Indicator: Phytoplankton populations in the Great Bay Estuary

Question

How have phytoplankton concentrations changed over time?

Short Answer

Chlorophyll-a concentrations—an accepted proxy for phytoplankton biomass—show no statistically significant trends at the eight stations sampled in the Great Bay Estuary. The Chlorophyll-a (Chl *a*) levels recorded in the Great Bay Estuary are often within ranges considered "good" or "fair" in the peer-reviewed literature. Periodically, however, Chl *a* levels increase to levels considered "poor."

PREP Goal
No increasing trends for phytoplankton (from the PREP Comprehensive Conservation and Management Plan, PREP 2010).

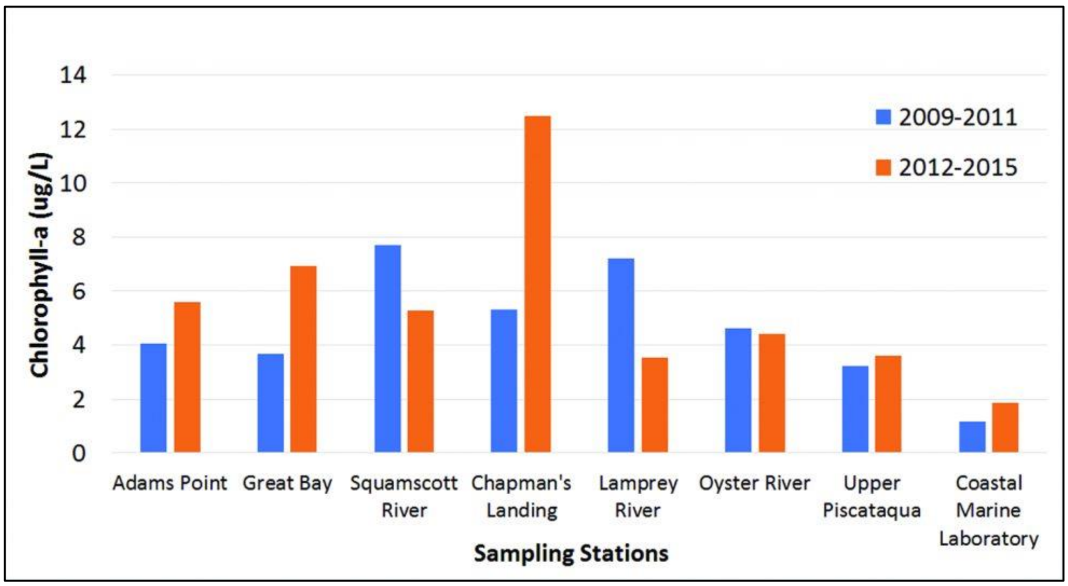


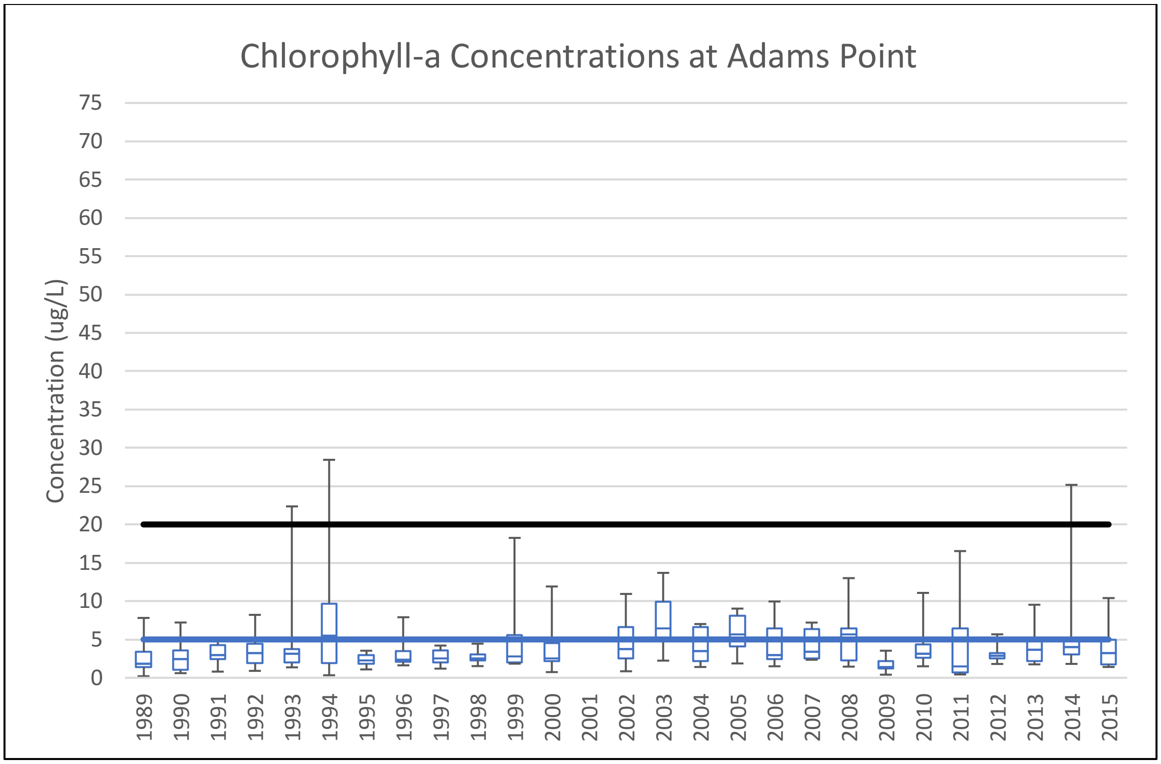
Figure P-1. Reporting average concentrations by sampling station. Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

