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Environmental Indicator Report: Water Quality

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Environmental Indicator Report

WATER QUALITY

FINAL

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NHEP Technical Advisory Committee

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Steve Jones, Chair	UNH-JEL
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Special thanks also to Norma Mason (EPA) for providing recent NPDES data for WWTFs.

INTRODUCTION

During the fall and winter of 2001-2002, the New Hampshire Estuaries Project's Technical Advisory Committee (TAC) developed a suite of environmental indicators to track progress toward the NHEP's management goals and objectives. These indicators were fully described in terms of their performance criteria, statistical methods, and measurable goals in the NHEP's Monitoring Plan published in May 2002.

The next step is to use these indicators to produce an updated "State of the Estuaries" report by the spring of 2003. The TAC decided to break this task into three sections: shellfish indicators in the fall of 2002; water quality indicators in the winter of 2002-2003; and land use/habitat indicators in the spring of 2003. For each group of indicators, the NHEP Coastal Scientist would prepare an "Indicator Report" that summarizes the available information and results of statistical tests for each of the indicators. The TAC would review and comment on this report, and then recommend a subset of the most important or illustrative indicators to be presented to the Management Committee. Finally, after being presented to both the TAC and the Management Committee, the indicator charts and interpretation would be incorporated in the State of the Estuaries report.

This report is the second of three indicator reports that will be presented to the TAC over the next six months. The focus of this report is the NHEP's water quality indicators (see list below). In an effort to be brief, the details of the monitoring programs for each indicator are not included. Please refer to the NHEP Monitoring Plan for additional details for each indicator.

<u>NHEP Water Quality Indicators Included in this Report</u>

<u>Bacteria</u>
BAC1 – Acre-days of shellfish harvest opportunities in estuarine waters
BAC2 – Trends in dry-weather bacteria indicators concentrations
BAC4 – Tidal bathing beach postings
BAC5 – Trends in bacteria concentrations at tidal bathing beaches
BAC6 – Violations of enterococci standard in tidal waters
BAC7 – Freshwater bathing beach postings
BAC8 – Bacteria load from wastewater treatment plants

<u>Toxic Contaminants</u>
TOX1 – Shellfish tissue concentrations relative to FDA standards
TOX3 – Trends in shellfish tissue contaminant concentrations

<u>Nutrients and Eutrophication</u>
NUT2 – Trends in estuarine nutrient concentrations
NUT3 – Trends in estuarine particulate concentrations
NUT5 – Exceedences of the instantaneous dissolved oxygen standard
NUT6 – Exceedences of the daily average dissolved oxygen standard
NUT7 – Trends in biological oxygen demand loading to Great Bay

ENVIRONMENTAL INDICATORS

BAC1: Acre-days of Shellfish Harvest Opportunities in Estuarine Waters

a. Monitoring Objectives

The objective of this indicator is to report on how much of the year the shellfish beds were closed to harvesting due to high bacteria concentrations. The DES Shellfish Program measures the opportunities for shellfish harvesting using "acre-days", which is the product of the acres of shellfish growing waters and the amount of time that these waters are open for harvest. The acre-days indicator is reported as the percentage of the total possible acre-days of harvesting for which the shellfish waters are actually open. In most cases, the reason why a shellfish growing area is closed to harvesting is somehow related to poor bacterial water quality (although closures due to PSP or "red-tide" do occur rarely). Therefore, this acre-day indicator is a good integrative measure of the degree to which water quality in the estuary is meeting fecal coliform standards for shellfish harvesting, which will answer the following monitoring question:

- Do NH tidal waters meet fecal coliform standards of the National Shellfish Sanitation Program for 'approved' shellfish areas?

which will, in turn, report on progress toward the following management objective:

- WQ1-1: Achieve water quality in Great Bay and Hampton Harbor that meets shellfish harvest standards by 2010.

b. Measurable Goal

The goal is to have 100% of all possible acre-days in estuarine waters open for harvesting.

c. Data Analysis and Statistical Methods

The acres of shellfish growing areas in under different classifications and acre-days of harvesting potential for the "approved" and "conditionally approved" estuarine areas were taken from the DES Shellfish Program annual reports. Acre-day calculations are based on updated growing area classifications and NHDES Shellfish Program records of all rainfall-closures, wastewater treatment plant failure-closures, emergency-closures, and others instituted during the year. Areas that are permanently closed due to their proximity to wastewater treatment plant outfalls or marinas, commonly referred to as "safety zones," are excluded from the acre-day calculation, as these areas are not closed for reasons of high bacteria. The acre-day calculation by the DES Shellfish Program is a precise number. Statistical methods are not needed to compare the results to the goal.

d. Results

Acre days of shellfishing opportunities have been tracked for the past two years. The results are summarized in the following tables. The first table shows that in 2000 and 2001, approximately 36 to 38% of the 13,718 acres of estuarine waters were classified as "Approved" or "Conditionally Approved" for shellfishing by the DES Shellfish Program. Between 43 and 49% of the waters had not been classified and 14 to 19% were classified as "Prohibited" or "Restricted" due to known or potential pollution sources.

Estuarine Shellfish Water Classifications

Classification	2000	2001
Approved or Conditionally Approved	36.3%	37.8%
Restricted or Prohibited	10.5%	11.2%
Safety Zone	3.8%	7.5%
Unclassified	49.4%	43.5%
Grand Total	100%	100%
Total Acres	13,718	13,718

Source: DES Shellfish Program Annual Reports, 2000 and 2001

Shellfishing opportunities in the open portions of the estuaries varied by location. In Great Bay and Little Bay, the shellfishing acre-days were close to 90% of the possible amount in 2001. However, in Hampton/Seabrook Harbor, the acre-day percentage was 29% in 2000 and 41% in 2001. The change in acre-day percentage in Hampton/Seabrook Harbor between the years is probably due to more frequent wet-weather in 2000 than 2001, which would have caused more wet-weather closures of the shellfish beds.

Percent Open Acre-Days for Hampton/Seabrook, Great Bay, and Little Bay

Acre-days of shellfish harvest opportunities in approved or conditionally approved estuarine waters (percent of total possible)	2000	2001	Goal
Great Bay (oyster)	93.4%	90.1%	100%
Hampton/Seabrook Harbor (clam)	29.1%	40.8%	100%
Upper Little Bay (clam)	74.7%	89.5%	100%
Lower Little Bay (clam)	74.7%	84.2%	100%

Source: DES Shellfish Program Annual Reports, 2000 and 2001

BAC2: Trends in Dry-Weather Bacterial Indicators Concentrations

a. Monitoring Objectives

The objective of this indicator is to identify long-term trends in bacteria concentrations during dry weather periods. Concentrations of the traditional bacteria indicators species (fecal coliforms, enterococci, *Escherichia coli*, and *Clostridium perfringens*) were measured at fixed stations in the estuary and tributaries at a pre-determined frequency. For each sampling day, the conditions were categorized as either "wet weather" or "dry weather" based on precipitation data. For the dry weather samples, the long-term trend in the concentrations were assessed. Trends in wet weather concentrations will be assessed in another indicator. The trends from this indicator will answer the following monitoring questions:

- Have fecal coliform, enterococci, and *E. coli* levels changed significantly over time?
- Has dry-weather bacterial contamination changed significantly over time?

which will, in turn, report on progress toward the following management objective:

- WQ1-1: Achieve water quality in Great Bay and Hampton Harbor that meets shellfish harvest standards by 2010

b. Measurable Goal

The goal is to document a statistically significant decrease in concentrations at stations in the tidal tributaries to the estuary.

c. Data Analysis and Statistical Methods

For the one NERR trend site in Great Bay/Little Bay, "dry weather" samples will be those collected when there has been less than 2 inches of rain in the previous 4 days. For the NERR trend sites in the Great Bay tributaries and Portsmouth Harbor, "dry weather" samples will be those collected when there has been less on 0.5 inches of rain in the previous 2 days. The reason why the rainfall criteria is different between the tributaries and the bay is because these areas have different response times to precipitation. Only samples collected at low-tide will be used. The Seasonal Kendall Test will be used to test for significant trends. A significance level of 0.10 will be used to identify statistically significant trends in two-sided tests. A Mann-Kendall test will also be run on yearly median values at each station to verify any trends detected using the raw, unaggregated data.

d. Results

At all three NERR stations in Great Bay, the trend analysis shows significantly decreasing trends for low-tide fecal coliform concentrations. The trends are strongest at the tributary sites, where decreases of 75% have occurred over the past decade. Decreasing trends for *E. coli* were also observed in the two tributary stations. The only parameter with a significant trend at the station in Portsmouth Harbor (CML) was *C. perfringens.*

The trends for fecal coliforms at Adams Point and Squamscott River stations and for *E. coli* at the Lamprey River and Squamscott River stations were confirmed by trends in the annual median of dry-weather samples. Therefore, these trends are the most robust.

Therefore, the goal of observing decreasing trends in the tidal tributaries is being met. WWTF upgrades and NHEP-funded stormwater projects are likely major contributors to the decreasing trends. However, only two of the seven tributaries to the Great Bay Estuary have been monitored for long enough to allow for trend analysis.

The results are summarized in the following table and figures.

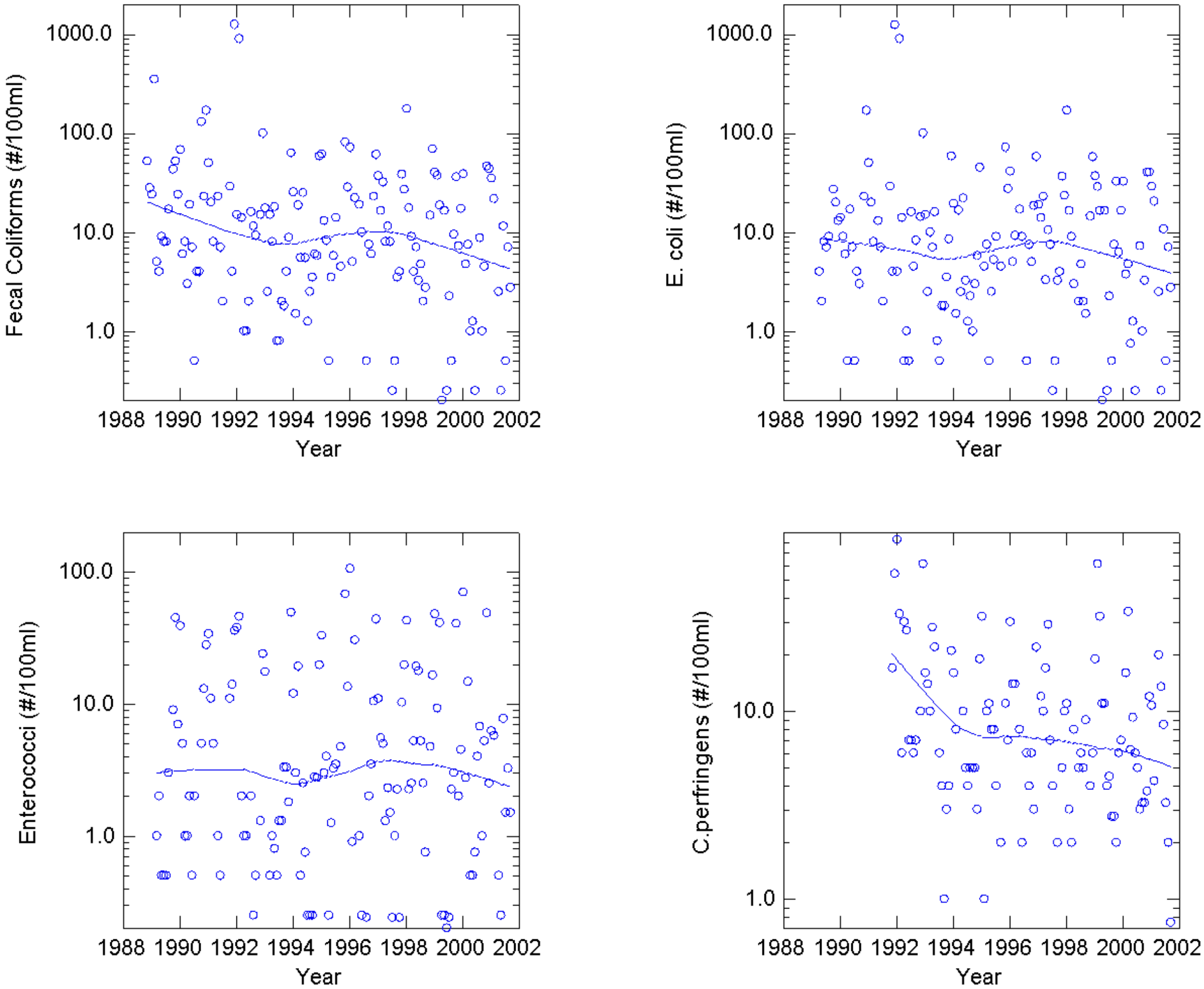
Trends in Dry-Weather Bacteria Concentrations at Estuarine Stations

Station	Parameter	Period of Record	Median (#/100ml)	Trend	Percent Change	Comments
Adams Point	Fecal coliforms	10/88 to 9/01	9	**Decreasing**	-30%	Trend also significant for annual medians.
Adams Point	*E. coli*	10/88 to 9/01	7	No significant trend		
Adams Point	Enterococci	10/88 to 9/01	3	No significant trend		
Adams Point	*C. perfringens*	10/91 to 9/01	7	**Decreasing**	-46%	
Lamprey River	Fecal coliforms	10/92 to 9/01	83	**Decreasing**	-76%	
Lamprey River	*E. coli*	10/92 to 9/01	73	**Decreasing**	-100% (approx)	Trend also significant for annual medians.
Lamprey River	Enterococci	10/92 to 9/01	33	No significant trend		
Lamprey River	*C. perfringens*	10/92 to 9/01	9	**Decreasing**	-53%	
Squamscott River	Fecal coliforms	10/88 to 9/01	80	**Decreasing**	-73%	Trend also significant for annual medians.
Squamscott River	*E. coli*	10/88 to 9/01	55	**Decreasing**	-51%	Trend also significant for annual medians.
Squamscott River	Enterococci	10/88 to 9/01	31	No significant trend		
Squamscott River	*C. perfringens*	10/91 to 9/01	29	No significant trend		
CML	Fecal coliforms	10/91 to 9/01	6	No significant trend		
CML	*E. coli*	10/91 to 9/01	4	No significant trend		
CML	Enterococci	10/91 to 9/01	2	No significant trend		
CML	*C. perfringens*	10/91 to 9/01	3	**Decreasing**	-66%	

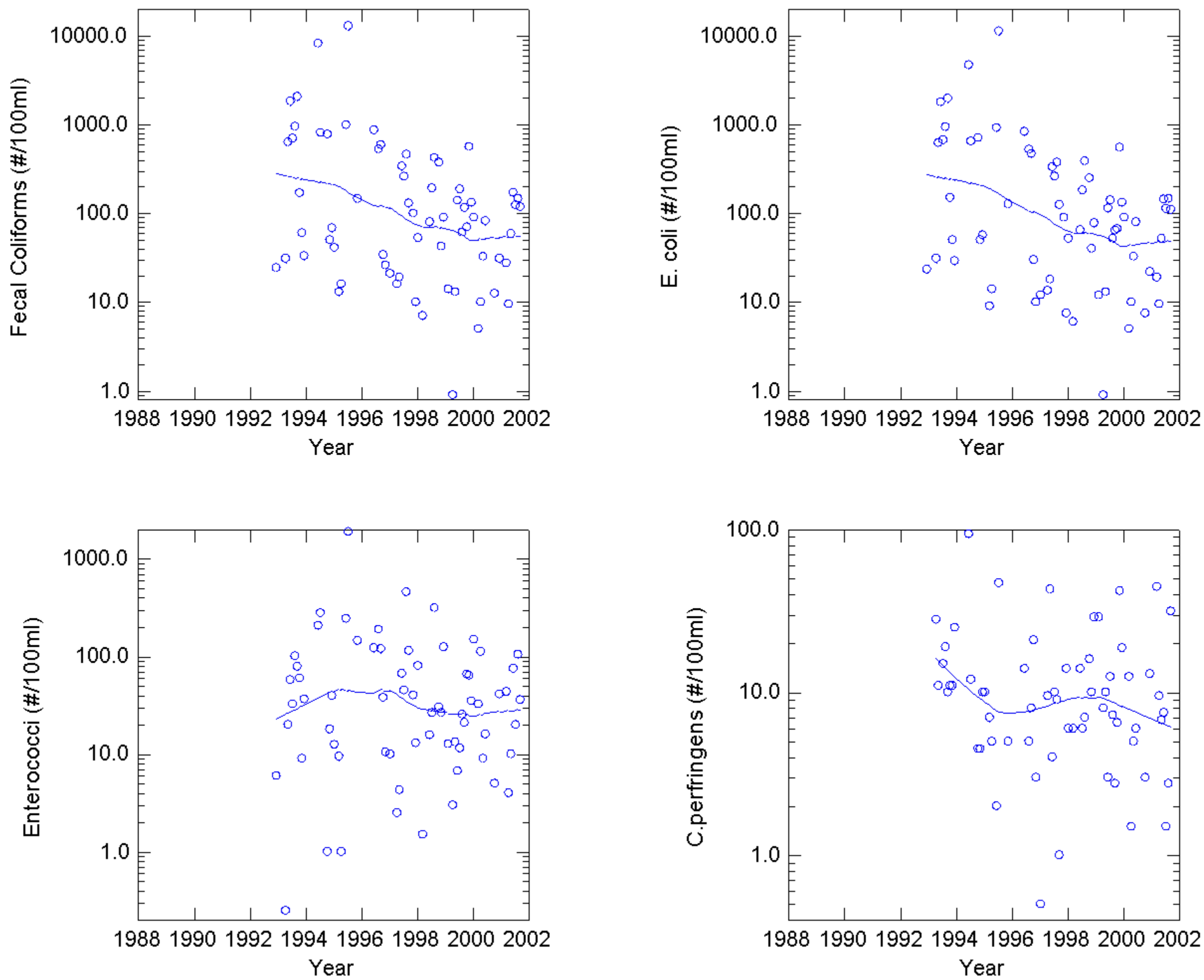
Source: NERR Water Quality Database (UNH-JEL, Dr. Steve Jones)

The following figures illustrate the trends in dry-weather bacteria concentrations at the four different locations in the estuary with sufficient data for trend analysis. The blue dots are the measurements. The blue lines are LOWESS smooths of the data with a tension of 0.5.

