EXHIBIT 36 (AR K.22)

DRAFT

ENVIRONMENTAL DATA REPORT

JULY 2012

Technical Support Document for the
2013 State of Our Estuaries Report

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PREP
Piscataqua Region Estuaries Partnership

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I. Introduction

The Piscataqua Region Estuaries Partnership (PREP) is part of the U.S. Environmental Protection Agency's National Estuary Program, which is a joint local/state/federal program established under the Clean Water Act with the goal of protecting and enhancing nationally significant estuarine resources. PREP is funded by the EPA and is administered by the University of New Hampshire.

PREP's Comprehensive Conservation and Management Plan for the estuaries of the Piscataqua Region (PREP, 2010) was updated in 2010 and implementation is ongoing. The Management Plan addresses current and emerging issues impacting the water quality and environmental health of estuaries in the Piscataqua Region. Priority action plans were developed for water resources, land use and habitat protection, living resources and habitat restoration, and watershed stewardship. Projects addressing these priorities are undertaken throughout the watershed, which includes 52 communities in New Hampshire and Maine.

Every three years, PREP prepares a State of Our Estuaries report with information on the status and trends of environmental indicators from the Piscataqua Region watershed and estuaries (see PREP, 2009b for latest example). The report provides PREP, state natural resource managers, local officials, conservation organizations, and the public with information on the effects of management actions and decisions.

Prior to developing each State of the Estuaries report, PREP publishes a data report that contains technical details and the latest information for the indicators tracked by PREP (see PREP, 2009a for latest example). The indicators cover a wide range of topics from water quality to biological resources to land use and conservation.

The following sections contain the most recent data for the 21 indicators currently tracked by PREP. For the 2013 State of Our Estuaries report, the indicators will be organized following a "Pressure-Condition-Management Response" framework (see Table 1 on the next page). This is a simplified version of the "Driver-Pressure-State-Impact-Response" framework used in the latest State of the Gulf of Maine report (Figure 1, GOMC, 2012). Pressure indicators represent stresses on the estuary. Condition indicators describe conditions in the estuary. Management Response indicators track what is being done to restore the estuary. In some cases PREP funds data collection and monitoring activities; however data for the majority of indicators are provided by other organizations. The details of the monitoring programs are provided in the section for each indicator. In addition to the indicators, this report also contains data summaries of supplemental information that is useful for interpreting the indicators.

The results and interpretations for the indicators presented in this report have been reviewed by the PREP Technical Advisory Committee and other experts in relevant fields. The Technical Advisory Committee consists of university professors, researchers and state and federal environmental managers from a variety of disciplines and perspectives. Comments on this report received from the Technical Advisory Committee and other stakeholders are summarized in the last chapter of this report. That chapter also contains PREP's responses to these comments.

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Table 1:

Pressure-Condition-Response Indicator Model
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Pressure Indicators "Stresses on the estuary"	**Condition Indicators** "Conditions in the estuary"	**Management Response Indicators** "What is being done to restore the estuary"
-Impervious Surfaces **-Population** **-Nitrogen load**	**-Nutrient concentrations** **-Algae** **-Dissolved oxygen** **-Eelgrass habitat** **-Suspended sediment** **-Bacteria concentrations** **-Beach closures** **-Shellfish harvest days** **-Toxic contaminants in shellfish** **-Oyster populations** **-Clam populations** **-Migratory fish returns**	**Land conservation** **-conservation lands** **-conservation focus areas** **Habitat Restoration** **-oysters** **-eelgrass** **-salt marsh** **-stream miles open to migratory fish**

Figure 1: Driver-Pressure-State-Impact-Response framework (from GOMC, 2012)

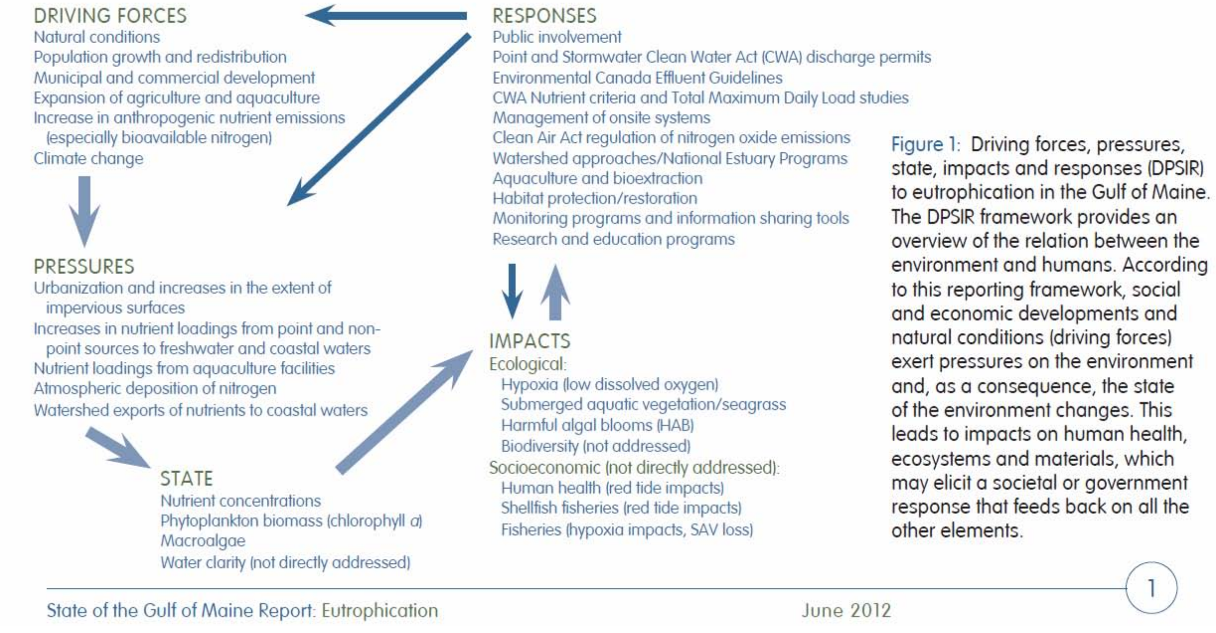

Figure 1: Driving forces, pressures, state, impacts and responses (DPSIR) to eutrophication in the Gulf of Maine. The DPSIR framework provides an overview of the relation between the environment and humans. According to this reporting framework, social and economic developments and natural conditions (driving forces) exert pressures on the environment and, as a consequence, the state of the environment changes. This leads to impacts on human health, ecosystems and materials, which may elicit a societal or government response that feeds back on all the other elements.

State of the Gulf of Maine Report: Eutrophication June 2012

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II. Indicators for the State of Our Estuaries Report

A. Pressure Indicators

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Indicator: LUD1. Impervious surfaces in coastal subwatersheds and towns

Objective

The objective of this indicator is to track the area of impervious surfaces in the HUC12 watersheds and towns of the Piscataqua Region watershed. Impervious surfaces such as paved parking lots, roadways, and building roofs increase the pollutant load, sediment load, volume, and velocity of stormwater flowing into the estuaries. Studies conducted in other regions of the country have demonstrated water quality deterioration where impervious surfaces cover greater than 10 percent of the watershed area (CWP, 2003). In 2005, a study in New Hampshire demonstrated the percent of urban land use in stream buffer zones and the percent of impervious surface in a watershed can be used as indicators of stream quality (Deacon et al., 2005). The study confirmed that between 7 and 14 percent impervious surface in the upstream watershed is the threshold at which water-quality and habitat become degraded.

PREP Goal

Obj LU 1.1: Promote sustainable land use practices in both new development and redevelopment of existing sites. AP LU-4: Maintain effective impervious cover below five percent in small and less developed watersheds. Consistent with previous PREP reports and the new Management Plan, the goal will be interpreted to be no increases in the number of watersheds and towns with >10% impervious cover and no decreases in the number of watersheds and towns with <5% impervious cover relative to 2010 levels.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

Impervious surfaces were mapped throughout the coastal watershed using satellite imagery. Using ArcGIS software, the total area of impervious surfaces in each HUC12 watershed and town was calculated and then divided by the total land area of that watershed or town to estimate the percent impervious cover. The land area was calculated by subtracting the areas of surface waters from the town and HUC12 boundary polygons. DES recalculated the surface water area in each HUC12 and town in 2012 using the most recent version of the National Hydrograph Dataset and the most recent HUC12 boundaries. Due to the higher resolutioin of the underlying data, the water and land area of each HUC12 and town may differ from previous reports. To determine the area of surface waters, DES combined the relevant National Hydrograph Dataset Waterbody features (with FType = 390 “LakePond”, 436 “Reservoir”, and 493 “Estuary”) and Area features (with FType = 336 “CanalDitch”, 364 “Foreshore”, 403 “Inundation Area”, 431 “Rapids”, 445 “SeaOcean”, 455 “Spillway”, and 460 “StreamRiver”).

Data Sources

The data source for this indicator was geographic data layers of impervious surfaces in the Piscataqua Region watershed produced by the UNH Complex Systems Research Center. The uncertainty in each percent impervious calculation is +/-0.7%. This uncertainty was calculated in NHEP (2006) for the average size watershed and town using the method of partial derivatives from Kline (1985).

Results

The percent impervious results for the 40 HUC12 watersheds and 52 municipalities in the Piscataqua Region watershed are reported on Table LUD1-1 and Table LUD1-2. Overall, the area of impervious surfaces has grown from 28,695 acres in 1990 to 42,590 acres in 2000 to 50,314 acres in 2005 to 63,241 in 2010. On a percentage basis, 4.4%, 6.5%, 7.6% and 9.6% of the land area in the watershed was covered by impervious surfaces in 1990, 2000, 2005 and 2010, respectively (Figure LUD1-1). In 2005 and 2010, the overall percent imperviousness for the whole watershed was within the range identified by Deacon et al. (2005) for potential water quality degradation (7 to 14%).

Between 1990 and 2000, 13,895 acres of impervious surfaces were added to the watershed (1,389 acres per year). Impervious surfaces were added at a slightly higher rate between 2000 and 2005 (1,545 acres per year). Between 2005 and 2010 impervious surfaces were added at a significantly higher rate (2,585 acres per year). On average, 1,840 acres of impervious surfaces were added to the watershed each year for the 20-year period, which amounts to 0.3% of the land area in the watershed each year. A total of 5.2% of the watershed was converted to impervious surfaces over this 20-year period.

Overall, the population for the 52 municipalities in the watershed has grown by 19% from 316,404 in 1990 to 377,427 in 2010. During this same period, the total impervious surfaces within the towns grew by 120%. Therefore, the rate of increasing impervious surfaces has been six times the rate of population growth.

The percent of impervious surfaces in each HUC12 watershed in 2010 is shown in Figure LUD1-3. A similar map for the coastal municipalities is provided in Figure LUD1-4. The watersheds and municipalities which had greater than 10% impervious cover in 2010 were mostly along the Atlantic Coast, in the Exeter River watershed and in the Great Bay watershed.

The PREP goal is expressed in terms of holding steady the number of watersheds with >10% imperviousness and <5% imperviousness. Figure LUD1-2 shows that there have been significant negative trends since 1990 in the percent of watersheds meeting these specific targets. The number of HUC12 watersheds with greater than 10% impervious surface cover increased from 2 in 1990, 9 in 2000, 10 in 2005 to 16 in 2010. The number of subwatersheds with less than 5% impervious surface cover has declined similarly (Figure LUD1-2).

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Table LUD1-1: Impervious surface coverage in HUC12 watersheds

Watershed			Mapped Area (acres)			Impervious Surfaces (acres)				Percent Imperviousness (%)					Meeting	
HUC10	HUC12	HUC12 Code	Water	Land	Total	1990	2000	2005	2010	1990	2000	2005	2010	Goal	Goal	
Great Works River	Great Works River (1) at North Berwick	010600030401	398	28,214	28,612	954.8	1,498.9	1,760.4	2,122.0	3.4%	5.3%	6.2%	7.5%	10%	Yes	
Great Works River	Great Works River (2) at mouth	010600030402	264	26,607	26,871	536.2	944.4	1,156.0	1,445.5	2.0%	3.5%	4.3%	5.4%	10%	Yes	
Salmon Falls River	Upper Branch River-Lovell Lake	010600030501	840	17,543	18,383	405.5	558.1	619.5	809.6	2.3%	3.2%	3.5%	4.6%	10%	Yes	
Salmon Falls River	Junes Brook-Branch River	010600030502	235	17,268	17,504	317.9	441.0	495.4	664.7	1.8%	2.6%	2.9%	3.8%	10%	Yes	
Salmon Falls River	Headwaters-Great East Lake	010600030503	2,556	15,118	17,739	264.3	407.8	471.9	645.1	1.7%	2.7%	3.1%	4.3%	10%	Yes	(1)
Salmon Falls River	Milton Pond	010600030504	1,174	13,666	14,858	287.3	423.9	510.3	670.9	2.1%	3.1%	3.7%	4.9%	10%	Yes	(1)
Salmon Falls River	Little River	010600030505	166	34,864	35,029	471.6	792.9	983.1	1,260.9	1.4%	2.3%	2.8%	3.6%	10%	Yes	
Salmon Falls River	Middle Salmon Falls River	010600030506	782	37,667	38,442	1,632.7	2,453.1	3,056.4	3,852.9	4.3%	6.5%	8.1%	10.2%	10%	No	(1)
Salmon Falls River	Lower Salmon Falls River	010600030507	568	13,269	13,811	668.6	998.9	1,200.2	1,479.5	5.0%	7.5%	9.0%	11.2%	10%	No	(1)
Cocheco River	Upper Cocheco River	010600030601	516	27,141	27,657	700.7	970.7	1,177.0	1,570.2	2.6%	3.6%	4.3%	5.8%	10%	Yes	
Cocheco River	Axe Handle Brook	010600030602	368	7,029	7,397	215.2	293.8	369.2	491.6	3.1%	4.2%	5.3%	7.0%	10%	Yes	
Cocheco River	Middle Cocheco River	010600030603	268	15,683	15,952	1,264.5	1,682.6	1,909.9	2,339.7	8.1%	10.7%	12.2%	14.9%	10%	No	
Cocheco River	Bow Lake	010600030604	1,240	7,885	9,125	119.3	182.2	213.3	315.7	1.5%	2.3%	2.7%	4.0%	10%	Yes	
Cocheco River	Nippo Brook-Isinglass River	010600030605	272	17,117	17,389	262.4	370.3	449.4	618.8	1.5%	2.2%	2.6%	3.6%	10%	Yes	
Cocheco River	Long Pond	010600030606	351	9,801	10,153	148.9	222.3	252.1	330.7	1.5%	2.3%	2.6%	3.4%	10%	Yes	
Cocheco River	Lower Isinglass River	010600030607	436	10,291	10,727	474.0	699.5	776.0	1,018.1	4.6%	6.8%	7.5%	9.9%	10%	Yes	
Cocheco River	Lower Cocheco River	010600030608	600	19,466	20,066	1,836.0	2,573.1	3,107.0	3,829.7	9.4%	13.2%	16.0%	19.7%	10%	No	
Lamprey River	Headwaters-Lamprey River	010600030701	212	21,715	21,927	368.9	589.2	721.6	958.7	1.7%	2.7%	3.3%	4.4%	10%	Yes	
Lamprey River	North Branch River	010600030702	139	10,908	11,047	254.3	391.6	459.6	614.9	2.3%	3.6%	4.2%	5.6%	10%	Yes	
Lamprey River	Middle Lamprey River	010600030703	624	25,597	26,222	1,228.2	1,870.7	2,205.9	2,845.5	4.8%	7.3%	8.6%	11.1%	10%	No	
Lamprey River	Pawtuckaway Pond	010600030704	914	12,139	13,052	111.9	171.3	194.8	271.4	0.9%	1.4%	1.6%	2.2%	10%	Yes	

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Watershed			Mapped Area (acres)			Impervious Surfaces (acres)				Percent Imperviousness (%)					Meeting	
HUC10	HUC12	HUC12 Code	Water	Land	Total	1990	2000	2005	2010	1990	2000	2005	2010	Goal	Goal	
Lamprey River	Bean River	010600030705	258	14,813	15,072	260.7	378.5	467.1	618.9	1.8%	2.6%	3.2%	4.2%	10%	Yes	
Lamprey River	North River	010600030706	65	8,786	8,851	163.7	267.1	335.6	457.4	1.9%	3.0%	3.8%	5.2%	10%	Yes	
Lamprey River	Little River (Lamprey)	010600030707	359	12,585	12,944	282.4	437.0	519.7	700.8	2.2%	3.5%	4.1%	5.6%	10%	Yes	
Lamprey River	Piscassic River	010600030708	103	14,407	14,510	517.5	888.2	1,094.9	1,426.1	3.6%	6.2%	7.6%	9.9%	10%	Yes	
Lamprey River	Lower Lamprey River	010600030709	543	12,683	13,226	521.9	769.8	832.6	1,052.7	4.1%	6.1%	6.6%	8.3%	10%	Yes	
Exeter River	Watson Brook	010600030801	97	10,478	10,575	334.0	537.7	646.5	847.0	3.2%	5.1%	6.2%	8.1%	10%	Yes	
Exeter River	Towle Brook-Lily Pond	010600030802	222	20,189	20,411	628.7	1,061.5	1,322.5	1,751.2	3.1%	5.3%	6.6%	8.7%	10%	Yes	
Exeter River	Spruce Swamp-Little River	010600030803	170	15,011	15,181	666.2	1,046.0	1,213.5	1,583.6	4.4%	7.0%	8.1%	10.5%	10%	No	
Exeter River	Little River (Exeter)	010600030804	39	10,109	10,148	567.7	829.7	1,007.9	1,274.9	5.6%	8.2%	10.0%	12.6%	10%	No	
Exeter River	Great Brook-Exeter River	010600030805	165	12,197	12,363	499.6	789.0	934.0	1,179.2	4.1%	6.5%	7.7%	9.7%	10%	Yes	
Exeter River	Squamscott River	010600030806	588	12,447	13,035	903.3	1,363.6	1,625.7	2,025.7	7.3%	11.0%	13.1%	16.3%	10%	No	
Great Bay Drainage	Winnicut River	010600030901	99	11,052	11,151	773.2	1,181.9	1,371.6	1,725.1	7.0%	10.7%	12.4%	15.6%	10%	No	
Great Bay Drainage	Oyster River	010600030902	561	19,323	19,884	968.4	1,482.1	1,661.8	2,149.6	5.0%	7.7%	8.6%	11.1%	10%	No	
Great Bay Drainage	Bellamy River	010600030903	1,278	20,355	21,634	1,153.9	1,712.4	2,036.7	2,581.3	5.7%	8.4%	10.0%	12.7%	10%	No	
Great Bay Drainage	Great Bay	010600030904	6,000	13,096	19,096	920.7	1,337.7	1,515.2	1,860.6	7.0%	10.2%	11.6%	14.2%	10%	No	
Coastal Drainage	Portsmouth Harbor	010600031001	5,185	25,087	31,098	3,469.2	4,810.0	5,545.9	6,497.3	13.8%	19.2%	22.1%	25.9%	10%	No	(1)
Coastal Drainage	Berrys Brook-Rye Harbor	010600031002	326	10,308	10,634	843.1	1,236.1	1,414.4	1,710.7	8.2%	12.0%	13.7%	16.6%	10%	No	
Coastal Drainage	Taylor River-Hampton River	010600031003	289	14,381	14,670	1,168.9	1,761.4	2,160.9	2,673.0	8.1%	12.2%	15.0%	18.6%	10%	No	
Coastal Drainage	Hampton Harbor	010600031004	2,136	12,162	14,298	1,529.2	2,164.2	2,519.1	2,970.2	12.6%	17.8%	20.7%	24.4%	10%	No	(5)
TOTAL			**31,409**	**658,455**	**690,741**	**28,695**	**42,590**	**50,314**	**63,241**	**4.4%**	**6.5%**	**7.6%**	**9.6%**			

(1) Includes both the NH and Maine or NH and Massachusetts portions of the watershed.
(2) Data Source: UNH Complex Systems Research Center
(3) The uncertainty for all the percent impervious values was assumed to be +/-0.7%. This value is the size of the error bar for an average watershed.
(4) Watersheds with >10% impervious cover are highlighted.
(5) Includes only the NH portion of the watershed

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Table LUD1-2: Impervious surface coverage in coastal municipalities

Town Name	Mapped Area (acres)			Impervious Surface (acres)				Percent Imperviousness (%)					Meeting Goal
	Total	Water	Land	1990	2000	2005	2010	1990	2000	2005	2010	Goal	
BARRINGTON, NH	31,117	1,399	29,718	764.2	1,187.7	1,389.4	1,877.2	2.6%	4.0%	4.7%	6.3%	10%	Yes
BRENTWOOD, NH	10,863	125	10,738	532.5	829.1	1,023.6	1,313.4	5.0%	7.7%	9.5%	12.2%	10%	No
BROOKFIELD, NH	14,880	287	14,593	138.8	190.7	198.7	266.7	1.0%	1.3%	1.4%	1.8%	10%	Yes
CANDIA, NH	19,557	217	19,340	531.0	792.8	930.8	1,241.7	2.7%	4.1%	4.8%	6.4%	10%	Yes
CHESTER, NH	16,718	100	16,618	422.8	719.5	853.6	1,134.5	2.5%	4.3%	5.1%	6.8%	10%	Yes
DANVILLE, NH	7,569	131	7,439	261.0	445.2	532.7	706.3	3.5%	6.0%	7.2%	9.5%	10%	Yes
DEERFIELD, NH	33,348	764	32,584	492.5	768.9	968.8	1,296.8	1.5%	2.4%	3.0%	4.0%	10%	Yes
DOVER, NH	18,592	1,559	17,033	1,873.6	2,627.0	3,176.7	3,872.9	11.0%	15.4%	18.7%	22.7%	10%	No
DURHAM, NH	15,852	1,600	14,252	675.0	1,026.4	1,099.1	1,403.9	4.7%	7.2%	7.7%	9.9%	10%	Yes
EAST KINGSTON, NH	6,381	63	6,318	220.6	334.2	438.6	565.4	3.5%	5.3%	6.9%	8.9%	10%	Yes
EPPING, NH	16,776	310	16,465	654.9	1,066.2	1,284.9	1,694.4	4.0%	6.5%	7.8%	10.3%	10%	No
EXETER, NH	12,813	264	12,549	936.9	1,372.2	1,556.5	1,957.0	7.5%	10.9%	12.4%	15.6%	10%	No
FARMINGTON, NH	23,640	422	23,218	685.8	964.0	1,088.6	1,418.9	3.0%	4.2%	4.7%	6.1%	10%	Yes
FREMONT, NH	11,142	108	11,035	330.4	539.4	658.8	870.9	3.0%	4.9%	6.0%	7.9%	10%	Yes
GREENLAND, NH	8,524	1,801	6,722	452.8	708.5	842.0	1,056.8	6.7%	10.5%	12.5%	15.7%	10%	No
HAMPTON, NH	9,073	1,056	8,017	1,179.5	1,609.1	1,721.9	2,050.3	14.7%	20.1%	21.5%	25.6%	10%	No
HAMPTON FALLS, NH	8,078	559	7,519	340.7	535.3	695.8	898.6	4.5%	7.1%	9.3%	12.0%	10%	No
KENSINGTON, NH	7,668	32	7,636	244.2	379.1	471.1	598.1	3.2%	5.0%	6.2%	7.8%	10%	Yes
KINGSTON, NH	13,450	956	12,494	652.2	1,022.5	1,214.2	1,562.0	5.2%	8.2%	9.7%	12.5%	10%	No
LEE, NH	12,927	241	12,686	468.7	741.6	842.2	1,110.9	3.7%	5.8%	6.6%	8.8%	10%	Yes
MADBURY, NH	7,799	400	7,399	250.7	392.8	391.4	531.4	3.4%	5.3%	5.3%	7.2%	10%	Yes
MIDDLETON, NH	11,843	284	11,559	204.1	283.7	349.5	474.7	1.8%	2.5%	3.0%	4.1%	10%	Yes
MILTON, NH	21,936	847	21,089	596.8	837.4	984.9	1,316.8	2.8%	4.0%	4.7%	6.2%	10%	Yes
NEW CASTLE, NH	1,348	841	506	108.2	155.1	171.0	207.3	21.4%	30.6%	33.8%	41.0%	10%	No
NEW DURHAM, NH	28,054	1,708	26,345	458.5	628.6	727.1	990.1	1.7%	2.4%	2.8%	3.8%	10%	Yes
NEWFIELDS, NH	4,647	106	4,541	142.6	251.7	308.9	391.2	3.1%	5.5%	6.8%	8.6%	10%	Yes
NEWINGTON, NH	7,917	2,701	5,216	678.3	931.1	1,045.8	1,242.1	13.0%	17.9%	20.1%	23.8%	10%	No
NEWMARKET, NH	9,080	1,141	7,939	479.9	707.0	821.7	1,011.4	6.0%	8.9%	10.3%	12.7%	10%	No
NORTH HAMPTON, NH	8,923	61	8,862	645.7	955.5	1,100.2	1,362.9	7.3%	10.8%	12.4%	15.4%	10%	No
NORTHWOOD, NH	19,357	1,383	17,973	423.3	608.1	715.1	977.0	2.4%	3.4%	4.0%	5.4%	10%	Yes
NOTTINGHAM, NH	30,997	1,122	29,874	448.2	692.8	841.5	1,142.3	1.5%	2.3%	2.8%	3.8%	10%	Yes

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Town Name	Mapped Area (acres)			Impervious Surface (acres)				Percent Imperviousness (%)					Meeting
	Total	Water	Land	1990	2000	2005	2010	1990	2000	2005	2010	Goal	Goal
PORTSMOUTH, NH	10,763	761	10,002	2,135.6	2,733.4	3,063.1	3,510.1	21.4%	27.3%	30.6%	35.1%	10%	No
RAYMOND, NH	18,943	505	18,439	976.4	1,483.0	1,712.0	2,175.9	5.3%	8.0%	9.3%	11.8%	10%	No
ROCHESTER, NH	29,081	759	28,322	2,394.3	3,302.3	3,937.0	4,918.6	8.5%	11.7%	13.9%	17.4%	10%	No
ROLLINSFORD, NH	4,843	161	4,681	266.7	383.4	436.8	557.3	5.7%	8.2%	9.3%	11.9%	10%	No
RYE, NH	8,406	408	7,997	579.3	870.7	1,012.9	1,242.9	7.2%	10.9%	12.7%	15.5%	10%	No
SANDOWN, NH	9,232	343	8,888	337.4	543.8	700.6	931.7	3.8%	6.1%	7.9%	10.5%	10%	No
SEABROOK, NH	6,161	946	5,215	800.6	1,204.6	1,536.7	1,807.8	15.4%	23.1%	29.5%	34.7%	10%	No
SOMERSWORTH, NH	6,398	179	6,219	767.8	1,020.7	1,252.4	1,517.9	12.3%	16.4%	20.1%	24.4%	10%	No
STRAFFORD, NH	32,779	1,627	31,151	432.4	636.3	724.8	989.8	1.4%	2.0%	2.3%	3.2%	10%	Yes
STRATHAM, NH	9,902	245	9,657	626.4	977.1	1,241.7	1,565.9	6.5%	10.1%	12.9%	16.2%	10%	No
WAKEFIELD, NH	28,717	3,453	25,264	877.3	1,223.7	1,404.6	1,879.6	3.5%	4.8%	5.6%	7.4%	10%	Yes
ACTON, ME	26,309	2,189	24,120	375.3	598.5	694.8	920.4	1.6%	2.5%	2.9%	3.8%	10%	Yes
BERWICK, ME	24,230	443	23,786	616.6	1,052.5	1,307.5	1,623.7	2.6%	4.4%	5.5%	6.8%	10%	Yes
ELIOT, ME	13,652	1,042	12,610	521.9	936.4	1,157.6	1,425.5	4.1%	7.4%	9.2%	11.3%	10%	No
KITTERY, ME	13,495	2,187	11,308	916.6	1,344.9	1,573.2	1,855.0	8.1%	11.9%	13.9%	16.4%	10%	No
LEBANON, ME	35,729	674	35,055	629.0	1,067.0	1,307.1	1,647.9	1.8%	3.0%	3.7%	4.7%	10%	Yes
NORTH BERWICK, ME	24,423	158	24,265	525.9	848.3	1,017.5	1,266.5	2.2%	3.5%	4.2%	5.2%	10%	Yes
SANFORD, ME	31,205	890	30,315	1,780.4	2,745.2	3,067.8	3,582.0	5.9%	9.1%	10.1%	11.8%	10%	No
SOUTH BERWICK, ME	20,890	422	20,469	483.1	795.4	965.8	1,210.7	2.4%	3.9%	4.7%	5.9%	10%	Yes
WELLS, ME	37,246	497	36,749	1,375.6	2,186.8	2,701.4	3,243.8	3.7%	6.0%	7.4%	8.8%	10%	Yes
YORK, ME	36,560	1,652	34,908	1,495.6	2,462.0	2,898.1	3,453.5	4.3%	7.1%	8.3%	9.9%	10%	Yes
TOTAL	**879,830**	**42,131**	**837,699**	**35,208**	**52,719**	**62,159**	**77,871**	**4.2%**	**6.3%**	**7.4%**	**9.3%**		

(1) Data Source: UNH Complex Systems Research Center
(2) The uncertainty for all the %impervious values was assumed to be +/-0.7%. This value is the size of the error bar for an average watershed.
(3) Towns with >10% impervious cover are highlighted.

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Figure LUD1-1: Impervious surface cover in the entire coastal watershed in 1990, 2000, 2005 and 2010

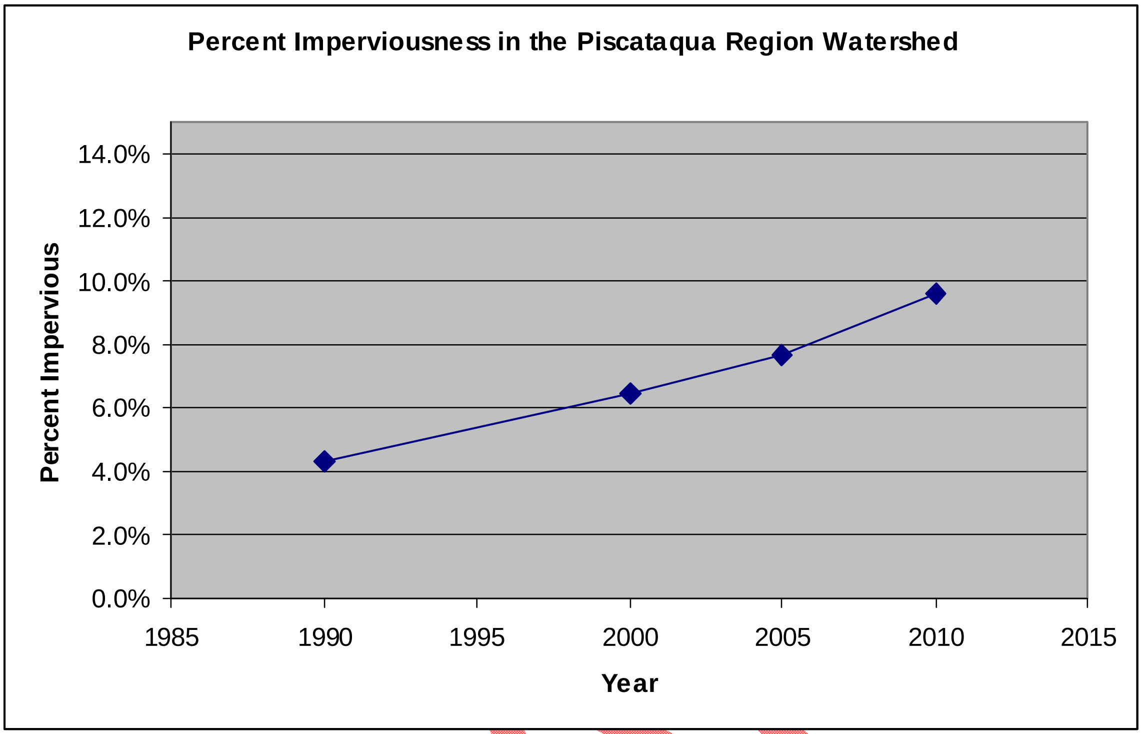

Figure LUD1-2: Number of watersheds and towns with greater than 10% impervious surface cover in 1990, 2000, 2005 and 2010

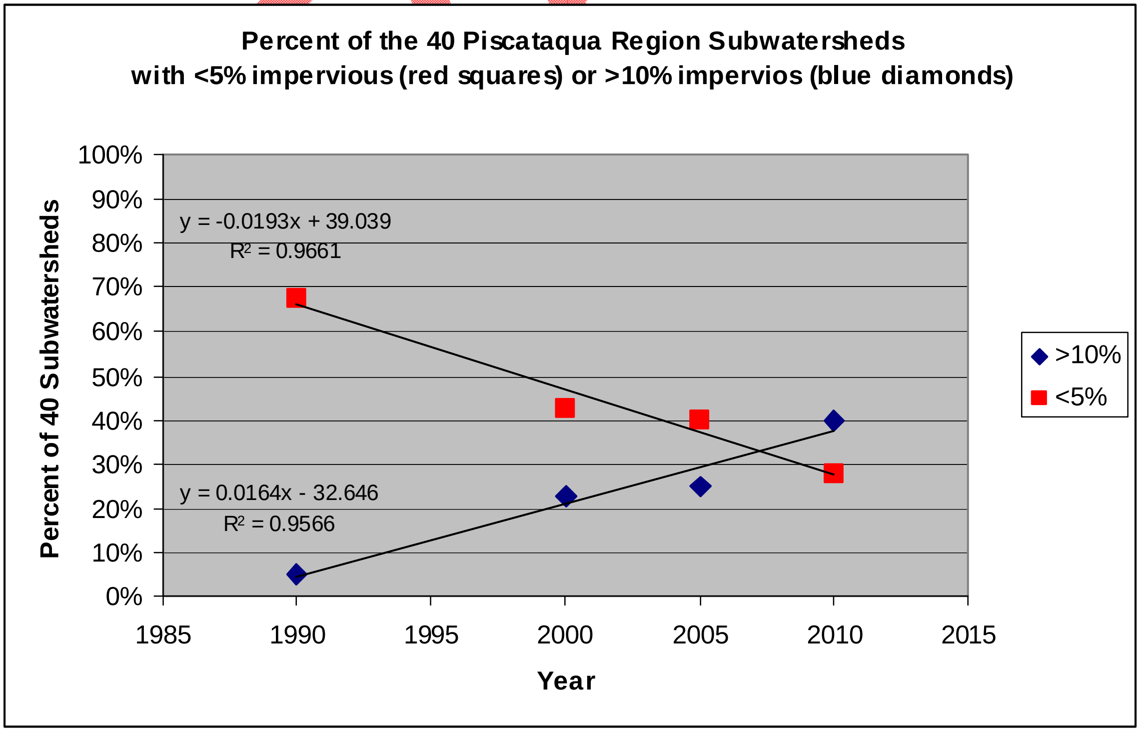

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Figure LUD1-3: Percent impervious surfaces in coastal watersheds in 2010

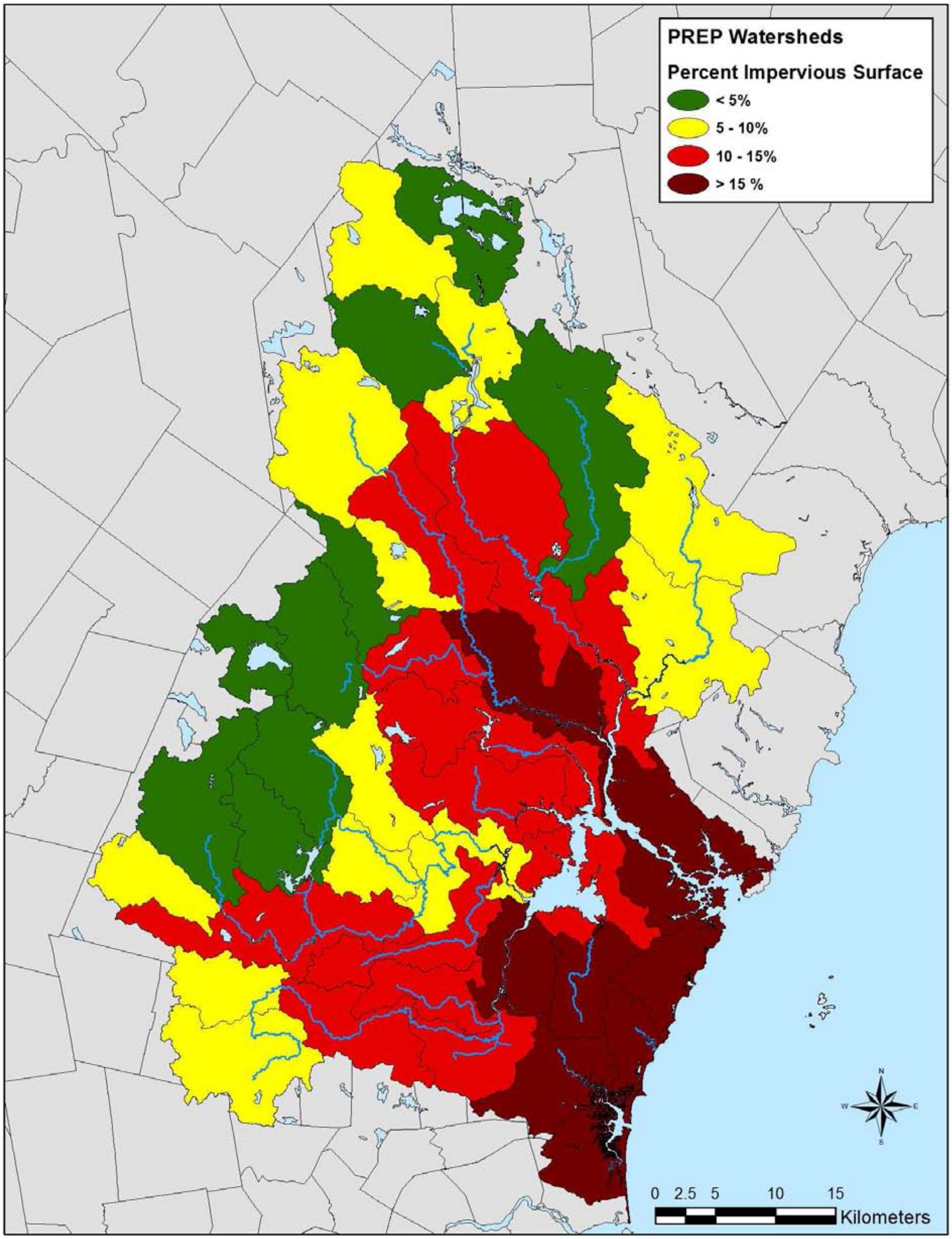

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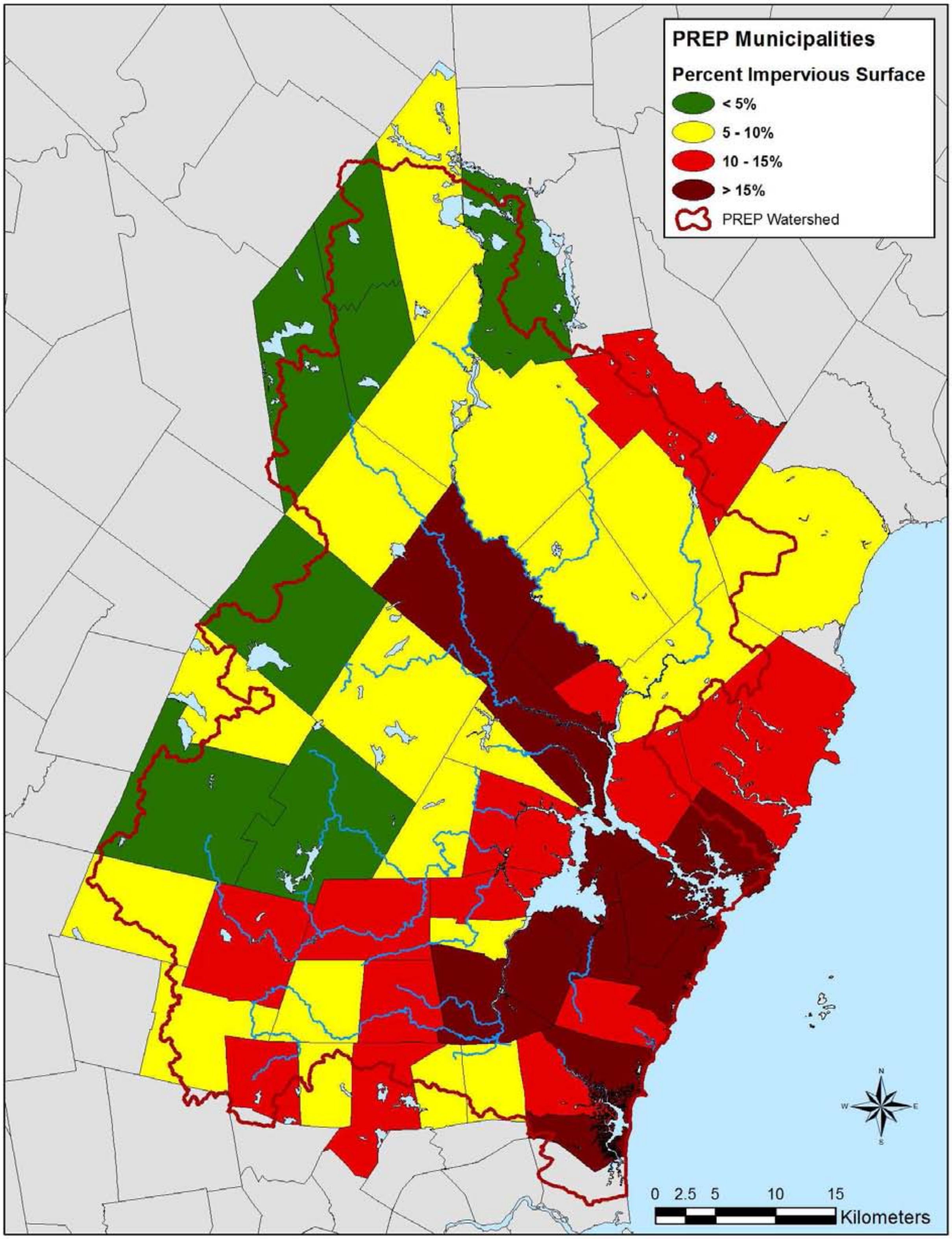
Figure LUD1-4: Percent impervious surfaces in coastal municipalities in 2010



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Indicator: NUT1. Nitrogen load to the Great Bay Estuary

Objective

The objective of this indicator is to estimate the annual load of total nitrogen (TN) and dissolved inorganic nitrogen (DIN) to the Great Bay Estuary upstream of Dover Point from the major tributaries and municipal wastewater treatment facilities (WWTF) in the Piscataqua Region watershed. Concentrations of TN and DIN in freshwater tributaries and the WWTF effluent will be combined with measurements of flow to estimate the load. Available information on atmospheric and groundwater loading of nitrogen will also be compiled. Established conceptual models for estuarine eutrophication (CBP, 2000; Cloern, 2001; Bricker et al., 2007; Burkholder et al., 2007; CENR, 2010) predict that excess nutrients in estuaries can cause algae blooms, low dissolved oxygen, species composition changes, and eelgrass habitat loss.

PREP Goal

Obj WR 1.3: Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. For the 2013 SOOE, attainment of Obj WR 1.3 will be evaluated qualitatively based on the narrative goal. If there are significant observations of typical eutrophication symptoms (e.g., low dissolved oxygen, increasing algae populations, or declining eelgrass), the nitrogen load to the estuary will be interpreted as being higher than the PREP goal.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

For the purposes of this evaluation, the following sources were identified that contribute to the nitrogen load to the Great Bay Estuary. It is assumed that these represent a complete accounting of contributing sources.

- Municipal Wastewater Treatment Facilities (WWTFs)
- Non-Point Sources (NPS) in Watersheds
- Groundwater Discharge to the Estuary
- Atmospheric Deposition to the Estuary

Nitrogen loads were calculated for the portion of the Great Bay Estuary system north and west of Dover Point (Great Bay, Little Bay, and the Upper Piscataqua River – the “study area”). A complete analysis of nitrogen loads to the Lower Piscataqua River was not completed, although the delivered loads from WWTFs in the Lower Piscataqua River were included in the calculations. The methods for the nitrogen loading calculations follow the procedures in NHDES (2010, Appendix A). Brief summaries of the methods and any deviations from the procedures are described below.

Point Source Discharges from WWTFs

The annual average TN and DIN load from each WWTF was estimated by multiplying the most recent average concentration by the annual average effluent flow. Monthy average loads were calculated in the same way except the monthly average flows were used. If nitrogen data were not available for a WWTF, then the average TN and DIN concentrations from monitored WWTFs were used. Monthly average effluent flows from the WWTFs were compiled from facility operating reports and then averaged over the modeling period. For WWTFs with intermittent discharges, the monthly average flow was calculated from the total volume of effluent discharged in the month divided by the number of days in the month.

For WWTFs that discharge to rivers upstream of the estuary, some of the nitrogen discharged from the WWTF is lost during transit to the estuary. For WWTFs that discharge to the Lower Piscataqua River, some of the nitrogen discharged from the WWTF does not reach as far upstream as Dover Point due to the limits of the tidal water movement. For these WWTFs, the nitrogen load should be reported in terms of its “delivered load” to the Great Bay Estuary study area. The delivered load was calculated by multiplying the discharged load by a “delivery factor”,

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which represents the percent of the discharged load that is delivered to the study area. The delivery factors for discharges to freshwater rivers were calculated based on travel time to the estuary following the methods of NHDES (2010). The delivery factors for WWTFs that discharge to the Lower Piscataqua River were calculated from particle tracking models used in NHDES (2010) or more recent models provided by Portsmouth and Kittery (ASA 2011a, ASA 2011b).

Non-Point Sources in Major Watersheds

The TN and DIN loads to the estuary from the eight major watersheds were calculated using measurements of TN and DIN concentrations and stream flow. The U.S. Geological Survey (USGS) LOADEST model was used to develop a calibrated model relating TN and DIN concentrations and daily average stream flow (Runkel et al., 2004). The LOADEST model was set to select the optimal model based on the calibration dataset, and, following advice from the USGS, all the parameters in the chosen model were included, even if their coefficients were not statistically significant. The inputs to the LOADEST model were monthly measurements of TN and DIN concentrations and daily average stream flow at the tidal dam for each river. For TN and DIN concentrations, non-detected samples were represented by one-half of the reporting detection limit. Stream flow at the tidal dams was estimated from USGS stream gages in the watersheds and drainage area transposition factors (see table below). The output of the LOADEST model was both the average load for the study period and the monthly loads during the study period. The NPS delivered load from watersheds was calculated by subtracting the delivered nitrogen load due to upstream WWTFs from the total measured load at each of the tidal dams.

Tributary Monitoring Station	Watershed Area for Station (sq miles)	USGS Streamgage Number	Watershed Area for Streamgage (sq miles)	Flow Multipier for Transpositions
Lamprey River	211.56	01073500	183	1.156052
Exeter River	106.92	01073587	63.5	1.683844
Oyster River	19.83	01073000	12.1	1.638450
Cocheco River	175.23	01072800	85.7	2.044650
Salmon Falls River	235.00	01073500		1.284153
Bellamy River[1]	27.30	01072800		0.1592940
		01073000		1.1282227
Winnicut River[2]	14.24	01073785	14.1	1.0096015
Great Works River	86.70	01072800		1.0116686

1. Flow in the Bellamy River was estimated by averaging cfsm transpositions from the Cocheco and Oyster River gages.
2. Flow in the Winnicut River was measured directly from 2002 to August 25, 2009 at gage 01073785. The gage was moved on August 25, 2009 after which the water level was affected by tides. From August 25, 2009 onwards, flow at 02-WNC was estimated by cfsm transposition from the Oyster River gage.

Non-Point Sources from Small Watersheds Adjacent to the Estuary

Runoff from land adjacent to the estuary was not captured in the load measurements at the tidal dams. Therefore, TN and DIN loads from these areas had to be estimated. Using the data from the major watersheds, relationships were developed between the percent of land shown as developed or agriculture and the TN and DIN yields (load per unit drainage area) after correcting for upstream WWTF discharges. The NPS loads from the small adjacent watersheds were estimated using the percent of land shown as developed or agriculture in the watershed and these regression equations (Figure NUT1-4). The regressions were developed for a range of land use from 11.6 to 30.8% developed or agriculture. These small adjacent watersheds typically were more developed than this range (25 to 57%). Therefore, the use of these regressions is an extrapolation of a linear model outside the calibration range. For monthly loading calculations, the average loads predicted from the regressions were pro-rated based on the ratio of the monthly NPS loads from the major watersheds to the average NPS loads from the major watersheds.

Groundwater Discharge

Some groundwater flow and nitrogen loading was accounted for in the NPS loading estimates for watersheds. However, regional groundwater flow was also expected to contribute some nitrogen to the estuaries. Ballestero et al. (2004) measured the nitrogen loading rate from groundwater seeps to be 0.13 tons N/yr per mile of tidal shoreline. This loading rate was applied to the length of tidal shoreline in the estuary to estimate the groundwater loading rate. The groundwater loading rate was assumed to be constant because no other information was available. All of the nitrogen contributed by this source was assumed to be in the DIN form.

Atmospheric Deposition

Atmospheric deposition of nitrogen directly to the estuary surface was estimated by multiplying the average deposition rate provided by Daley et al. (2010) (2.11 tons/mi2/yr or 7.41 kg/ha/yr) by the surface area of the estuary. This loading rate was assumed to be constant. Atmospheric deposition of nitrogen to the land surface is accounted for in the NPS load contribution. All of the nitrogen contributed by this source was assumed to be in the DIN form.

Nitrogen Load Summary

The annual and monthly TN and DIN loads were calculated by summing the individual components of the nitrogen load: Delivered WWTF loads, NPS loads from watersheds above the tidal dams, NPS loads from watersheds below the tidal dams, groundwater loads, and atmospheric deposition to the estuary. Subtotals for WWTFs and NPS were also calculated.

Data Sources

For the nitrogen load from WWTFs, flow data was obtained from monthly operating reports filed by the WWTFs. Nitrogen concentrations in WWTF effluent were obtained from the WWTFs, NHEP (2008), and any other relevant studies.

The loading from the tidal tributaries was estimated from monthly (March-December) nutrient concentrations collected by the PREP Tidal Tributary Monitoring Program at the head of tide stations on the Winnicut, Exeter, Lamprey, Oyster, Bellamy, Cocheco, Salmon Falls and Great Works Rivers. Flow data for the Winnicut, Exeter, Lamprey, Oyster and Cocheco Rivers were obtained from the USGS Streamflow Monitoring Program.

Results

The Great Bay Estuary watershed, the major tributaries, and WWTFs are shown on Figure NUT1-1.

The TN and DIN loads from the 18 WWTFs in the Great Bay Estuary watershed are shown in Table NUT1-1 and Figure NUT1-2. The WWTF with the largest delivered nitrogen load was Rochester followed by Dover and Exeter. These three WWTFs accounted for 71% of the nitrogen delivered to the estuary by all WWTFs combined.

The TN and DIN loads from the eight major tributaries are shown in Table NUT1-2 and Figure NUT1-3. The Cocheco River produced the highest annual load. The loads from the Salmon Falls and Lamprey rivers were slightly lower. The remaining five rivers delivered considerably less nitrogen. In Table NUT1-2, the loading model statistics for each river are shown.

In Figure NUT1-4, the TN and DIN non-point source yields from Table NUT1-3 has been plotted against the percent of land in each watershed that was classified as developed or agricultural in 2006 (NOAA C-CAP imagery). The statistically significant relationships were used to estimate the non-point source loads from the small watersheds below the tidal dams that drain directly to the estuary. The predicted values for these drainage areas are shown on the figure.

The results from all the loading estimates are combined in Table NUT1-4 and Figure NUT1-5. The TN load to the Great Bay Estuary in 2009-2011 was 1,225 tons/year. The DIN load was 597 tons/year. WWTF point sources contributed 32% of the TN load and 52% of the DIN load. When the loads are analyzed by month (Figure NUT1-6), WWTF point sources were responsible for more than 50% of the TN load during the months of July, August, and September. WWTFs accounted for the majority of the DIN load most of the year (May through November).

The TN load to the Great Bay Estuary was estimated to be 1,206 tons/year in 2003-2004, 1,662 tons/year in 2005-2006, and 1,355 tons/year in 2007-2008 (NHDES, 2010) using the same methods as this indicator. Therefore, the TN load to the estuary in 2009-2011 was lower than during the 2005-2008 but still higher than the estimate for 2003-2004. The majority of the changes in loading between the years can be explained by changes in non-point source loads which are correlated with precipitation and watershed runoff (Figure NUT1-7). High rainfall totals in 2005 and 2006 resulted in a 29% increase in non-point source loads during these years relative to 2003-2004 and 2007-2011.

The PREP goal for nitrogen loads to the estuary is to reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. For the 2013 SOOE, attainment of the goal will be evaluated qualitatively based on the narrative goal. If there are significant observations of typical eutrophication symptoms (e.g., low dissolved oxygen, increasing algae populations, or declining eelgrass), the nitrogen load to the estuary will be interpreted as being higher than the PREP goal. For dissolved oxygen, the state water quality standard is exceeded in some tidal rivers for up to several weeks per year (see indicator NUT5). For algae, phytoplankton concentrations (as measured by chlorophyll-a) have not changed in Great Bay between 1975 and 2011; however, populations of macroalgae such as *Ulva* and *Gracilaria* have increased in some areas (see indicator NUT3b). For eelgrass, there are statistically significant, long-term declining trends in most areas of the estuary, although populations in Great Bay were higher in the last three years (see indicator HAB2). In the scientific literature it has been reported by Nixon et al. (2001) that negative effects on eelgrass in shallow estuaries may occur when DIN loads are greater than 2 mmol per square meter of estuary area per day, which for the Great Bay Estuary would amount to 396 tons of DIN per year. The DIN load to the Great Bay Estuary in 2009-2011 was 597 tons per year. The total nitrogen loads to the estuary in 2009-2011 also exceed apparent thresholds for eelgrass loss derived by Latimer and Rego (2010) for shallow estuaries in southern New England.

In summary, the combination of these PREP indicators and information from the scientific literature supports the conclusion that the Great Bay Estuary exhibits all of the typical eutrophication symptoms at the current level of nitrogen loading so the PREP goal has not been attained.

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Table NUT1-1: Estimated nitrogen loads from wastewater treatment facilities in 2009-2011

(A) Total Nitrogen

WWTF	Discharge Location	Ave. [TN] (mg N/L)	Data Source[1]	Annual Ave. Flow 2009-2011 (MGD)[2]	Delivery Factor[3] (%)	Delivered TN Load in 2009-2011 (tons/yr)
Durham	Oyster River (tidal)	10.28	2010 Town of Durham Data	0.952	100.00%	14.88
Exeter	Exeter River (tidal)	14.43	NHEP (2008)	1.906	100.00%	41.80
Newfields	Exeter River (tidal)	21.53	2011 Town of Newfield Data	0.056	100.00%	1.83
Newmarket	Lamprey River (tidal)	30.10	NHEP (2008)	0.612	100.00%	27.99
Dover	Upper Piscataqua River (tidal)	22.33	NHEP (2008)	2.770	100.00%	94.02
South Berwick	Salmon Falls River (tidal)	5.90	2010 South Berwick Sewer District Data	0.343	100.00%	3.08
Kittery	Lower Piscataqua River	15.99	NHEP (2008)	1.124	14.20%	3.88
Newington	Lower Piscataqua River	17.97	Estimated	0.133	26.34%	0.96
Portsmouth	Lower Piscataqua River	27.35	2010 City of Portsmouth Data	5.676	12.50%	29.49
Pease ITP	Lower Piscataqua River	8.74	2008 City of Portsmouth	0.709	26.34%	2.48
Farmington	Cocheco River	19.86	2010 Monthly Operating Reports	0.297	41.93%	3.75
Rochester	Cocheco River	35.46	2010 City of Rochester Data	3.438	75.56%	140.01
Epping	Lamprey River	17.97	Estimated	0.259	58.20%	4.12
Berwick	Salmon Falls River	16.68	NHEP (2008)	0.218	94.55%	5.24
Milton	Salmon Falls River	17.97	Estimated	0.082	65.70%	1.47
Rollinsford	Salmon Falls River	17.97	Estimated	0.085	98.96%	2.30
Somersworth	Salmon Falls River	4.95	NHEP (2008)	1.582	94.94%	11.31
North Berwick	Great Works River	17.97	Estimated	0.110	51.56%	1.54
Total				20.351		390.16

(B) Dissolved Inorganic Nitrogen

WWTF	Discharge Location	Ave. [DIN] (mg N/L)	Data Source[1]	Annual Ave. Flow 2009-2011 (MGD)[2]	Delivery Factor[3] (%)	Delivered DIN Load in 2009-2011 (tons/yr)
Durham	Oyster River (tidal)	8.95	2010 Town of Durham Data	0.952	100.00%	12.95
Exeter	Exeter River (tidal)	10.41	TDN from NHEP (2008)	1.906	100.00%	30.15
Newfields	Exeter River (tidal)	18.96	2002 data from Bolster et al. (2003)	0.056	100.00%	1.61
Newmarket	Lamprey River (tidal)	19.56	TDN from NHEP (2008)	0.612	100.00%	18.18
Dover	Upper Piscataqua River (tidal)	15.31	TDN from NHEP (2008)	2.770	100.00%	64.46
South Berwick	Salmon Falls River (tidal)	4.58	Estimated using measured TN and DIN:TN at SB WWTF in 2008.	0.343	100.00%	2.39
Kittery	Lower Piscataqua River	12.98	2010 Monthly Operating Reports	1.124	14.20%	3.15
Newington	Lower Piscataqua River	14.10	Estimated using average TN and DIN:TN for monitored WWTFs.	0.133	26.34%	0.75
Portsmouth	Lower Piscataqua River	19.11	2010 City of Portsmouth Data	5.676	12.50%	20.60
Pease ITP	Lower Piscataqua River	6.86	Estimated using average TN and average DIN:TN for monitored WWTFs.	0.709	26.34%	1.95
Farmington	Cocheco River	17.33	2010 Monthly Operating Reports	0.297	41.93%	3.27
Rochester	Cocheco River	32.19	2010 City of Rochester Data	3.438	75.56%	127.10
Epping	Lamprey River	14.10	Estimated using average TN and DIN:TN for monitored WWTFs.	0.259	58.20%	3.24
Berwick	Salmon Falls River	12.55	TDN from NHEP (2008)	0.218	94.55%	3.94
Milton	Salmon Falls River	14.10	Estimated using average TN and DIN:TN for monitored WWTFs.	0.082	65.70%	1.16
Rollinsford	Salmon Falls River	14.10	Estimated using average TN and DIN:TN for monitored WWTFs.	0.085	98.96%	1.80
Somersworth	Salmon Falls River	4.35	TDN from NHEP (2008)	1.582	94.94%	9.92
North Berwick	Great Works River	14.10	Estimated using average TN and DIN:TN for monitored WWTFs.	0.110	51.56%	1.21
Total				20.351		307.84

1. Data on effluent concentrations of total nitrogen (TN) and dissolved inorganic nitrogen (DIN) were taken from previous studies by PREP or monitoring conducted by municipalities. For "Estimated", no data were available for this WWTF. For these WWTFs, TN was assumed to be the average TN concentration in monitored WWTFs (17.97 mg/L) and DIN was assumed based on the average TN and the average ratio of DIN to TN in monitored WWTFs (78.5%).
2. The flows in this table are annual averages. The monthly average flows from NPDES discharge monitoring reports were averaged.
3. Delivery factor is the percent of the discharged load that is delivered to the GB/UPR estuary. For WWTFs in the watersheds, attenuation loss estimated using the travel time for water between the WWTF outfall and the estuary and a first order loss coefficient. For the LPR WWTFs, the delivery factor was estimated from the percent of particles in GB, LB, and UPR at steady state in the Dartmouth particle tracking model or particle tracking models provided by Portsmouth and Kittery.

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Table NUT1-2: Estimated nitrogen loads from major tributaries in 2009-2011

(A) Total Nitrogen

Tributary	TN Load (tons/yr)	Standard Error (tons/yr)	R^2	PPCC	Model
Winnicut	19.14	1.43	0.9635	0.9342	4
Exeter	89.31	6.12	0.9675	0.9901	2
Lamprey	176.30	12.78	0.9782	0.9415	9
Oyster	20.88	1.50	0.9638	0.9818	3
Bellamy	23.54	1.58	0.9623	0.9873	2
Cocheco	269.01	18.07	0.8608	0.9598	1
Salmon Falls	172.28	11.50	0.9503	0.9852	3
Great Works	59.86	3.67	0.9580	0.9379	2
Total	830.30				

(B) Dissolved Inorganic Nitrogen

Tributary	DIN Load (tons/yr)	Standard Error (tons/yr)	R^2	PPCC	Model
Winnicut	5.50	0.86	0.8850	0.9644	2
Exeter	25.82	4.15	0.9170	0.9119	2
Lamprey	57.45	7.68	0.9155	0.9878	4
Oyster	7.73	1.14	0.9273	0.9722	2
Bellamy	5.74	0.51	0.9193	0.9778	4
Cocheco	179.76	12.23	0.7817	0.9924	3
Salmon Falls	57.88	4.70	0.9447	0.9827	6
Great Works	18.98	1.89	0.9310	0.9793	6
Total	358.87				

1. TN loads estimated using USGS software "LOADEST" with water quality data from the PREP Tidal Tributary Monitoring Program and streamflow data from USGS.
2. R^2 is a measure of the quality of the loading regression model (0=worst, 1=best)
3. PPCC is a measure of the normality of the residuals (0=worst, 1=best)
4. The model number refers to the specific model chosen. The models are defined in the LOADEST users manual (Runkel et al, 2004).

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Table NUT1-3: WWTF and non-point source nitrogen yields from Great Bay watersheds 2009-2011

(A) Total Nitrogen

Watershed	TN Load[1] (tons/yr)	Upstream WWTF TN Load[2,3] (tons/yr)	NPS TN Load (tons/yr)	NPS TN Yield (tons/yr/mi²)	Percent of Watershed Developed[4]
Winnicut River	19.14	0.00	19.14	1.35	30.83%
Exeter River	89.31	0.00	89.31	0.84	22.21%
Lamprey River	176.30	4.12	172.17	0.81	11.57%
Oyster River	20.88	0.00	20.88	1.05	22.23%
Bellamy River	23.54	0.00	23.54	0.86	19.40%
Cocheco River	269.01	143.77	125.24	0.71	16.93%
Salmon Falls River	172.28	20.31	151.97	0.65	13.07%
Great Works River	59.86	1.54	58.31	0.67	15.28%

(B) Dissolved Inorganic Nitrogen

Watershed	DIN Load[1] (tons/yr)	Upstream WWTF DIN Load[2,3] (tons/yr)	NPS DIN Load (tons/yr)	NPS DIN Yield (tons/yr/mi²)	Percent of Watershed Developed[4]
Winnicut River	5.50	0.00	5.50	0.39	30.83%
Exeter River	25.82	0.00	25.82	0.24	22.21%
Lamprey River	57.45	3.24	54.21	0.26	11.57%
Oyster River	7.73	0.00	7.73	0.39	22.23%
Bellamy River	5.74	0.00	5.74	0.21	19.40%
Cocheco River	179.76	130.38	49.38	0.28	16.93%
Salmon Falls River	57.88	16.82	41.06	0.17	13.07%
Great Works River	18.98	1.21	17.77	0.20	15.28%

1. TN loads estimated using USGS software "LOADEST" with water quality data from the PREP Tidal Tributary Monitoring Program and streamflow data from USGS.
2. The following WWTFs are located upstream of the tributary monitoring stations. The Epping WWTF is upstream of the Lamprey River station. The Rochester and Farmington WWTFs are upstream of the Cocheco River station. The Milton, Berwick, Somersworth and Rollinsfored WWTFs are upstream of the Salmon Falls River station. The North Berwick WWTF is upstream of the Great Works River station.
3. Upstream WWTF loads were reduced using an attenuation loss model to estimate the delivered load to the estuary.
4. Percent of watershed in developed or agriculture land cover classes in 2006 NOAA C-CAP Land Cover Dataset.

