Indicator: Bacterial indicators of fecal pollution in the Great Bay Estuary

Question

How have bacterial pollution concentrations changed over time in the Great Bay Estuary?

Short Answer

Between 1989 and 2016, dry weather concentrations of bacterial indicators of fecal pollution in the Great Bay Estuary have typically fallen 67% to 93% at four monitoring stations due to pollution control efforts in most, but not all, areas.

PREP Goal

No increasing trends for fecal coliform, enterococci, or *Escherichia coli* in the Great Bay Estuary (from the PREP Comprehensive Conservation and Management Plan, PREP 2010).

Why This Matters

Elevated concentrations of bacterial pollutants in estuarine waters can indicate the presence of pathogens from sewage and other fecal sources. Illness-causing microorganisms pose a public health risk, and are a primary reason why shellfish beds can be closed and beach advisories can be posted.

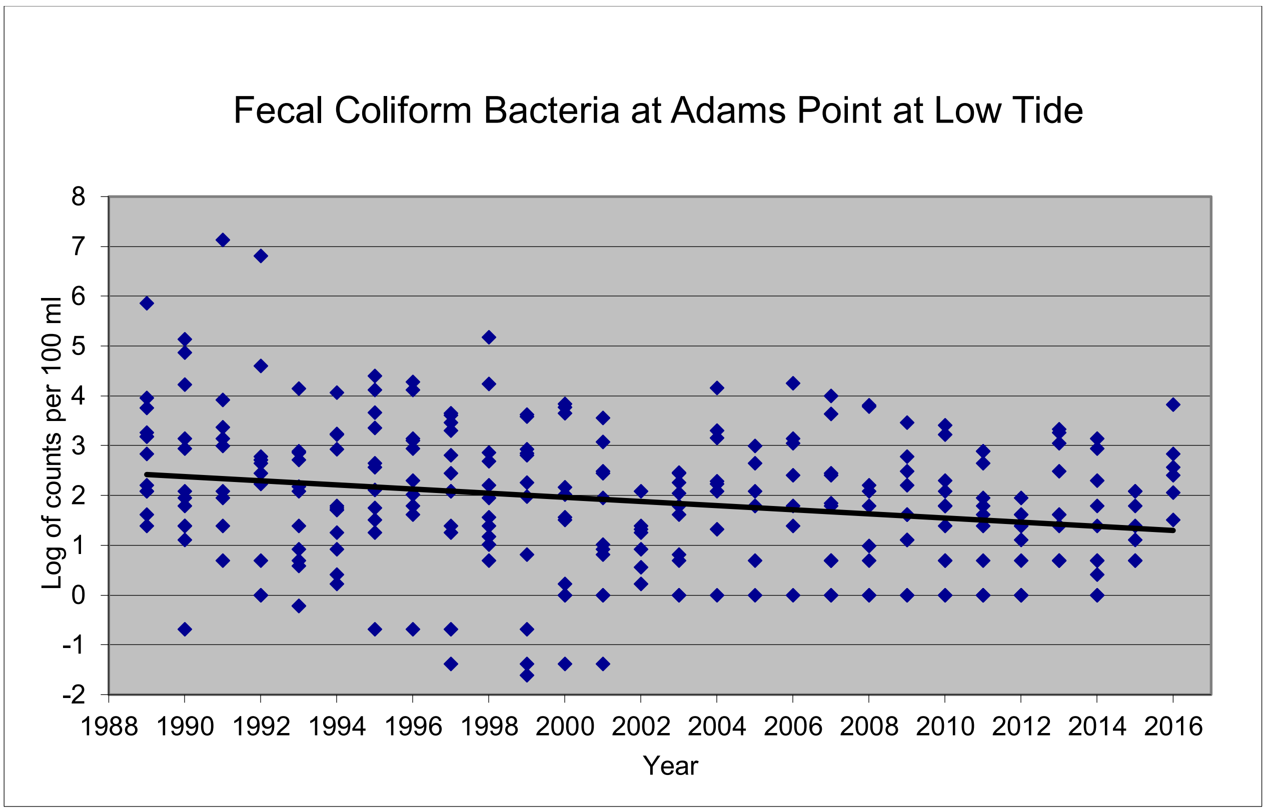

Figure B-1. Fecal coliform bacteria concentrations at low tide during dry weather at Adams Point. Line shows a statistically significant trend. Data are log-transformed for better visualization. "0" values translate to a count of "1" colony forming unit (CFU). Values less than "0" indicate an original value between "0" and "1." Data Source: Great Bay National Estuarine Research Reserve and the UNH Jackson Estuarine Laboratory.

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Explanation (from 2018 State of Our Estuaries Report)

Elevated levels of fecal-borne indicator bacteria in our estuaries can indicate the presence of sewage pollution from failing septic systems, overboard marine toilet discharges, wastewater treatment facility overflows, illicit connections between sewers and storm drains, and sewer line failures, as well as livestock, pet, and wildlife waste that can run off impervious surfaces. Such indicator bacteria can also originate from polluted sediments that become resuspended in the estuary due to waves and tides. Increases in rainfall often cause increases in indicator bacteria concentrations because stormwater runoff can cause flushes of pollution into the estuary. PREP uses measurements from days without significant rainfall to reflect chronic contamination levels rather than include data from rainfall events that would cause runoff-induced peak levels of bacteria. Data for this indicator is only presented for the Great Bay Estuary.

At all four long-term water pollution-monitoring stations in the estuary, a decrease in fecal coliform bacteria during dry weather has been observed over the past 26 years. For example, at Adams Point, fecal coliform bacteria decreased by 67% between 1989 and 2016 (Figure B-1). Upgrades to wastewater treatment facilities, improvements to stormwater and sewage infrastructure, and microbial source tracking studies that identify and address sources of bacterial pollution are all contributing factors to the long-term decreasing trend. It should be noted that not all trends were decreasing. Fecal coliform bacteria measurements in Portsmouth Harbor and *enterococci* at Adams Point, the Squamscott River, and Portsmouth Harbor showed no significant trends.

Methods and Data Sources
Fecal coliforms, enterococci and *Escherichia coli* bacteria are referred to as fecal-indicating bacteria; they are themselves not harmful to humans, but rather indicate the potential presence of harmful pathogens associated with fecal matter from warm-blooded animals (US EPA 2012). Since the 1970s, recommendations regarding the usage of these three indicators have changed as a result of updated testing, development of new methods and implementation of epidemiology studies. The most recent recreational water quality criteria—that is, developed for protecting the health of swimmers—recommend that enterococci be used for marine or fresh water and that *E. coli* be used for freshwater only (US EPA 2012.) These recommendations no longer endorse using fecal coliforms for recreational water quality criteria; however, fecal coliforms are still used by the National Shellfish Sanitation Program (NSSP) for setting water quality levels for the harvest and consumption of shellfish (NSSP 2017).

Data for samples that were collected at low tide during dry weather were queried from the overall bacterial dataset. Measurements of bacteria concentrations (fecal coliforms, enterococci, and *E. coli*) at long-term trend stations in the estuary were compiled. Field duplicate and quality-assurance samples were excluded and results reported as non-detected (less than ten percent of the samples) were replaced with one-half the method detection limit. Each measurement was paired with the antecedent rainfall in Portsmouth in the preceding two days and the preceding four days. For sites in the middle of Great Bay/Little Bay, “dry weather” samples were defined as those collected when there had been less than 2 inches of rain in the previous 4 days. For all other sites, a sample was considered to be dry if there had been less than 0.5 inches of rain in the previous 2 days. The two different criteria are used to identify “dry weather” samples because water quality at stations in the middle of the bay responds slower to rainfall runoff than at stations in the tidal tributaries. The samples collected at low tide and under dry-weather conditions were extracted from this dataset for trend analysis. It is important to keep in mind that these data represent ideal conditions, since wet weather samples were excluded from the analysis.