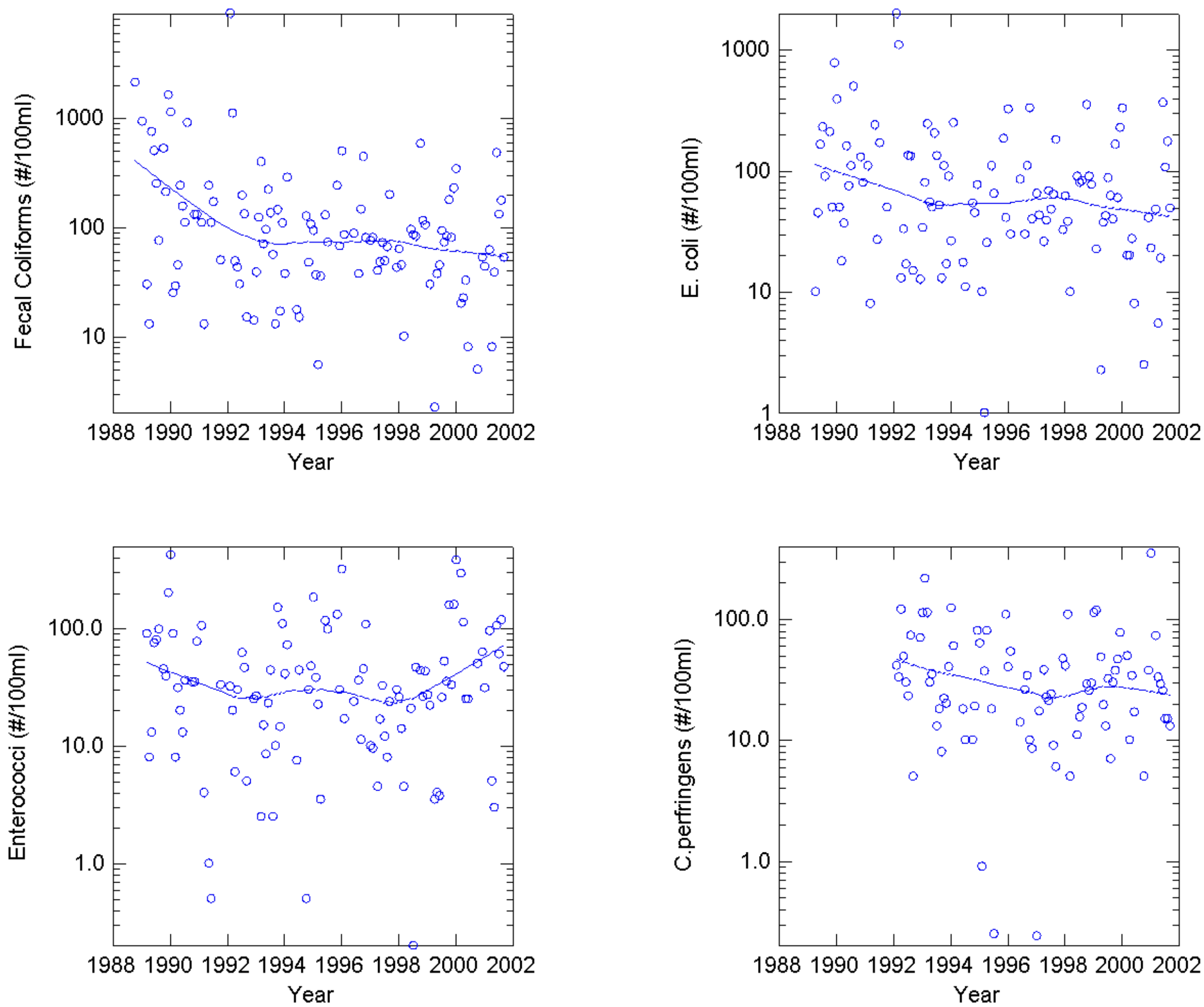
Dry-weather bacteria trends at low tide at Adams Point



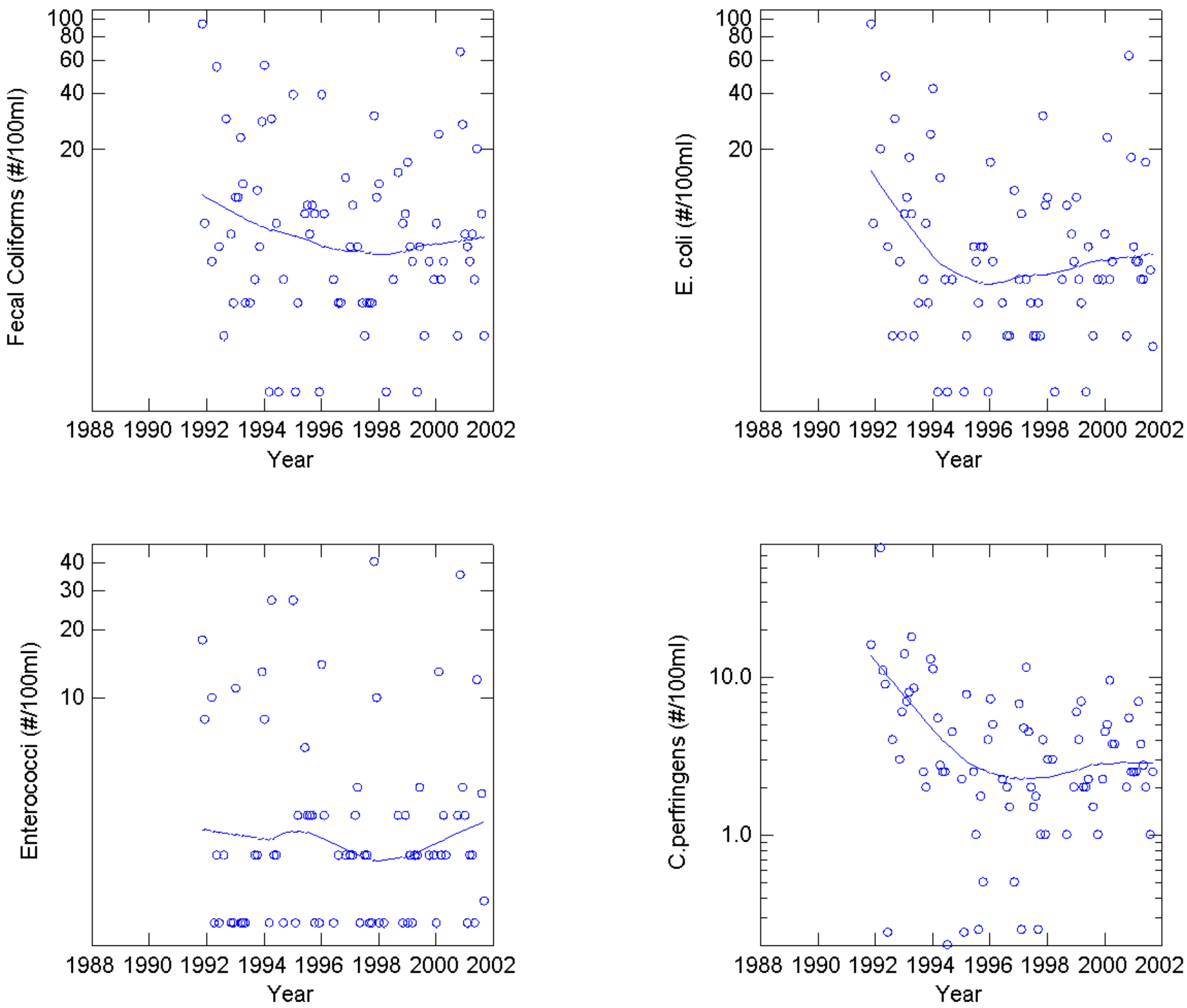
Dry-weather bacteria trends at low tide at Lamprey River



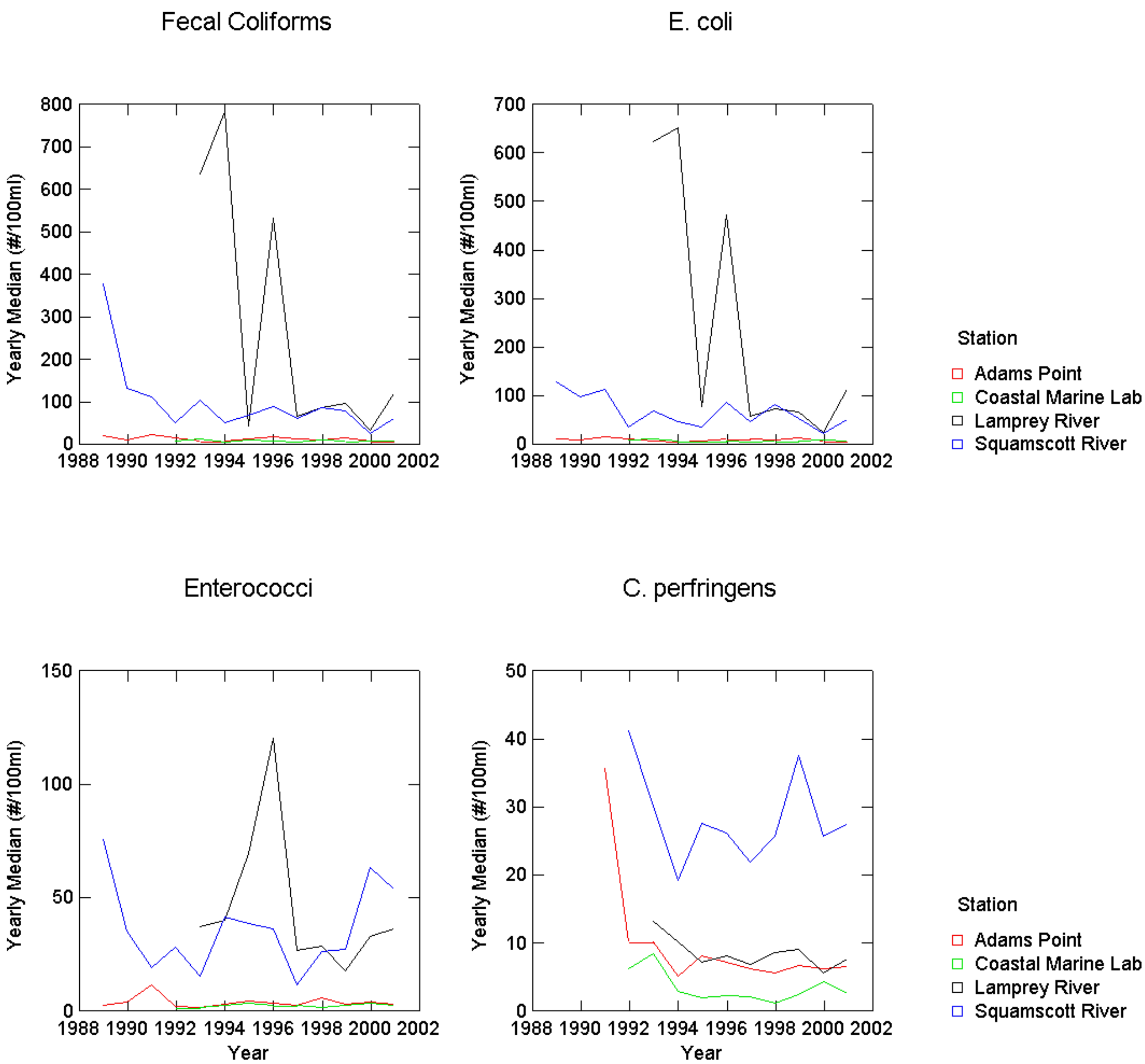
Dry-weather bacteria trends at low tide at Squamscott River



Dry-weather bacteria trends at low tide at the Coastal Marine Lab in Portsmouth Harbor



Trends in Annual Median Bacteria Concentrations in Dry-Weather Samples



BAC4. Tidal Bathing Beach Postings

a. Monitoring Objectives

The objectives for this indicator are to track the number of postings at designated tidal bathing beaches in NH waters. The DES Beach Program monitors designated tidal bathing beaches along the Atlantic Coast of NH during the summer months (Memorial Day to Labor Day). If the concentrations of enterococci in the water do not meet state water quality standards for designated tidal beaches (104 enterococci/100 ml in a single sample), DES recommends that an advisory be posted at the beach. Therefore, the number of postings at tidal beaches should be a good indicator of bacterial water quality at the beaches, which will answer the following monitoring question:

- Do NH tidal waters, including swimming beaches, meet the state enterococci standards?

which will, in turn, report on progress toward the following management objective(s):

- WQ1-2: Minimize beach closures due to failure to meet water quality standards for tidal waters

b. Measurable Goal

The goal is to have 0 postings at the tidal bathing beaches over the summer season.

c. Data Analysis, Statistical Methods, and Hypothesis

The DES Beach Program analyzes the water quality results for each beach and makes a determination whether or not to recommend posting. No other analysis is needed.

d. Results

There have never been any advisories issued for the tidal bathing beaches in New Hampshire since testing began in 1995-1996. Therefore, the management goal is being met. However, please see the next indicator for trends in bacteria concentrations at the tidal bathing beaches.