EXHIBIT 36 (AR K.22)

Table NUT1-4: Summary of nitrogen loads to the Great Bay and Upper Piscataqua River estuaries

(A) Total Nitrogen

Source	TN Load (tons/year)	Comments
WWTFs Upstream of Dam	169.75	
WWTFs Downstream of Dam	183.60	
WWTFs in Lower Piscataqua River	36.81	
NPS Upstream of Dam	660.56	
NPS Downstream of Dam	130.82	
NPS Groundwater	14.55	
NPS Atmospheric Deposition to Tidal Waters	28.66	
Subtotal - WWTF	390.16	32% WWTF
Subtotal - Non-point sources	834.59	68% NPS
Total	1,224.74	

(B) Dissolved Inorganic Nitrogen

Source	DIN Load (tons/year)	Comments
WWTFs Upstream of Dam	151.65	
WWTFs Downstream of Dam	129.74	
WWTFs in Lower Piscataqua River	26.45	
NPS Upstream of Dam	207.22	
NPS Downstream of Dam	39.15	
NPS Groundwater	14.55	
NPS Atmospheric Deposition to Tidal Waters	28.66	
Subtotal - WWTF	307.84	52% WWTF
Subtotal - Non-point sources	289.57	48%NPS
Total	597.41	

1. WWTF = Wastewater Treatment Facility
2. NPS = Non-Point Source

Figure NUT1-1: Watersheds draining to the Great Bay Estuary

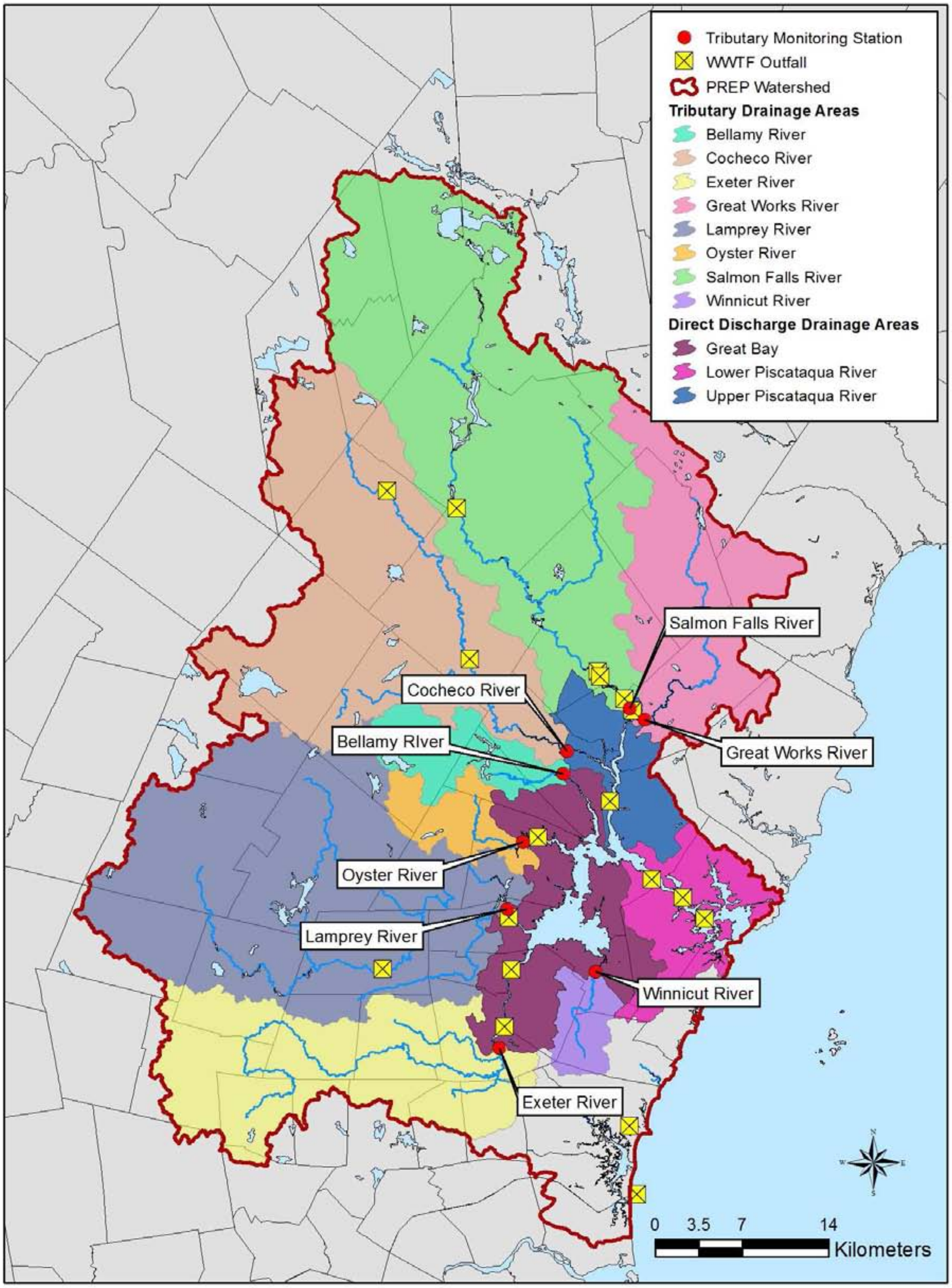


Figure NUT1-2: Estimated total nitrogen and dissolved inorganic nitrogen loads from wastewater treatment facilities in 2008

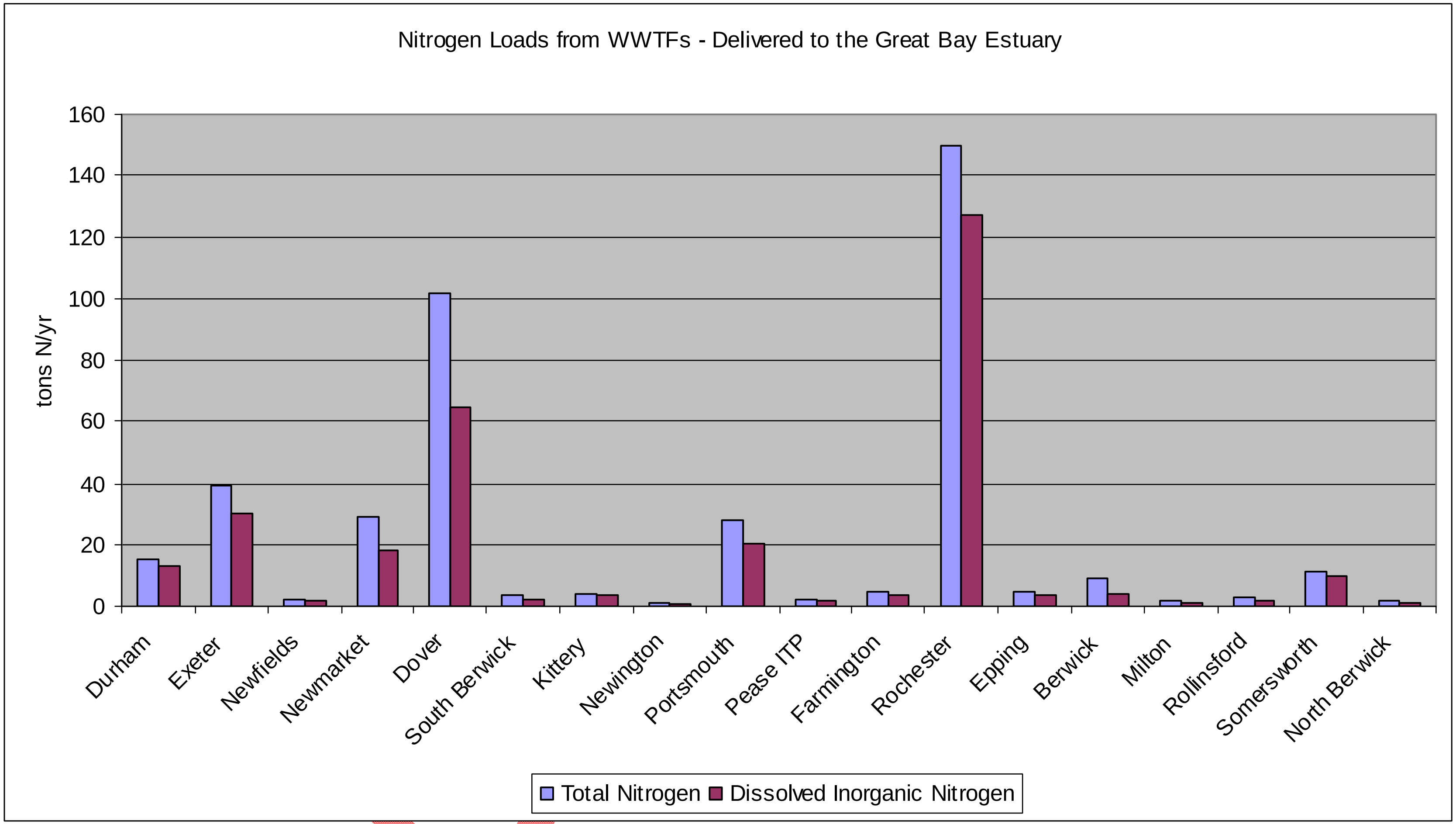
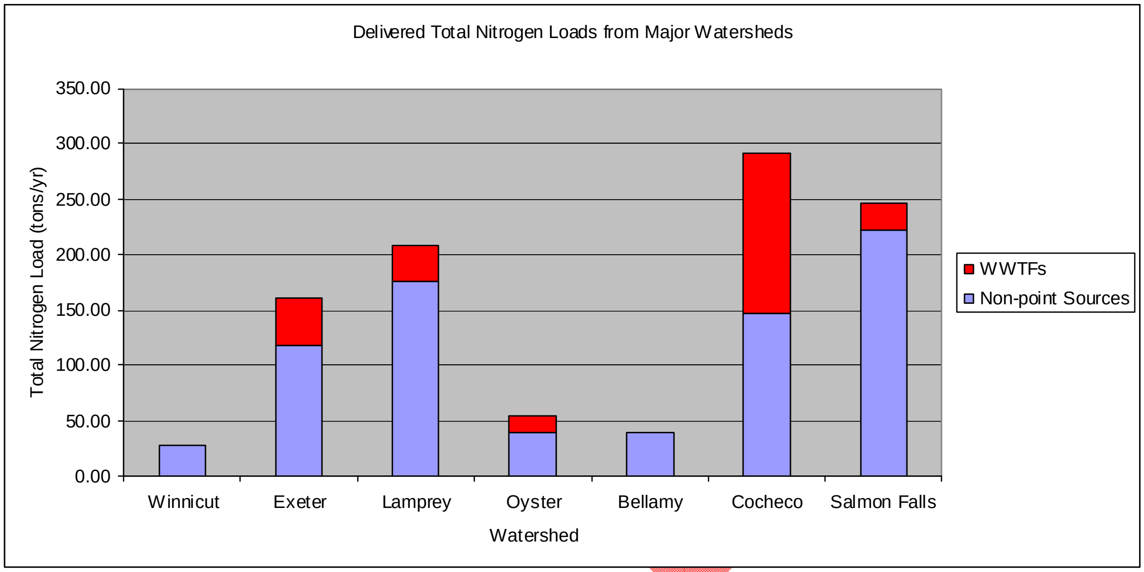


EXHIBIT 36 (AR K.22)

Figure NUT1-3: Estimated nitrogen loads from major tributaries in 2006-2008
(A) Total Nitrogen



(B) Dissolved Inorganic Nitrogen

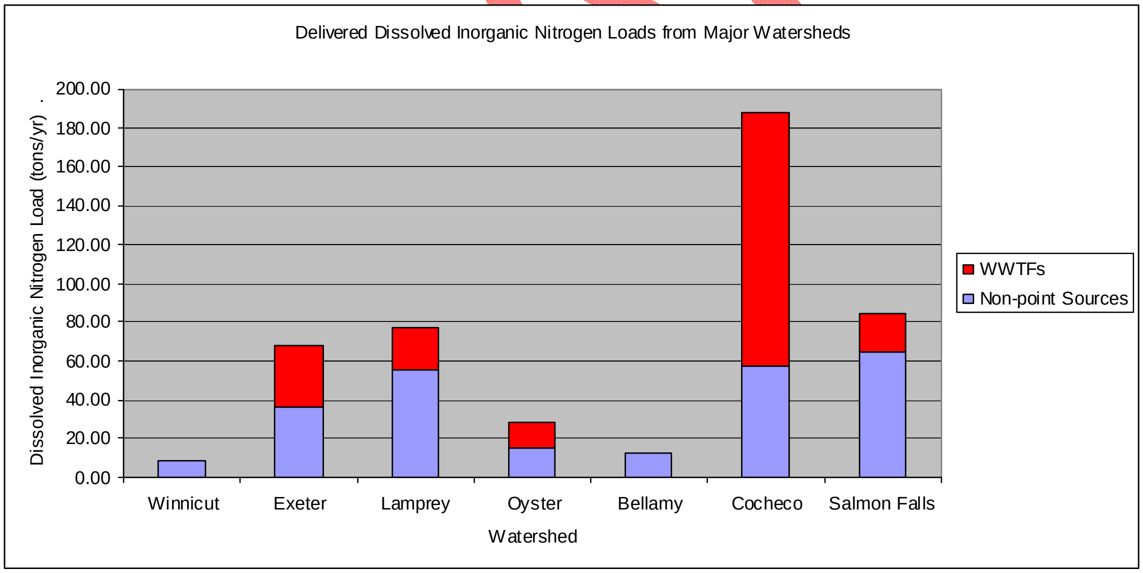
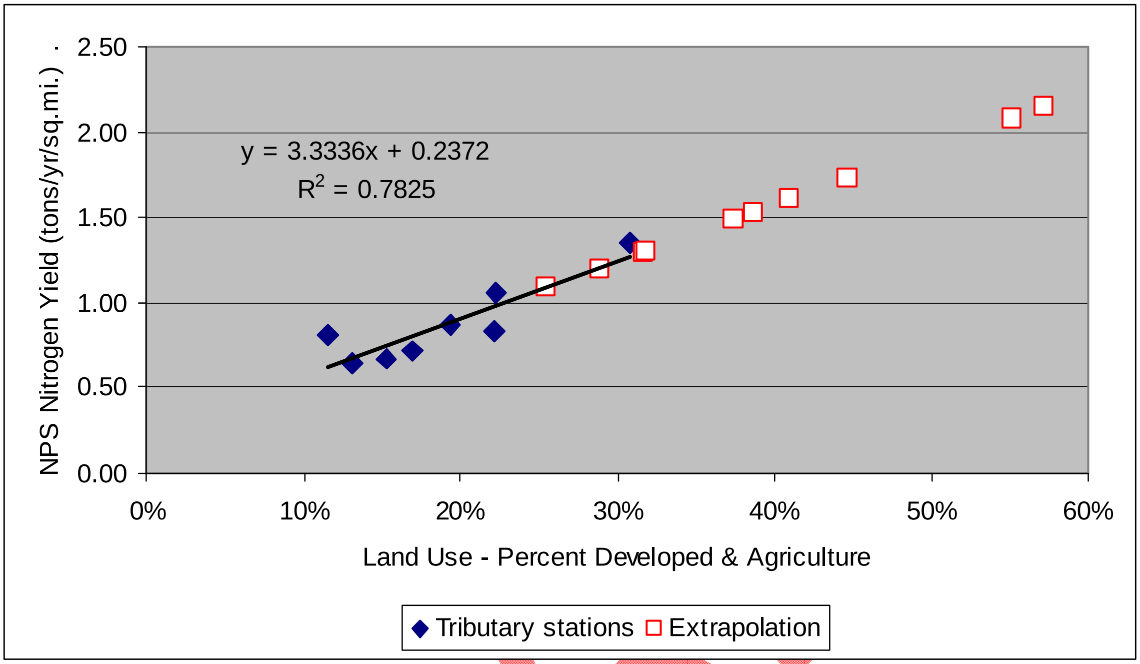


EXHIBIT 36 (AR K.22)

Figure NUT1-4: Relationship between non-point source nitrogen yields and land use in major watersheds and extrapolations to small watersheds downstream of dams

(A) Total Nitrogen



(B) Dissolved Inorganic Nitrogen

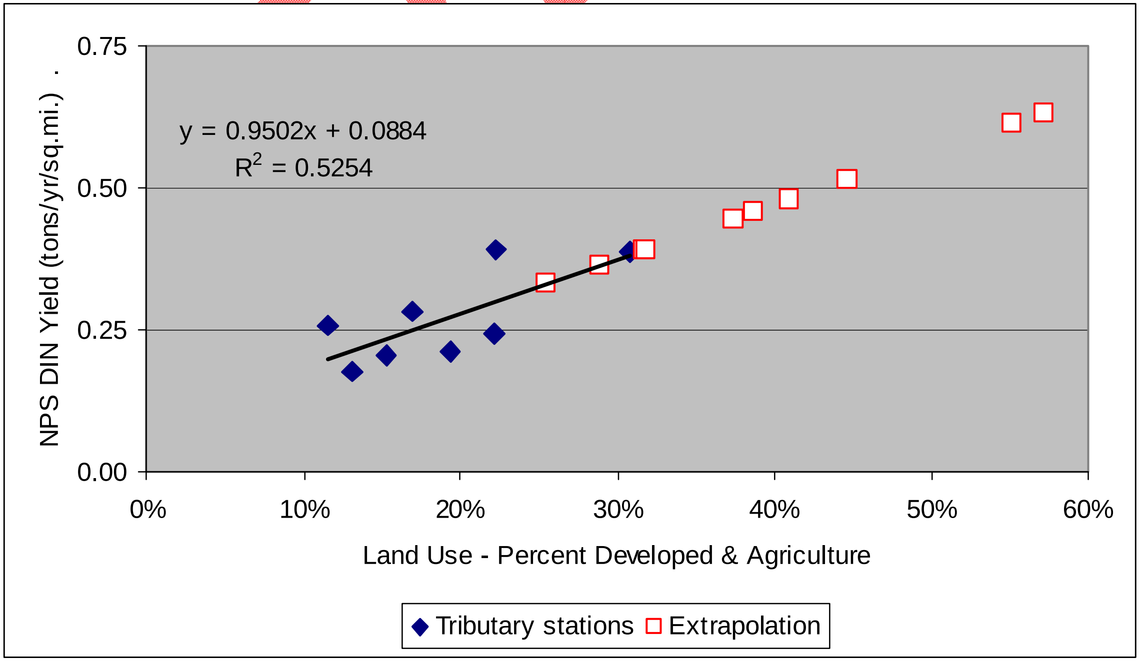
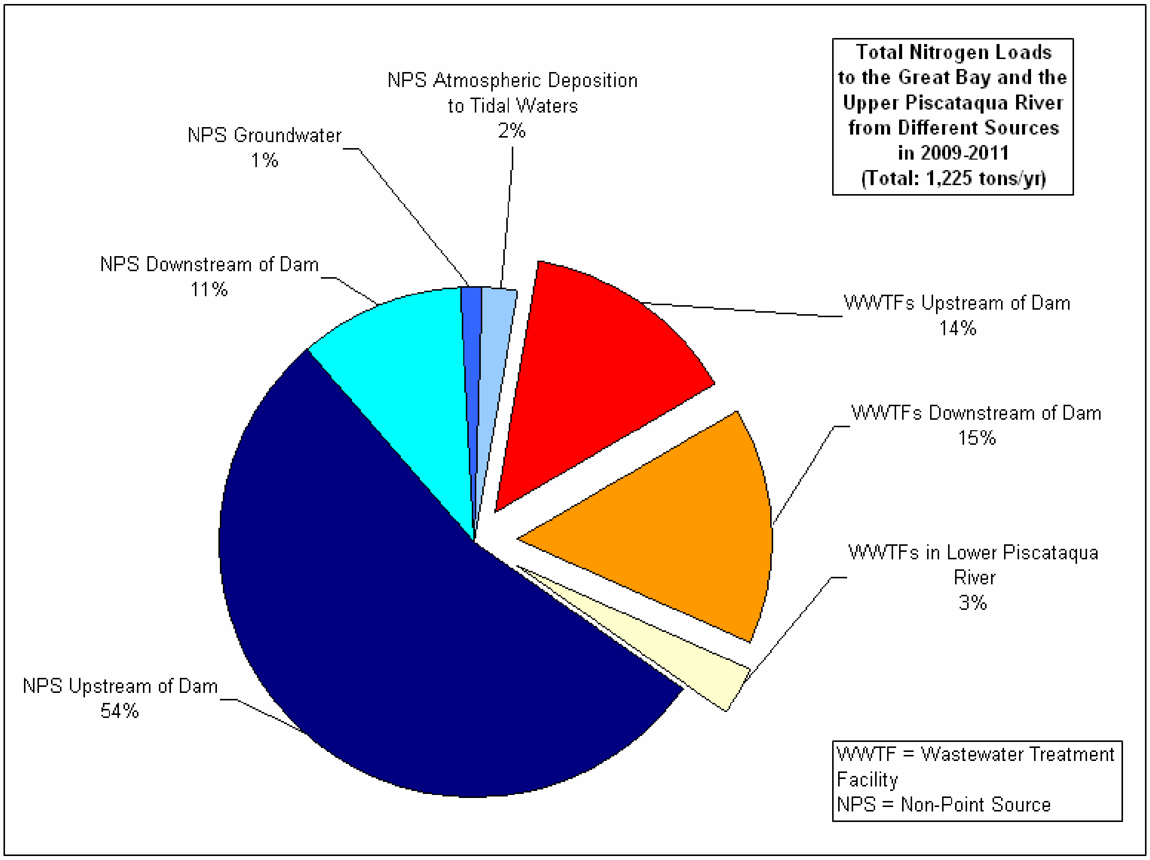


Figure NUT1-5: Nitrogen loads to the Great Bay Estuary from different sources in 2009-2011

(A) Total Nitrogen



(B) Dissolved Inorganic Nitrogen

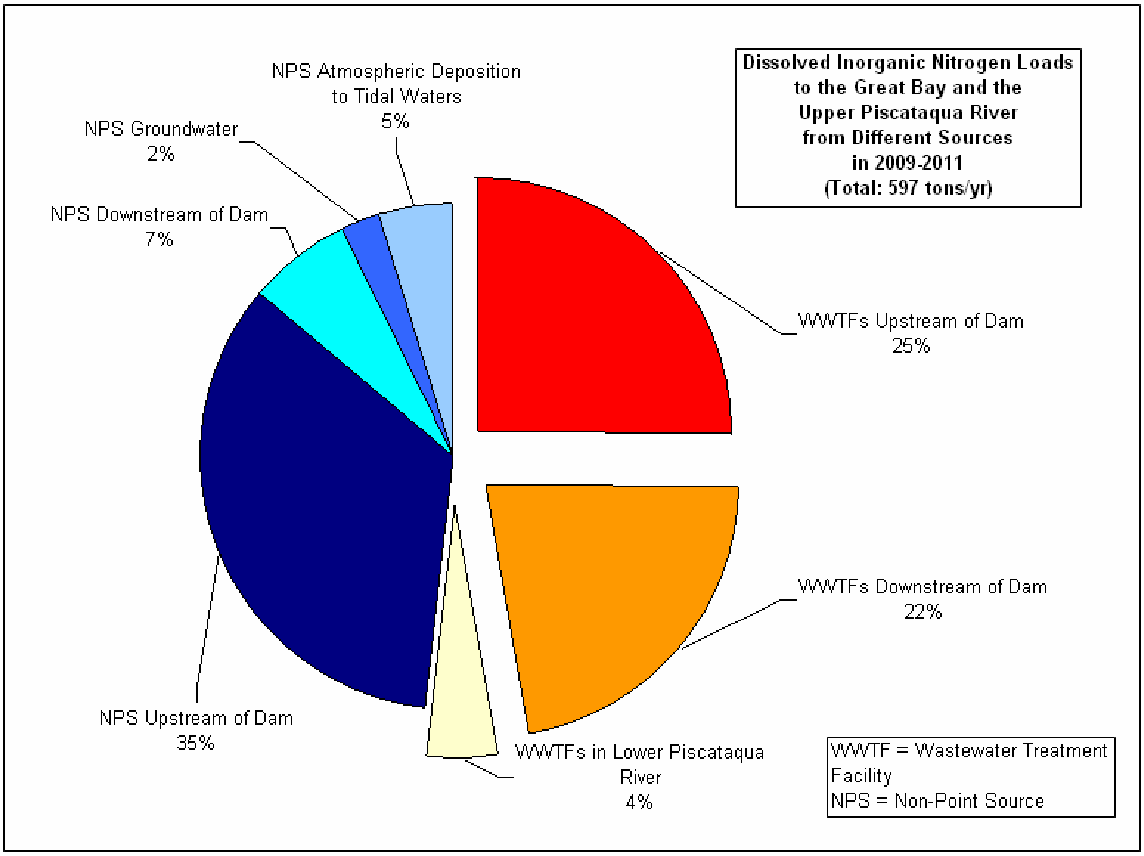


Figure NUT1-6: Percent of nitrogen load to the Great Bay Estuary from wastewater treatment facilities by month

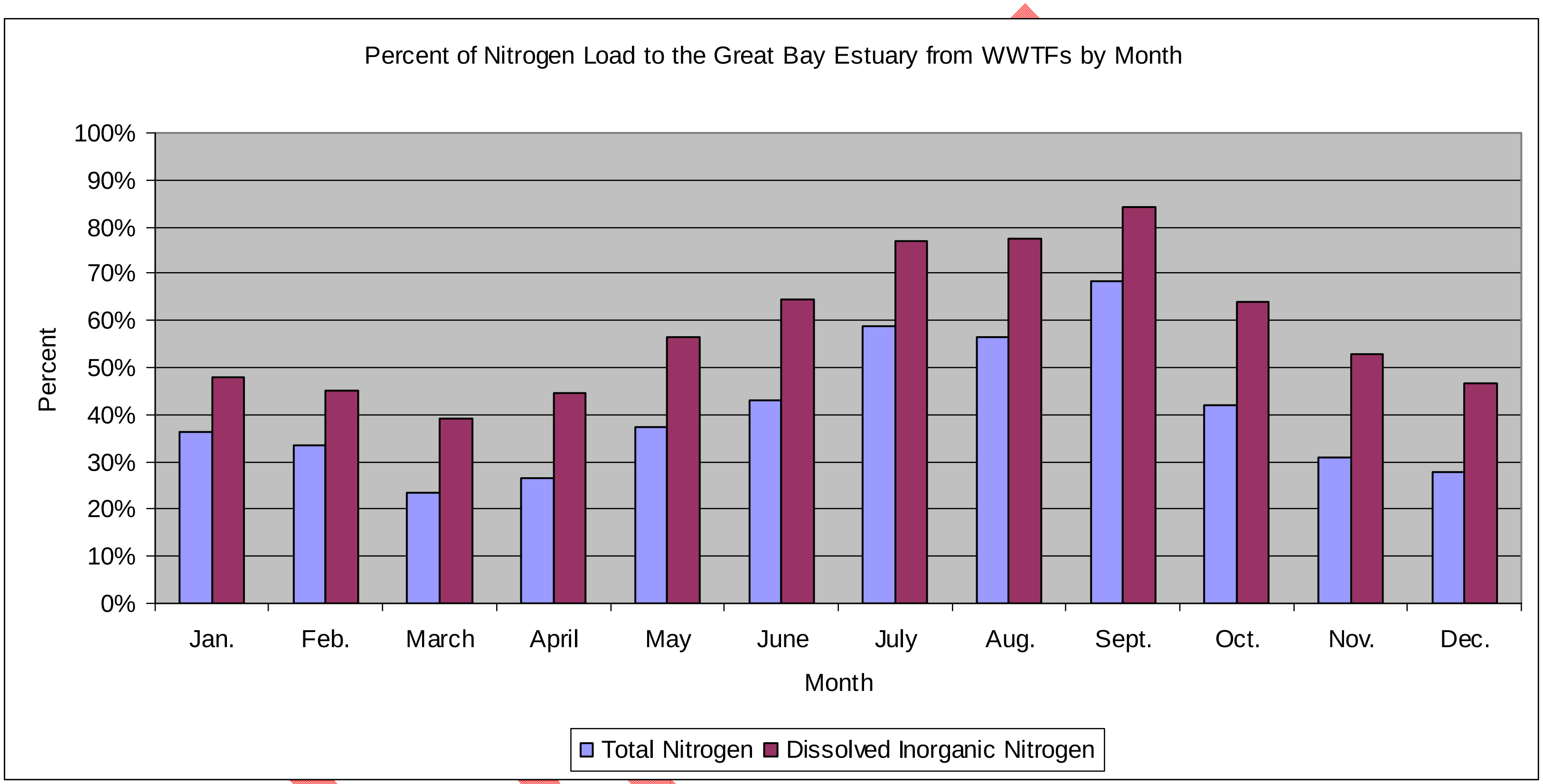
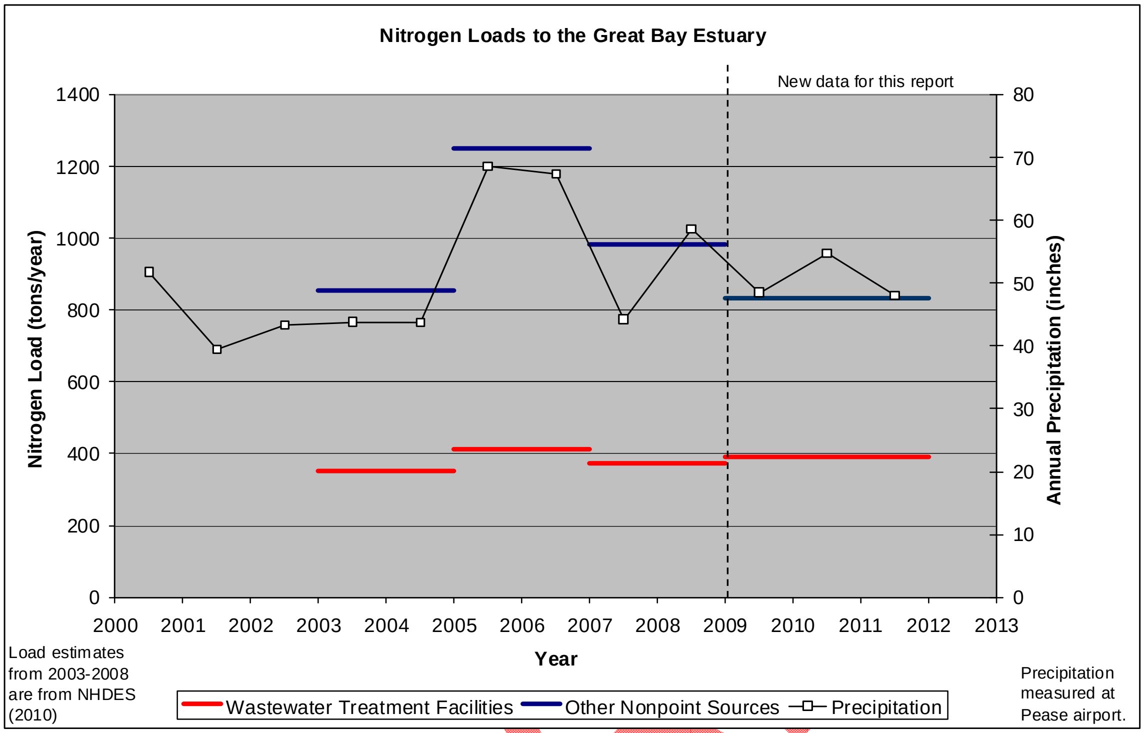


Figure NUT1-7: Trends in nitrogen loads and precipitation from 2003 through 2011



Nitrogen Loads to the Great Bay Estuary

Load estimates from 2003-2008 are from NHDES (2010)

Precipitation measured at Pease airport.

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II. Indicators for the State of Our Estuaries Report

B. State Indicators

Indicator: NUT2. Nutrient concentrations in the estuary

Objectives

The objective of this indicator is to quantify trends in nutrient concentrations (nitrogen and phosphorus) in estuarine waters. Established conceptual models for estuarine eutrophication (CBP, 2000; Cloern, 2001; Bricker et al., 2007; Burkholder et al., 2007; CENR, 2010) predict that excess nutrients in estuaries lead to algae blooms, low dissolved oxygen, species composition changes, and eelgrass habitat loss.

PREP Goal

Obj WR 1.3: Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. Consistent with previous PREP reports, the goal will be interpreted to be no increasing trends for any nitrogen or phosphorus species.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

Trend analysis for nitrogen and phosphorus species was performed at the following stations (Figure NUT2-1):

- 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)
- NH-0057A (Upper Piscataqua River)
- GRBCML (Portsmouth Harbor)

The nitrogen parameters for trend analysis were ammonia, nitrate+nitrite, dissolved inorganic nitrogen, total dissolved nitrogen, and total nitrogen. The phosphorus parameter for trend analysis was orthophosphate.

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. Results reported as "below detection level" were included in the analysis with a value equal to one-half the laboratory method detection limit (or one-half the lowest detected concentration for the historic datasets) because there were few censored values (<5% for most parameters, 16% for orthophosphate). Field duplicate samples collected for quality-assurance were not included in the trend analysis. 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. At station GRBAP, which is monitored year round, years with data in 10 or more months were considered to have complete data because samples were collected in all four seasons. At the other stations, which are monitored from April to December, years with data in seven or more months between April and December were considered to have complete data. It was important to identify years with complete data to avoid introducing 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 monthly measurements from years with complete data were regressed against the year variable. Data from years with incomplete data were not included in the regression calculation. Trends were considered significant if the coefficient of the year variable was significant at the $p<0.05$ level. The overall change over the period of record was determined by calculating the value of the regression line for the first and last years with complete data. The difference between the two values divided by the first value was used to represent the average percent change over the period of record.

Analysis of variance was used to test for short-term changes between the most recent three-year period and the preceding three-year period. The monthly measurements from years with complete data in the two three-year periods were tested for differences in the mean using ANOVA. Data from years with incomplete data were not included in the calculation. Differences between the means at the $p<0.05$ level were considered significant.

For each station, the annual average for each nitrogen and phosphorus species was plotted versus year. For years with complete data, the standard deviation of the data in the year was shown as an error bar.

Data Sources
Data for this indicator were provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Programs. Historic datasets from 1974 to 1981 (Norall et al, 1982; Loder et al, 1983) were also included in the trend analysis for station GRBAP.

Data Gaps
Trend monitoring stations are missing in the Winnicut, Bellamy, Cocheco, Salmon Falls, and Piscataqua Rivers and in Hampton-Seabrook Harbor.

Results

The results of the trend analysis for nitrogen and phosphorus compounds are summarized in Tables NUT2-1 and NUT2-2. Plots of each nitrogen and phosphorus compound at each station are shown on Figures NUT2-2 through NUT2-7.

For long-term trends, the concentrations of ammonia, nitrate+nitrite, and dissolved inorganic nitrogen have increased between 63 and 84% at Adams Point between 1974 and 2011. There were also increasing trends for nitrate+nitrite, total dissolved nitrogen, and total nitrogen at Chapmans Landing. Dissolved inorganic nitrogen decreased by 39% in the Oyster River between 2003 and 2011. Orthophosphate decreased by 26% between 1974 and 2011 at Adams Point and by 32% between 1992 and 2011 at Chapmans Landing.

For short term changes, the concentrations of all nitrogen compounds at Adams Point were lower in the last three years than in the preceding three-year period. There were also lower concentrations of some nitrogen compounds in the Squamscott River, Oyster River and Portsmouth Harbor. The one exception was ammonia at Chapmans Landing which increased in recent years. Orthophosphate concentrations at trend stations did not change recently except in the Lamprey River, where they increased.

For the State of the Gulf of Maine Report (GOMC, 2012), the authors evaluated data on dissolved inorganic nitrogen from estuaries around the gulf, including the Piscataqua Region estuaries. DIN concentrations greater than 0.1 mg/L were considered fair/moderate and concentrations greater than 0.5-1.0 mg/L were considered poor conditions. The samples from the Piscataqua region predominantly fell in the fair/moderate category when compared to the thresholds used in the GOMC (2012) report.

In summary, at Adams Point, where the most data have been collected, there are long-term trends of increasing nitrogen compounds (63-84% increase since 1974) and decreasing orthophosphate (26% decrease since 1974). In the last three years, the nitrogen concentrations at Adams Point and a few other locations have fallen.

Figure NUT2-1: Trend stations for nitrogen and phosphorus compounds

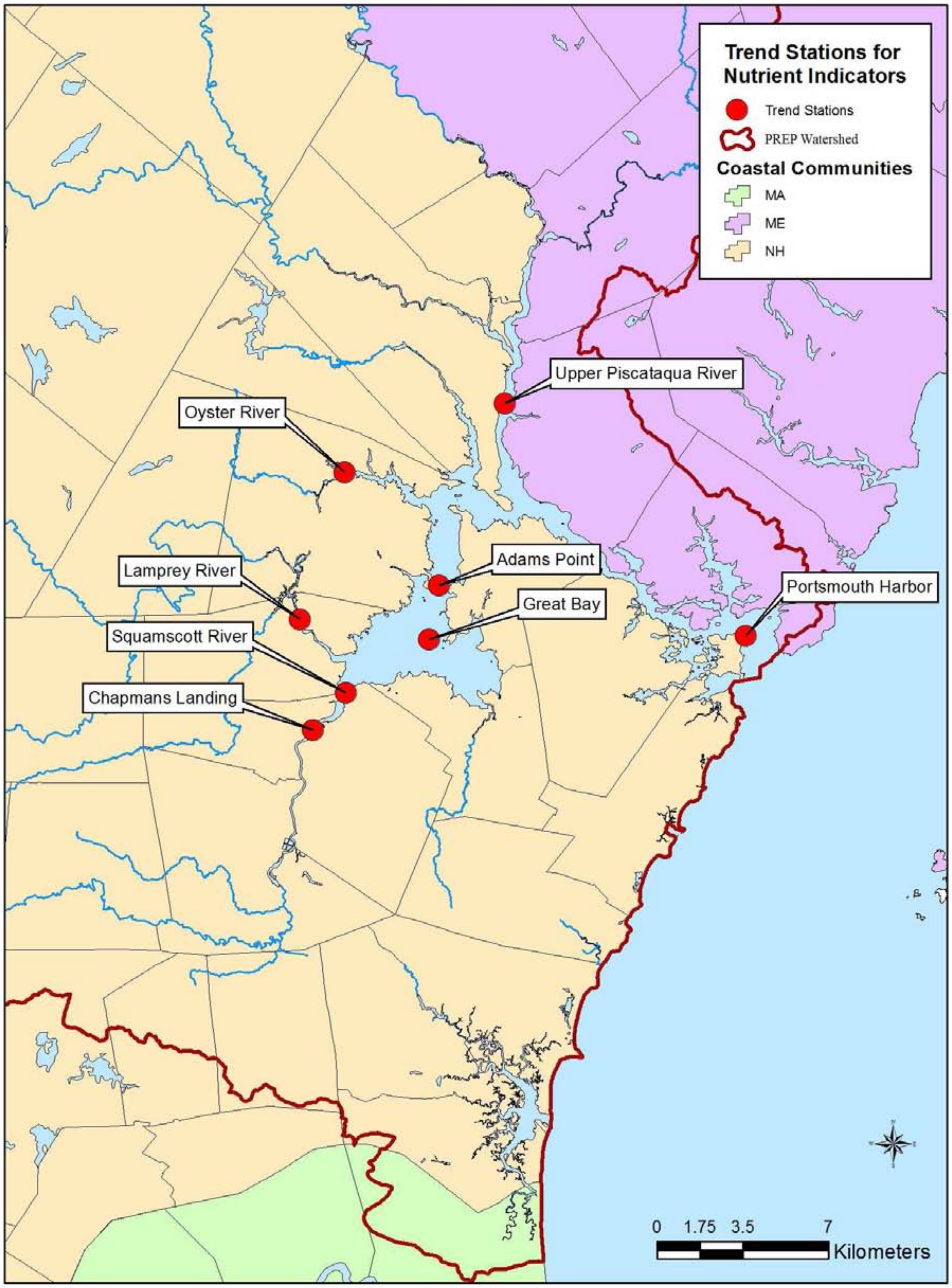

Table NUT2-1: Trends for nitrogen compounds in the Great Bay Estuary

Station	Parameter	Period	Average Conc. in 2009-2011 (mg/L)	Long Term Trend	Recent Change
Adams Point GRBAP (full year)	Ammonia	1974-2011	0.033	84% increase, 0.04 to 0.07 mg/L	Lower
	Nitrate+Nitrite	1974-2011	0.084	63% increase, 0.06 to 0.10 mg/L	Lower
	Dissolved Inorganic Nitrogen	1974-2011	0.116	68% increase, 0.10 to 0.17 mg/L	Lower
	Total Dissolved Nitrogen	2006-2011	0.290	No significant trend	Lower
	Total Nitrogen	2006-2011	0.380	No significant trend	Lower
Chapmans Landing GRBCL (Apr-Dec)	Ammonia	1992-2011	0.156	No significant trend	Higher
	Nitrate+Nitrite	1992-2011	0.166	37% increase, 0.14 to 0.19 mg/L	
	Dissolved Inorganic Nitrogen	1992-2011	0.322	No significant trend	
	Total Dissolved Nitrogen	2004-2011	0.625	36% increase, 0.47 to 0.65 mg/L	
	Total Nitrogen	2004-2011	0.772	20% increase, 0.66 to 0.79 mg/L	
Squamscott River GRBSQ (Apr-Dec)	Ammonia	2002-2011	0.122	No significant trend	
	Nitrate+Nitrite	2002-2011	0.129	No significant trend	
	Dissolved Inorganic Nitrogen	2002-2011	0.251	No significant trend	
	Total Dissolved Nitrogen	2004-2011	0.519	No significant trend	Lower
	Total Nitrogen	2004-2011	0.672	No significant trend	
Lamprey River GRBLR (Apr-Dec)	Ammonia	1992-2011	0.051	No significant trend	
	Nitrate+Nitrite	1992-2011	0.097	No significant trend	
	Dissolved Inorganic Nitrogen	1992-2011	0.148	No significant trend	
	Total Dissolved Nitrogen	2004-2011	0.379	No significant trend	
	Total Nitrogen	2004-2011	0.494	No significant trend	
Great Bay GRBGB (Apr-Dec)	Ammonia	2002-2011	0.037	No significant trend	
	Nitrate+Nitrite	2002-2011	0.063	No significant trend	
	Dissolved Inorganic Nitrogen	2002-2011	0.100	No significant trend	
	Total Dissolved Nitrogen	2004-2011	0.293	No significant trend	
	Total Nitrogen	2004-2011	0.376	No significant trend	
Oyster River GRBOR (Apr-Dec)	Ammonia	2003-2011	0.046	No significant trend	
	Nitrate+Nitrite	2002-2011	0.118	No significant trend	
	Dissolved Inorganic Nitrogen	2003-2011	0.164	39% decrease, 0.26 to 0.16 mg/L	Lower
	Total Dissolved Nitrogen	2004-2011	0.405	No significant trend	
	Total Nitrogen	2004-2011	0.532	No significant trend	
Upper Piscataqua River NH-0057A (Apr-Dec)	Ammonia	2007-2011	0.052	No significant trend	
	Nitrate+Nitrite	2007-2011	0.185	No significant trend	
	Dissolved Inorganic Nitrogen	2007-2011	0.237	No significant trend	
	Total Dissolved Nitrogen	2007-2011	0.440	No significant trend	
	Total Nitrogen	2009-2011	0.496	No significant trend	
Portsmouth Harbor GRBCML (Apr-Dec)	Ammonia	2001-2011	0.053	No significant trend	
	Nitrate+Nitrite	2001-2011	0.061	No significant trend	
	Dissolved Inorganic Nitrogen	2001-2011	0.113	No significant trend	
	Total Dissolved Nitrogen	2003-2011	0.198	No significant trend	Lower
	Total Nitrogen	2005-2011	0.255	No significant trend	Lower

Table NUT2-2: Trends for phosphorus compounds in the Great Bay Estuary

Station	Parameter	Period	Average Conc. in 2009-2011 (mg/L)	Long Term Trend	Recent Change
GRBAP (full year)	Orthophosphate	1974-2011	0.021	26% decrease, 0.026 to 0.020 mg/L	
GRBCL (Apr-Dec)	Orthophosphate	1992-2011	0.028	32% decrease, 0.045 to 0.031 mg/L	
GRBSQ (Apr-Dec)	Orthophosphate	2005-2011	0.029	No significant trend	
GRBLR (Apr-Dec)	Orthophosphate	1992-2011	0.017	No significant trend	Higher
GRBGB (Apr-Dec)	Orthophosphate	2002-2011	0.025	No significant trend	
GRBOR (Apr-Dec)	Orthophosphate	2004-2011	0.049	No significant trend	
NH-0057A (Apr-Dec)	Orthophosphate	2007-2011	0.020	No significant trend	
GRBCML (Apr-Dec)	Orthophosphate	2002-2011	0.026	No significant trend	

Station Locations
GRBAP (Adams Point between Great Bay and Little Bay)
GRBCL (Chapmans Landing in the Squamscott River)
GRBSQ (Squamscott River at the railroad trestle)
GRBLR (Lamprey River)
GRBGB (Great Bay)
GRBOR (Oyster River)
NH-0057A (Upper Piscataqua River)
GRBCML (Portsmouth Harbor)

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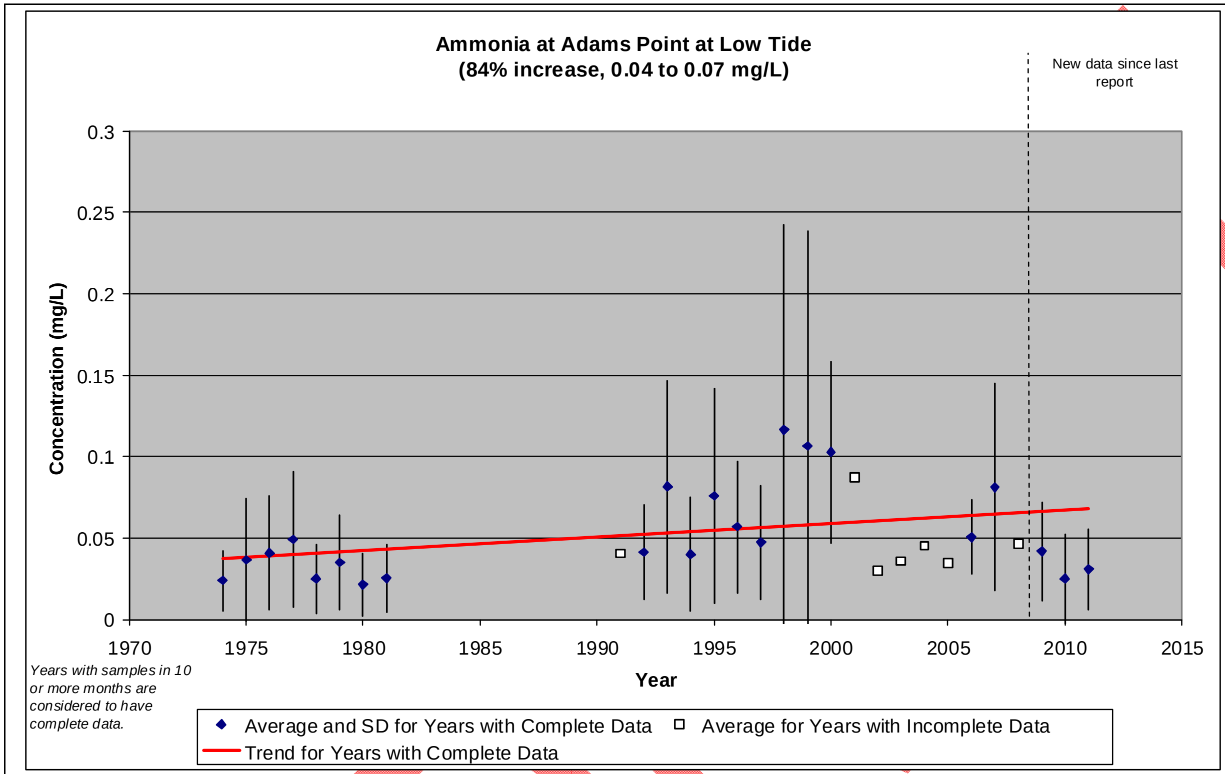
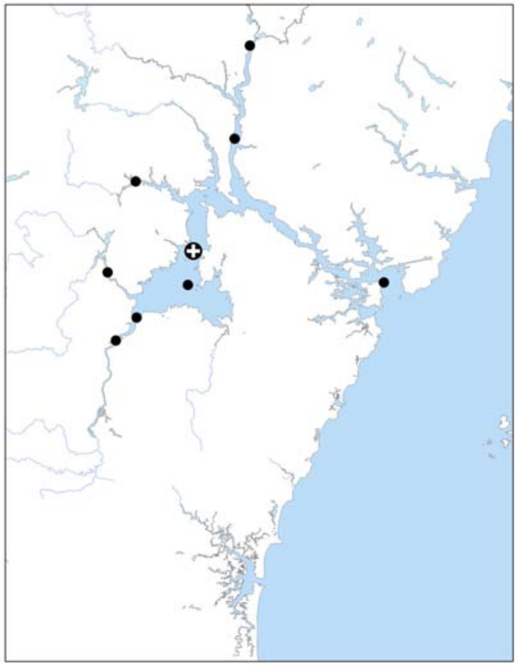
Figure NUT2-2: Ammonia concentration trends at stations in the Great Bay Estuary



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



Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 0.033 mg/L

Long Term Trend: 84% increase, 0.04 to 0.07 mg/L

Recent Change: Lower

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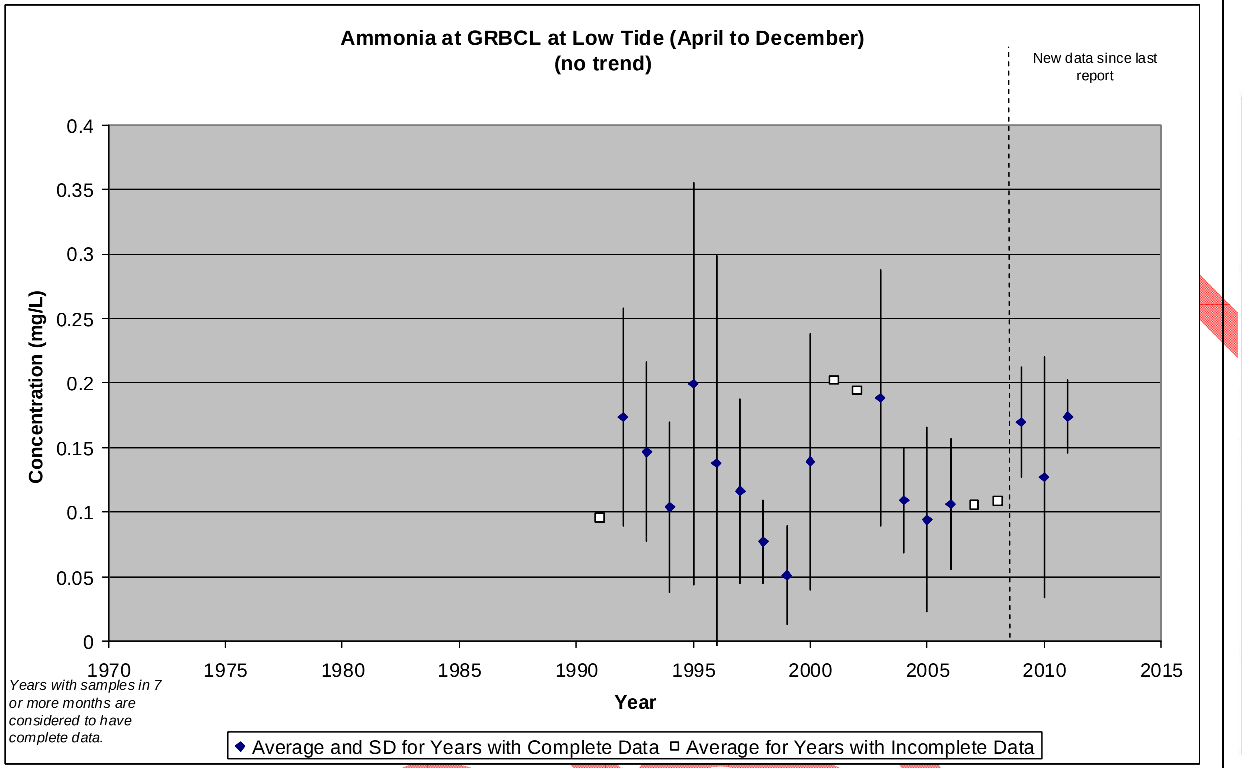
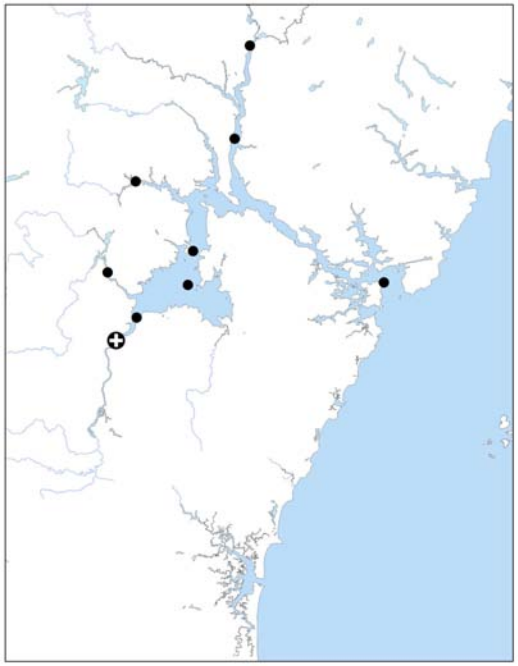


Ammonia at GRBCL at Low Tide (April to December)
(no trend)

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



Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 0.156 mg/L

Long Term Trend: No significant trend

Recent Change: Higher

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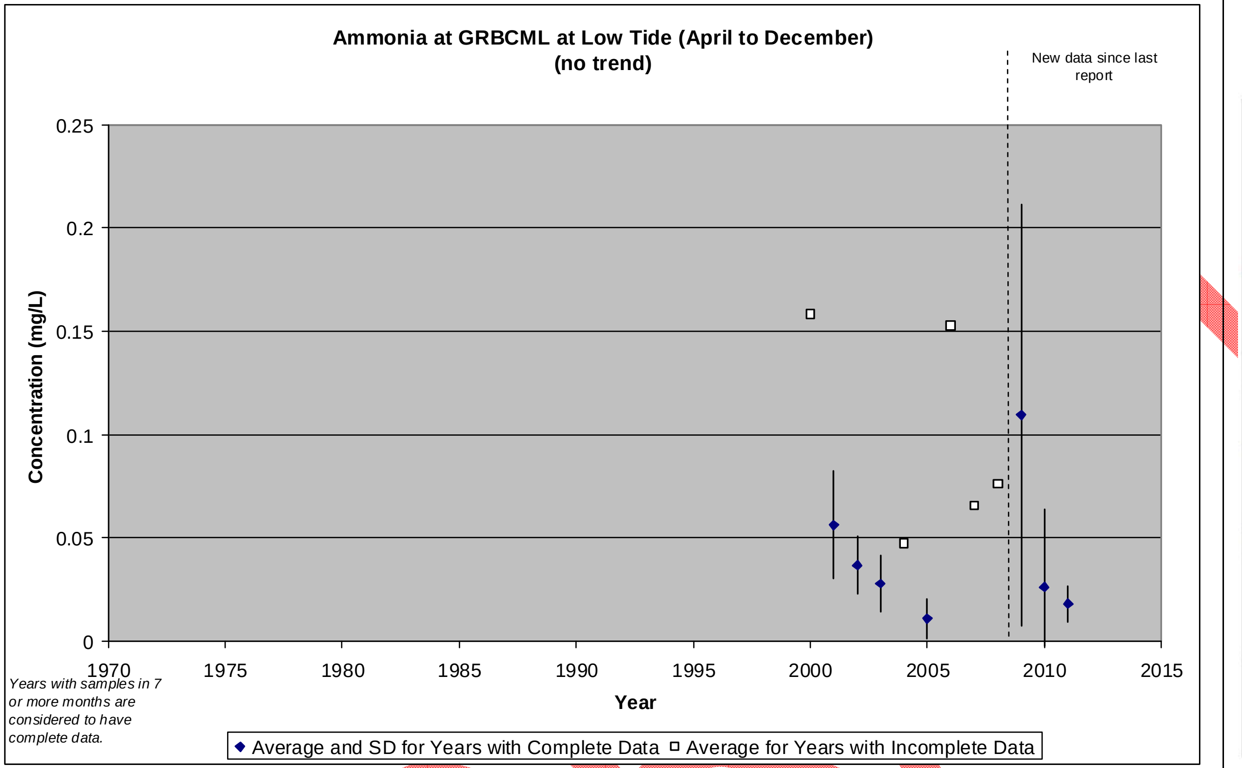
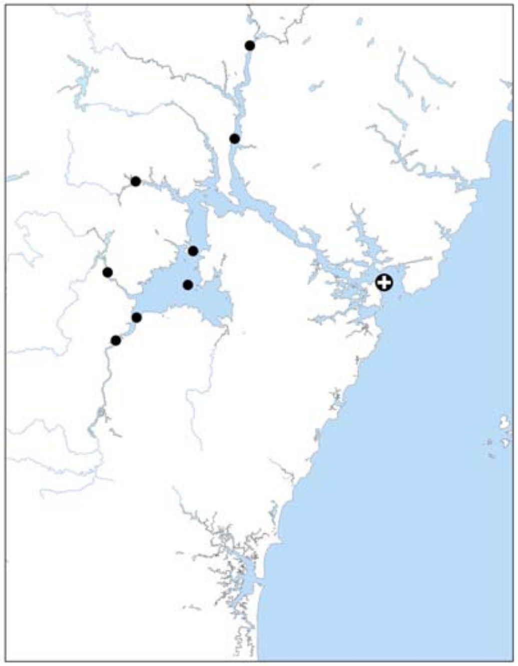


Monitoring Location (GRBCML)
(black circle with white plus sign)



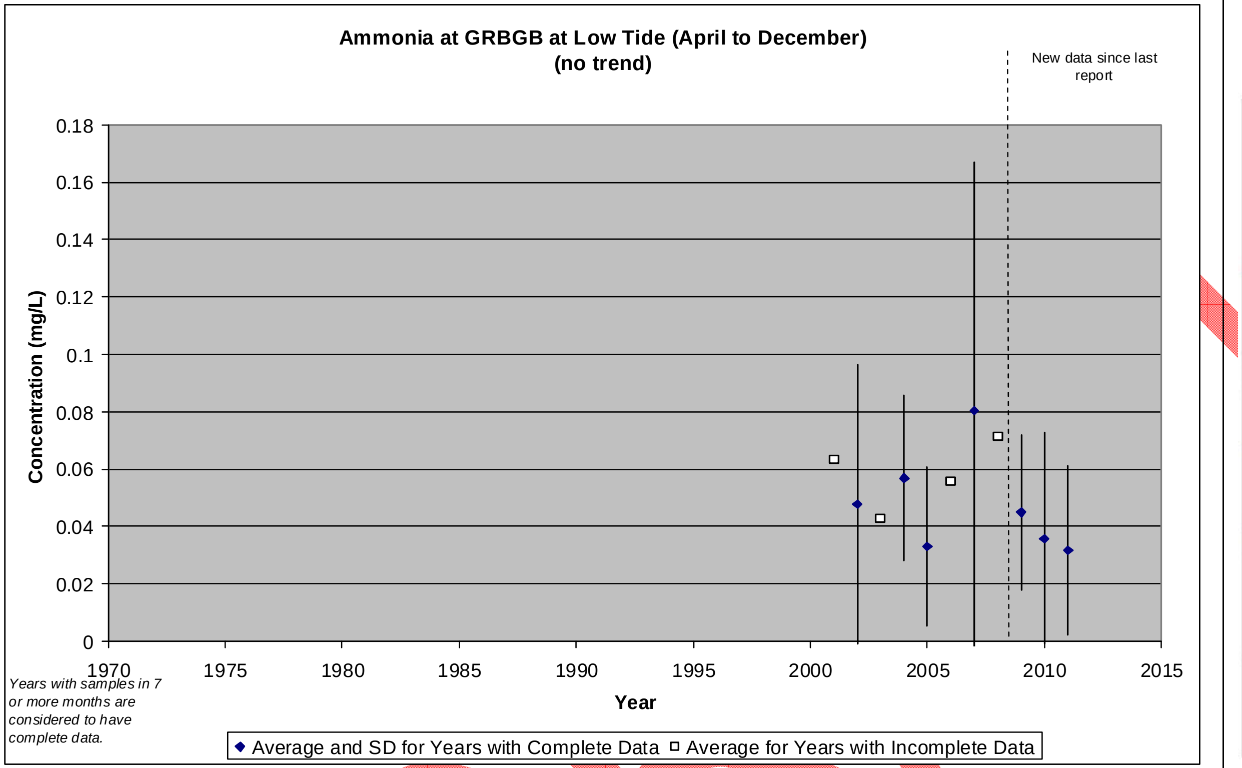
Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.053 mg/L

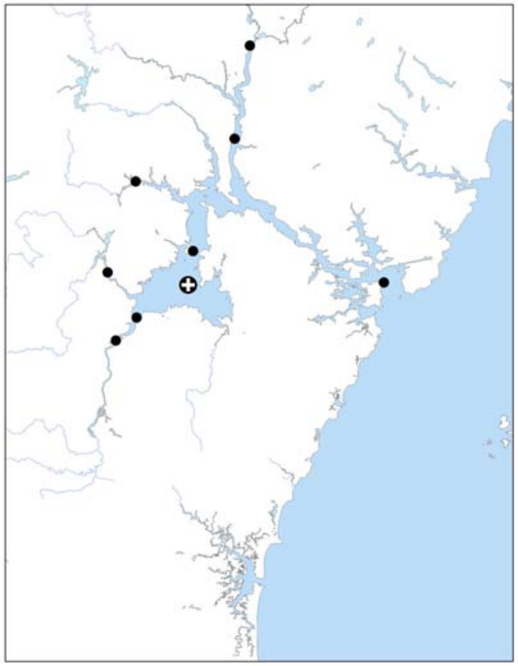
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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



Station: GRBGB (Great Bay)

Average Concentration in 2009-2011: 0.037 mg/L

Long Term Trend: No significant trend

Recent Change: None

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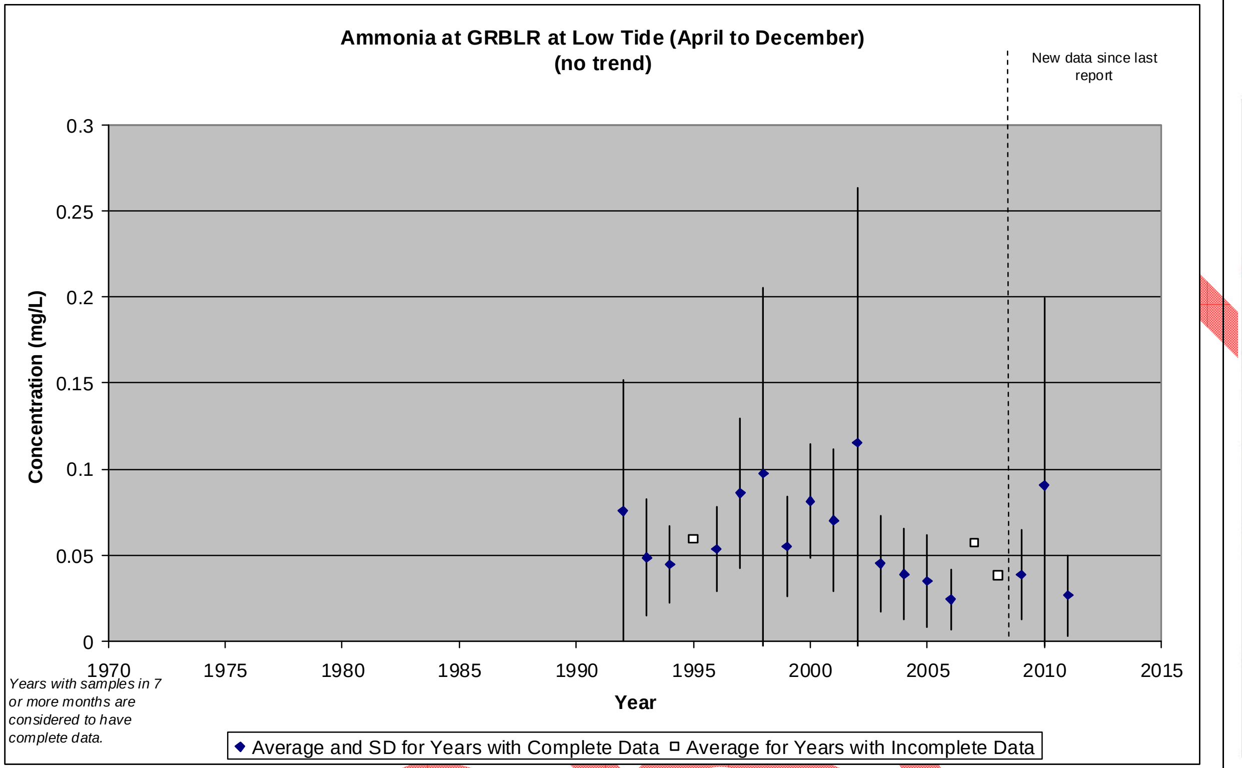
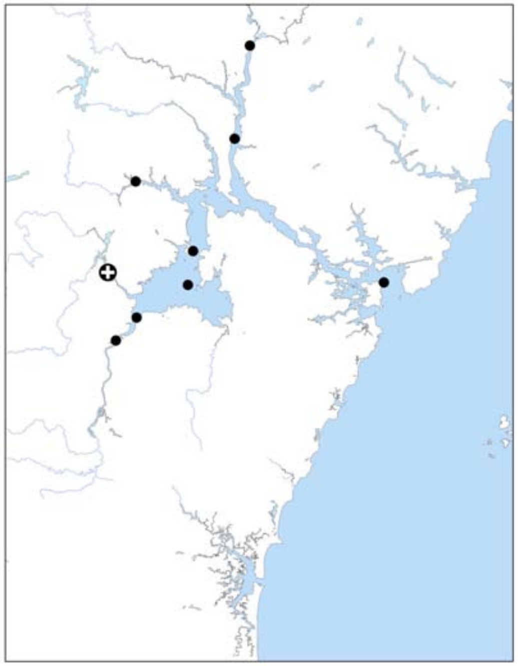


Monitoring Location (GRBLR)
(black circle with white plus sign)



Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 0.051 mg/L

Long Term Trend: No significant trend

Recent Change: None

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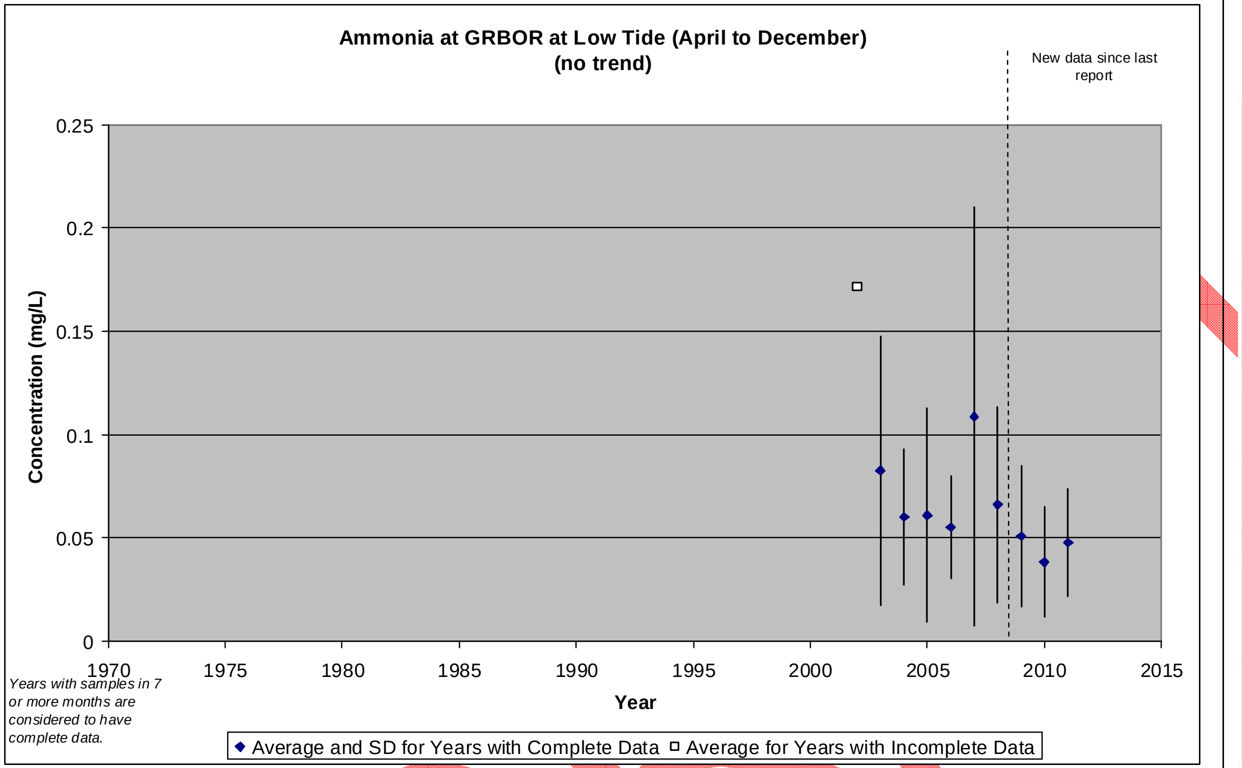
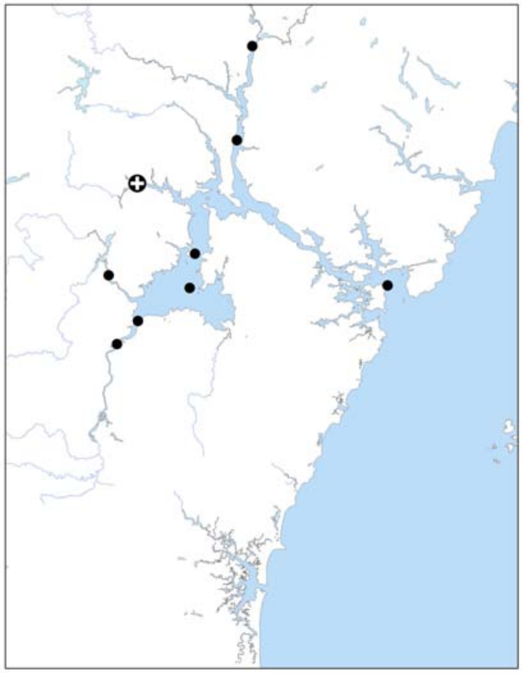


Ammonia at GRBOR at Low Tide (April to December)
(no trend)

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



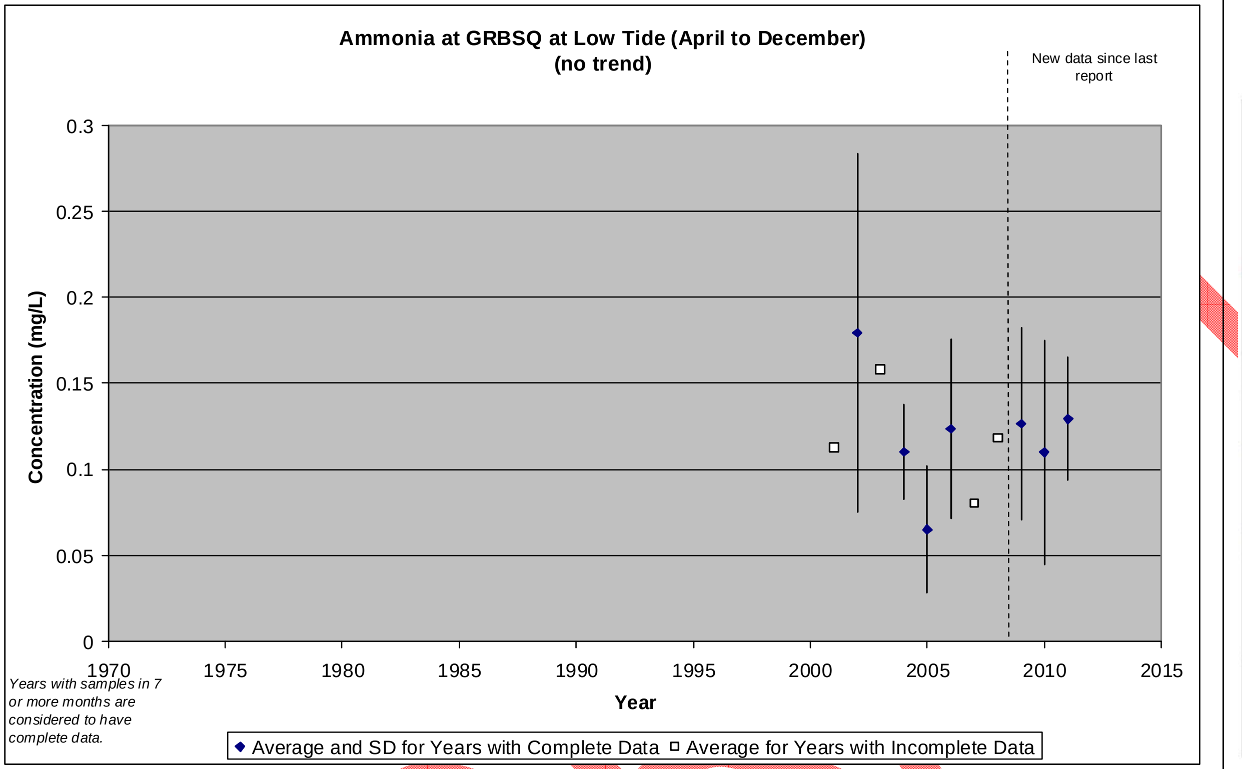
Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 0.046 mg/L

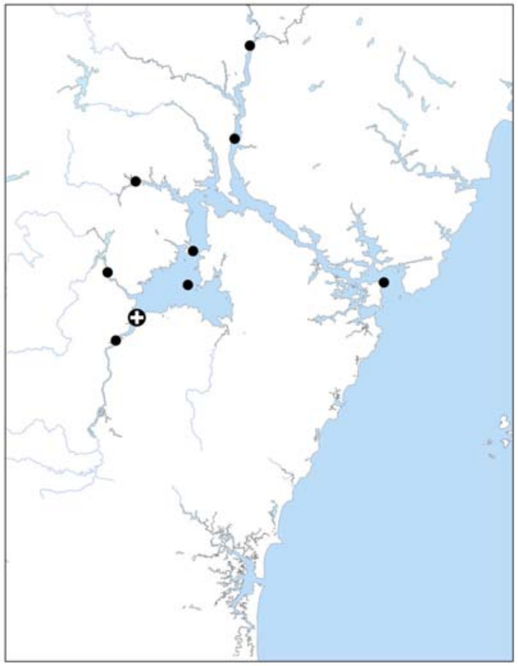
Long Term Trend: No significant trend

Recent Change: None

PREP
Piscataqua Region Estuaries Partnership



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

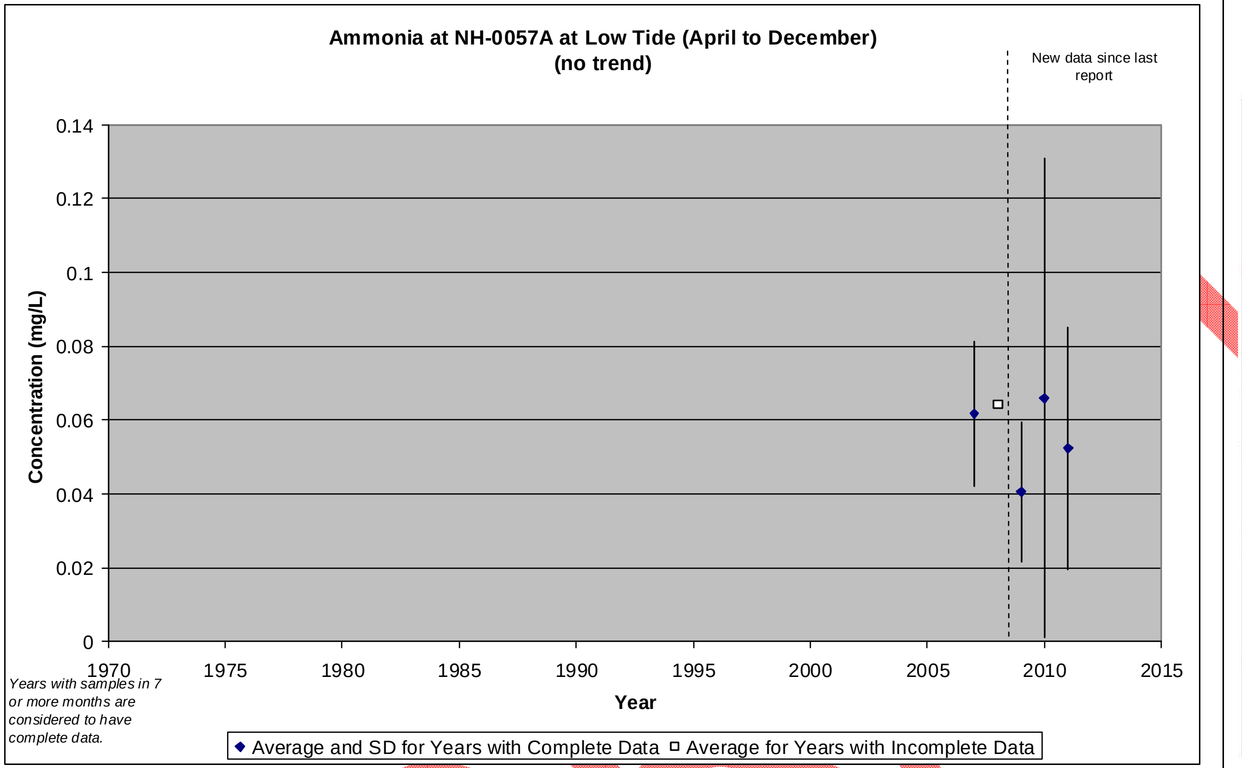


Station: GRBSQ (Squamscott River at the railroad trestle)

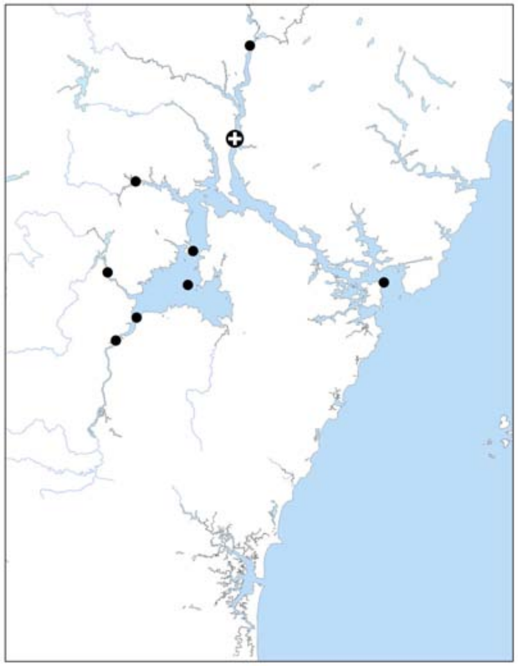
Average Concentration in 2009-2011: 0.122 mg/L

Long Term Trend: No significant trend

Recent Change: None



Monitoring Location (NH-0057A)
(black circle with white plus sign)



Station: NH-0057A (Upper Piscataqua River)

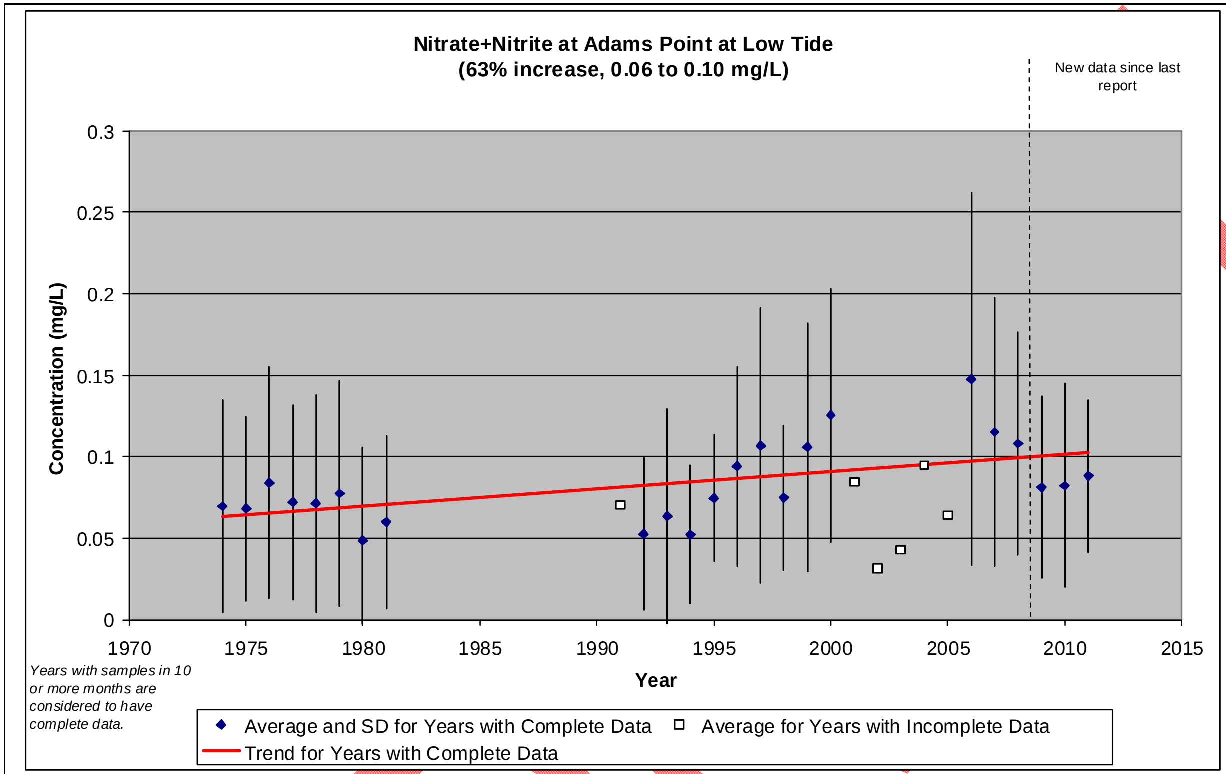
Average Concentration in 2009-2011: 0.052 mg/L

Long Term Trend: No significant trend

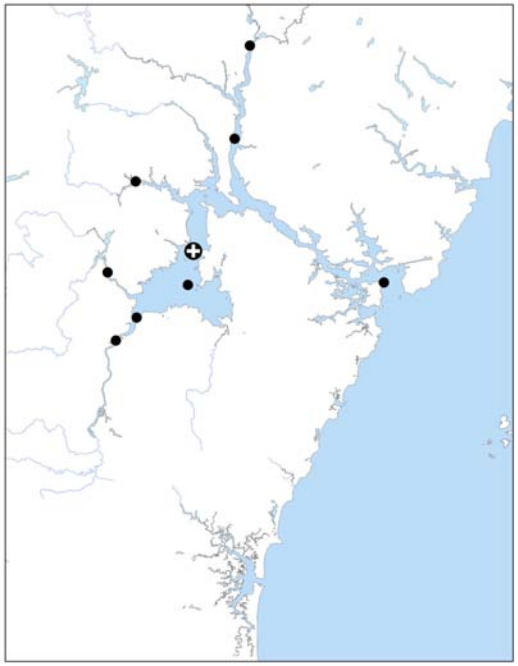
Recent Change: None

EXHIBIT 36 (AR K.22)

Figure NUT2-3: Nitrate+nitrite concentration trends at stations in the Great Bay Estuary



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



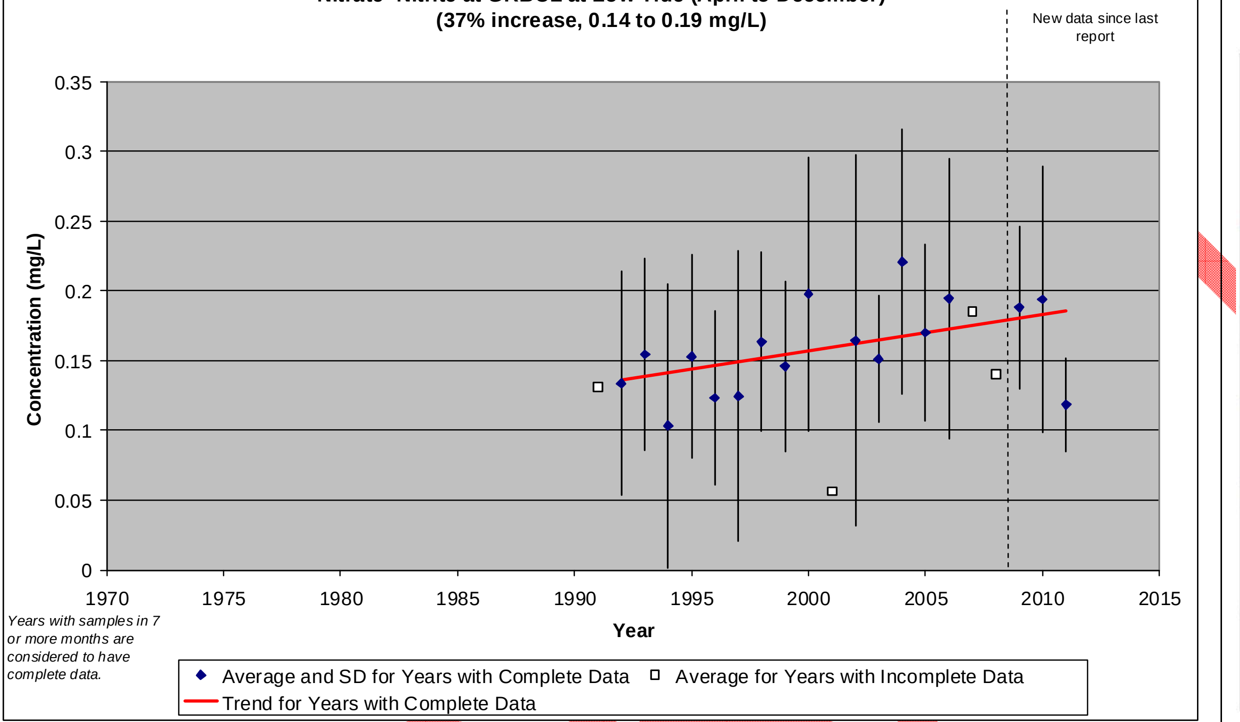
Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 0.084 mg/L

Long Term Trend: 63% increase, 0.06 to 0.10 mg/L

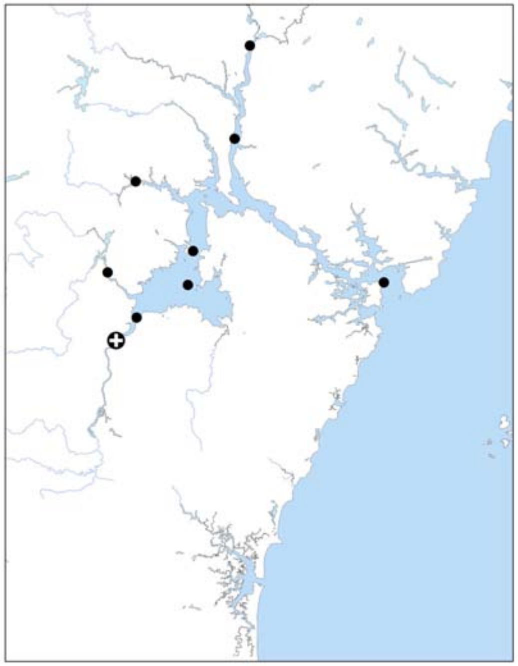
Recent Change: Lower

Nitrate+Nitrite at GRBCL at Low Tide (April to December)
(37% increase, 0.14 to 0.19 mg/L)



Years with samples in 7 or more months are considered to have complete data.