Why This Matters

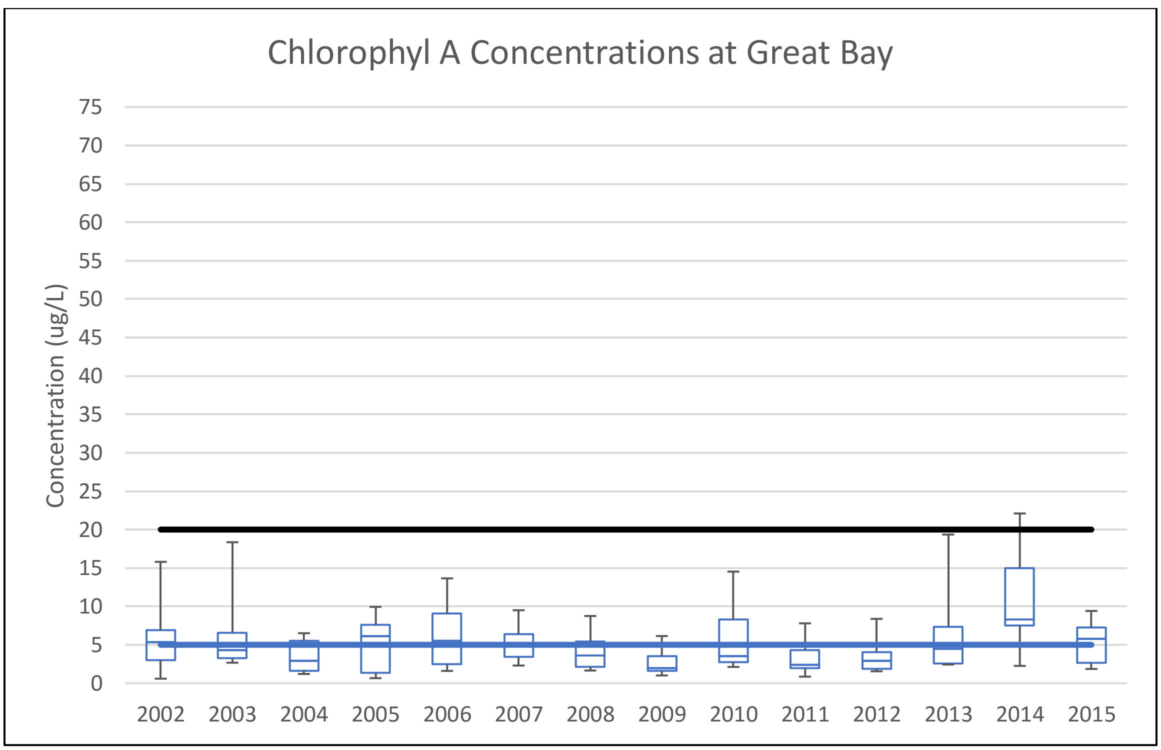
Phytoplankton convert the sun's energy into biomass and are a key part of the food web. Phytoplankton can impact water clarity and compete with eelgrass and seaweeds for available light. Additionally, when large populations of phytoplankton die, their decomposition consumes the dissolved oxygen needed by fish and benthic invertebrates.

Explanation (from 2018 State of Our Estuaries Report)

National assessments note that less than 5 ug/L chlorophyll-a (Chl *a*) is considered "good;" between 5 and 20 ug/L is considered "fair" and above 20 ug/L is considered "poor" (Bricker et al. 2003; US EPA 2012). For the years 2012 to 2015, monthly sampling results suggest that, much of the time, Chl *a* levels in the Great Bay Estuary were within ranges regarded as "good" or "fair," but that they sometimes exceeded 20 ug/L. As noted in Figure P-1, changes since the last reporting period (2009–2011) vary, depending on the sampling station.



Figures P-2 (above) and P-3 (below). Chlorophyll-a concentrations at Adams Point and Great Bay. 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. Levels between the blue and the black line are considered "fair." Levels above the black line are considered "poor." Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.



All of the data were collected at low tide, when daily concentrations of Chl *a* tend to be highest. None of the eight stations sampled on a monthly basis show a statistically significant trend (Figure P-1). At Adams Point (Figure P-2), between 2012 and 2015, median Chl *a* levels ranged from 2.9 to 4.0 ug/L and maximum values ranged from 5.7 to 25.2 ug/L. At the Great Bay station (Figure P-3), between 2012 and 2015, median levels ranged from 2.9 to 8.3 ug/L and maximum values ranged from 8.4 to 22.1 ug/L.

The Chapman's Landing station indicated the highest levels of Chl *a*. Since 2012, median levels ranged from 4.8 to 6.9 ug/L and maximum levels ranged from 18.3 to 71.7 ug/L. At the Lamprey River station, median levels ranged from 1.4 to 4.6 ug/L and maximum levels ranged from 2.1 to 21.0 ug/L. At the Upper Piscataqua River Station, median levels ranged from 2.1 to 3.2 ug/L with maximum levels from 4.1 to 24.5 ug/L. Note that 2012 was the only year that levels rose above 20 ug/L for this station. Chl *a* levels at the remaining three stations (Squamscott River, Oyster River and Coastal Marine Laboratory) did not exceed 12 ug/L between 2012 and 2015.

(See Table P-1 and Figure P-5.)

Other parts of the Great Bay Estuary—in addition to the eight stations reported here—also show counts in excess of 20 ug/L. For example, Little Bay registered 25.2 ug/L in 2014 and the Cocheco River indicated a maximum of 28.9 ug/L in 2015 (NH DES 2017).

<u>Methods and Data Sources</u>

Trend analysis for chlorophyll-a was performed at the following stations (Figure P-4):

- 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 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.

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.

Additional Results (Beyond What Was Reported in the SOOE)

The results of the trend analysis for chlorophyll-a compounds are summarized in Table P-1. Plots for each station are shown on Figure P-5. Table P-1 indicates the range of median values straddle the 0.5 ug/L boundary separating "good" conditions from "fair" conditions, using EPA's (2012) thresholds. However, it is also important to review the maximum values (Table P-1 and Figure P-5) 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. Table P-1 and Figure P-5 indicate that only one of the eight stations (at the Coastal Marine Laboratory in Portsmouth Harbor) consistently registers chl-a levels below 5 ug/L.