Number of advisories issued for designated tidal bathing beaches in the coastal watershed

Beach	Town	1996	1997	1998	1999	2000	2001	Goal
Hampton Beach S.P.	Hampton	0	0	0	0	0	0	0
North Beach	Hampton	0	0	0	0	0	0	0
Sawyer Beach	Rye	0	0	0	0	0	0	0
Jenness State Beach	Rye	0	0	0	0	0	0	0
Cable Beach	Rye	0	0	0	0	0	0	0
Pirates Cove Beach	Rye	0	0	0	0	0	0	0
Wallis Sands S.P.	Rye	0	0	0	0	0	0	0
Seabrook Beach	Seabrook	0	0	0	0	0	0	0
New Castle Town Beach	New Castle	0	0	0	0	0	0	0

* The following beaches were added to the DES Beach Program starting in 2002: North Hampton State Beach (North Hampton), Northside Park (Hampton), Bass Beach (Rye), and Foss Beach (Rye)

** Source: DES Beach Program

BAC5. Trends in Bacteria Concentrations at Tidal Bathing Beaches

a. Monitoring Objectives

The objective of this indicator is to determine whether the bacteria concentrations at tidal bathing beaches are increasing or decreasing over time. This information will be useful to managers to determine if pollution control efforts are having a positive effect and as advance warning of potential problems at beaches in the future. This indicator will provide useful supporting information to the management objective of:

- WQ1-2: Minimize beach closures due to failure to meet water quality standards for tidal waters.

b. Measurable Goal

The goal is for no tidal beaches to have significantly increasing trends in enterococci concentrations.

c. Data Analysis, Statistical Methods, and Hypothesis

Routine monitoring data for each beach were extracted from the DES Beach Program database (5-10 samples per beach during the summer season). Non-detected values were assigned a concentration equal to one-half the method detection limit. For each beach, all the results for the summer season were aggregated by calculating a median value for the summer. The Mann-Kendall Test was used to assess significant trends over years with a significance level of 0.10 for a two-sided test. Trend analysis was not completed unless at least 5 years of data were available for a site.

d. Results

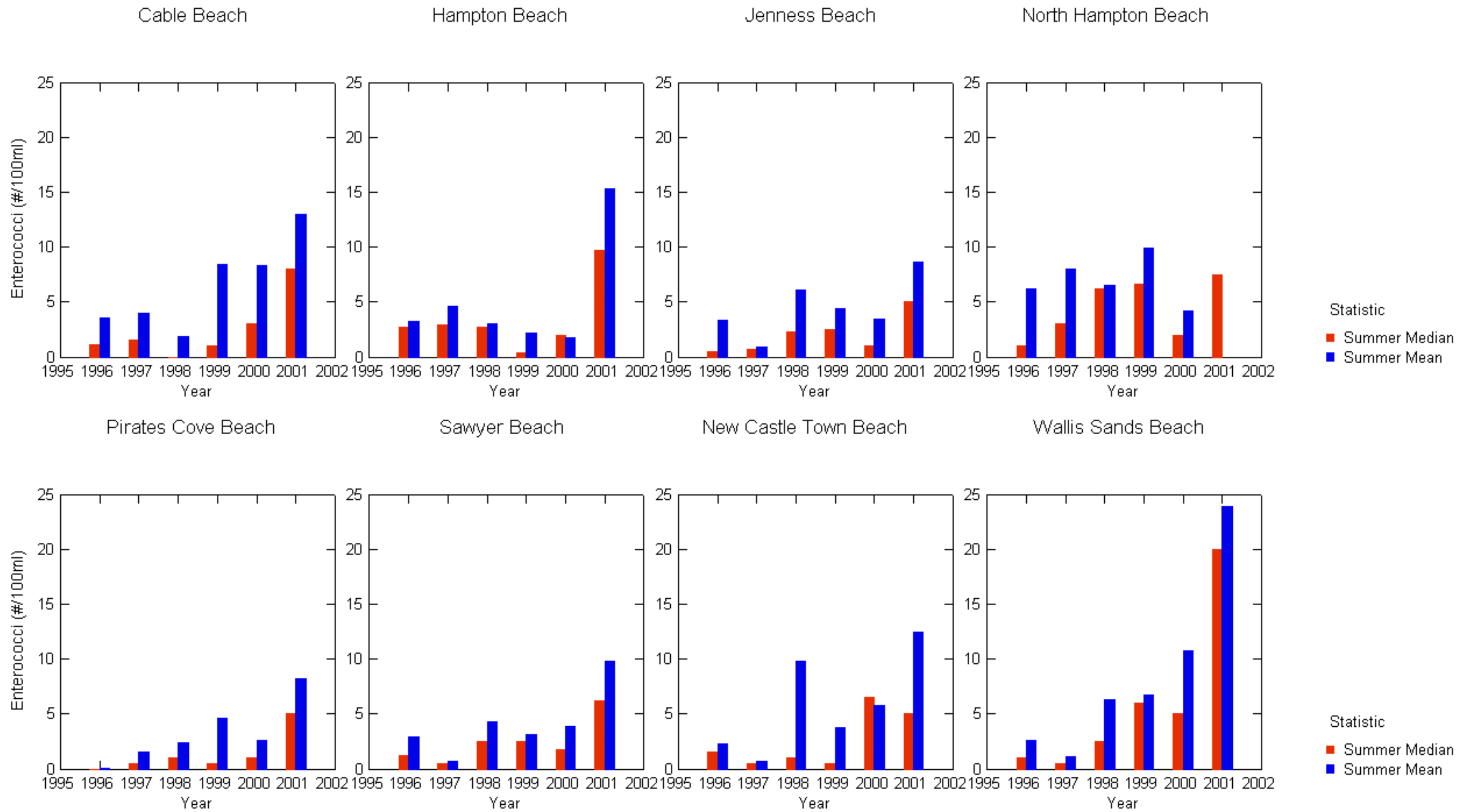
Enterococci concentrations are generally very low at all the tidal beaches. However, three of the beaches had statistically significant trends: Jenness State Beach, Pirates Cove Beach, and Wallis Sands Beach. Therefore, the management goal is not being met. Even though no water quality standards have been violated, the enterococci concentrations at these three beaches have increased by 875-1,000% over the past six years. The trend and absolute concentrations were greatest at Wallis Sands Beach. The following table and figure illustrate the trends at each of the beaches.

Enterococci concentrations and trends at designated tidal bathing beaches in NH

Beach	Town	Median (#/100ml)	Trend (1996-2001)	Percent Change	Comments
Hampton Beach S.P.	Hampton	2.8	No significant trend		
North Beach	Hampton	4.0	No significant trend		
Sawyer Beach	Rye	2.0	No significant trend		
Jenness State Beach	Rye	2.0	**Increasing**	875%	
Cable Beach	Rye	2.0	No significant trend		
Pirates Cove Beach	Rye	1.0	**Increasing**	1,000%	
Wallis Sands S.P.	Rye	4.2	**Increasing**	1,000%	
Seabrook Beach	Seabrook	NA	NA		Not enough data for trend analysis
New Castle Town Beach	New Castle	1.5	No significant trend		

Source: DES Beach Program

Trends in the summer enterococci concentrations at designated tidal beaches in New Hampshire



BAC6. Violations of Enterococci Standard in Tidal Waters

a. Monitoring Objectives

The state water quality standard for swimming in tidal waters (RSA 485-A:8) is based on the concentrations of enterococci bacteria in the water (104 #/100ml for individual samples, 35 #/100ml for the geometric mean of 3 or more samples collected over 60 day period). This indicator will use measurements of enterococci bacteria throughout the estuaries to determine the number of violations of the state standards, which will answer the following monitoring question:

- Do NH tidal waters, including swimming beaches, meet the state Enterococci standards?

which will, in turn, report on progress toward the following management objective(s):

- WQ-1-2: Minimize beach closures due to failure to meet water quality standards for tidal waters.

b. Measurable Goal

The goal is to have 0 violations of RSA 485-A:8 per year in the estuarine waters.

c. Data Analysis, Statistical Methods, and Hypothesis

Concentrations were evaluated relative to standards using the DES Assessment and Listing Methodology for the 2002 305b Water Quality Report.

d. Results

Data reviewed for the 2002 305b report identified four areas where the measured water quality met the conditions to be listed as impaired for enterococci. These locations, as well as other areas of the estuary that were tested for enterococci, are shown on the following table.

Area	Assessment Unit	Enterococci Violations	Comments
Lamprey River	NHEST600030709-01	**Yes**	
Squamscott River	NHEST600030806-01	**Yes**	
Bellamy River	NHEST600030903-01	No	This segment was still listed as impaired due to sewage discharges from Mill Street SSO in Dover.
Great Bay	NHEST600030904-04	No	
Upper Little Bay	NHEST600030904-05	No	
Lower Little Bay	NHEST600030904-06-01	No	
Upper Piscataqua River	NHEST600031001-01	No	
Back Channel	NHEST600031001-05	No	This segment was still listed as impaired due to direct discharges of untreated sewage.
Upper Portsmouth Harbor	NHEST600031001-06	No	
South Mill Pond	NHEST600031001-09	**Yes**	
North Mill Pond	NHEST600031001-10	**Yes**	
Little Harbor	NHEST600031002-02	No	
Hampton River	NHEST600031004-04-03	No	
Hampton/Seabrook Harbor	NHEST600031004-09-01	No	
Hampton/Seabrook Harbor	NHEST600031004-09-02	No	This segment was still listed as impaired due to WWTF bypasses.

Source: DES Watershed Management Bureau, Water Quality Planning Section

BAC7. Freshwater Bathing Beach Postings

a. Monitoring Objectives

The objectives for this indicator are to track the number of postings at designated freshwater bathing beaches in NH's coastal watershed. The DES Beach Program monitors designated freshwater bathing beaches in the coastal watershed during the summer months (Memorial Day to Labor Day). If the concentrations of *E. coli* in the water do not meet state water quality standards for designated freshwater beaches (88 *E. coli*/100ml in a single sample), DES recommends that an advisory be posted at the beach. Therefore, the number of postings at freshwater beaches should be a good indicator of bacterial water quality at the beaches, which will answer the following monitoring question:

- Do NH freshwater beaches meet the state *E. coli* standards?

which will, in turn, report on progress toward the following management objective(s):

- WQ1-3: Increase the water bodies in NH's coastal watershed designated "swimmable" by achieving state water quality standards.

b. Measurable Goal

The goal is to have 0 postings at freshwater bathing beaches in the coastal watershed over the summer.

c. Data Analysis, Statistical Methods, and Hypothesis

The DES Beach Program analyzes the water quality results for each beach and makes a determination whether or not to recommend posting. No other analysis is needed.

d. Results

Advisories have been issued for several of the designated freshwater bathing beaches in the coastal watershed, notably the beach at Pawtuckaway State Park. In 2001, four of the beaches were posted. Therefore, the management goal is not being met. The recent beach postings in the coastal watershed are shown in the following table.

Number of advisories issued for designated freshwater bathing beaches in the coastal watershed

Beach	Town	1993	1994	1995	1996	1997	1998	1999	2000	2001	Goal
Lovell Pond Town Beach	Wakefield								1	1	0
Sunrise Lake Town Beach	Middleton							1			0
Milton Three Ponds Recreation Area	Milton							1			0
Bow Lake Town Beach	Strafford		1			1				1	0
Bow Lake Mary Waldron Beach	Northwood										0
Lucas Pond Town Beach	Northwood										0
Pawtuckaway Lake Town Beach	Nottingham										0
Pawtuckaway Lake State Park	Nottingham	3	3	1	2	5	3		1	2	0
Carroll Lake Town Beach	Raymond										0
Phillips Pond Town Beach	Sandown									1	0

Source: DES Beach Program

BAC8. Bacteria Load from Wastewater Treatment Plants

a. Monitoring Objectives

Several municipal WWTF discharge treated effluent directly to NH's tidal waters. These bacteria loads are one of the factors influencing the ambient bacteria concentrations in the estuary. WWTF are required to report their monthly discharges of bacteria as part of the NPDES program. Therefore, in order to better understand the relationship between ambient concentrations, this readily available information was gathered and analyzed. This supporting variable will be helpful for interpreting other indicators related to the following management goal:

- Water Quality Goal #1: Ensure that NH's estuarine waters and tributaries meet standards for pathogenic bacteria including fecal coliform, *E. coli*, and enterococci.

b. Measurable Goal

This is a supporting variable so no measurable goals have been established. These data will be collected to provide additional information to help interpret the results of other indicators.

c. Data Analysis, Statistical Methods, and Hypothesis

For each WWTF that discharges directly to NH estuarine waters, the mean monthly discharge and monthly geomean total coliform concentration were multiplied to estimate the mean monthly total coliform load in units of billions of organisms discharged per day. Trends in the monthly loads, monthly total coliform concentrations, and monthly flows were assessed using the Seasonal Kendall Test with a significant level of 0.10 for two-tailed test.

Some of the wastewater treatment plants have recently switched from recording total coliforms to recording fecal coliforms. This trend analysis has only been done on the total coliforms data to avoid having to estimate fecal coliform concentrations based on measurements of total coliforms. Therefore, some of the time series analyzed end before 2001 at the point when the WWTF switch from total to fecal coliforms.

Data for the eight WWTFs in NH were obtained from EPA Region I and analyzed for trends. There was incomplete data for the two WWTFs in Maine so trends could not be assessed. Bacteria loads from the Portsmouth WWTF could not be calculated because this WWTF is only required to report the monthly maximum total coliform concentration, not the monthly average, on its Discharge Monitoring Reports.

d. Results

The results show that in Great Bay, the bacteria loads from WWTFs are generally increasing. There are statistically significant increases from the Durham and Dover WWTFs. The Exeter WWTF does not exhibit statistically significant trends but the graph shows that the discharges from this plant are increasing following a drop in the mid-1990s. In contrast, the bacteria loads to Hampton Harbor have undergone a significant decrease over the past decade.

Bacteria loads are the product of monthly flow and monthly average total coliform concentrations at each plant. Therefore, the increasing loads could be due to increased flow (e.g., from growth of population served) or increased total coliform concentrations in the effluent. Trend analysis of the concentrations and flows separately indicates that increased concentrations in the WWTF effluent are largely responsible for the increased loading.

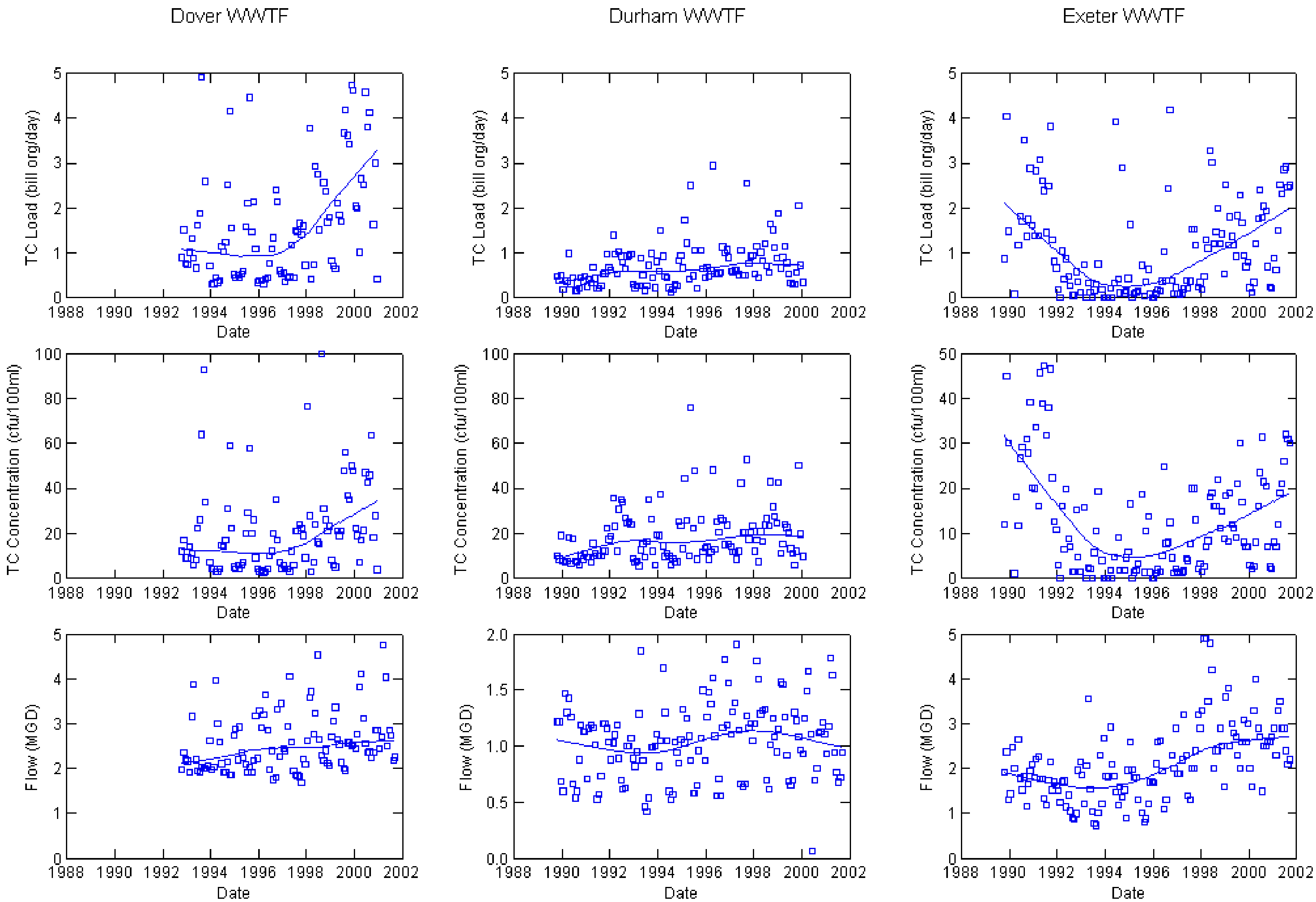
The results of the trend analysis are shown in the following table. Time series of the total coliform loads from the six largest plants are shown in the following figures. These figures also show the trends in flow and total coliform concentrations at these plants.