Trends in low-tide dry weather samples were assessed using linear regression of natural log transformed concentrations versus year. 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 was provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Program.

Additional Results (Beyond What Was Reported in the SOOE)

Eight out of 12 combinations of three indicators at four stations showed decreasing trends (Table B-1). There were no increasing trends. Of the four combinations that did not show trends, three of these were for enterococci; of the four stations, only enterococci at the Lamprey River station showed a decreasing trend. The only non-enterococci combination that did not show a trend was fecal coliforms at the Coastal Marine Laboratory station in Portsmouth Harbor.

Table B-1: Summary table of three fecal-indicating bacteria from four stations with long-term data.

Station	Parameter	Period of Record	Trend
GRBAP (Adams Point)	Fecal coliforms	1989-2016	**Decreasing**
	Enterococci		no significant trend
	E. coli		**Decreasing**
GRBLR (Lamprey River)	Fecal coliforms	1992-2016	**Decreasing**
	Enterococci		**Decreasing**
	E. coli		**Decreasing**
GRBCL (Squamscott River)	Fecal coliforms	1989-2016	**Decreasing**
	Enterococci		no significant trend
	E. coli		**Decreasing**
GRBCML (Portsmouth Harbor)	Fecal coliforms	1992-2016	no significant trend
	Enterococci		no significant trend
	E. coli		**Decreasing**

References Cited

NSSP. 2017. National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish 2017 Revision. Interstate Shellfish Sanitation Conference and U.S. Food and Drug Administration. Published online: https://www.fda.gov/Food/GuidanceRegulation/FederalStateFoodPrograms/ucm2006754.htm

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/. Accessed 14 September 2017.

US EPA. 2012. Recreational water quality criteria. Office of Water. 820-F-12-058. https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf

Figure B-2: Trend stations for bacteria indicator species.

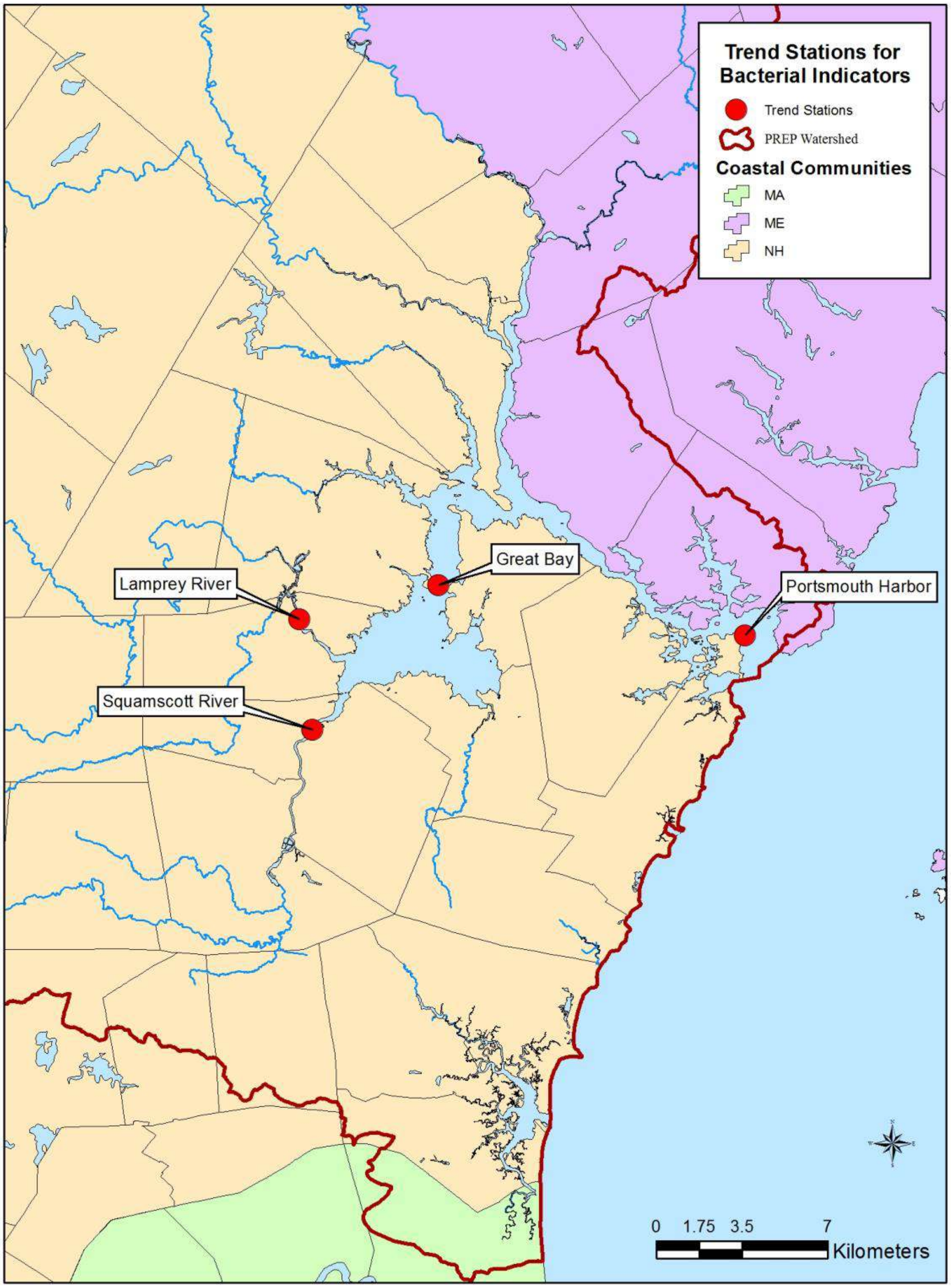
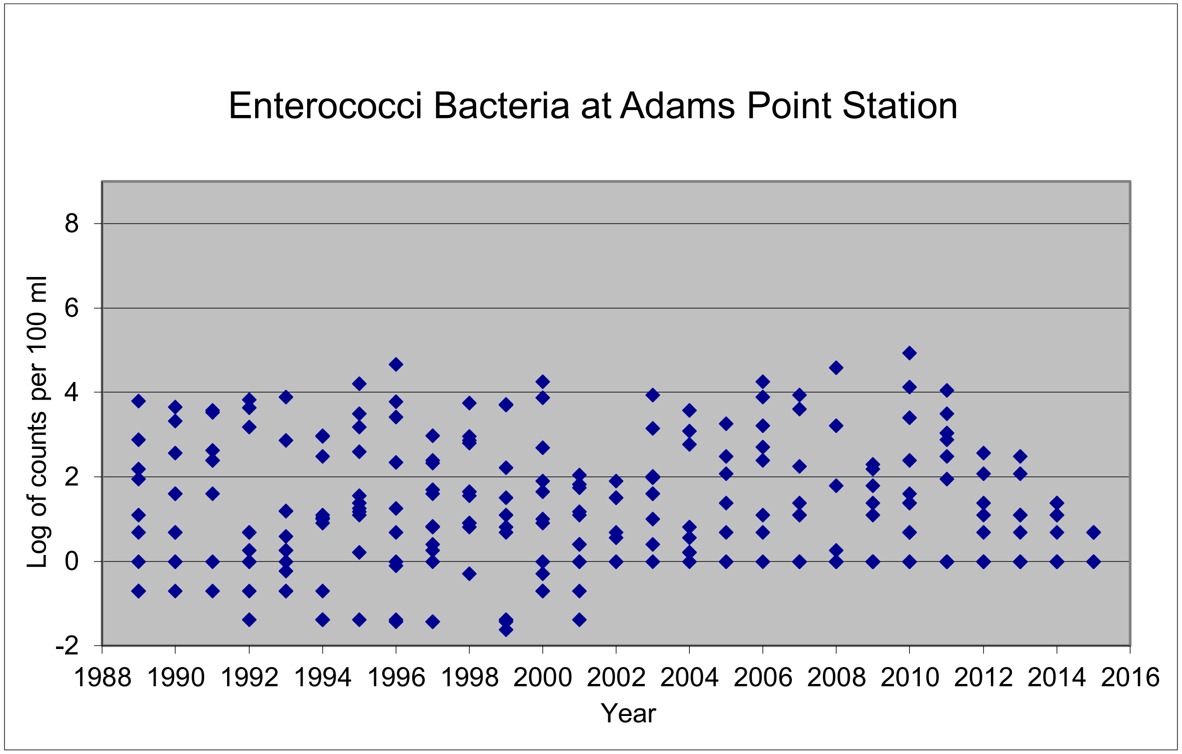


Figure B-3: Enterococci concentrations at the four trend stations in the Great Bay Estuary. Enterococci is recommended as an indicator for marine and/or fresh water. Trendline only shown when there is a statistically significant relationship. Data are log-transformed for better visualization. "0" values translate to a count of "1" colony forming unit (CFU). Values less than "0" indicate an original value between "0" and "1."