Technical Advisory Committee (TAC) Discussion Highlights

The Relationship Between Phytoplankton 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). While many of the TAC participants expressed concerns about episodic blooms (levels higher than 20ug/L) of phytoplankton (Figure P-5), a smaller group of UNH scientists and stakeholder point out that phytoplankton levels are frequently low; moreover, the data do not demonstrate any change over time in phytoplankton levels, leading some to conclude that phytoplankton cannot be implicated in the loss of eelgrass habitat.

Others TAC participants—including all three external advisors to the TAC—encourage a more holistic perspective. Specifically, they advocate that all light-attenuating components (e.g., seaweeds, total suspended solids, 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).

References Cited

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

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

Table P-1: Trends for chlorophyll-a in the Great Bay Estuary.

Station	Period	Range of Recent (Median Values) & Maximum Values 2012 -2015, ug/L	Long Term Trend
GRBAP (Adams Point)	1989-2015	(2.9 to 4.0) 5.7 to 25.2	No significant trend
GRBCL (Chapmans Landing)	1989-2015	(4.8 to 6.9) 18.3 to 71.7	No significant trend
GRBSQ (Squamscott River)	2002-2015	(4.3 to 6.1) 8.5 to 10.9	No significant trend
GRBLR (Lamprey River)	1992-2015	(1.4 to 4.6) 2.1 to 21.0	No significant trend
GRBGB (Great Bay)	2002-2015	(2.8 to 8.3) 8.4 to 22.1	No significant trend
GRBOR Oyster River	2002-2015	(2.8 to 5.6) 6.8 to 11.8	No significant trend
GRBUPR Upper Piscataqua River	2007-2015	(2.1 to 3.2) 4.1 to 24.5	No significant trend
GRBCML Coastal Marine Laboratory Portsmouth Harbor	2002-2015	(1.3 to 2.3) 2.5 to 4.7	No significant trend

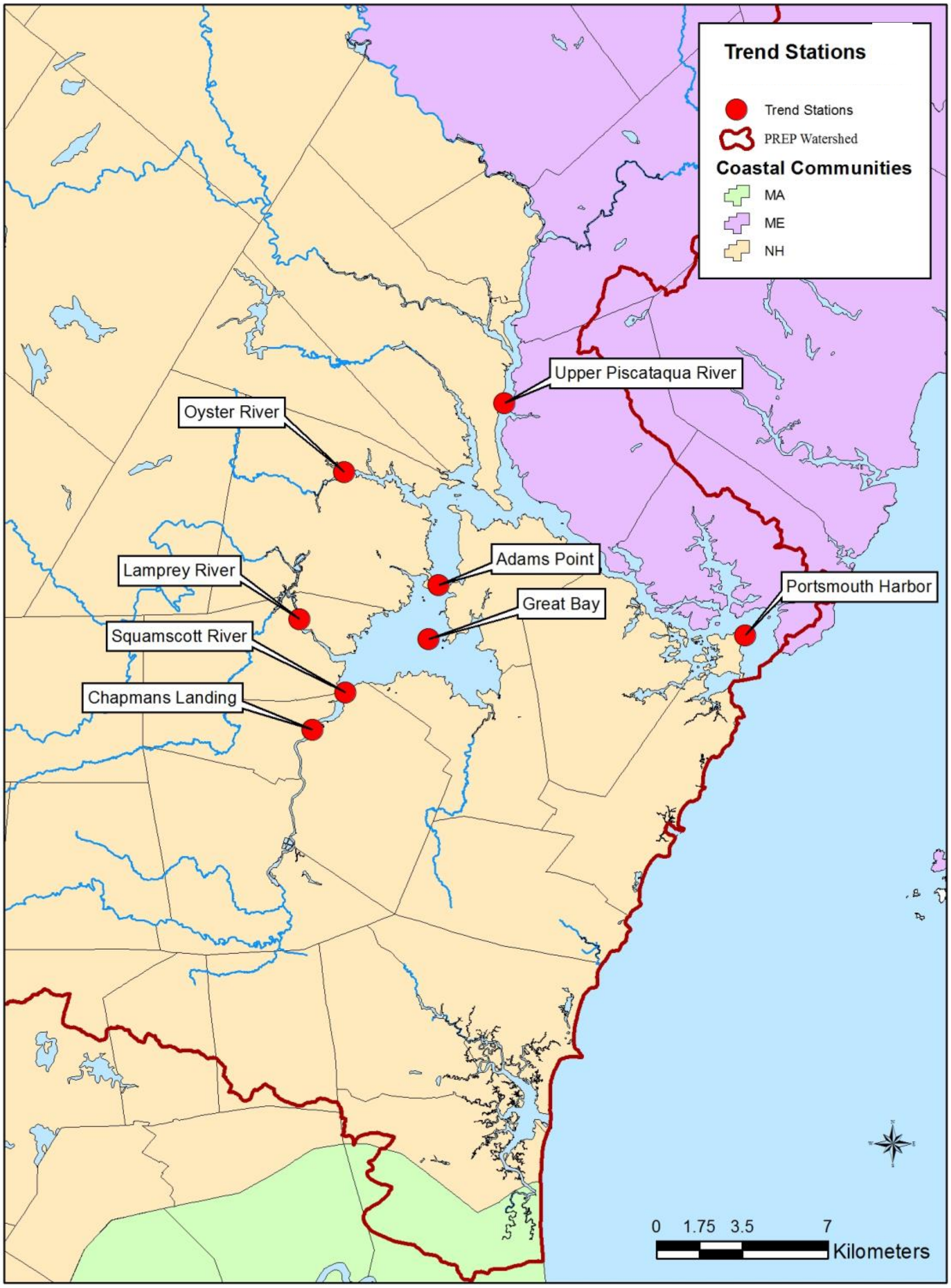
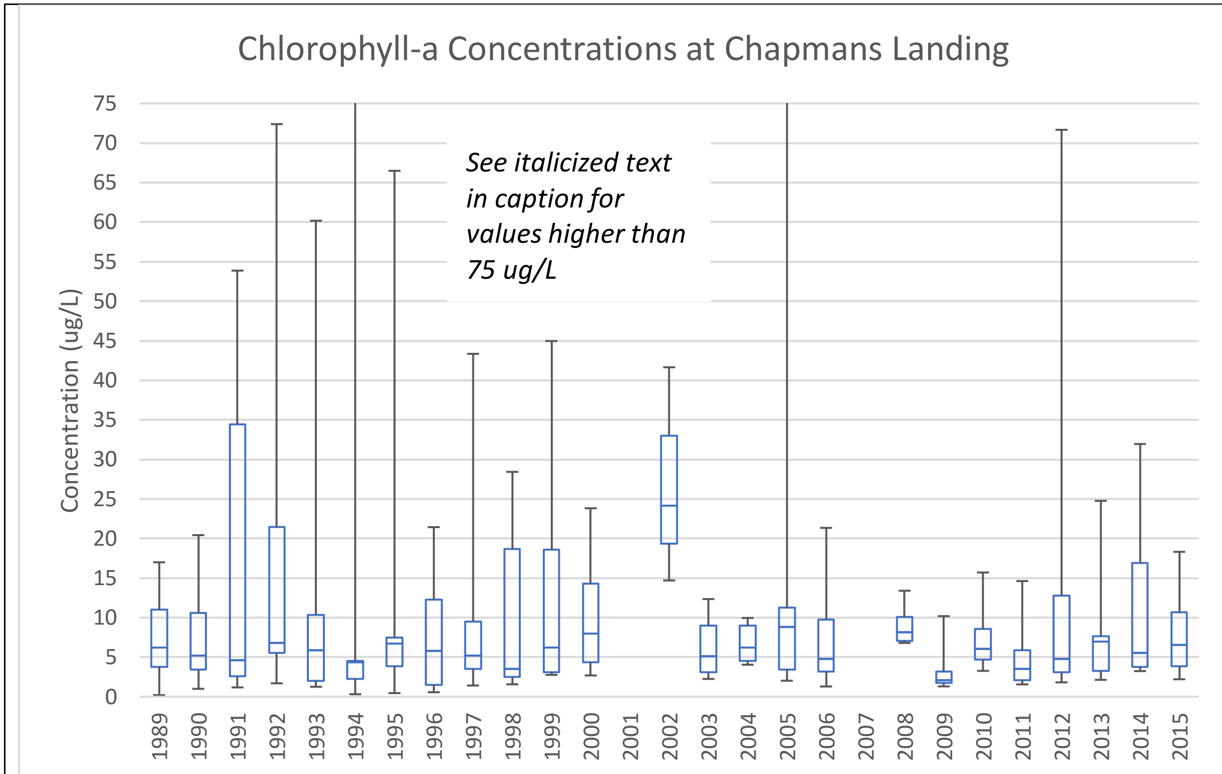
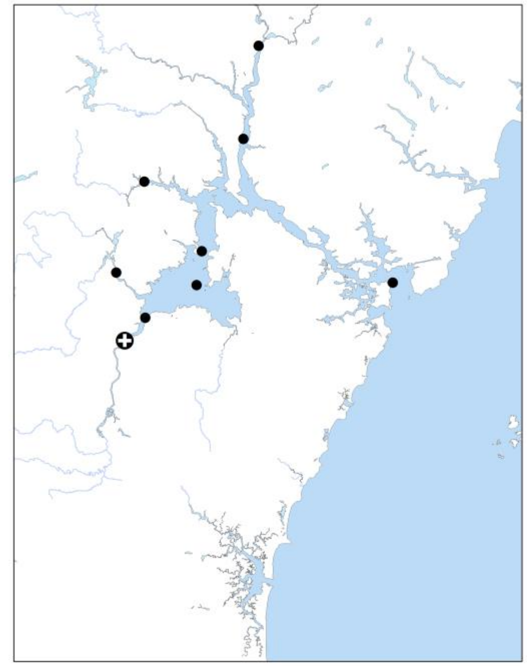