Bacteria load from wastewater treatment plants discharging to NH estuarine waters

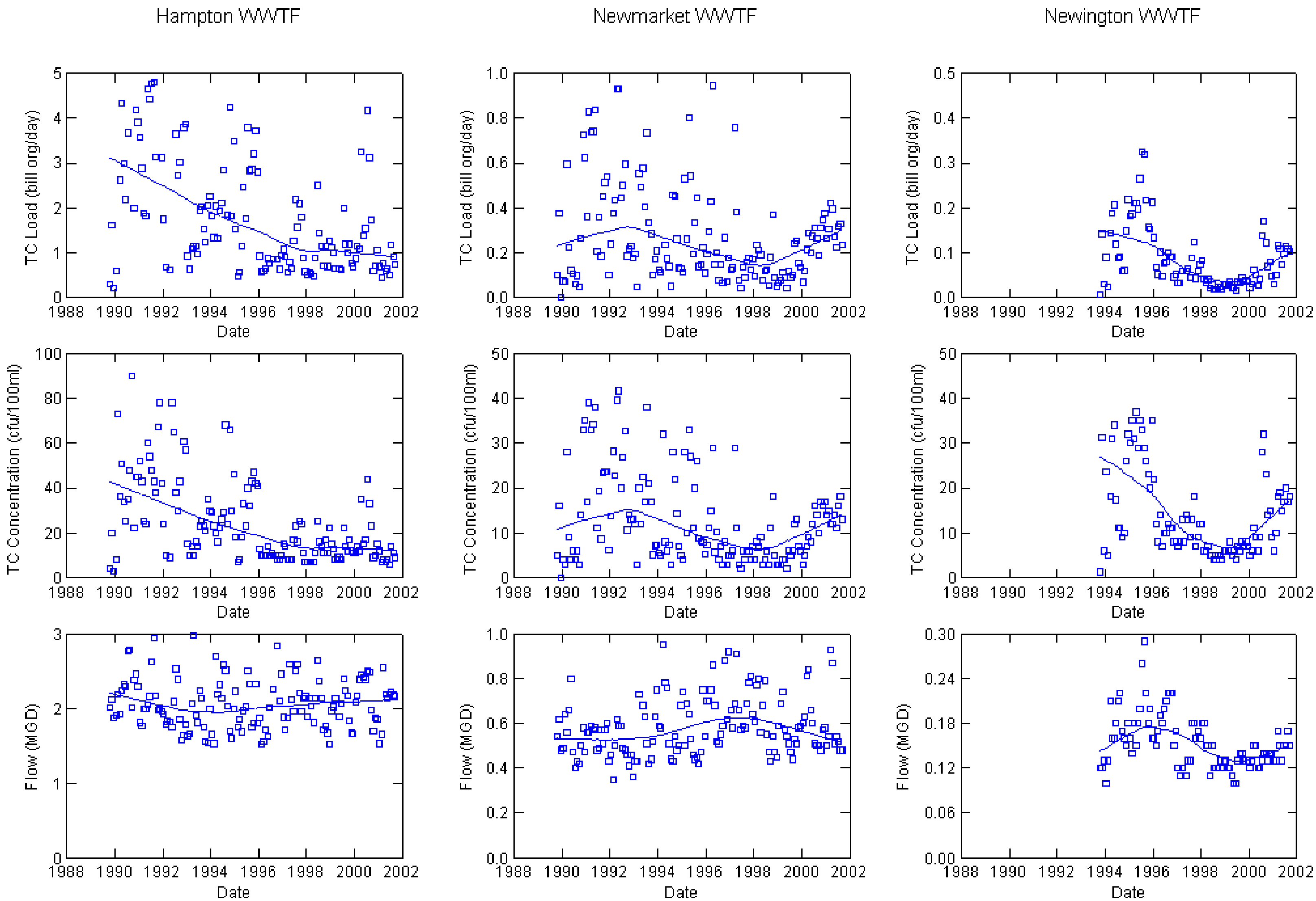
WWTF	Period of Record	Median (bill org/day)	Bacteria Load Trend	Percent Change	Bacteria Concentration Trend	Flow Trend	Comments
Dover WWTF	10/90 to 9/00	1.46	**Increasing**	202%	99%	29%	
Durham WWTF	10/89 to 9/99	0.58	**Increasing**	131%	82%	16%	
Exeter WWTF	10/89 to 9/01	0.75	No Significant Trend		No Significant Trend	109%	
Hampton WWTF	10/89 to 9/01	1.38	**Decreasing**	-91%	-88%	No Significant Trend	
Newfields WWTF	10/96 to 9/01	0.02	No Significant Trend		-56%	36%	
Newington WWTF	10/93 to 9/01	0.06	**Decreasing**	-75%	-55%	-23%	
Newmarket WWTF	10/89 to 9/01	0.21	**Decreasing**	-41%	-50%	14%	
Portsmouth WWTF	NA	NA					DMRs only report monthly maximum TC.
Kittery WWTF	NA	NA					Data not available in time for this report.
So. Berwick WWTF	NA	NA					Data not available in time for this report.

Source: EPA Region I, PCS database

Bacteria load, bacteria concentrations, and flow from wastewater treatment plants discharging to NH estuarine waters



Bacteria load, bacteria concentrations, and flow from wastewater treatment plants discharging to NH estuarine waters (continued)



TOX1. Shellfish Tissue Concentrations relative to FDA Standards

a. Monitoring Objectives and Performance Criteria

The objective of this indicator is to determine whether shellfish from the estuaries contain toxic contaminants in their tissues at concentrations greater than FDA guidance values, and, if they do, how much of the estuary is affected by this contamination. For this indicator, the concentrations of toxic contaminants in mussel, oyster, and clam tissue from various locations in the estuary have been measured. The chemicals measured in the tissue were: heavy metals, PCBs, PAHs, and chlorinated pesticides. The results from this indicator will partially answer the following monitoring question:

- Are shellfish, lobsters, finfish, and other seafood species from NH coastal waters fit for human consumption?

and will directly report on progress toward the following management objective:

- WQ-2-1A: Reduce toxic contaminants levels in indicator species so that no levels persist or accumulate according to FDA guideline levels.

b. Measurable Goal and Performance Criteria

The goal is for 0% of stations to have mean shellfish tissue concentrations greater than FDA guidance values

c. Data Analysis, Statistical Methods and Hypothesis

For data analysis, procedures for aggregating congeners, testing for normality, and calculating descriptive statistics from the Gulfwatch Program were followed (Chase et al., 2001). For each compound at each station, the replicate samples were used to compute an average and standard deviation. The mean concentration was tested against the FDA guidance value by computing the 95th percentile upper confidence level (UCL) of the mean and comparing it to the FDA criteria. This process is equivalent to using a one sample t-test with an alpha value of 0.05 to test for differences between the mean value and the criteria.

d. Results

Between 1993 and 1999, 12 stations in NH's estuaries have been tested for toxic contaminants in blue mussel tissue under the Gulfwatch Program. Five of the stations were tested in multiple years. The upper confidence level of the mean for each parameter at each station is listed in the following table. The station locations are shown in figure on the page after the table. None of the UCL values were greater than FDA criteria. Therefore, the goal of having no stations with concentrations greater than FDA values has been met for the period 1993-1999.

Of all the compounds, only lead had concentrations approaching its respective FDA standard. The maximum UCL lead concentration was 8.8 ug/g compared to its guidance value of 11.5 ug/g. In contrast, the maximum PCB concentration of 87 ng/g was only 0.7% of its tolerance level (13,000 ng/g). Mercury, one of the priority pollutants for the Gulf of Maine Council, had maximum UCL concentrations equal to 20% of the FDA guidance value.

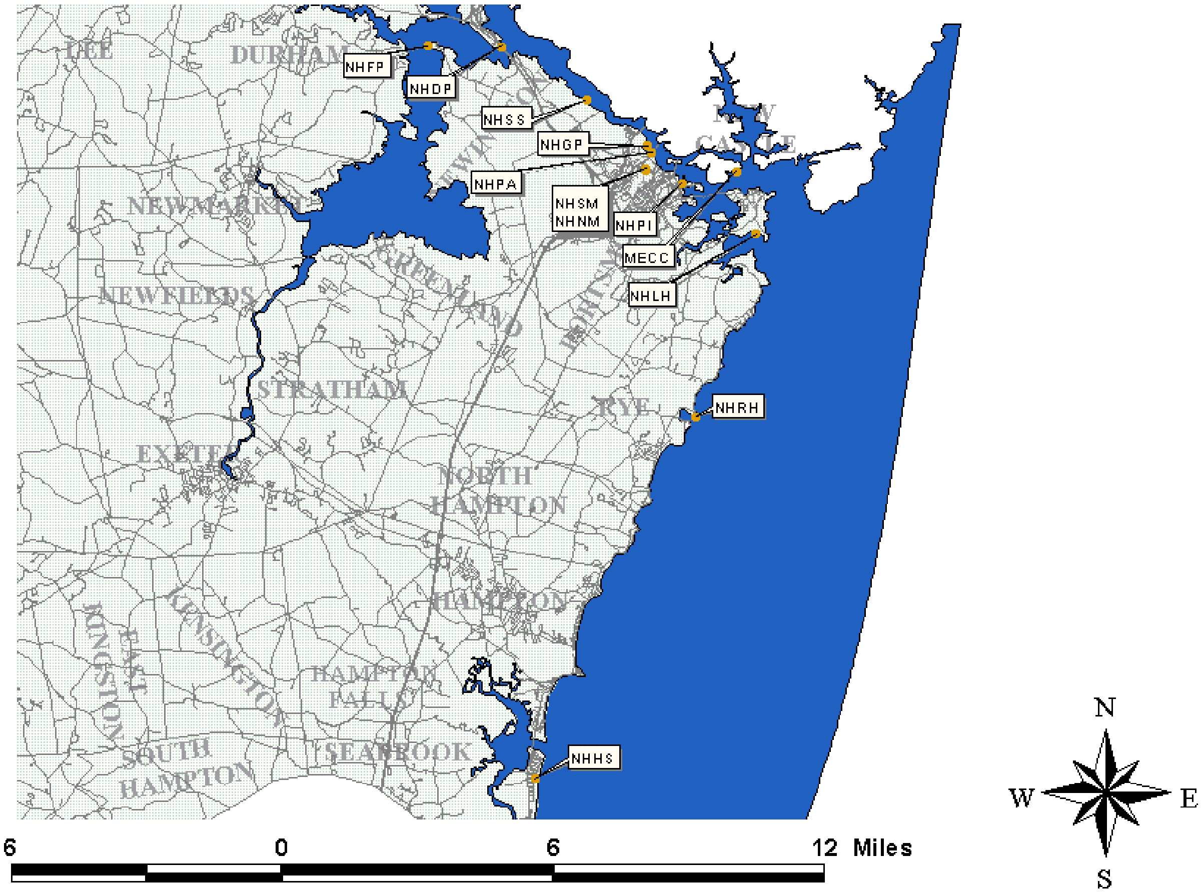
Gulfwatch mussel tissue samples, 95th percentile upper confidence limit of the mean concentrations, 1993-1999

STATION	YEAR	AG	AL	CD	CR	CU	FE	HG	NI	PB	ZN	PAH24	PCB24	PEST17	DDT6
MECC	1993	0.17	315	2.80	5.34	8.88	754	0.84	2.90	8.81	152	228	87.3	19.5	19.5
MECC	1994	0.05	190	1.85	2.16	9.27	461	0.71	1.75	5.36	105	152	74.4	14.6	14.6
MECC	1995	0.19	387	1.93	4.63	12.16	597	0.76	1.93	7.13	151	219	51.5	15.3	15.3
MECC	1996	0.10	409	2.03	3.40	9.20	615	1.35	1.63	5.87	120	238	40.2	9.6	9.6
MECC	1997	0.09	519	2.03	3.53	8.88	789	0.76	2.29	6.77	162	177	50.6	23.3	15.6
MECC	1998	0.05	400	2.28	4.28	8.26	654	0.99	4.04	6.86	173	240	54.3	19.0	14.8
MECC	1999	0.05	245	1.58	2.03	7.75	378	0.67	1.46	4.81	129	225	46.3	5.3	5.3
NHDP	1994	0.12	281	3.58	3.48	9.27	547	0.88	1.95	3.85	178	213	36.1	14.3	10.3
NHDP	1997	0.08	290	1.95	3.04	7.37	376	0.80	1.54	2.19	132	330	74.3	26.7	21.5
NHDP	1998	0.05	264	3.25	3.04	7.17	465	1.04	2.02	3.52	153	276	45.2	20.2	16.1
NHHS	1993	0.06	127	2.52	2.32	6.93	355	0.85	1.79	2.79	135	79	11.5	5.2	5.2
NHHS	1995	0.05	287	1.98	2.69	9.81	456	0.45	1.68	3.19	170	106	28.1	15.8	13.8
NHHS	1996	0.15	201	1.79	1.75	8.69	308	0.63	1.23	3.68	131	210	43.3	9.6	9.6
NHHS	1999	0.05	193	2.43	1.53	7.97	278	0.42	1.54	3.69	144	63	13.2	9.1	7.6
NHLH	1995	0.08	439	2.64	3.31	10.21	704	0.85	1.88	8.33	183	95	15.5	14.5	14.5
NHLH	1998	0.05	212	2.58	4.30	5.65	472	1.09	2.00	5.24	133	97	15.3	11.5	5.7
NHRH	1994	0.05	141	1.63	1.63	7.47	303	0.71	1.63	2.43	118	35	6.6	3.9	3.9
NHRH	1997	0.12	276	2.19	4.03	10.93	471	0.90	2.88	3.60	177	83	14.5	15.4	11.1
NHNM	1998	0.05	346	2.56	3.02	7.51	641	0.98	1.56	7.47	168	743	80.7	82.5	75.9
NHPA	1999	0.05	239	2.22	2.36	8.31	336	0.89	1.95	3.96	134	323	58.2	20.8	14.9
NHPI	1999	0.05	281	2.77	3.91	9.19	520	0.90	1.53	6.31	184	305	51.5	16.7	14.5
NHSM	1999	0.05	277	1.10	3.32	7.34	498	0.94	3.51	5.19	67	466	45.5	37.0	32.7
NHSS	1998	0.05	247	3.06	2.59	6.90	445	1.24	1.83	3.91	143	268	40.0	18.1	11.5
NHFP	1999	0.21	313	2.67	2.89	7.64	471	0.73	1.68	3.73	167	403	66.3	20.3	16.0
NHGP	1998	0.05	253	2.75	2.96	6.72	522	1.00	1.73	4.21	151	184	28.0	17.1	12.1

Maximum		0.21	519	3.58	5.34	12.16	789	1.35	4.04	8.81	184	743	87.26	82.48	75.86
FDA criteria		NA	NA	25	87	NA	NA	6.7	533	11.5	NA	NA	13000	700	33000
Units		ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ng/g	ng/g	ng/g	ng/g

Source: GOMC/NH Gulfwatch Program

Gulfwatch Stations in Coastal NH



TOX3: Trends in Shellfish Tissue Contaminant Concentrations

a. Monitoring Objectives

The objective of this supporting variable is to answer the following monitoring question:

- Have the concentrations of toxic contaminants in estuarine biota significantly changed over time?

which will, in turn, report on progress toward the following management objective:

- WQ2-1A: Reduce toxic contaminants levels in indicator species so that no levels persist or accumulate according to FDA guideline levels.

In order to achieve this objective, the concentrations of toxic contaminants (metals, PCBs, PAHs, pesticides) in mussel tissue has been measured at a benchmark site in consecutive years to assess trends over time.

b. Measurable Goal

No goals have been established for this supporting variable. These data will be collected to provide the NHEP scientists with additional information to help interpret the results of hypothesis tests for other indicators.

c. Data Analysis and Statistical Methods

For data analysis, procedures for aggregating congeners, testing for normality, and calculating descriptive statistics from the Gulfwatch Program were followed (Chase et al. 2001). Repeated measures Analysis of Variance (ANOVA) with a first-degree polynomial model (which is identical to linear regression) was used to determine whether there is a significantly increasing or decreasing linear trend in concentrations over time. ANOVA calculations were run on both raw and log-transformed data. Linear coefficients with a probability of <0.05 of being different from zero were considered to be statistically significant.

d. Results

For the period between 1993 and 1999, mussel tissue has been analyzed annually in Portsmouth Harbor. Statistical analyses showed that four of the compounds have statistically significant linear trends. Silver, PCBs, and DDT have exhibited a decreasing trend. PAHs have an increasing trend over time. These trends were significant for both the raw and the log-transformed data. The regression results for the raw data are summarized in the following table and figure. The significant trend for silver is probably erroneous so it was replaced on the figure by a graph of mercury concentrations (a GOMC priority pollutant). Silver concentrations were below detection limits in all replicates from Portsmouth Harbor in 1994, 1998, and 1999. Since there was no variability between replicates in these years, the regression was skewed.

Using data from Portsmouth Harbor from 1993-1997, Chase et al. (2001) determined that there were significantly increasing trends for aluminum and significantly decreasing trends for cadmium, nickel, zinc, and PCBs. The results from the analysis above, based on two additional years of Gulfwatch data, show that only the decreasing PCB trend persists and that new trends for PAHs and DDTs have emerged. The decreasing PCB and DDT concentrations match the trend of decreased use of these chemicals. One explanation for the increasing PAH concentrations is that the growing amount of impervious surfaces in the Seacoast has caused for more petroleum-polluted runoff to be discharged to the estuary via stormwater conduits.