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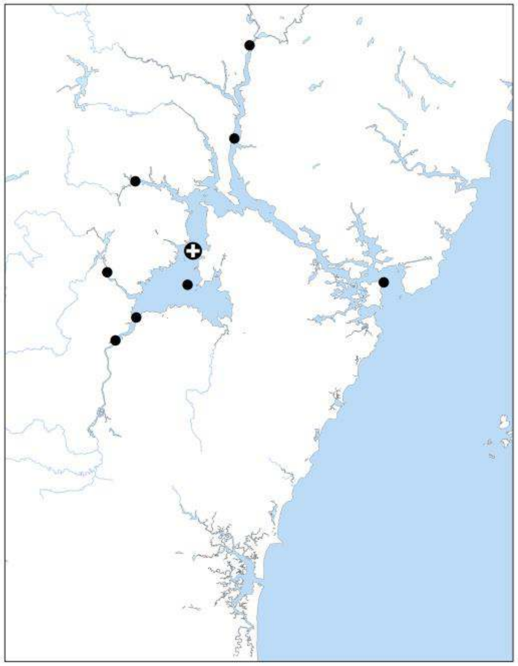

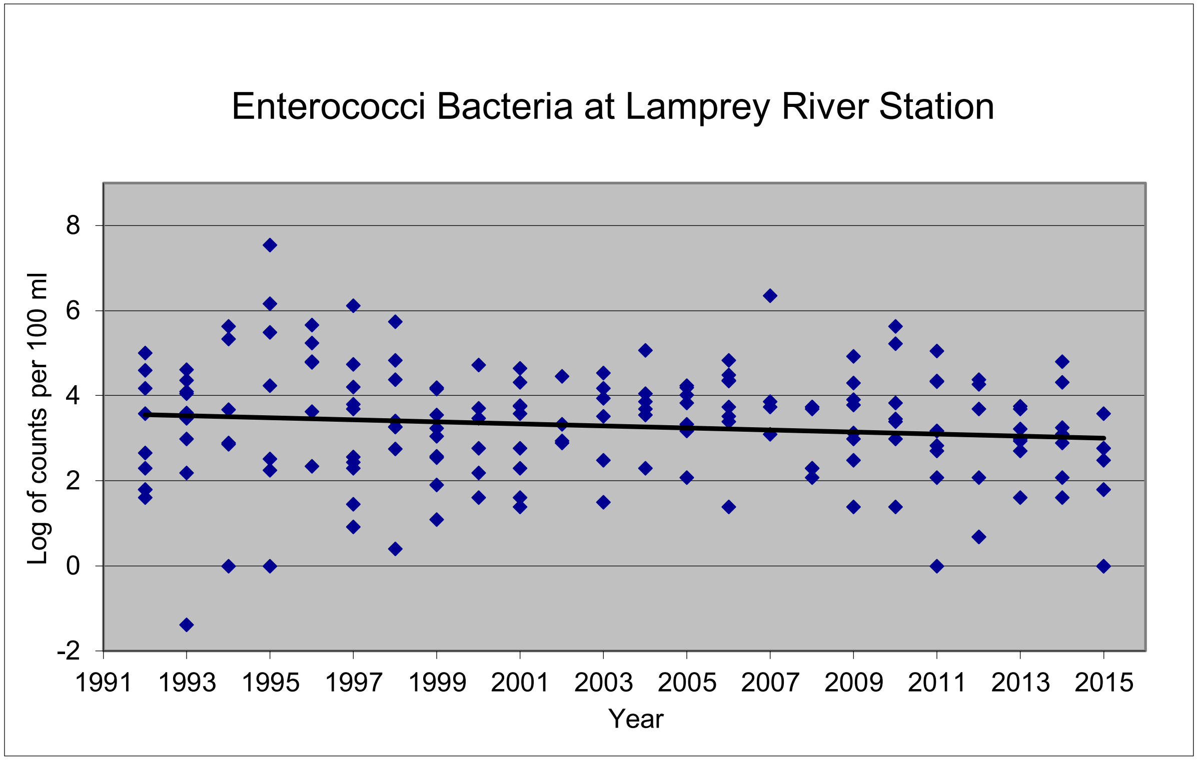

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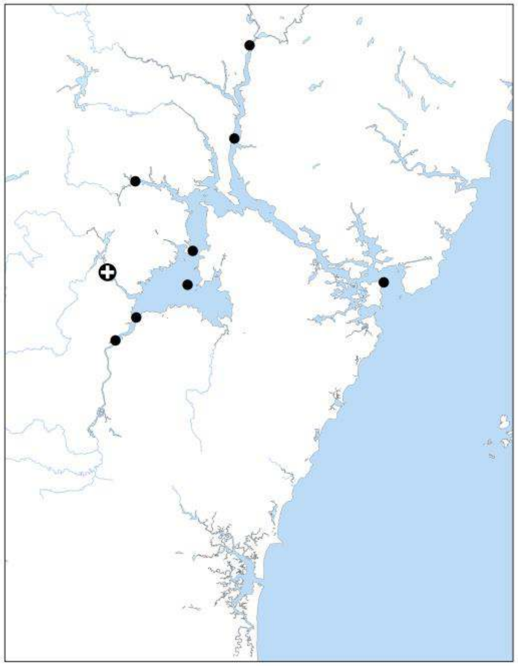