Figure P-4: Map of trend stations for chlorophyll-a.

Figure P-5: Chlorophyll-a concentrations at Stations in the Great Bay Estuary.



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

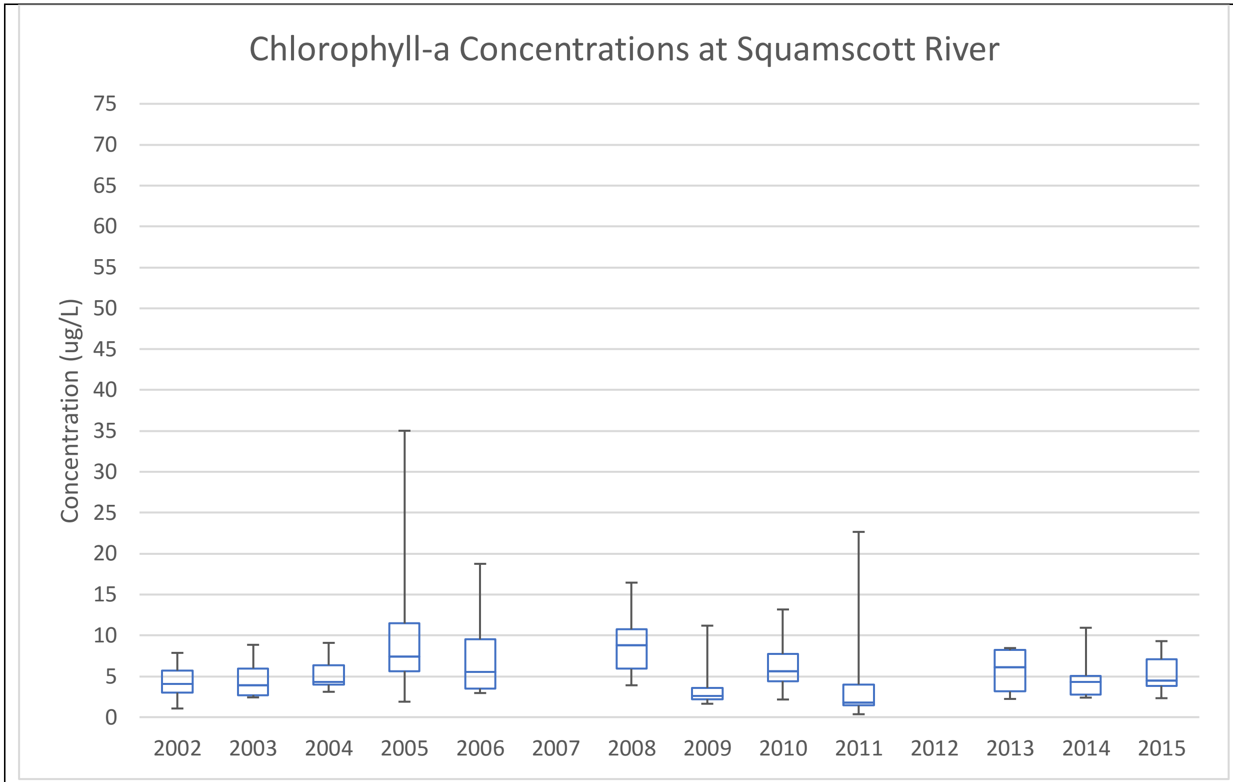


Station: GRBCL (Chapmans Landing in the Squamscott River)

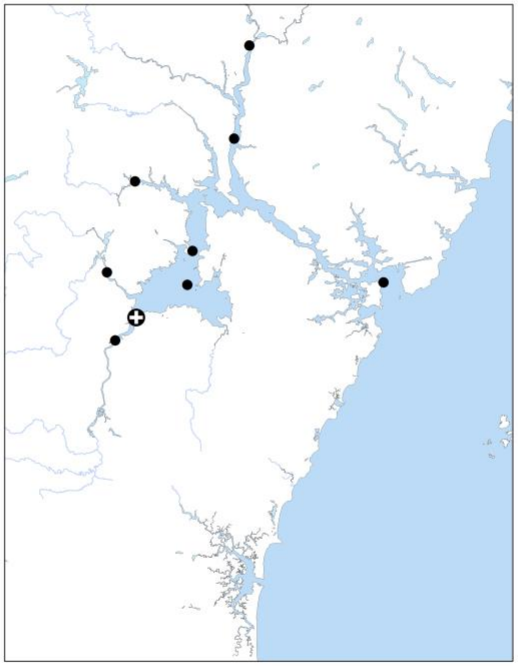
Long Term Trend: No significant trend.

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.

Values Higher Than 75 ug/L: 1994 = 160 ug/L; 2005 = 106 ug/L



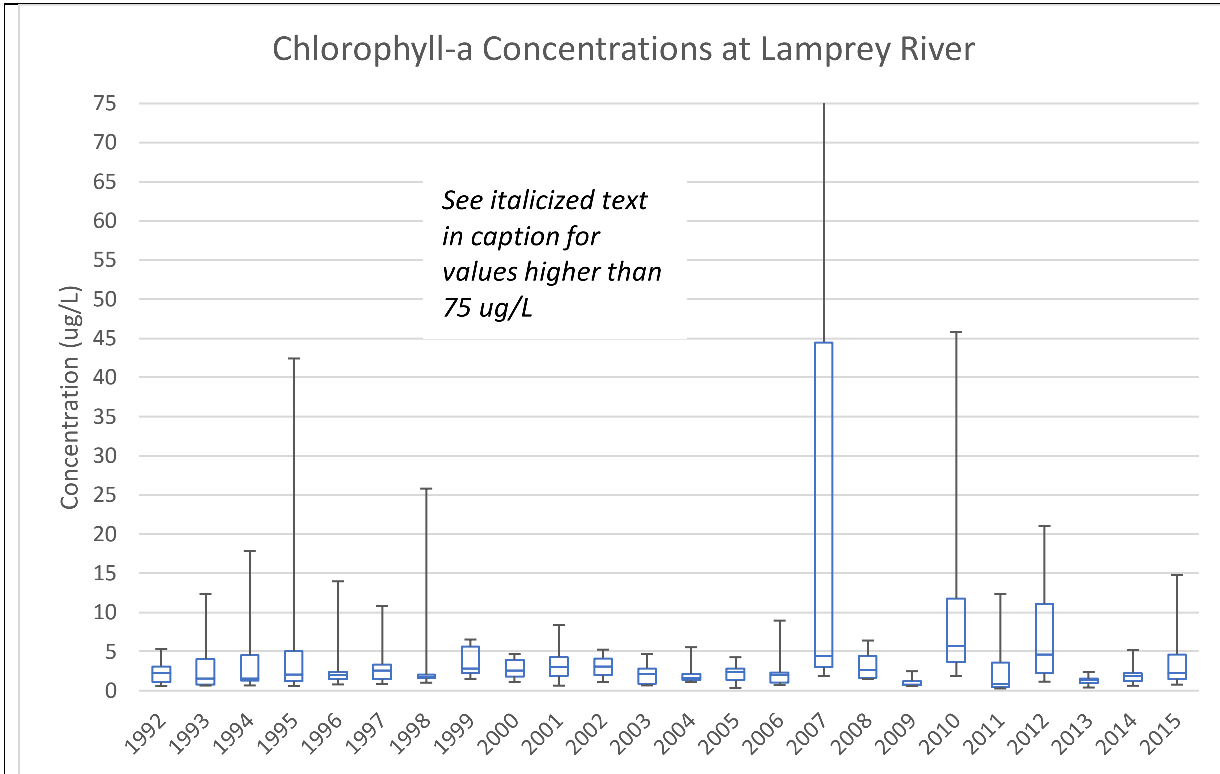
Monitoring Location (GRBSQ)
Squamscott River
(black circle with white plus sign)