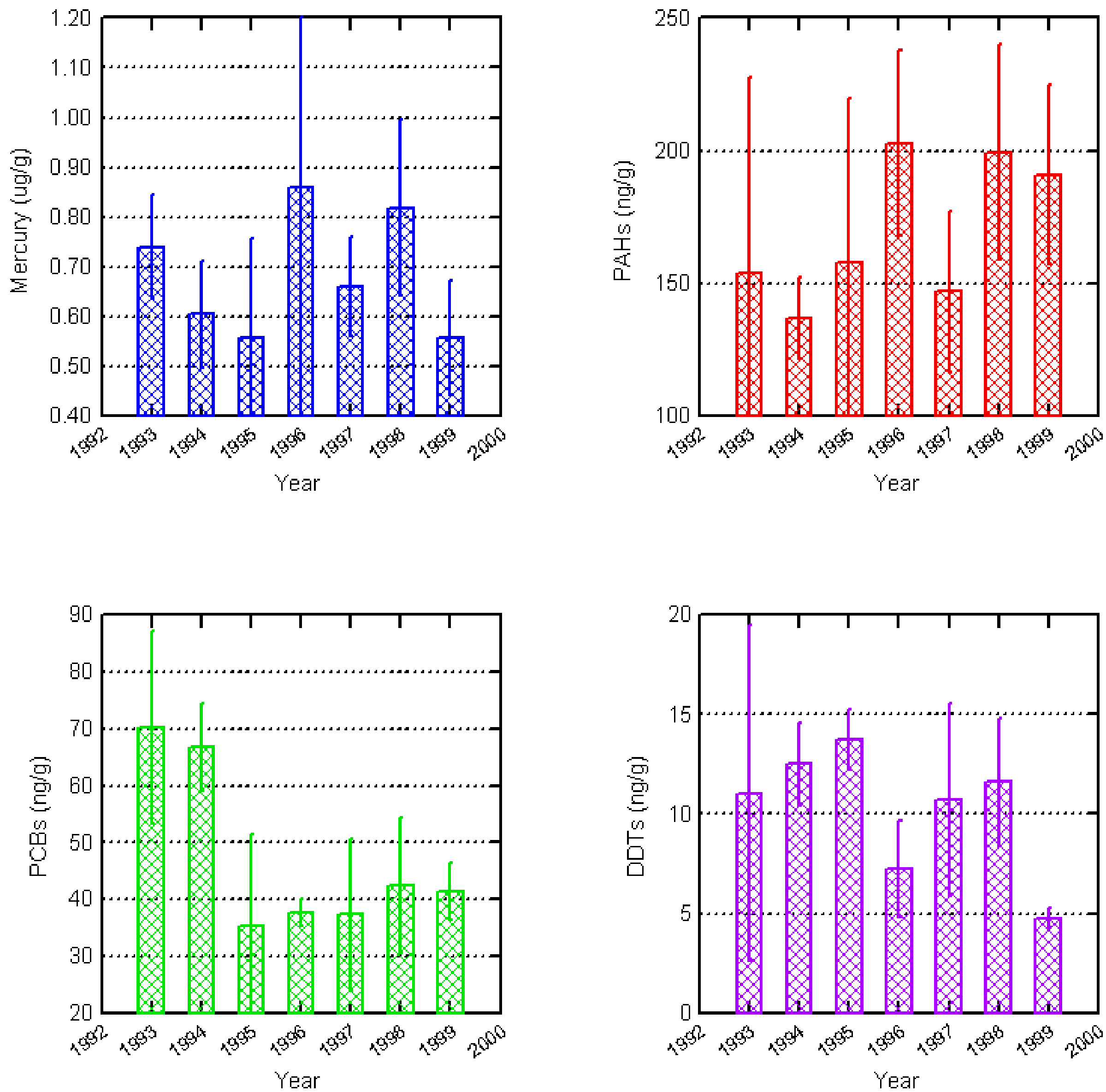
Trends in contaminant concentrations in mussel tissue from Portsmouth Harbor, 1993-1999

Contaminant	Trend for 1993-1999	Median	Regression Equation	Percent Change 1993-1999
Silver	**Decreasing**	0.05 ug/g	AG= -0.007*YEAR + 13.257	-6%
Aluminum	No significant trend			
Cadmium	No significant trend			
Chromium	No significant trend			
Copper	No significant trend			
Iron	No significant trend			
Mercury	No significant trend			
Nickel	No significant trend			
Lead	No significant trend			
Zinc	No significant trend			
PAHs	**Increasing**	119.29 ng/g	PAH = 8.062*YEAR - 15922	+33%
PCBs	**Decreasing**	25.09 ng/g	PCB = -4.765*YEAR + 9557	-47%
Pesticides (PEST17)	No significant trend			
DDTs	**Decreasing**	4.38 ng/g	DDT= -0.843*YEAR + 1693	-39%

Source: GOMC/NH Gulfwatch Program

The following figures illustrate the changes over time for the compounds with statistically significant linear trends. The error bars on the graphs are 2 standard errors of the mean.

Trends for Toxic Contaminants in Blue Mussel Tissue from Portsmouth Harbor



NUT2: Trends in Estuarine Nutrient Concentrations

a. Monitoring Objectives

The objective of this supporting variable is to quantify long-term trends in nutrient concentrations (nitrate, nitrite, ammonia, and orthophosphate) in estuarine waters. This indicator will answer the following monitoring question:

- Have levels of dissolved and particulate nitrogen and phosphorous signficantly changed over time?

which will, in turn, provide supporting information toward the following management objectives:

- WQ3-1: Maintain inorganic nutrients, nitrogen, phosphorus, and chlorophyll-a in Great Bay, Hampton Harbor, and their tributaries at 1998-2000 baseline levels.
- WQ3-2: Maintain organic nutrients in Great Bay, Hampton Harbor, and their tributaries at 1994-1996 baseline levels

b. Measurable Goals

This is a supporting variable so no measurable goal has been established. These data will be collected to provide additional information to help interpret the results of other indicators.

c. Data Analysis and Statistical Methods

For the GBNERR stations at Adams Point in Great Bay, Squamscott River at Chapmans Landing, Lamprey River at the Newmarket Town Landing trends in 13 years of monthly measurements of the nutrient species were assessed using the Seasonal Kendall Test. The full dataset was used in the SKT analysis for ammonia and orthophosphate. However, only data from October 1991 onwards were used for nitrate+nitrate trends because different analytical methods for nitrate+nitrite were used before this date. A significance level of 0.10 was used to identify statistically significant trends in two-sided tests. Nutrients are being measured at other locations in the estuary but no other stations have amassed the 5 years of monthly measurements that are needed for trend analysis.

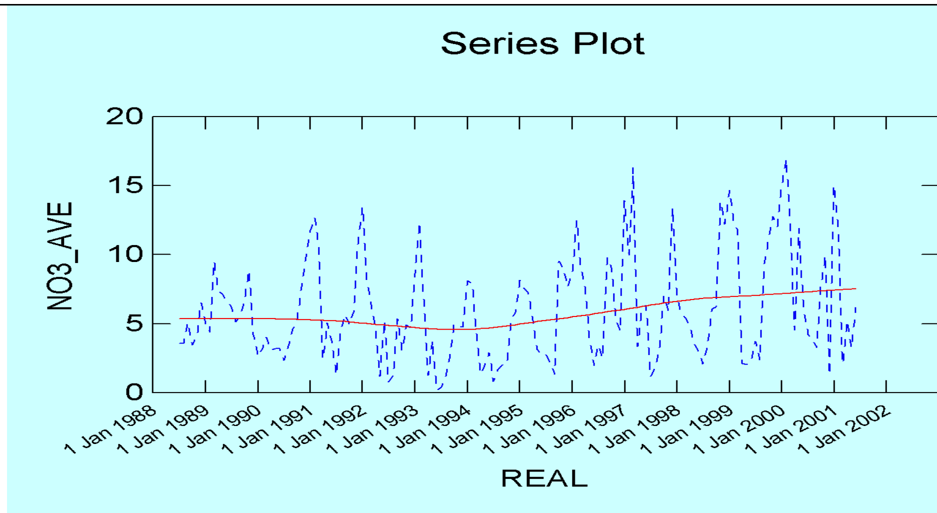
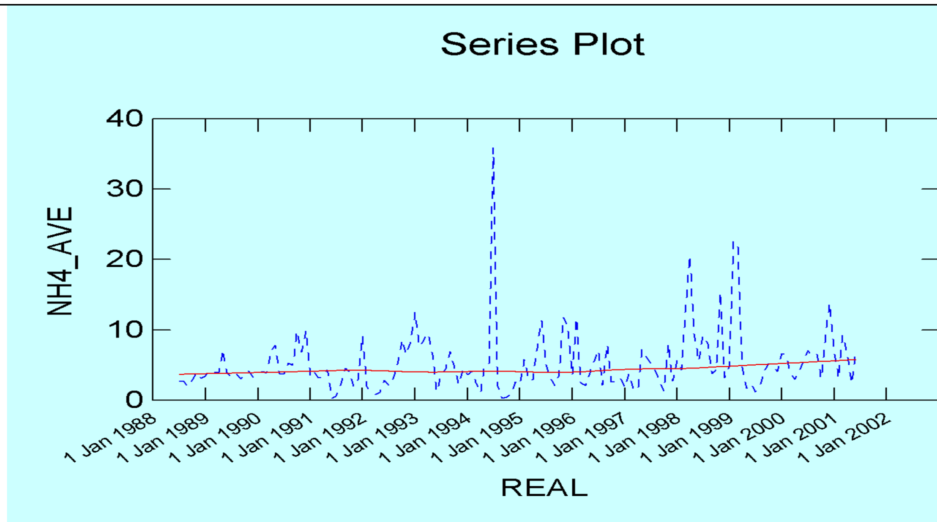
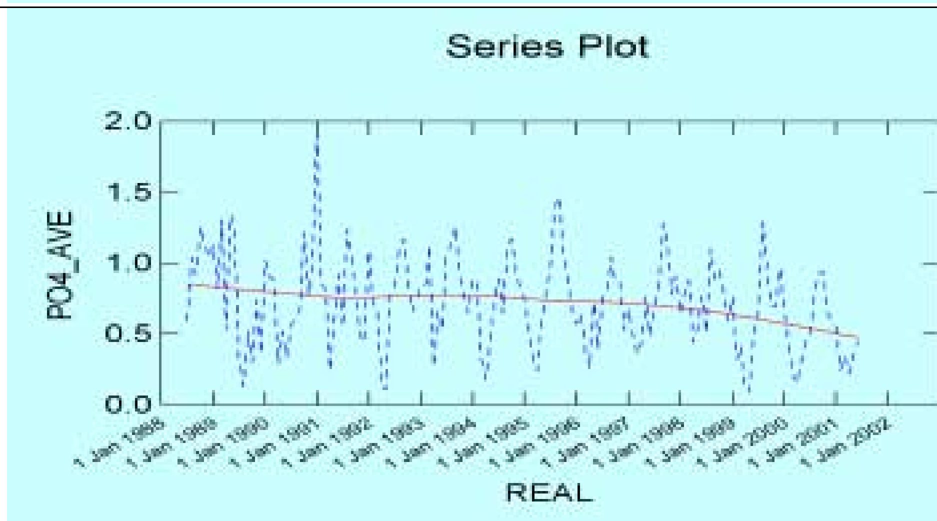
d. Results

The trend analysis shows a significantly increasing trend for nitrate+nitrite and ammonia at the Adams Point and Lamprey River stations but no significant trend at the Squamscott River station. Likewise, orthophosphate concentrations have dropped significantly in at Adams Point and the Lamprey River but not in the Squamscott.

These results are summarized in the following figures. The blue lines are measurements. The red lines are LOWESS smooths of the data with a 0.5 tension. Results of the Seasonal Kendall Test are listed next to each time series plot.

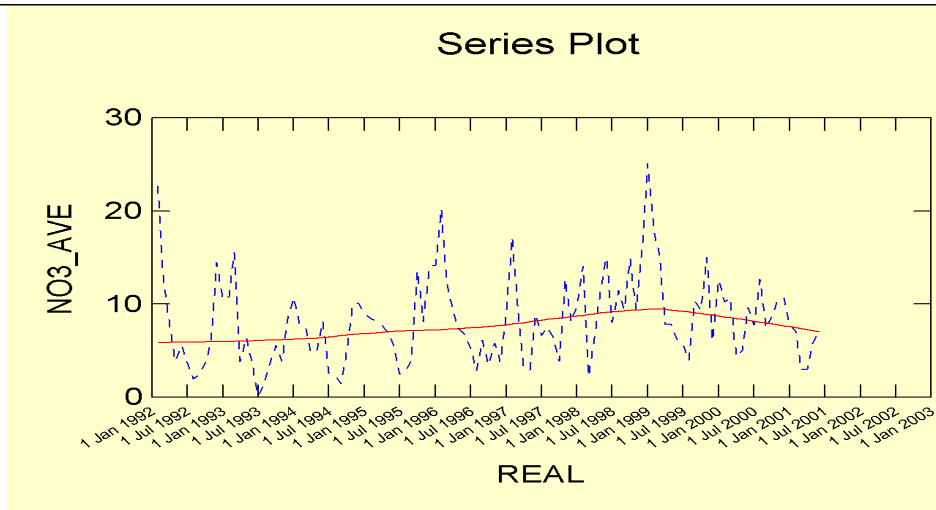
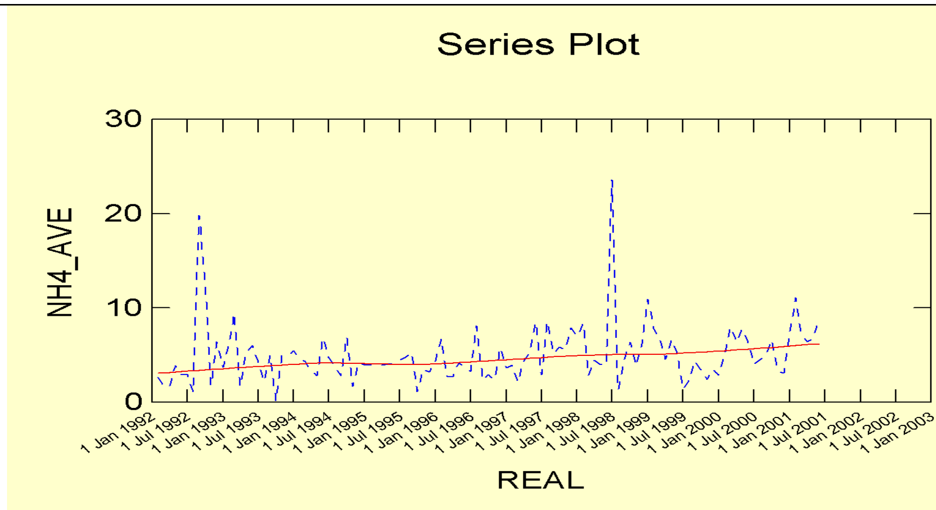
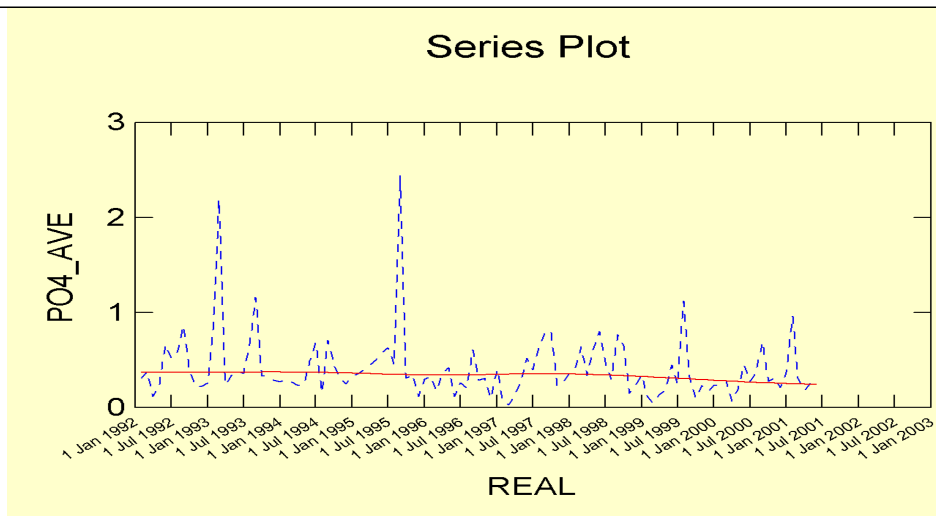
Despite the increasing concentrations of nitrogen and phosphorous in the estuary, trends for a typical eutrophication variable, chlorophyll-a concentrations, are not-significant.