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



Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 0.166 mg/L

Long Term Trend: 37% increase, 0.14 to 0.19 mg/L

Recent Change: None

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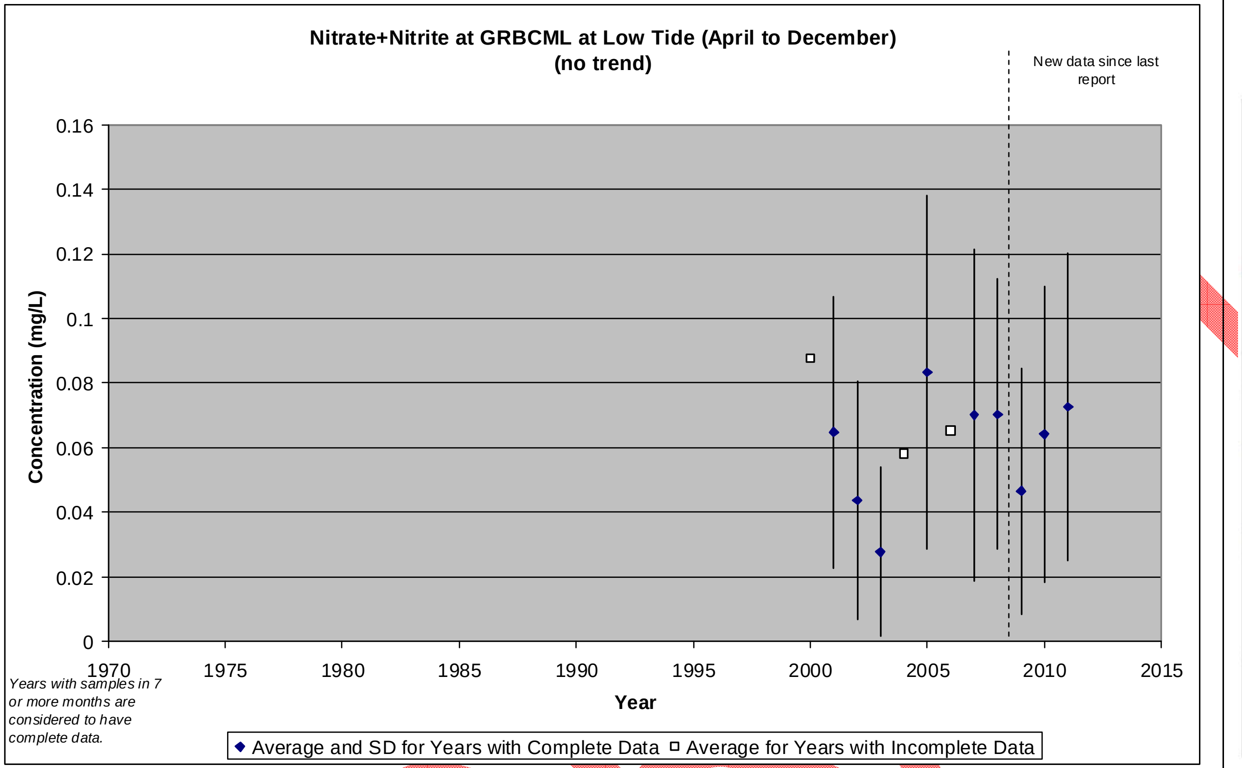
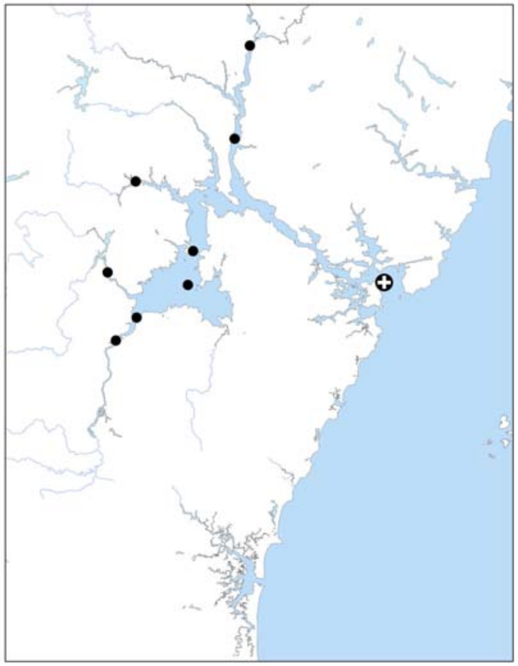


Nitrate+Nitrite at GRBCML at Low Tide (April to December)
(no trend)

Monitoring Location (GRBCML)
(black circle with white plus sign)



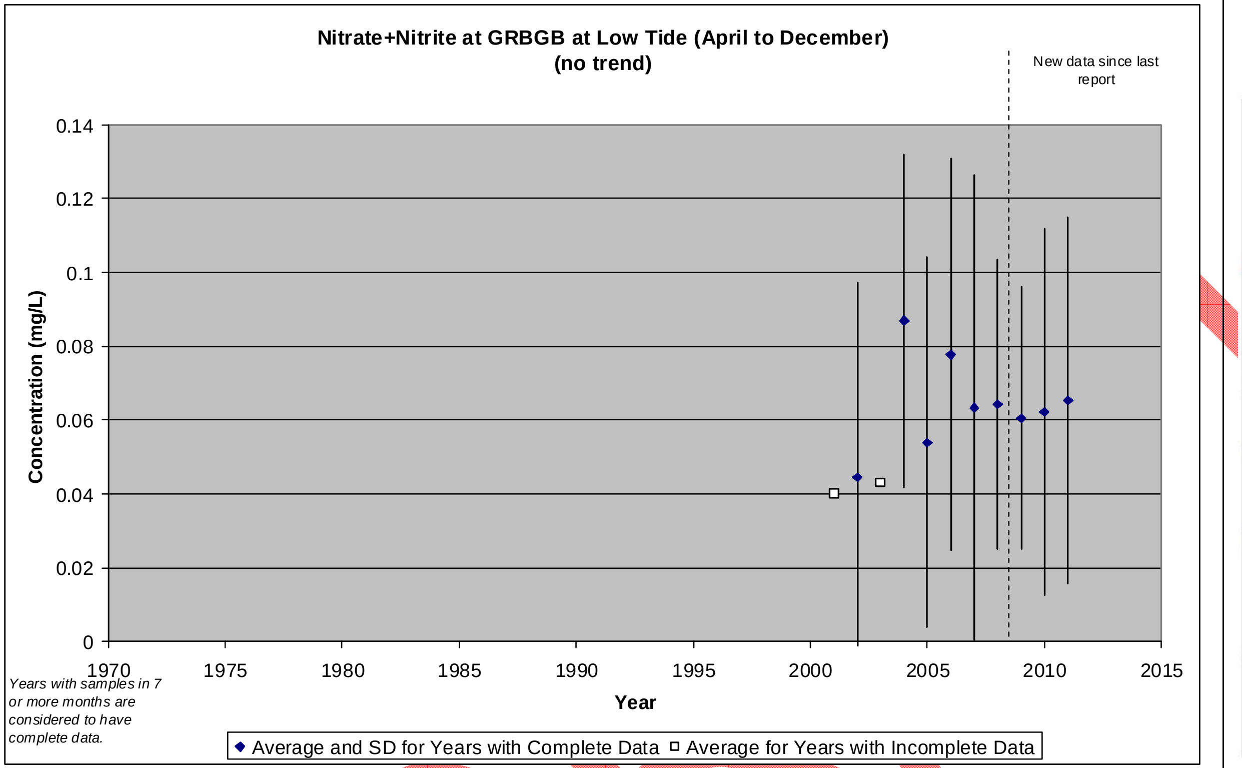
Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.061 mg/L

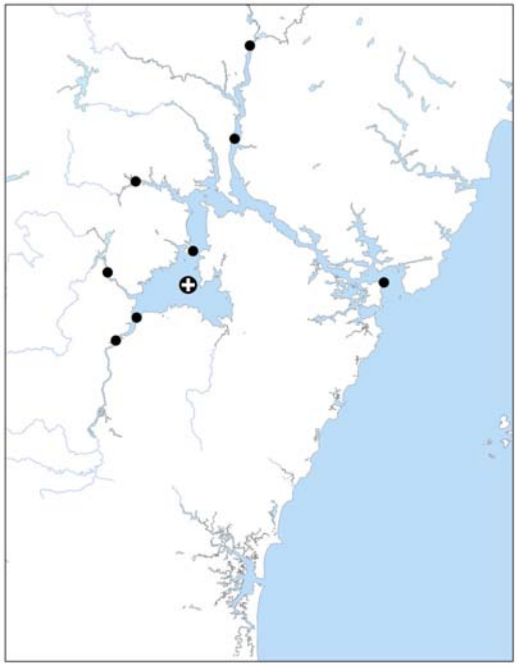
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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



Station: GRBGB (Great Bay)

Average Concentration in 2009-2011: 0.063 mg/L

Long Term Trend: No significant trend

Recent Change: None

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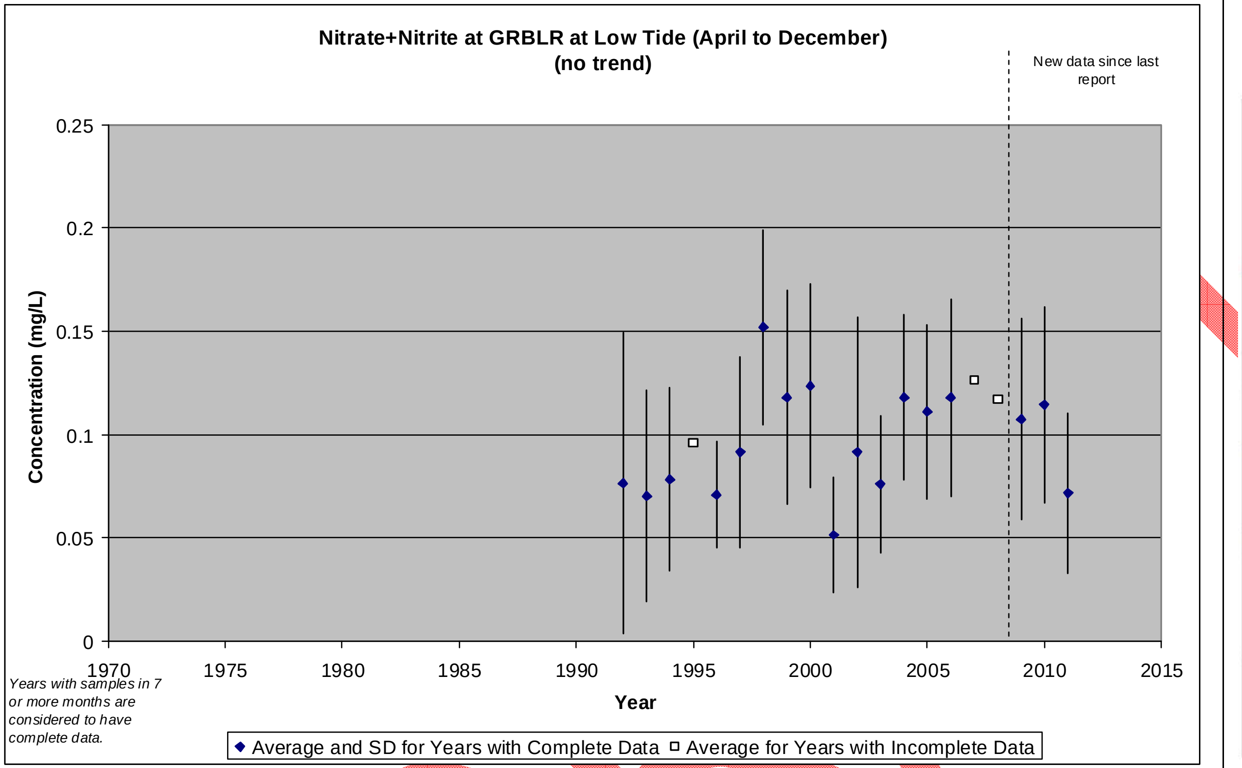
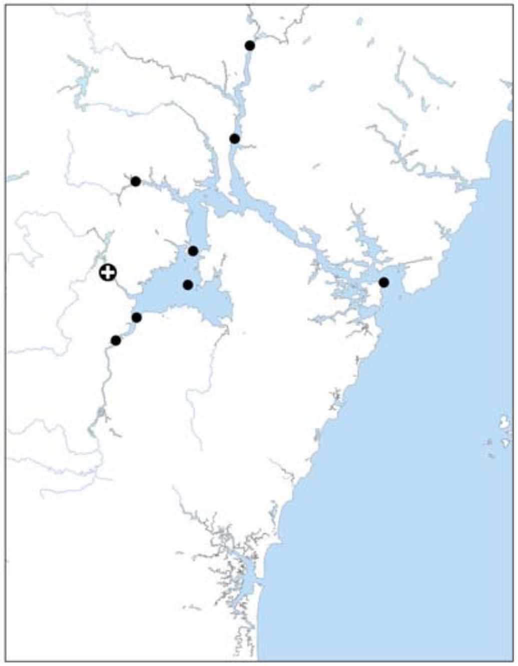


Monitoring Location (GRBLR)
(black circle with white plus sign)



Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 0.097 mg/L

Long Term Trend: No significant trend

Recent Change: None

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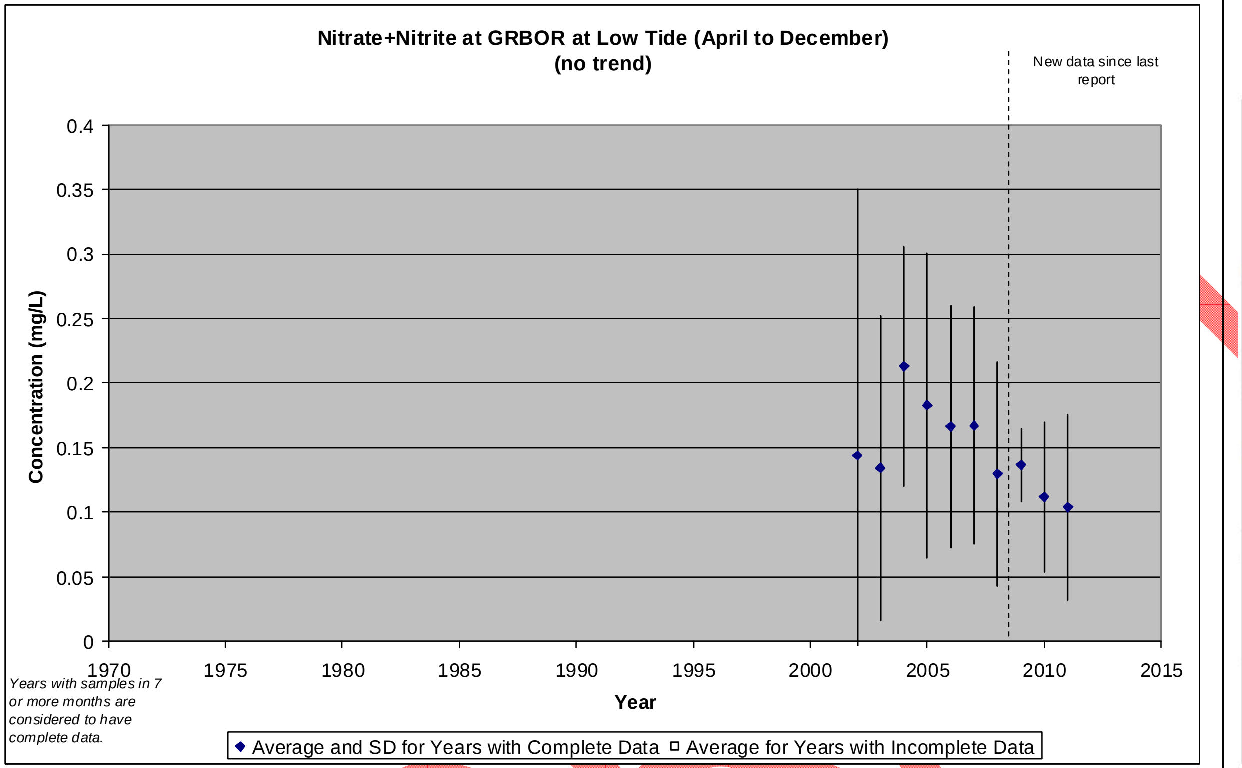
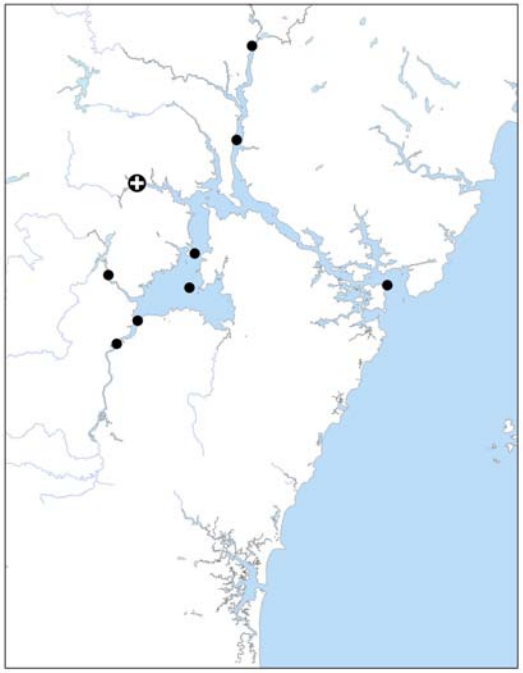


Monitoring Location (GRBOR)
(black circle with white plus sign)

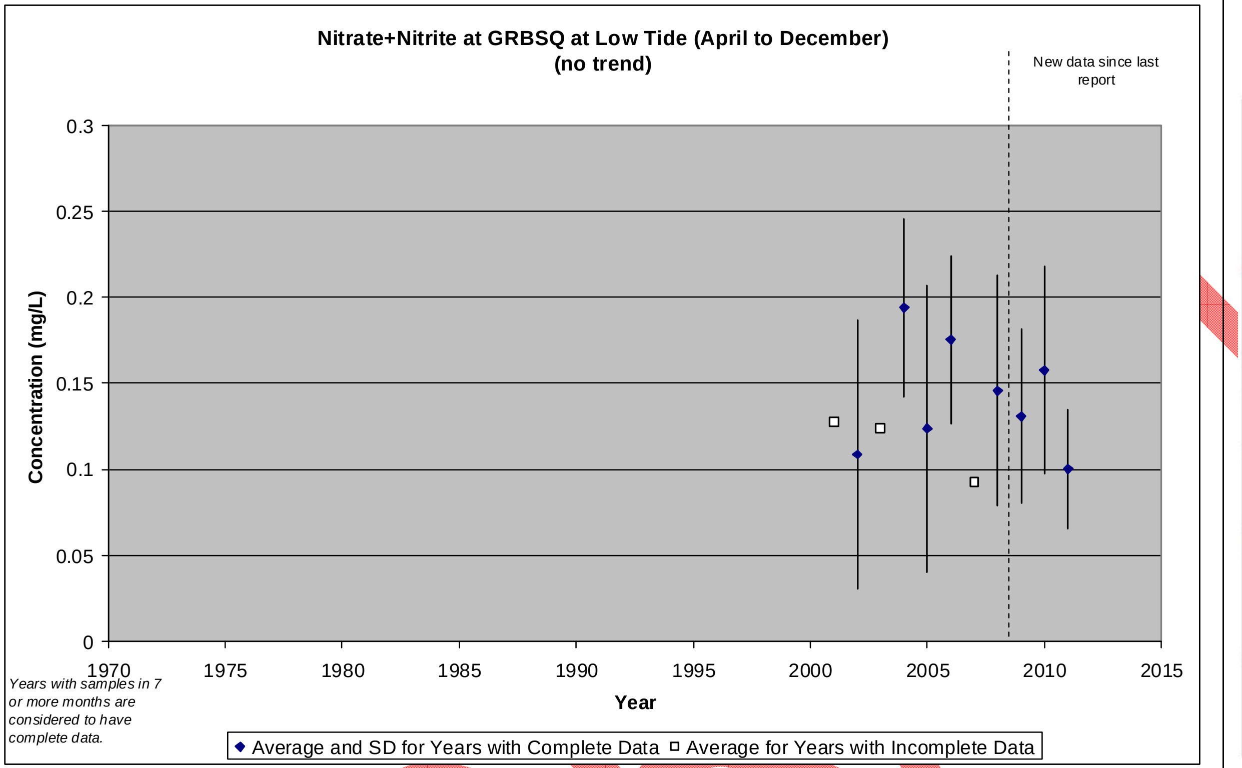


Station: GRBOR (Oyster River)

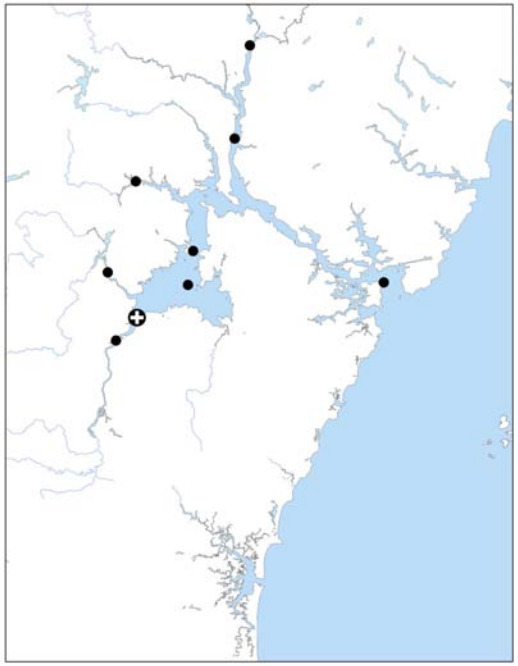
Average Concentration in 2009-2011: 0.118 mg/L

Long Term Trend: No significant trend

Recent Change: None



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

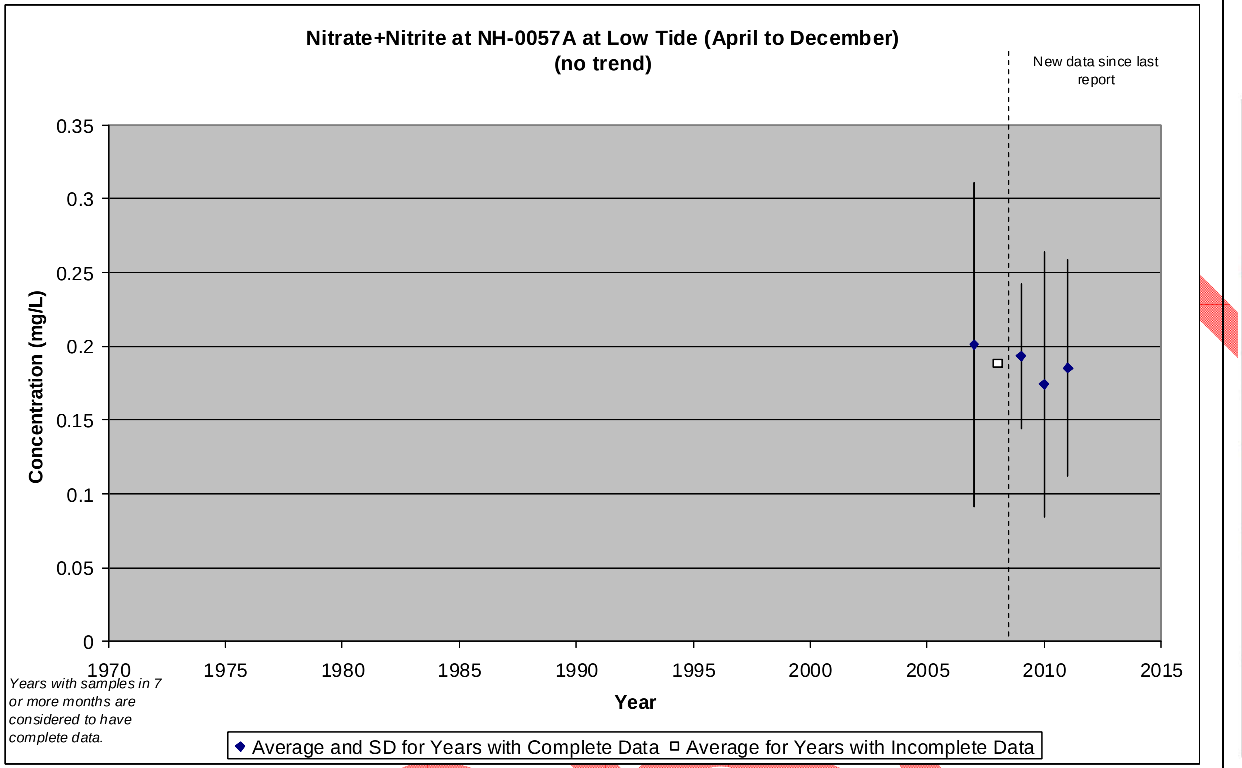


Station: GRBSQ (Squamscott River at the railroad trestle)

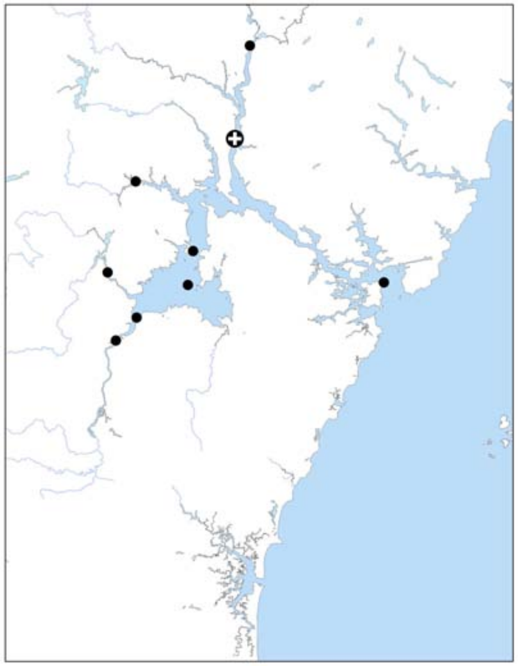
Average Concentration in 2009-2011: 0.129 mg/L

Long Term Trend: No significant trend

Recent Change: None


Nitrate+Nitrite at NH-0057A at Low Tide (April to December)
(no trend)

Monitoring Location (NH-0057A)
(black circle with white plus sign)



Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 0.185 mg/L

Long Term Trend: No significant trend

Recent Change: None

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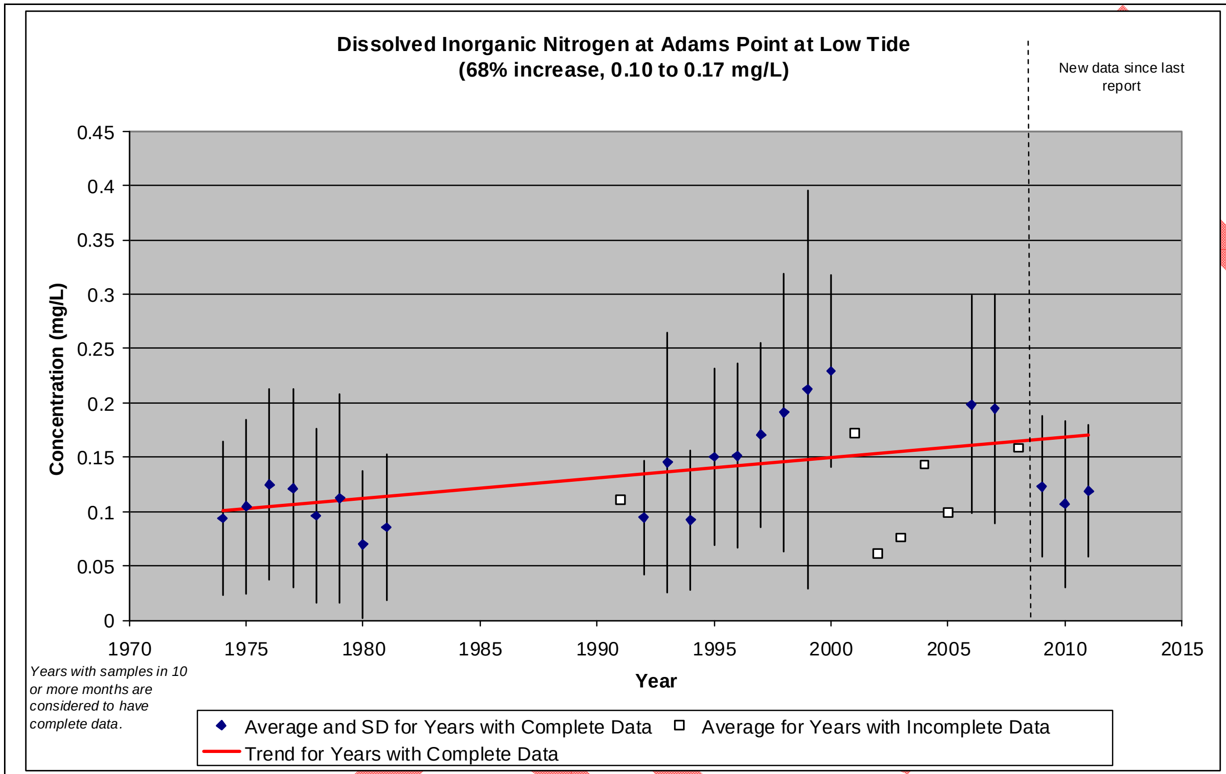
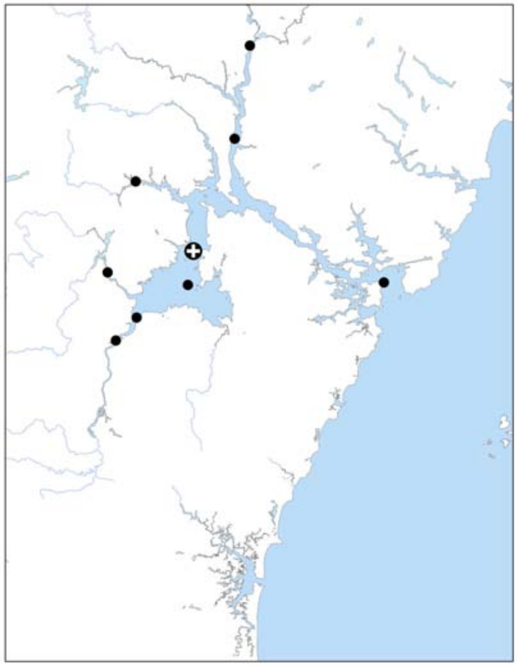
Figure NUT2-4: Dissolved inorganic nitrogen concentration trends at stations in the Great Bay Estuary



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

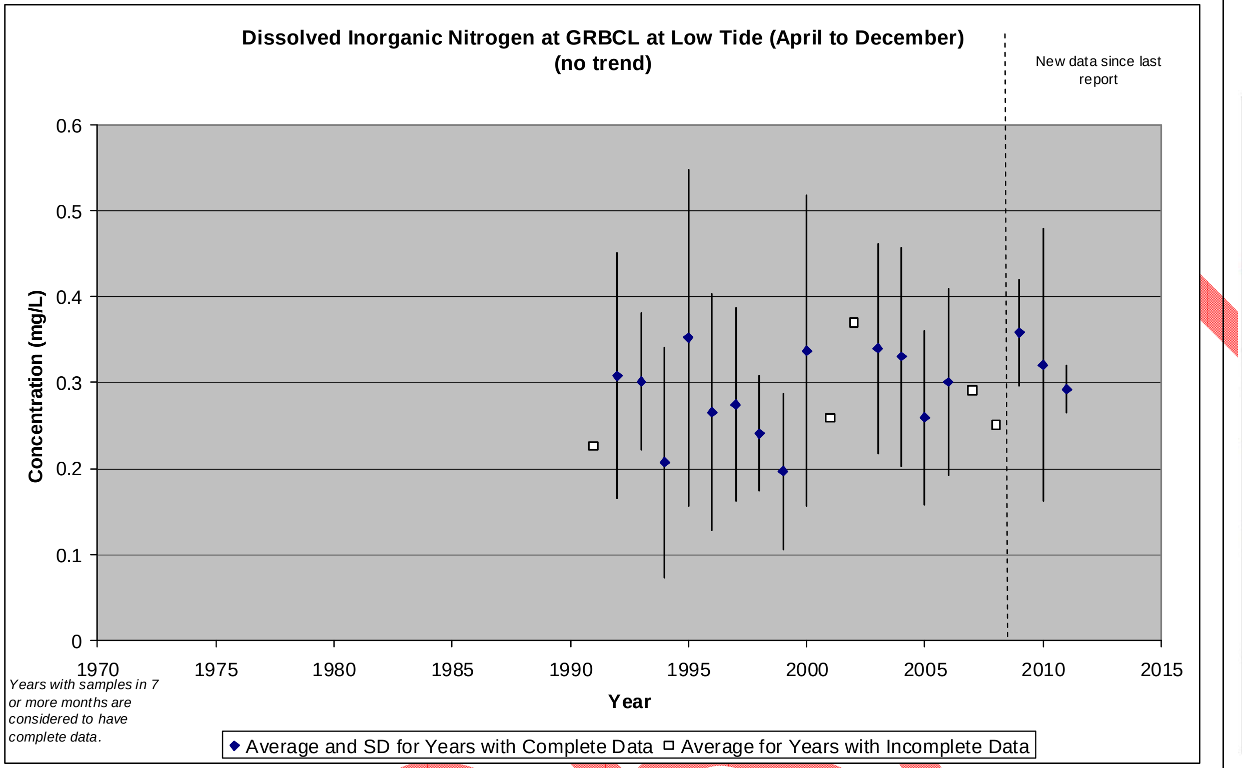


Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 0.116 mg/L

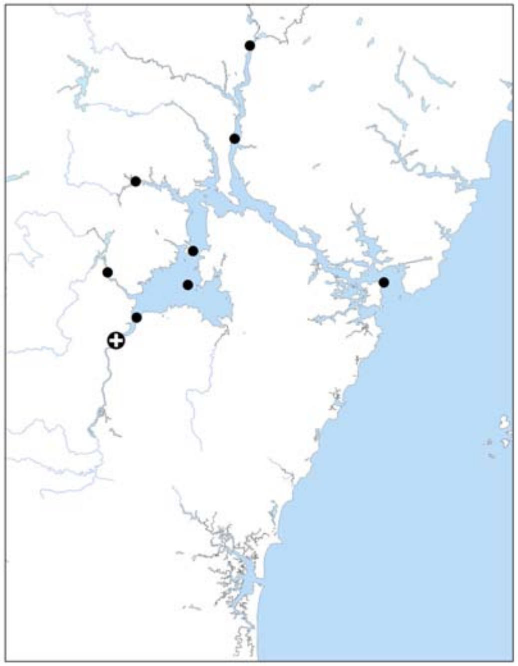
Long Term Trend: 68% increase, 0.10 to 0.17 mg/L

Recent Change: Lower



Dissolved Inorganic Nitrogen at GRBCL at Low Tide (April to December)
(no trend)

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

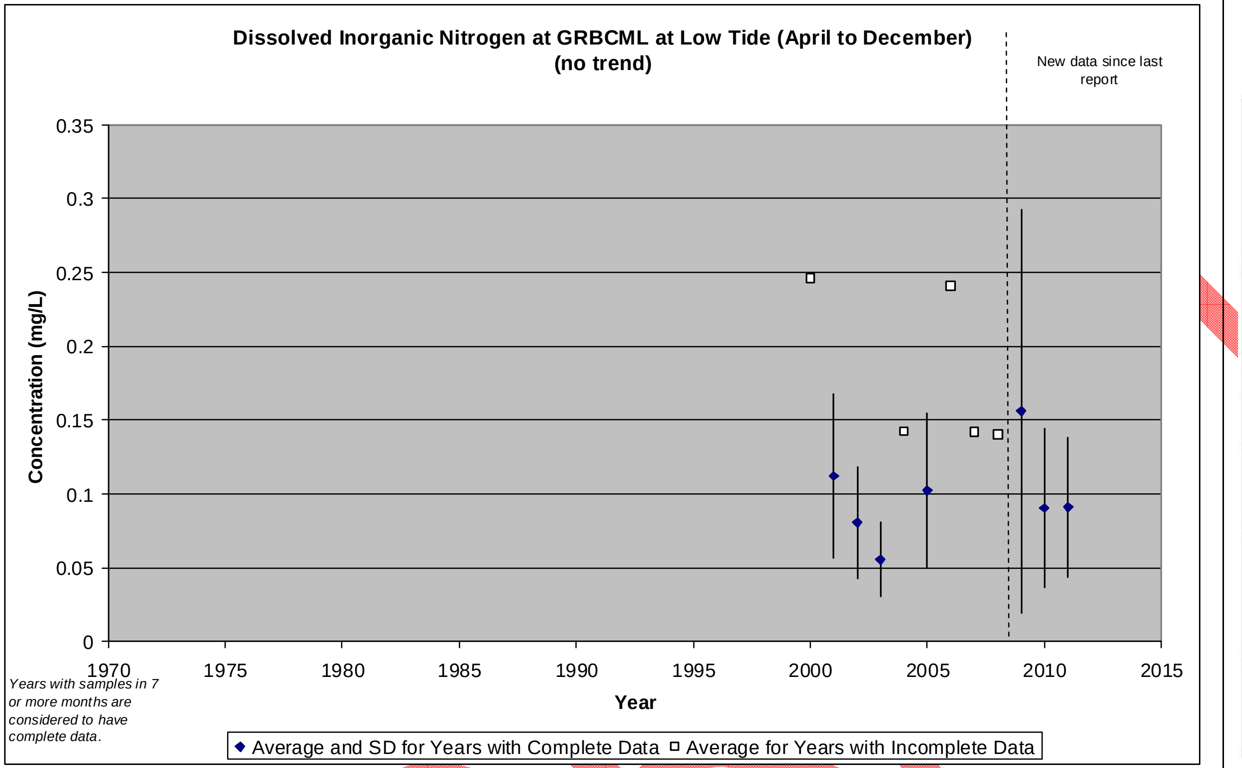


Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 0.322 mg/L

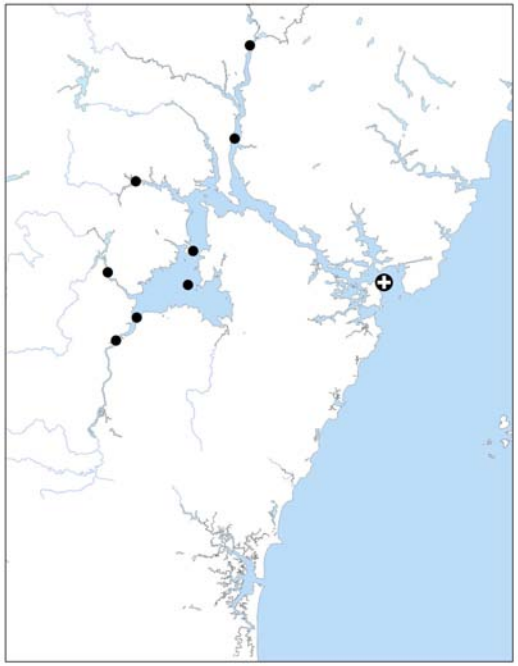
Long Term Trend: No significant trend

Recent Change: None



Dissolved Inorganic Nitrogen at GRBCML at Low Tide (April to December) (no trend)

Monitoring Location (GRBCML) (black circle with white plus sign)



Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.113 mg/L

Long Term Trend: No significant trend

Recent Change: None

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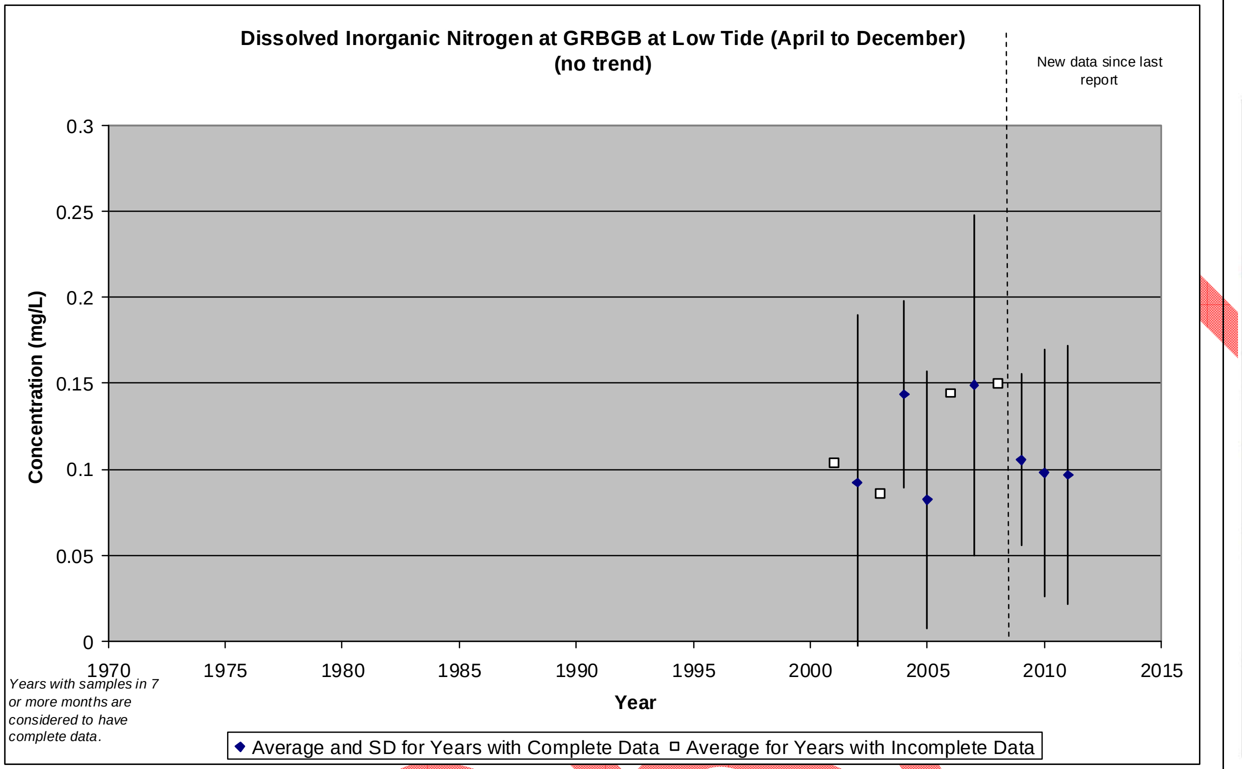
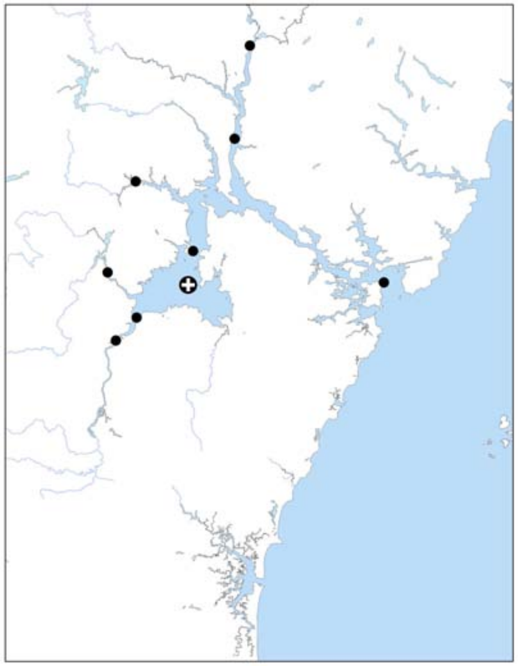


Years with samples in 7 or more months are considered to have complete data.

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

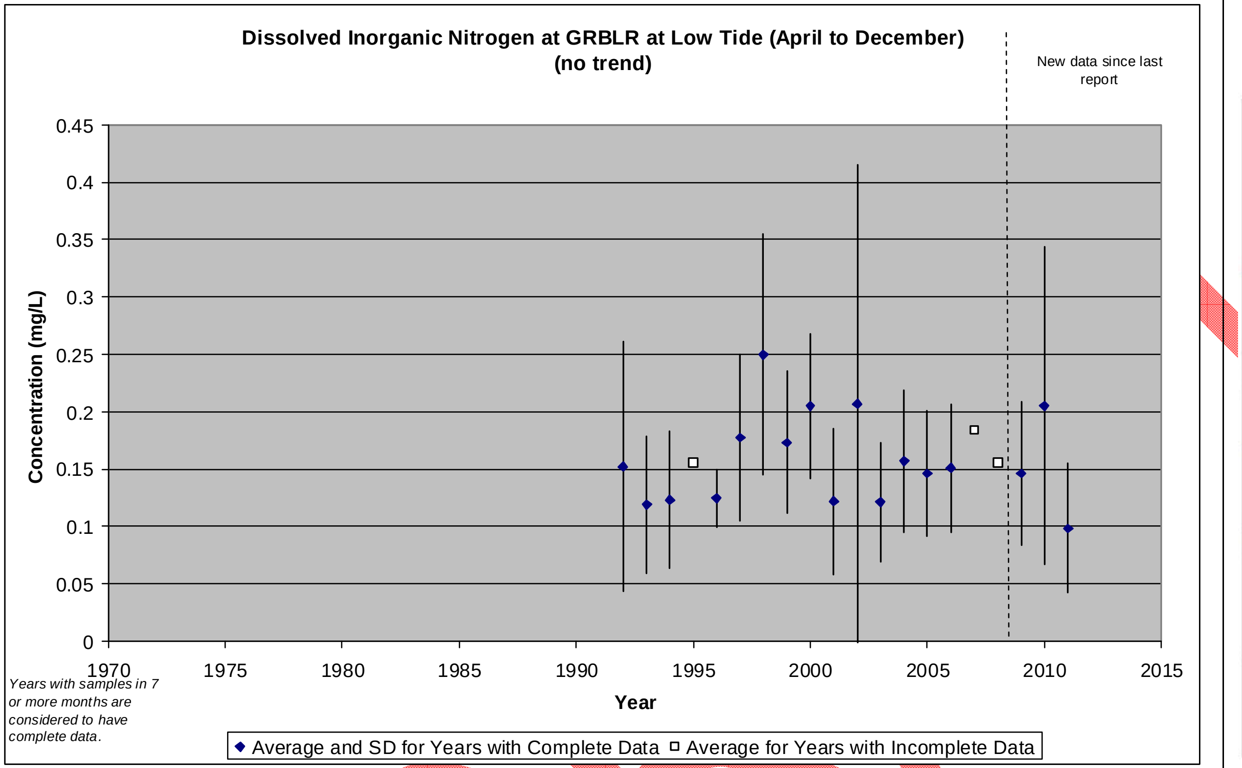


Station: GRBGB (Great Bay)

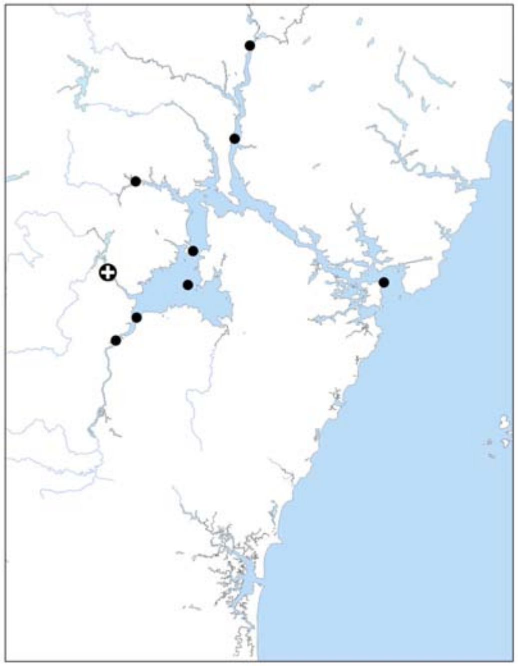
Average Concentration in 2009-2011: 0.100 mg/L

Long Term Trend: No significant trend

Recent Change: None



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



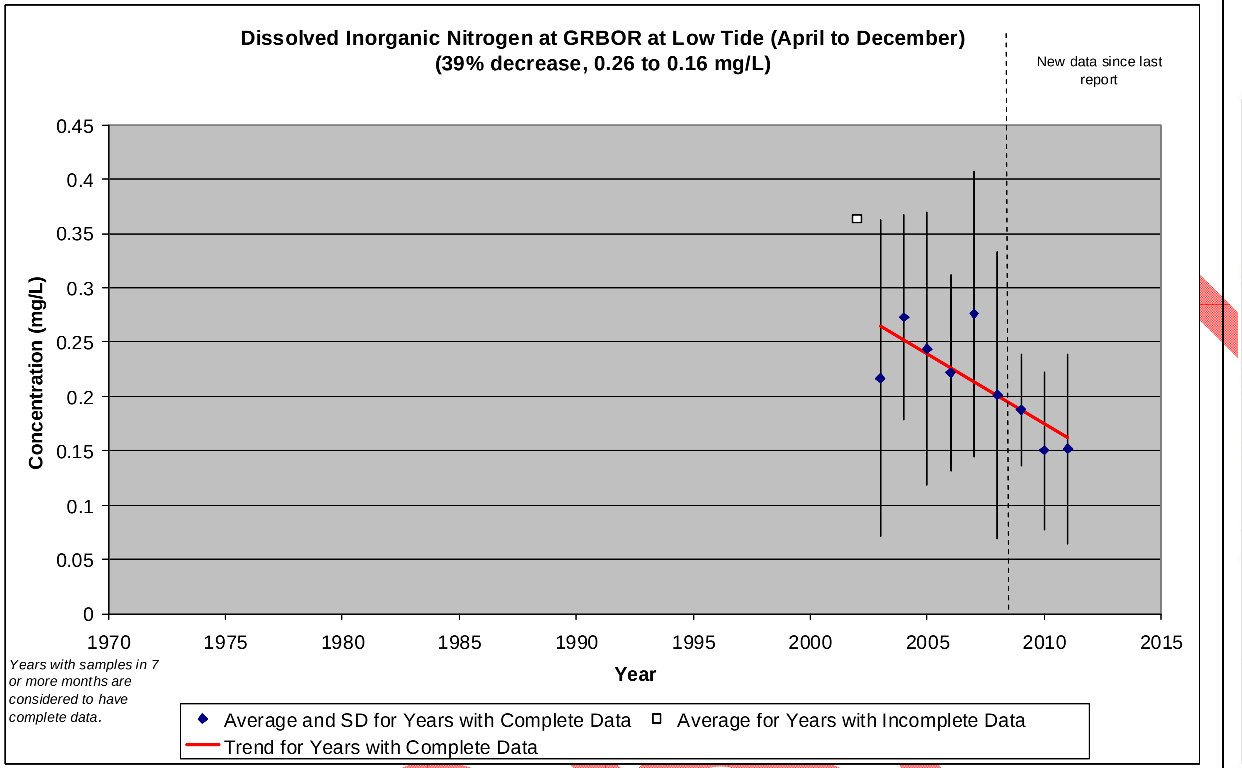
Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 0.148 mg/L

Long Term Trend: No significant trend

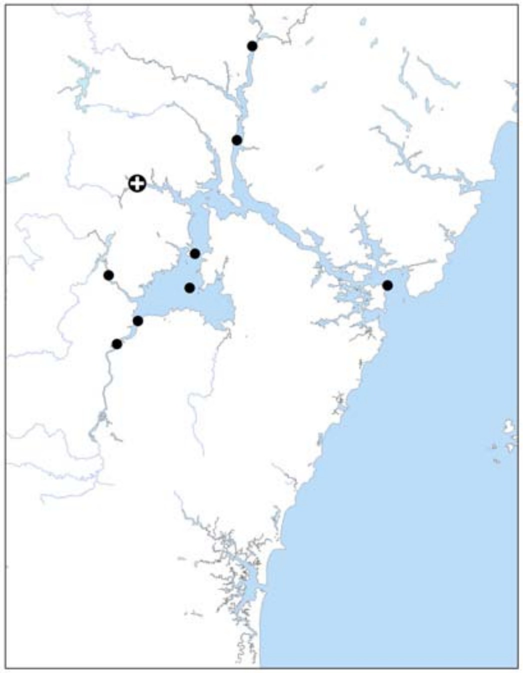
Recent Change: None

EXHIBIT 36 (AR K.22)



Dissolved Inorganic Nitrogen at GRBOR at Low Tide (April to December)
(39% decrease, 0.26 to 0.16 mg/L)

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



Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 0.164 mg/L

Long Term Trend: 39% decrease, 0.26 to 0.16 mg/L

Recent Change: Lower

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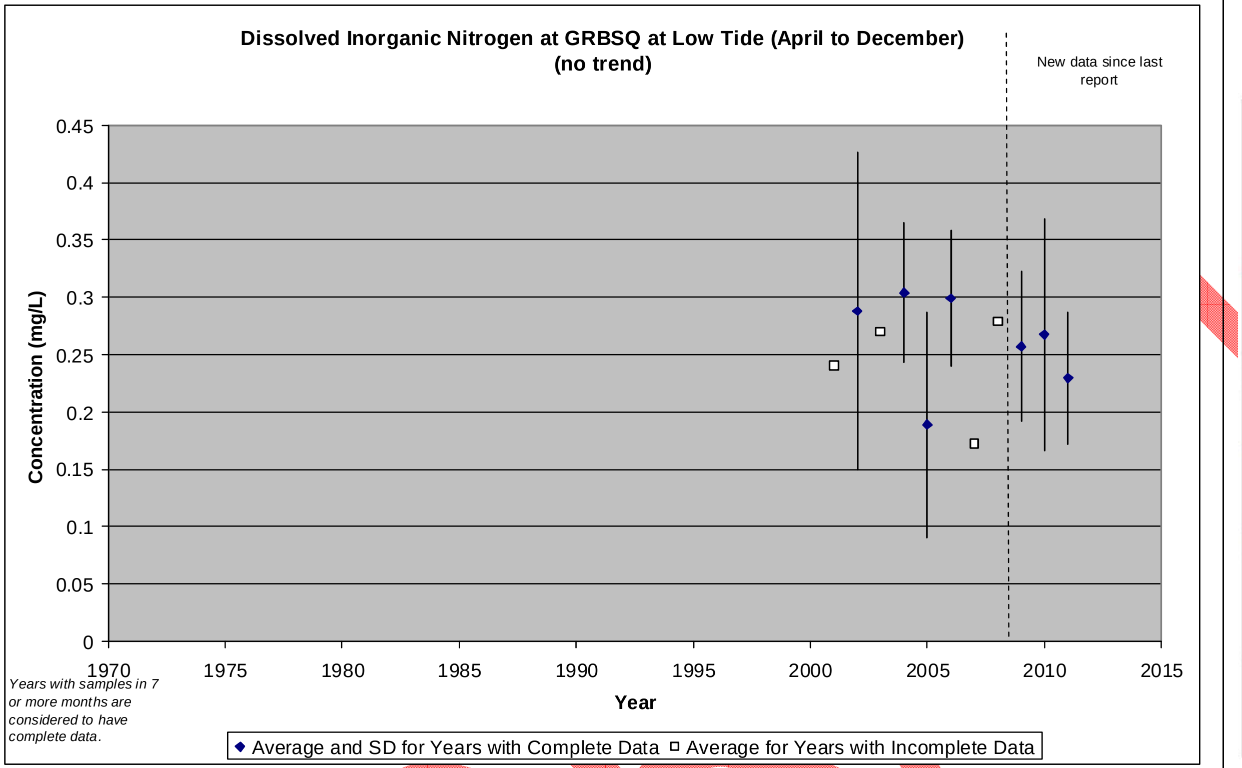
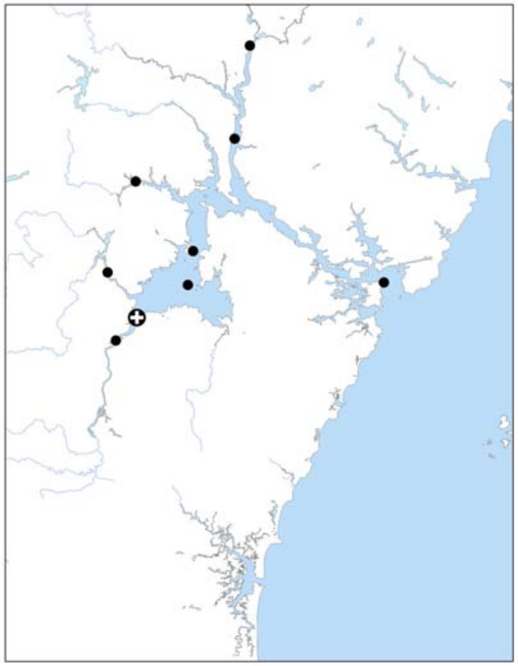
EXHIBIT 36 (AR K.22)



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



Station: GRBSQ (Squamscott River at the railroad trestle)

Average Concentration in 2009-2011: 0.251 mg/L

Long Term Trend: No significant trend

Recent Change: None

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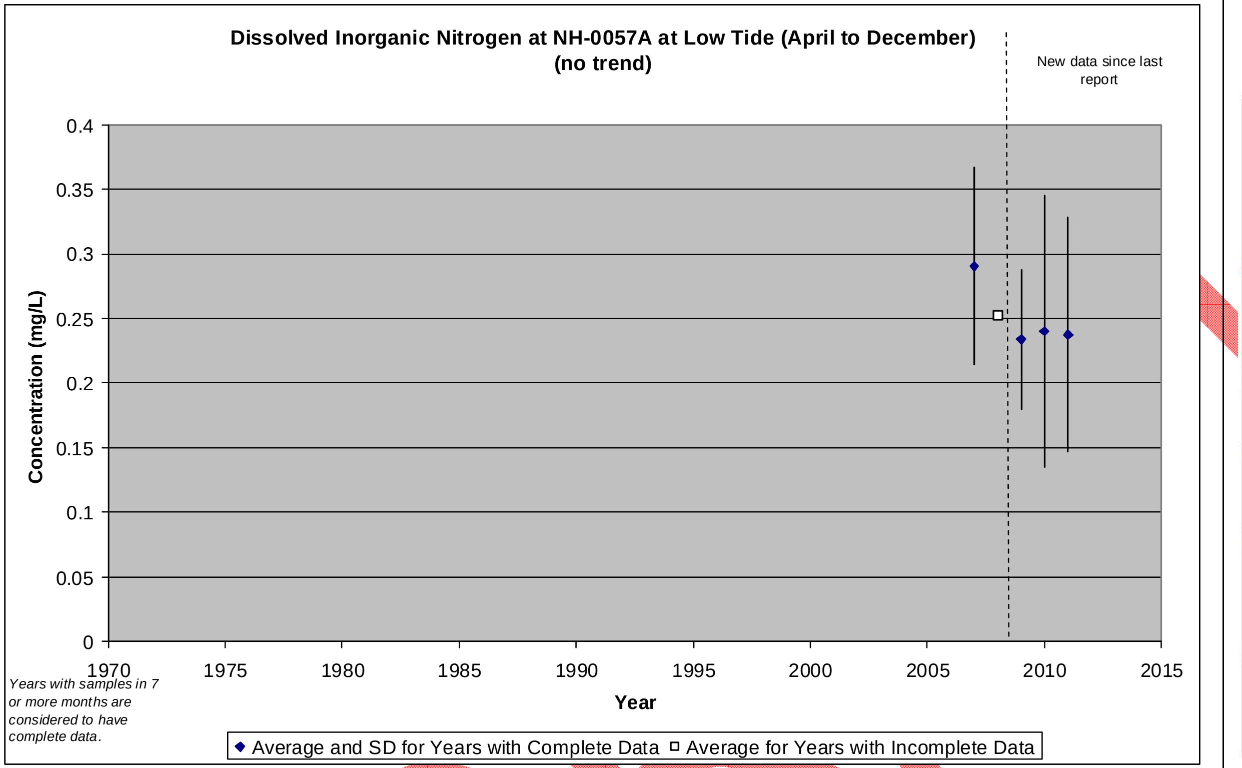
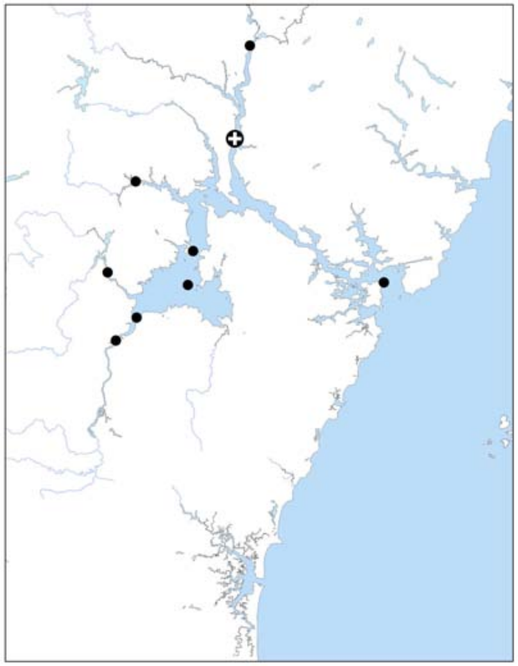


Monitoring Location (NH-0057A)
(black circle with white plus sign)



Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 0.237 mg/L

Long Term Trend: No significant trend

Recent Change: None

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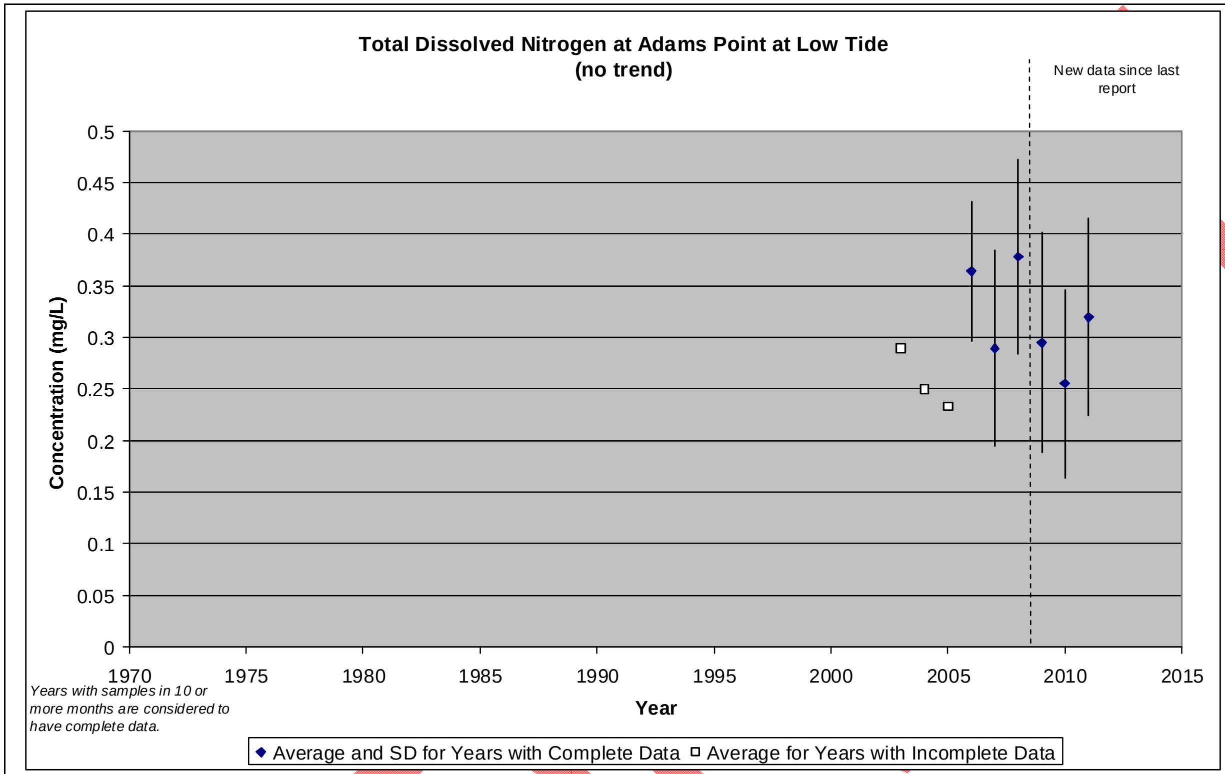
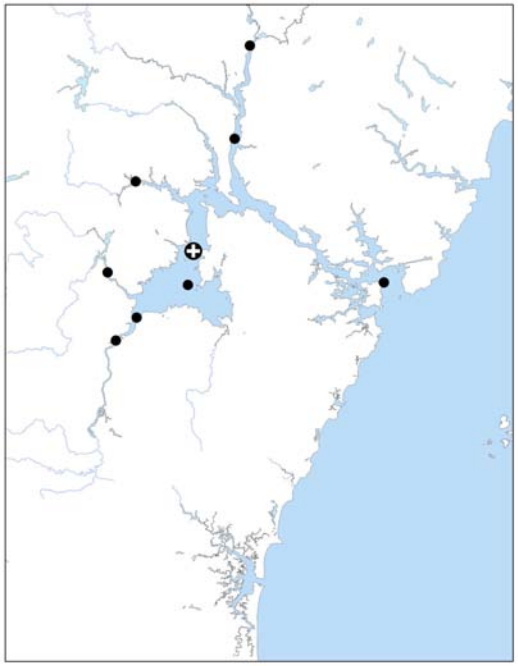
EXHIBIT 36 (AR K.22)

Figure NUT2-5: Total dissolved nitrogen concentration trends at stations in the Great Bay Estuary



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

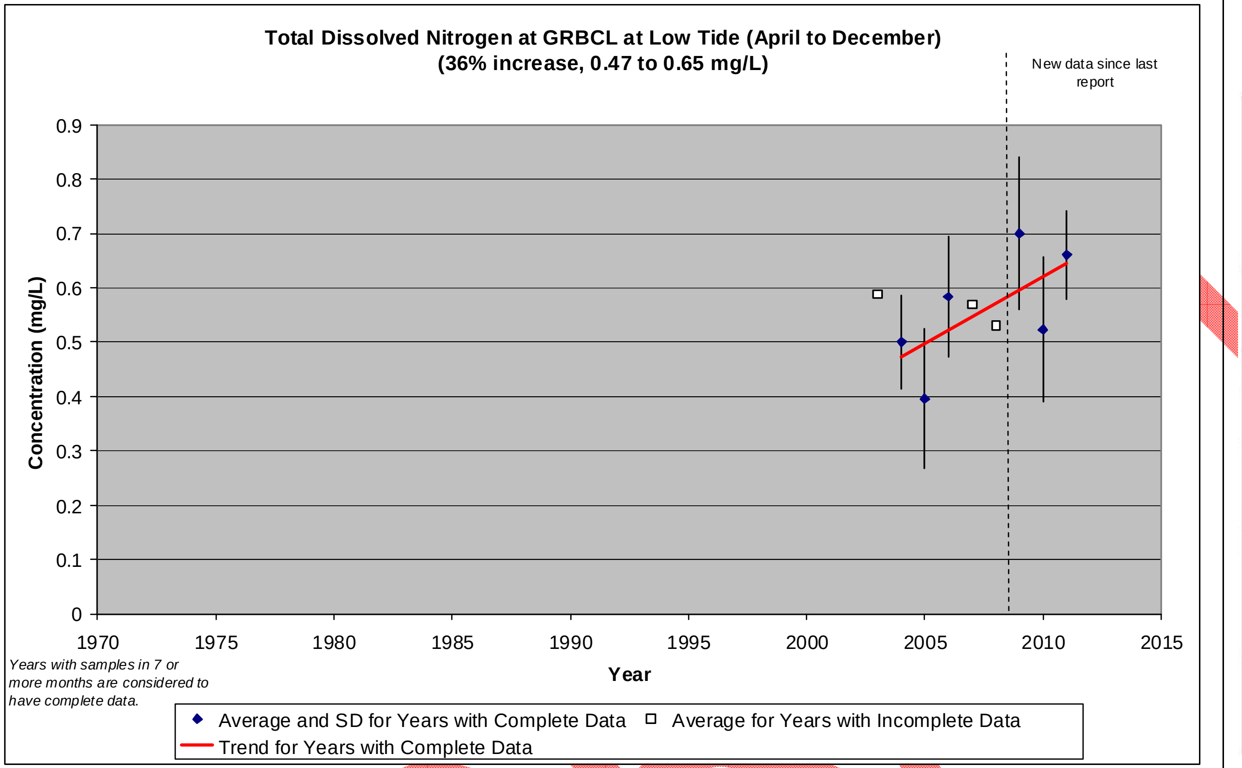


Station: GRBAP (Adams Point between Great Bay and Little Bay)