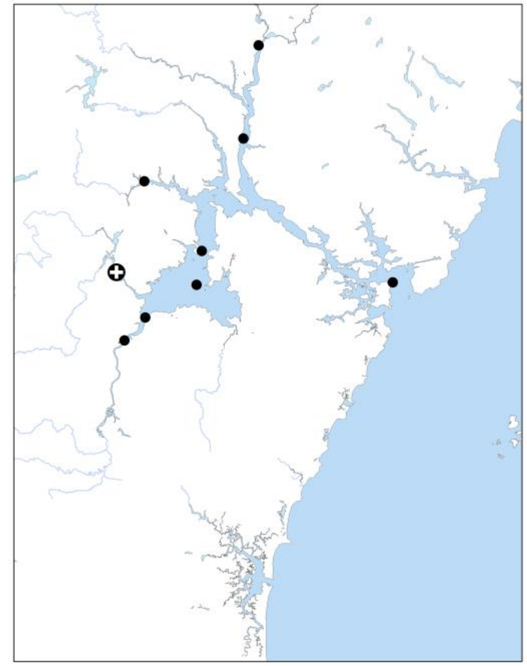
Station: GRBSQ (Squamscott River)

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)

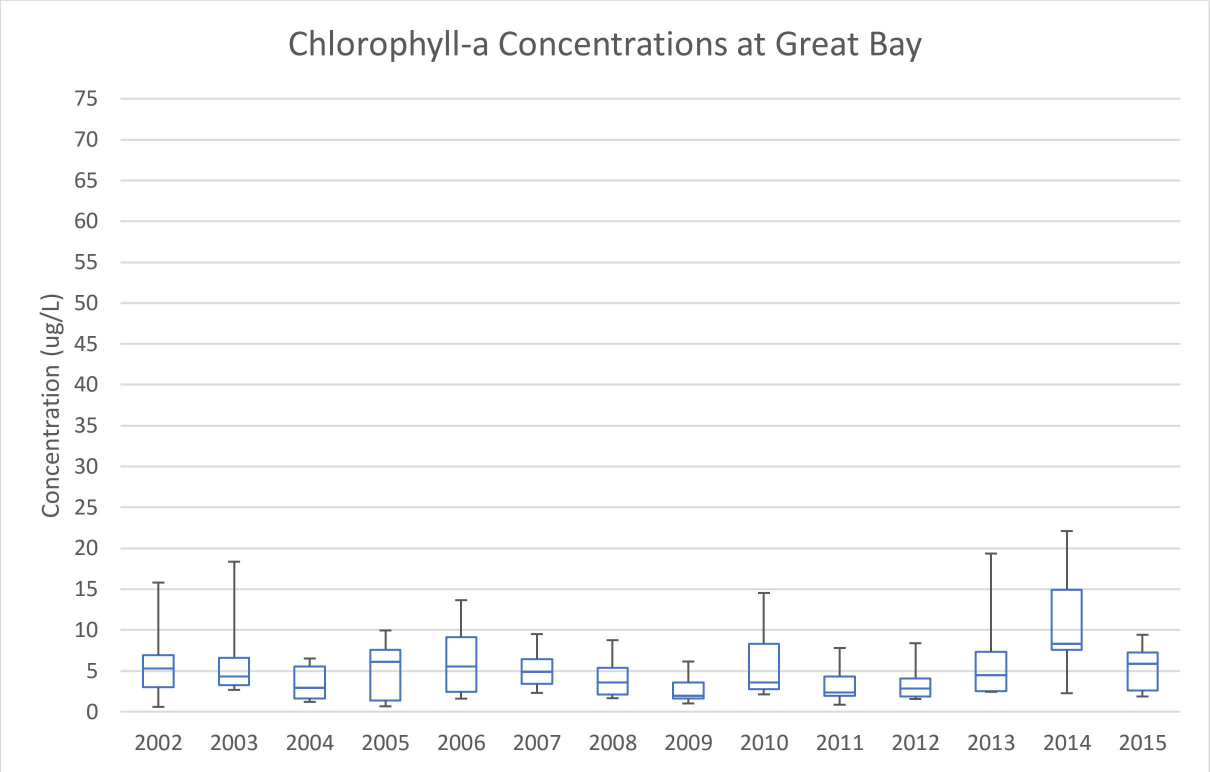


Station: GRBLR (Lamprey River)

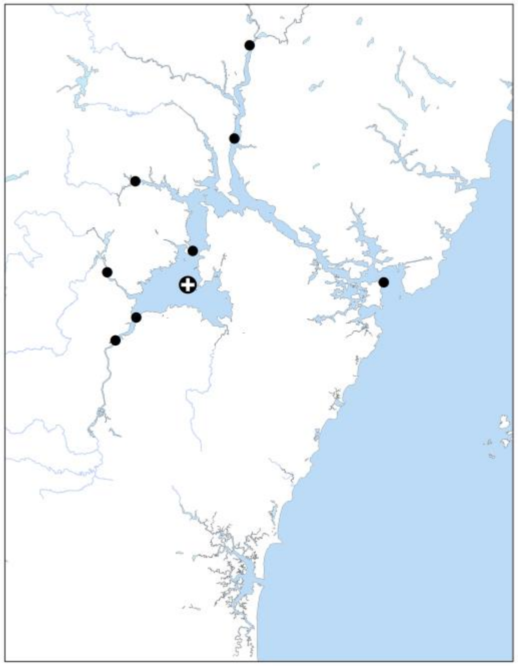
Long Term Trend: No significant trend.

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.

