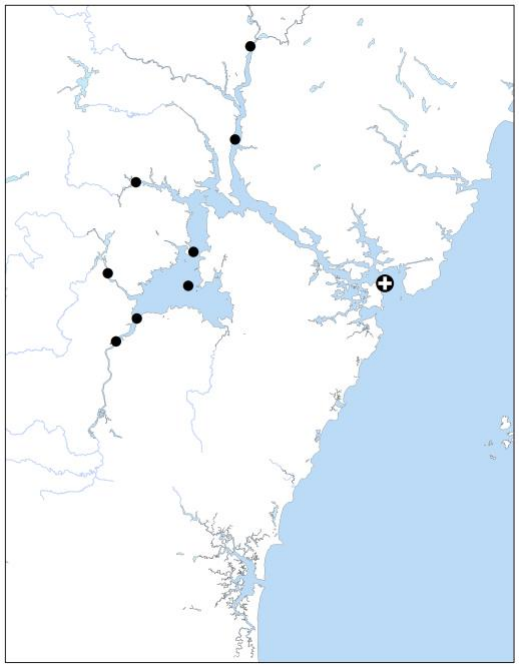
Station: GRBUPR (Upper Piscataqua River)

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.



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.