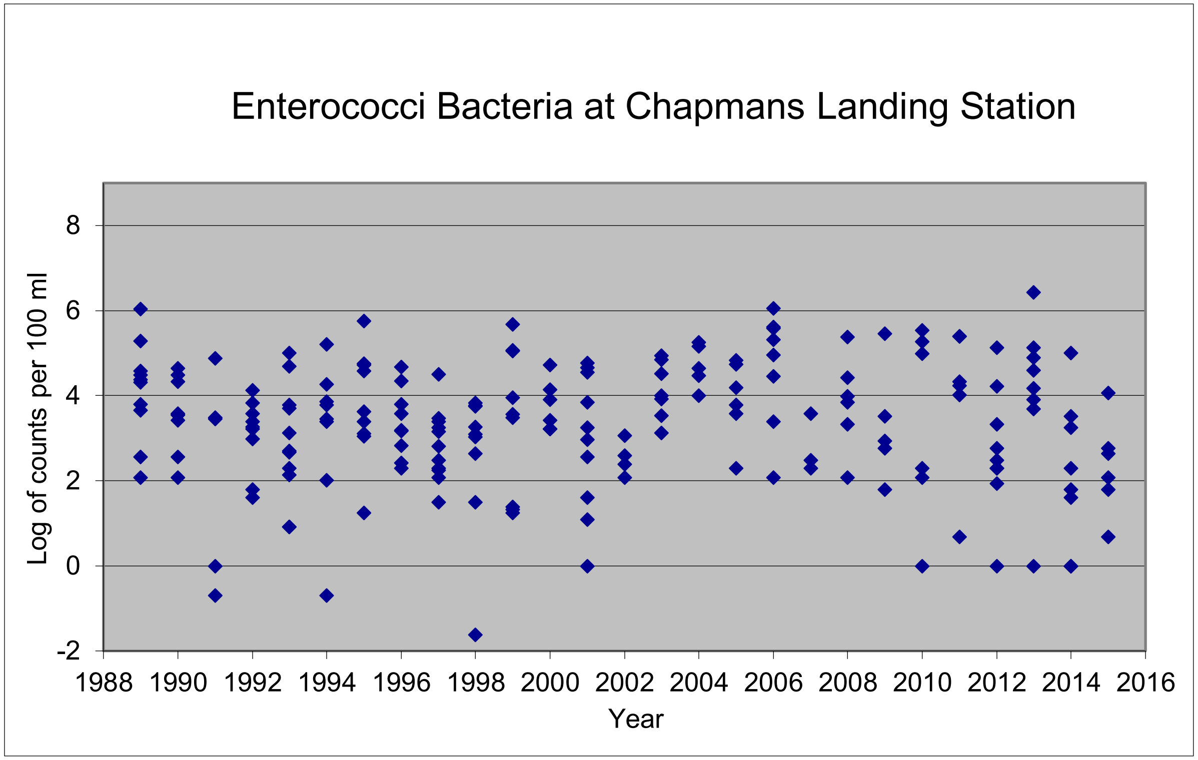

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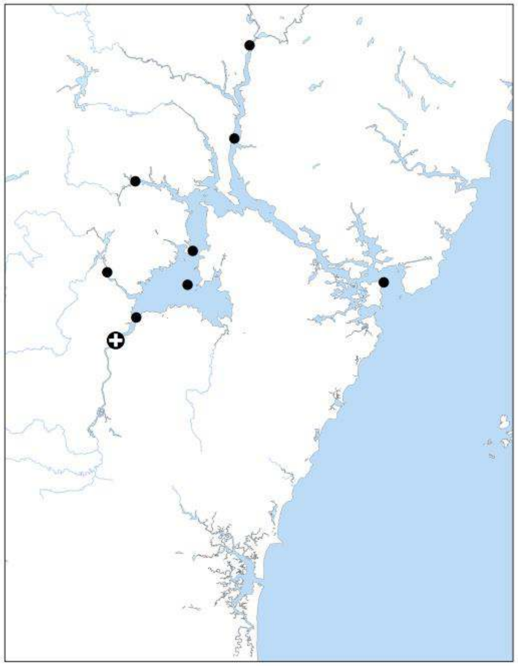

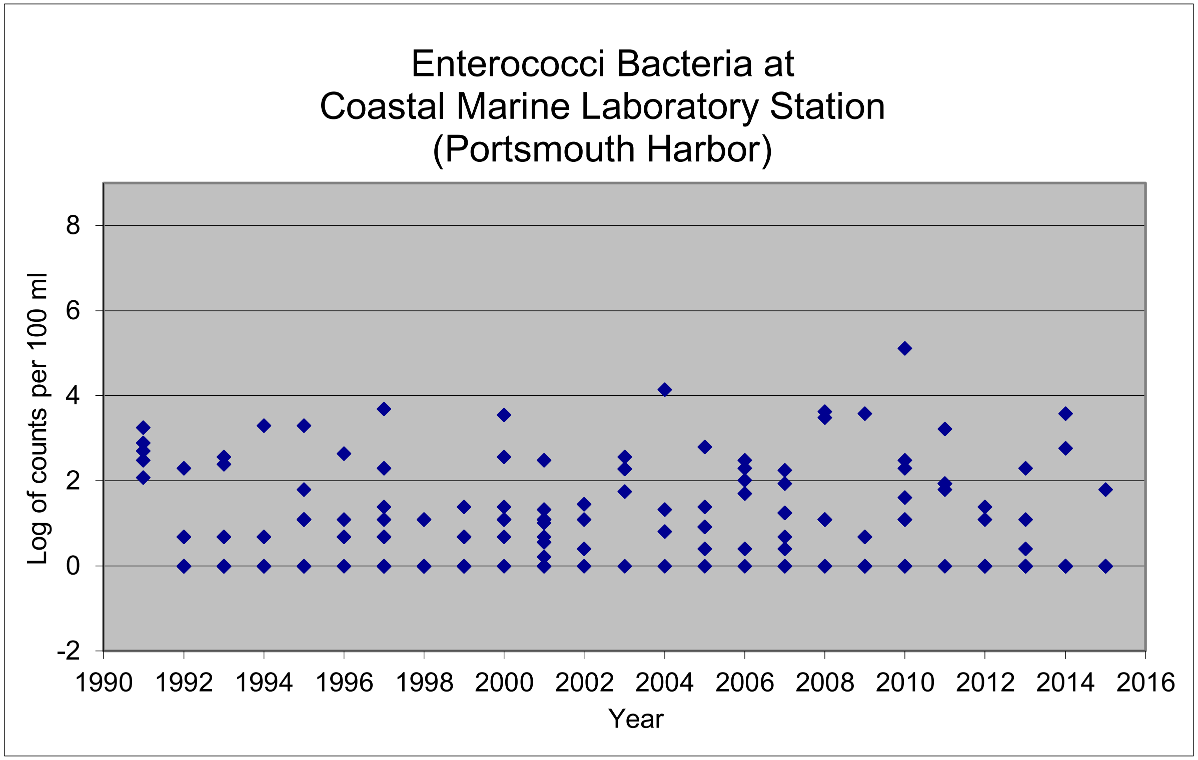

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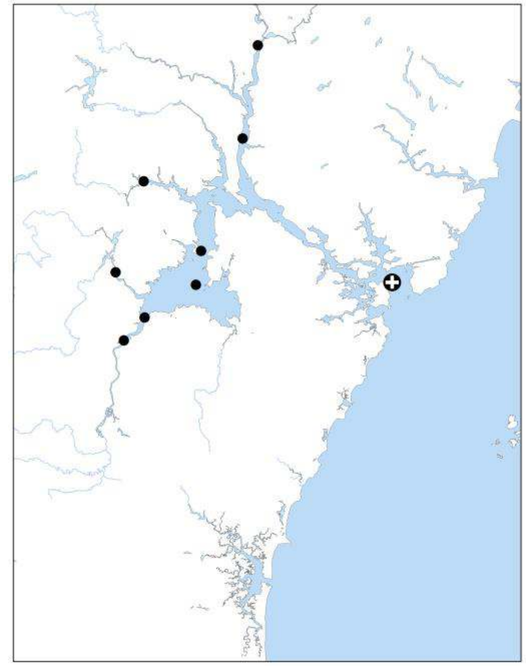
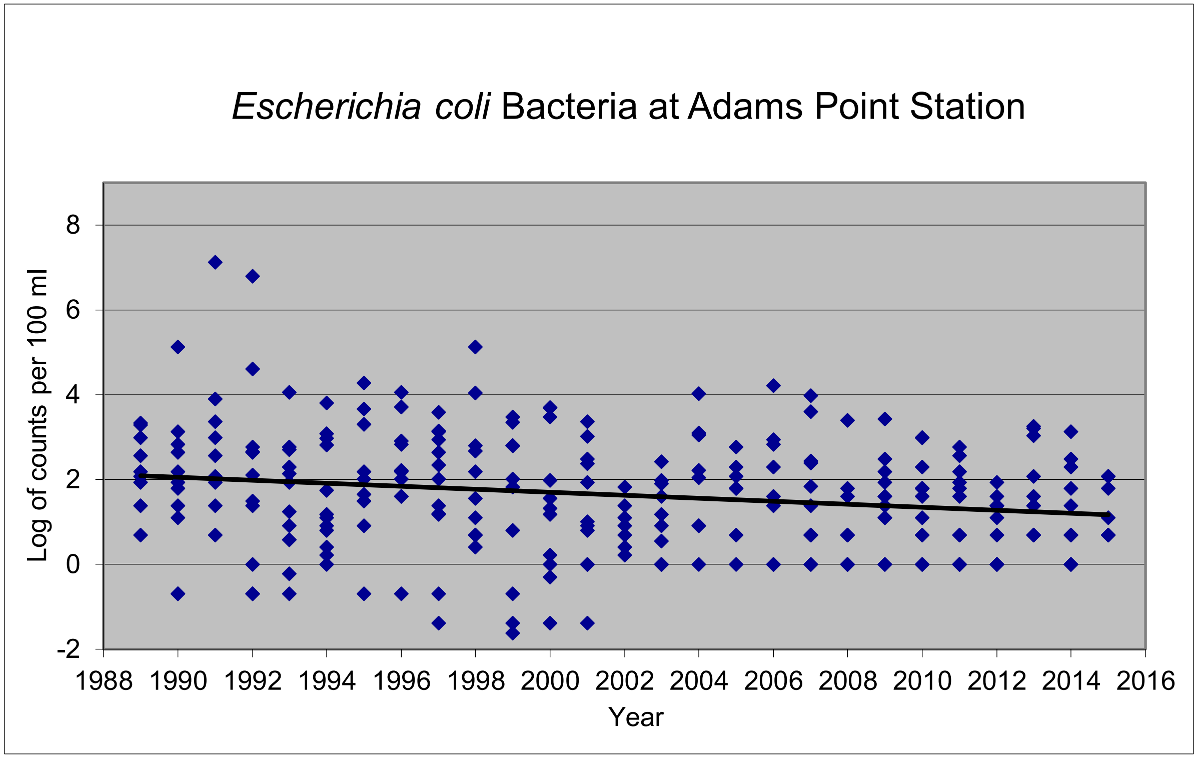