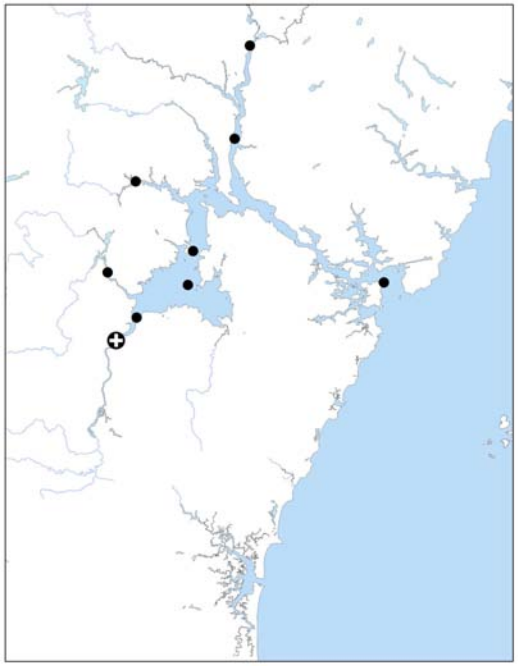
Average Concentration in 2009-2011: 0.290 mg/L

Long Term Trend: No significant trend

Recent Change: Lower



**Monitoring Location (GRBCL)
(black circle with white plus sign)**



Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 0.625 mg/L

Long Term Trend: 36% increase, 0.47 to 0.65 mg/L

Recent Change: None

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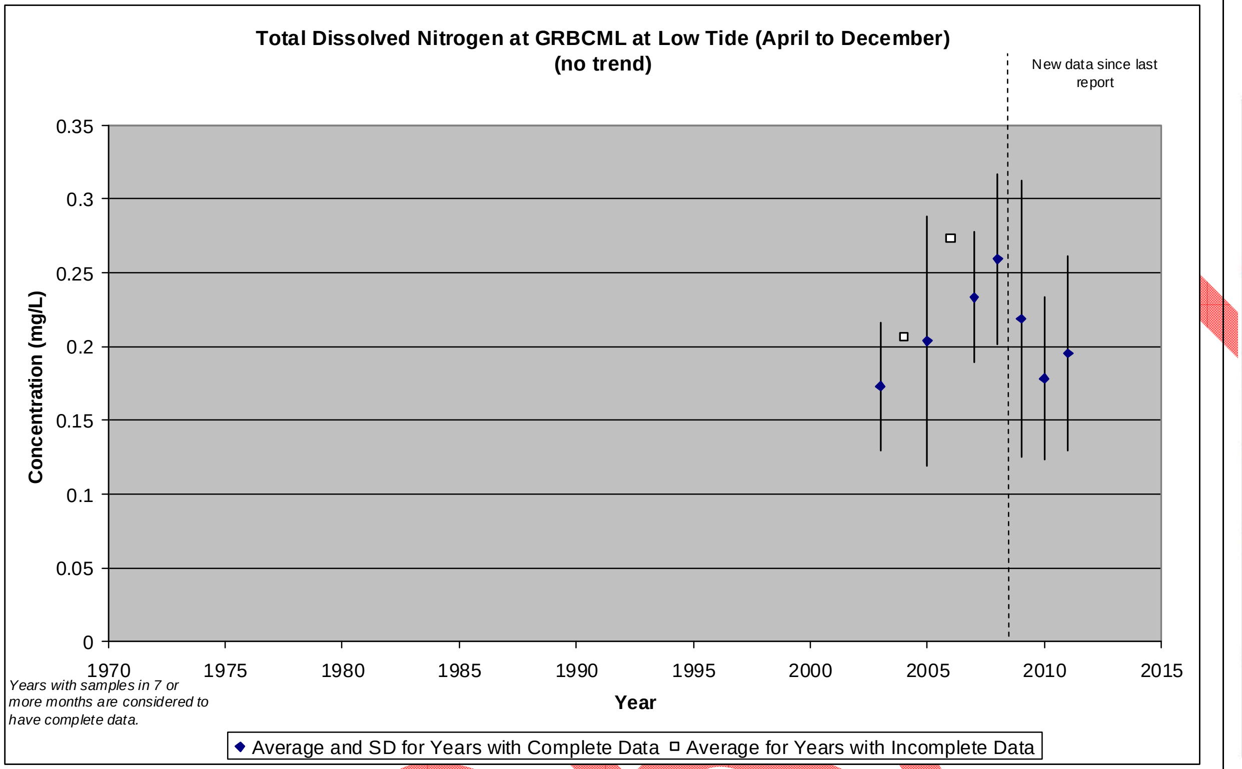
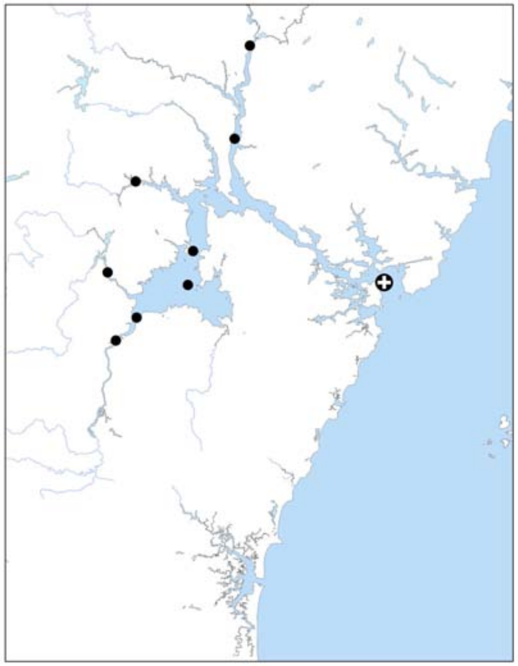


Total Dissolved Nitrogen at GRBCML at Low Tide (April to December)
(no trend)

Monitoring Location (GRBCML)
(black circle with white plus sign)



Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.198 mg/L

Long Term Trend: No significant trend

Recent Change: Lower

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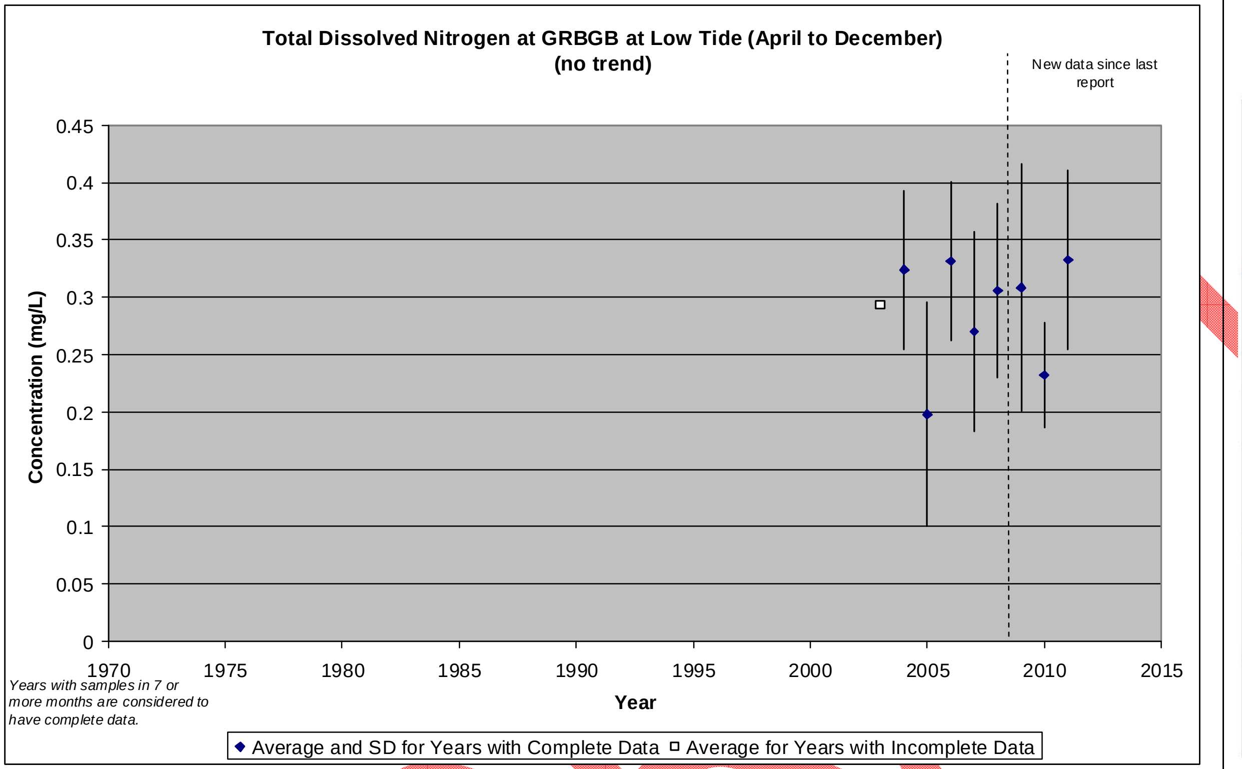
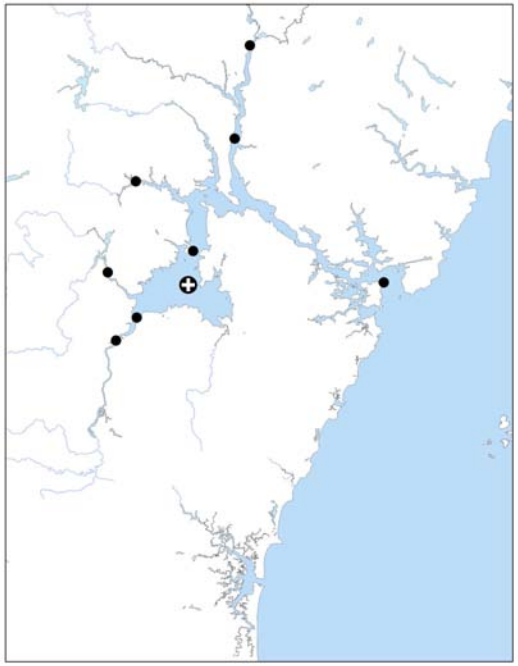


Monitoring Location (GRBGB)
(black circle with white plus sign)



Station: GRBGB (Great Bay)

Average Concentration in 2009-2011: 0.293 mg/L

Long Term Trend: No significant trend

Recent Change: None

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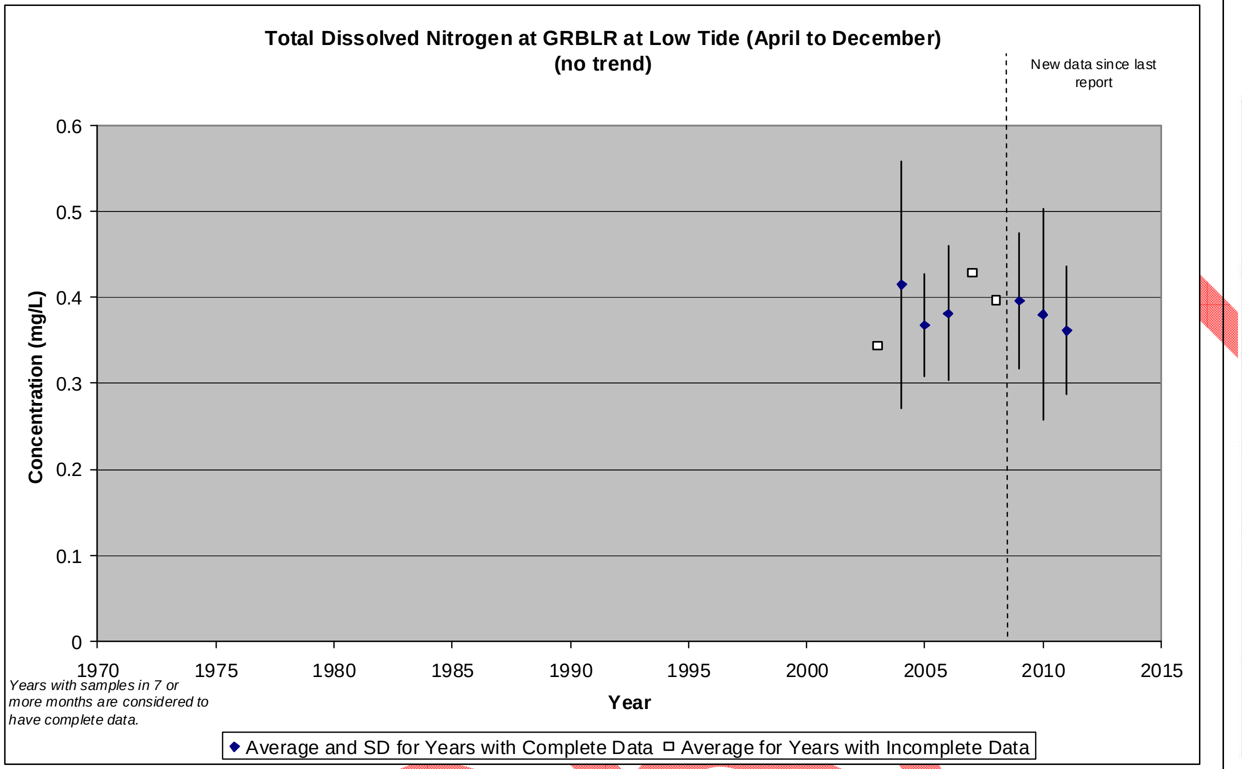
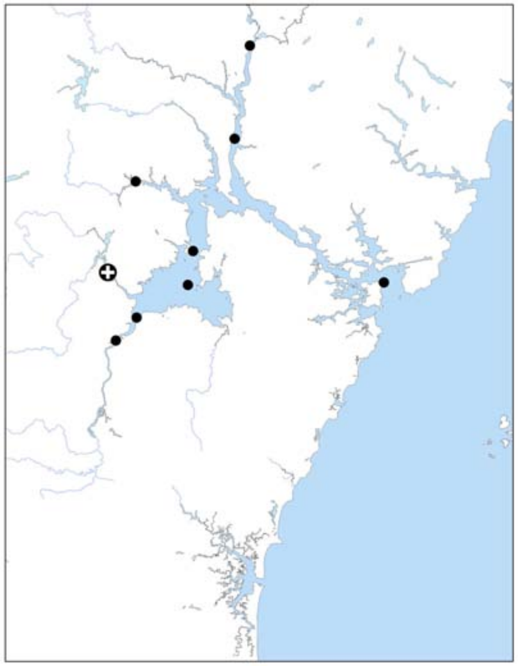


Monitoring Location (GRBLR)
(black circle with white plus sign)

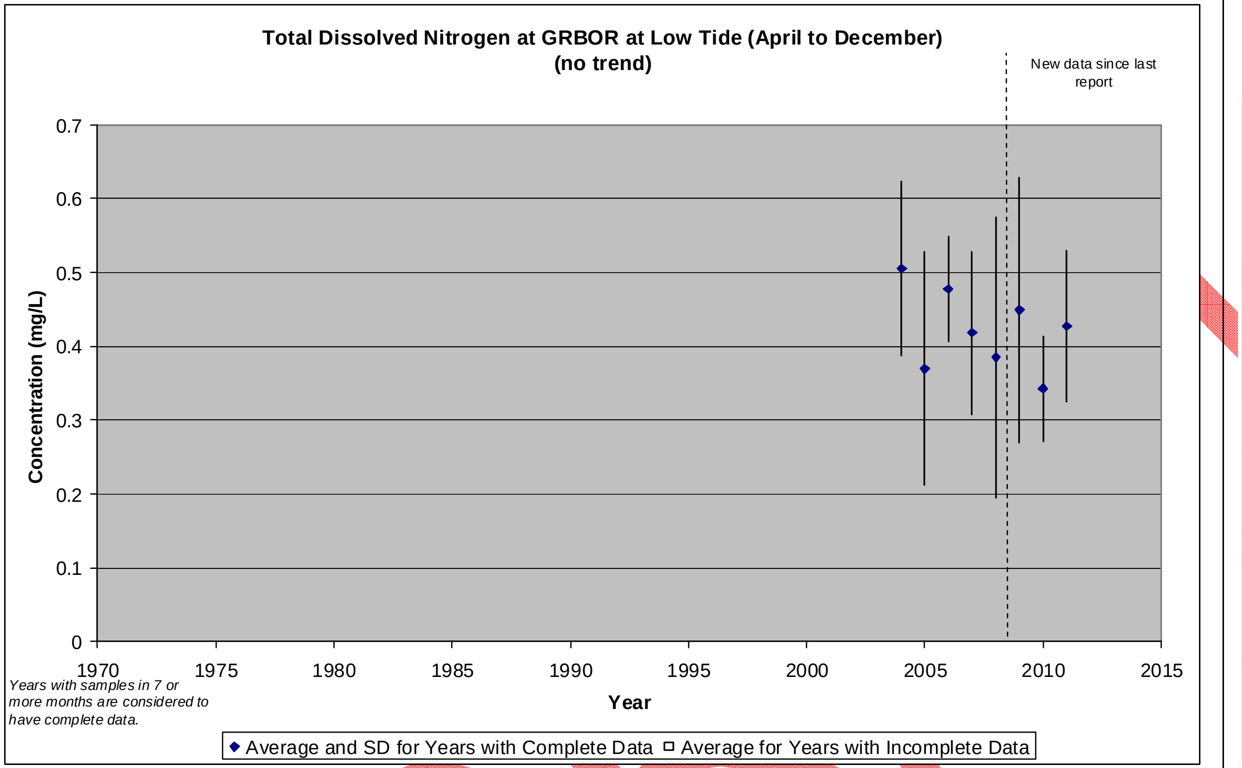


Station: GRBLR (Lamprey River)

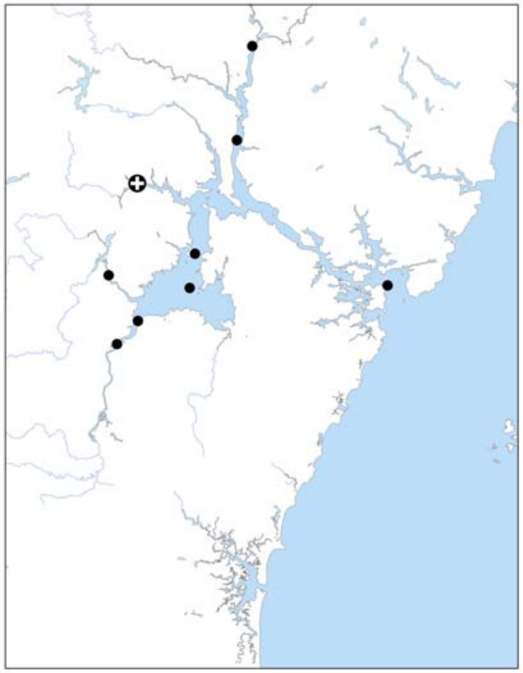
Average Concentration in 2009-2011: 0.379 mg/L

Long Term Trend: No significant trend

Recent Change: None



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



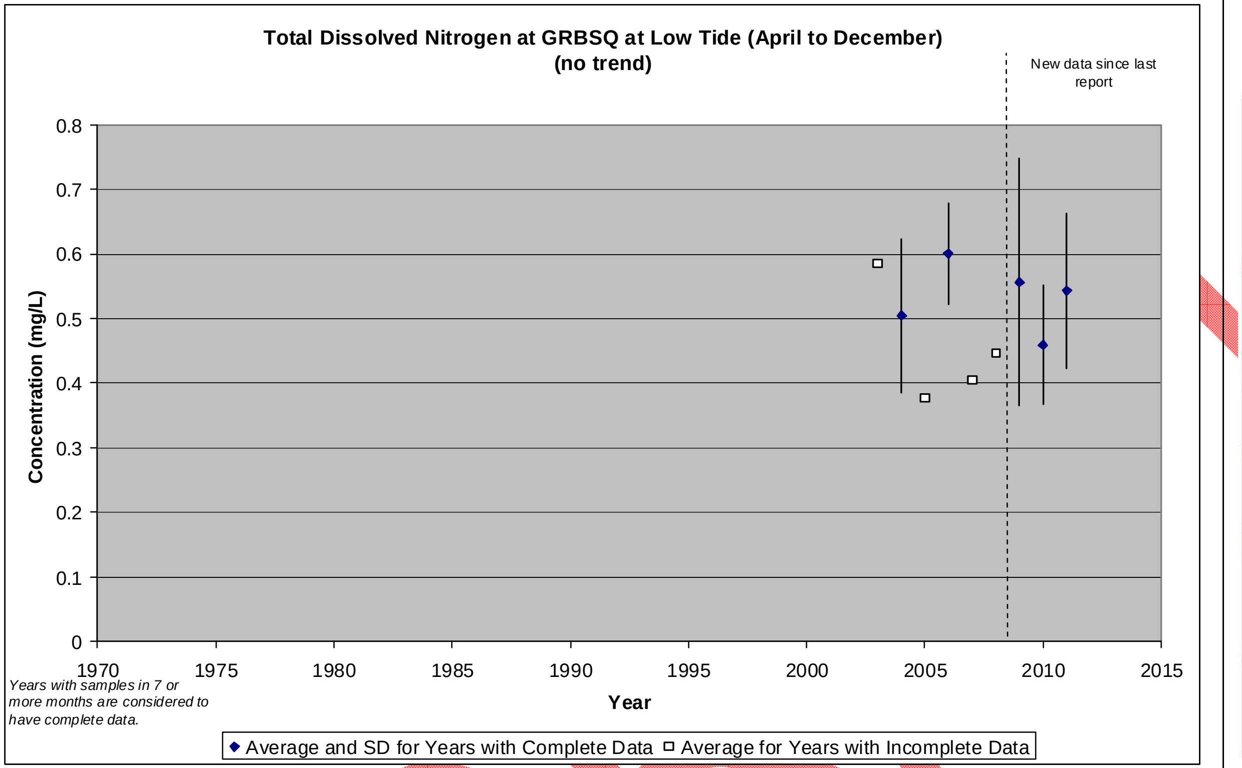
Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 0.405 mg/L

Long Term Trend: No significant trend

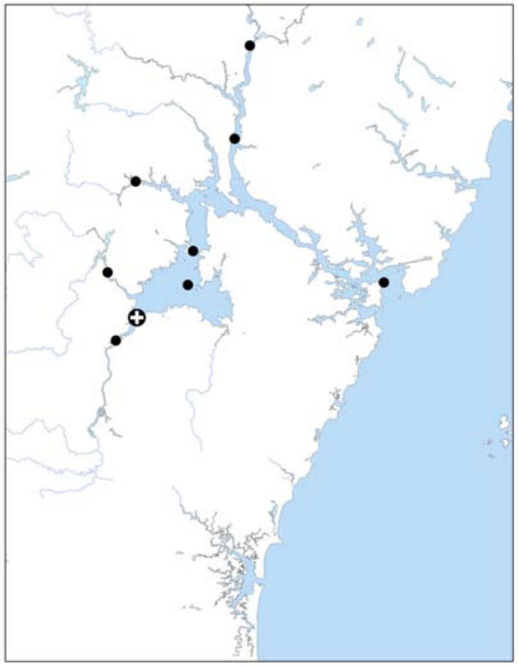
Recent Change: None

EXHIBIT 36 (AR K.22)



Total Dissolved Nitrogen at GRBSQ at Low Tide (April to December) (no trend)

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



Station: GRBSQ (Squamscott River at the railroad trestle)

Average Concentration in 2009-2011: 0.519 mg/L

Long Term Trend: No significant trend

Recent Change: Lower

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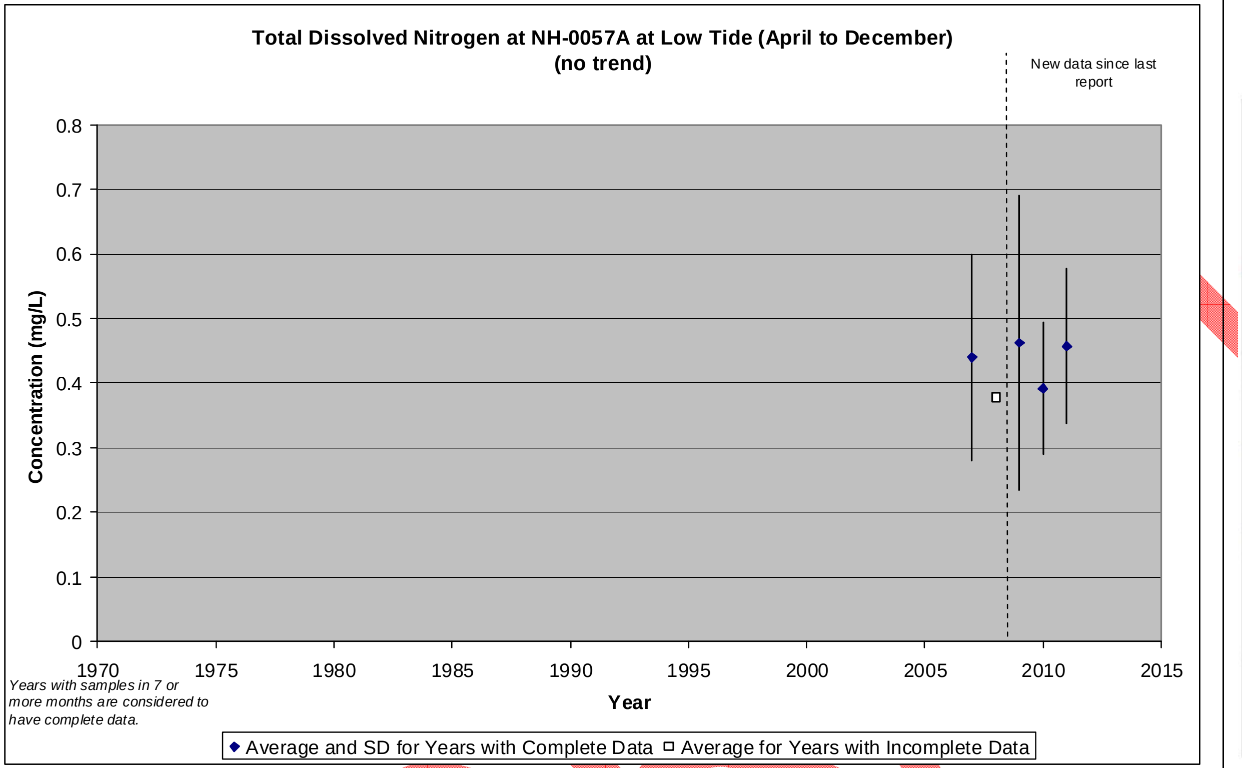
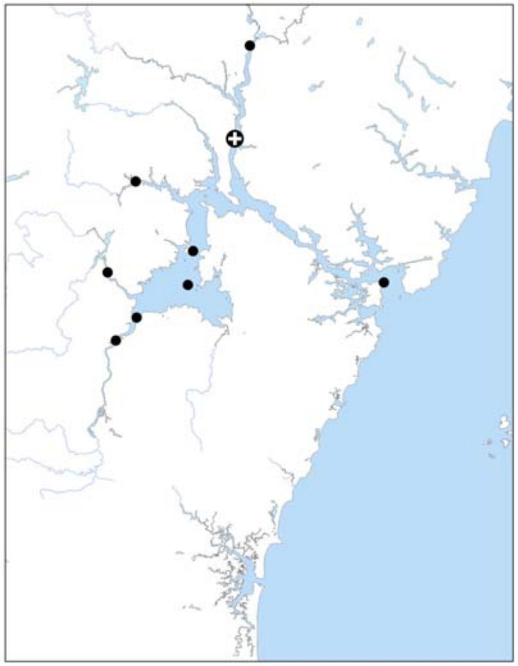


Monitoring Location (NH-0057A)
(black circle with white plus sign)



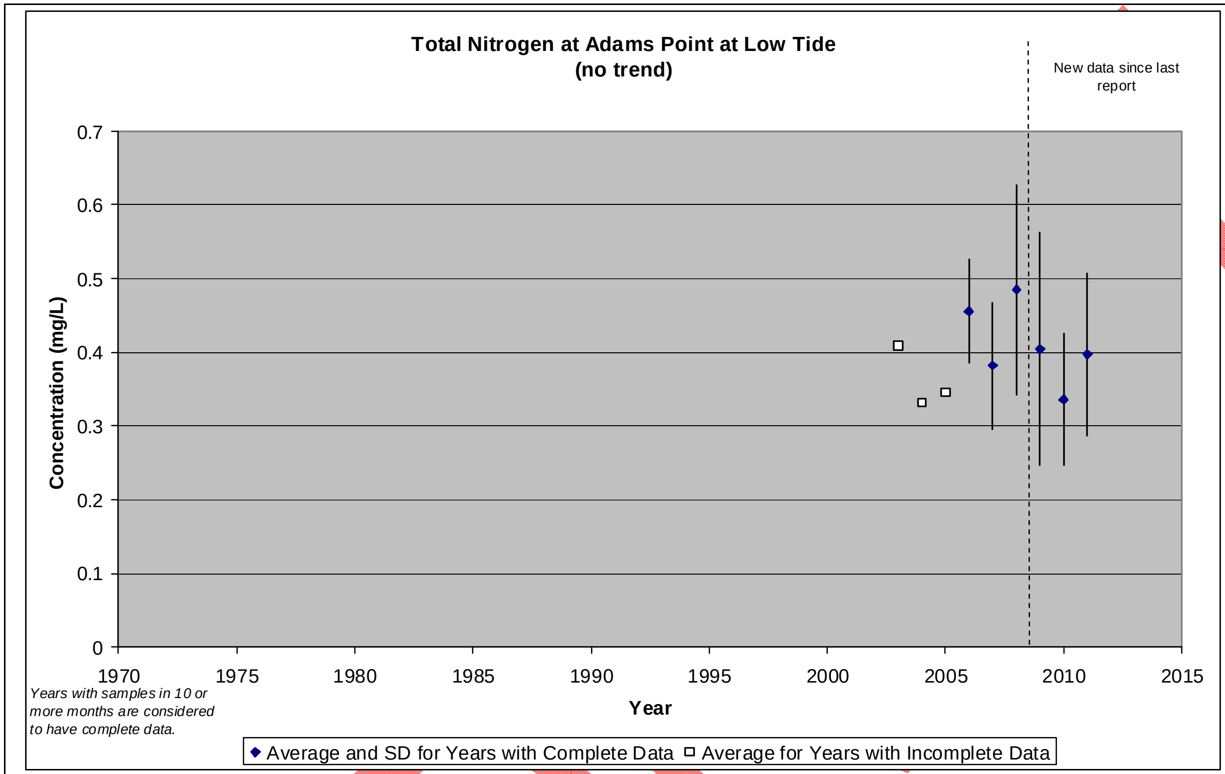
Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 0.440 mg/L

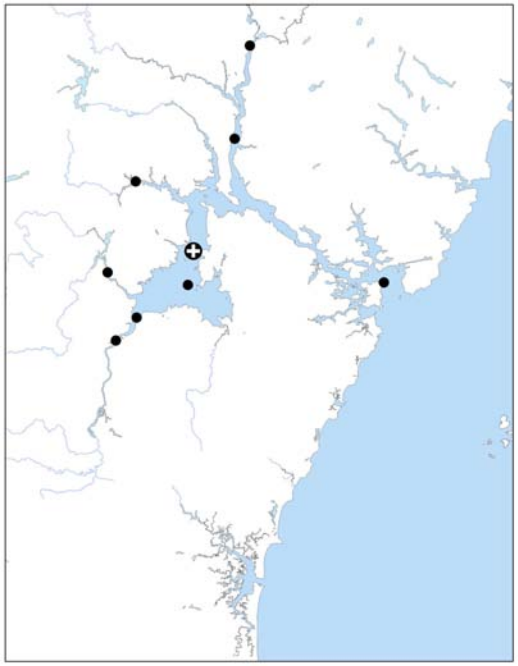
Long Term Trend: No significant trend

Recent Change: None

Figure NUT2-6: Total nitrogen concentration trends at stations in the Great Bay Estuary



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



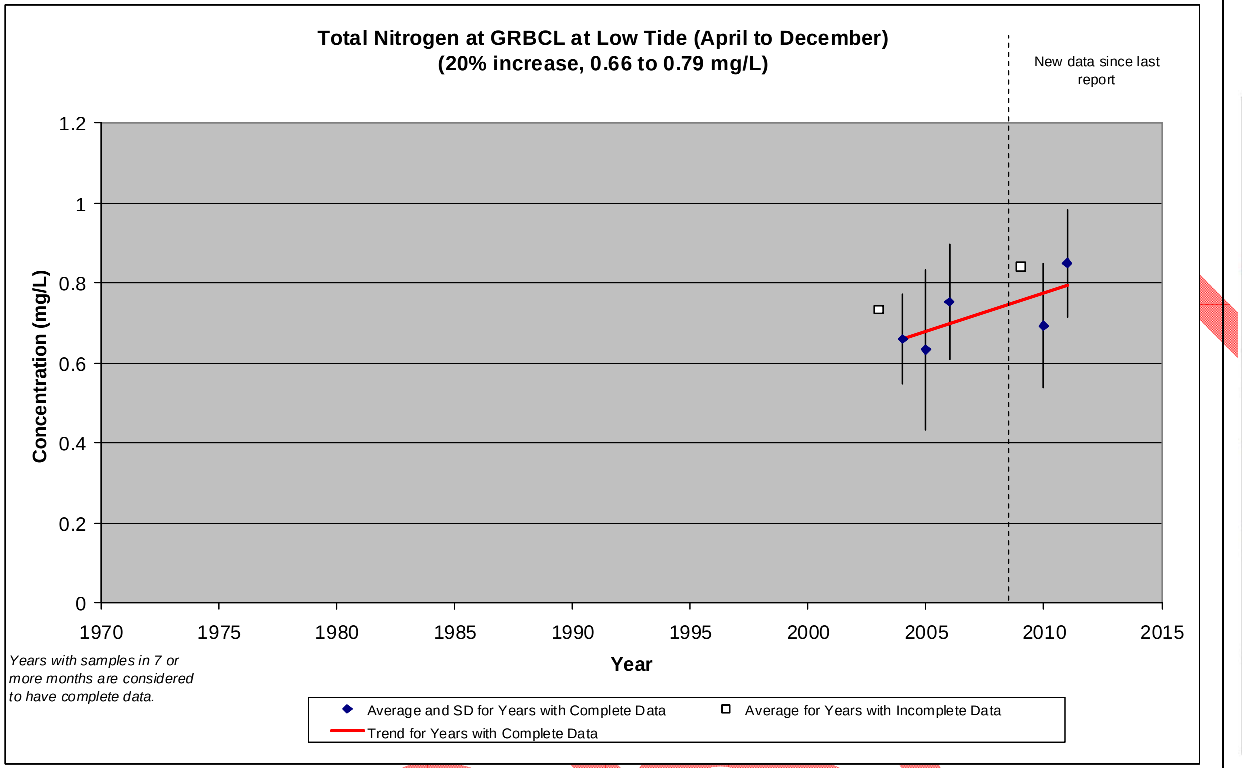
Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 0.380 mg/L

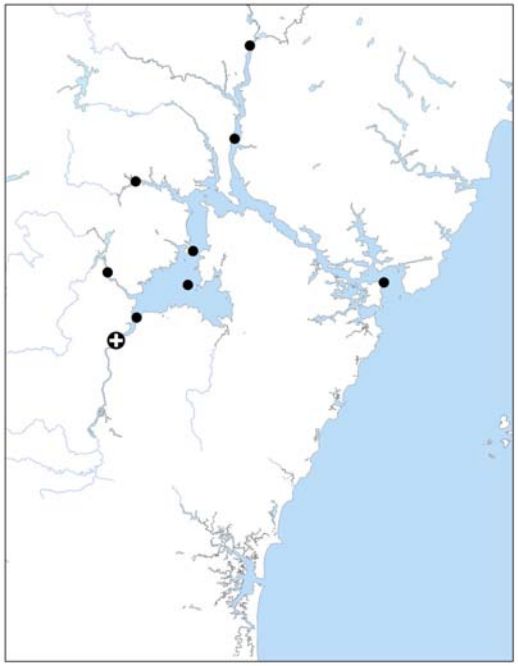
Long Term Trend: No significant trend

Recent Change: Lower

EXHIBIT 36 (AR K.22)



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



Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 0.772 mg/L

Long Term Trend: 20% increase, 0.66 to 0.79 mg/L

Recent Change: None

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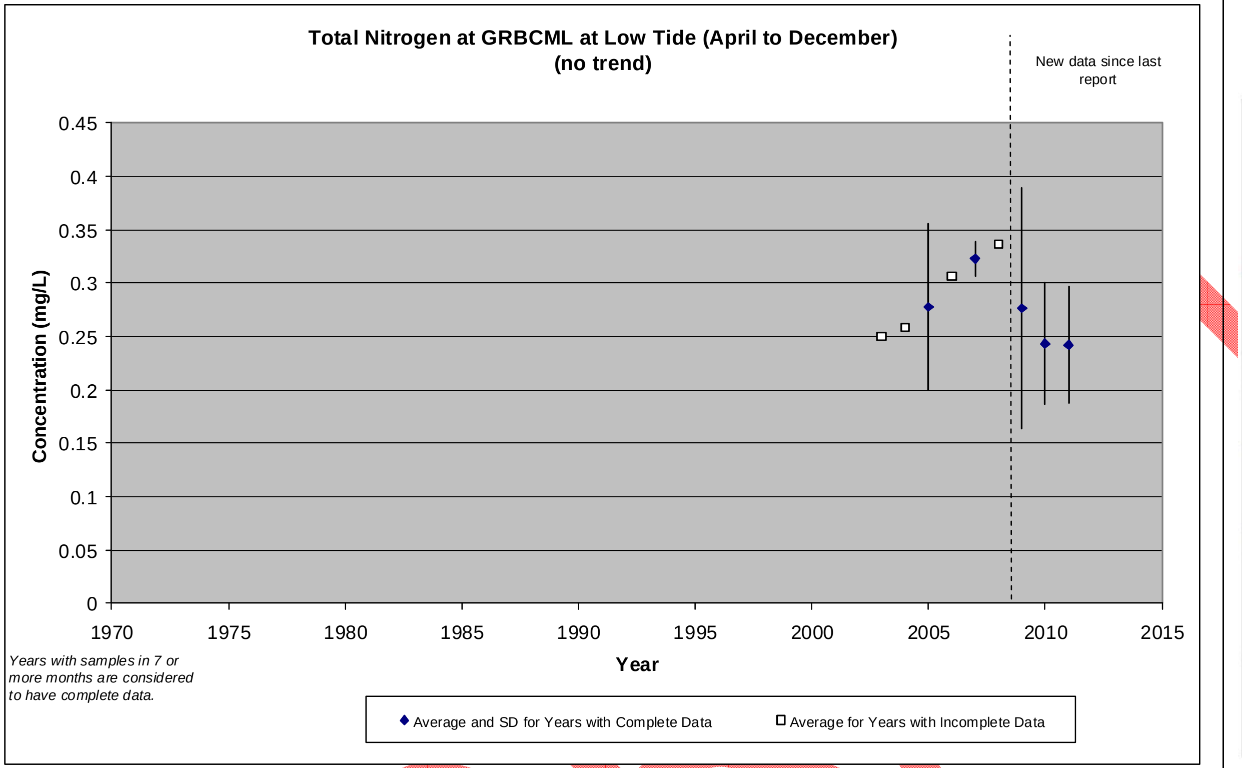
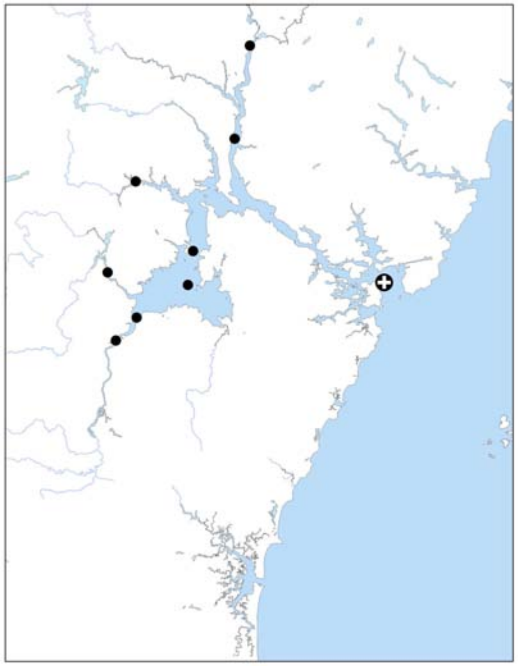
EXHIBIT 36 (AR K.22)



Monitoring Location (GRBCML)
(black circle with white plus sign)



Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.255 mg/L

Long Term Trend: No significant trend

Recent Change: Lower

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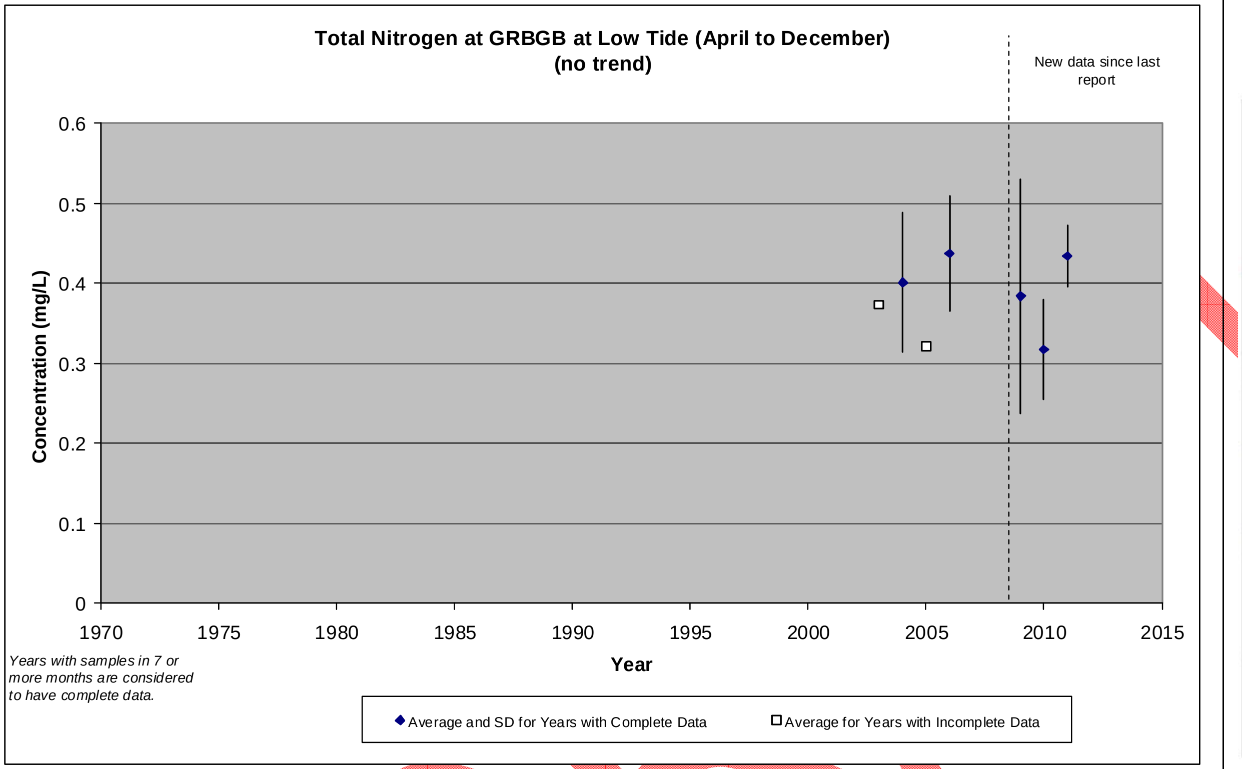
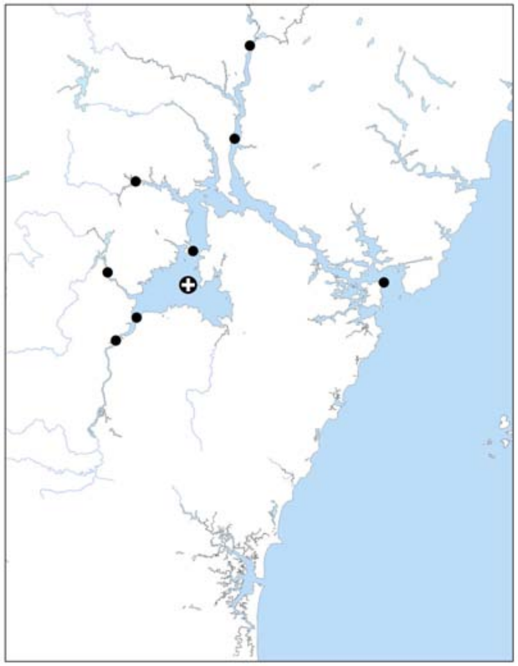
EXHIBIT 36 (AR K.22)


Total Nitrogen at GRBGB at Low Tide (April to December)
(no trend)

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



Station: GRBGB (Great Bay)

Average Concentration in 2009-2011: 0.376 mg/L

Long Term Trend: No significant trend

Recent Change: None

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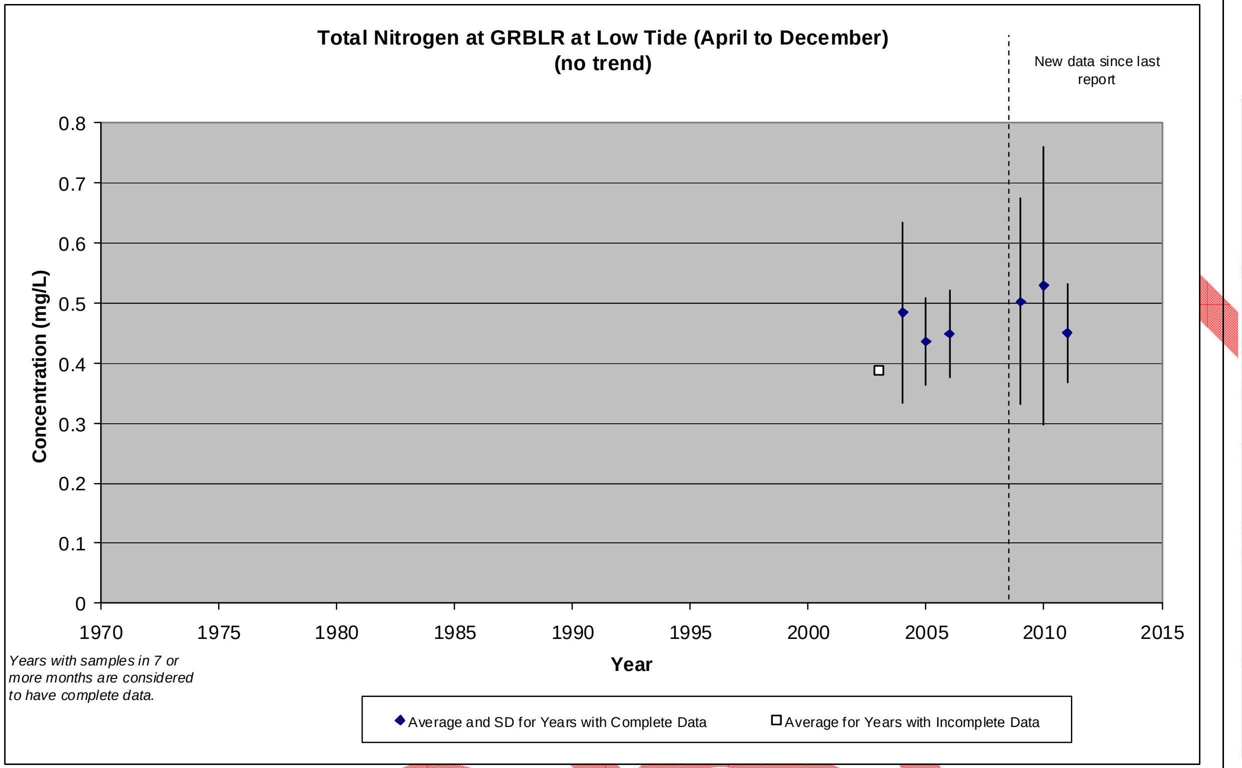
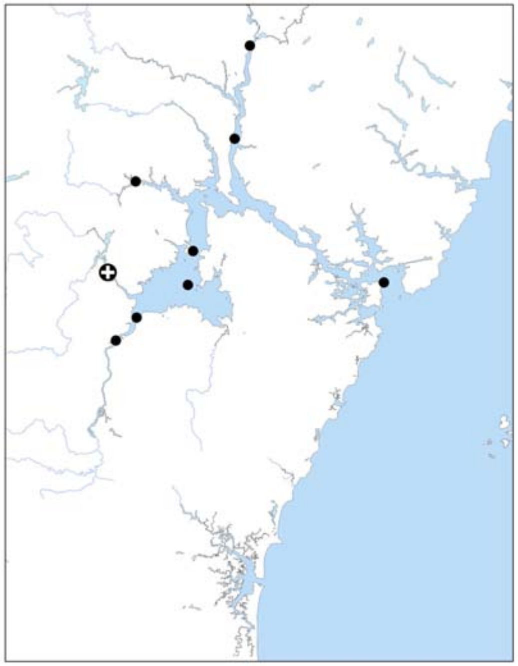


Monitoring Location (GRBLR)
(black circle with white plus sign)

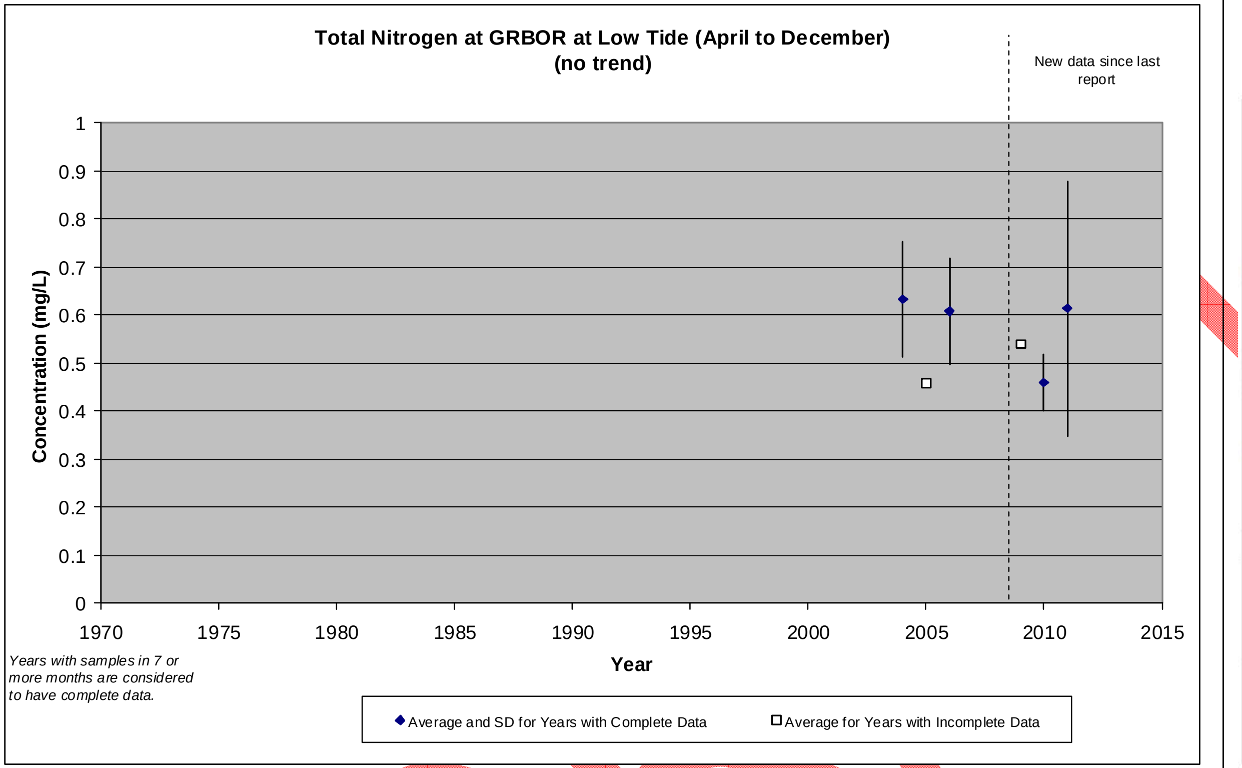


Station: GRBLR (Lamprey River)

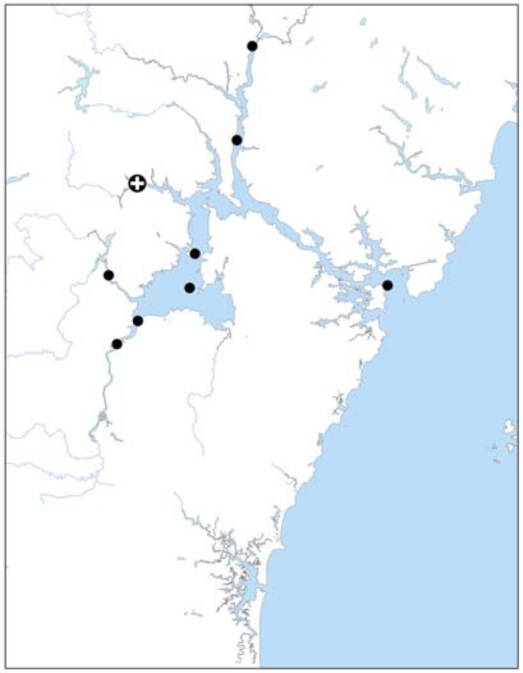
Average Concentration in 2009-2011: 0.494 mg/L

Long Term Trend: No significant trend

Recent Change: None



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



Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 0.532 mg/L

Long Term Trend: No significant trend

Recent Change: None

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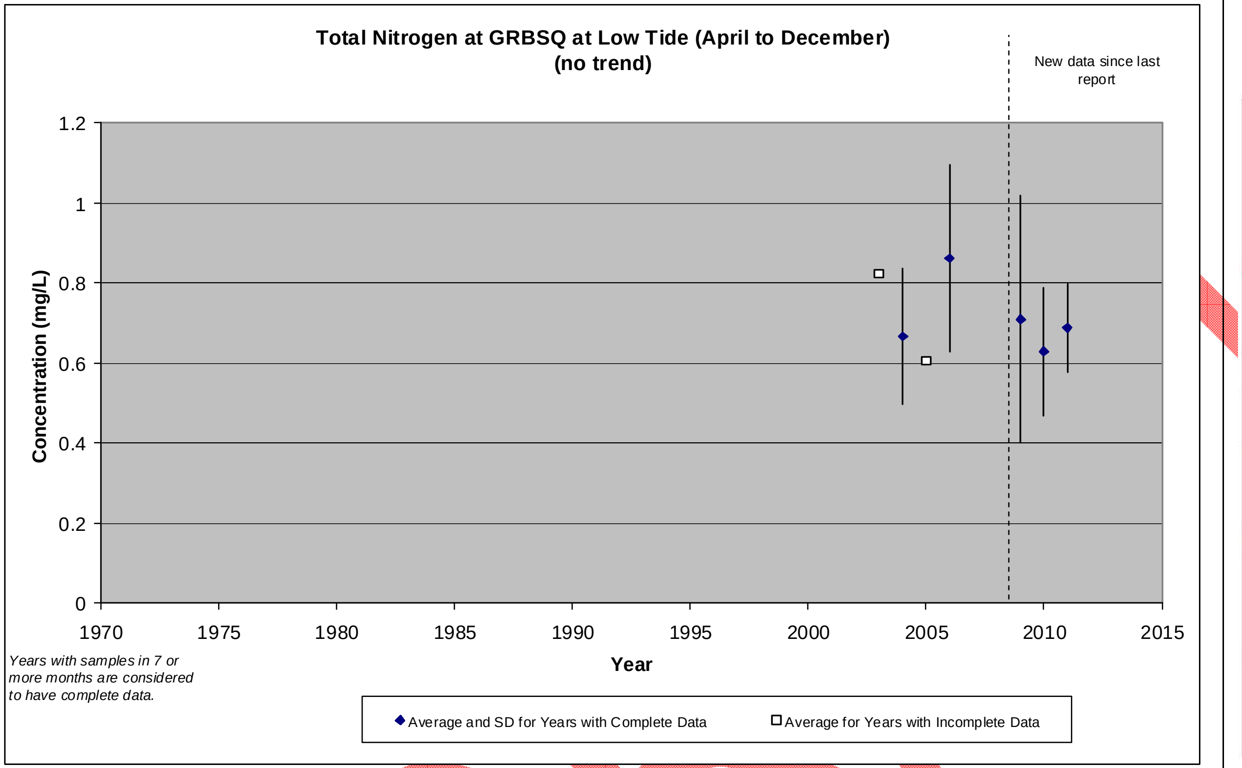
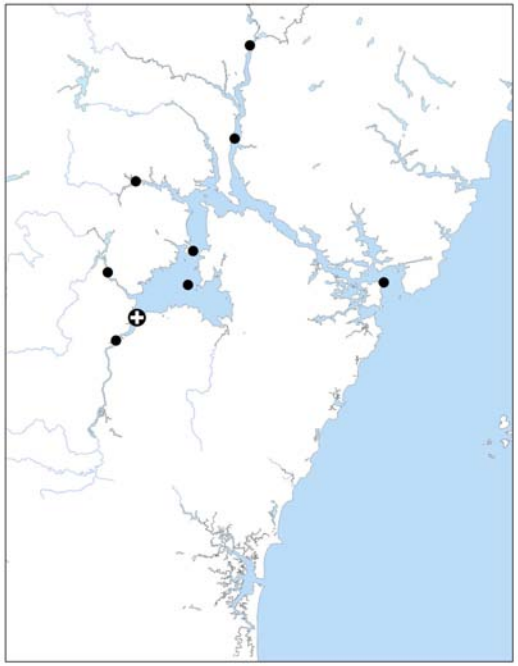


Monitoring Location (GRBSQ)
(black circle with white plus sign)



Station: GRBSQ (Squamscott River at the railroad trestle)

Average Concentration in 2009-2011: 0.672 mg/L

Long Term Trend: No significant trend

Recent Change: None

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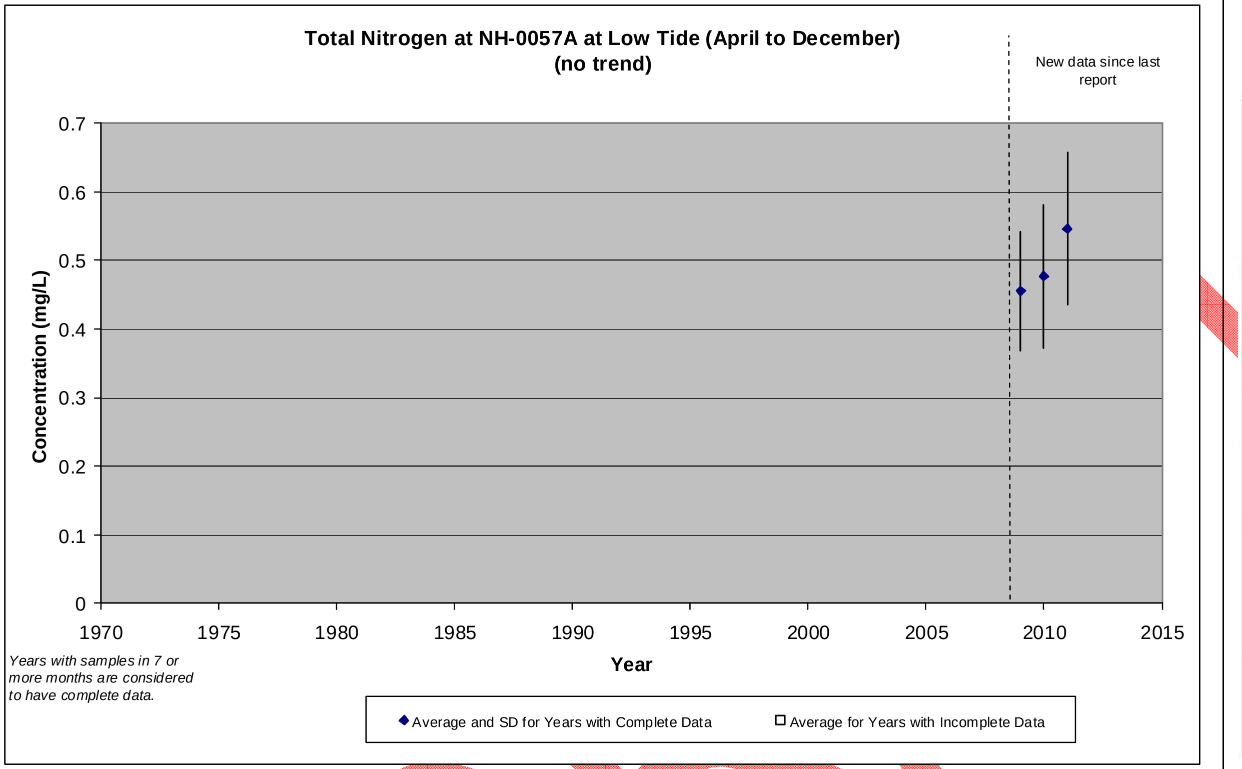
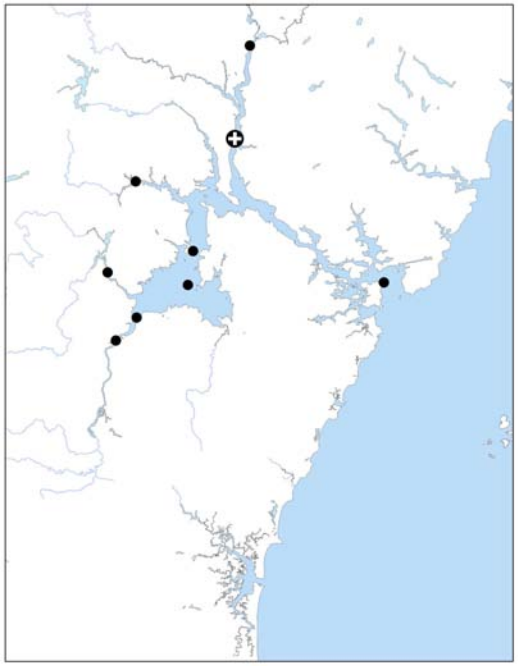


Monitoring Location (NH-0057A)
(black circle with white plus sign)



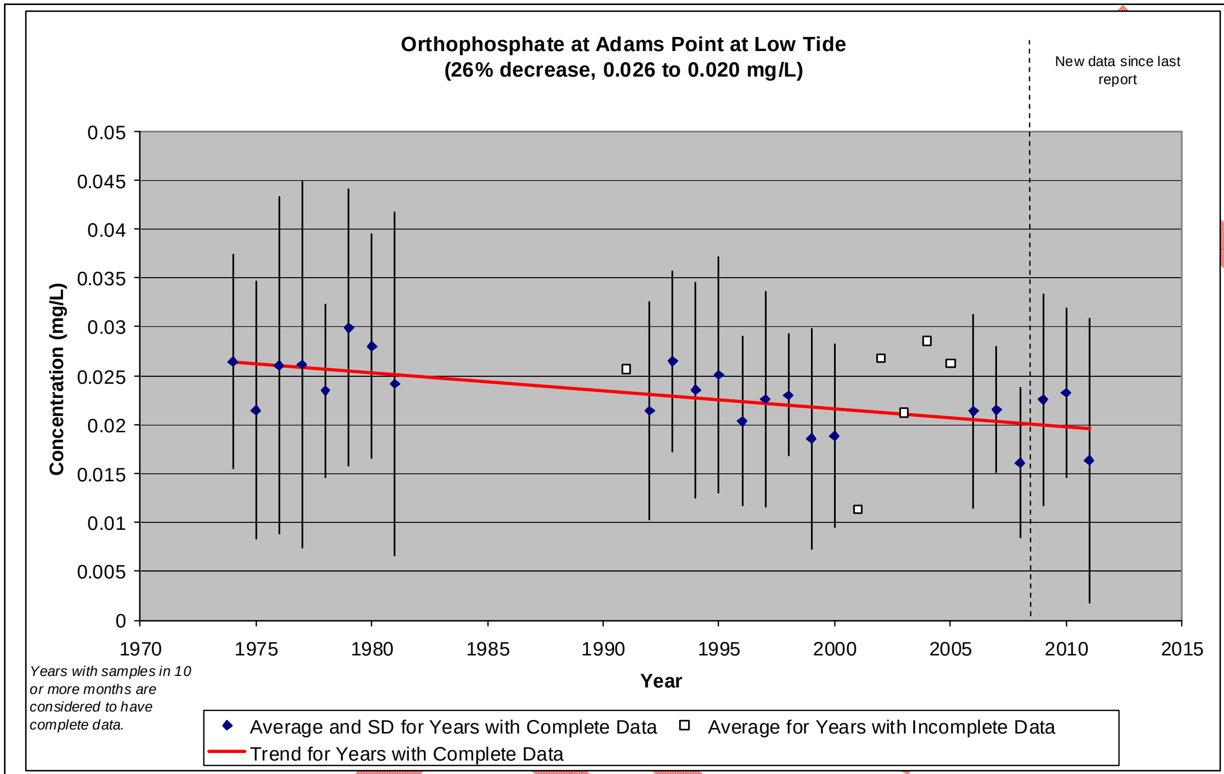
Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 0.496 mg/L

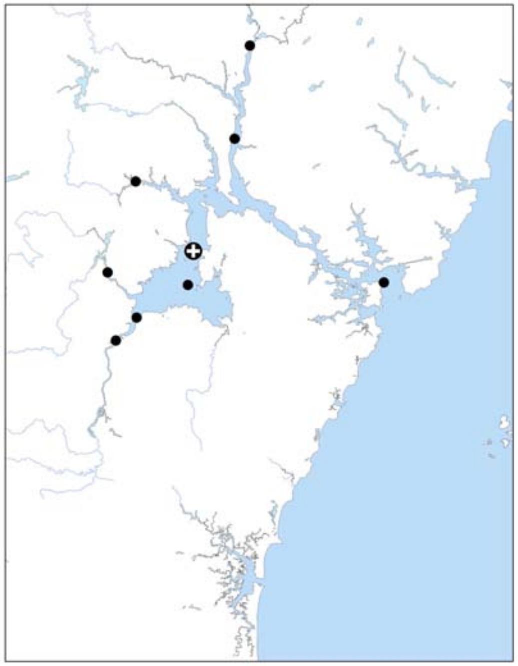
Long Term Trend: No significant trend

Recent Change: None

Figure NUT2-7: Orthophosphate concentration trends at stations in the Great Bay Estuary



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



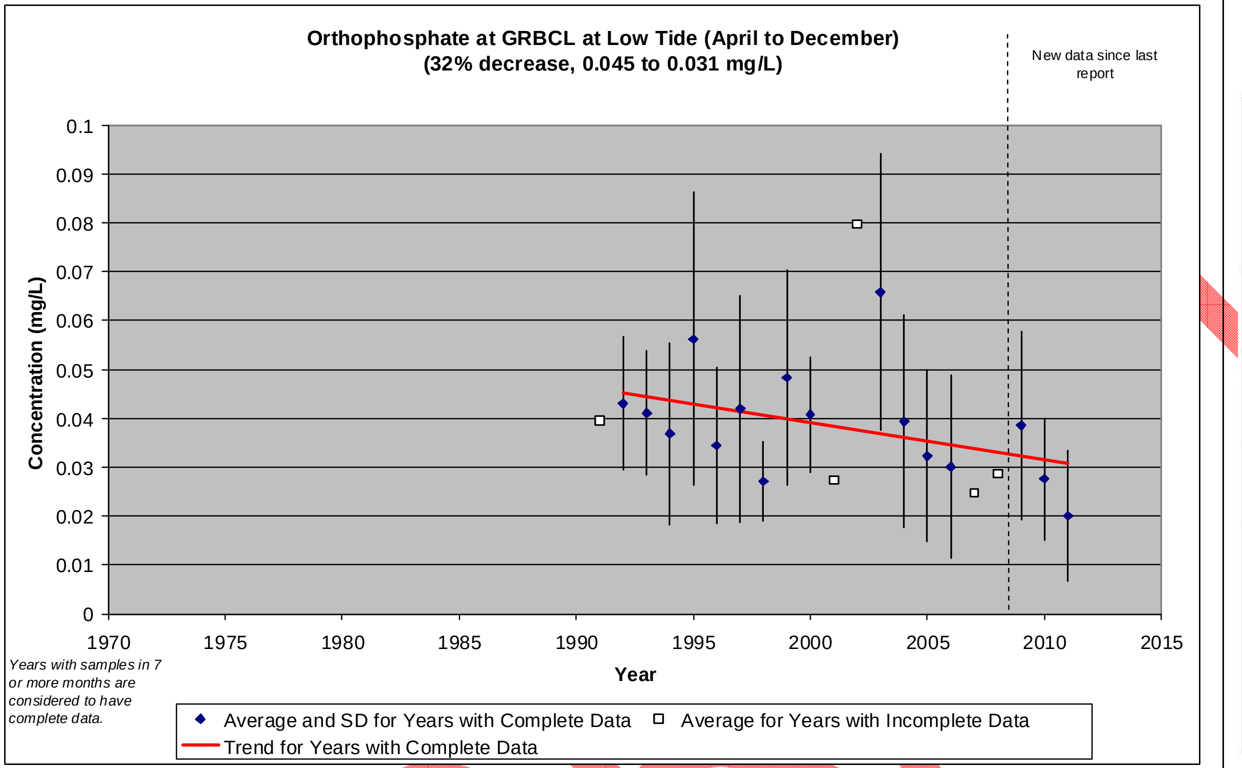
Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 0.021 mg/L

Long Term Trend: 26% decrease, 0.026 to 0.020 mg/L

Recent Change: None

EXHIBIT 36 (AR K.22)

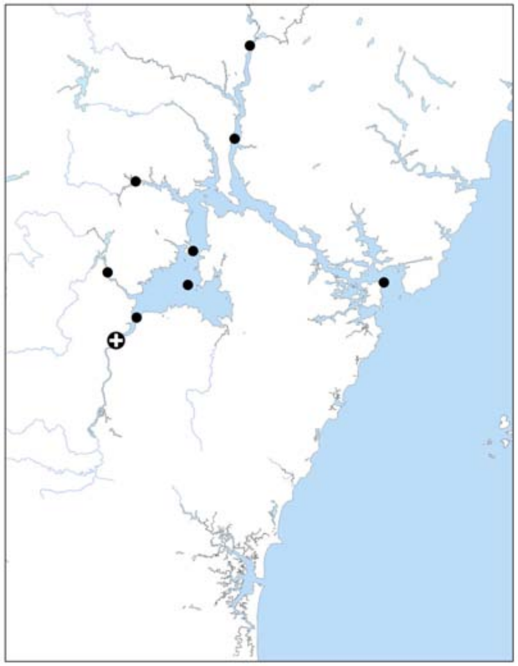


Orthophosphate at GRBCL at Low Tide (April to December)
(32% decrease, 0.045 to 0.031 mg/L)

New data since last report

Years with samples in 7 or more months are considered to have complete data.