Values Higher Than 75 ug/L: 2007 = 145 ug/L



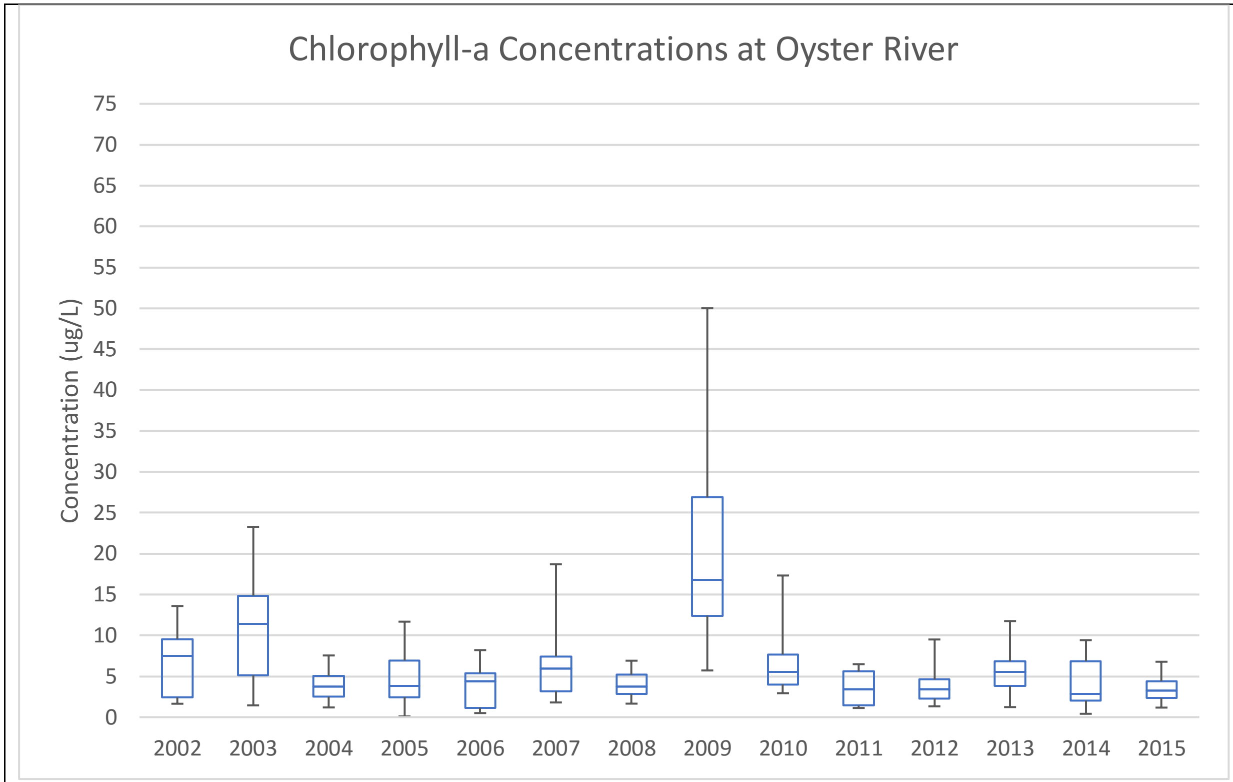
Monitoring Location (GRBGB)
Great Bay
(black circle with white plus sign)



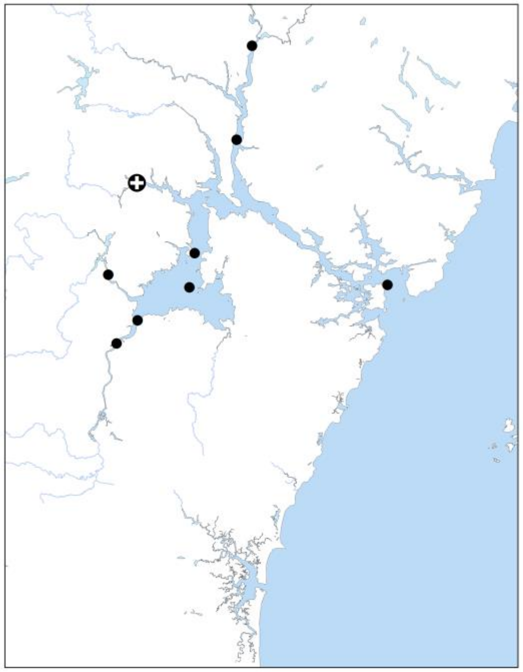
Station: GRBGB (Great Bay)

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.

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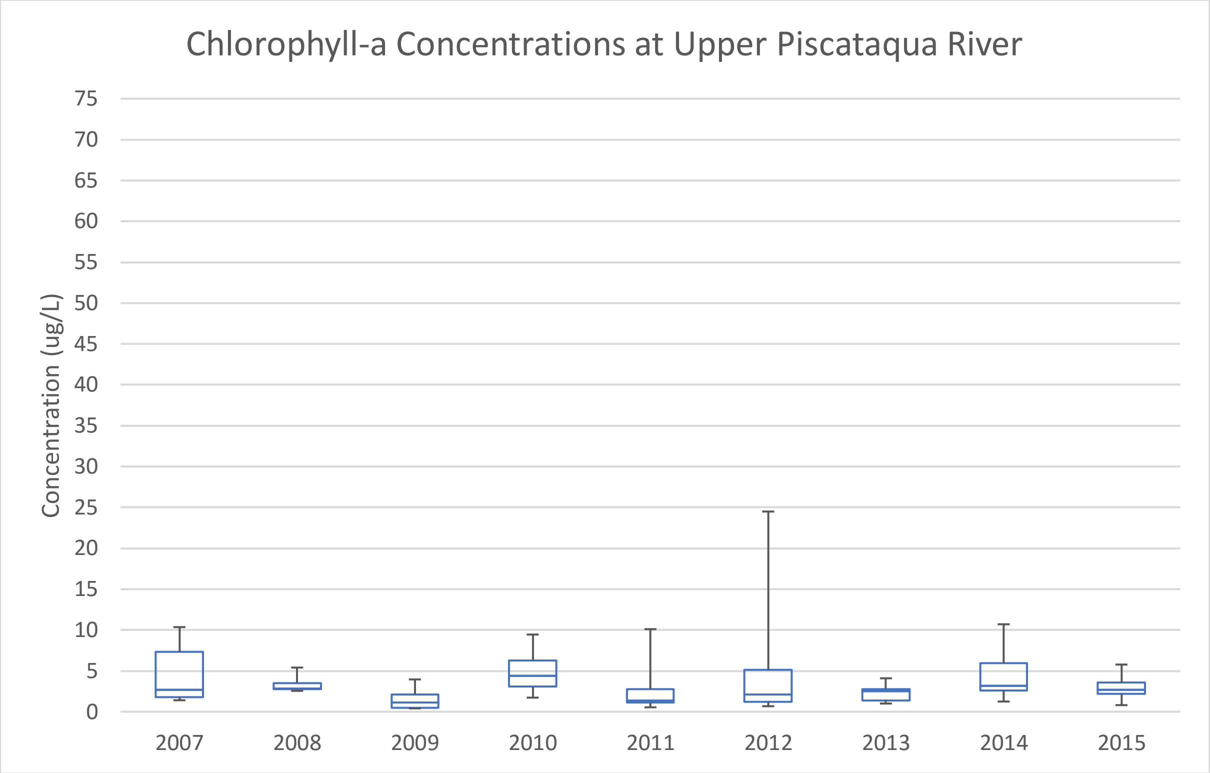
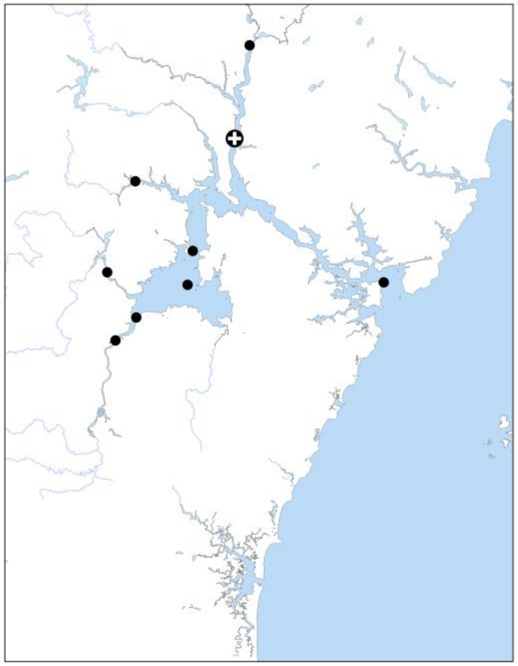