Figure B-4: *E. coli* concentrations at the four trend stations in the Great Bay Estuary. *E. coli* is recommended as a fecal indicator for fresh water only. Trendline only shown when there is a statistically significant relationship. "0" values translate to a count of "1" colony forming unit (CFU). Values less than "0" indicate an original value between "0" and "1."



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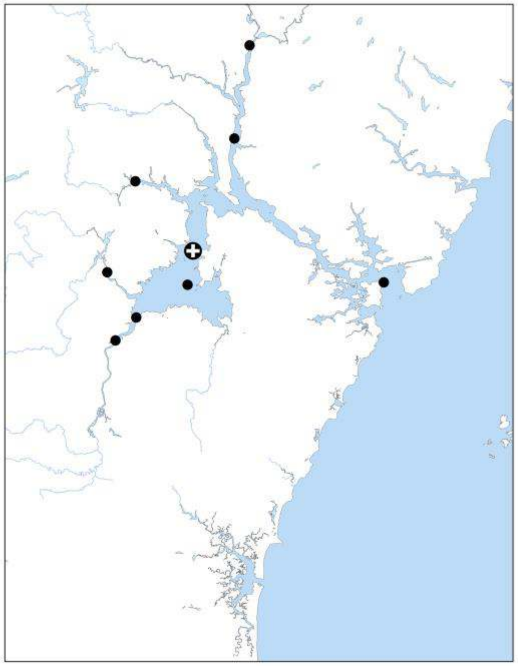

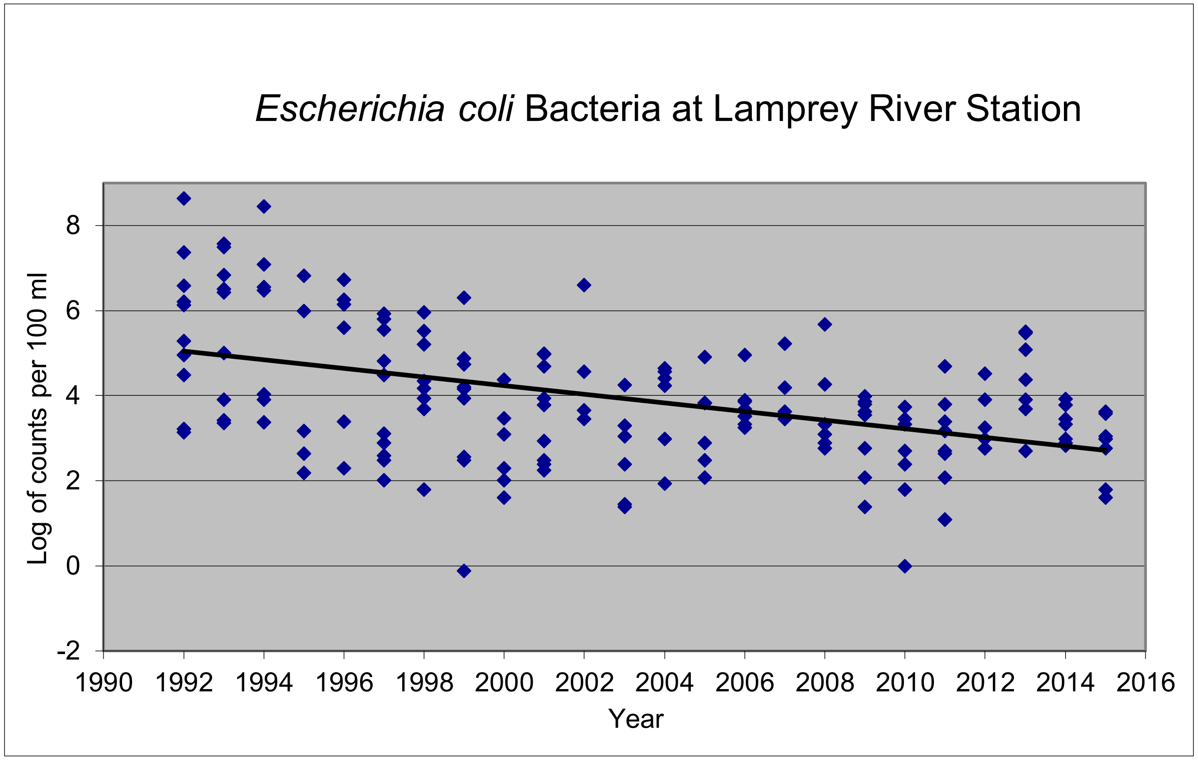

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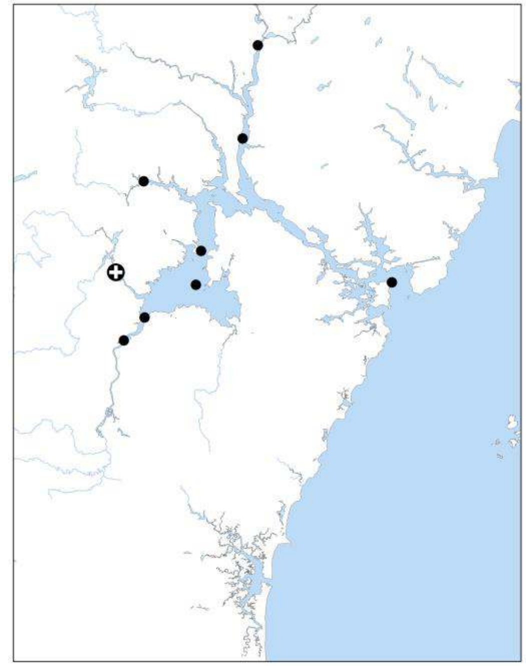