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

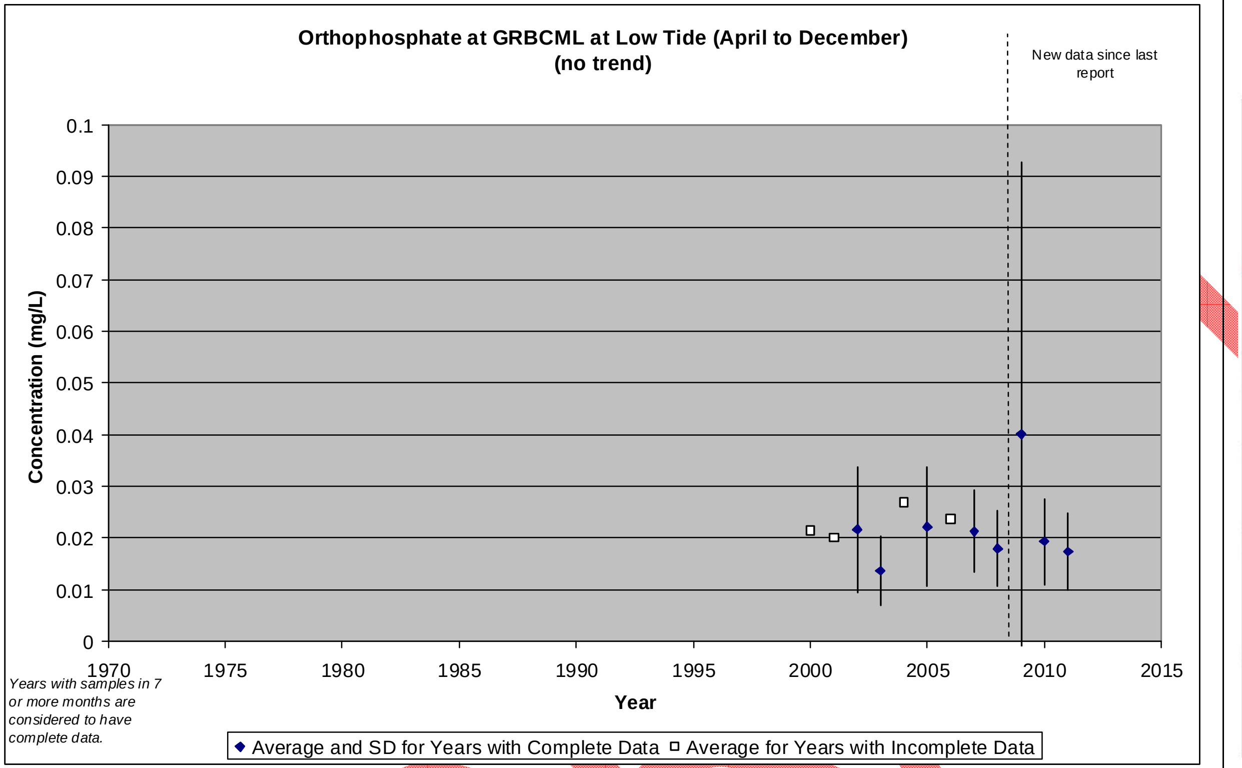


Station: GRBCL (Chapmans Landing in the Squamscott River)

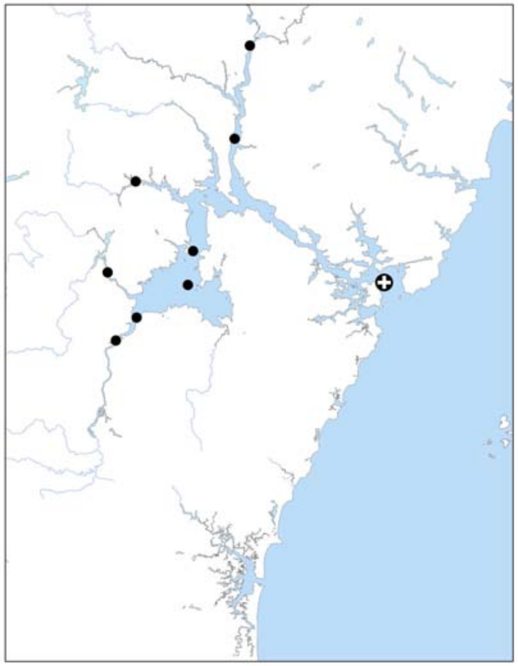
Average Concentration in 2009-2011: 0.028 mg/L

Long Term Trend: 32% decrease, 0.045 to 0.031 mg/L

Recent Change: None



Monitoring Location (GRBCML)
(black circle with white plus sign)



Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 0.026 mg/L

Long Term Trend: No significant trend

Recent Change: None

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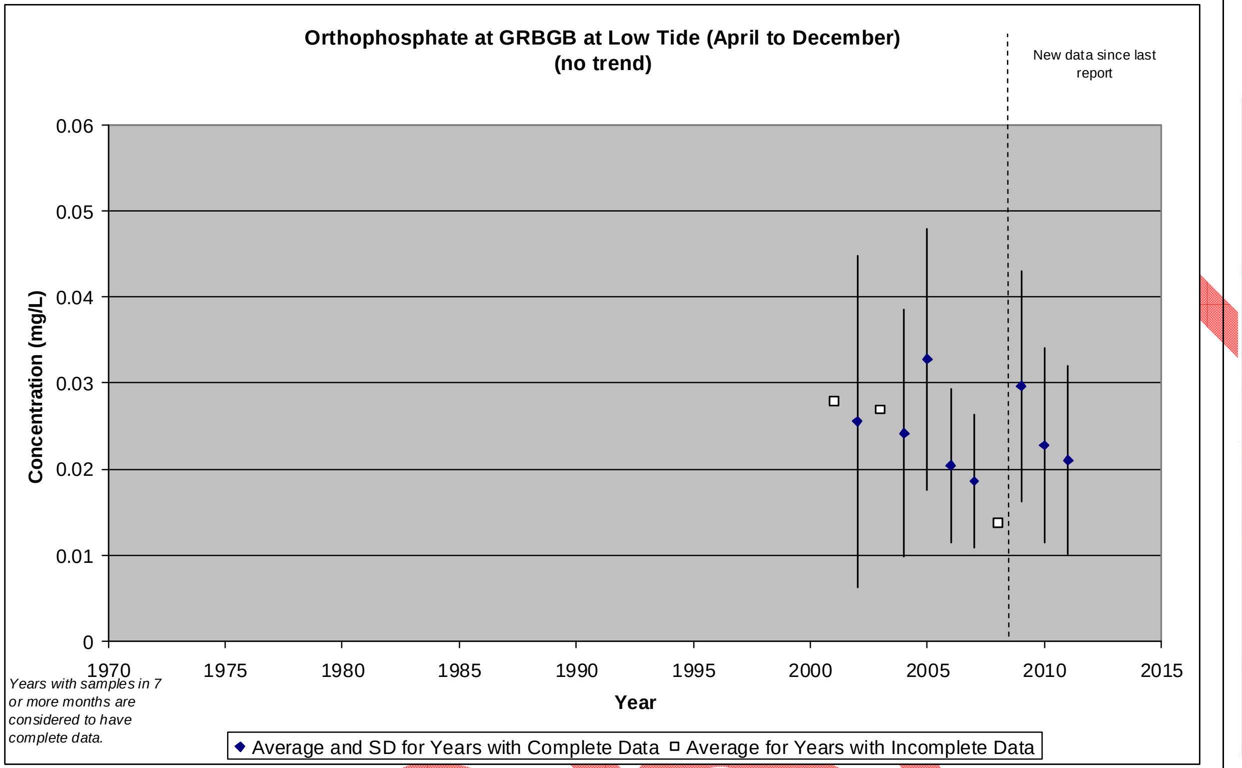
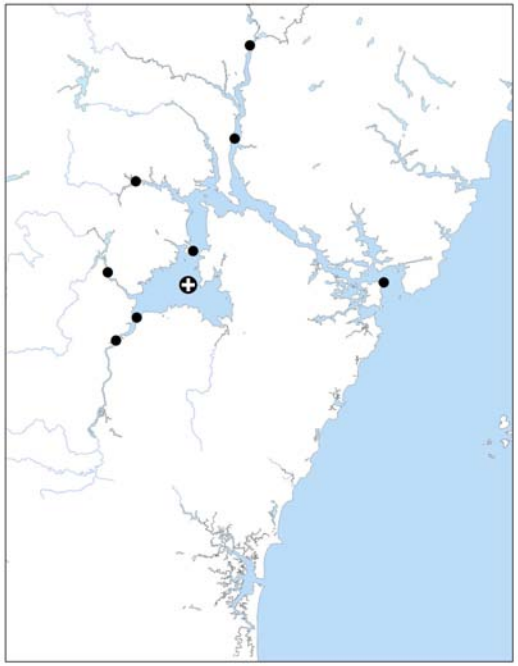


Monitoring Location (GRBGB)
(black circle with white plus sign)



Station: GRBGB (Great Bay)

Average Concentration in 2009-2011: 0.025 mg/L

Long Term Trend: No significant trend

Recent Change: None

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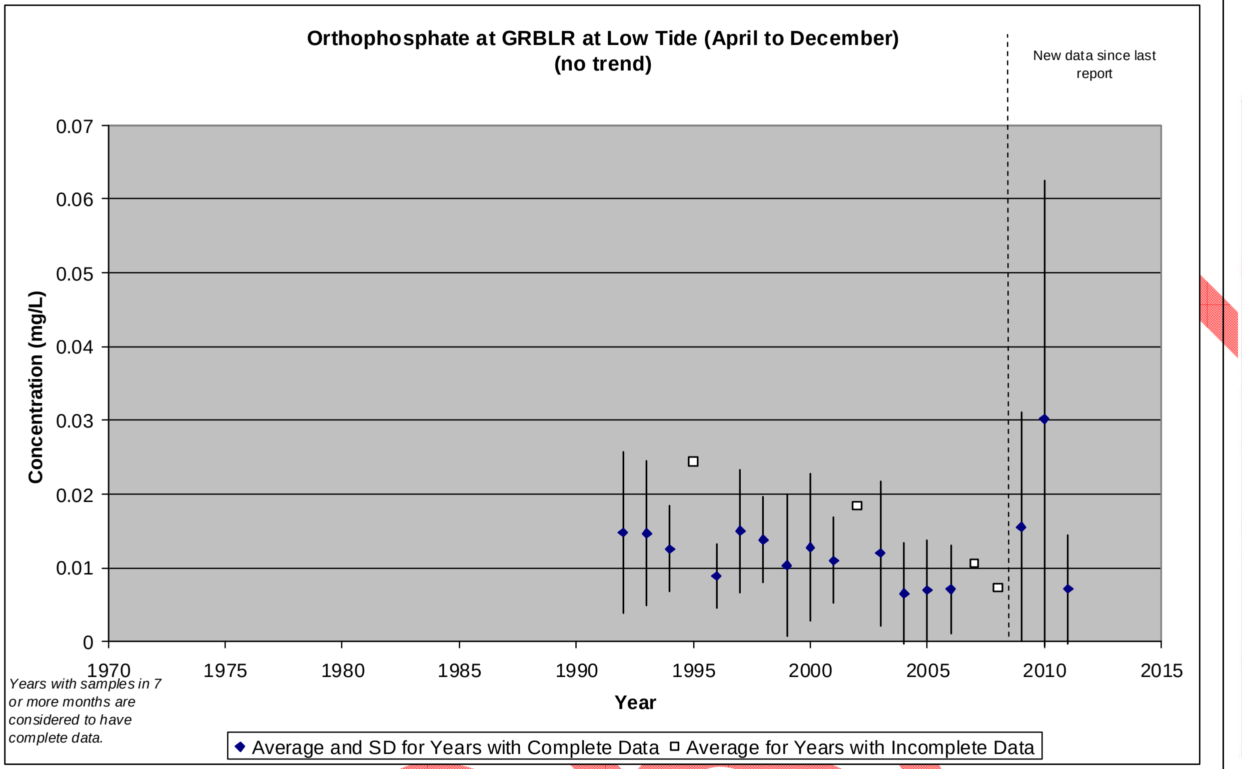
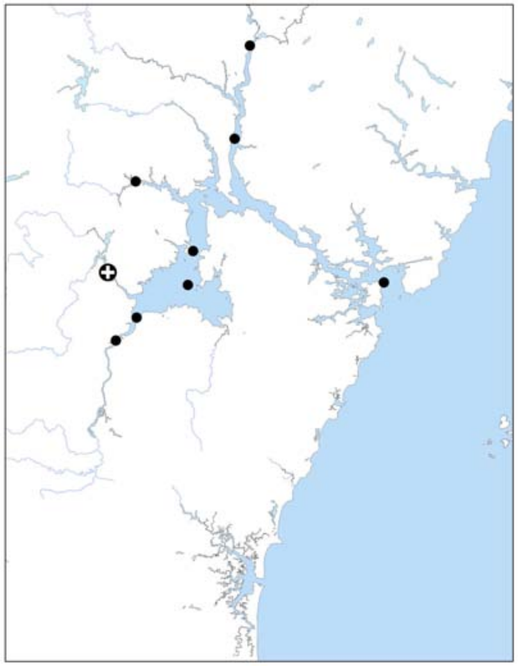


Monitoring Location (GRBLR)
(black circle with white plus sign)



Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 0.017 mg/L

Long Term Trend: No significant trend

Recent Change: Higher

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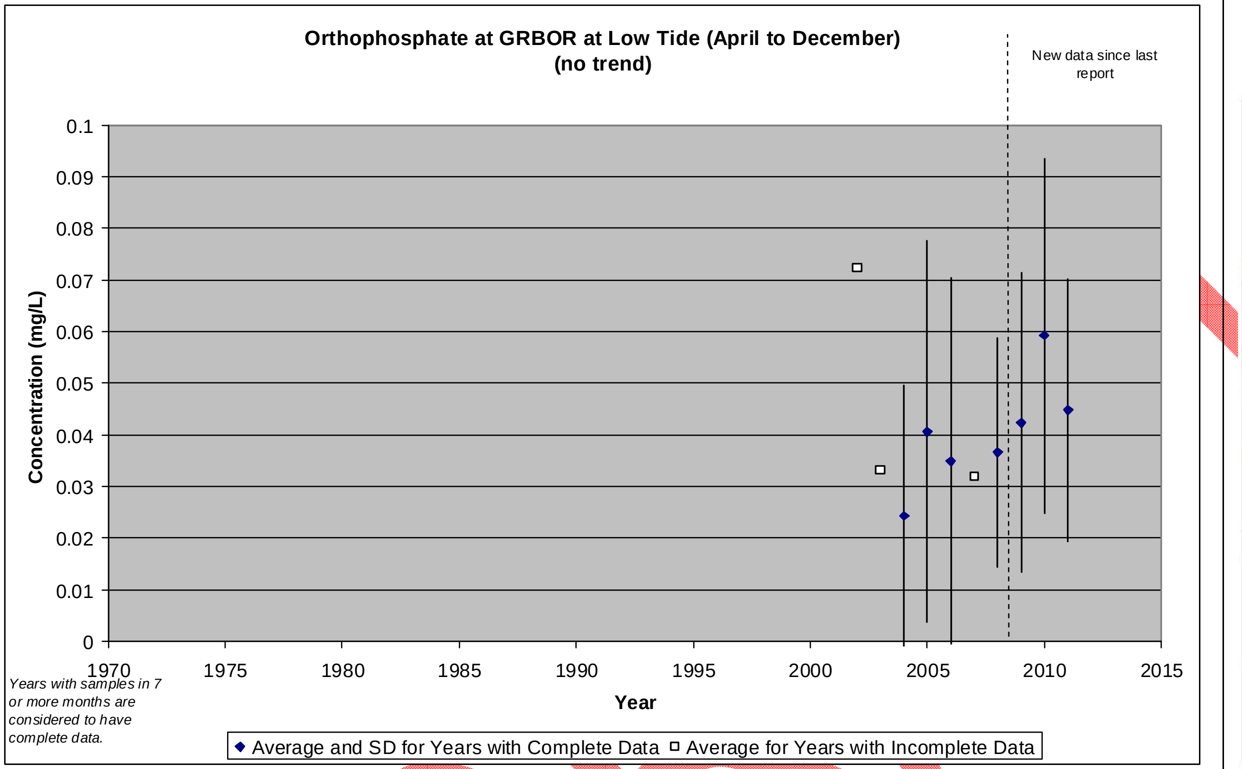
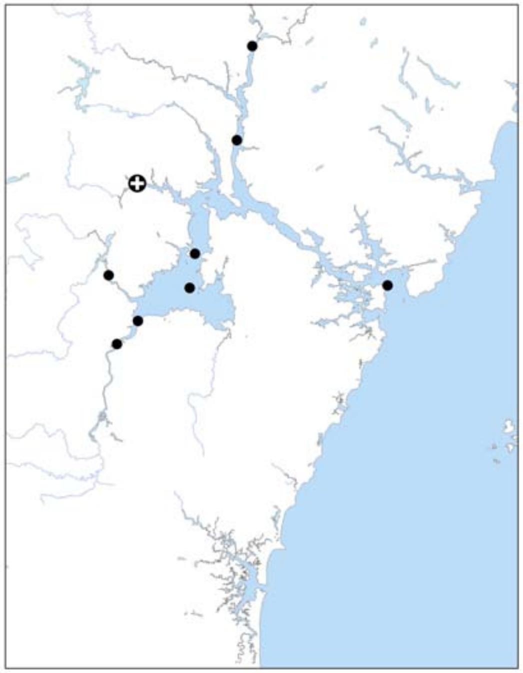


Orthophosphate at GRBOR at Low Tide (April to December)
(no trend)

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



Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 0.049 mg/L

Long Term Trend: No significant trend

Recent Change: None

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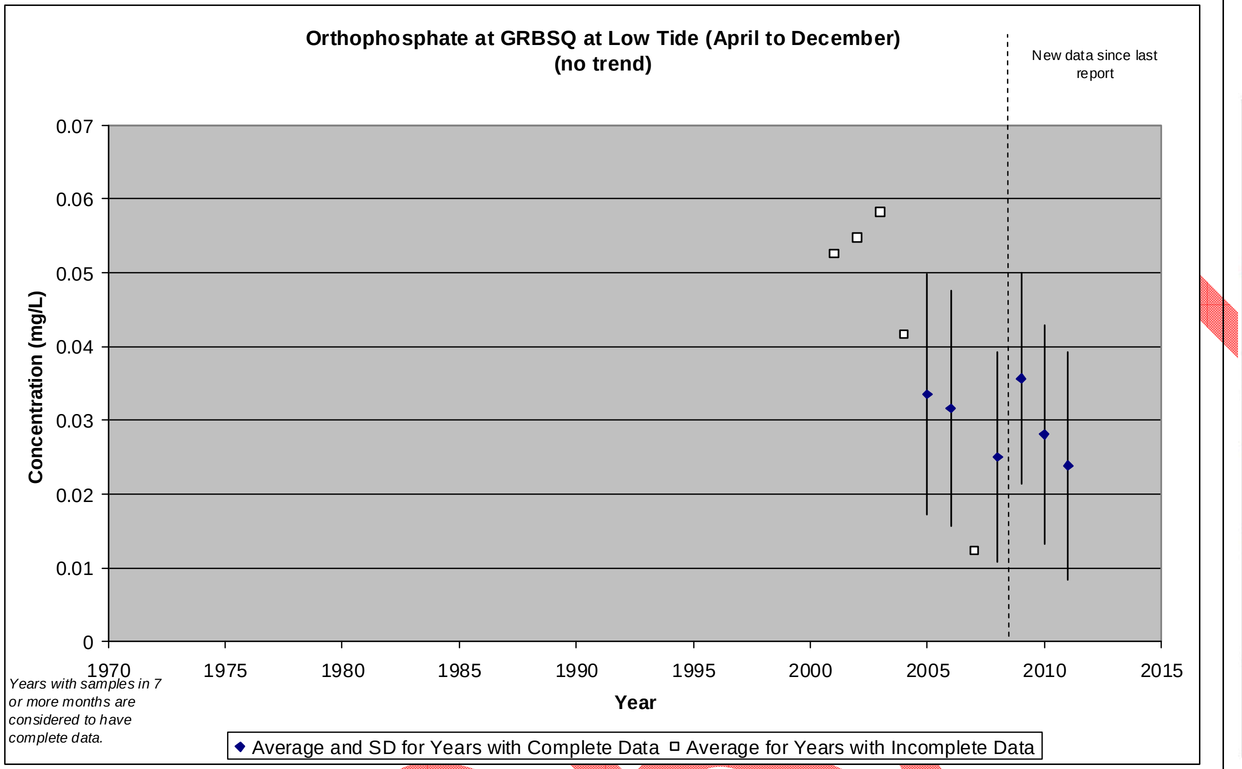
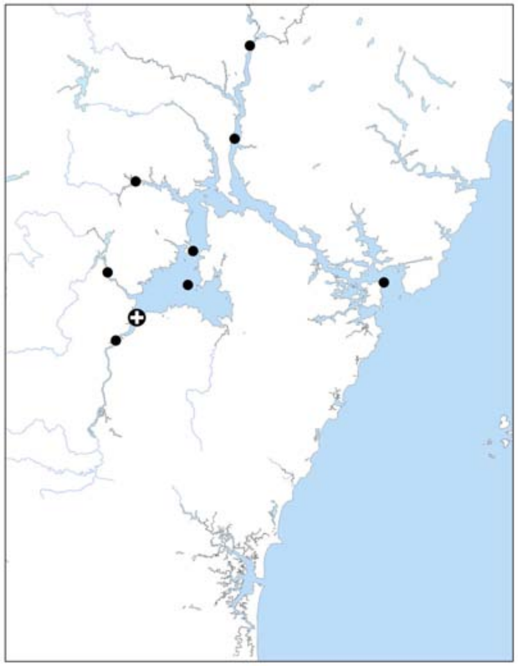
EXHIBIT 36 (AR K.22)



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

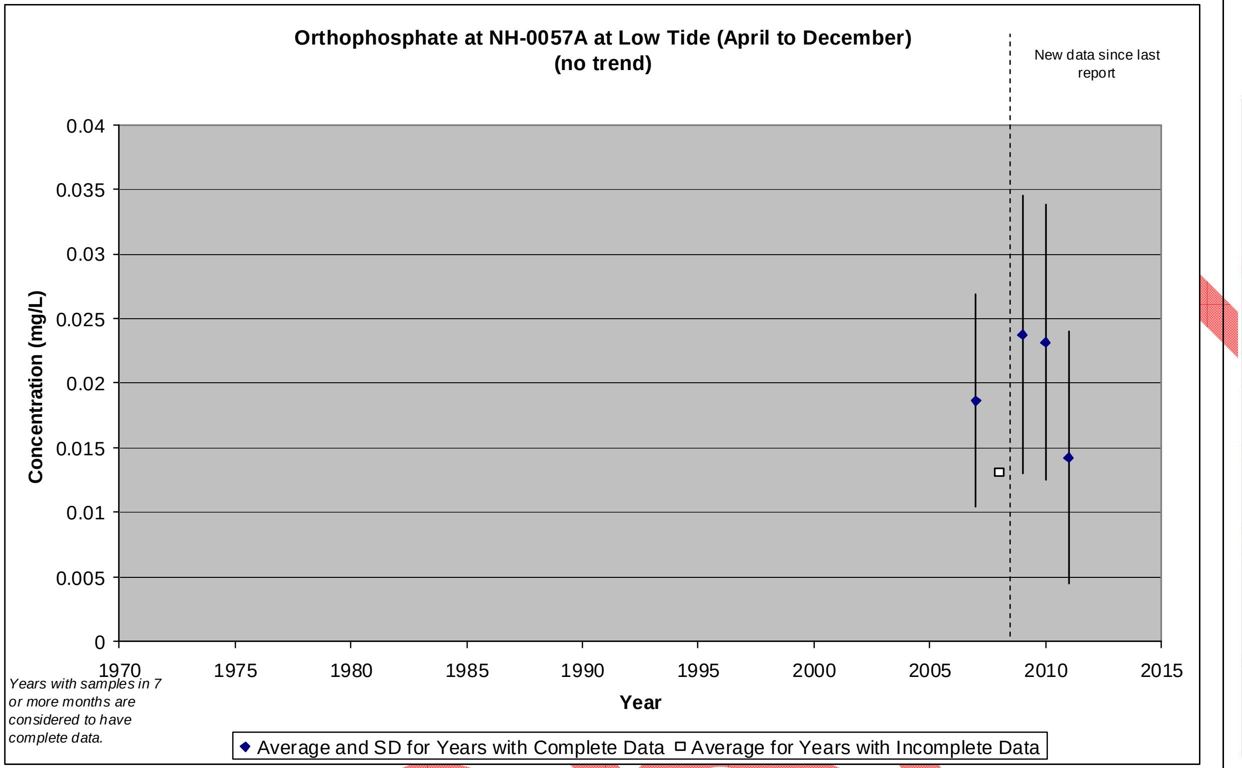


Station: GRBSQ (Squamscott River at the railroad trestle)

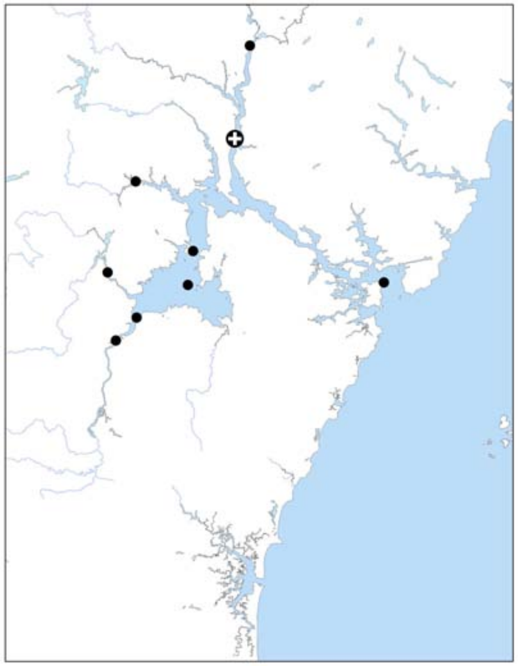
Average Concentration in 2009-2011: 0.029 mg/L

Long Term Trend: No significant trend

Recent Change: None



Monitoring Location (NH-0057A)
(black circle with white plus sign)



Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 0.020 mg/L

Long Term Trend: No significant trend

Recent Change: None

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Indicator: NUT3b. Algae populations in the estuary

Objectives

The objective of this indicator is to quantify long-term trends in phytoplankton populations and macroalgae populations in estuarine waters. Increasing nitrogen inputs to nitrogen-limited environments, such as estuaries (Howarth and Marino, 2006) can stimulate primary productivity in the form of phytoplankton or rooted or free-floating macroalgae (Cloern, 2001; Bricker et al., 2007). Chlorophyll-a is a measure of phytoplankton, one of the sources of primary productivity in the estuary. Phytoplankton blooms can decrease water clarity and deplete dissolved oxygen in the water (Cloern, 2001; Bricker et al., 2007, CERN, 2010). Macroalgae species such as the ulvoid green algae (*Ulva* spp.) and red algae (*Gracilaria* spp.) can entangle, smother and cause the death of eelgrass within the low intertidal/shallow subtidal zones (pers. com. A. C. Mathieson; Valiela et al., 1997; Hauxwell et al., 2001; McGlathery, 2001). Macroalgae have lower light requirements for survival than eelgrass and thrive in high nitrogen environments (Fox et al., 2008).

PREP Goal

Obj WR 1.3: Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. Consistent with previous PREP reports, the goal will be interpreted to be no increasing trends for algae.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

Trend analysis for chlorophyll-a was performed at the following stations (Figure NUT3b-1):

- 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)
- NH-0057A (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. Results reported as “below detection level” were included in the analysis with a value equal to one-half the laboratory method detection limit (or one-half the lowest detected concentration for the historic datasets) because there were few censored values (<5% for most parameters). Field duplicate samples collected for quality-assurance were not included in the trend analysis. 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. At station GRBAP, which is monitored year round, years with data in 10 or more months were considered to have complete data because samples were collected in all four seasons. At the other stations, which are monitored from April to December, years with data in seven or more months between April and December were considered to have complete data. It was important to identify years with complete data to avoid introducing 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 monthly chlorophyll-a measurements from years with complete data were regressed against the year variable. Data from years with incomplete data were not included in the regression calculation. Trends were considered significant if the coefficient of the year variable was significant at the $p<0.05$ level. The overall change over the period of record was determined by calculating the value of the regression line for the first and last years with complete data. The difference between the two values divided by the first value was used to represent the average percent change over the period of record.

Analysis of variance was used to test for short-term changes between the most recent three-year period and the preceding three-year period. The monthly measurements from years with complete data in the two three-year periods were tested for differences in the mean using ANOVA. Data from years with incomplete data were not included in the calculation. Differences between the means at the $p<0.05$ level were considered significant.

For each station, the annual average for chlorophyll-a was plotted versus year. For years with complete data, the standard deviation of the data in the year was shown as an error bar.

Macroalgae populations have not been monitored as frequently as phytoplankton populations. Changes in the macroalgae populations were described qualitatively based on the available field studies in the Great Bay Estuary

Data Sources
Data for this indicator were provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Programs. Historic datasets from 1974 to 1981 (Norall et al, 1982; Loder et al, 1983) were also included in the trend analysis for station GRBAP. Field studies with information about macroalgae in the Great Bay Estuary are Chock and Mathieson (1983), Hardwick-Witman and Mathieson (1983), Pe'eri et al. (2008), and Nettleton et al. (2011).

Data Gaps
Trend monitoring stations for phytoplankton are missing in the Winnicut, Bellamy, Cocheco, Salmon Falls and Piscataqua Rivers and in Hampton-Seabrook Harbor. There is no consistent monitoring program for macroalgae in the estuary.

<u>Results</u>
The results of the trend analysis for chlorophyll-a are summarized in Table NUT3b-1. Plots of chlorophyll-a at each station are shown on Figure NUT3b-2.

For chlorophyll-a, there were no statistically significant, long-term trends at any station, nor were there any short term changes in the last three years. Phytoplankton blooms are episodic and variable in size depending on a variety of factors. As a result, it can be difficult to detect trends in chlorophyll-a based on a monthly monitoring program.

For macroalgae, there is evidence that populations have increased. Baseline measurements of some macroalgae species at some locations were made by Chock and Mathieson (1983) and Hardwick-Witman and Mathieson (1983) between 1972 and 1980. In 2008-2010, Nettleton et al. (2011) repeated these field studies using the same methods to document changes in populations. The report concluded that "Great increases in both mean and peak Ulva and Gracilaria biomass and percent cover have occurred in the Great Bay Estuarine System" (Nettleton et al., 2011, p. 82). For example, at sites in the Great Bay, the mean percent cover of *Ulva lactuca* had increased from 0.8% in 1979-1980 to 21-39% in 2008-2010 with maximum values up to 90% at some sites on some dates (Figure NUT3b-3). In 2007, a field study by Pe'eri et al (2008) documented that there were 137 acres of macroalgae mats in the Great Bay in August 2007, which amounted to over 3% of the entire bay surface (Figure NUT3b-4).

For the State of the Gulf of Maine Report (GOMC, 2012), the authors evaluated chlorophyll-a and macroalgae data from estuaries around the gulf, including the Piscataqua Region estuaries. The report concluded that for chlorophyll-a: "Fair-to-poor conditions are found predominantly in the Great Bay estuary and tributaries in New Hampshire; some of the more elevated nutrient and chlorophyll conditions are found in the tributary areas." For macroalgae, the report stated "that one third of the systems exhibit moderate-to-high level problems from macroalgae and the spatial extent of macroalgae has increased in Great Bay, New Hampshire, Hampton Harbor, New Hampshire and Cape Cod Bay, Massachusetts since the early 1990s."

In summary, phytoplankton, as measured by chlorophyll-a concentrations, have not changed in the Great Bay between 1975-2011. In contrast, macroalgae populations in the estuary have increased, dramatically in some areas, during approximately the same period.

Figure NUT3b-1: Trend stations for chlorophyll-a monitoring

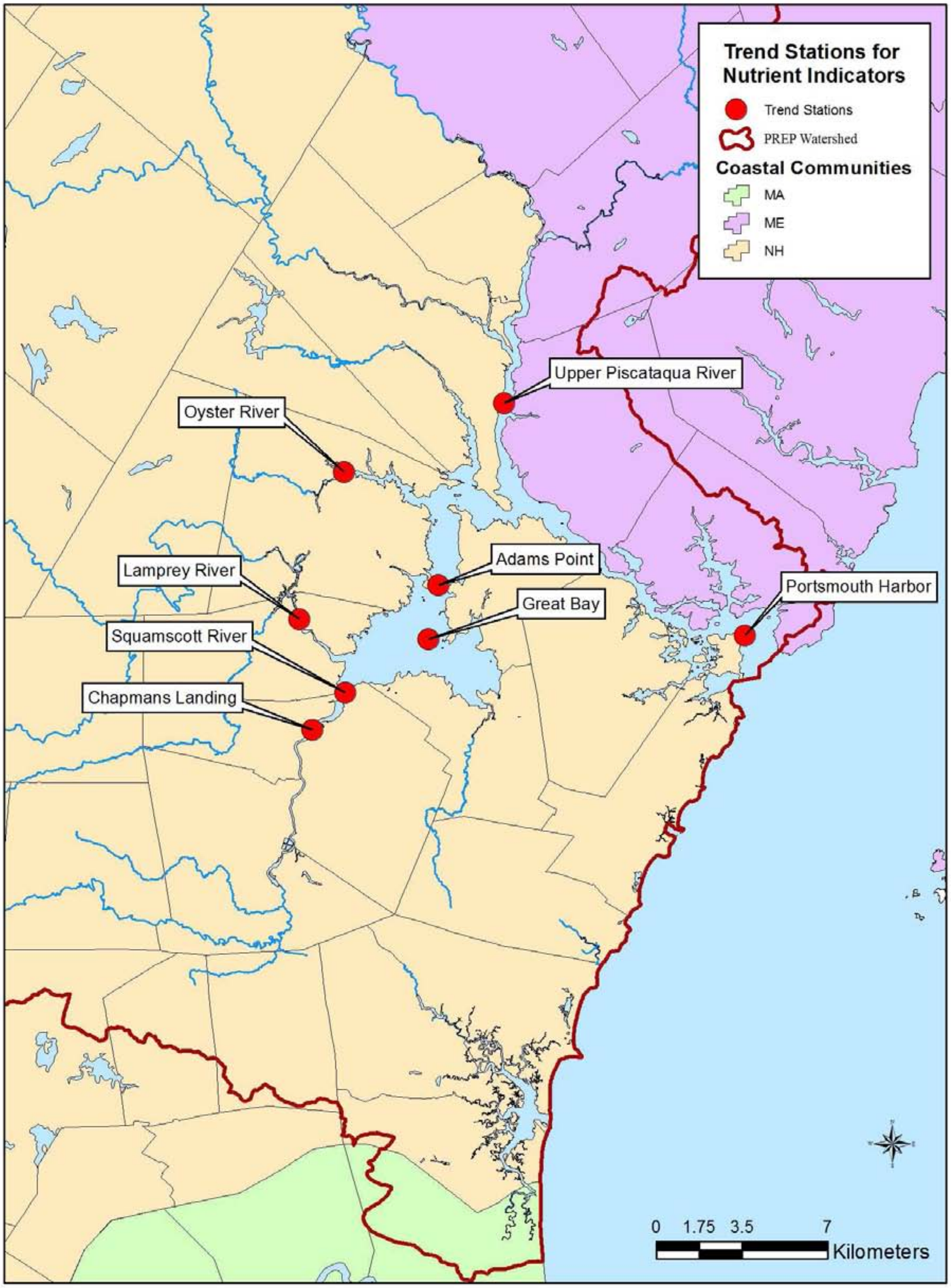

Table NUT3b-1: Trends for chlorophyll-a in the Great Bay Estuary

Station	Parameter	Period	Average Conc. in 2009-2011 (mg/L)	Long Term Trend	Recent Change
GRBAP	Chlorophyll-a	1975-2011	3.6	No significant trend	
(full year)					
GRBCL	Chlorophyll-a	1992-2011	5.4	No significant trend	
(Apr-Dec)					
GRBSQ	Chlorophyll-a	2002-2011	4.8	No significant trend	
(Apr-Dec)					
GRBLR	Chlorophyll-a	1992-2011	5.5	No significant trend	
(Apr-Dec)					
GRBGB	Chlorophyll-a	2002-2011	3.8	No significant trend	
(Apr-Dec)					
GRBOR	Chlorophyll-a	2002-2011	5.5	No significant trend	
(Apr-Dec)					
NH-0057A	Chlorophyll-a	2007-2011	2.9	No significant trend	
(Apr-Dec)					
GRBCML	Chlorophyll-a	2002-2011	1.3	No significant trend	
(Apr-Dec)					

Station Locations
GRBAP (Adams Point between Great Bay and Little Bay)
GRBCL (Chapmans Landing in the Squamscott River)
GRBSQ (Squamscott River at the railroad trestle)
GRBLR (Lamprey River)
GRBGB (Great Bay)
GRBOR (Oyster River)
NH-0057A (Upper Piscataqua River)
GRBCML (Portsmouth Harbor)

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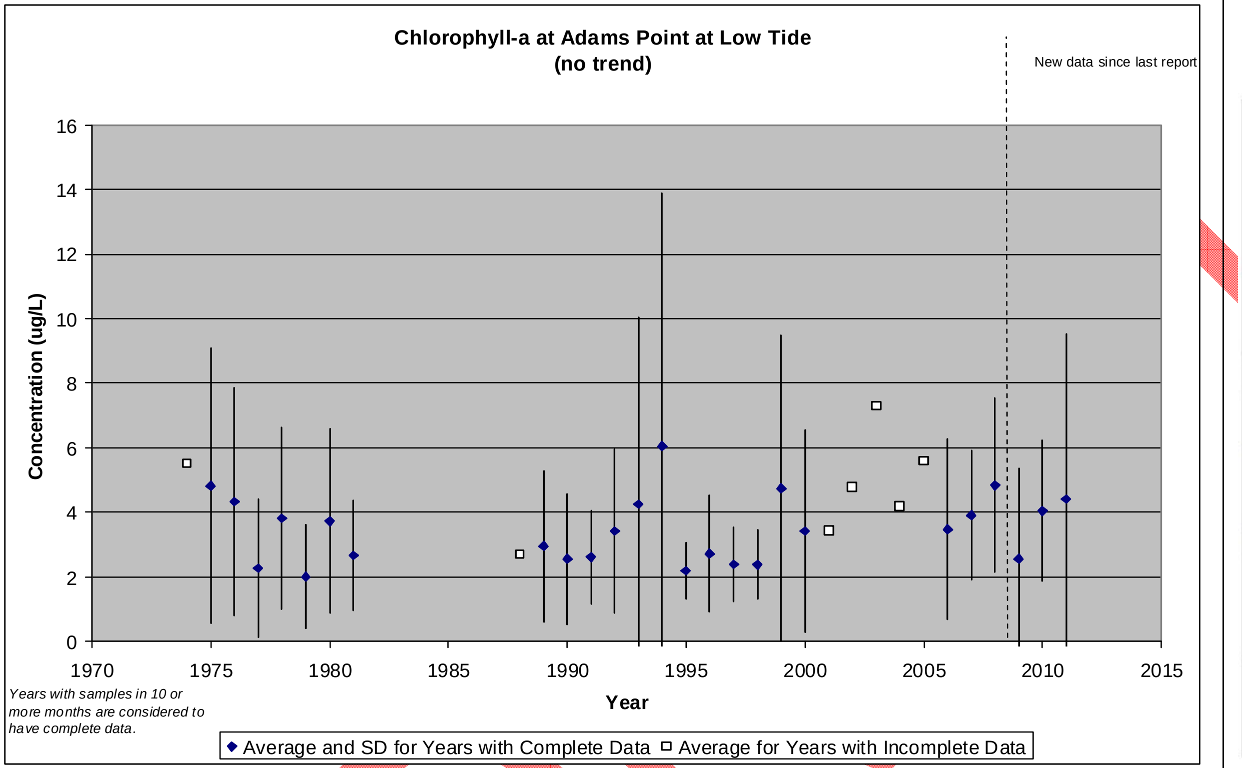
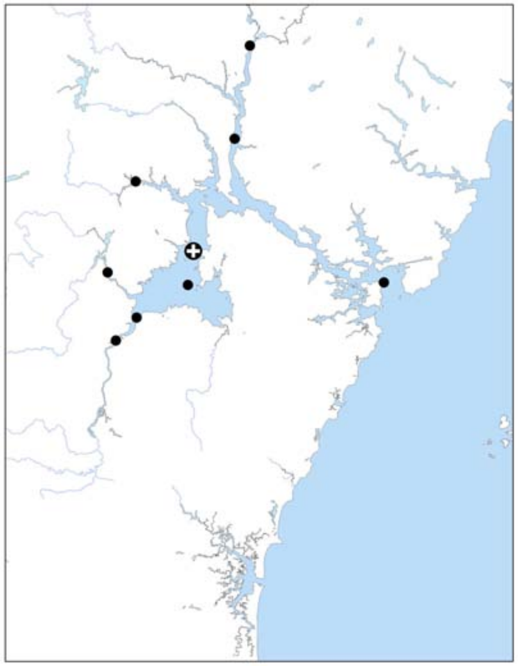
Figure NUT3b-2: Chlorophyll-a trends at stations in the Great Bay Estuary



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



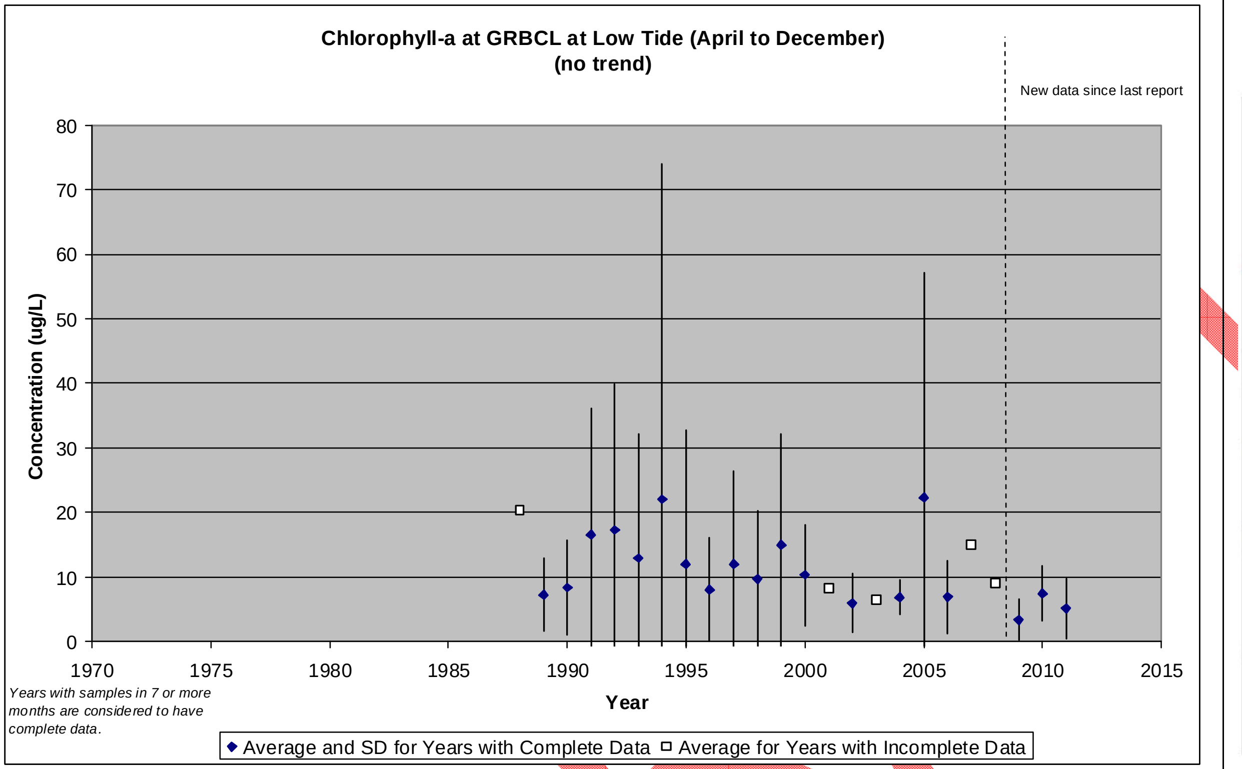
Station: GRBAP (Adams Point between Great Bay and Little Bay)

Average Concentration in 2009-2011: 3.6 ug/L

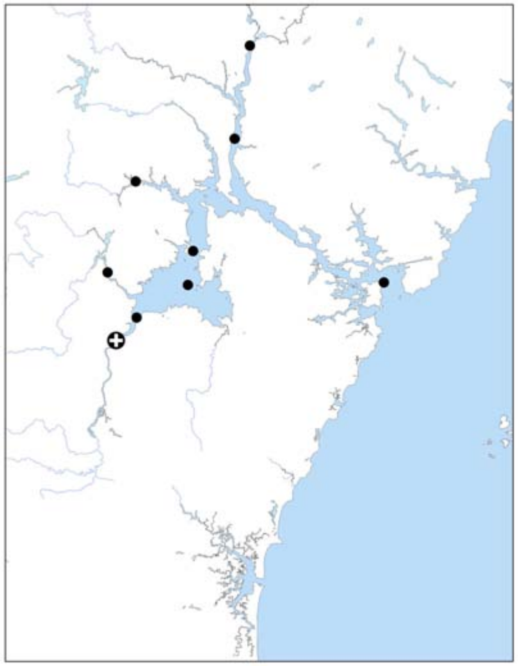
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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



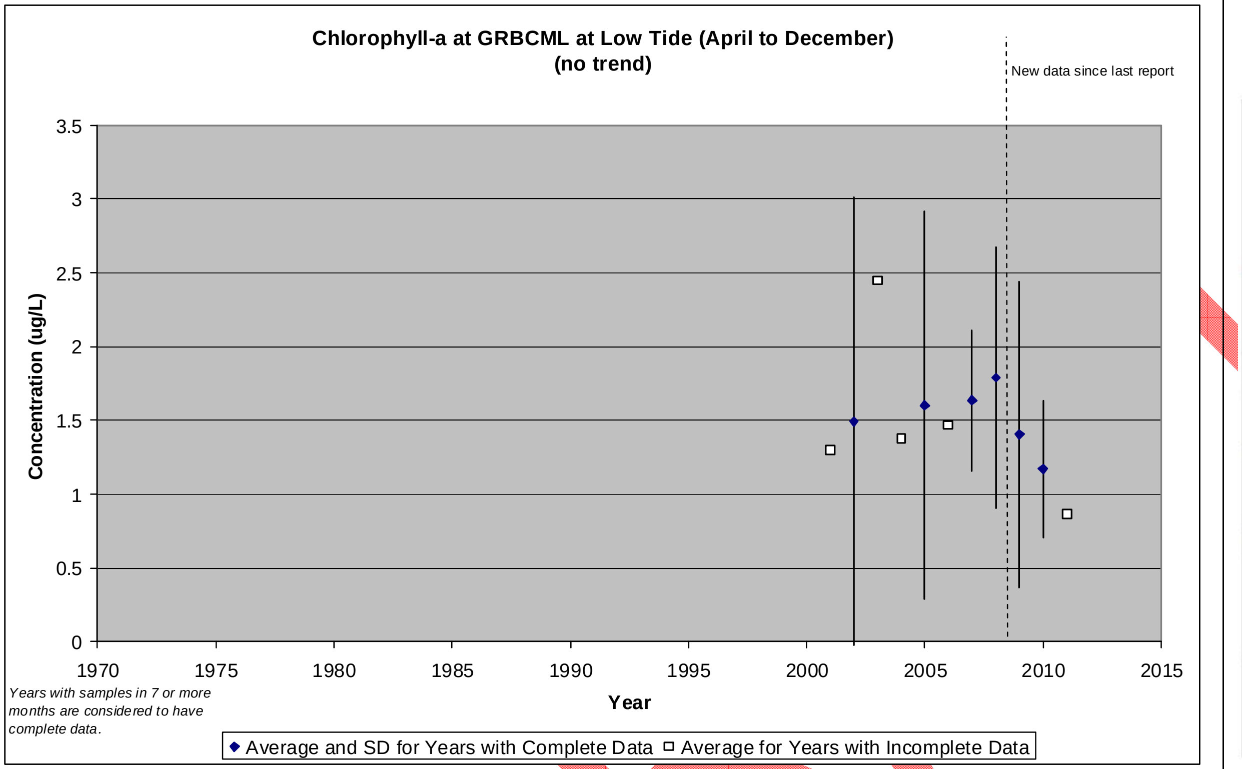
Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 5.4 ug/L

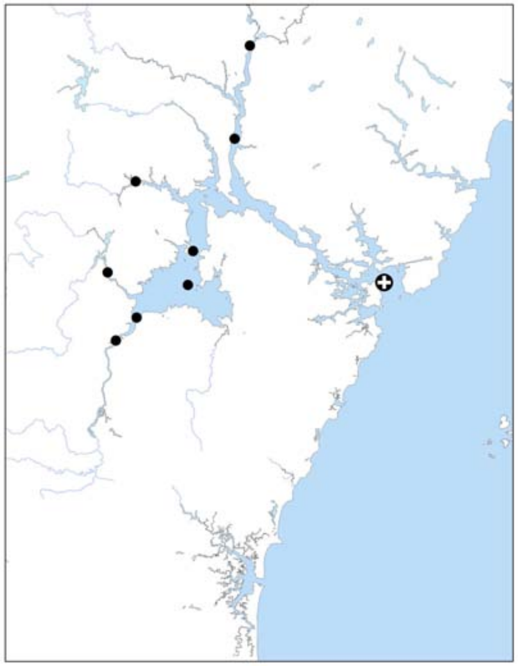
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



Monitoring Location (GRBCML)
(black circle with white plus sign)



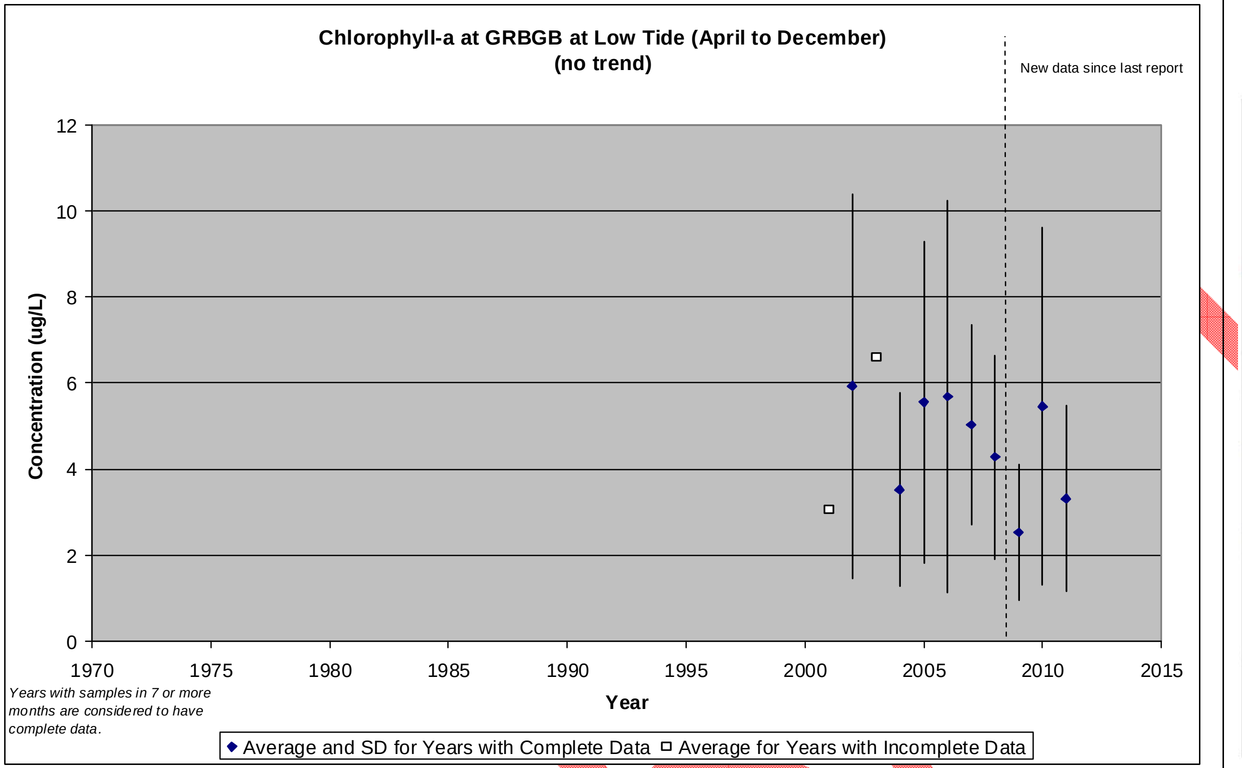
Station: GRBCML (Portsmouth Harbor)

Average Concentration in 2009-2011: 1.3 ug/L

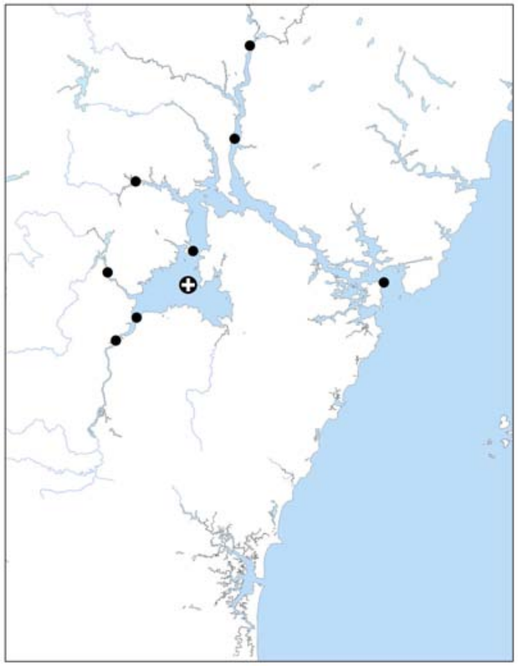
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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

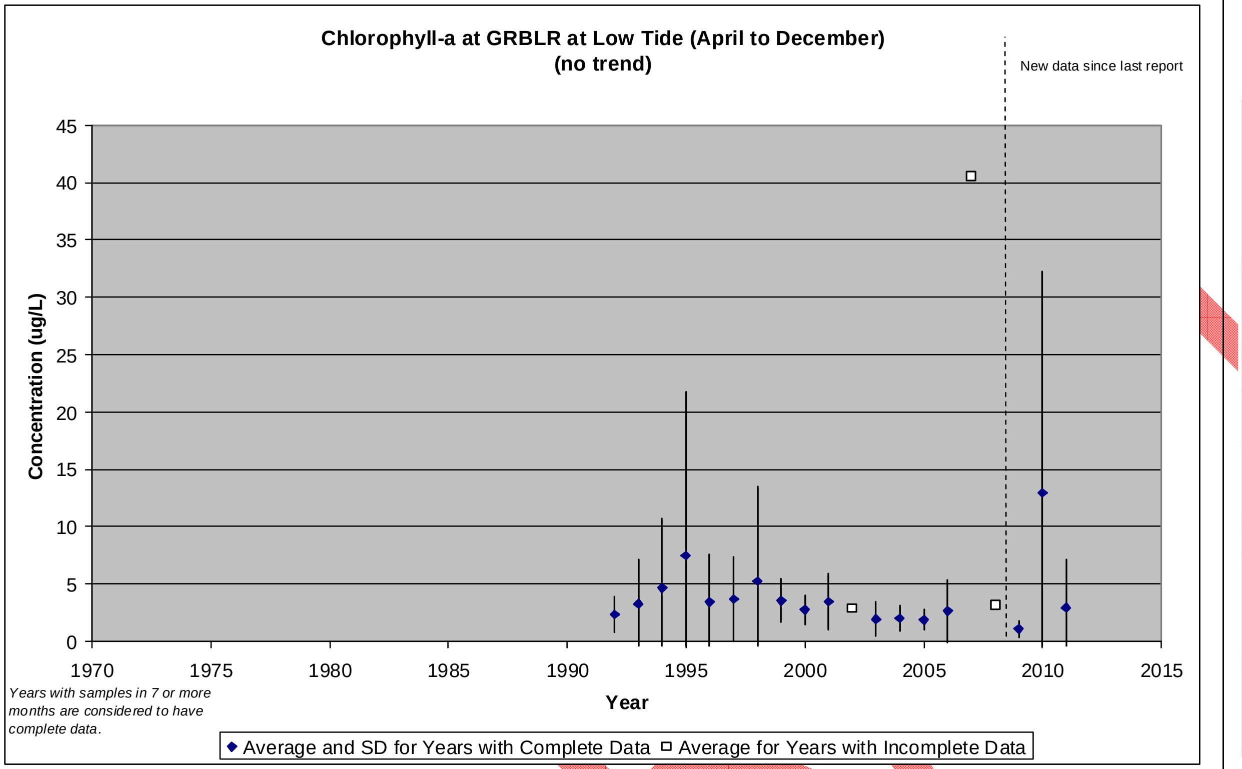


Station: GRBGB (Great Bay)

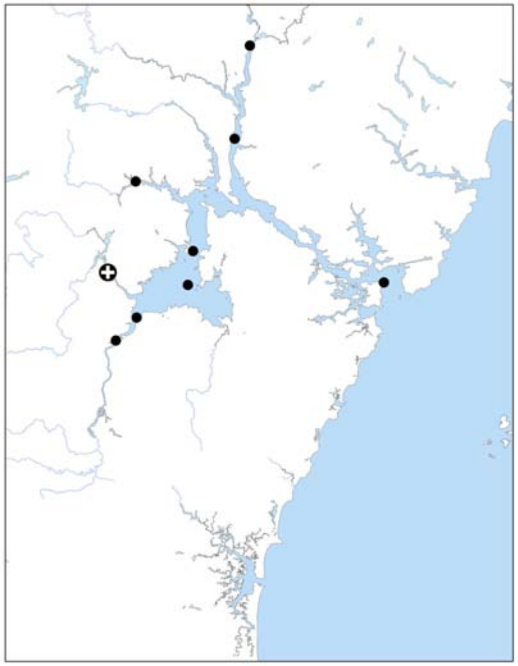
Average Concentration in 2009-2011: 3.8 ug/L

Long Term Trend: No significant trend

Recent Change: None



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



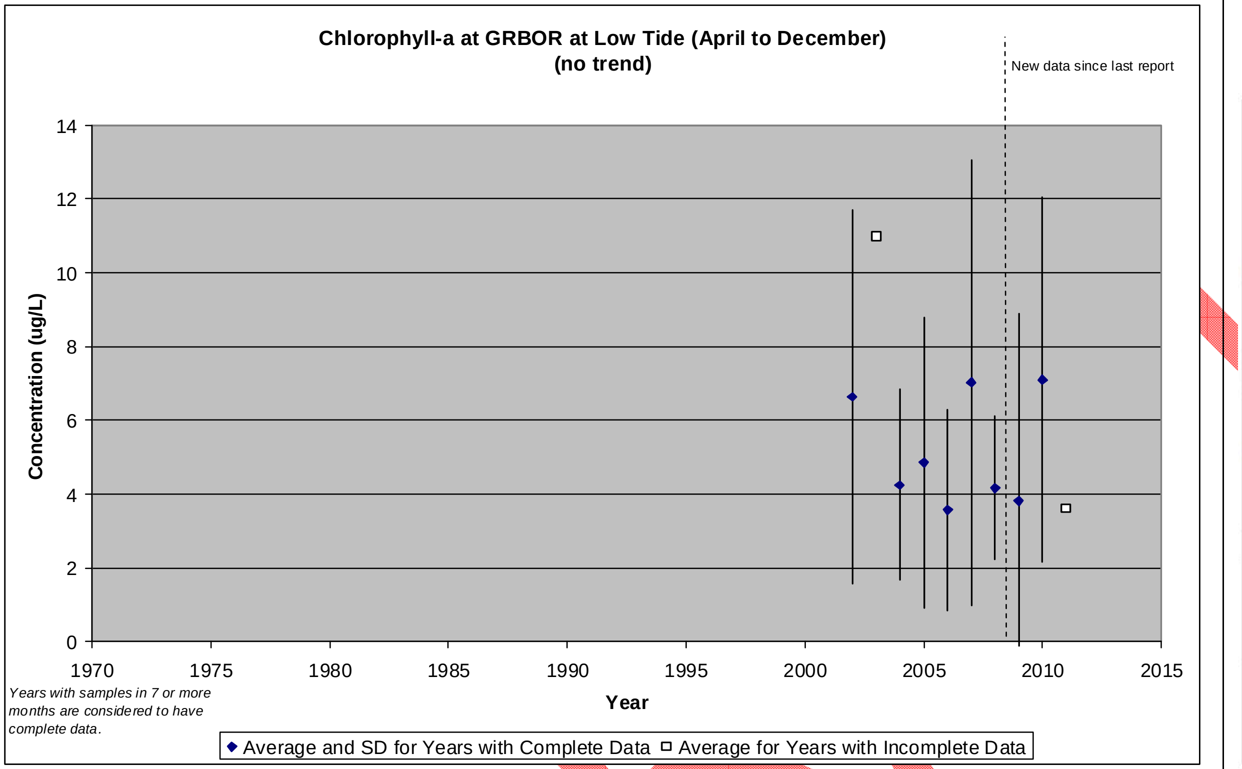
Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 5.5 ug/L

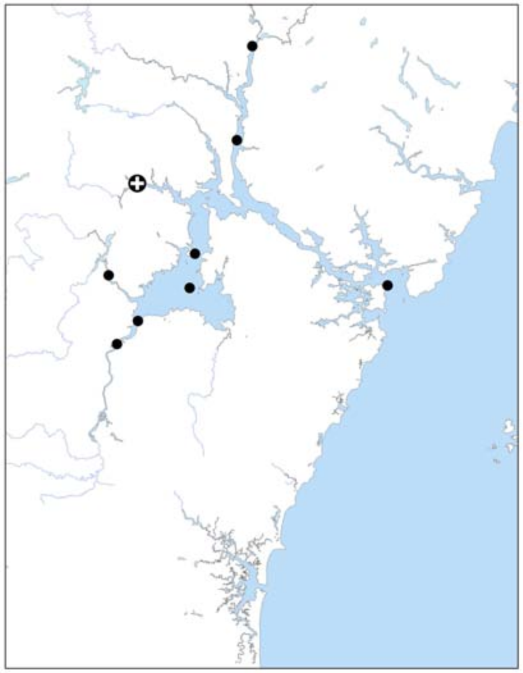
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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



Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 5.5 ug/L

Long Term Trend: No significant trend

Recent Change: None

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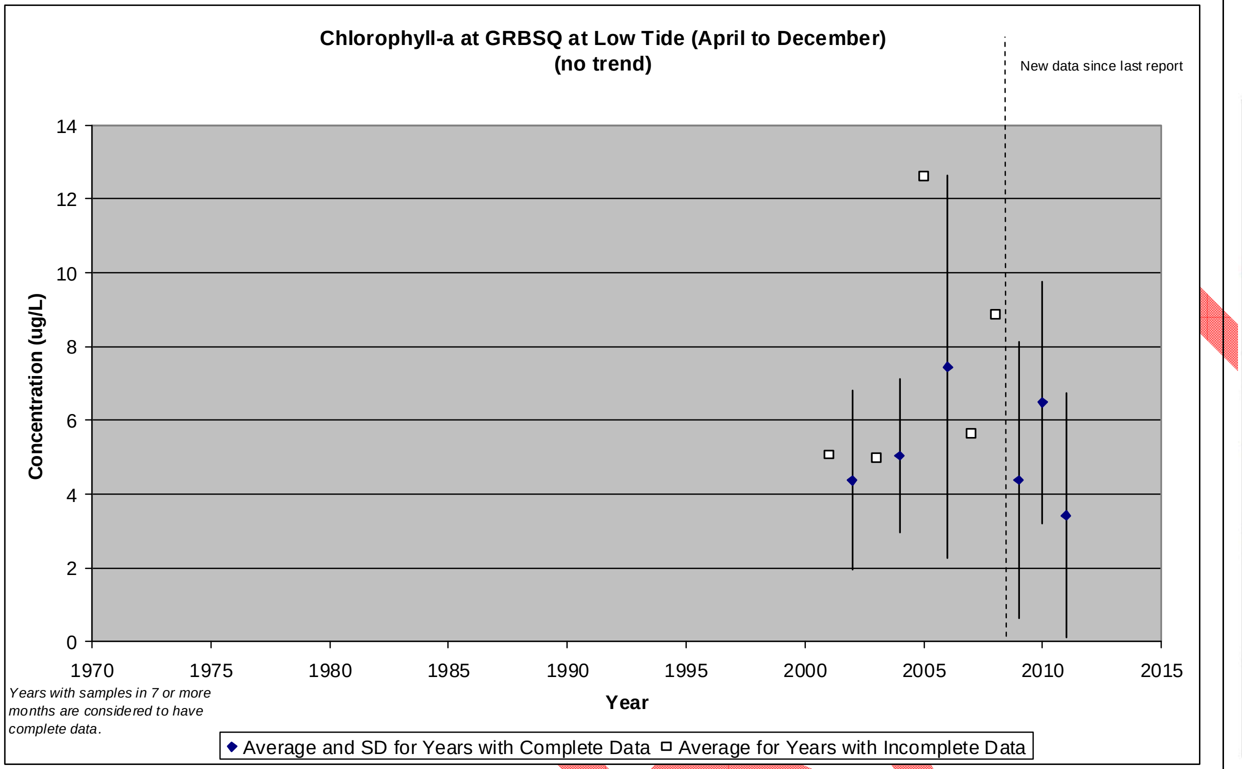
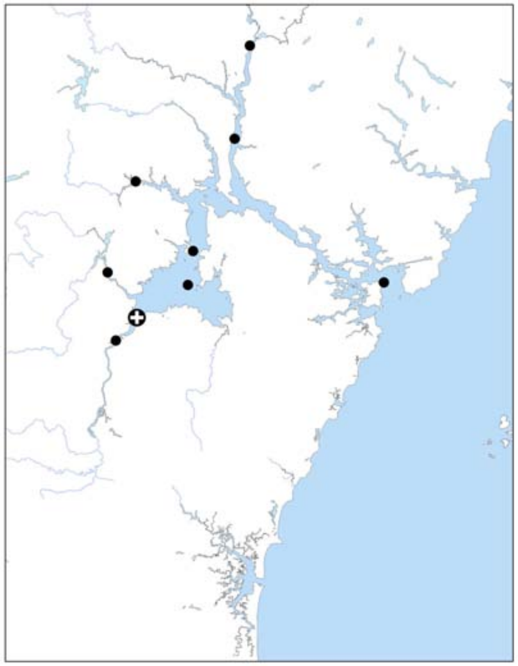
EXHIBIT 36 (AR K.22)



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

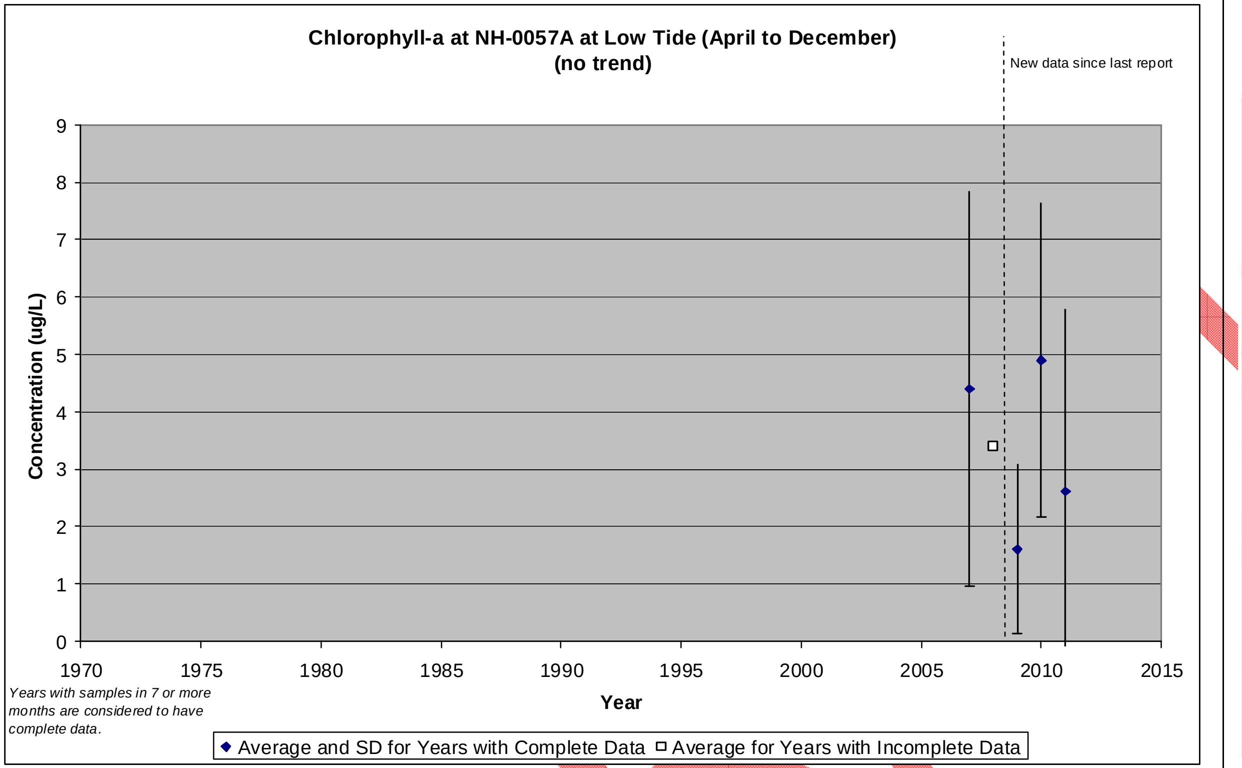


Station: GRBSQ (Squamscott River at the railroad trestle)

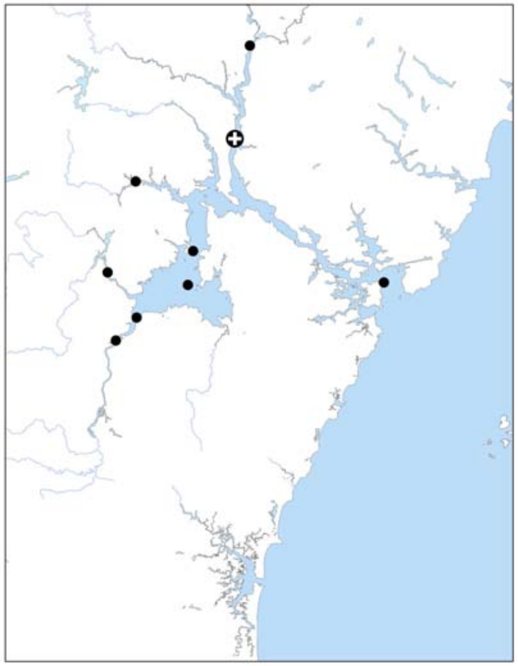
Average Concentration in 2009-2011: 4.8 ug/L

Long Term Trend: No significant trend

Recent Change: None



**Monitoring Location (NH-0057A)
(black circle with white plus sign)**



Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 2.9 ug/L

Long Term Trend: No significant trend

Recent Change: None

Figure NUT3b-3: Macroalgae percent cover in Great Bay in 1979-1980 and 2008-2010

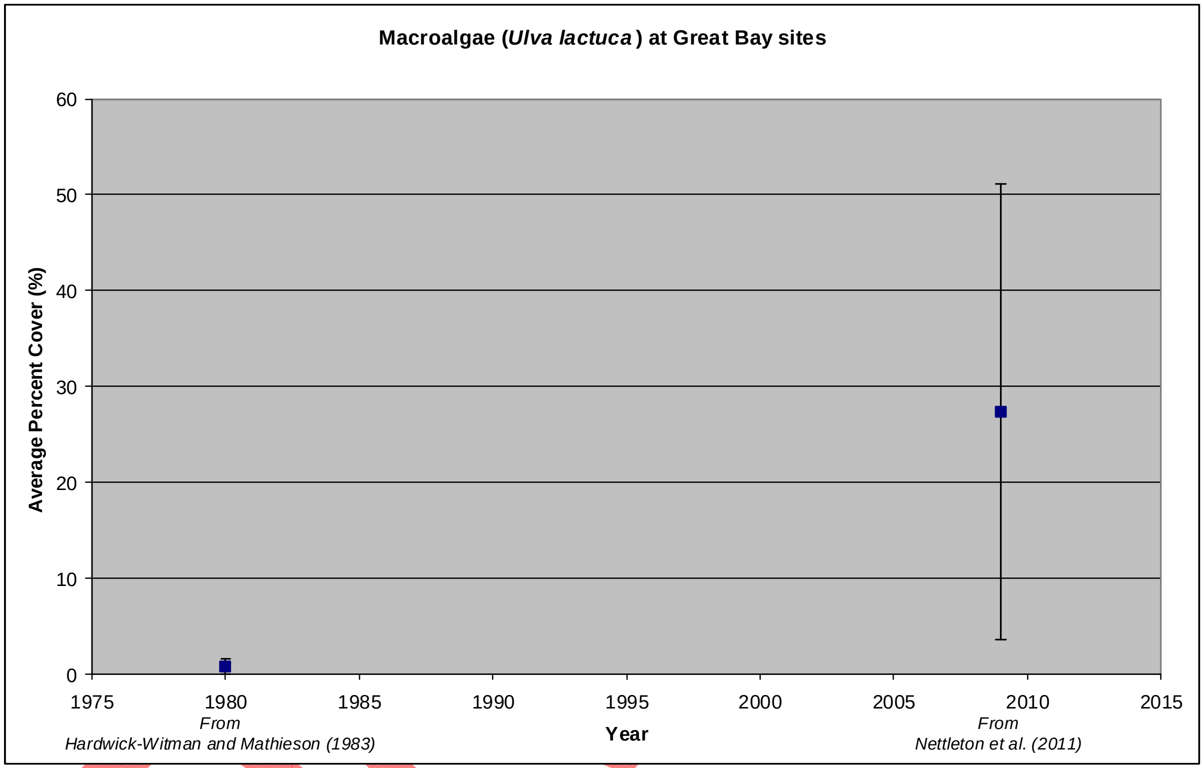


Figure NUT3b-4: Eelgrass and macroalgae in Great Bay in 2007

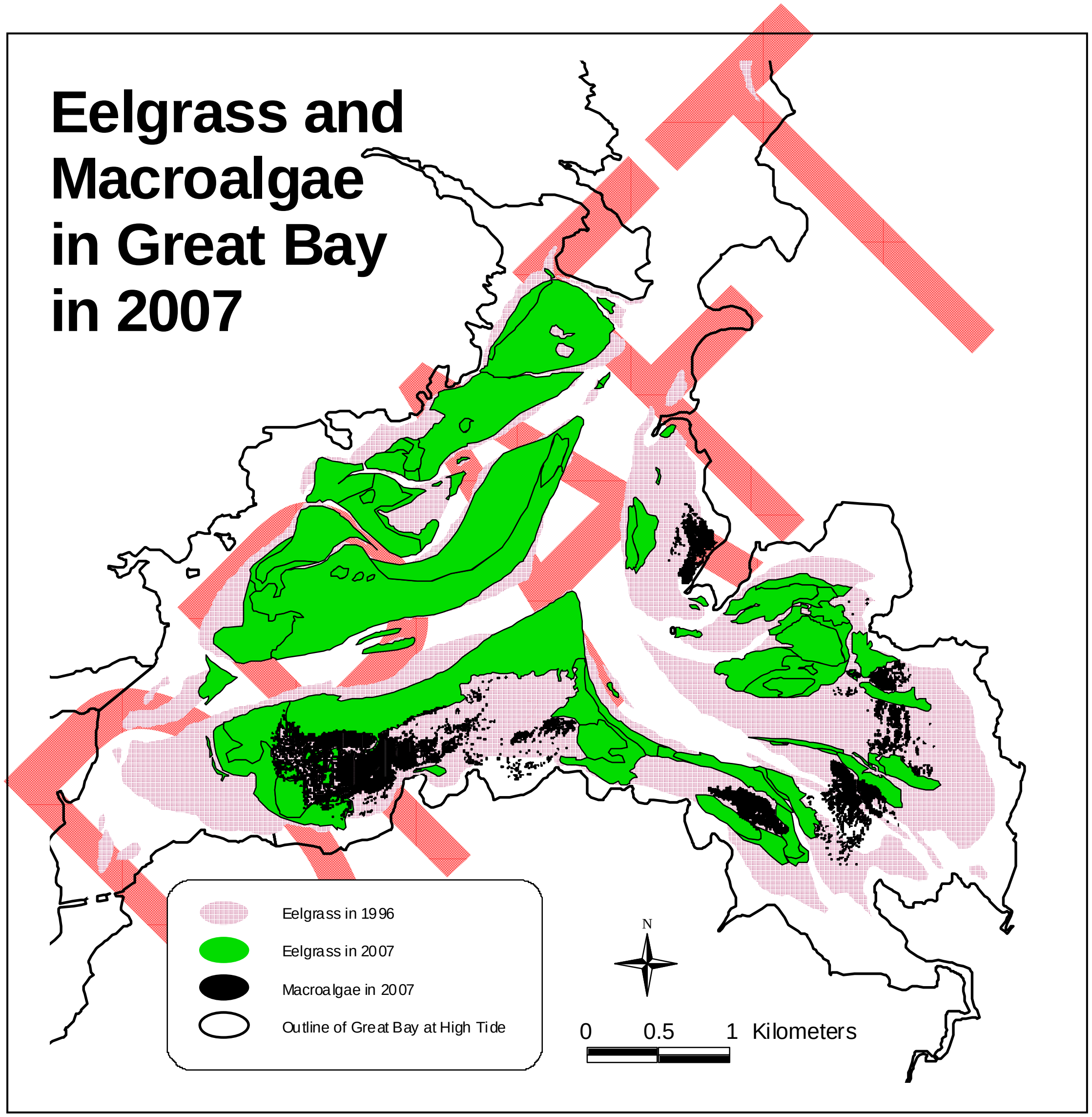


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EXHIBIT 36 (AR K.22)

Indicator: NUT5. Exceedences of the dissolved oxygen standard in the estuary

Objectives

The objective of this indicator is to estimate the number of exceedences of the state water quality standards for dissolved oxygen in the estuary each year. Low dissolved oxygen is a well established indicator of eutrophication in estuaries (NRC, 2000; Cloern, 2001; Bricker et al., 2007; EPA, 2001; Diaz and Rosenberg, 2008). Respiration of the organic matter created by the primary productivity consumes oxygen from the water column and sediments. The resulting low oxygen conditions affect fish and benthic communities (Diaz and Rosenberg, 2008; Cloern, 2001; Bricker et al. 2007). Effects on species include death, compressed habitats, and shifts in species composition to opportunistic benthic species with short life spans and smaller body sizes (Diaz and Rosenberg, 2008; NRC, 2000).