Average of high and low tide nutrient concentrations at Adams Point

Nitrate+Nitrite (NO3+NO2) (uM) **Increasing trend**. Approximately 110% increase in central tendency concentrations from 10/91 to 9/01. (p=0.000, tau=0.34)	
Ammonia (NH4) (uM) **Increasing trend**. Approximately 50% increase in central tendency concentrations from 10/88 to 9/01. (p=0.041, tau=0.13)	
Orthophosphate (PO4) (uM) **Decreasing trend**. Approximately 30% decrease in central tendency concentrations from 10/88 to 9/01. (p<0.001, tau=-0.24)	

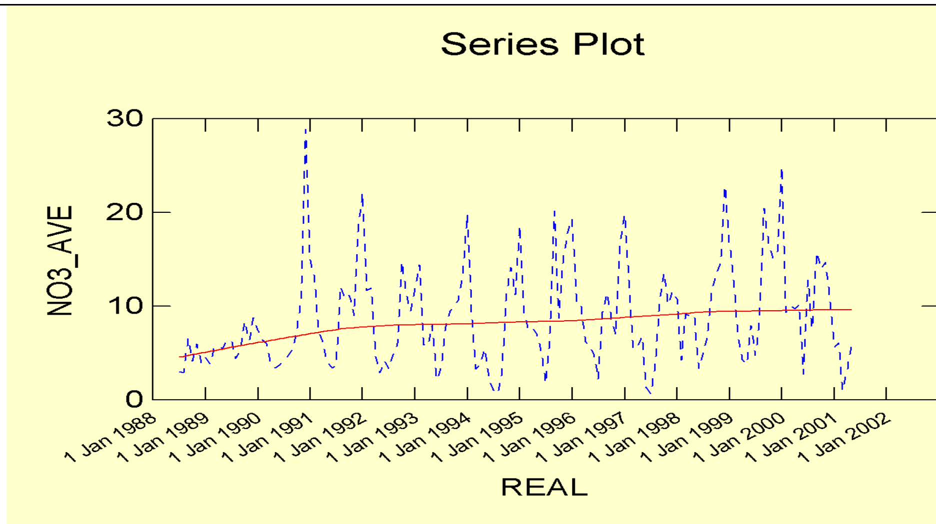
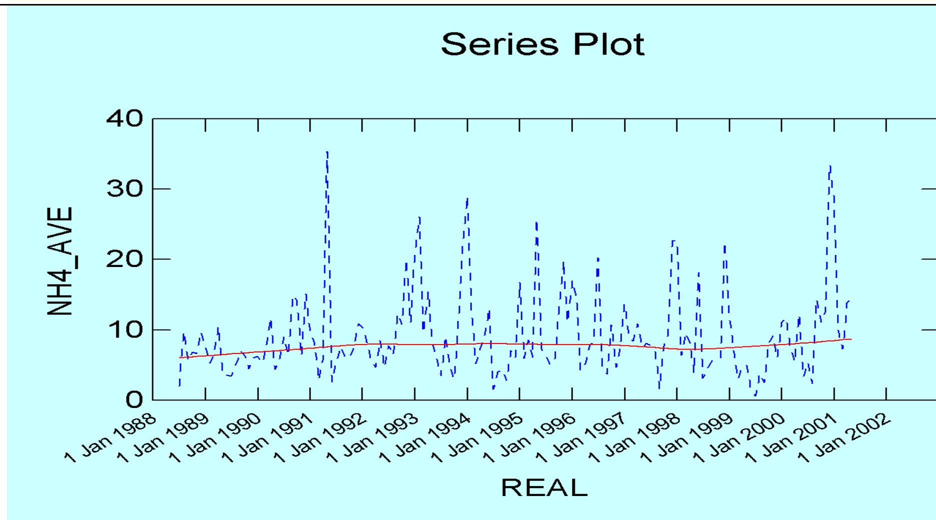
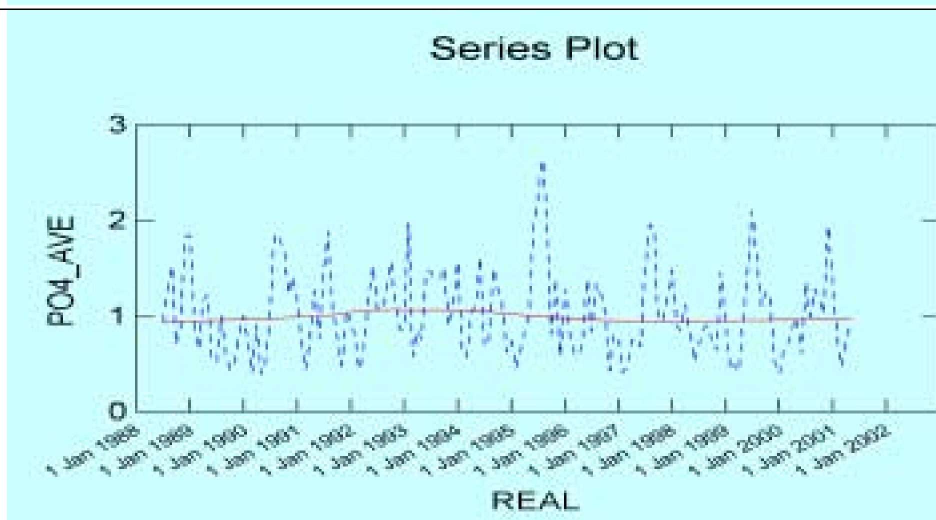
Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

Average of high and low tide nutrient concentrations at Lamprey River (Newmarket Town Landing)

Nitrate+Nitrite (NO3+NO2) (uM) **Increasing trend**. Approximately 70% increase in central tendency concentrations from 10/92 to 9/01. (p=0.0056, tau=0.24)	
Ammonia (NH4) (uM) **Increasing trend**. Approximately 55% increase in central tendency concentrations from 10/92 to 9/01. (p=0.033, tau=0.24)	
Orthophosphate (PO4) (uM) **Decreasing trend**. Approximately 25% decrease in central tendency concentrations from 10/92 to 9/01. (p=0.054, tau=0.18)	

Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

Average of high and low tide nutrient concentrations at Squamscott River at Chapmans Landing

Nitrate+Nitrite (NO3+NO2) (uM) **No significant trend**	
Ammonia (NH4) (uM) **No significant trend**	
Orthophosphate (PO4) (uM) **No significant trend**	

Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

NUT3: Trends in Estuarine Particulate Concentrations

a. Monitoring Objectives

The objective of this supporting variable is to quantify long-term trends in particulate concentrations (total suspended solids, particulate organic matter) in estuarine waters. This indicator will answer the following monitoring question:

- Have surface tidal or freshwaters shown a significant change in turbidity over time?

which will, in turn, provide supporting information on the following management objectives:

- WQ3-1: Maintain inorganic nutrients, nitrogen, phosphorous, and chlorophyll-a in Great Bay, Hampton Harbor, and their tributaries at 1998-2000 baseline levels.
- WQ3-2: Maintain organic nutrients in Great Bay, Hampton Harbor, and their tributaries at 1994-1996 baseline levels

b. Measurable Goals

This is a supporting variable so no measurable goal has been established. These data will be collected to provide additional information to help interpret the results of other indicators.

c. Data Analysis and Statistical Methods

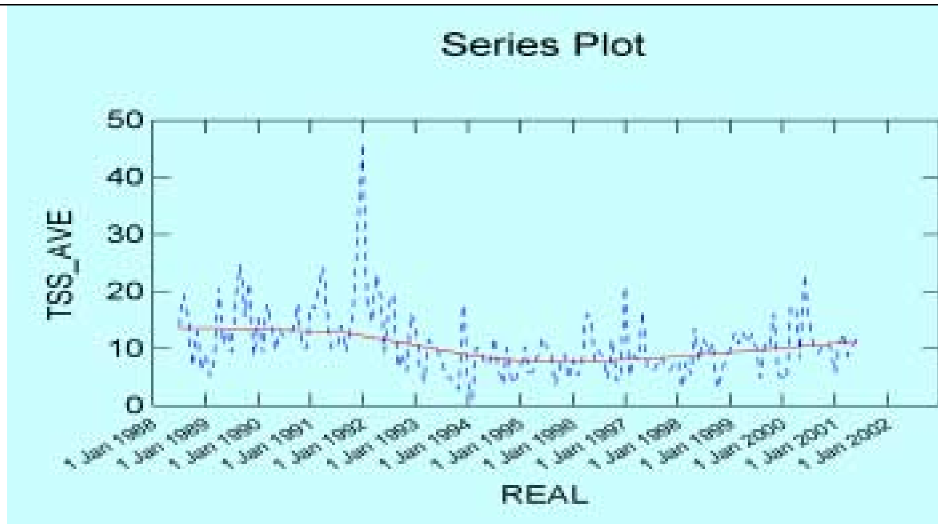
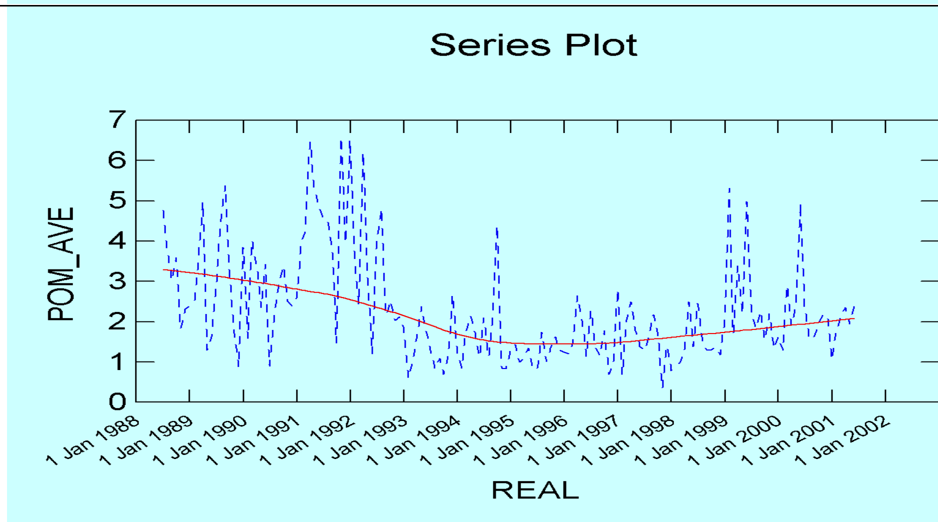
For the GBNERR stations at Adams Point in Great Bay, Squamscott River at Chapmans Landing, Lamprey River at the Newmarket Town Landing trends in 13 years of monthly measurements of the particulates were assessed using the Seasonal Kendall Test. A significance level of 0.10 was used to identify statistically significant trends in two-sided tests. Particulates are being measured at other locations in the estuary but no other stations have amassed the 5 years of monthly measurements that are needed for trend analysis.

d. Results

The trend analysis shows a decreasing trend for both total suspended solids and particulate organic matter at Adams Point and the Squamscott River. The trend for particulates in the Lamprey River is increasing. However, the concentrations of particulates in the Lamprey River are low – lower than those observed in the middle of the bay at Adams Point.

These results are summarized in the following figures. The blue lines are measurements. The red lines are LOWESS smooths of the data with a 0.5 tension. Results of the Seasonal Kendall Test are listed next to each time series plot.

Average of high and low tide particulate concentrations at Adams Point

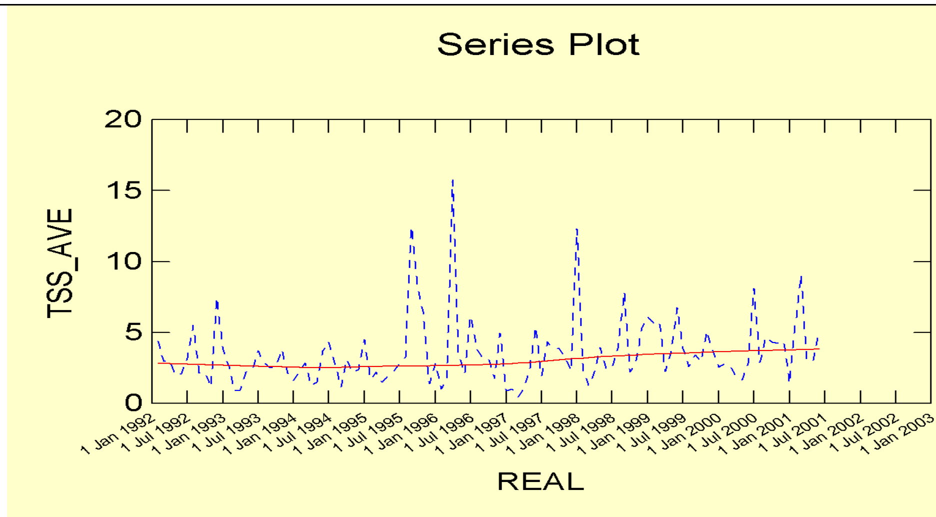
Total Suspended Solids (TSS) (mg/l) **Decreasing trend**. Approximately 30% decrease in central tendency concentrations from 10/88 to 9/01. (p=0.019, tau=-0.15)	
Particulate Organic Matter (POM) (mg/l) **Decreasing trend**. Approximately 45% decrease in central tendency concentrations from 10/88 to 9/01. (p=0.002, tau=-0.19)	

Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

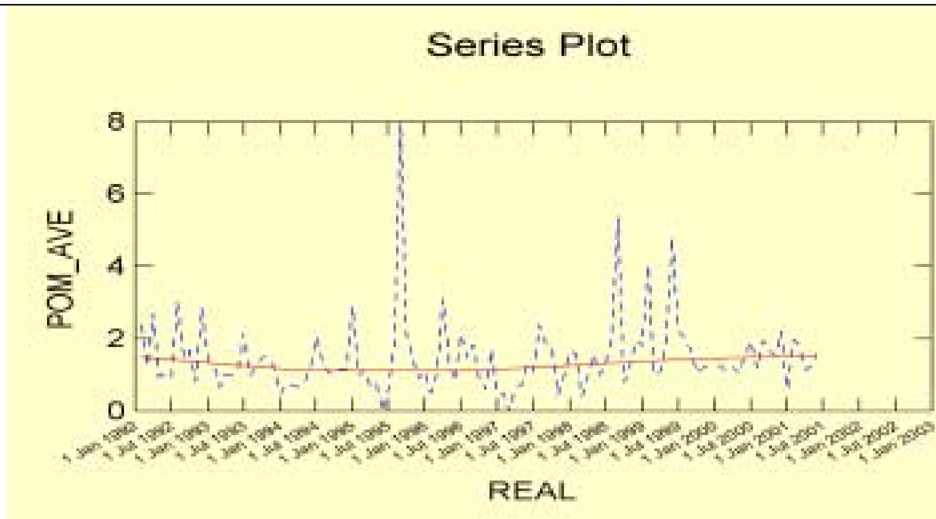
Average of high and low tide particulate concentrations at Lamprey River (Town Landing)

<table>
<tr>
<td>Total Suspended Solids
(TSS) (mg/l)

Increasing trend. Approximately 110% increase in central tendency concentrations from 10/92 to 9/01.

(p=0.001, tau=0.27)</td>
<td>
</td>
</tr>
<tr>
<td>Particulate Organic Matter
(POM) (mg/l)

Increasing trend. Approximately 50% increase in central tendency concentrations from 10/92 to 9/01.