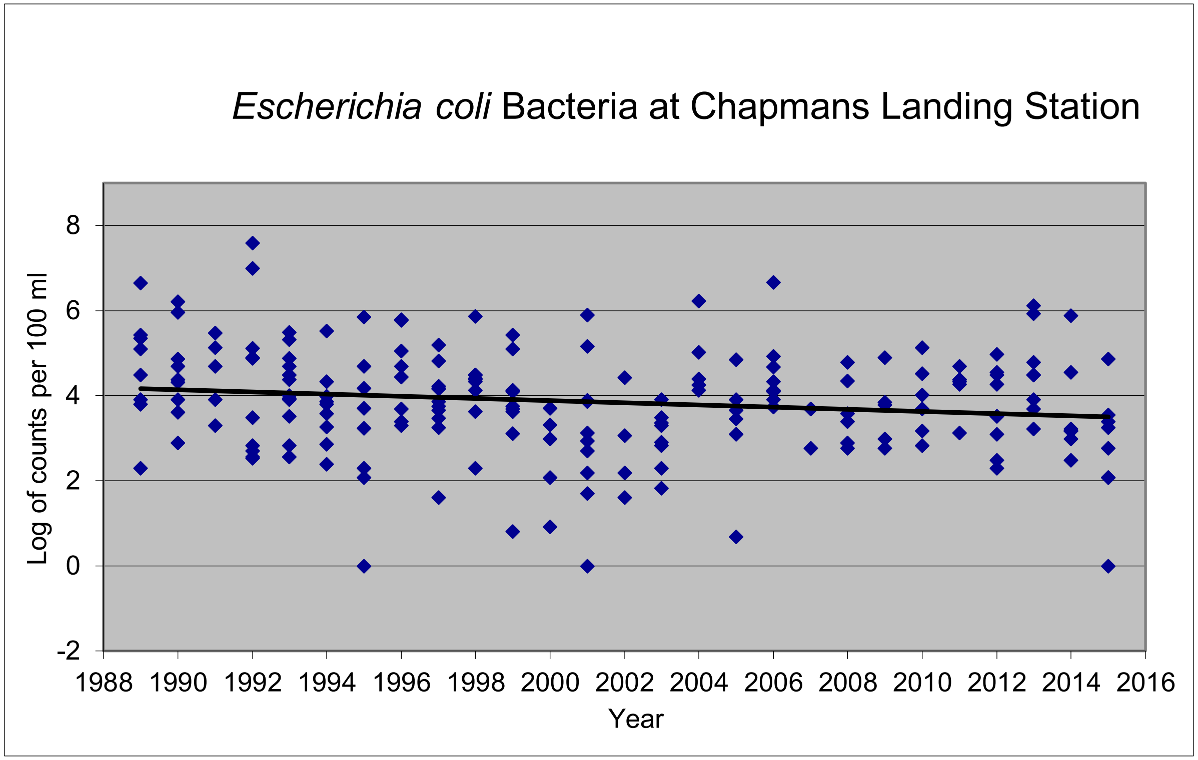

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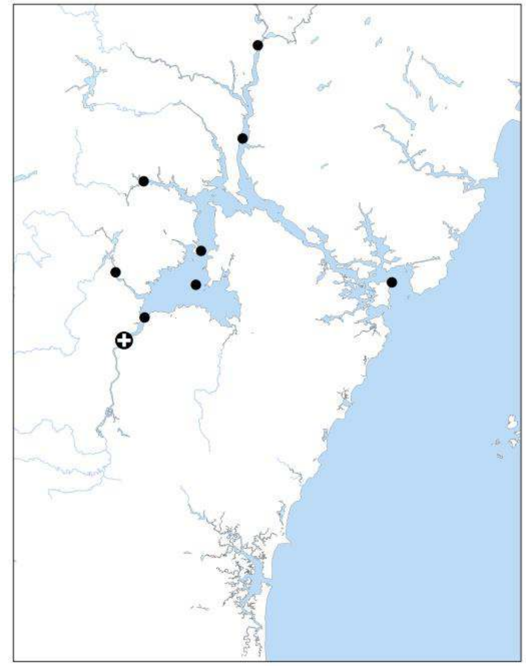