PREP Goal

Obj WR 1.3: Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. Consistent with previous PREP reports, the goal will be interpreted to be zero days with exceedences of the state water quality standard for dissolved oxygen.

Methods and Data Sources

Data Analysis and Statistical Methods

The New Hampshire water quality standard for dissolved oxygen (Env-Wq 1703.07) 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 and daily average standards. The goal is to have zero days with exceedences of the dissolved oxygen standards.

The Maine water standards for classification of estuarine and marine waters for dissolved oxygen (38 MRSA Section 465-B) have three components: (1) dissolved oxygen content of Class SA waters shall be as naturally occurs, (2) the dissolved oxygen content of Class SB waters must be not less than 85% of saturation, and (3) the dissolved oxygen content of Class SC waters must be not less than 70% of saturation.

The New Hampshire standards were used for this indicator for consistency with previous calculations and because any violations of the New Hampshire standard for dissolved oxygen saturation would also indicate a violation of the Maine standard.

In a system as well mixed as the Great Bay Estuary, low DO events may occur rapidly. Therefore, DO measurements taken at a high frequency by in-situ datasondes deployed at depth (1-2 meters above the sediments) in the tidal tributaries (where low DO is the most likely) were used for this indicator.

The daily minimum dissolved oxygen concentration was calculated for each datasonde in the Great Bay Estuary (Figure NUT5-1) for each date. If the minimum value was less than 5 mg/L, then that date was counted as a having a exceedence of the instantaneous dissolved oxygen standard.

The daily average dissolved oxygen saturation concentration was calculated for each datasonde in the Great Bay Estuary (Figure NUT5-1) for each date with complete (i.e., 100% valid measurements for the day) dissolved oxygen data. If the average dissolved oxygen saturation concentration was less than 75%, then the day was counted as exceeding the standard.

For each sonde, the number of days per year with at least one exceedence of the standard was tabulated and compared to the goal of zero days. Inter-annual trends could not be assessed quantitatively because the number of days monitored varied between years.

Data Sources
The Great Bay National Estuarine Research Reserve Datasonde Program and the UNH Datasonde Program provided data for this indicator. The data used for this indicator were quality assured by staff from the Great Bay National Estuarine Research Reserve and NHDES. For data from 2004 and later, the dissolved oxygen measurements were validated by pre- and post-deployment checks with an independently calibrated dissolved oxygen sensor or post-deployment calibration checks in the laboratory. For earlier years, for which quality control data were not available, only measurements from the first 96 hours of the sonde deployment were used.

Results

The exceedences of the dissolved oxygen and dissolved oxygen saturation standard during the summer months at each station are summarized in Tables NUT5-1 and NUT5-2. Trends over years in the number of days with exceedences are shown in Figures NUT5-2 and NUT5-3. Finally, Figure NUT5-4 shows the daily minimum dissolved oxygen recorded at each datasonde between July 1, 2011 and September 30, 2011 relative to the state standard (5 mg/L).

The dissolved oxygen concentrations in Great Bay in the summer have never fallen below 5 mg/L. In Portsmouth Harbor there has been only one day with dissolved oxygen less than 5 mg/l (in 2010). The dissolved oxygen saturation in the Great Bay and Portsmouth Harbor has consistently met the 75% daily average saturation standard. Based on these data, the well mixed areas of Great Bay and Portsmouth Harbor essentially meet the goal of having zero days with violations of the dissolved oxygen standard.

There were persistent and numerous exceedences of the dissolved oxygen standards at stations in the tidal tributaries. The number of summer days with violations varied over time at the stations. Based on these data, the tidal tributaries do not meet the goal of having zero days with dissolved oxygen less than 5 mg/l or a daily average less than 75% saturation. No major fish kills due to low dissolved oxygen have been reported for the tidal rivers in recent years. However, fish and other organisms may still experience sub-lethal effects in areas where the state standard is not attained.

The most exceedences and the lowest dissolved oxygen concentrations were observed in the Lamprey River. Pennock (2005) conducted a detailed study of this river and concluded that the datasonde accurately represents the dissolved oxygen in the river but that density stratification was a significant factor related to the low dissolved oxygen concentrations that were observed.

Relatively few exceedences of the daily average saturation standard have been observed in the Squamscott River, despite the fact that the dissolved oxygen concentration often falls below 5 mg/L at this station. In 2011, the Great Bay Municipal Coalition hired HydroQual to conduct a study of dissolved oxygen in the Squamscott River (HydroQual, 2012). The study confirmed that dissolved oxygen concentrations in the river periodically exceeded the state standard and that algae discharged from the Exeter wastewater treatment facility was a factor affecting dissolved oxygen levels. The study concluded that relationships between nutrients and dissolved oxygen were complicated but mass balance calculations showed that there was substantial algal growth in the Upper Squamscott River due to nutrient discharges.

Jones (2005) measured dissolved oxygen at randomized locations in the Squamscott and Lamprey Rivers during the early morning on two dates in 2004 but did not detect any areas of low dissolved oxygen.

For the State of the Gulf of Maine Report (GOMC, 2012), the authors evaluated dissolved oxygen data from estuaries around the gulf, including the Piscataqua Region estuaries. The report concluded that there were no major problems with dissolved oxygen in the Piscataqua Region estuaries or other estuaries in the Gulf of Maine. However, this study only evaluated grab samples for dissolved oxygen, not datasonde measurements.

EXHIBIT 36 (AR K.22)

Table NUT5-1: Measurements of dissolved oxygen concentrations less than 5 mg/L at in-situ datasondes in the Great Bay Estuary

Station	Year	Number of Summer Days with Valid DO Data	Number of Summer Days with Minimum DO <5 mg/L
Portsmouth Harbor	2002	16	0
Portsmouth Harbor	2003	20	0
Portsmouth Harbor	2004	21	0
Portsmouth Harbor	2005	49	0
Portsmouth Harbor	2006	51	0
Portsmouth Harbor	2007	15	0
Portsmouth Harbor	2008	92	0
Portsmouth Harbor	2009	92	0
Portsmouth Harbor	2010	88	1
Portsmouth Harbor	2011	92	0
Great Bay	2000	9	0
Great Bay	2001	20	0
Great Bay	2002	29	0
Great Bay	2003	24	0
Great Bay	2004	20	0
Great Bay	2005	47	0
Great Bay	2006	59	0
Great Bay	2007	92	0
Great Bay	2008	92	0
Great Bay	2009	92	0
Great Bay	2010	80	0
Great Bay	2011	74	0
Lamprey River	2000	7	0
Lamprey River	2001	20	3
Lamprey River	2002	25	21
Lamprey River	2003	15	9
Lamprey River	2004	52	33
Lamprey River	2005	44	10
Lamprey River	2006	55	1
Lamprey River	2007	92	49
Lamprey River	2008	92	12
Lamprey River	2009	77	1
Lamprey River	2010	92	87
Lamprey River	2011	92	51
Oyster River	2002	25	9
Oyster River	2003	19	1
Oyster River	2004	52	21
Oyster River	2005	35	2
Oyster River	2006	30	1
Oyster River	2007	92	4
Oyster River	2008	53	7
Oyster River	2009	92	3
Oyster River	2010	12	2

Station	Year	Number of Summer Days with Valid DO Data	Number of Summer Days with Minimum DO <5 mg/L
Oyster River	2011	92	31
Salmon Falls River	2002	10	0
Salmon Falls River	2003	17	6
Salmon Falls River	2004	60	12
Salmon Falls River	2005	10	1
Salmon Falls River	2006	28	0
Salmon Falls River	2007	15	1
Salmon Falls River	2008	41	2
Salmon Falls River	2009	78	4
Salmon Falls River	2010	25	7
Salmon Falls River	2011	45	8
Squamscott River	2000	15	4
Squamscott River	2001	20	0
Squamscott River	2002	20	8
Squamscott River	2003	18	8
Squamscott River	2004	92	19
Squamscott River	2005	37	4
Squamscott River	2006	73	12
Squamscott River	2007	92	7
Squamscott River	2008	88	14
Squamscott River	2009	92	10
Squamscott River	2010	80	36
Squamscott River	2011	92	25

Note: Summer days are defined as days in the months of July, August, and September.

Table NUT5-2: Measurements of daily average dissolved oxygen saturation less than 75% at in-situ datasondes in the Great Bay Estuary

Station	Year	Number of Summer Days with Complete DO Data	Number of Summer Days with Average DOsat <75%
Portsmouth Harbor	2002	9	0
Portsmouth Harbor	2003	12	0
Portsmouth Harbor	2004	16	0
Portsmouth Harbor	2005	46	0
Portsmouth Harbor	2006	45	0
Portsmouth Harbor	2007	9	0
Portsmouth Harbor	2008	91	0
Portsmouth Harbor	2009	92	0
Portsmouth Harbor	2010	86	0
Portsmouth Harbor	2011	92	0
Great Bay	2000	5	0
Great Bay	2001	12	0
Great Bay	2002	18	0
Great Bay	2003	15	0
Great Bay	2004	18	0
Great Bay	2005	42	0
Great Bay	2006	57	0
Great Bay	2007	92	0
Great Bay	2008	90	0
Great Bay	2009	92	0
Great Bay	2010	76	0
Great Bay	2011	50	0
Lamprey River	2000	4	1
Lamprey River	2001	11	0
Lamprey River	2002	15	6
Lamprey River	2003	9	6
Lamprey River	2004	50	31
Lamprey River	2005	30	3
Lamprey River	2006	53	7
Lamprey River	2007	78	23
Lamprey River	2008	91	2
Lamprey River	2009	74	0
Lamprey River	2010	90	65
Lamprey River	2011	85	38
Oyster River	2002	13	2
Oyster River	2003	6	0
Oyster River	2004	46	13
Oyster River	2005	29	0
Oyster River	2006	25	2
Oyster River	2007	90	1
Oyster River	2008	48	6
Oyster River	2009	91	4
Oyster River	2010	7	0
Oyster River	2011	90	10
Salmon Falls River	2002	6	0

Station	Year	Number of Summer Days with Complete DO Data	Number of Summer Days with Average DOsat <75%
Salmon Falls River	2003	9	2
Salmon Falls River	2004	55	6
Salmon Falls River	2005	6	0
Salmon Falls River	2006	24	0
Salmon Falls River	2007	9	0
Salmon Falls River	2008	39	2
Salmon Falls River	2009	75	5
Salmon Falls River	2010	18	1
Salmon Falls River	2011	42	9
Squamscott River	2000	8	0
Squamscott River	2001	12	0
Squamscott River	2002	12	0
Squamscott River	2003	10	0
Squamscott River	2004	76	2
Squamscott River	2005	31	0
Squamscott River	2006	71	1
Squamscott River	2007	92	0
Squamscott River	2008	50	3
Squamscott River	2009	92	0
Squamscott River	2010	77	4
Squamscott River	2011	90	0

Note: Summer days are defined as days in the months of July, August, and September.

Figure NUT5-1: Datasonde stations

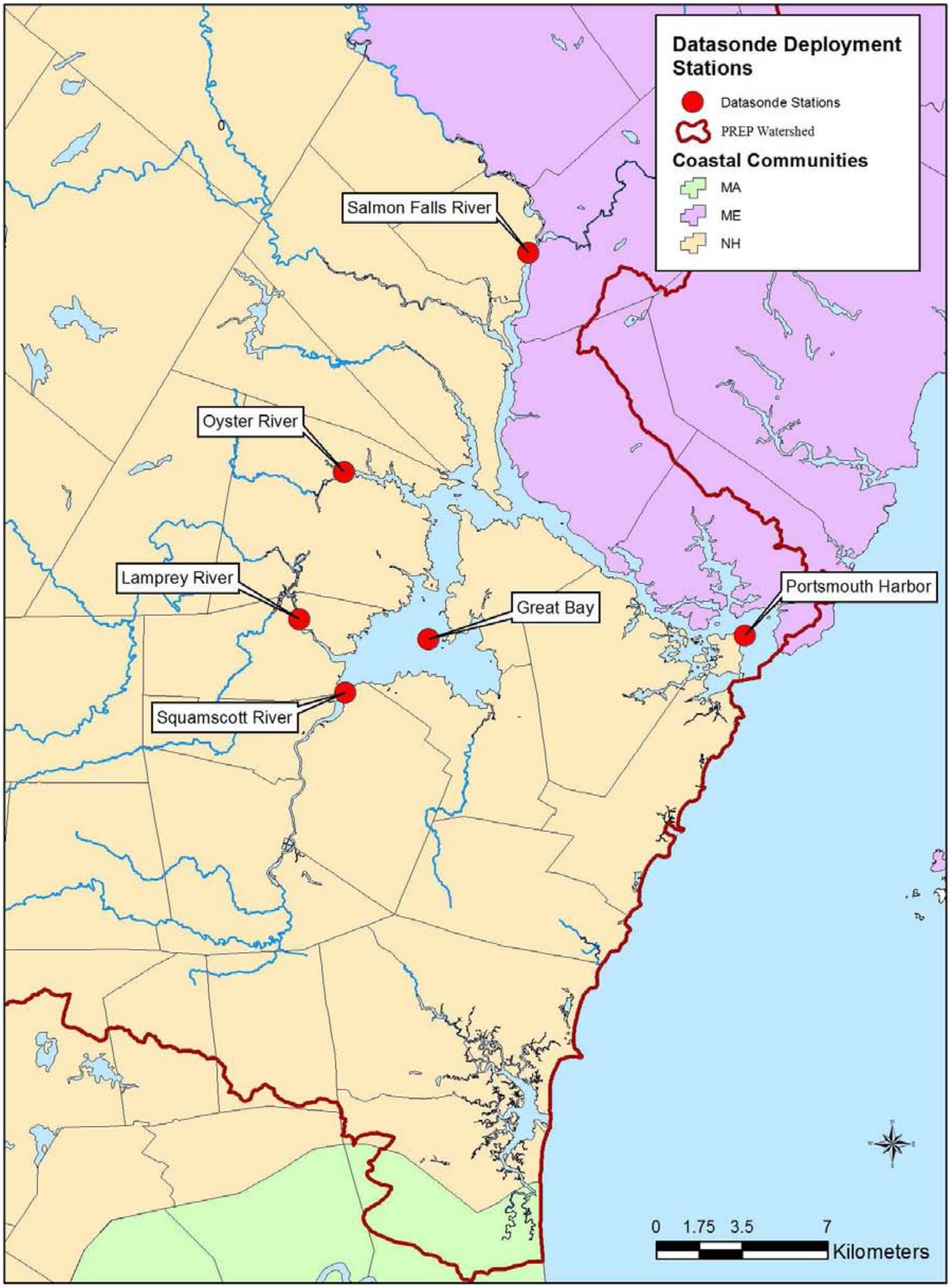
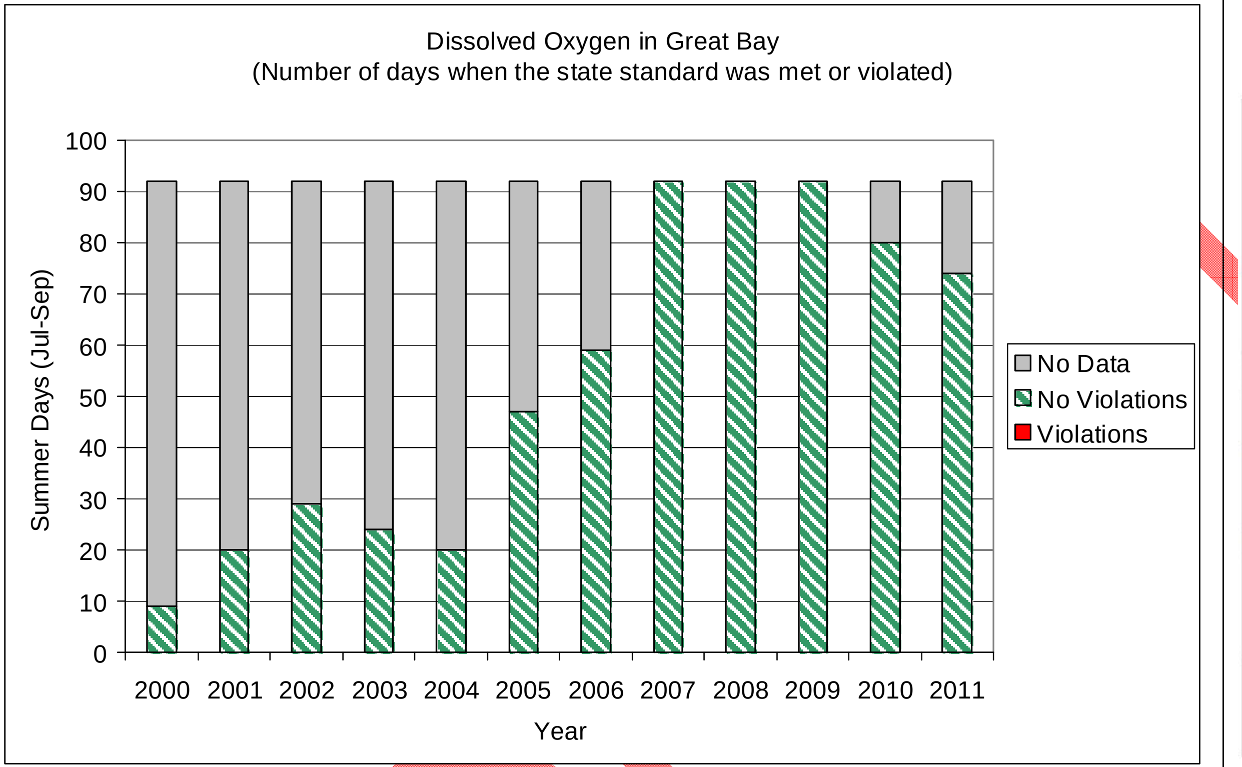
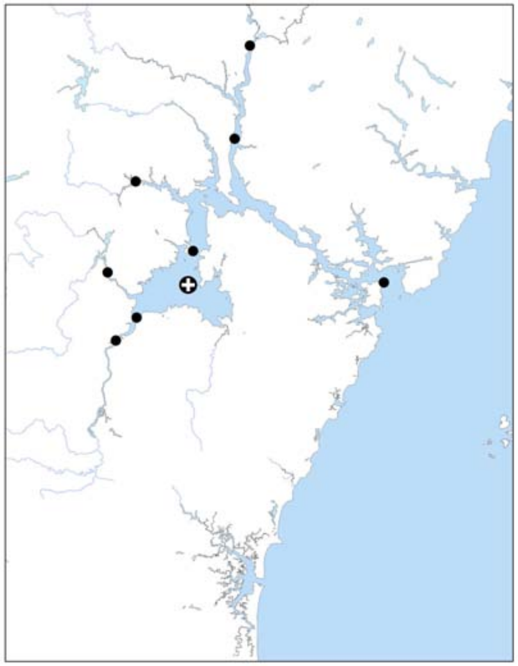


Figure NUT5-2: Number of days in July, August, and September when the state standard for dissolved oxygen was met or violated at stations in the Great Bay Estuary



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

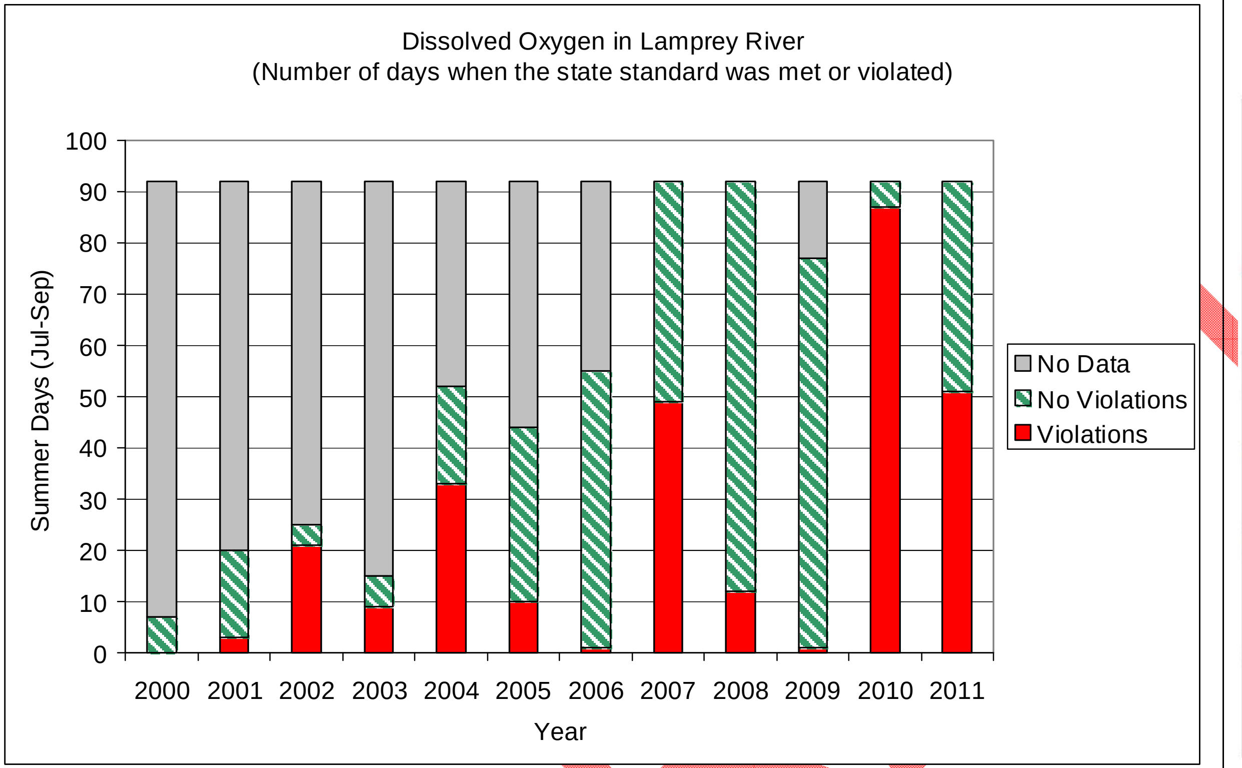


Station: GRBGB (Great Bay)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 0 (2010), 0 (2011)

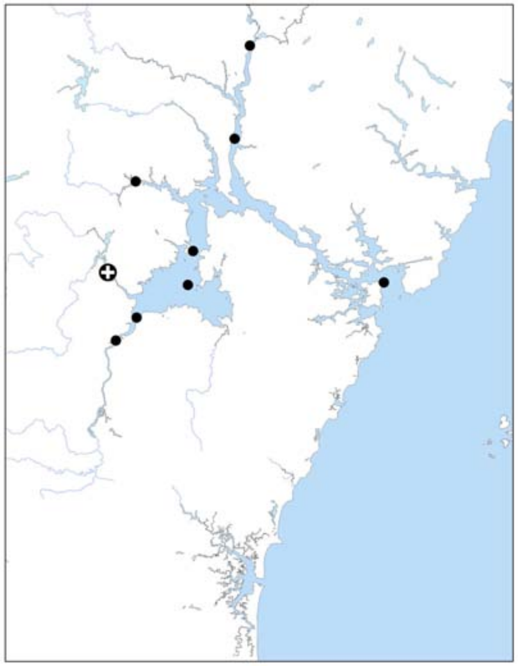
Long Term Trend: Could not be determined

Recent Change: Could not be determined



Dissolved Oxygen in Lamprey River
(Number of days when the state standard was met or violated)

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

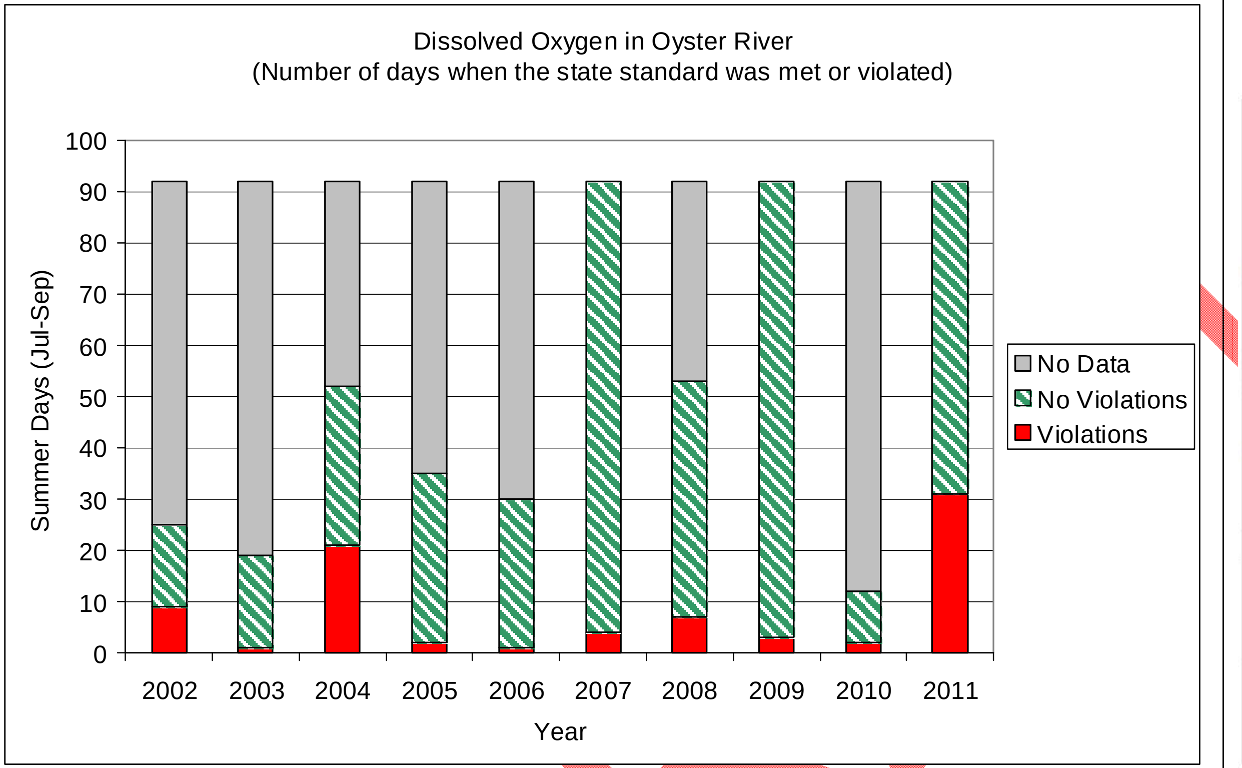


Station: GRBLR (Lamprey River)

Number of Days in July, August, and September in Violation of State Standards: 1 (2009), 87 (2010), 51 (2011)

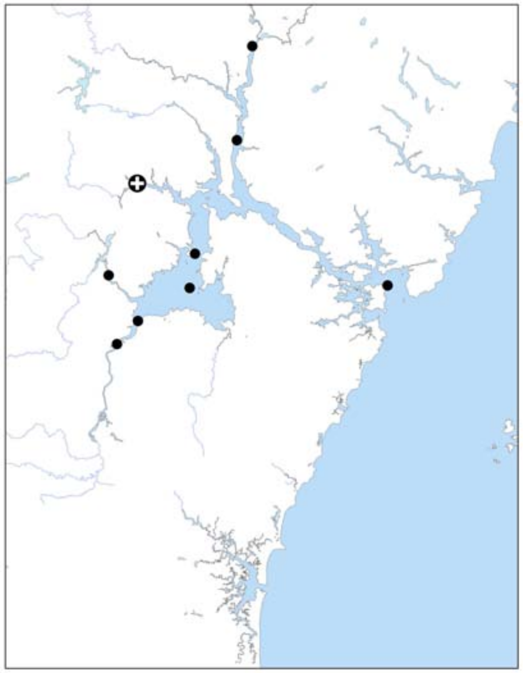
Long Term Trend: Could not be determined

Recent Change: Could not be determined



Dissolved Oxygen in Oyster River
(Number of days when the state standard was met or violated)

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



Station: GRBOR (Oyster River)

Number of Days in July, August, and September in Violation of State Standards: 3 (2009), 2 (2010), 31 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

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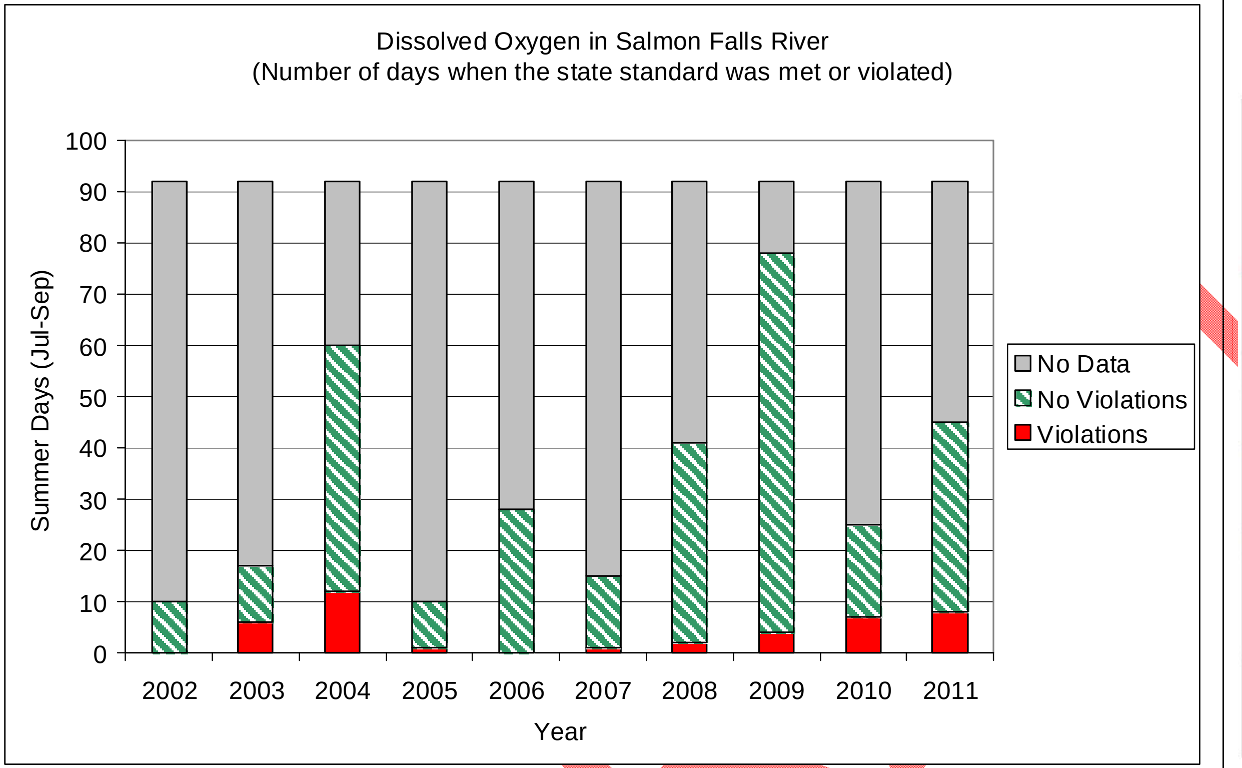
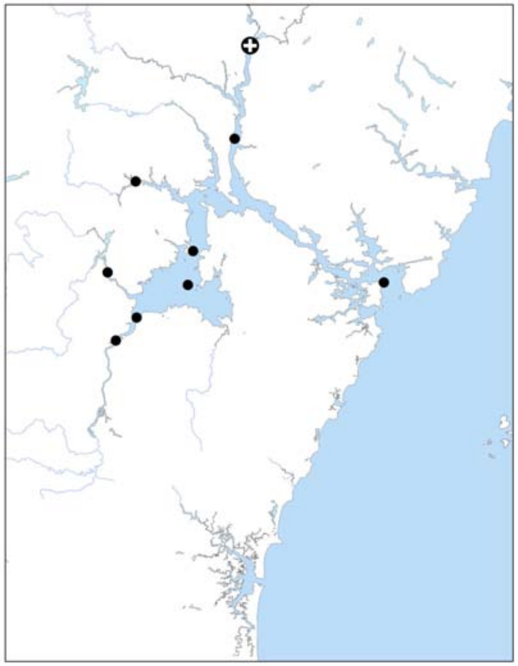


Monitoring Location (GRBSF)
(black circle with white plus sign)



Station: GRBSF (Salmon Falls River)

Number of Days in July, August, and September in Violation of State Standards: 4 (2009), 7 (2010), 8 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

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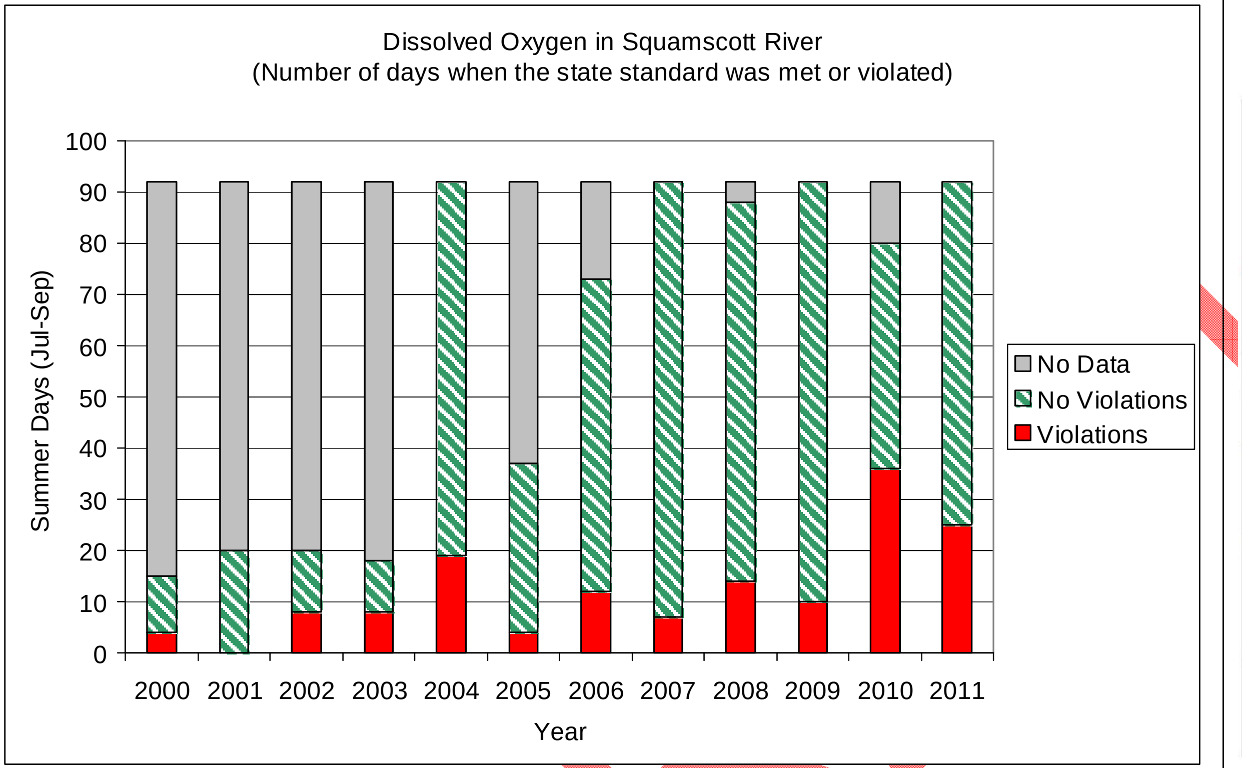
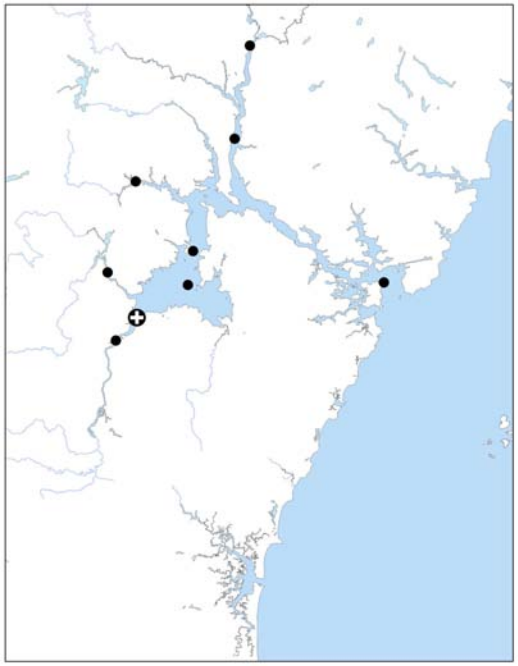


Monitoring Location (GRBSQ)
(black circle with white plus sign)



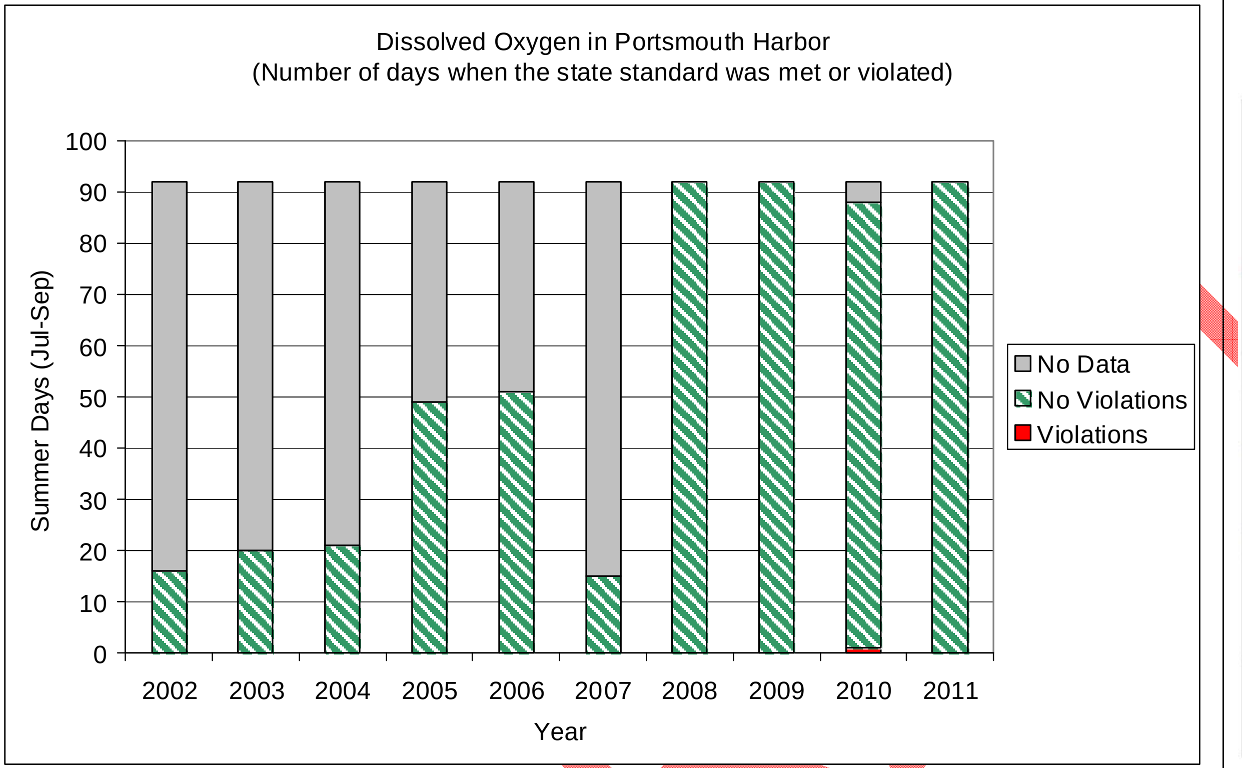
Station: GRBSQ (Squamscott River at the railroad trestle)

Number of Days in July, August, and September in Violation of State Standards: 10 (2009), 36 (2010), 25 (2011)

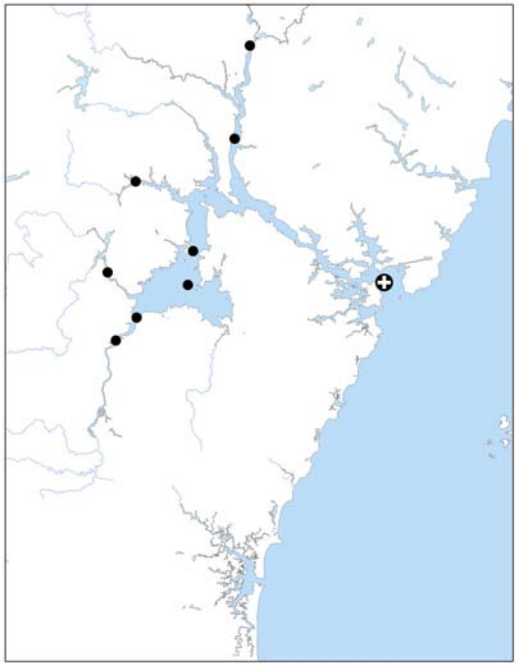
Long Term Trend: Could not be determined

Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)



Monitoring Location (GRBCML)
(black circle with white plus sign)



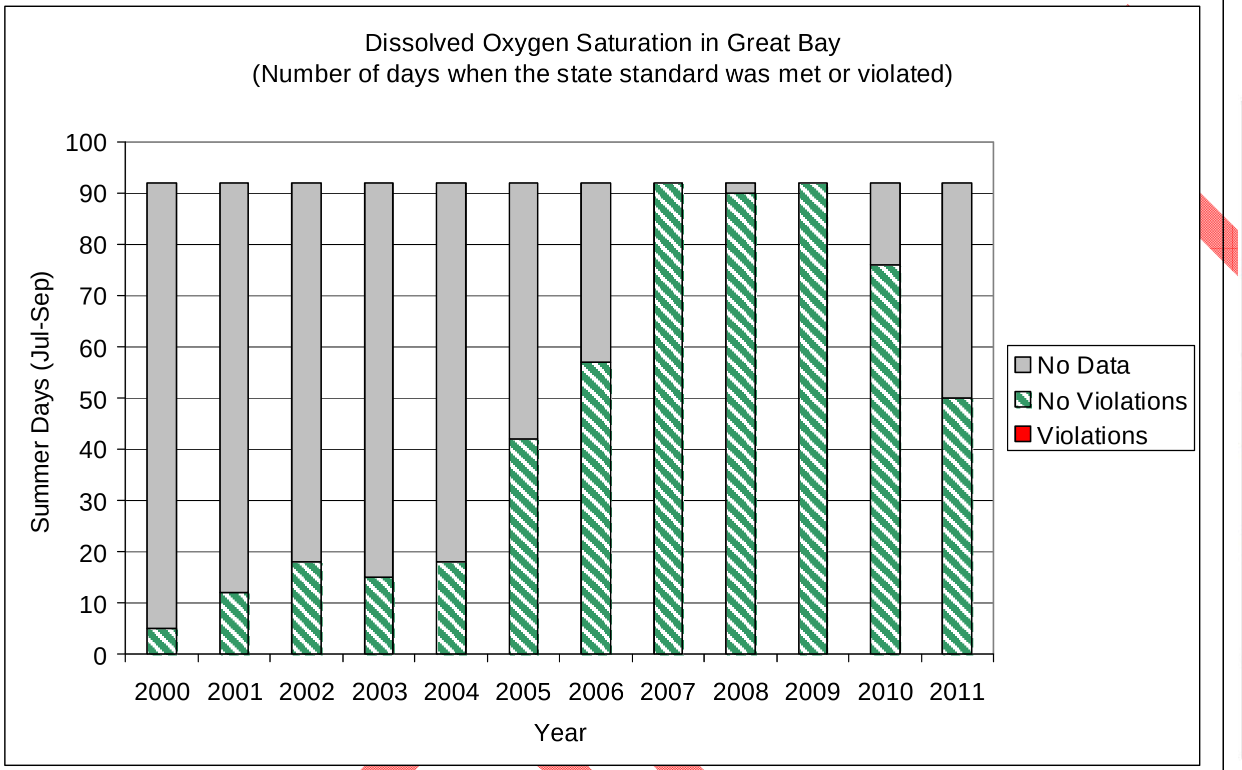
Station: GRBCML (Portsmouth Harbor)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 1 (2010), 0 (2011)

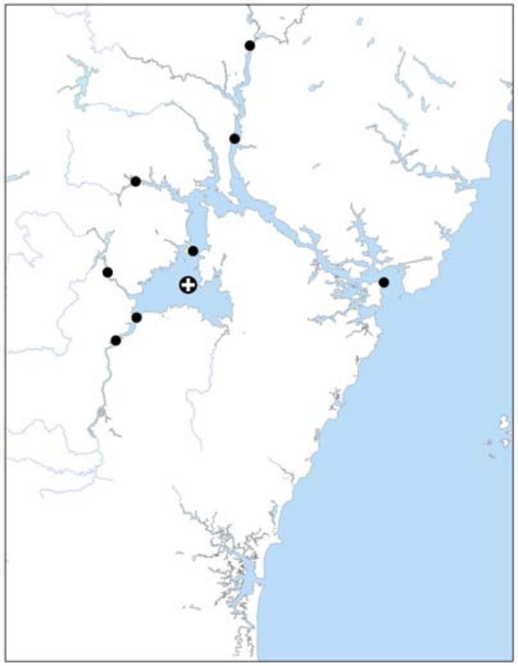
Long Term Trend: Could not be determined

Recent Change: Could not be determined

Figure NUT5-3: Number of days in July, August, and September when the state standard for dissolved oxygen saturation was met or violated at stations in the Great Bay Estuary



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



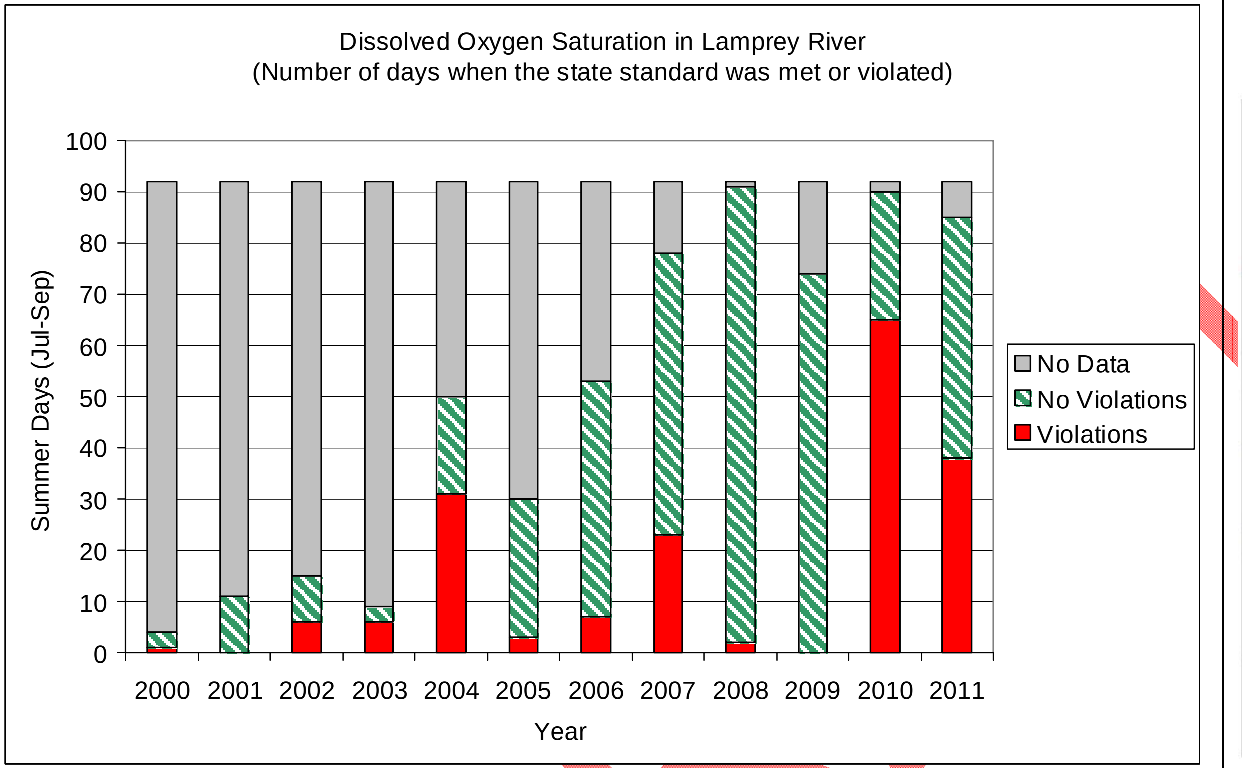
Station: GRBGB (Great Bay)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 0 (2010), 0 (2011)

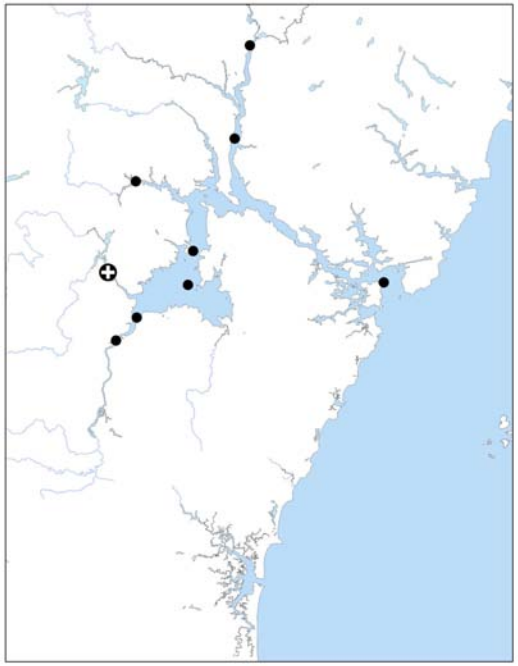
Long Term Trend: Could not be determined

Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)



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



Station: GRBLR (Lamprey River)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 65 (2010), 38 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

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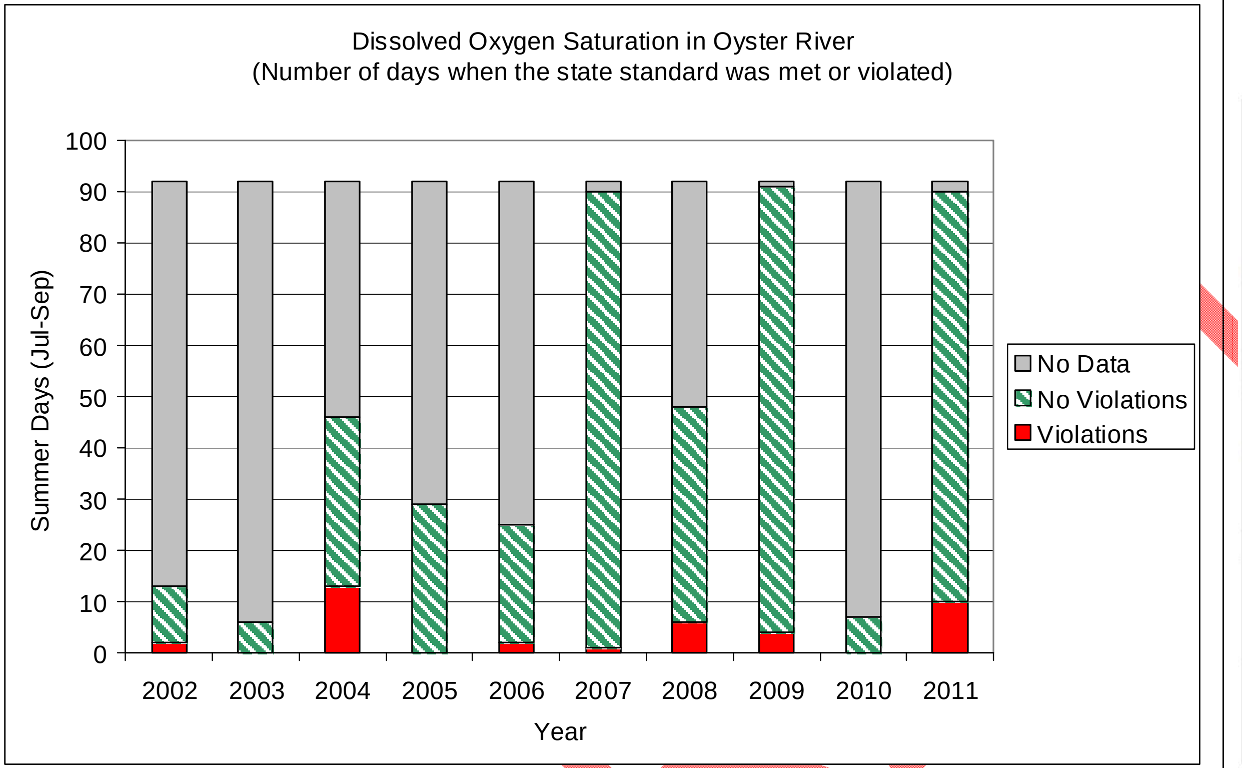
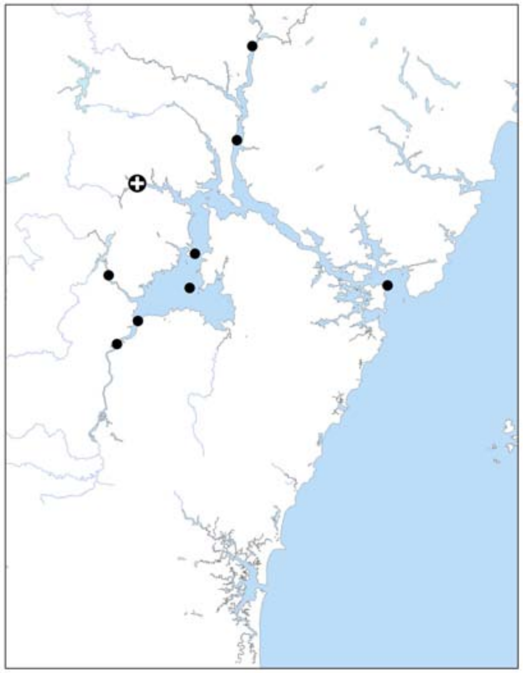


Monitoring Location (GRBOR)
(black circle with white plus sign)



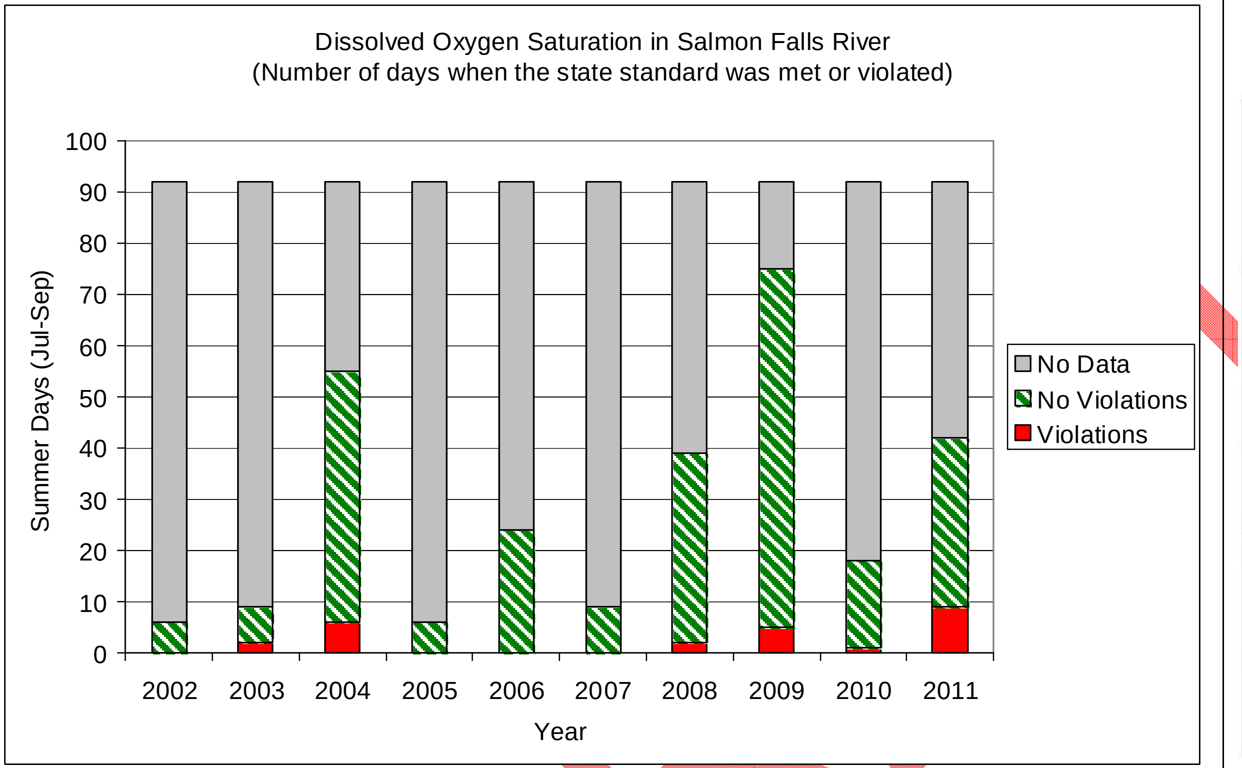
Station: GRBOR (Oyster River)

Number of Days in July, August, and September in Violation of State Standards: 4 (2009), 0 (2010), 10 (2011)

Long Term Trend: Could not be determined

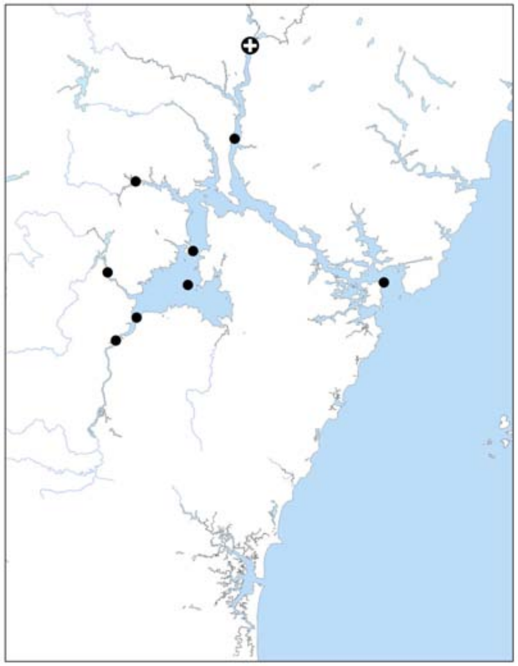
Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)



Dissolved Oxygen Saturation in Salmon Falls River
(Number of days when the state standard was met or violated)

Monitoring Location (GRBSF)
(black circle with white plus sign)



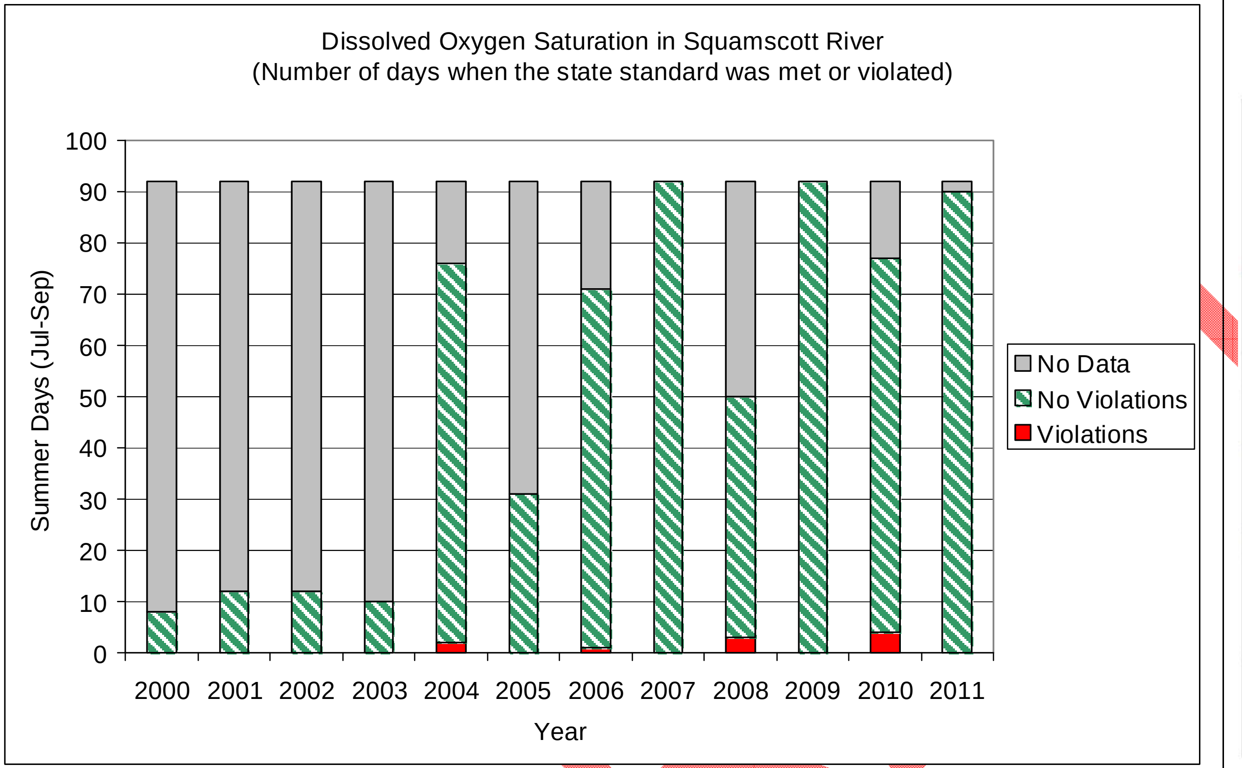
Station: GRBSF (Salmon Falls River)

Number of Days in July, August, and September in Violation of State Standards: 5 (2009), 1 (2010), 9 (2011)

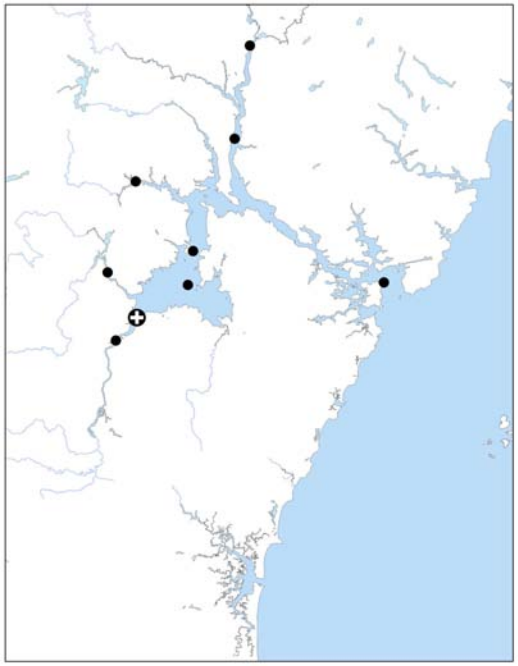
Long Term Trend: Could not be determined

Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)


Dissolved Oxygen Saturation in Squamscott River
(Number of days when the state standard was met or violated)

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



Station: GRBSQ (Squamscott River at the railroad trestle)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 4 (2010), 0 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

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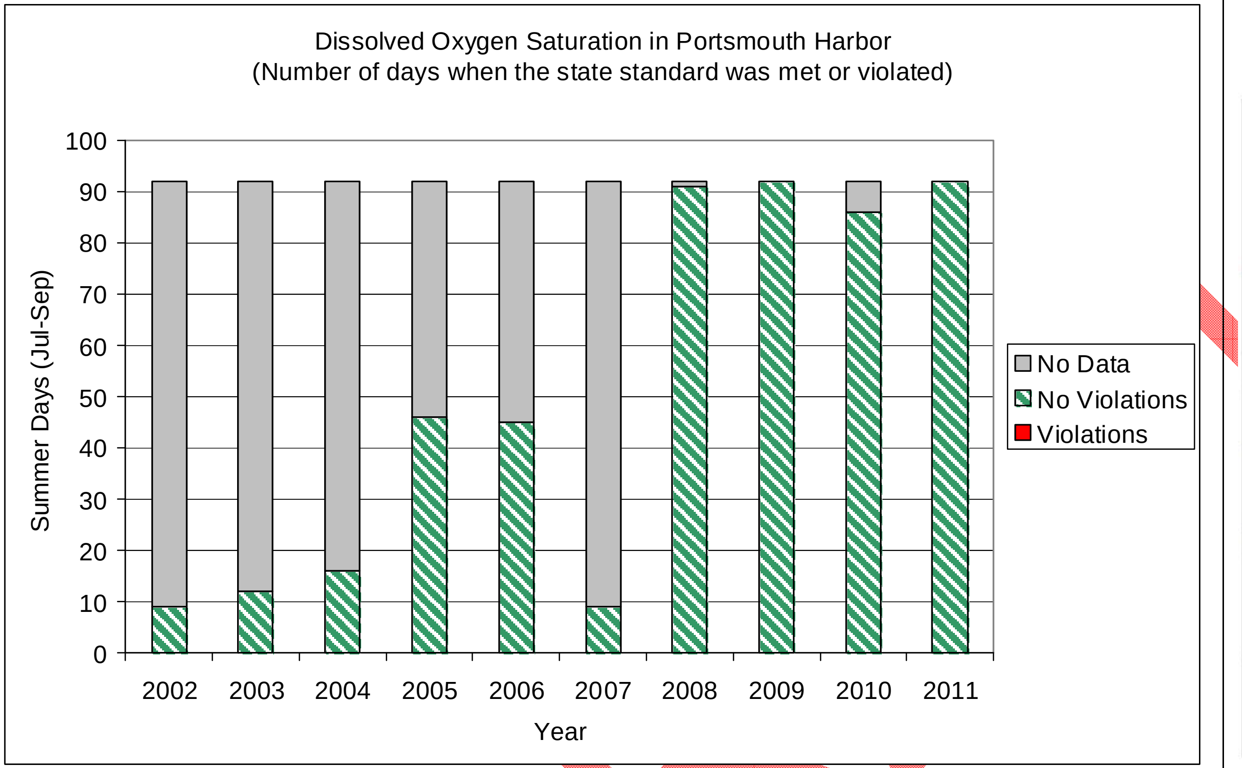
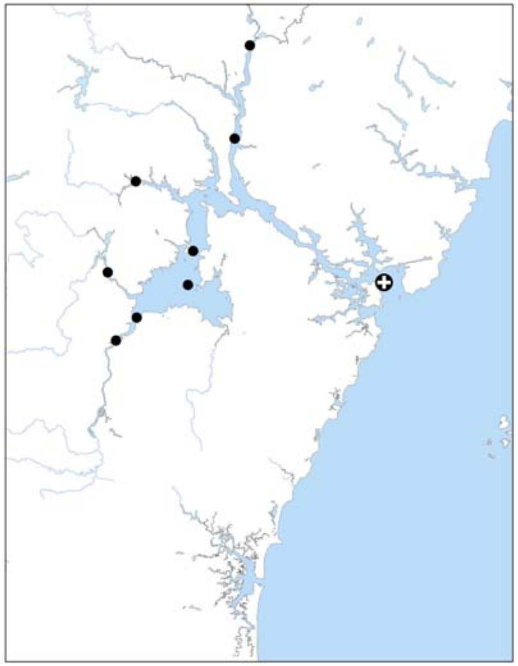


Dissolved Oxygen Saturation in Portsmouth Harbor
(Number of days when the state standard was met or violated)



Monitoring Location (GRBCML)
(black circle with white plus sign)

Station: GRBCML (Portsmouth Harbor)

Number of Days in July, August, and September in Violation of State Standards: 0 (2009), 0 (2010), 0 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

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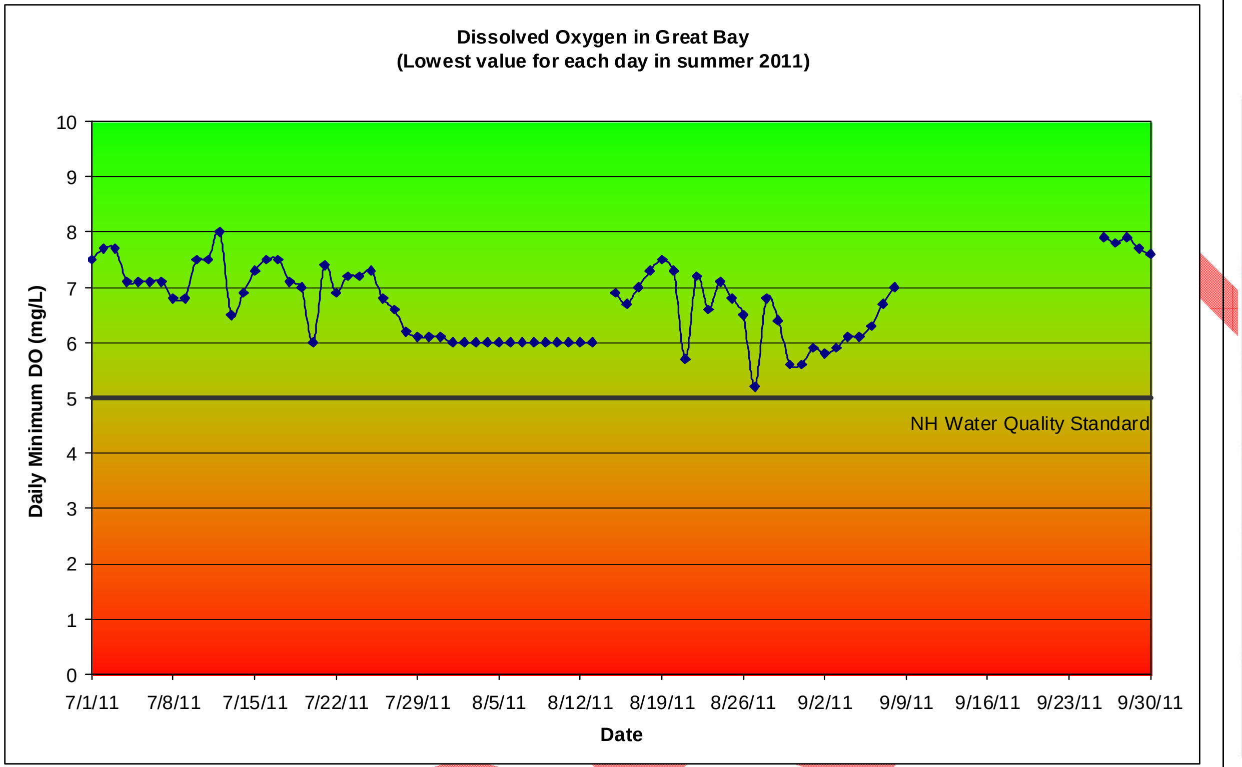
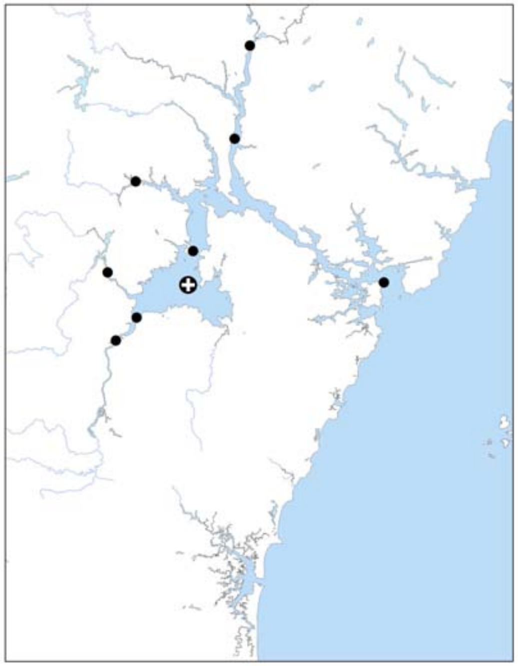
EXHIBIT 36 (AR K.22)