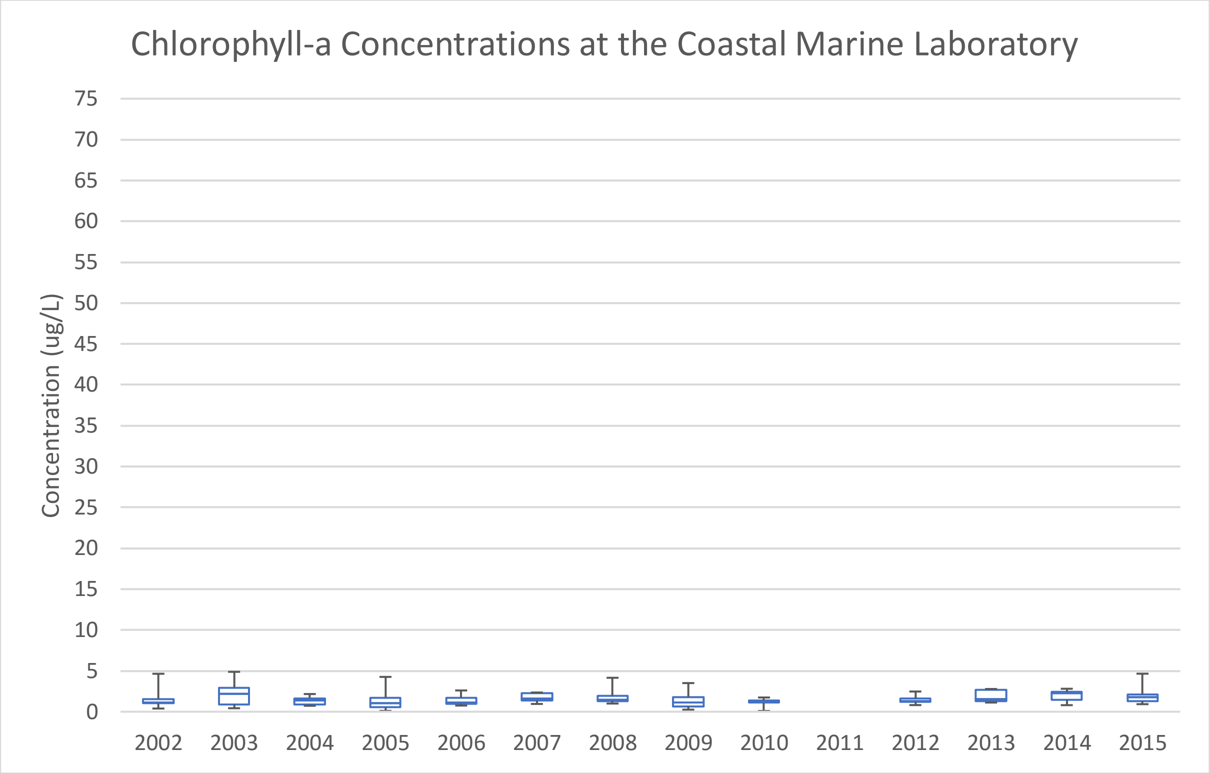
Monitoring Location (GRBUPR)
Upper Piscataqua River
(black circle with white plus sign)



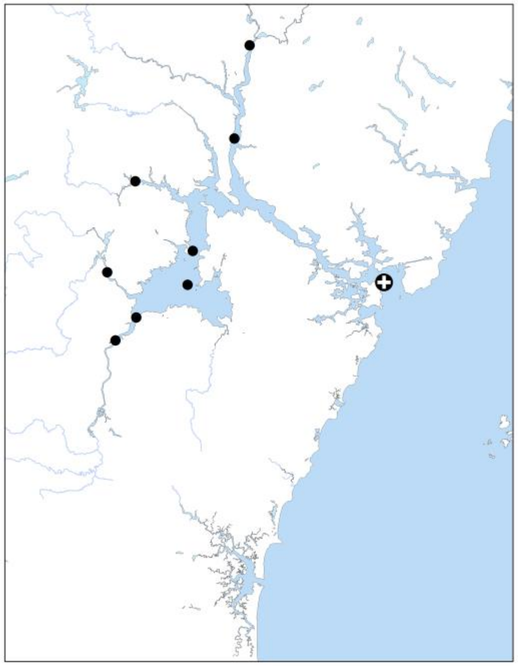
Station: GRBUPR (Upper Piscataqua River)

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.

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