(p=0.011, tau=0.21)</td>
<td>
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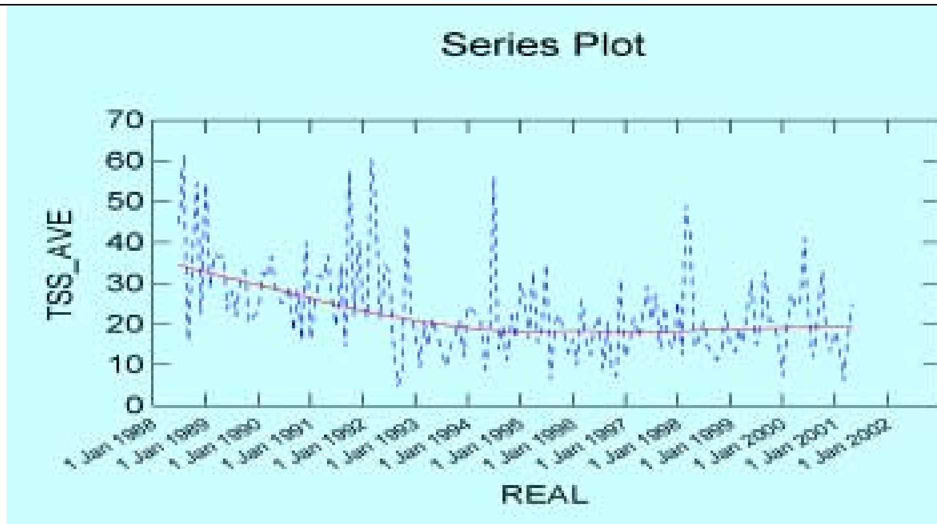
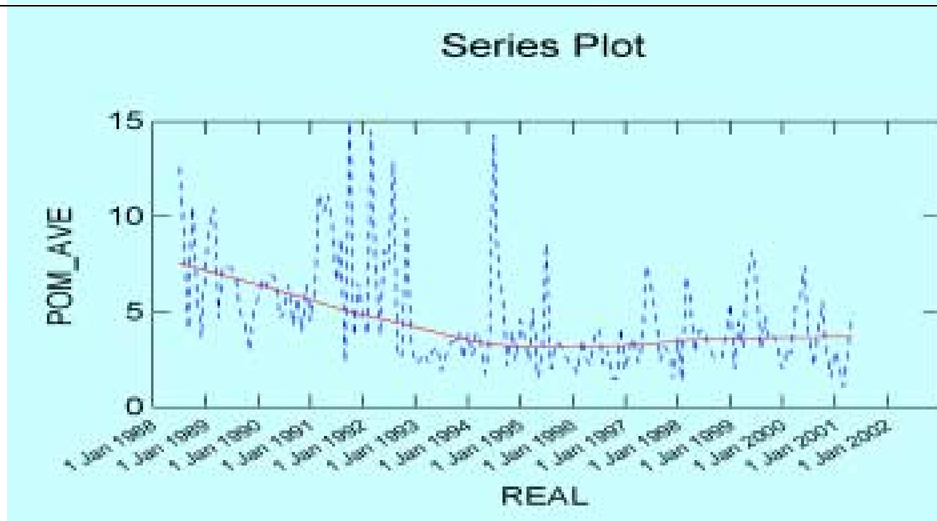
Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

Average of high and low tide particulate concentrations at Squamscott River (Chapmans Landing)

Total Suspended Solids (TSS) (mg/l) **Decreasing trend**. Approximately 45% decrease in central tendency concentrations from 10/88 to 9/01. (p<0.001, tau=-0.24)	
Particulate Organic Matter (POM) (mg/l) **Decreasing trend**. Approximately 60% decrease in central tendency concentrations from 10/88 to 9/01. (p<0.001, tau=-0.32)	

Source: NERR Water Quality database (UNH-JEL, Dr. Rich Langan)

NUT5: Exceedences of Instantaneous Dissolved Oxygen Standard

a. Monitoring Objectives

The objective of this indicator is to estimate the number of exceedences of the state water quality standard for instantaneous dissolved oxygen concentrations in the estuary each year. Low dissolved oxygen (DO) concentrations are a common manifestation of eutrophication. In a system as well mixed as the Great Bay, low DO events are not likely to last longer than one tidal cycle. Therefore, DO measurements taken at a high frequency by in-situ sondes deployed near the sediments in the tidal tributaries (where low DO is the most likely) have the best chance of capturing these events in the Great Bay. This indicator will partially answer the following monitoring question:

- Do any surface tidal or freshwaters show less than 75% saturation of dissolved oxygen? For what period of time?

which will, in turn, report on progress toward the following management objective:

- WQ3-3: Maintain dissolved oxygen levels at: >4 mg/l for tidal rivers, >6 mg/l for bays, >7 mg/l for oceanic areas.

b. Measurable Goals

The State water quality standard for dissolved oxygen has two components: (1) the *daily average* concentration must remain above 75% saturation, and (2) the *instantaneous* dissolved oxygen concentration must remain above 5 mg/l. This indicator will track the number of exceedences of the instantaneous standard. Another indicator will track exceedences of the daily average standard.

The goal is to have 0 days with exceedences of the instantaneous standard.

c. Data Analysis and Statistical Methods

Each in-situ measurement was compared to the instantaneous standard of 5 mg/l, using the accuracy of the measurements (0.2 mg/l) as error bars. For each sonde, the number of days per year with at least one exceedence of the standard was compiled and compared to the goal of zero days with exceedences. Inter-annual trends were assessed qualitatively using the frequency of days with exceedences relative to the number of full days that the sonde was deployed during July, August, and September.

d. Results

The following table summarizes the number of exceedences of the instantaneous 5 mg/l standard that have been recorded by the datasondes. Rarely did the dissolved oxygen in the middle of Great Bay dip below the 5 mg/l standard. In the Squamscott River, there were a handful of days over the summer months when the DO fell below 5 mg/l for some time during the day. Data from the Lamprey River appear to show persistent low DO concentrations in 1999 and 2001. However, the data from 1999 are suspect. Metadata for the Lamprey River sonde deployment in 1999 note that the probe was installed for the three months (July, August, September) but all data except for the last three weeks of August was thrown out because of membrane and probe problems. Therefore, the anomalous readings in August 1999 are probably due to sensor error, not actual low DO. The low DO readings in 2001 occurred during the month of July. Metadata for the sonde deployment during this time do not indicate problems different than those experienced by the other sondes.

Based on these data, the tidal tributaries do not meet the goal of having zero days with DO <5 mg/l. The Lamprey River exhibits more signs of low DO than the Squamscott River. The cause of these apparent low DO episodes is unknown. Sensor error or natural causes cannot be ruled out without further study. DO concentrations in the middle of Great Bay consistently meet the water quality standard.

Summary of Dissolved Oxygen Concentrations Measured by Datasondes

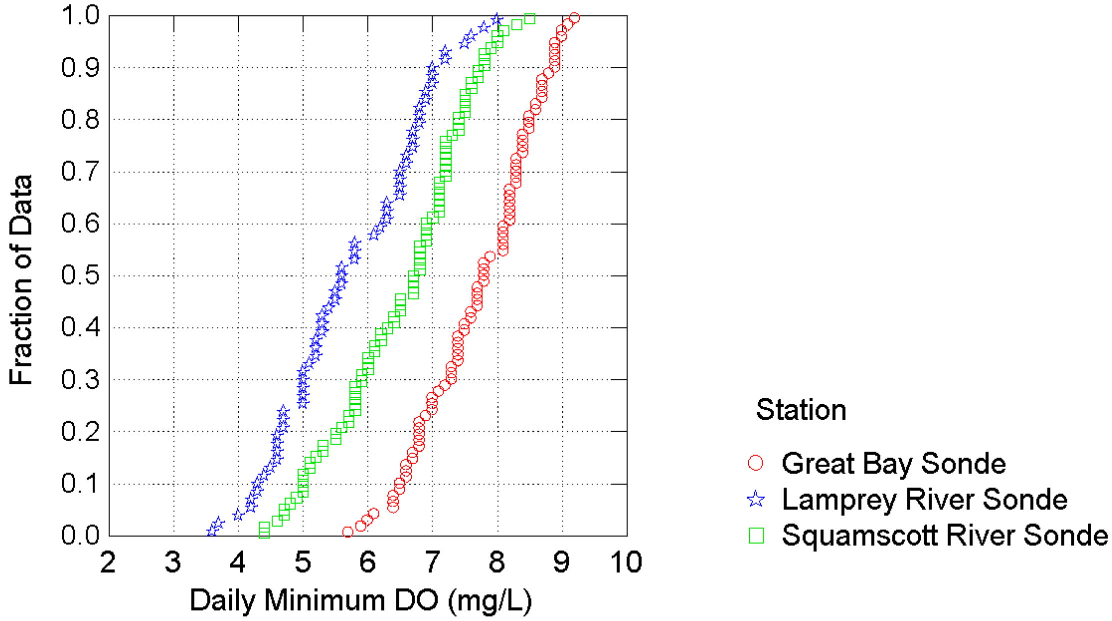
Station	Year	# days with DO measurements in July, August, and September	# days with exceedences of 5 mg/l standard in July, August, and September	Goal (# of days with exceedences)
Great Bay	1995	59	0	0
Great Bay	1996	70	0	0
Great Bay	1997	80	0	0
Great Bay	1998	85	1	0
Great Bay	1999	92	0	0
Great Bay	2000	77	0	0
Great Bay	2001	85	0	0
Lamprey River	1999	30	21*	0
Lamprey River	2000	92	7	0
Lamprey River	2001	65	16	0
Squamscott River	1997	72	5	0
Squamscott River	1998	72	7	0
Squamscott River	1999	88	7	0
Squamscott River	2000	75	4	0
Squamscott River	2001	89	5	0

* Data suspect due to problems with DO probe during this period.
Source: NERR/SWMP

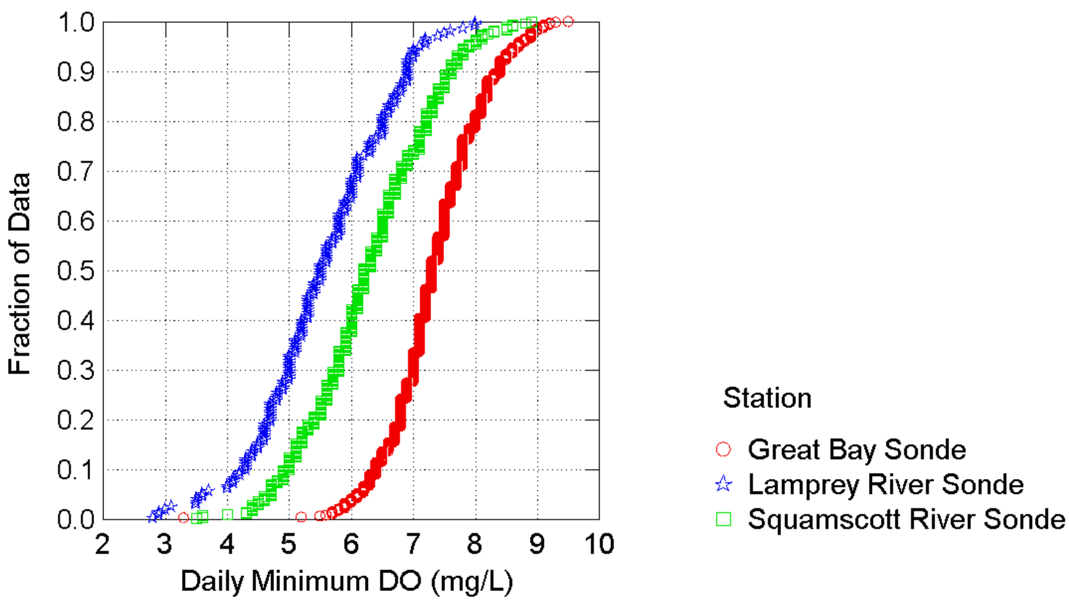
The following two figures illustrate the distribution of daily minimum dissolved oxygen concentrations at the three stations in 2001 and for the period 1995-2001. Note that, for the Lamprey River sonde, approximately 30% of the days had DO concentrations less than the water quality standard. In contrast, the Squamscott River and Great Bay sondes, had low DO readings on only 10% and 0% of the days deployed, respectively.

The third figure shows that most of the exceedences at the Lamprey River sonde were observed in 1999 which appears to have been an anomalous year compared to readings from 2000 and 2001 at this same location.

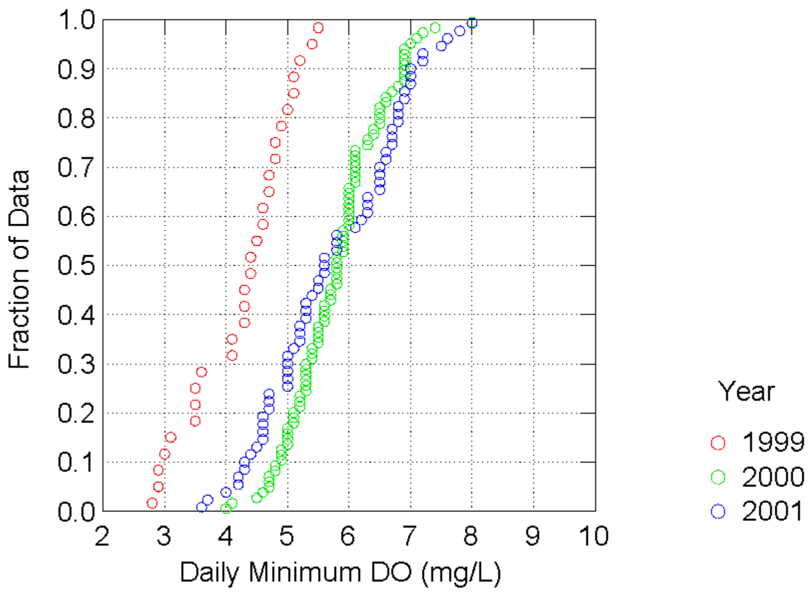
Daily Minimum DO for July, August, and September 2001



Daily Minimum DO for July, August, and September, 1995-2001



Daily Minimum DO (summer months) in the Lamprey River



NUT6: Exceedences of the Daily Average Dissolved Oxygen Standard

a. Monitoring Objectives

The objective of this indicator is to estimate the number of exceedences in the estuary each year of the state water quality standard for daily average dissolved oxygen concentrations. This indicator will partially answer the following monitoring question:

- Do any surface tidal or freshwaters show less than 75% saturation of dissolved oxygen? For what period of time?

which will, in turn, report on progress toward the following management objective:

- WQ3-3: Maintain dissolved oxygen levels at: >4 mg/l for tidal rivers, >6 mg/l for bays, >7 mg/l for oceanic areas.

b. Measurable Goals

The State Water Quality Standard for dissolved oxygen has two components: (1) the *daily average* concentration must remain above 75% saturation, and (2) the *instantaneous* dissolved oxygen concentration must remain above 5 mg/l. This indicator will track the number of exceedences of the daily-average standard. The previous indicator will track exceedences of the instantaneous standard.

The goal is to have 0 days with exceedences of the daily average standard.

c. Statistical Methods and Data Analysis

The data analysis methods were the same as were described for the previous indicator except that all the measurements of dissolved oxygen on days with complete data (i.e., 48 DO measurements) were averaged. The average concentration was compared to the standard of 75% using a one sample t-test (one-sided) with a 0.05 alpha level. Specifically, the 95% upper confidence level of the mean was be compared to the water quality standard.

d. Results

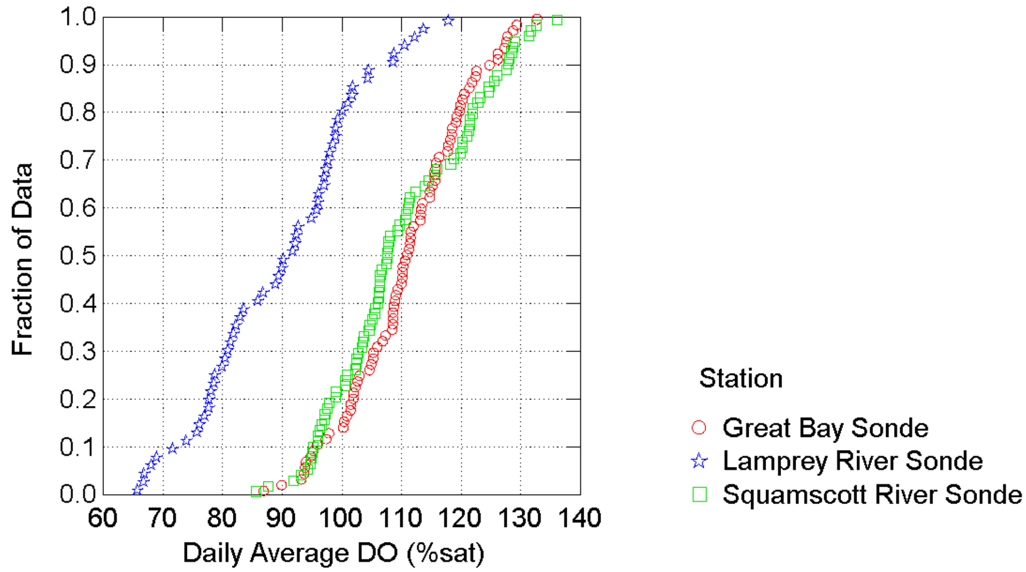
Water quality in the Great Bay and the Squamscott River consistently meets the 75% daily average standard for dissolved oxygen. In the Lamprey River, the standard is not met for several days each year. The causes of these exceedences are unknown. Data from the Lamprey River sonde in 1999 is suspect (as discussed the previous section) and probably represents sensor error rather than actual low DO readings.

Station	Year	# days with complete data in July, August, and September	# of days with exceedences of 75% daily average standard	Goal (# of days with exceedences)
Great Bay	1995	51	0	0
Great Bay	1996	58	0	0
Great Bay	1997	61	0	0
Great Bay	1998	71	0	0
Great Bay	1999	89	0	0
Great Bay	2000	60	0	0
Great Bay	2001	83	0	0
Lamprey River	1999	27	13*	0
Lamprey River	2000	87	2	0
Lamprey River	2001	58	6	0
Squamscott River	1997	63	0	0
Squamscott River	1998	61	0	0
Squamscott River	1999	83	0	0
Squamscott River	2000	38	0	0
Squamscott River	2001	86	0	0

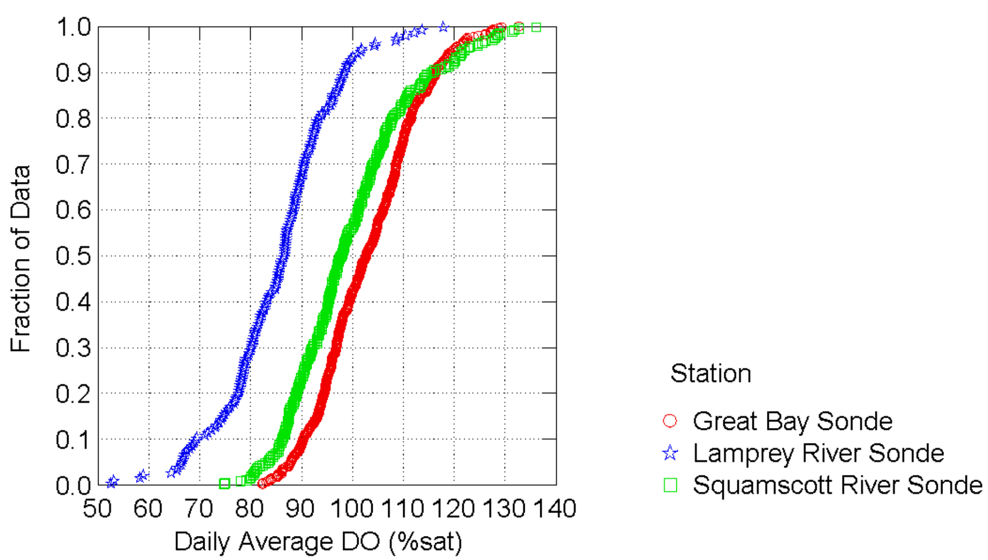
* Data suspect.
Source: NERR/SWMP

The following plots illustrate that the percent saturation of DO is nearly identical for the Great Bay and the Squamscott River sondes and is almost always above the 75% saturation standard. The percent saturation at the Lamprey River sonde is much lower. Daily average DO in the Lamprey River fails to meet the water quality standard approximately 10% of the time.