Figure NUT5-4: Daily minimum dissolved oxygen between July 1 and September 30, 2011 at stations in the Great Bay Estuary



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

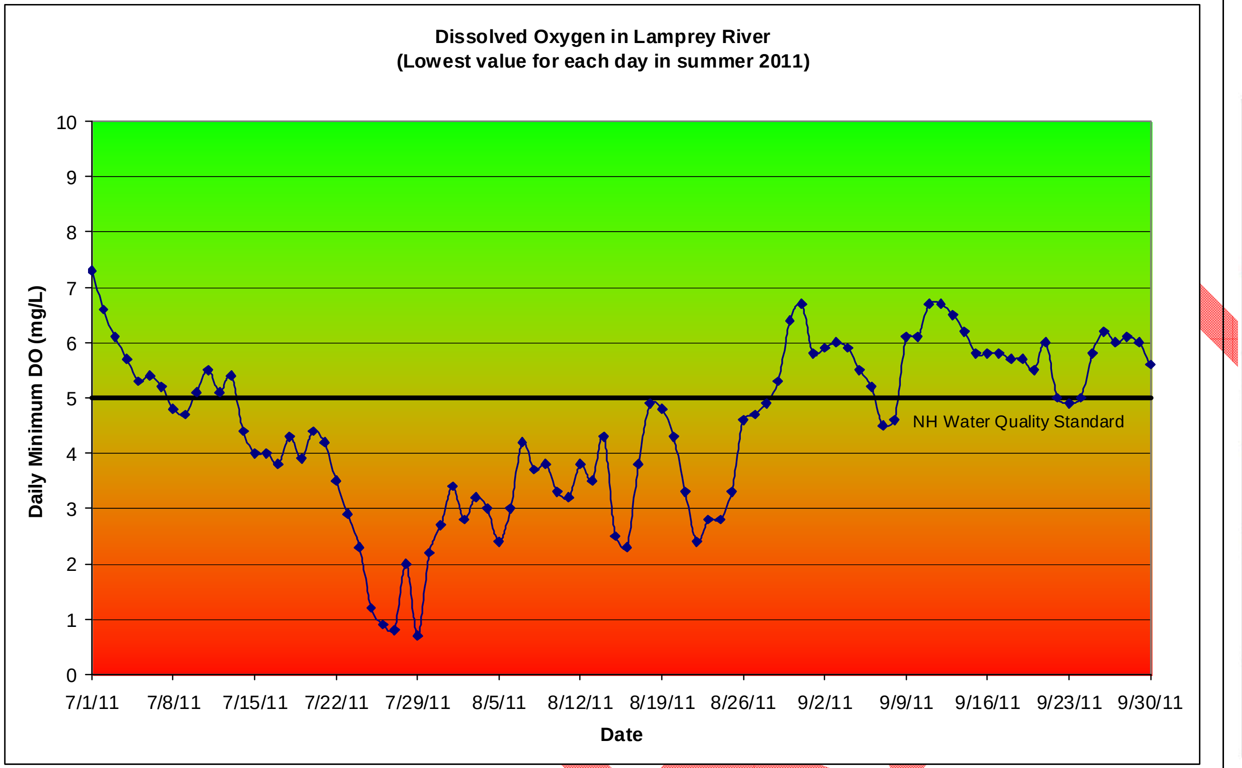


Station: GRBGB (Great Bay)

Number of Days in July, August, and September in Violation of State Standards: 0 (2011)

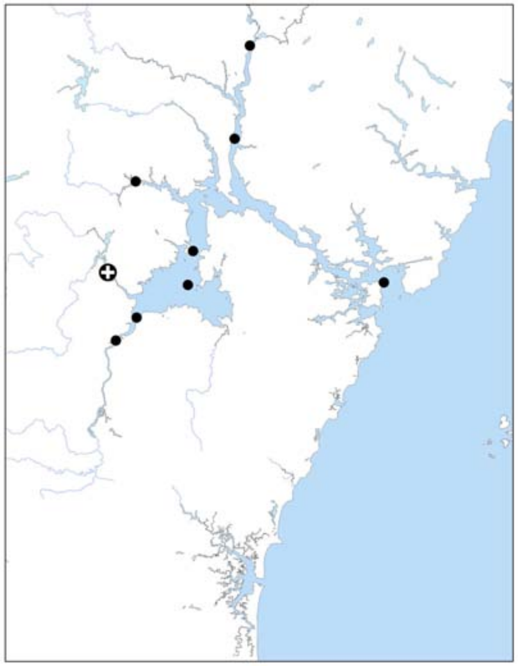
Long Term Trend: Could not be determined

Recent Change: Could not be determined



Dissolved Oxygen in Lamprey River
(Lowest value for each day in summer 2011)

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



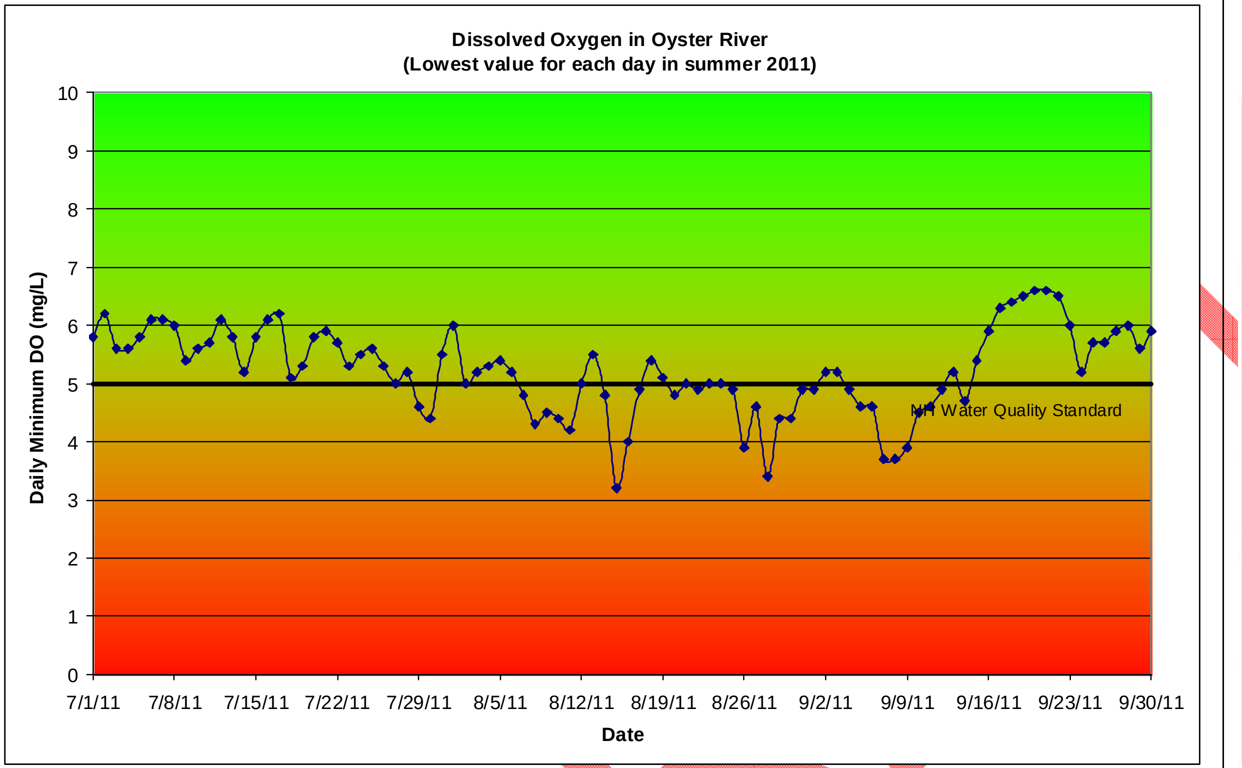
Station: GRBLR (Lamprey River)

Number of Days in July, August, and September in Violation of State Standards: 51 (2011)

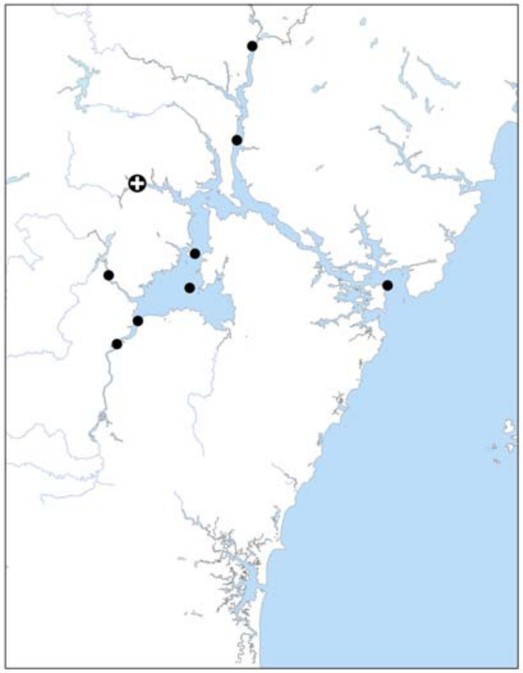
Long Term Trend: Could not be determined

Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)



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



Station: GRBOR (Oyster River)

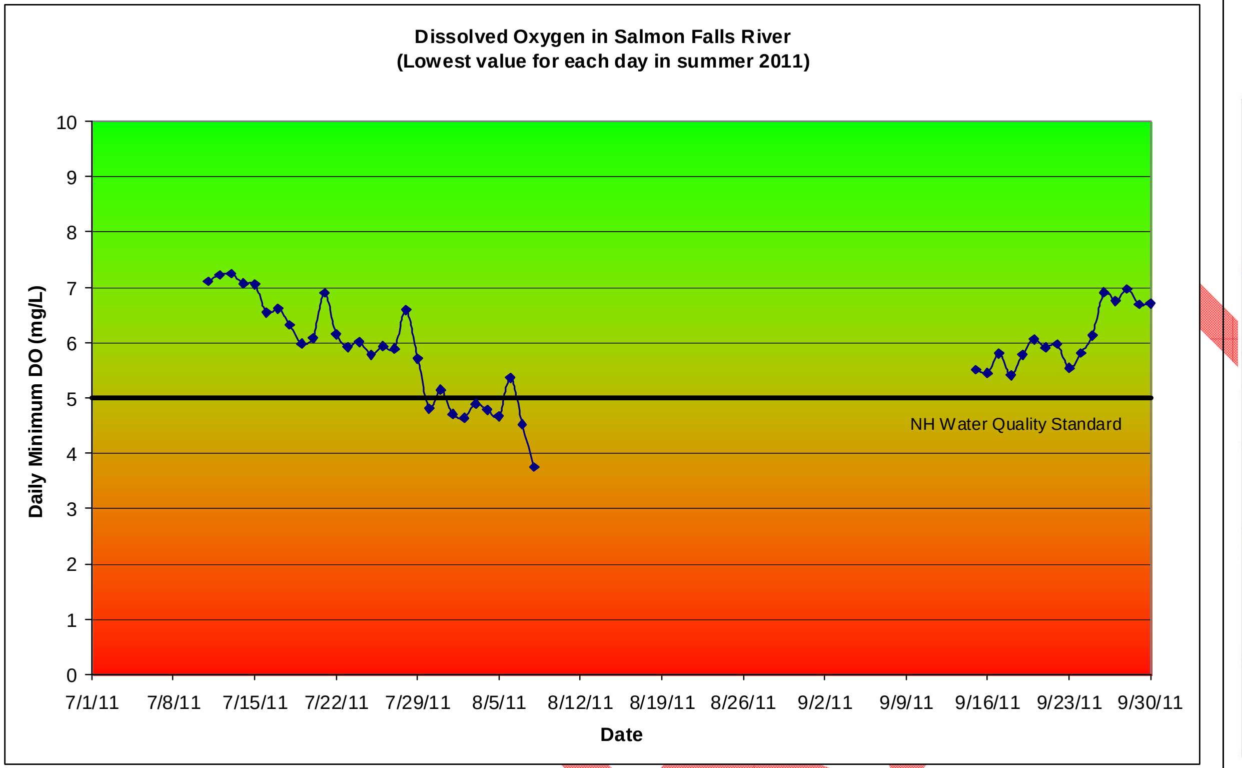
Number of Days in July, August, and September in Violation of State Standards: 31 (2011)

Long Term Trend: Could not be determined

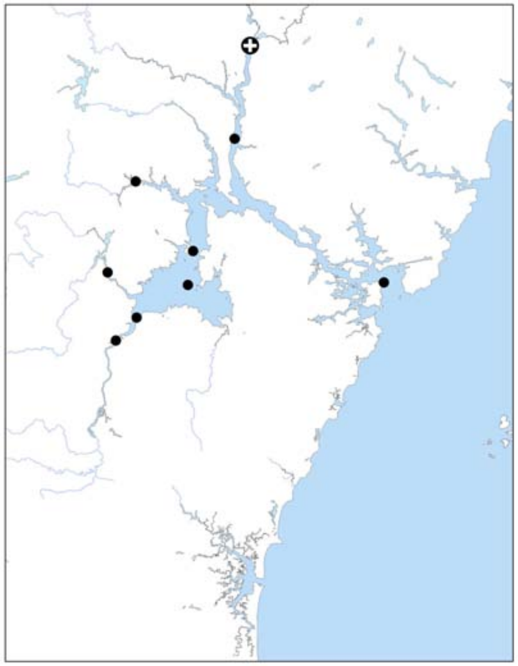
Recent Change: Could not be determined

PREP
Piscataqua Region Estuaries Partnership

EXHIBIT 36 (AR K.22)



Monitoring Location (GRBSF)
(black circle with white plus sign)



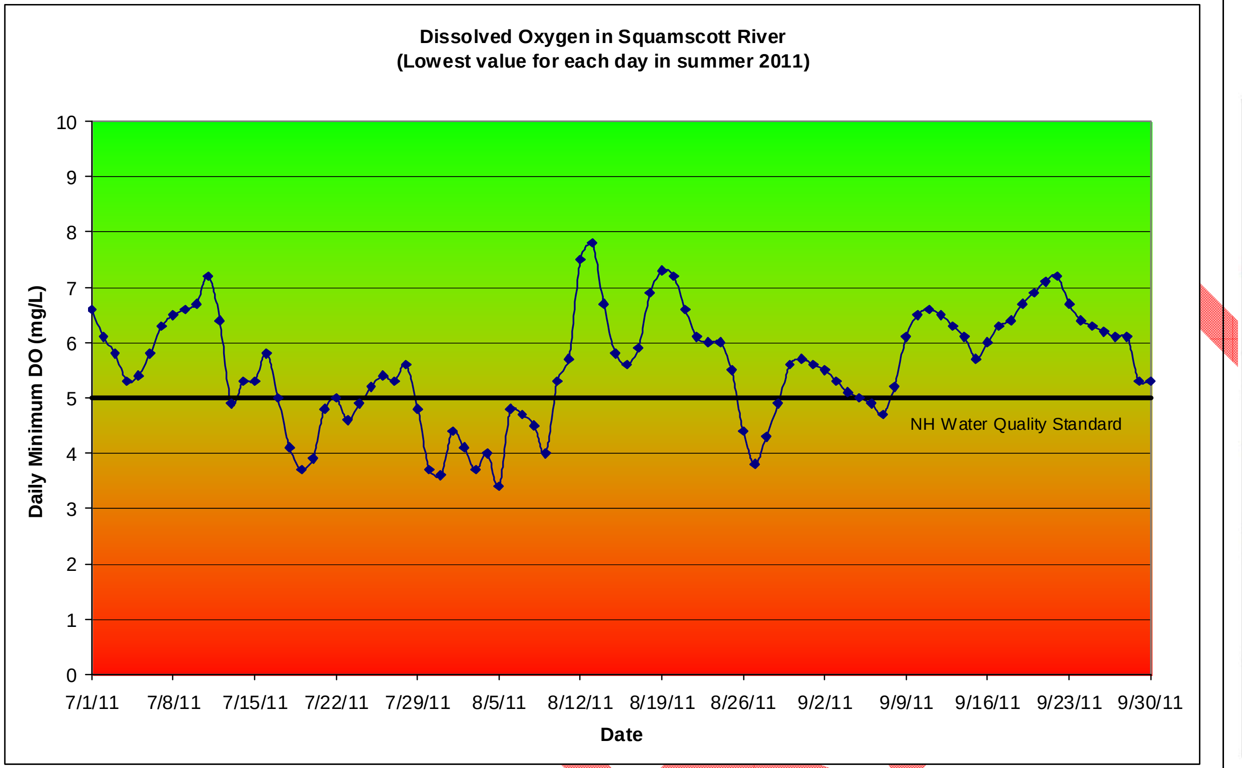
Station: GRBSF (Salmon Falls River)

Number of Days in July, August, and September in Violation of State Standards: 8 (2011)

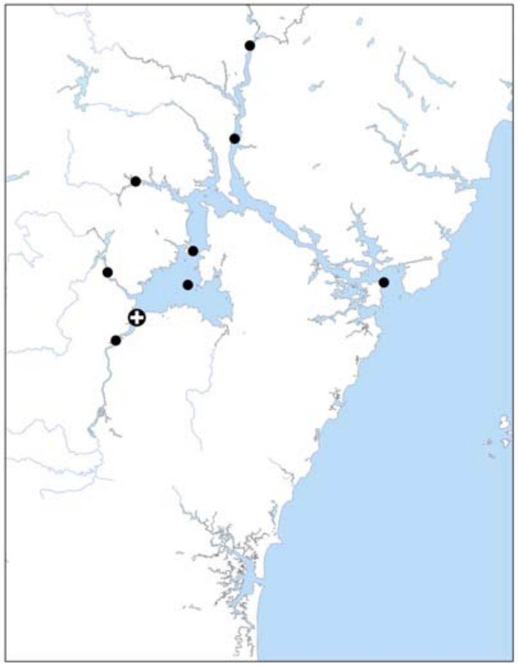
Long Term Trend: Could not be determined

Recent Change: Could not be determined

EXHIBIT 36 (AR K.22)


Dissolved Oxygen in Squamscott River
(Lowest value for each day in summer 2011)

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

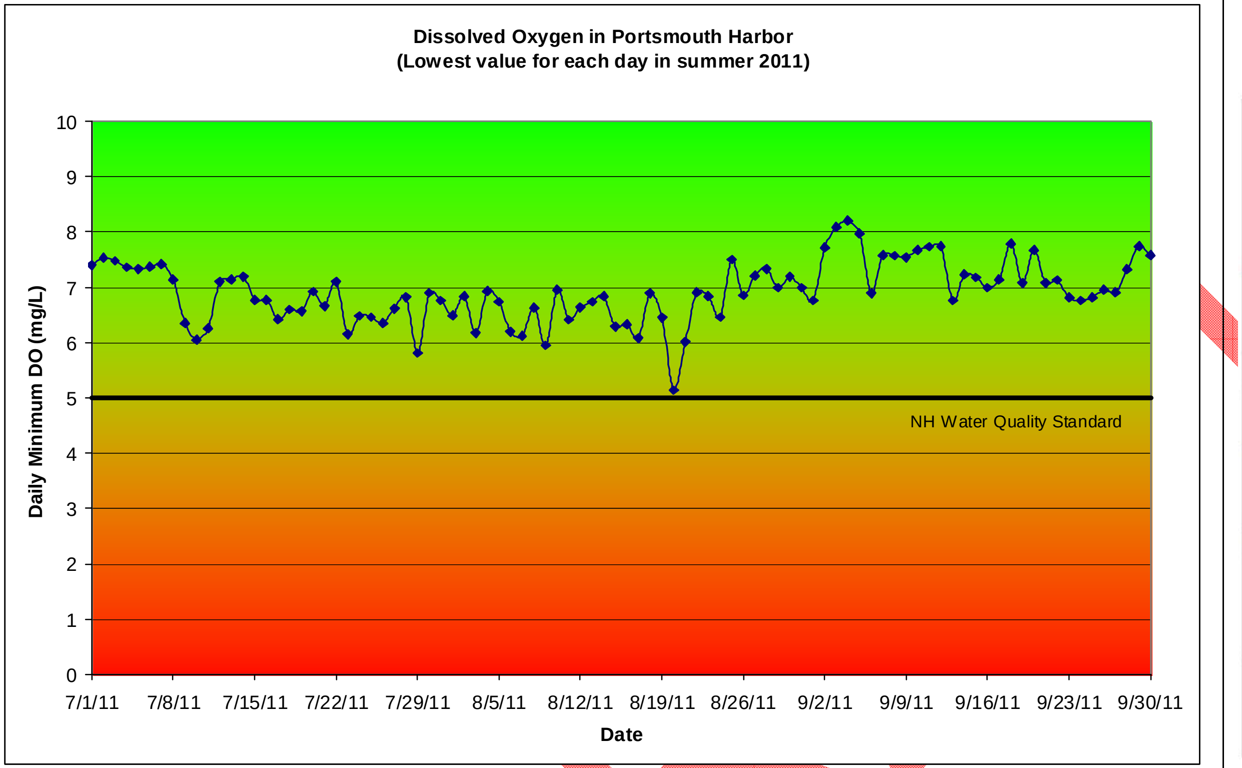


Station: GRBSQ (Squamscott River at the railroad trestle)

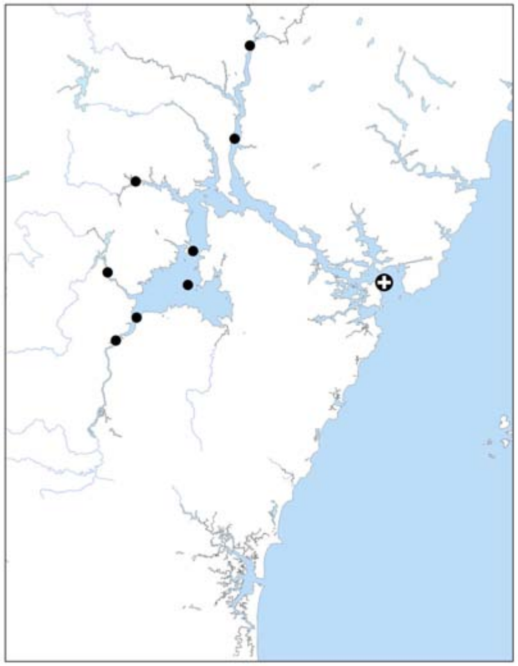
Number of Days in July, August, and September in Violation of State Standards: 25 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined



Monitoring Location (GRBCML)
(black circle with white plus sign)



Station: GRBCML (Portsmouth Harbor)

Number of Days in July, August, and September in Violation of State Standards: 0 (2011)

Long Term Trend: Could not be determined

Recent Change: Could not be determined

Indicator: HAB2. Eelgrass habitat in the estuary

Objectives

The objective of this indicator is to track the area of eelgrass (*Zostera marina*) present in the Great Bay Estuary. Eelgrass is the base of the estuarine food web in the Great Bay Estuary. Healthy eelgrass beds filter water and stabilize sediments (Short and Short, 1984) and provide habitat for fish and shellfish (Duarte, 2001; Heck et al., 2003). While eelgrass is only one species in the estuarine community, the presence of eelgrass is critical for the survival of many species. Loss of eelgrass habitat changes the species composition of an estuary resulting in a detrimental difference in community structure and function. In particular, if eelgrass habitat were lost, the estuary would likely be colonized by macroalgae species which do not provide the same habitat functions as eelgrass (Short et al., 1995; Hauxwell et al., 2003; McGlathery et al, 2007).

PREP Goal

Obj LR 1.3: Increase the aerial extent of eelgrass cover to 2,900 acres and restore connectivity of eelgrass beds throughout the Great Bay Estuary by 2020.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

The UNH Seagrass Ecology Group has mapped the distribution of eelgrass every year from 1986 to 2011 in Great Bay. The entire Great Bay Estuary (Great Bay, Little Bay, tidal tributaries, Piscataqua River, Little Harbor, and Portsmouth Harbor) was mapped by these researchers in 1996, and annually from 1999 through 2011. The method for eelgrass mapping follows an approved Quality Assurance Project Plan (UNH, 2010). DES has conducted additional quality assurance checks on the GIS files provided by UNH with topology rules to identify and eliminate overlapping polygons (NHDES, 2012).

The area of eelgrass in each segment of the estuary was calculated using the GIS files provided by UNH and the ArcGIS Identity tool. Trends in the area of eelgrass cover in each segment versus year were identified using linear regression with $p<0.05$ defined as the level of significance. The trend analysis for the Great Bay and its tributaries (Winnicut River, Squamscott River, and Lamprey River) used data from 1990 to present. In 1988-1989, there was a wasting disease event that affected eelgrass populations (Muehlstein et al., 1991).The trends since 1990 reflect changes in the eelgrass population in these areas after it had recovered from this wasting disease event. In the rest of the estuary, trend analysis used data from the earliest year of the existing monitoring program (1996) to present. The change in eelgrass between two dates evaluated for trends was defined as the difference between the value of the statistically significant regression equation at the ending and beginning date.

The PREP goal for eelgrass cover is to equal the amount that was observed in 1996 (2,900 acres) and to restore connectivity of eelgrass beds throughout the Great Bay Estuary. To evaluate this goal, the total eelgrass cover in the estuary was totaled and plotted over time. In addition, the most recent map of eelgrass cover in the whole estuary was superimposed on the 1996 eelgrass map.

Data Sources

Data on eelgrass cover in the estuary is provided by the UNH Seagrass Ecology Group, with funding from the PREP. The monitoring protocols are described in the Quality Assurance Project Plan (UNH, 2010).

Results

Trend Analysis

Since 1990, there have been statistically significant declining trends in eelgrass cover in the Great Bay and Winnicut River (Figure HAB2-1). In the Great Bay, there has been a 38% decline with 945 acres lost (these numbers reflect the long-term regression equation, not the actual measurements of eelgrass cover in 1990 and 2011). In the Winnicut River, 100% of the eelgrass has been lost (14 acres, based on the regression). Trends in the Squamscott and Lamprey Rivers could not be evaluated because eelgrass has not been found in these segments since 1990 except for a few acres at the mouth of the Lamprey River in two of the years surveyed.

In other areas of the estuary, there have been statistically significant declining trends in eelgrass cover since 1996 in the Upper Piscataqua River, Lower Piscataqua River North, Little Harbor, and Portsmouth Harbor (Figure HAB2-1). The eelgrass losses since 1996 in these areas (expressed as both percents and acres based on the regressions) are listed below.

- Upper Piscataqua River (-100%, -2 acres)
- Lower Piscataqua River North (-97%, -17 acres)
- Little Harbor (-47%, -32 acres)
- Portsmouth Harbor (-43%, -126 acres)

There was no statistically significant trend for eelgrass in Little Bay. Starting in 1996, eelgrass had declined in this area over time and was essentially absent from 2007 through 2010. However, in 2011, a 48 acre eelgrass bed was observed in this area. The large variance in eelgrass cover in this area means that there are no clear trends. Data from 2012 and future years are needed to determine if there is a short-term improving trend in Little Bay.

Comparison to PREP Goal

The total eelgrass cover in the entire Great Bay Estuary for years with complete data is plotted in Figure HAB2-2. In 2011, the total eelgrass cover in the estuary was 1,891 acres, 35% below the PREP goal of 2,900 acres derived from the 1996 eelgrass maps. The total has been relatively steady for the past three years and higher than the previous three years (2006-2008), which were 44 to 48% below the goal. The actual location and connectivity of the eelgrass in the estuary is very important. Figures HAB2-3, HAB2-4, and HAB2-5 show the 2011 eelgrass maps relative to the 1996 eelgrass maps. These figures show that the loss of eelgrass in the Piscataqua River disrupts the connectivity of eelgrass between Portsmouth Harbor and Great Bay, eelgrass is absent from the tidal rivers, and the new eelgrass bed in Little Bay is larger than the one that was mapped in 1996.

In 2009, UNH obtained 1981 aerial photographs of the estuary and used this information to map eelgrass in most of the estuary for that year (UNH, 2009). The eelgrass total for the estuary from 1981 was 2,752 acres and this value is included on Figure HAB2-2. One reason why the 1981 total eelgrass cover was less that the 1996 level (2,900 acres) is because the 1981 dataset was incomplete. Eelgrass in some portions of the estuary could not be mapped because the imagery had glare in some areas. The interference affected mapping in the Oyster River, Lower Piscataqua River, Portsmouth Harbor and Little Harbor. As a result, the 1981 values on Figure HAB2-2 and Table HAB2-1 underestimate actual eelgrass habitat in 1981. The 1981 data were included in Table HAB2-1 and Figure HAB2-2 to provide a historical perspective because this was prior to the wasting disease event in the late 1980s.

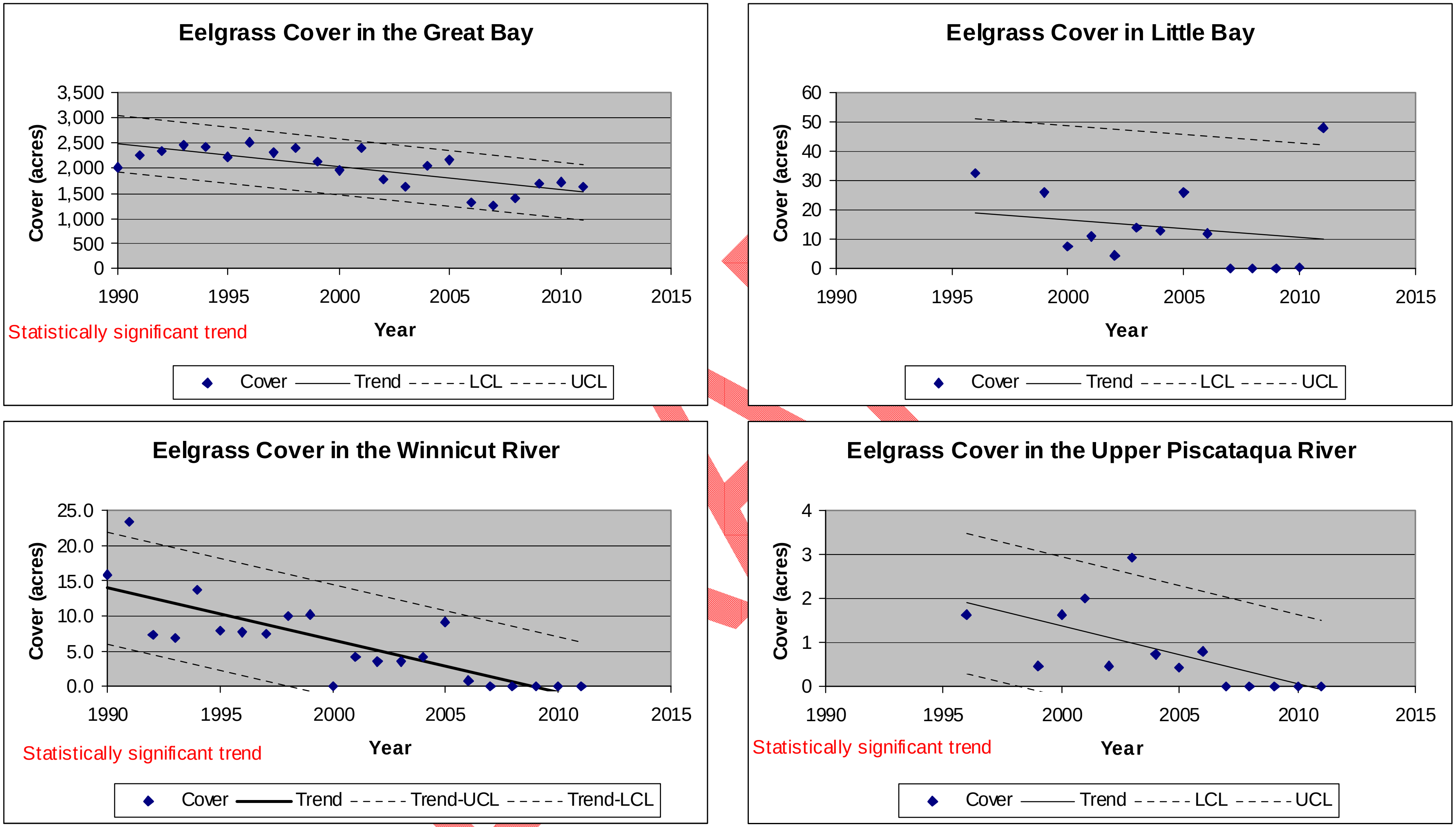
The most recent field study of eelgrass in the Great Bay Estuary by Short (2011) concluded that "While the short-term trend may seem encouraging, the 2010 gains are largely a result of plant reproductive response to nitrogen stress and the 2010 growing season's ideal weather conditions for eelgrass growth. The 2010 gains do not offset the longer-term trend of decline and as yet we do not know if the newly created beds survived the subsequent winter." This study also noted that "Nuisance macroalgae in Great Bay continued to proliferate in 2010 and impact eelgrass by smothering eelgrass shoots and reducing shoot density. The abundance of epiphytes growing on eelgrass in Great Bay greatly increased in 2010."

Table HAB2-1: Eelgrass coverage in the Great Bay Estuary

Year	Winnicut River	Squamscott River	Lamprey River	Oyster River	Bellamy River	Great Bay	Little Bay	Upper Piscataqua River*	Lower Piscataqua River North*	Lower Piscataqua River South*	Portsmouth Harbor*	Little Harbor	Sagamore Creek
1981	0.0	0.0	0.0	a	3.4	2130.7	252.0	0.5	60.1	5.1	227.7	68.8	4.1
1986	2.2	0.0	0.0	a	a	2015.2	a	a	a	a	a	a	a
1987	2.2	0.0	0.0	a	a	1685.7	a	a	a	a	a	a	a
1988	0.0	0.0	0.0	a	a	1187.5	a	a	a	a	a	a	a
1989	0.0	0.0	0.0	a	a	312.6	a	a	a	a	a	a	a
1990	15.9	0.0	0.0	a	a	2024.2	a	a	a	a	a	a	a
1991	23.4	0.0	0.0	a	a	2255.8	a	a	a	a	a	a	a
1992	7.3	0.0	0.0	a	a	2334.4	a	a	a	a	a	a	a
1993	6.9	0.0	0.0	a	a	2444.9	a	a	a	a	a	a	a
1994	13.8	0.0	0.0	a	a	2434.3	a	a	a	a	a	a	a
1995	7.8	0.0	0.0	a	a	2224.9	a	a	a	a	a	a	a
1996	7.6	0.0	0.0	14.0	0.0	2495.4	32.7	1.6	20.9	10.2	245.6	70.1	1.8
1997	7.5	0.0	0.0	a	a	2297.8	a	a	a	a	a	a	a
1998	10.0	0.0	0.0	a	a	2387.8	a	a	a	a	a	a	a
1999	10.2	0.0	0.0	0.0	0.0	2119.5	26.2	0.5	7.4	4.0	244.0	50.1	3.0
2000	0.0	0.0	0.0	0.0	0.0	1944.5	7.5	1.6	3.8	7.6	260.5	60.9	0.9
2001	4.1	0.0	0.0	0.0	0.0	2388.2	10.9	2.0	9.7	10.7	274.2	45.3	2.2
2002	3.5	0.0	0.0	0.0	0.0	1791.8	4.3	0.5	8.0	9.3	268.9	63.1	2.3
2003	3.5	0.0	2.2	0.0	0.0	1620.9	14.2	2.9	22.9	9.2	270.1	54.7	2.2
2004	4.2	0.0	0.0	0.0	0.8	2037.6	12.8	0.7	13.5	6.5	225.2	65.8	2.5
2005	9.1	0.0	0.0	0.0	0.0	2165.7	25.8	0.4	14.5	9.6	232.5	47.9	6.1
2006	0.8	0.0	0.0	0.0	0.0	1319.8	12.2	0.8	10.8	11.6	217.6	52.1	0.9
2007	0.0	0.0	0.0	0.0	0.0	1245.3	0.1	0.0	0.4	5.6	201.3	42.7	0.6
2008	0.0	0.0	0.0	0.0	0.0	1394.9	0.0	0.0	0.0	3.9	183.8	41.4	2.3
2009	0.1	0.0	0.0	0.0	0.0	1700.6	0.0	0.0	0.0	6.4	155.0	30.2	0.5
2010	0.0	0.0	0.0	0.0	0.0	1722.2	0.3	0.0	0.0	3.5	128.0	42.5	0.2
2011	0.0	0.0	0.5	0.0	0.0	1623.2	48.2	0.0	0.0	6.9	178.8	31.6	1.5

Units = Acres   a = not mapped   Total coverage includes all mapped eelgrass of all densities
* The acreages for 1981,1996-2008 include beds from both the NH and ME sides of the Piscataqua River but not the tidal creeks along the Maine shore.

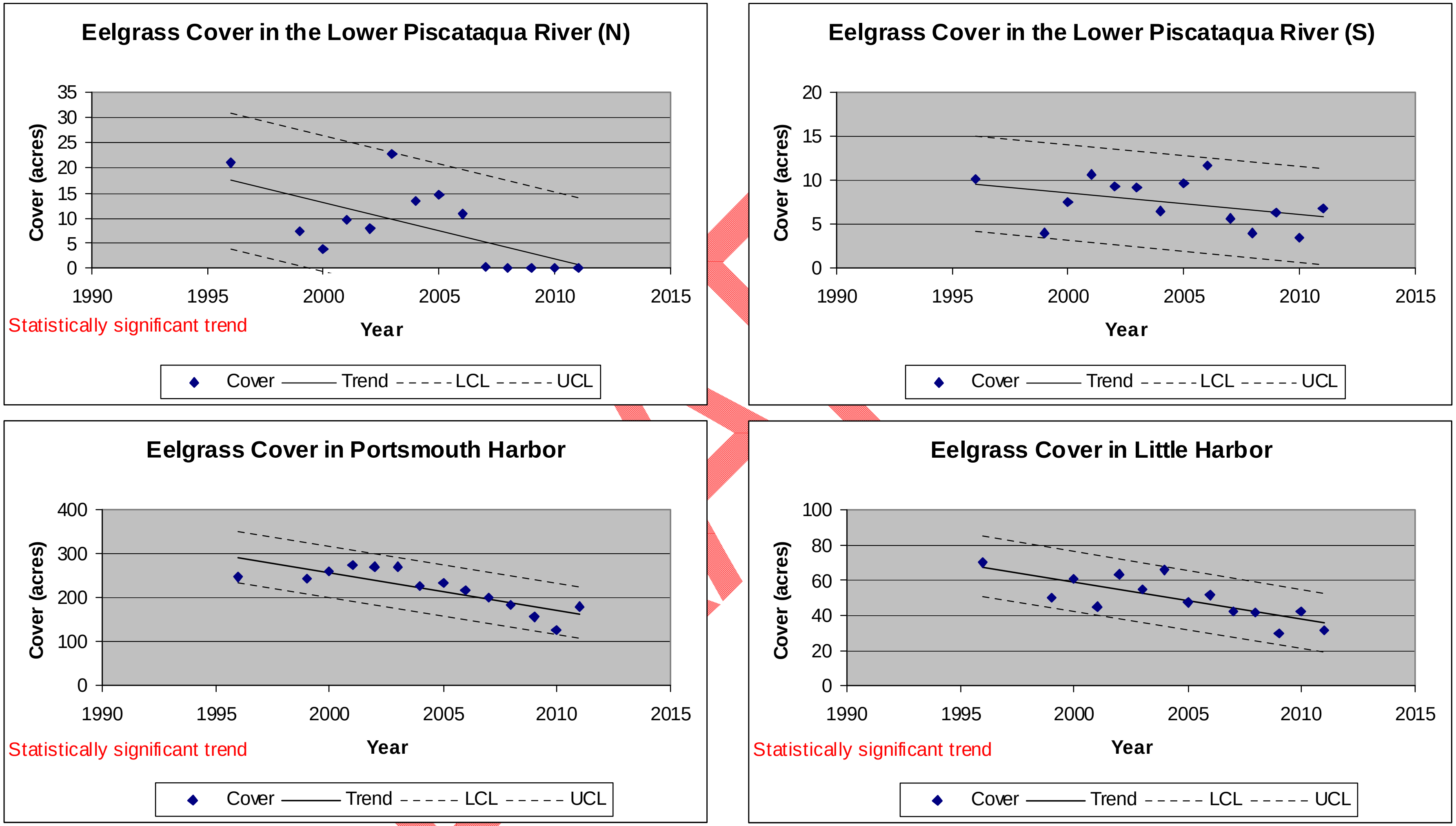
Figure HAB2-1: Eelgrass coverage in segments of the Great Bay Estuary



* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

EXHIBIT 36 (AR K.22)

Figure HAB2-1: Eelgrass coverage in segments of the Great Bay Estuary (cont.)



Eelgrass Cover in the Lower Piscataqua River (N)

Statistically significant trend

Eelgrass Cover in the Lower Piscataqua River (S)

Eelgrass Cover in Portsmouth Harbor

Statistically significant trend

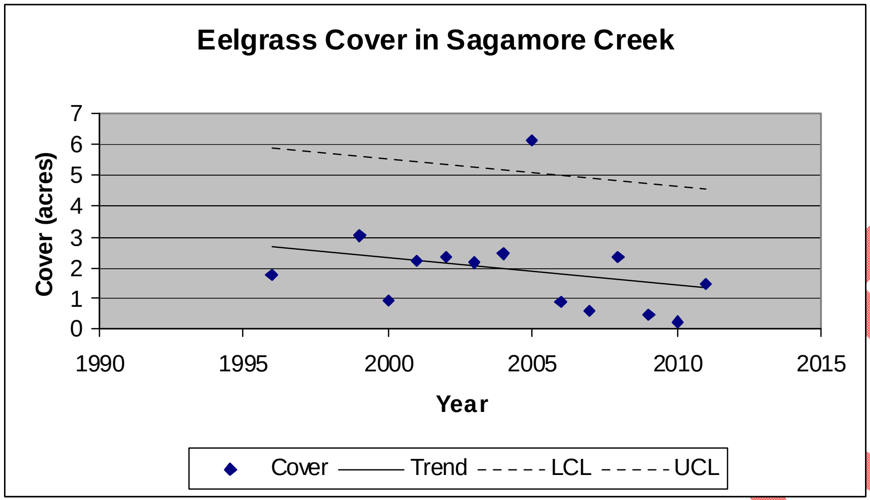
Eelgrass Cover in Little Harbor

Statistically significant trend

* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

EXHIBIT 36 (AR K.22)

Figure HAB2-1: Eelgrass coverage in segments of the Great Bay Estuary (cont.)



* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

EXHIBIT 36 (AR K.22)

Figure HAB2-2: Total eelgrass cover in the Great Bay Estuary

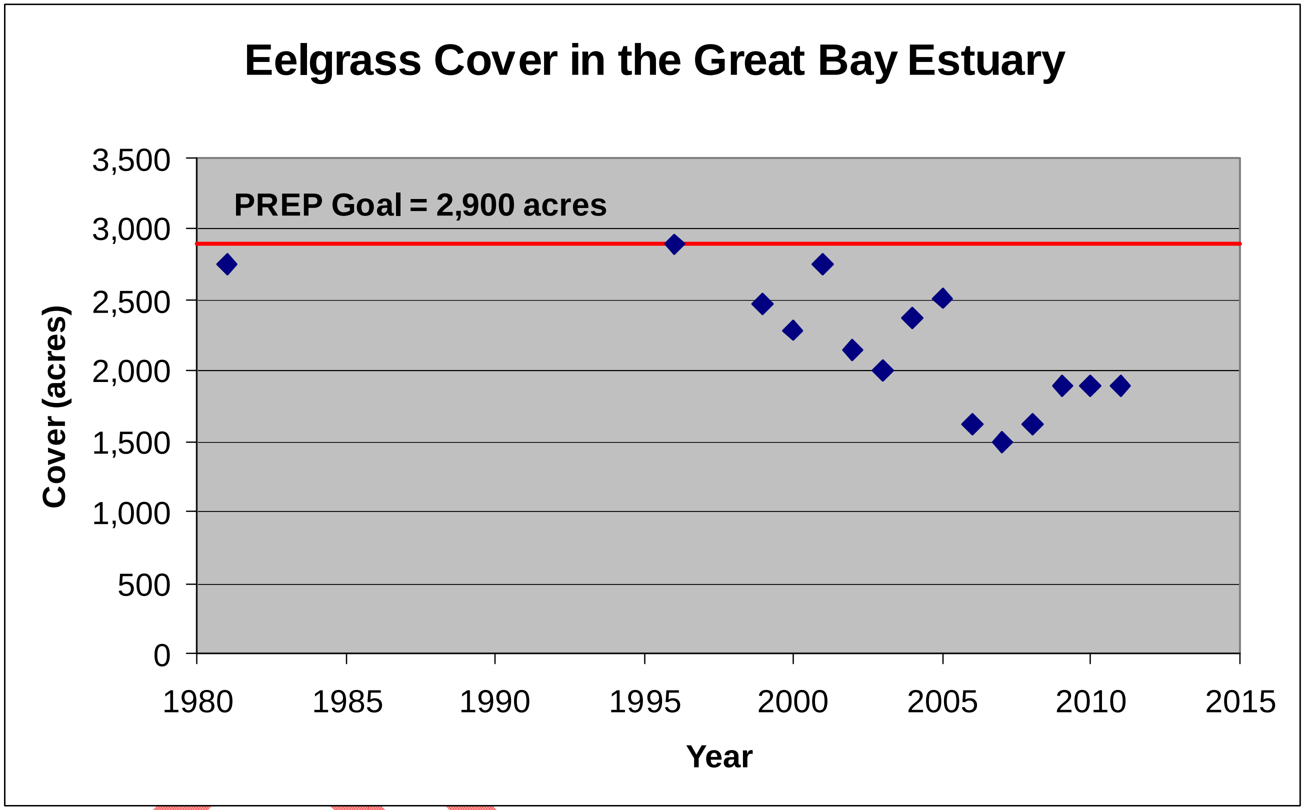
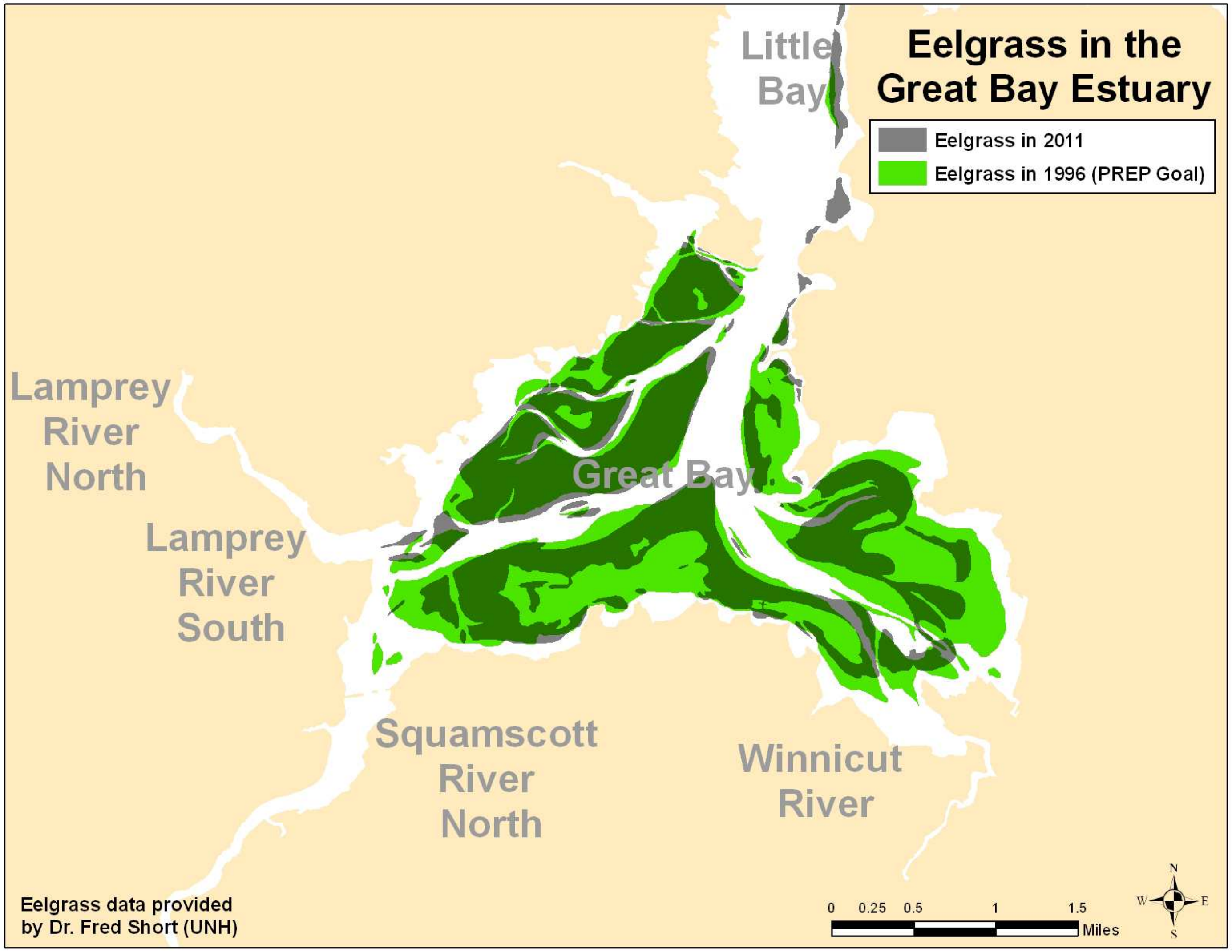
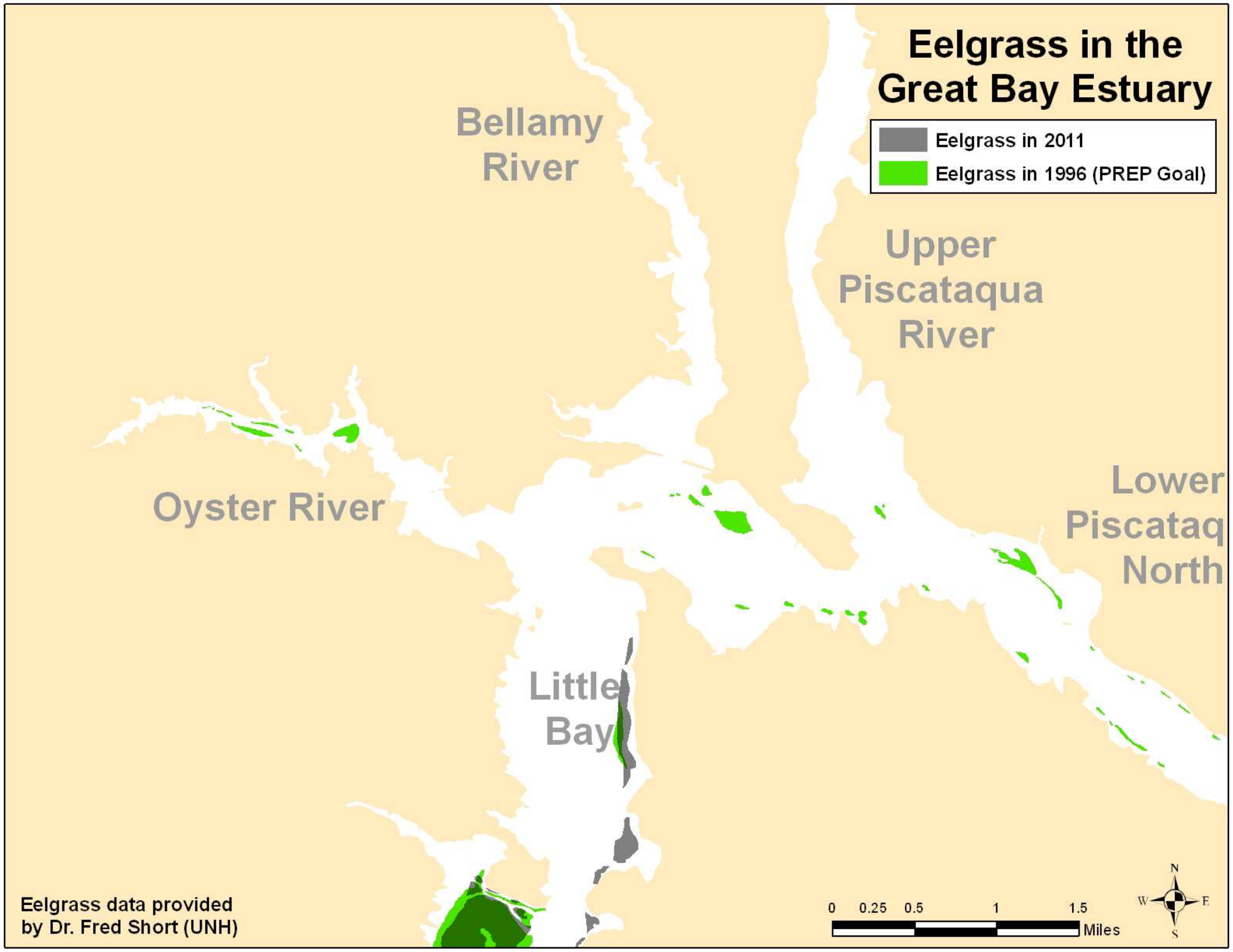


Figure HAB2-3: Eelgrass cover in Great Bay and its tributaries in 1996 and 2011



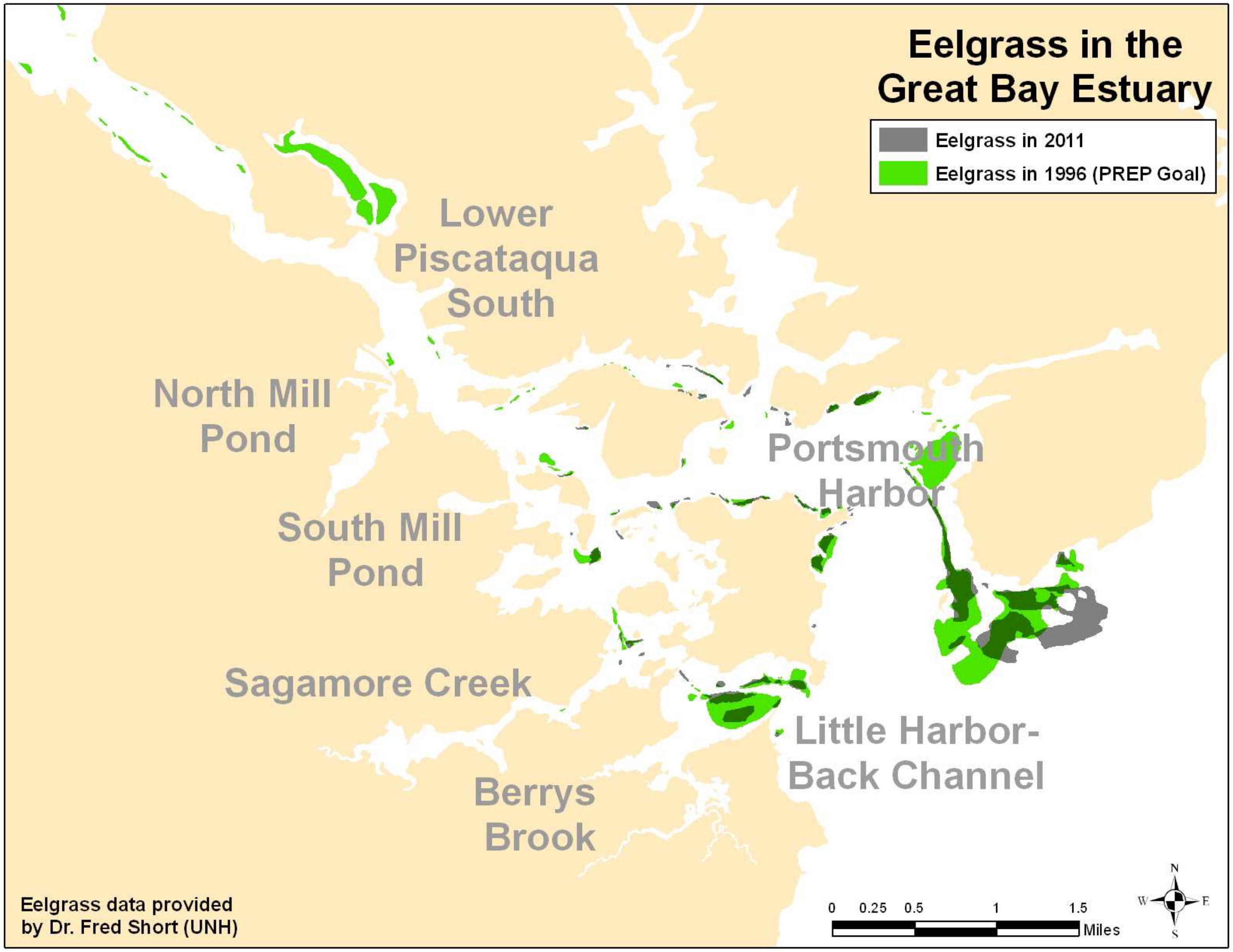
Eelgrass data provided by Dr. Fred Short (UNH)

Figure HAB2-4: Eelgrass cover in Little Bay and its tributaries in 1996 and 2011



Eelgrass data provided by Dr. Fred Short (UNH)

Figure HAB2-5: Eelgrass cover in the Lower Piscataqua River, Little Harbor, and Portsmouth Harbor in 1996 and 2011



Eelgrass data provided by Dr. Fred Short (UNH)

Indicator: NUT3a. Suspended sediment concentrations in the estuary

Objectives

The objective of this indicator is to quantify long-term trends in suspended sediment concentrations in estuarine waters. Suspended sediments in the water column can affect the clarity of the water (Gallegos, 2001; Morrison et al., 2008). Water clarity is critical for the survival of eelgrass beds (CBP, 2000). The possible sources of suspended particles in the estuary are primary productivity in the estuary, resuspension of sediments within the bay, and erosion from the developed landscape.

PREP Goal

Obj WR 1.4: Reduce sediment loads to the estuaries and the ocean so that adverse, sediment-related effects do not occur. Consistent with previous PREP reports, the goal will be interpreted to be no increasing trends for suspended sediments.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

Trend analysis for suspended sediment was performed at the following stations (Figure NUT3a-1):

- 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)
- NH-0057A (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. Results reported as “below detection level” were included in the analysis with a value equal to one-half the laboratory method detection limit (or one-half the lowest detected concentration for the historic datasets) because there were few censored values (<5% for most parameters). Field duplicate samples collected for quality-assurance were not included in the trend analysis. 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. At station GRBAP, which is monitored year round, years with data in 10 or more months were considered to have complete data because samples were collected in all four seasons. At the other stations, which are monitored from April to December, years with data in 7 or more months between April and December were considered to have complete data. It was important to identify years with complete data to avoid introducing bias from years for which the data do not reflect the full range of seasons.

Linear regression of was used to test for long-term trends. The monthly measurements from years with complete data were regressed against the year variable. Data from years with incomplete data were not included in the regression calculation. Trends were considered significant if the coefficient of the year variable was significant at the $p<0.05$ level. The overall change over the period of record was determined by calculating the value of the regression line for the first and last years with complete data. The difference between the two values divided by the first value was used to represent the average percent change over the period of record.

Analysis of variance was used to test for short-term changes between the most recent three-year period and the preceding three-year period. The monthly measurements from years with complete data in the two three-year periods were tested for differences in the mean using

ANOVA. Data from years with incomplete data were not included in the calculation. Differences between the means at the $p<0.05$ level were considered significant.

For each station, the annual average suspended sediment concentration was plotted versus year. For years with complete data, the standard deviation of the data in the year was shown as an error bar.

Data Sources
Data for this indicator were provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Programs. Historic datasets from 1974 to 1981 (Norall et al, 1982; Loder et al, 1983) were also included in the trend analysis for station GRBAP.

Data Gaps
Trend monitoring stations are missing in the Winnicut, Bellamy, Cocheco, Salmon Falls, and Piscataqua Rivers and in Hampton-Seabrook Harbor.

<u>Results</u>

The results of the trend analysis for suspended sediments are summarized in Table NUT3a-1. Plots of suspended sediments at each station are shown on Figure NUT3a-2.

The only statistically significant long-term trend was at Adams Point where the concentrations of suspended sediment have increased by 284% between 1976 and 2011.

The only statistically significant short term change was at Chapmans Landing where the concentrations of suspended solids were higher in the last three years than in the preceding three-year period.

Suspended sediment concentrations are important because Morrison et al. (2008) found that non-algal particles contributed significantly to light attenuation in the vicinity of the Great Bay Coastal Buoy in 2007.

In summary, at Adams Point, where the most data have been collected, there have been long-term trends of increasing suspended solids (284% increase since 1976). There were no other significant trends at other stations.

EXHIBIT 36 (AR K.22)

Figure NUT3a-1: Trend stations for suspended sediment monitoring

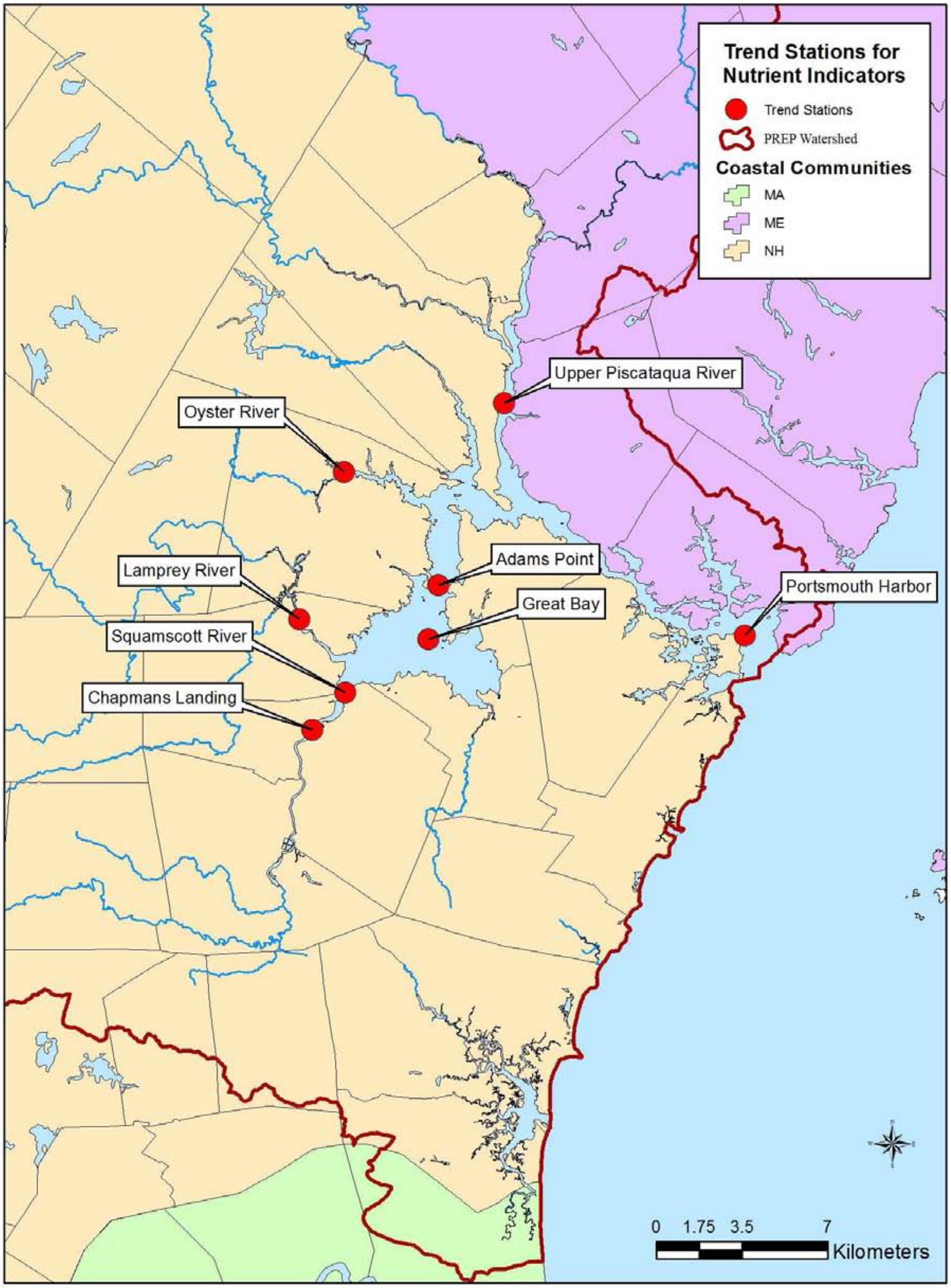


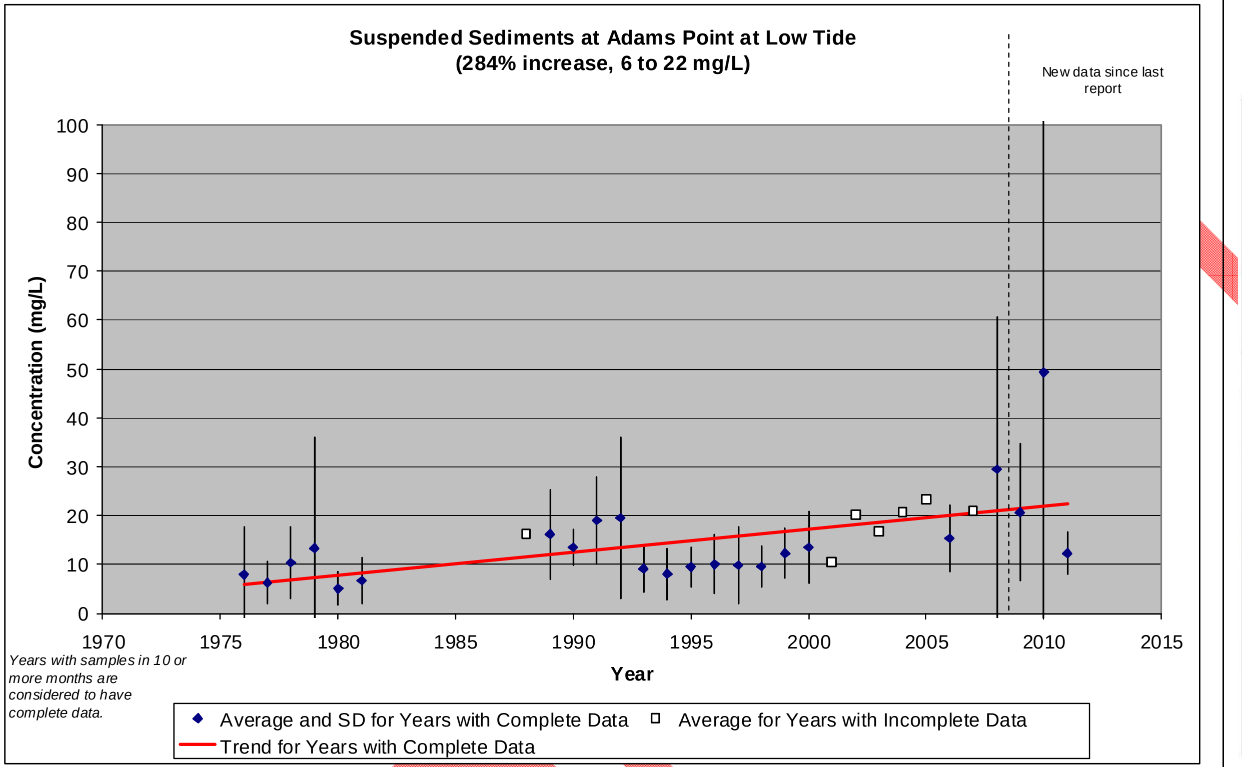
EXHIBIT 36 (AR K.22)

Table NUT3a-1: Trends for suspended sediments in the Great Bay Estuary

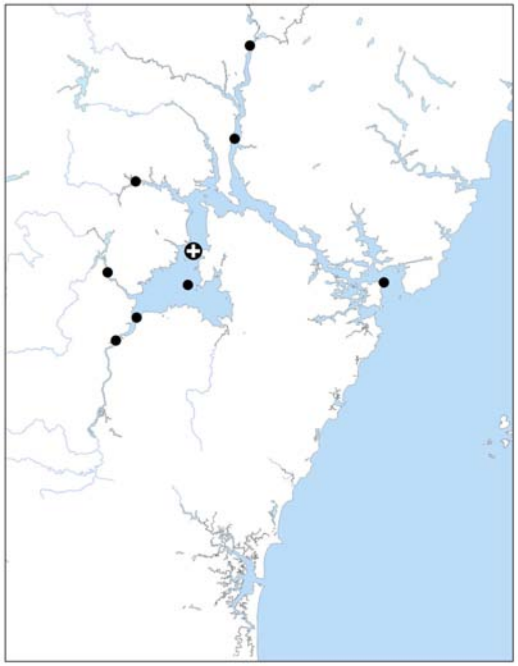
Station	Parameter	Period	Average Conc. in 2009-2011 (mg/L)	Long Term Trend	Recent Change
GRBAP (full year)	Suspended Solids	1976-2011	27.0	284% increase, 6 to 22 mg/L	
GRBCL (Apr-Dec)	Suspended Solids	1989-2011	25.8	No significant trend	Higher
GRBSQ (Apr-Dec)	Suspended Solids	2004-2011	44.7	No significant trend	
GRBLR (Apr-Dec)	Suspended Solids	1992-2011	4.6	No significant trend	
GRBGB (Apr-Dec)	Suspended Solids	2002-2011	18.9	No significant trend	
GRBOR (Apr-Dec)	Suspended Solids	2004-2011	23.4	No significant trend	
NH-0057A (Apr-Dec)	Suspended Solids	2007-2011	12.0	No significant trend	
GRBCML (Apr-Dec)	Suspended Solids	2002-2011	12.5	No significant trend	

Station Locations
GRBAP (Adams Point between Great Bay and Little Bay)
GRBCL (Chapmans Landing in the Squamscott River)
GRBSQ (Squamscott River at the railroad trestle)
GRBLR (Lamprey River)
GRBGB (Great Bay)
GRBOR (Oyster River)
NH-0057A (Upper Piscataqua River)
GRBCML (Portsmouth Harbor)

Figure NUT3a-2: Suspended sediment trends at stations in the Great Bay Estuary



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

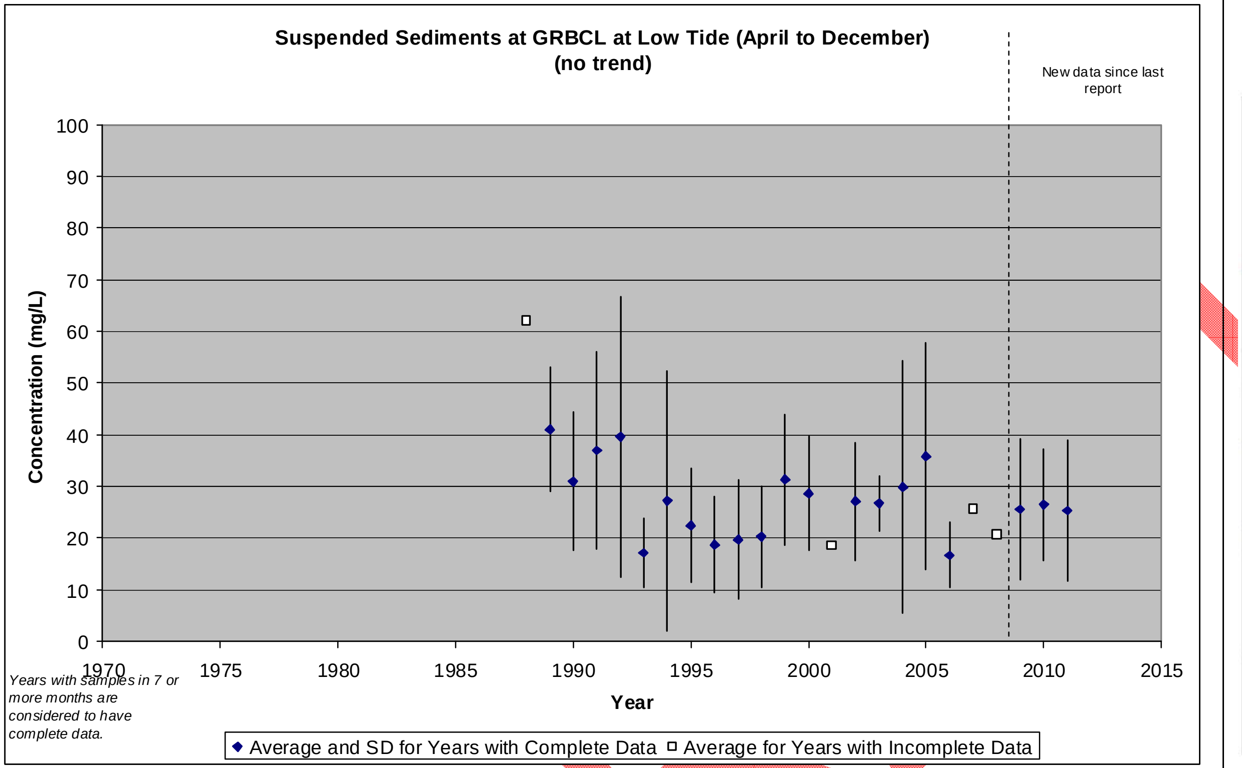


Station: GRBAP (Adams Point between Great Bay and Little Bay)