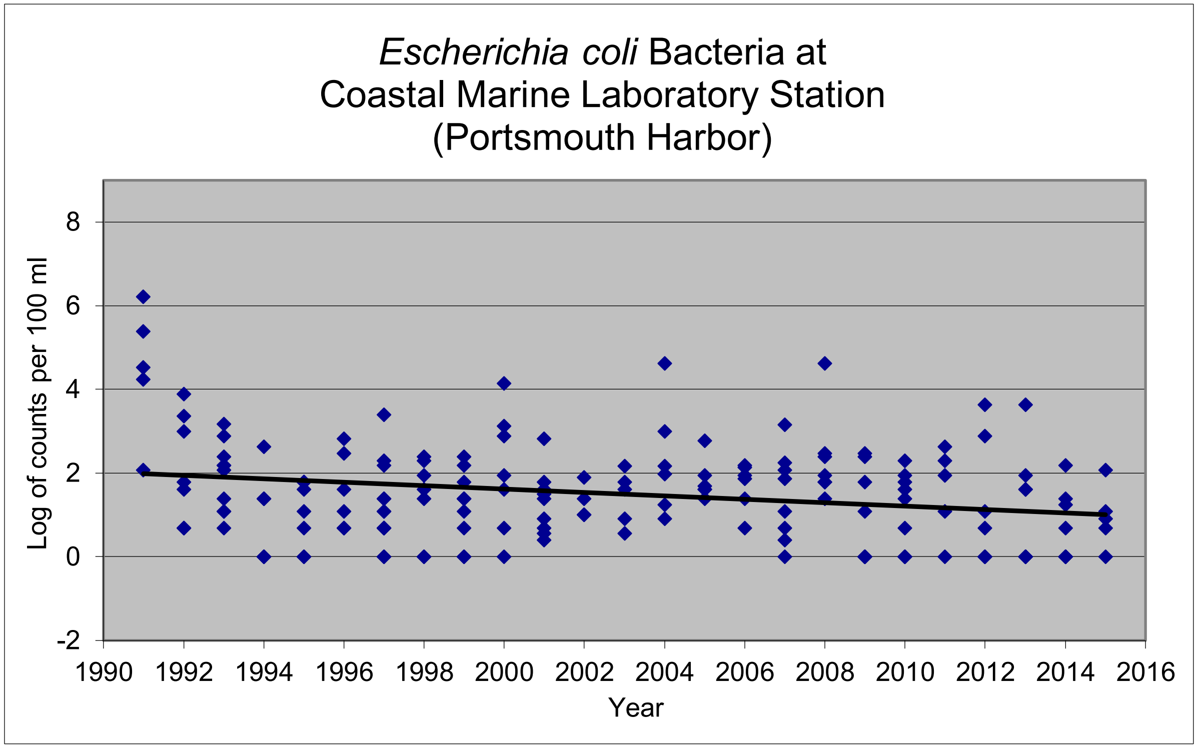

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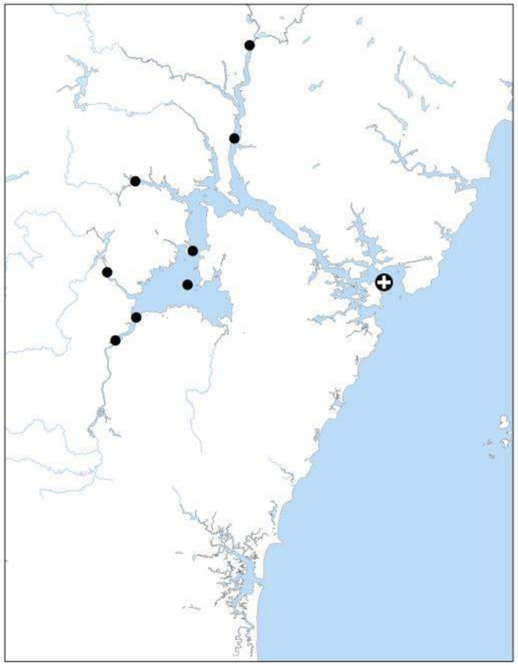
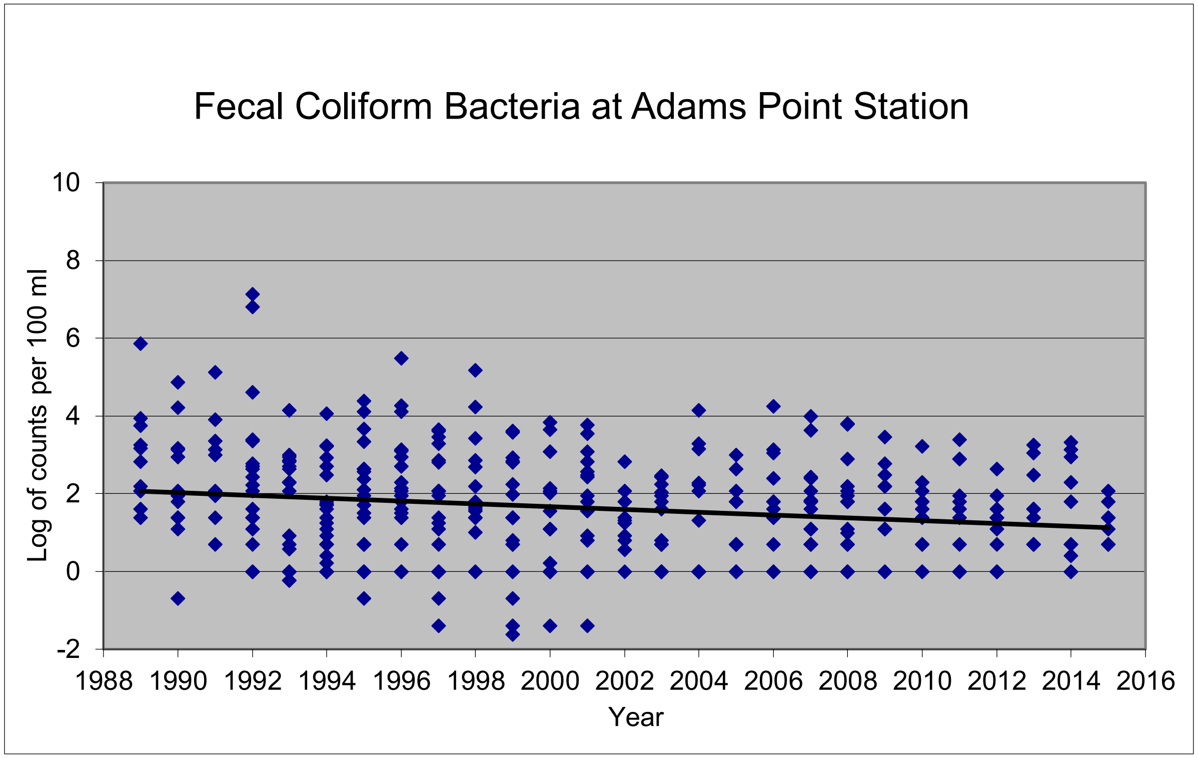


Figure B-5: Fecal coliform concentrations at the four trend stations in the Great Bay Estuary. Fecal coliform is recommended as a fecal indicator for shellfish purposes only. Trendline only shown when there is a statistically significant relationship. “0” values translate to a count of “1” colony forming unit (CFU). Values less than “0” indicate an original value between “0” and “1.”



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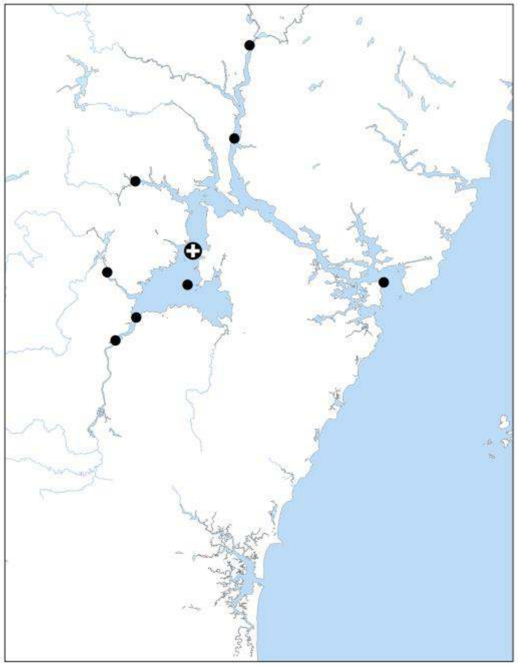

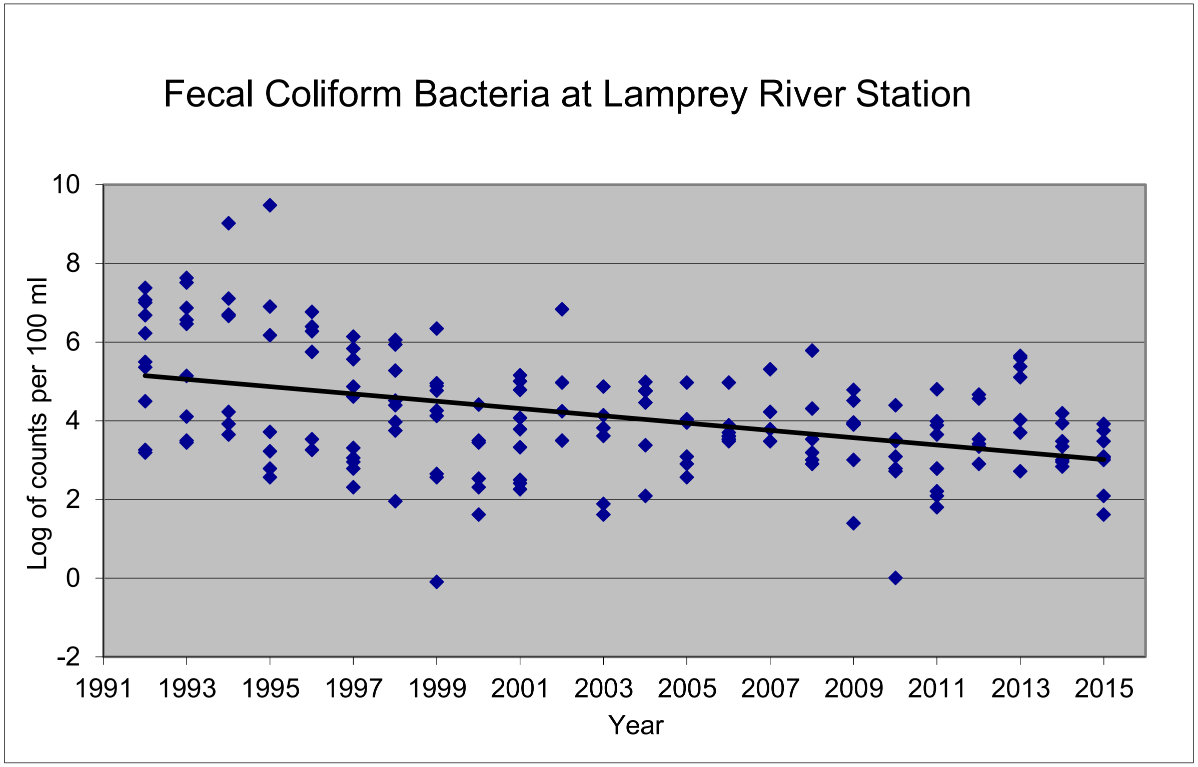

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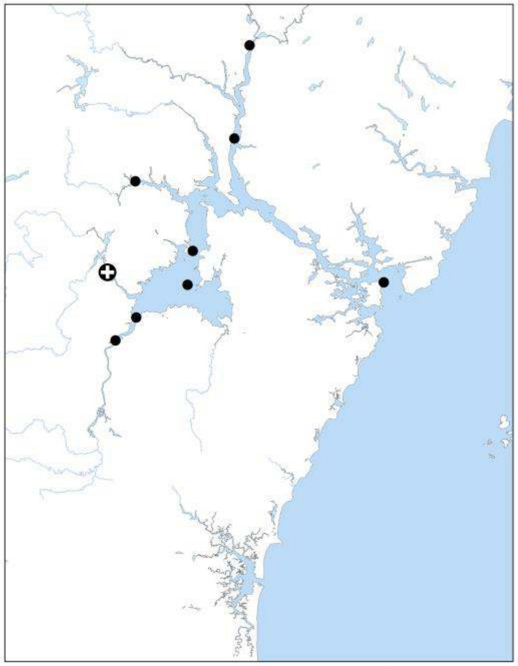