Daily Average DOSAT for July, August, and September 2001

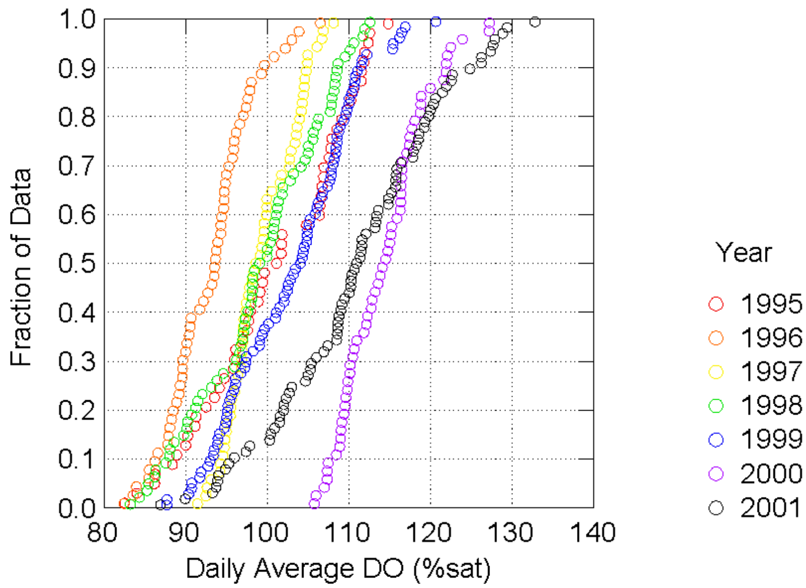


Daily Average DOSAT for July, August, and September, 1995-2001

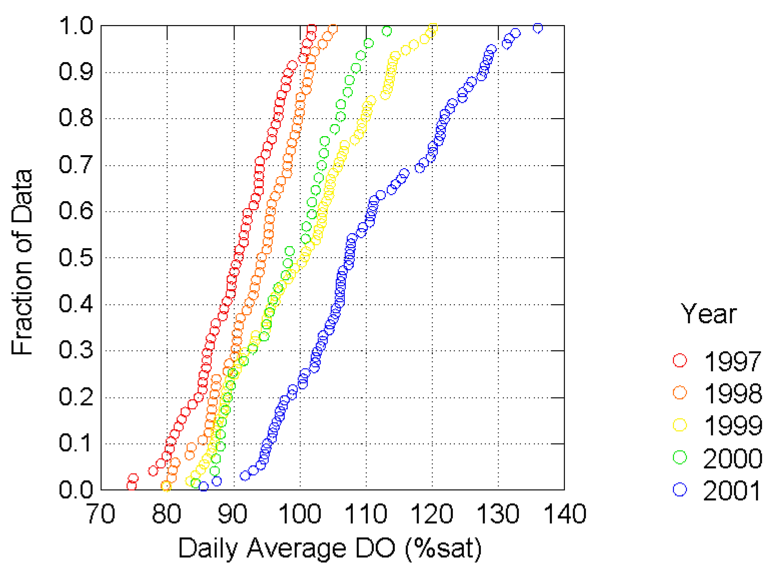


The following three graphs show the distribution of daily average DO at each station for each year. In recent years, the distributions have shifted toward greater saturation in Great Bay and the Squamscott River. The three years of data in the Lamprey River also indicate an improvement in DO saturation since 1999.

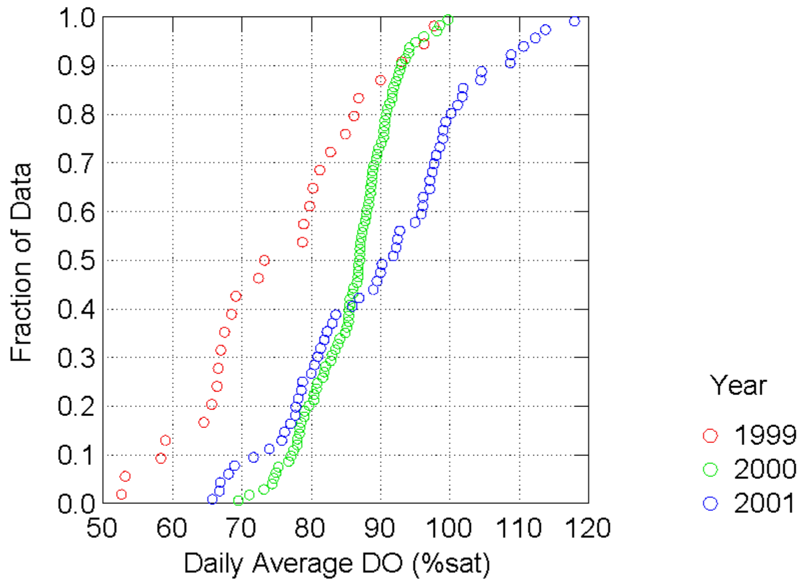
Daily Average DOSAT (summer months) in Great Bay



Daily Average DOSAT (summer months) in the Squamscott River



Daily Average DOSAT (summer months) in the Lamprey River



NUT7. Trends in Biological Oxygen Demand (BOD) Loading to Great Bay

a. Monitoring Objectives

One factor that can lead to hypoxia in the estuary is the BOD load from WWTF and tidal tributaries. This indicator will track the monthly loading from the tributaries to Great Bay and the WWTF that discharge directly to the tidal waters to determine if the loads are changing over time. This indicator will answer the following monitoring question:

- Do any surface tidal or freshwaters show a significant change in BOD?

which will, in turn, report on progress toward the following management objective:

- WQ3-4: Maintain NPDES permit levels for BOD at wastewater facilities in the NH coastal watershed.

b. Measurable Goals

The goal is for no WWTF or tributary to have significantly increasing trends in BOD loading. This is a goal for the NHEP but it is not legally binding for WWTF operators. Many WWTF are allowed under their existing permits to discharge more BOD than they currently do. WWTF discharges cannot be required to be less than permitted levels unless the discharge can be shown to cause a water quality impact.

c. Data Analysis, Statistical Methods and Hypothesis

The monthly BOD loads from tributaries were estimated by multiplying monthly measurements of BOD at the tidal dams by the mean monthly flow over the dam (as estimated by area transposition from USGS stream gages). Monthly average BOD loads from WWTF will be taken from NPDES Discharge Monitoring Reports filed by the facility. The long-term trend in monthly load estimates was determined by the Seasonal Kendall Test using $p<0.10$ as critical value and two tailed test to determine significance.

d. Results

The trend analysis showed the BOD loads from WWTFs are either decreasing or stable with the exception of Portsmouth which has increased by 25% over the past 12 years. Flow through the Portsmouth WWTF increased by 37% over the same time period so the increased loading appears to be due to growth in the service population. BOD loading from the Dover and Durham WWTFs decreased despite a small increasing trend in flow at these plants.

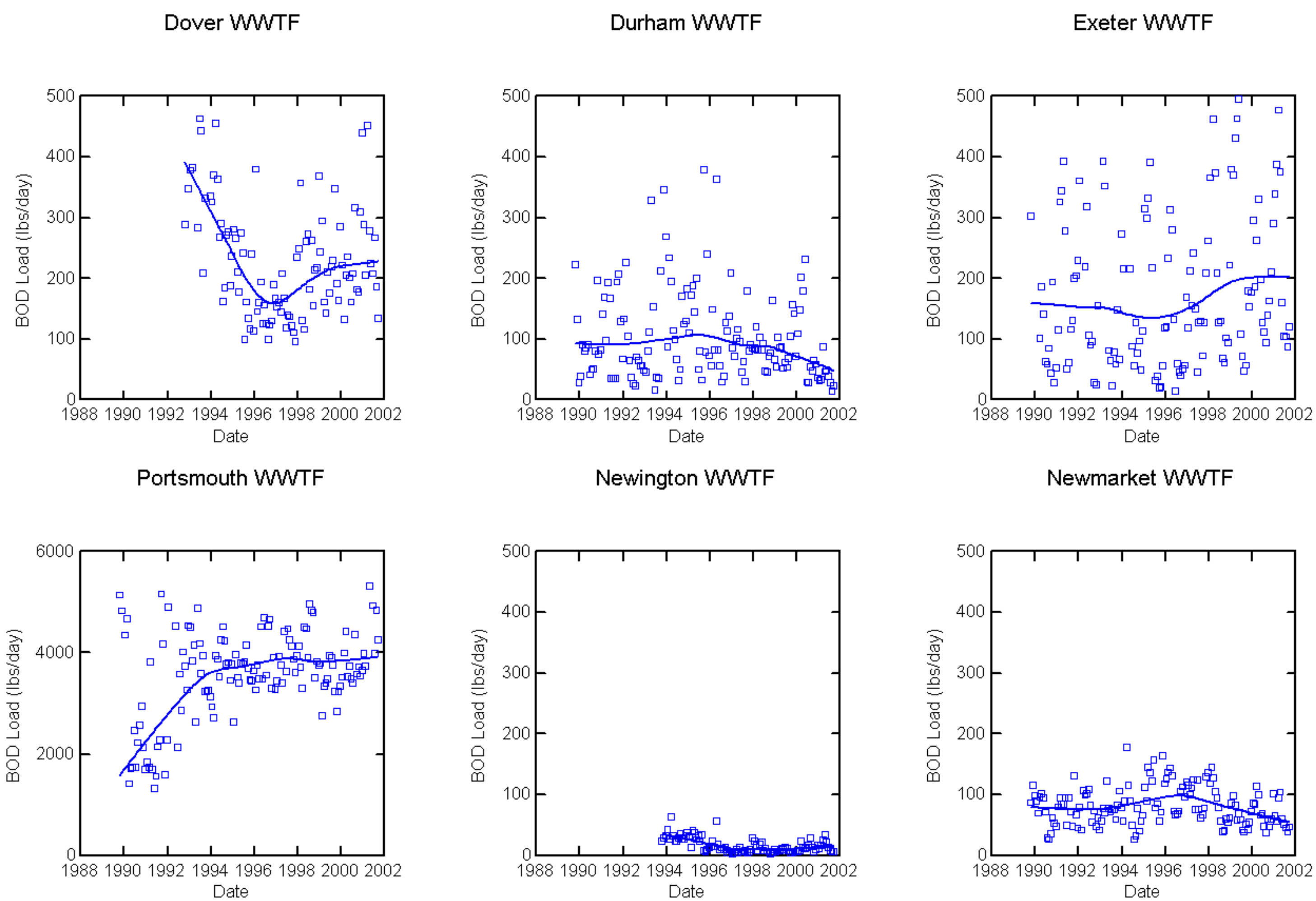
There is not enough data from the tributaries to determine trends in BOD loading from the tributaries. In terms of total loading, approximately 70% of the total load of BOD to the estuary is from the watershed tributaries, with the Salmon Falls River and Lamprey Rivers having the largest individual loads. WWTF discharges account for approximately 30% of the total load to the estuary. The Portsmouth WWTF is the largest single source of BOD to the watershed (27% of the total).

BOD load to the Great Bay from wastewater treatment plants and tidal tributaries

WWTF	Period of Record	Median (pounds/day)	Trend	Percent Change	Comments
Dover WWTF	10/92 to 9/01	213	**Decreasing**	-38%	Trend in flow is increasing (29%)
Durham WWTF	10/89 to 9/01	83	**Decreasing**	-22%	Trend in flow is increasing (16%)
Exeter WWTF	10/89 to 9/01	154	No Significant Trend		Trend in flow is increasing (109%)
Newfields WWTF	10/96 to 9/01	7.5	No Significant Trend		No significant trend in flow.
Newington WWTF	10/93 to 9/01	12.5	**Decreasing**	-78%	Trend in flow is decreasing (-23%)
Newmarket WWTF	10/89 to 9/01	77	No Significant Trend		Trend in flow is increasing (14%)
Portsmouth WWTF	10/89 to 9/01	3,740	**Increasing**	25%	Trend in flow is increasing (37%)
Kittery WWTF	3/01 to 12/01	NA			Data not available in time for this report.
So. Berwick WWTF	3/01 to 12/01	NA			Data not available in time for this report.
Winnicut River	3/01 to 12/01	NA			No data available.
Squamscott River	3/01 to 12/01	1,510*			Only 1 year of data is available.
Lamprey River	3/01 to 12/01	2,540*			Only 1 year of data is available.
Oyster River	3/01 to 12/01	250*			Only 1 year of data is available.
Bellamy River	3/01 to 12/01	680*			Only 1 year of data is available.
Cocheco River	3/01 to 12/01	1,730*			Only 1 year of data is available.
Salmon Falls River	3/01 to 12/01	3,020*			Only 1 year of data is available.

* Average BOD load from 2001 tributary monitoring
Source: EPA Region I, PCS database and DES Watershed Management Bureau

BOD load from wastewater treatment plants discharging to the Great Bay (pounds per day)



WATER QUALITY INDICATORS MISSING FROM THIS REPORT

Several of the water quality indicators from the Monitoring Plan were not included in this report. The main reason for this was insufficient data. The list of missing indicators and the reason why they were not included is below.

Indicator	Reason for absence
BAC3: Trends in wet-weather bacteria indicators	In NHEP (2002b), it was determined that the existing monitoring programs would not have sufficient data to detect trends with this indicator. More intense monitoring will be implemented in 2003 to provide data for this indicator.
BAC9: Microbial Source Tracking	Insufficient data.
TOX2: Public health risks from toxic contaminants in shellfish tissue	The NH Bureau of Environmental and Occupational Health must make any determination of public health risks.
TOX4: Trends in finfish tissue contaminant concentrations	This indicator cannot be calculated until all the data from Years 1 and 2 of the National Coastal Assessment are available. These data are scheduled for release in 2003.
TOX5: Sediment contaminant concentrations relative to NOAA guidelines	Same as above.
TOX6: Trends in sediment contaminant concentrations	This indicator cannot be calculated until after data from Year 6 of the NCA are available (2006).
NUT1. Annual Load of Nitrogen to Great Bay from WWTF and Watershed Tributaries	This indicator cannot be calculated until the NHEP-funded project studying nitrogen concentrations in WWTF effluent is complete (2003).
NUT4: Eelgrass distribution in Great Bay	This indicator has been moved to the critical species and habitats chapter of the Monitoring Plan. Therefore, it will be reported in the “Land Use and Habitats” indicator report in 2003.

SUMMARY

While it is hard to summarize overall conditions in the estuary, the water quality indicators presented in this report show that New Hampshire's estuaries:

- Are impaired because bacteria pollution results in shellfish bed closures and violations of the state swimming standards, although there are signs of decreasing dry-weather bacteria concentrations;
- Have not had any tidal beach closures, but that concentrations of enterococci at the tidal beaches are increasing;
- Have experienced stable or decreasing toxic contaminant concentrations in mussel tissue for most compounds, with the notable exception of PAHs, which exhibits an increasing trend;
- Exhibit no strong signs of eutrophication (e.g., seasonal hypoxia), but central tendency nitrate+nitrite concentrations in Great Bay have doubled over the past 11 years and possible signs of low DO concentrations have begun to appear in the tidal portion of the Lamprey River.

REFERENCES CITED

Chase et al. (2001) Evaluation of Gulfwatch 1998: Eighth year of the Gulf of Maine Environmental Monitoring Plan. University of New Hampshire, Durham. December 2001.

NHEP (2002a) Monitoring Plan, New Hampshire Estuaries Project. Portsmouth, NH. May 2002.

NHEP (2002b) Evaluation of Monitoring Programs for the NHEP Monitoring Plan. New Hampshire Estuaries Project, Portsmouth, NH. September 2002.

NHEP (2002c) Environmental Indicator Report: Shellfish. New Hampshire Estuaries Project, Portsmouth, NH. September 2002.