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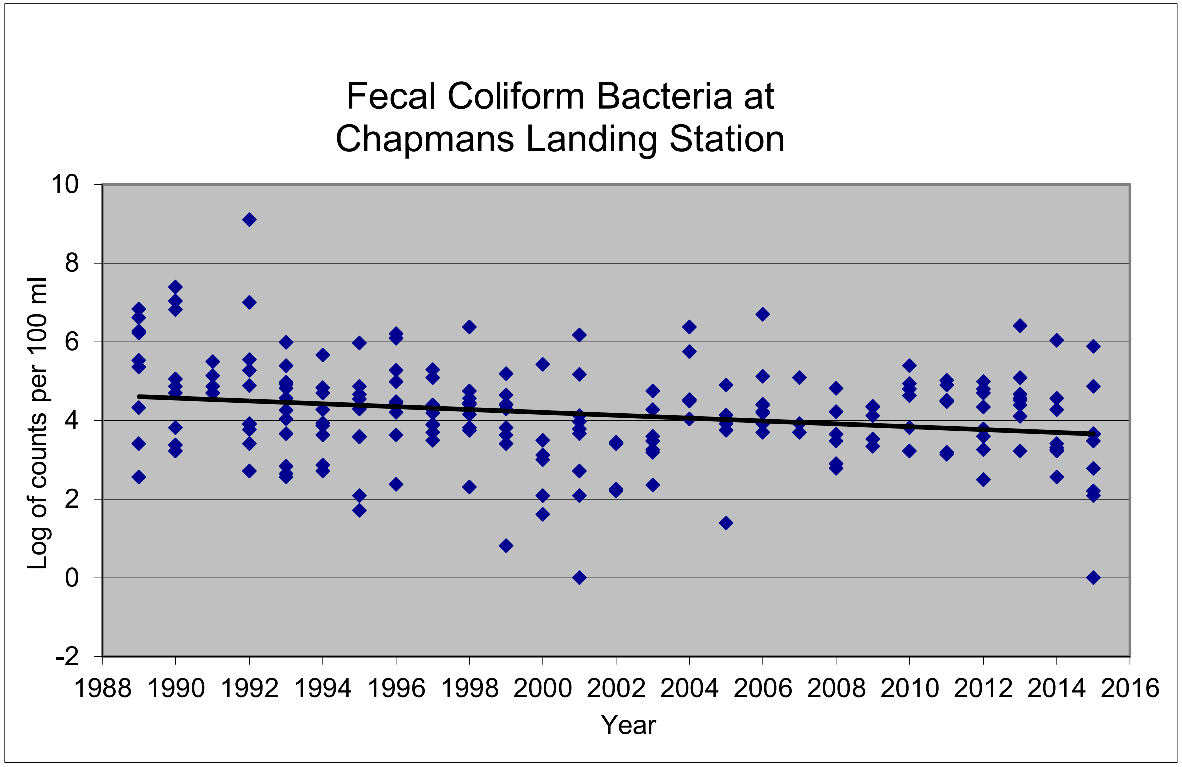

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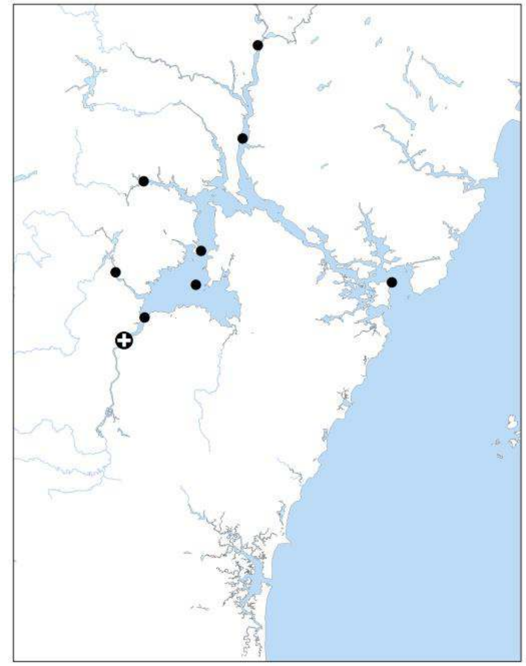

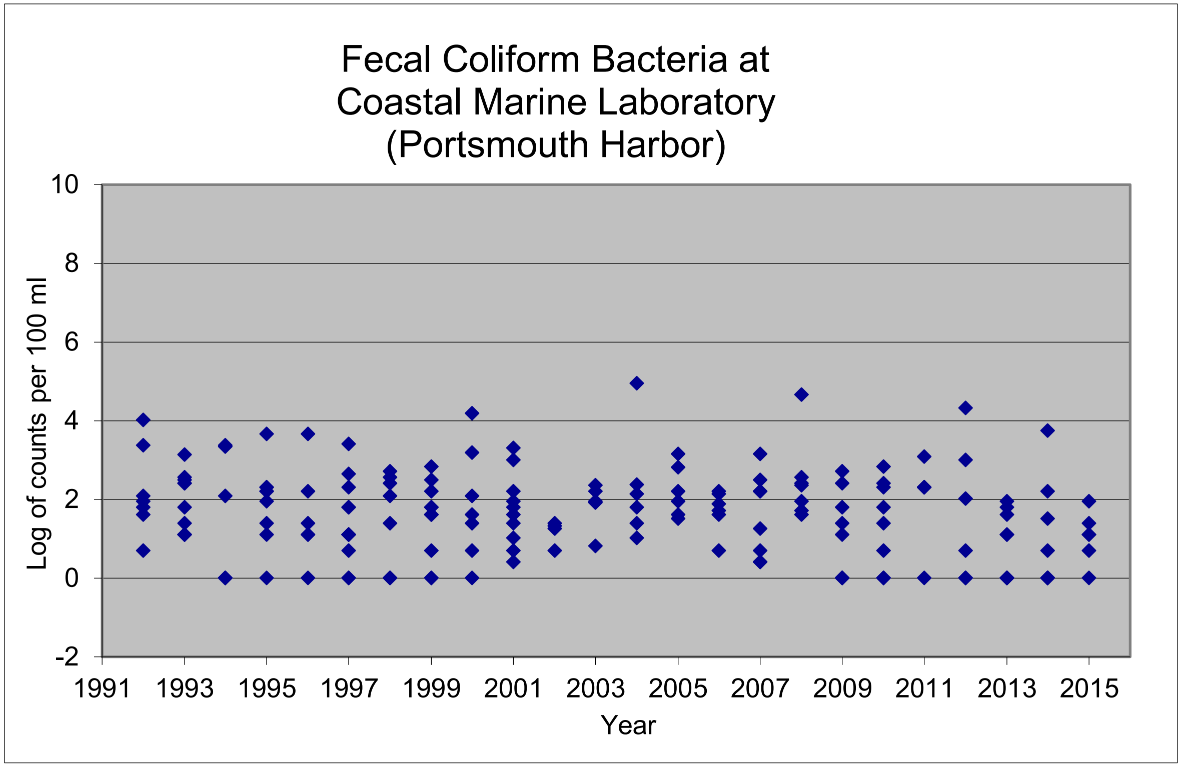

Monitoring Location (GRBCML)
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