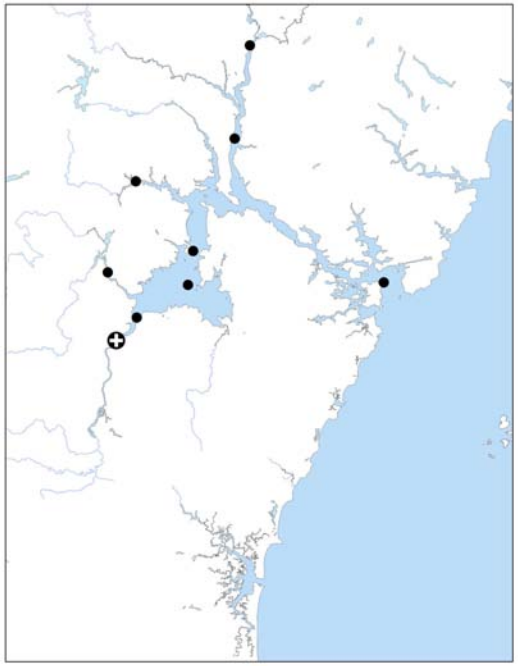
Average Concentration in 2009-2011: 27.0 mg/L

Long Term Trend: 284% increase, 6 to 22 mg/L

Recent Change: None



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



Station: GRBCL (Chapmans Landing in the Squamscott River)

Average Concentration in 2009-2011: 25.8 mg/L

Long Term Trend: No significant trend

Recent Change: Higher

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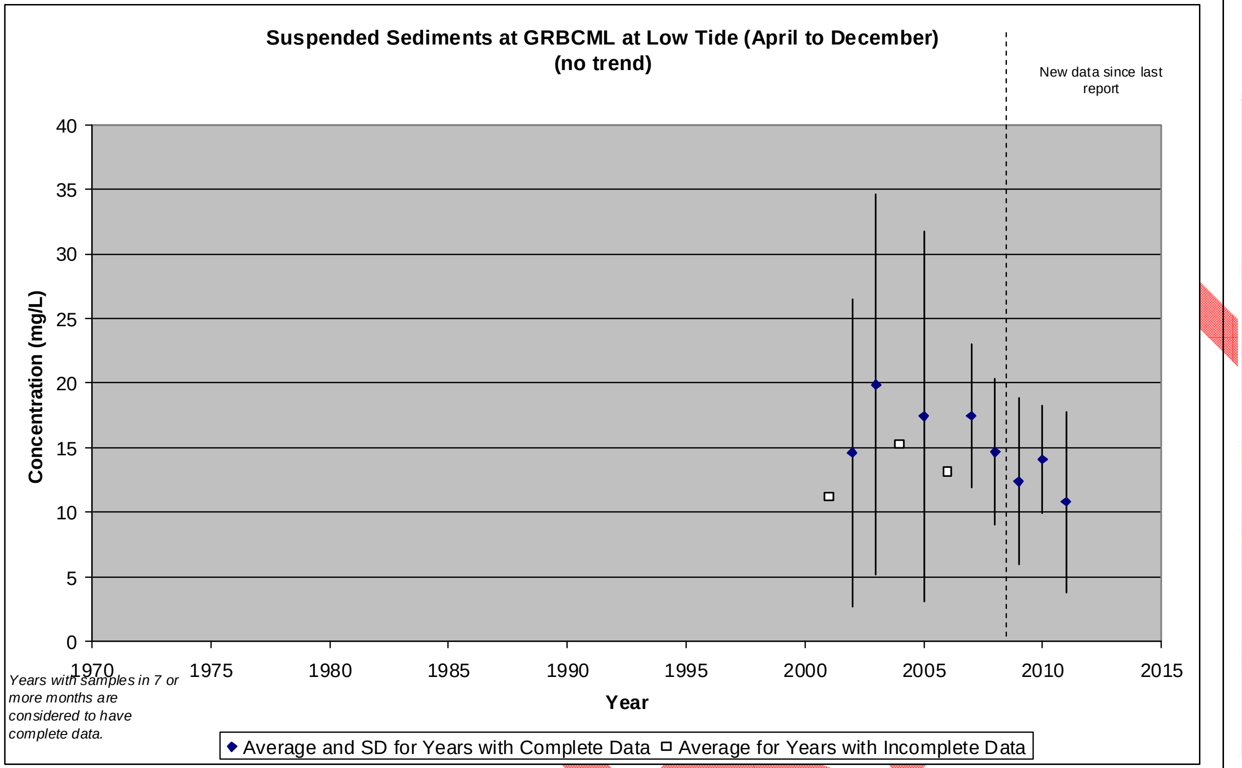
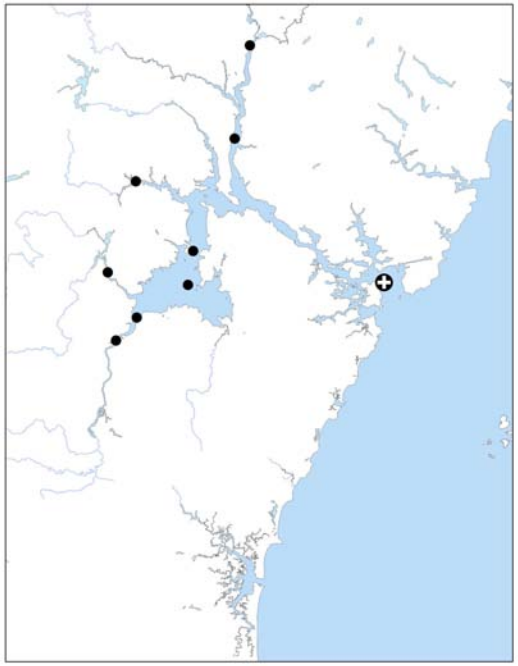


Monitoring Location (GRBCML)
(black circle with white plus sign)

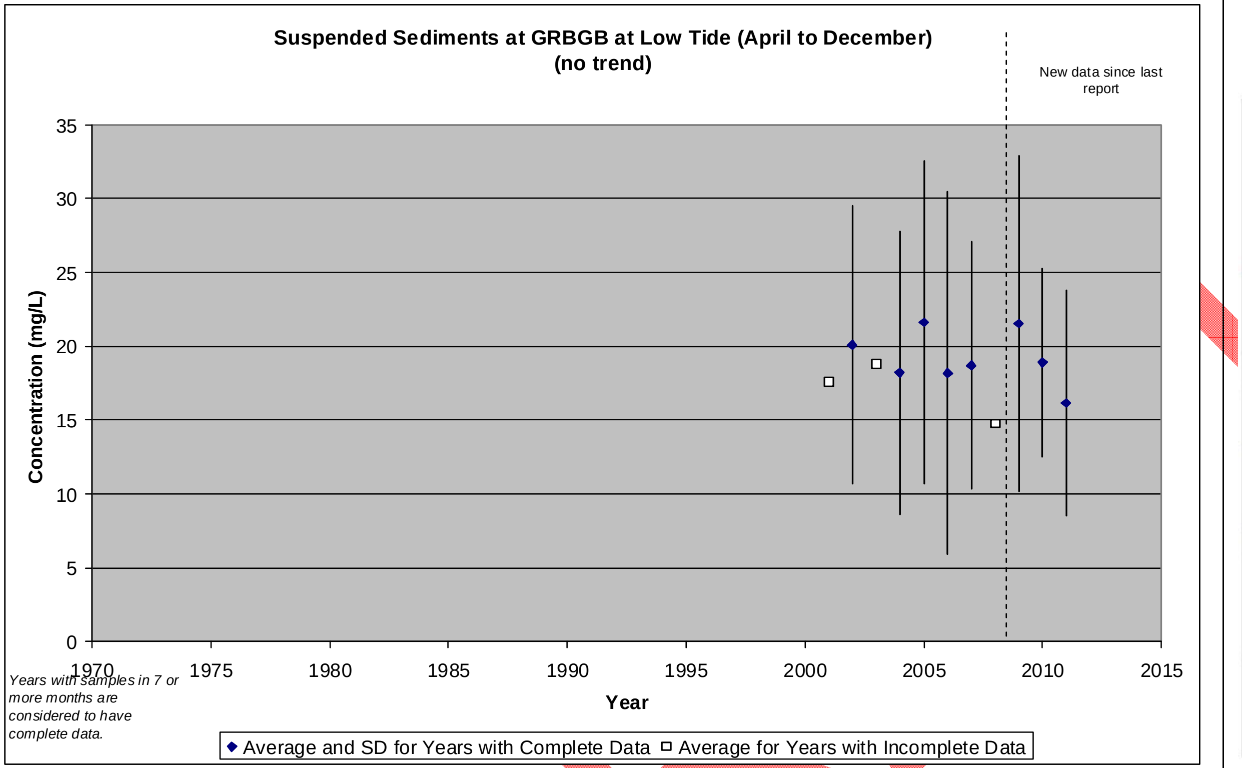


Station: GRBCML (Portsmouth Harbor)

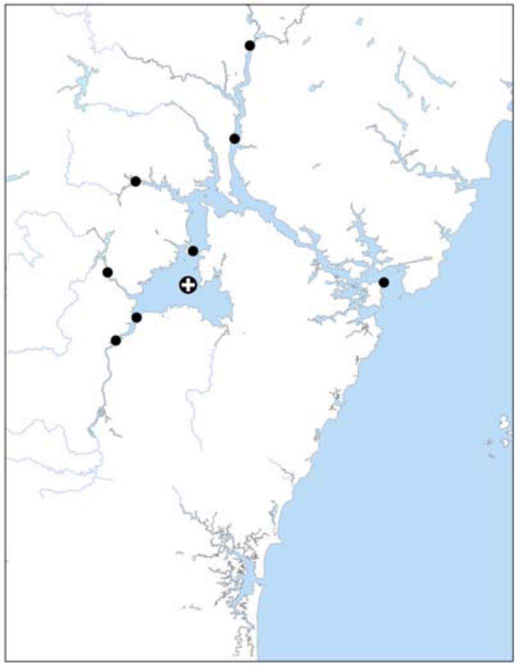
Average Concentration in 2009-2011: 12.5 mg/L

Long Term Trend: No significant trend

Recent Change: None



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

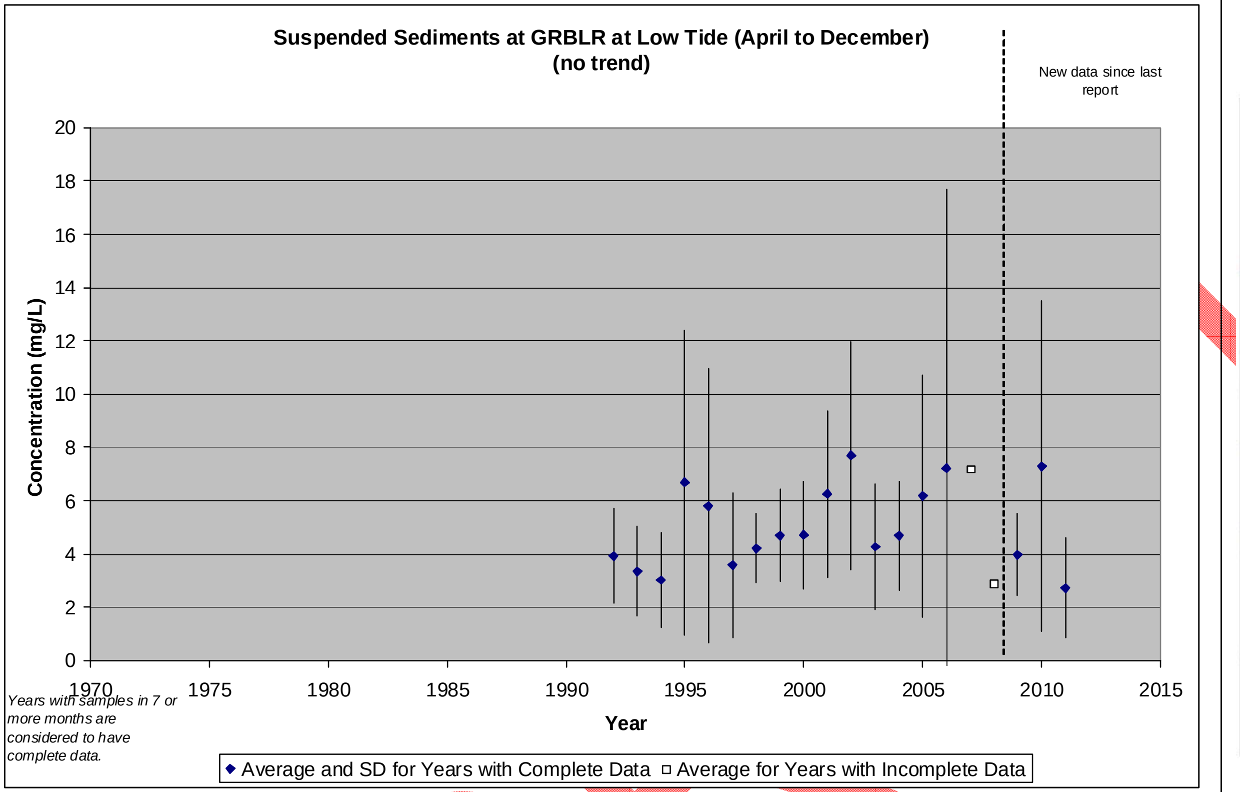


Station: GRBGB (Great Bay)

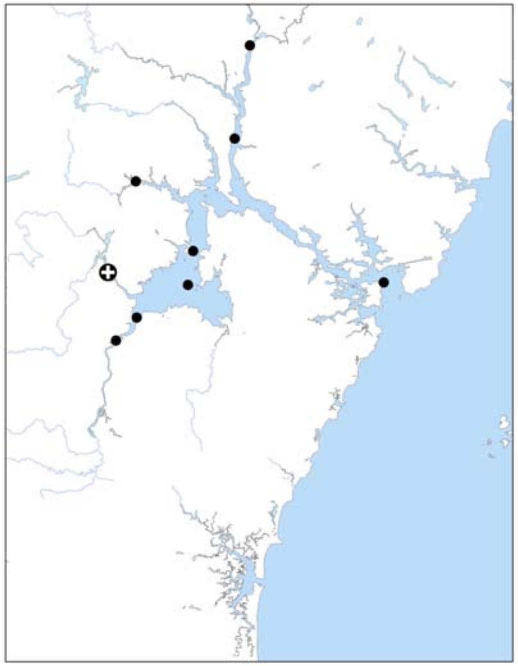
Average Concentration in 2009-2011: 18.9 mg/L

Long Term Trend: No significant trend

Recent Change: None



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



Station: GRBLR (Lamprey River)

Average Concentration in 2009-2011: 4.6 mg/L

Long Term Trend: No significant trend

Recent Change: None

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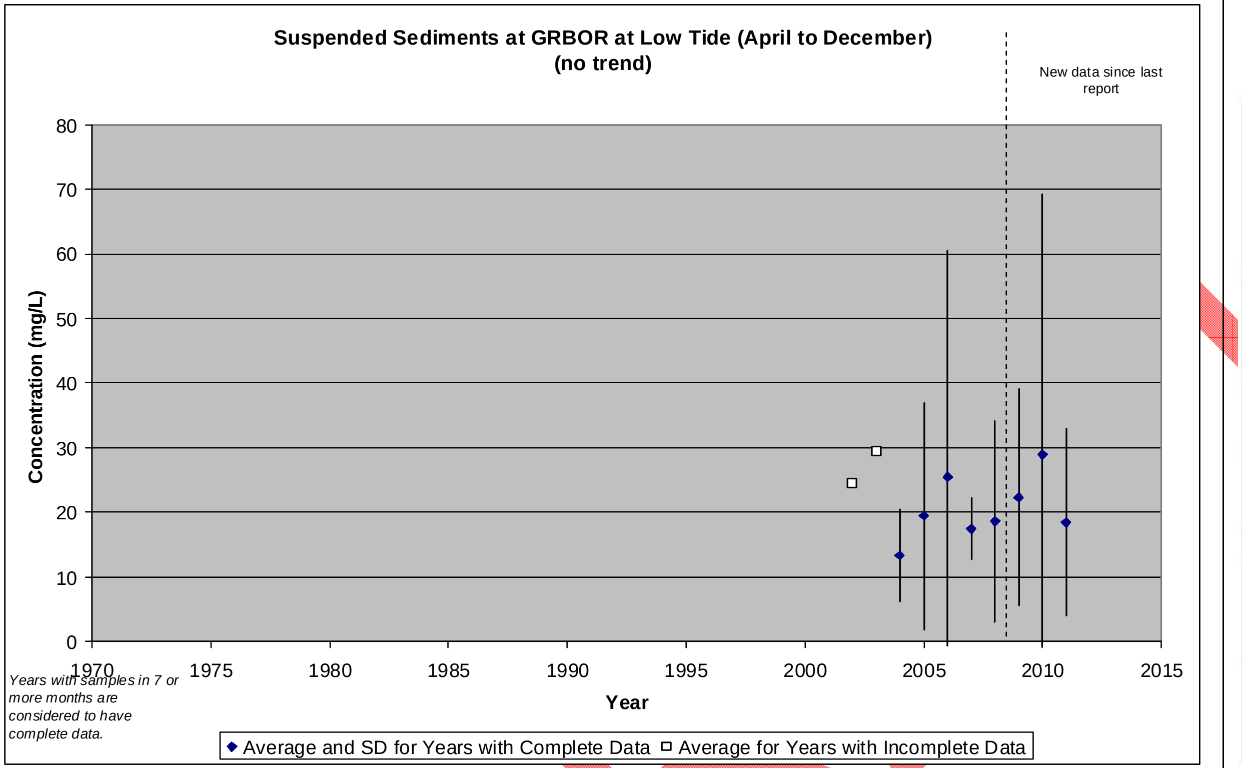
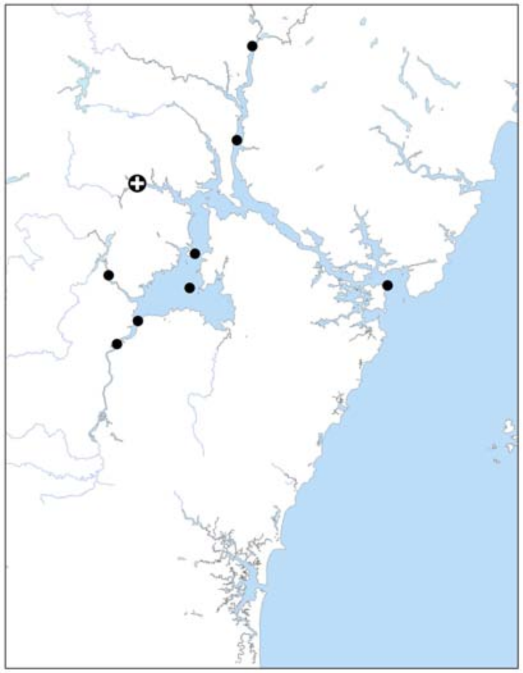
Suspended Sediments at GRBOR at Low Tide (April to December)
(no trend)



Years with samples in 7 or more months are considered to have complete data.

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



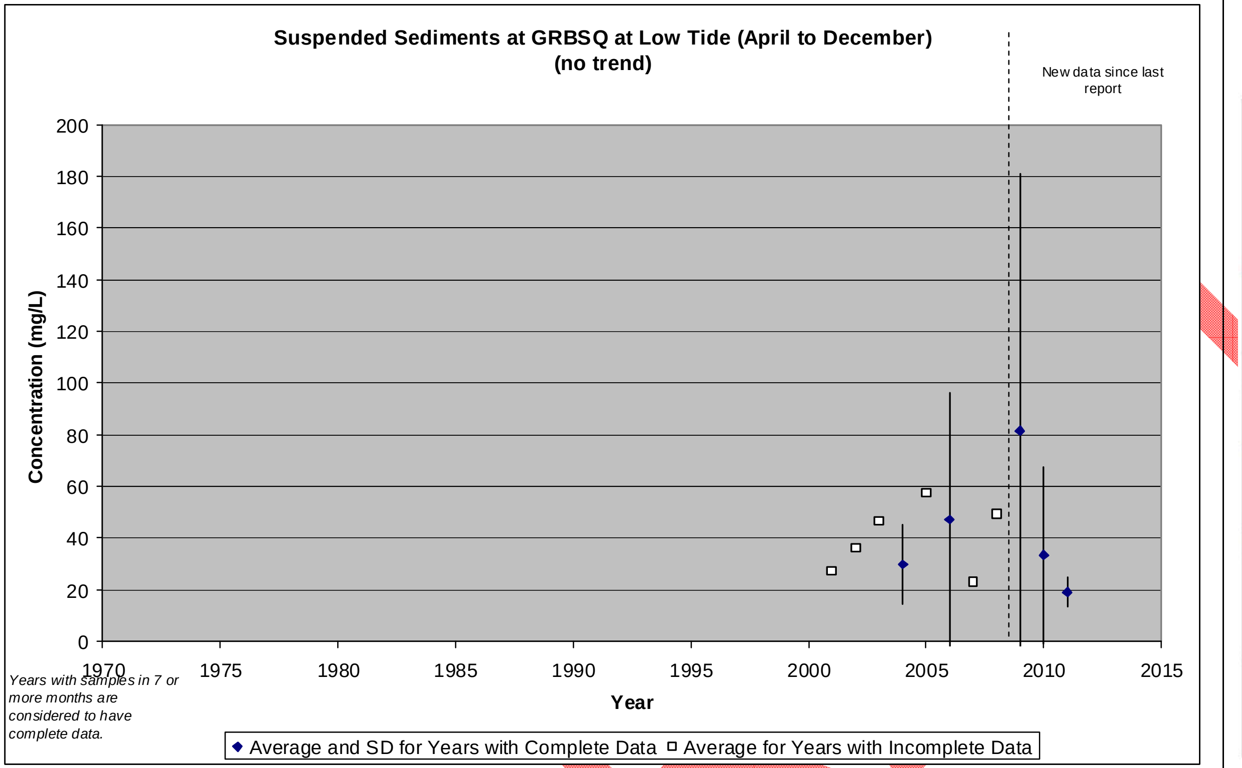
Station: GRBOR (Oyster River)

Average Concentration in 2009-2011: 23.4 mg/L

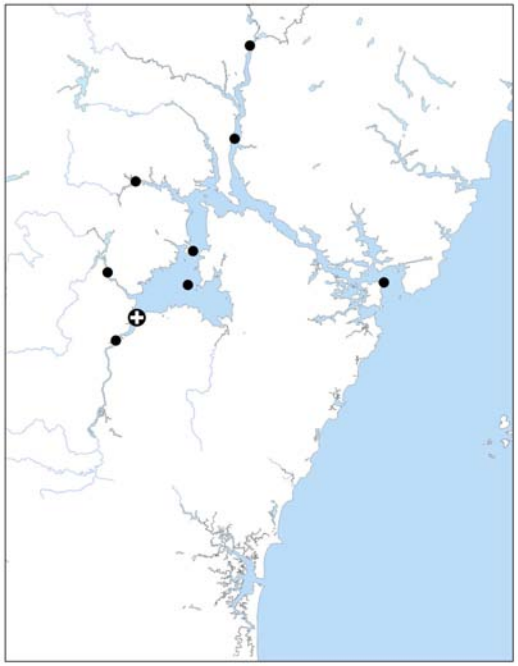
Long Term Trend: No significant trend

Recent Change: None

EXHIBIT 36 (AR K.22)



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



Station: GRBSQ (Squamscott River at the railroad trestle)

Average Concentration in 2009-2011: 44.7 mg/L

Long Term Trend: No significant trend

Recent Change: None

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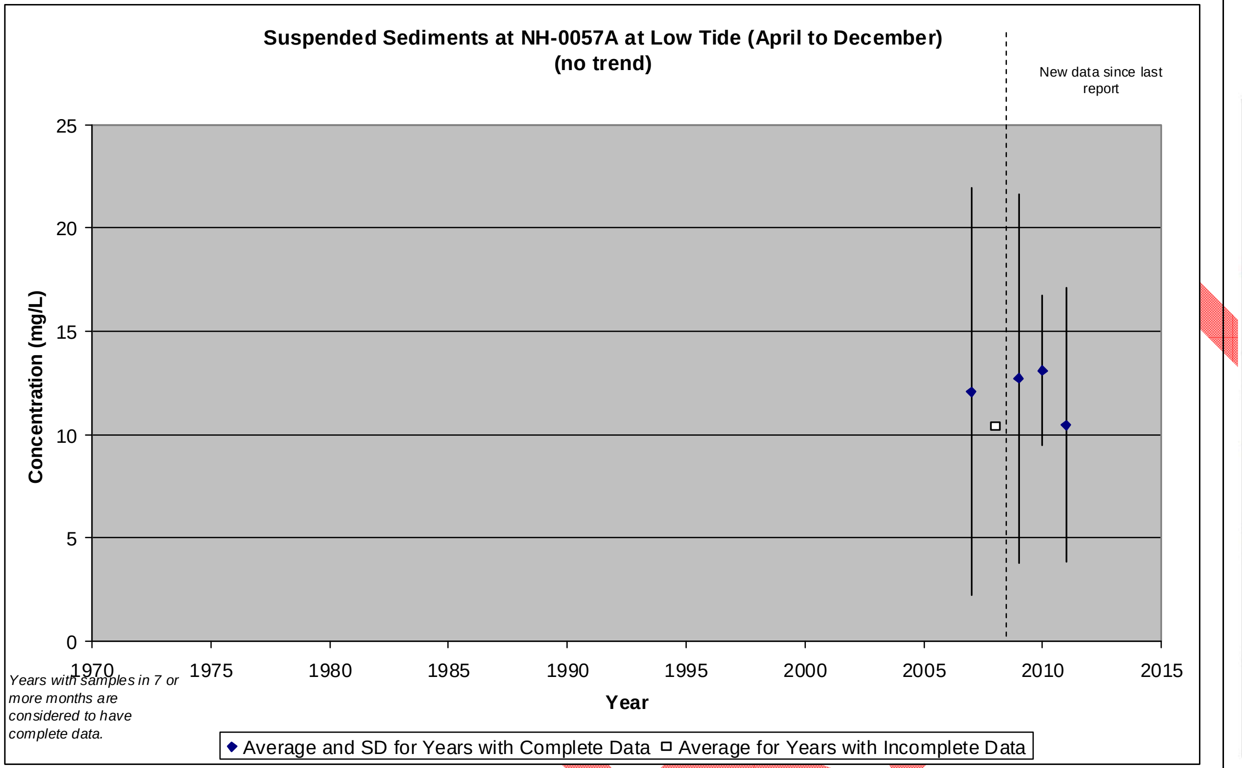
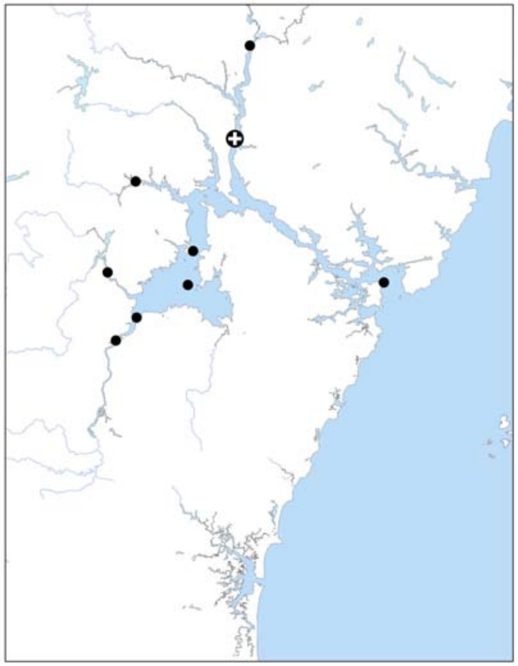


Suspended Sediments at NH-0057A at Low Tide (April to December)
(no trend)

Years with samples in 7 or more months are considered to have complete data.

Monitoring Location (NH-0057A)
(black circle with white plus sign)



Station: NH-0057A (Upper Piscataqua River)

Average Concentration in 2009-2011: 12.0 mg/L

Long Term Trend: No significant trend

Recent Change: None

Indicator: BAC2. Dry-weather bacteria concentrations in the estuary

Objective

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, and *Escherichia coli*) will be measured monthly at fixed stations in the estuary and tributaries. The results from dry weather samples will be analyzed for long-term trends. Bacteria in surface waters may indicate the presence of pathogens due to sewage contamination. Pathogens, which are disease-causing microorganisms, pose a public health risk and are the primary reason why shellfish beds and public beaches are closed.

PREP Goal

Obj WR 1.1: Improve water quality and identify and mitigate pollution sources so additional estuarine areas meet water quality standards for bacteria for shellfish harvesting. The goal will be interpreted to be no increasing trends for any bacteria species.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

First, samples that were collected at low tide during dry weather were queried from the dataset. Measurements of bacteria concentrations (fecal coliforms, enterococcus, and *Escherichia 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.

Second, 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 coefficient of the year variable was significant at the $p<0.05$ level. The percent change in concentrations was calculated following Helsel and Hirsch (1992). Specifically, the coefficient of the year variable, b1, was converted to a percent change per year by $(e^{b1}-1)*100$. The overall change over the period of record was determined from the percent change per year and a first order differential equation. Trend analysis was not completed unless at least ten years of data were available for a site.

Data Sources

Data for this indicator was provided by the UNH and Great Bay NERR Tidal Water Quality Monitoring Program

Data Gaps

Monthly low tide samples for bacteria were not available for Hampton-Seabrook Harbor or the Piscataqua River. The Oyster River was the only other location regularly monitored for bacteria at low tide but there were only seven years of data at this site in 2011.

Results

The results of the trend analysis at the four stations are summarized in Table BAC2-1. Graphs of the bacteria indicator species over time at each station are shown in Figures BAC2-1 through BAC2-4. For each station, the graphs show the trends over the full period of record on the left and for the most recent 10 years (2002-2011) on the right. The locations of the trend stations are shown in Figure BAC2-5.

Fecal coliform and *Escherichia coli* concentrations decreased at the four long-term trend sites in the Great Bay, Portsmouth Harbor, Lamprey River, and the Squamscott River for the full period of record. The magnitude of the decrease at each station was between 50 and 92 percent. Paradoxically, enterococcus in the Squamscott River shows a statistically significant increasing trend for the full period of record. The magnitude of the increase was 122%.

In the most recent 10 years (see Table BAC2-1B), the only statistically significant trends were observed in the Lamprey River. Fecal coliform and *Escherichia coli* concentrations decreased by 59% and 60%, respectively, between 2002 and 2011.

Therefore, for the full period of record (1989-2011) the goal of observing decreasing trends in the tidal tributaries is mostly being met. The only increasing trend was seen in the Squamscott River for enterococcus. WWTF upgrades and stormwater management projects are likely major contributors to the decreasing trends. However, all of the trend conclusions are based on data from only four stations in the estuary. Moreover, most of the trends became non-significant in the last decade, with the exception of fecal coliforms and *Escherichia coli* in the Lamprey River.

The observed trends may have been driven by large decreases in the late 1980s and early 1990s, with smaller changes occurring in the past decade. Alternatively, continued population growth in the Piscataqua Region watershed may be counteracting the ongoing pollution control efforts. It should be noted, that although not statistically significant, fecal coliform and *Escherichia coli* concentrations in the Squamscott River have been trending upwards over the last ten years (Figure BAC2-3).

EXHIBIT 36 (AR K.22)

Table BAC2-1: Trends in dry weather bacteria concentrations at low tide at long-term monitoring stations

A. Trends for full period of record

Station Location	Parameter	Period of Record	Median (cts/100ml)	Trend	Percent Change	Comments
Adams Point	Fecal coliforms	1989-2011	7.3	**Decreasing**	-68%	
	Enterococcus		3.0	No significant trend		
	E. coli		6.0	**Decreasing**	-58%	
Lamprey River	Fecal coliforms	1992-2011	52.0	**Decreasing**	-89%	
	Enterococcus		35.0	No significant trend		
	E. coli		45.0	**Decreasing**	-92%	
Squamscott River	Fecal coliforms	1989-2011	70.0	**Decreasing**	-61%	
	Enterococcus		35.0	**Increasing**	122%	
	E. coli		50.0	**Decreasing**	-50%	
Portsmouth Harbor	Fecal coliforms	1991-2011	6.3	**Decreasing**	-56%	
	Enterococcus		2.1	No significant trend		
	E. coli		5.0	**Decreasing**	-52%	

B. Trends for the most recent 10 years

Station Location	Parameter	Period of Record	Median (cts/100ml)	Trend	Percent Change	Comments
Adams Point	Fecal coliforms	2002-2011	6.0	No significant trend		
	Enterococcus		3.0	No significant trend		
	E. coli		4.5	No significant trend		
Lamprey River	Fecal coliforms	2002-2011	40.0	**Decreasing**	-59%	
	Enterococcus		38.0	No significant trend		
	E. coli		32.0	**Decreasing**	-60%	
Squamscott River	Fecal coliforms	2002-2011	56.0	No significant trend		
	Enterococcus		52.4	No significant trend		
	E. coli		42.0	No significant trend		
Portsmouth Harbor	Fecal coliforms	2002-2011	6.0	No significant trend		
	Enterococcus		3.0	No significant trend		
	E. coli		5.0	No significant trend		

Source: UNH and Great Bay NERR Tidal Water Quality Monitoring Programs

Significant trends have $P<0.05$

EXHIBIT 36 (AR K.22)

Figure BAC2-1: Long-term trends in bacteria indicators at Adams Point in Great Bay

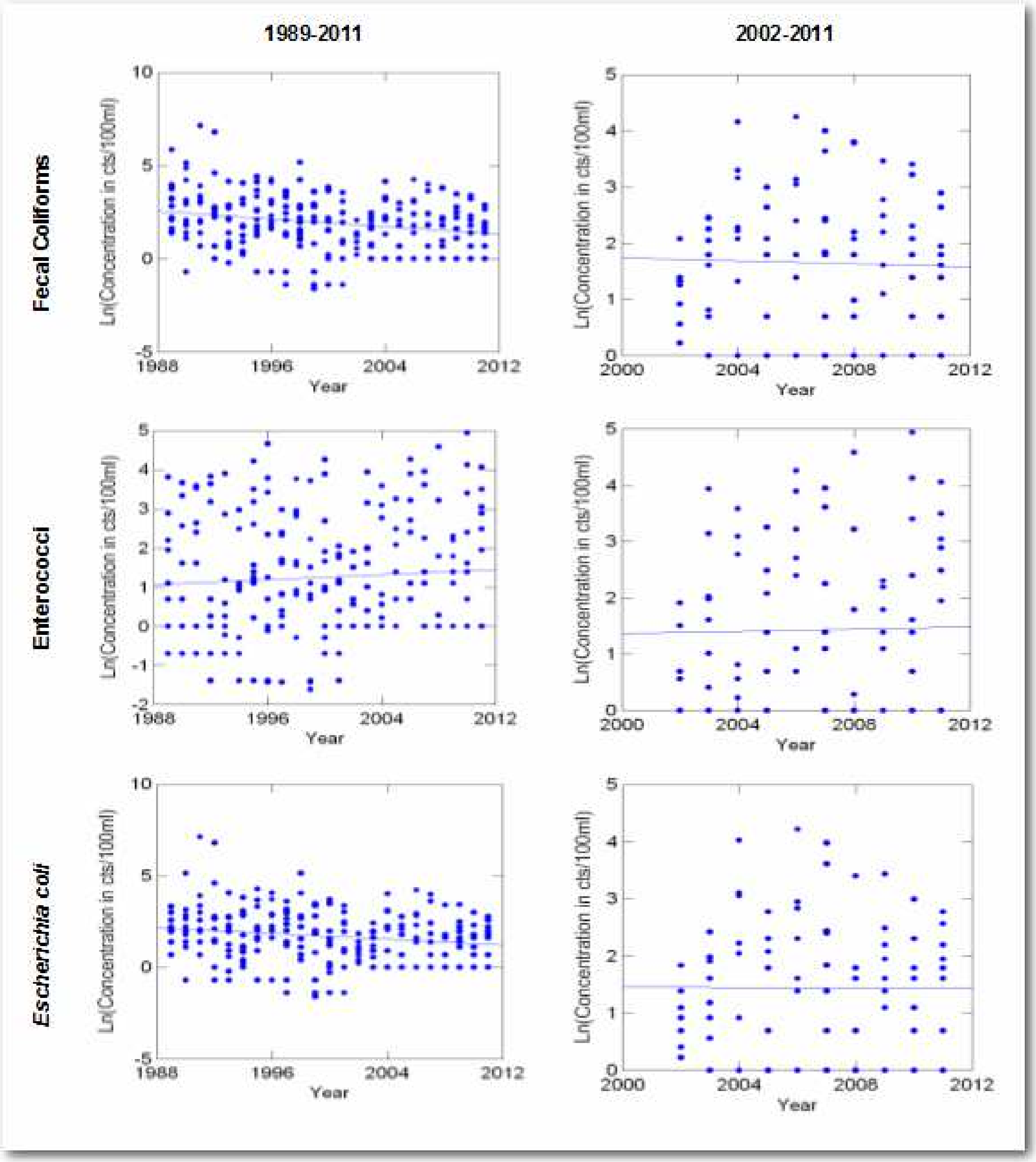


Figure BAC2-2: Long-term trends in bacteria indicators at the Newmarket Town Landing on the Lamprey River (tidal portion)

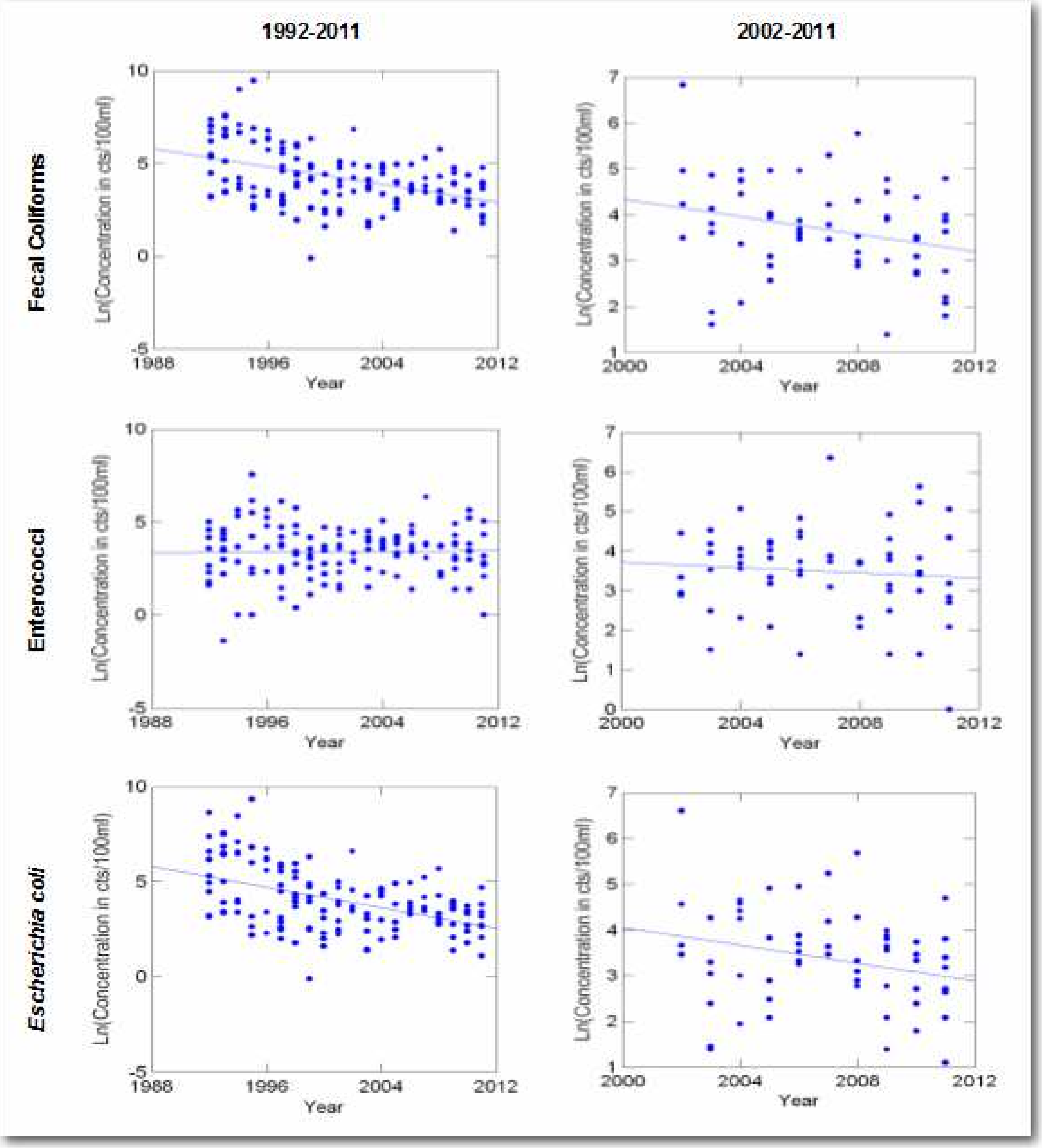


EXHIBIT 36 (AR K.22)

Figure BAC2-3: Long-term trends in bacteria indicators at Chapmans Landing on the Squamscott River

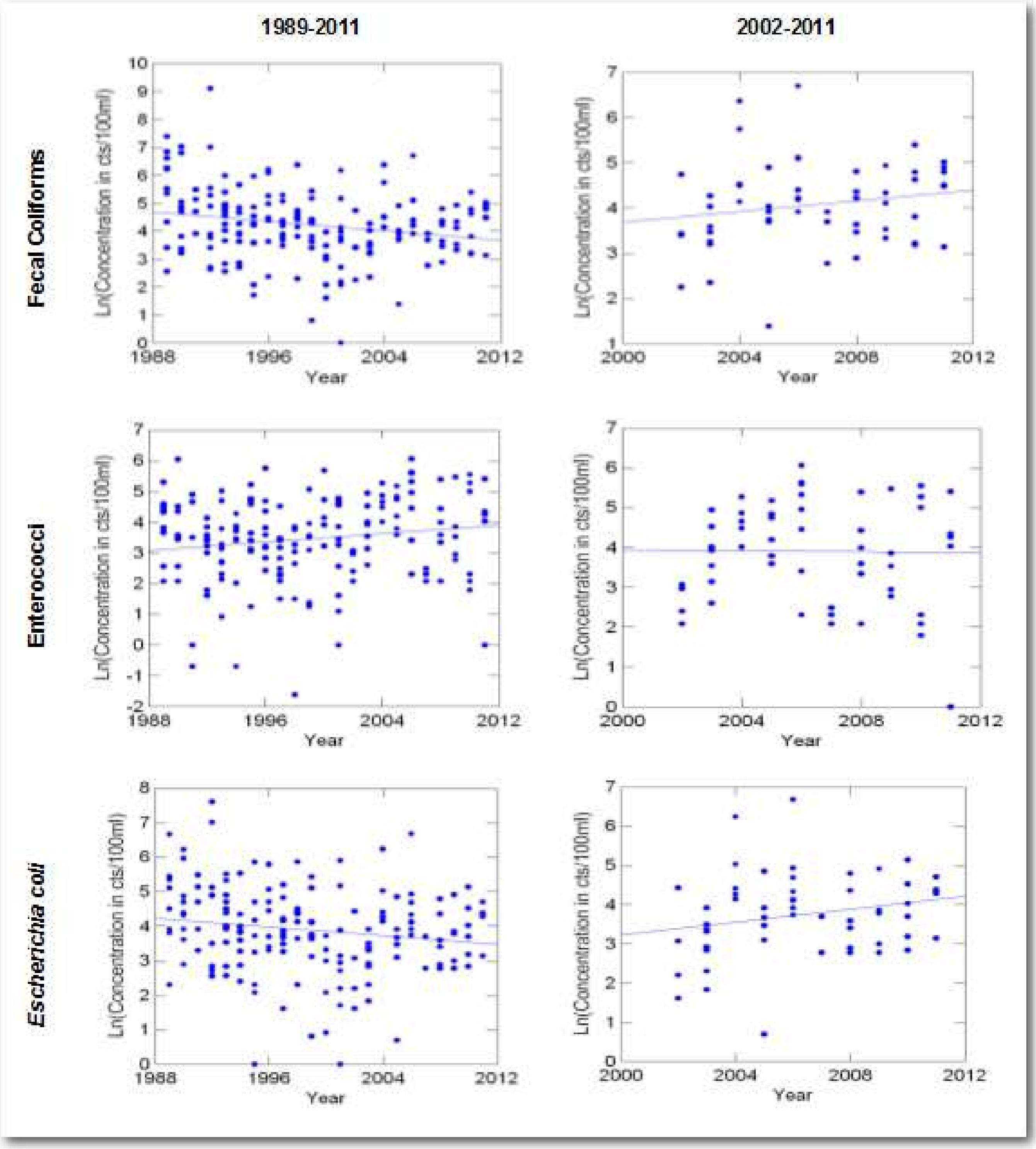


EXHIBIT 36 (AR K.22)

Figure BAC2-4: Long-term trends in bacteria indicators at Fort Point in Portsmouth Harbor

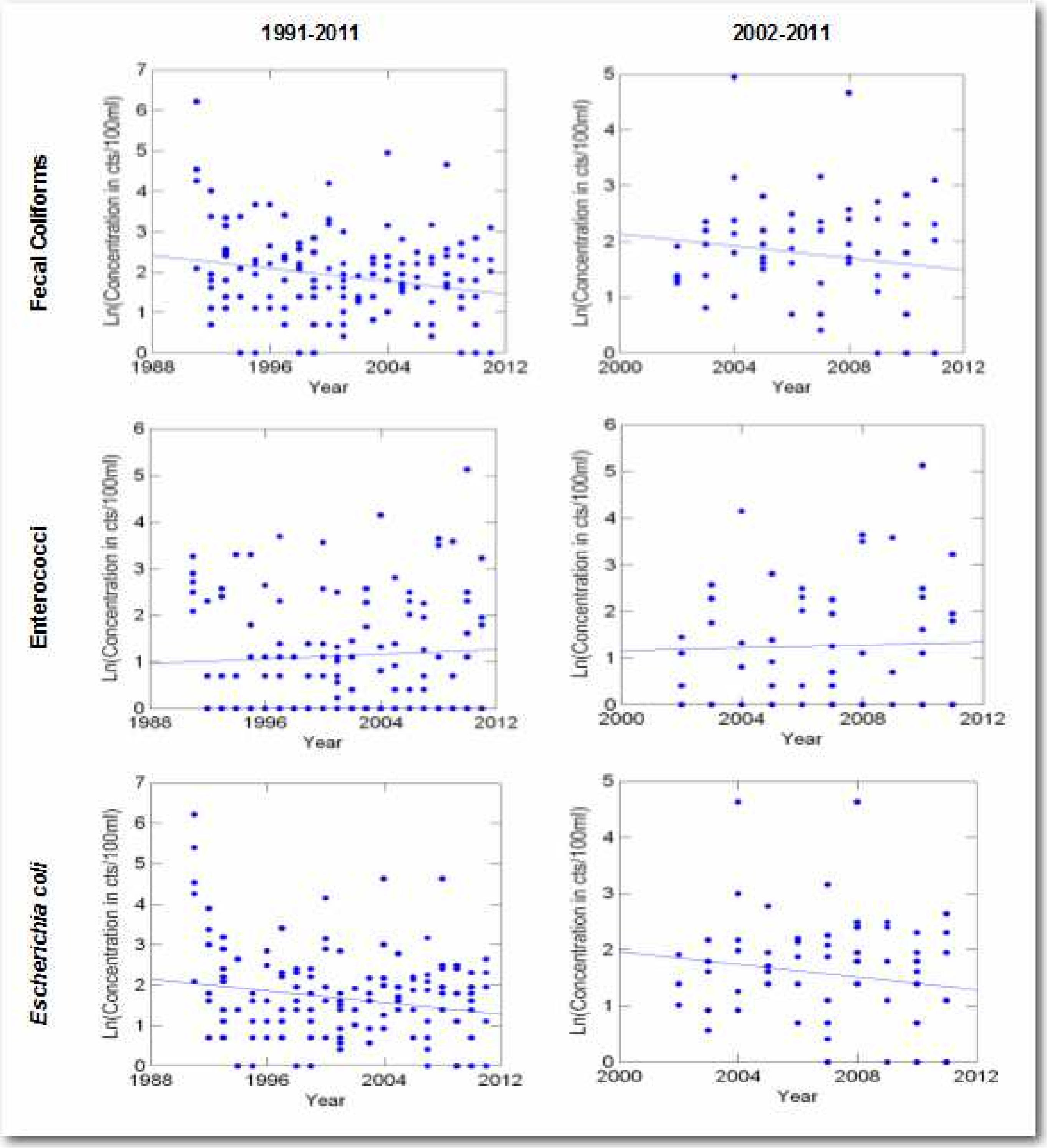
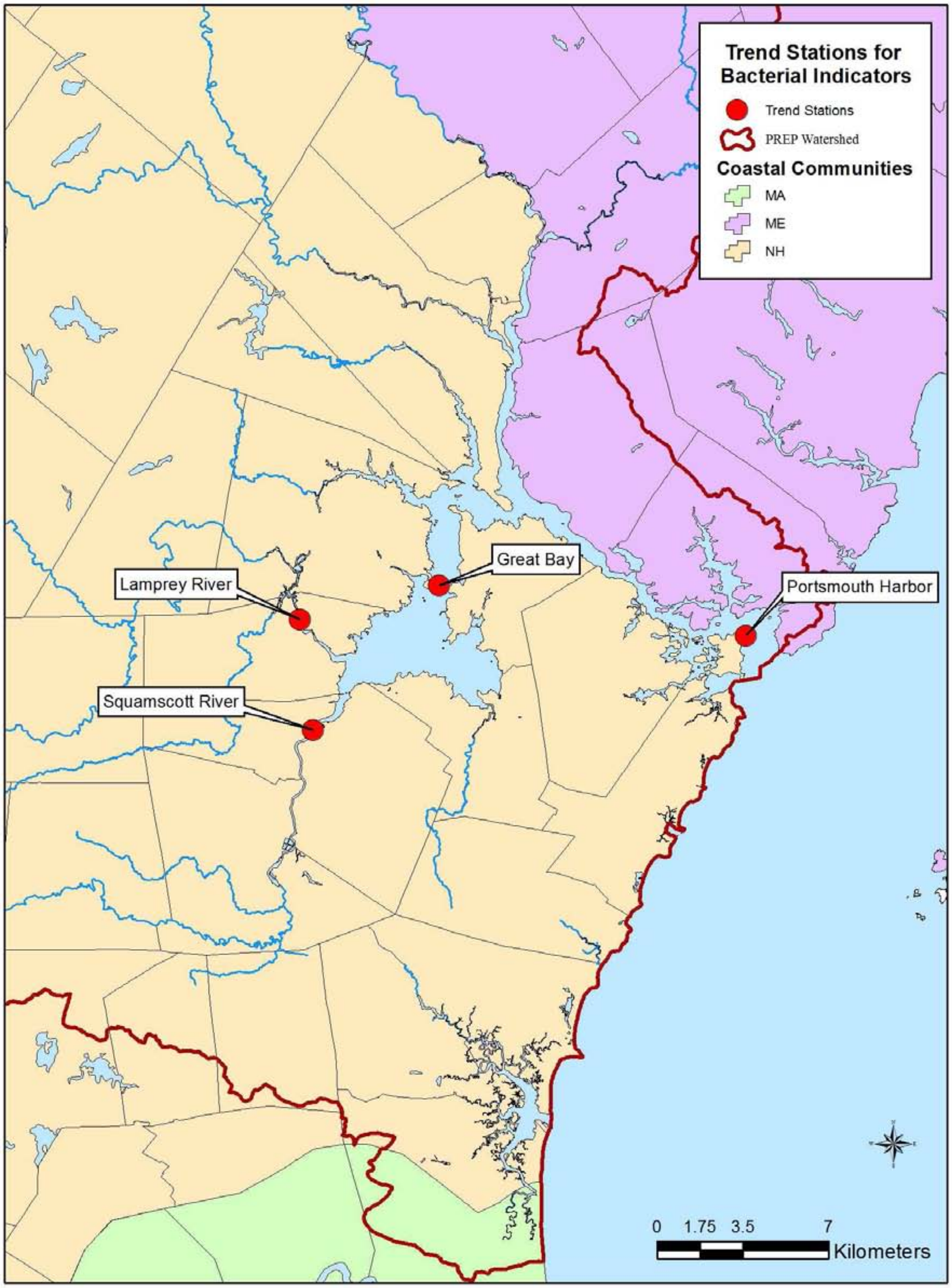


Figure BAC2-5: Trend stations for bacteria indicator species



Indicator: BAC1 - Shellfish harvesting opportunities in the estuary

Objective

The objective of this indicator is to report on how much of the year the shellfish beds are closed to harvesting due to high bacteria concentrations. The NHDES Shellfish Program and Maine Department of Marine Resources classify different segments of the estuary as either approved, conditionally approved (often depending on rainfall), prohibited or restricted for shellfish harvest. For the conditionally approved areas, the total harvesting opportunities over the year can be measured using an “acre-days” indicator, 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 related to the potential for high bacteria in the growing waters (although closures due to PSP or “red-tide” do occur). 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.

PREP Goal

Obj WR 1.1: Improve water quality and identify and mitigate pollution sources so additional estuarine areas meet water quality standards for bacteria for shellfish harvesting. Consistent with previous PREP reports, the goal will be interpreted to be 100% of possible acre-days in estuarine waters open for harvesting.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

First, the areas of estuarine waters in each NSSP classification category were compiled in a table showing the percentage of the estuarine waters in the “approved” or “conditionally approved”, “restricted” or “prohibited” categories. All estuarine waters in both the New Hampshire and Maine were included. Ocean waters were not included.

Second, for areas that are classified as “approved” or “conditionally approved”, the percent of possible acre-days that were actually open for harvesting was calculated. The NHDES 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 a percentage of the total possible acre-days of harvesting for the year (this total does not include days when harvesting is not allowed during the summer oyster reproductive season). All estuarine waters in both the New Hampshire and Maine in the “approved” or “conditionally approved” categories were included. Ocean waters were not included. The results for this indicator were reported for five regions: Great Bay, Upper Little Bay, Lower Little Bay, Little Harbor, and Hampton-Seabrook Harbor.

The acre-day calculation by the NHDES Shellfish Program is a precise number. Statistical methods are not needed to compare the results to the goal. No statistical hypothesis is needed.

Data Sources

The acres of estuarine waters in each NSSP classification and the acre-days of harvesting potential for the estuary were taken from annual reports by the NHDES Shellfish Program (http://des.nh.gov/organization/divisions/water/wmb/shellfish/index.htm) and Maine Department of Marine Resources (http://www.maine.gov/dmr/rm/public_health/G_A_reports/index.htm). Shellfish growing area classifications and harvest closures are determined by NHDES and Maine DMR following protocols from NSSP (2009).

Results

Shellfishing classifications and acre-days of shellfishing opportunities have been tracked from 2000 through 2011. Table BAC1-1 shows that in 2000 and 2001, approximately 29 to 31% of the 16,941 acres of estuarine waters were classified as "Approved" or "Conditionally Approved" for shellfishing by the NHDES and the Maine DMR Shellfish Programs. By 2003, the percentage of waters in the "Approved" or "Conditionally Approved" classifications had grown to 38%. The percentage of waters in the "Approved" or "Conditionally Approved" classifications has remained relatively constant from 2004 to 2011, ranging from 35 to 36%. Note that data could not be obtained from the Maine DMR Shellfish Program for 2000 through 2005. The acreage information provided in Table BAC1-1 for 2000 through 2005 are estimates based on the 2006-2011 growing area annual reports from Maine DMR.

Table BAC1-2 shows the trends in shellfish harvesting acre-days for the major growing areas of New Hampshire's estuarine waters. In Great Bay, the shellfishing acre-days averaged 90% of the possible amount in 2000-2005. In Upper and Lower Little Bay, the acre-day average was above 70% between 2000 and 2005. In Hampton-Seabrook Harbor and Little Harbor, the acre-day average was below 40% for the same period. By 2011, the acre-day percentage ranged from 50 to 72% for all areas. There has been an improving trend in the Little Harbor growing area. This area was closed to shellfishing before 2001, but by 2011 it was open 50% of the possible acre-days. There had been a declining trend in shellfish harvesting acre-days in the Great Bay and Little Bay growing areas from a high of 97% open in 2002 to 50% open in 2008. However, between 2009 and 2011 the acre-days indicator for Great Bay and Little Bay increased to between 63-75% of the possible acre-days. There are currently no estuarine waters on the Maine side of the Piscataqua Region watershed that are classified as "Approved" or "Conditionally Approved" due to the presence of several municipal and residential overboard discharges and wastewater treatment plant outfalls on both the New Hampshire and Maine coasts. Therefore, the acre-days indicator for Maine waters could not be calculated.

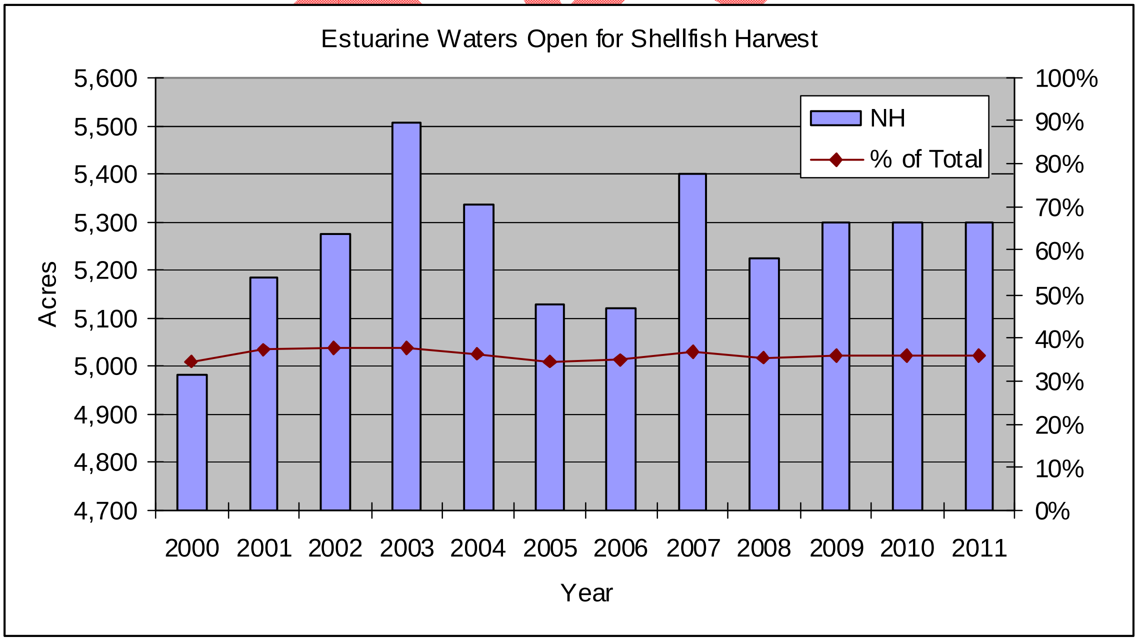
The goal for the acre-days indicator is for all estuarine waters to be open for harvesting 100% of the time. This goal is not being met. Only 36% of the estuarine waters are classified as "Approved" or "Conditionally Approved" for shellfishing. Of these areas, shellfish harvesting can be done only 42% of the possible acre-days. Stormwater runoff is the predominant cause for the harvest restrictions in all areas. Direct runoff of bacteria pollution from the land surface and the occasional wastewater treatment plant overflow cause elevated bacteria concentrations in the shellfish growing areas which prompts the harvest restrictions.

Table BAC1-1: Percent of estuarine waters in each NSSP shellfish classification

Year	Approved or Conditionally Approved (acres)				Restricted or Prohibited (acres)				Total (acres)
	NH	ME	Total	% of Total	NH	ME	Total	% of Total	NH & ME
2000	4979.6	0*	4979.6	29%	8738.4	3223.5*	11961.8	71%	16,941
2001	5185.4	0*	5185.4	31%	8532.6	3223.5*	11756.1	69%	16,941
2002	5275.8	0*	5275.8	31%	8477.0	3223.5*	11700.4	69%	16,976
2003	5507.2	0*	5507.2	38%	5847.8	3223.5*	9071.3	62%	14,578
2004	5336.6	0*	5336.6	36%	6115.4	3223.5*	9338.8	64%	14,675
2005	5125.9	0*	5125.9	35%	6471.1	3223.5*	9694.6	65%	14,820
2006	5120.6	0	5120.6	35%	6374.9	3223.5	9598.4	65%	14,719
2007	5400.0	0	5400.0	36%	6188.0	3223.5	9411.5	64%	14,811
2008	5226.6	0	5226.6	35%	6362.4	3223.5	9585.8	65%	14,812
2009	5298.2	0	5298.2	36%	6291.0	3223.5	9514.5	64%	14,813
2010	5298.2	0	5298.2	36%	6291.8	3223.5	9515.3	64%	14,814
2011	5298.2	0	5298.2	36%	6291.8	3223.5	9515.3	64%	14,814

* Data not provided by ME DMR. Values are estimated from the 2006-2011 growing area annual reports available on the ME DMR website.

Figure BAC1-1: Estuarine waters classified as approved or conditionally approved for shellfish harvest (acres and percent of total acres)



* There are no estuarine waters on the Maine side of the Piscataqua River that classified as approved or conditionally approved.

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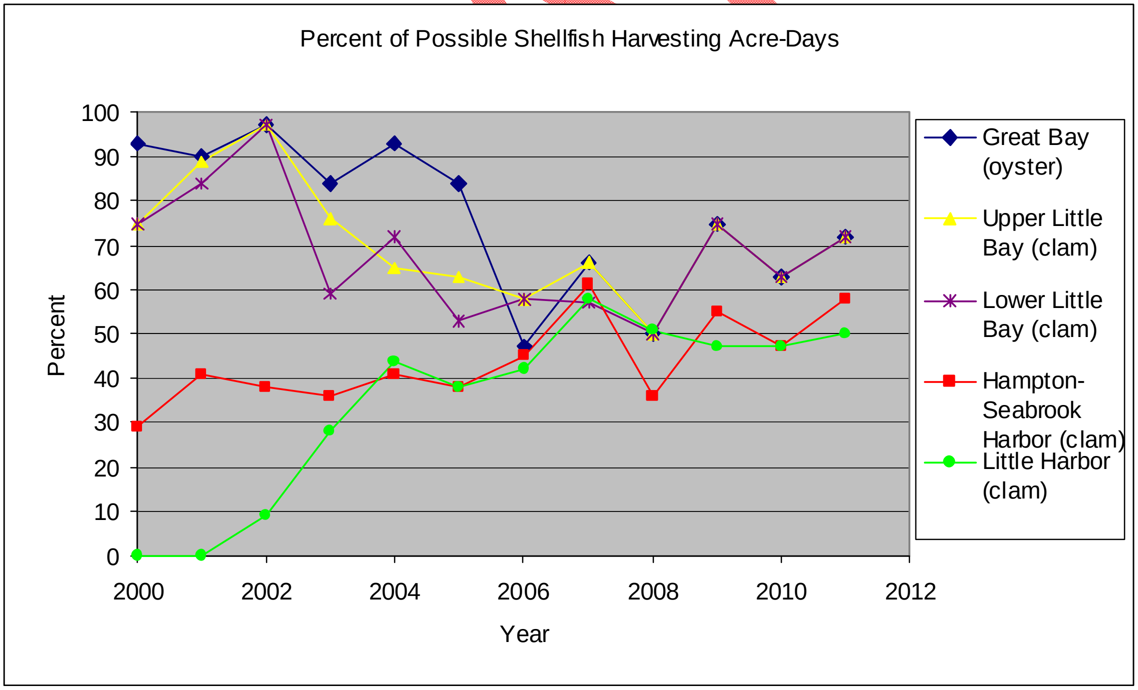
Table BAC1-2: Percent of possible acre-days during which shellfish harvesting was allowed in approved or conditionally approved estuarine waters

Year	Great Bay (oyster)	Hampton-Seabrook Harbor (clam)	Upper Little Bay (clam)	Lower Little Bay (clam)	Little Harbor (clam)	Goal
2000	93	29	75	75	0	100
2001	90	41	89	84	0	100
2002	97	38	97	97	9	100
2003	84	36	76	59	28	100
2004	93	41	65	72	44	100
2005	84	38	63	53	38	100
2006	47	45	58	58	42	100
2007	66	61	66	57	58	100
2008	50	36	50	50	51	100
2009	75	55	75	75	47	100
2010	63	47	63	63	47	100
2011	72	58	72	72	50	100

Figure BAC1-2: Percent of possible acre-days during which shellfish harvesting was allowed in approved or conditionally approved estuarine waters



Indicator: BAC4. Tidal bathing beach closures

Objective

The objective for this indicator is to track the number of postings at designated tidal bathing beaches in the Piscataqua Region watershed. The NHDES Beach Program and the Maine Healthy Beaches Program monitor designated tidal bathing beaches along the Atlantic Coast 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, the agencies may recommend 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.

PREP Goal

Obj WR 1.2: Minimize coastal beach closures due to failure to meet water quality standards for bacteria in estuaries and the ocean. The goal will be interpreted to be less than 1% of summer beach days over the summer season affected by closures due to bacteria pollution.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The advisories at all tidal bathing beaches in New Hampshire and Maine that are within the Piscataqua Region watershed were compiled for each year. Currently, the list of beaches includes all tidal beaches monitored by NHDES and the Fort Foster beach monitored by Maine Healthy Beaches. Only advisories due to water quality contamination were included. For each advisory, the number of days that the advisory was in effect was calculated and then the total number beach advisory days were calculated for the year. The number of advisories were summed for each year and then compared to the number of beach days between Memorial Day and Labor Day (number of days multiplied by the number of beaches monitored).

The number of postings is an exact measure. Therefore, statistical methods are not needed to compare the indicator to the goal. No hypothesis will be tested.

Data Sources

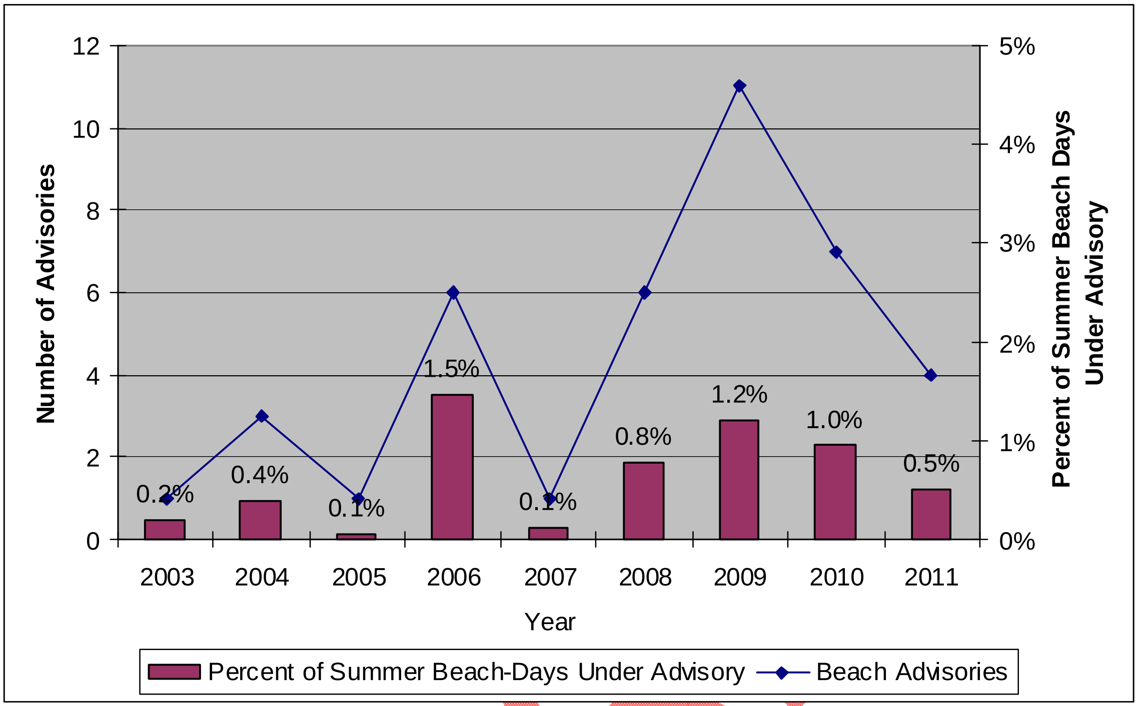
Records of beach postings are available from the NHDES Beach Program (http://des.nh.gov/organization/divisions/water/wmb/beaches/index.htm) and from the Maine Healthy Beaches Program (www.mainecoastdata.org). The NHDES Beach Program and the Maine Healthy Beaches Program review the water quality results for each beach and make a determination whether or not to recommend posting.

Results

The advisories posted at tidal beaches are shown on Figure BAC4-1. Before 2003, sampling was conducted, but no process existed for issuing advisories at tidal bathing beaches in the Piscataqua Region watershed. Once an advisory protocol was in place, at least one advisory has been posted for a tidal beach since 2003. The greatest number of advisories occurred in 2009 (11 advisories affecting 6 beaches for a total of 23 days or 1.2% of the total beach-days for that summer). In 2011, there were four advisories affecting three beaches for a total of nine days (or 0.5% of total beach-days for that summer). Therefore, the PREP goal of having minimal (i.e., <1%) advisories at tidal beaches is currently being met. The beaches with the most advisories are the New Castle Town Beach (9), the North Hampton State Beach (7), and Fort Foster in Maine (5).

Relative to other parts of the country, the water quality at the tidal beaches in the PREP study area is good. In both the 2010 and 2011 “Testing the Waters” reports by the National Resources Defense Council ranked New Hampshire’s tidal beaches as the best in the nation for water quality (NRDC, 2011).

Figure BAC4-1: Number of Advisories at Tidal Beaches 1996-2011



Source: NHDES Beach Program & Maine Healthy Beaches Program

EXHIBIT 36 (AR K.22)

Indicator: TOX1. Toxic contaminants in shellfish tissue

Objective

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 (NSSP 2009, converted to dry-weight assuming 85% of the wet-weight is due to water in the tissue), 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 will be measured. This indicator also tracks trends in concentrations of toxic contaminants in blue mussel tissue at three benchmark sites in the Piscataqua Region estuaries over time. Mussels, clams, and oysters accumulate toxic contaminants from polluted water in their tissues. In addition to being a public health risk, the contaminant level in shellfish tissue is a long-term indicator of water quality in the estuaries.

PREP Goal

Obj WR 1.5: Monitor and reduce loading of toxic contaminants and emerging contaminants to the estuaries and the ocean. Consistent with previous PREP reports, the goal will be interpreted to be zero percent of sampling stations in the estuary to have mean shellfish tissue concentrations greater than FDA guidance values and no increasing trends for any contaminant.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

Each mussel tissue sample consisted of either four measurements from replicate subsamples and/or a composite sample from the replicates. Clam and oyster samples consisted of either two replicate subsamples and/or a composite sample from the replicates. The maximum concentration for each toxic contaminant in each tissue type was calculated and compared to the FDA guidance values in the table below. Results found to be above the FDA guidance values, were checked to determine if the result was from the most recent sample at that station. Results from PCB, DDT, and PAH congeners were added together separately to calculate the “Sum PCB”, “Sum DDT”, and “Sum PAH” values. Only detected congeners were included in the sums. FDA guidance values were used as reference values to conform with NSSP model ordinance.

Parameter	Threshold (wet-weight)	Threshold (dry-weight)	Units
Mercury	1	6.7	Mg/kg
Lead*	1.7	11.5	Mg/kg
Cadmium*	4	27	Mg/kg
Chromium*	13	87	Mg/kg
Nickel*	80	533	Mg/kg
Mirex	100	700	µg/kg
Alpha-Chlordane	300	2000	µg/kg
Dieldrin	300	2000	µg/kg
Heptachlor epoxide	300	2000	µg/kg
Aldrin	300	2000	µg/kg
Heptachlor	300	2000	µg/kg
Sum of PCBs	2000	13000	µg/kg
Sum of DDTs	5000	33000	µg/kg

* analyte was removed following the 2007 revision of the NSSP. Lead, cadmium, chromium and nickel were not included in the 2009 revision of the NSSP. The actions levels have been retained for consistency in the indicator.

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Trends were evaluated at the three benchmark sites in the estuary: MECC (Portsmouth Harbor), NHDP (Dover Point) and NHHS (Hampton-Seabrook Harbor). In 2008, the Gulfwatch program changed the sample design from collecting four replicates at each station to collecting three replicates plus one composite of the three replicates. Funding limitations in recent years only allowed for the analysis of composite samples and replicate samples at select sites. The averages from all results (replicates and composites) for each parameter were regressed against the year of collection using a linear model. Linear coefficients with a probability of <0.05 of being different from zero were considered statistically signficant. Results from PCB, DDT, and PAH congeners were added together separately to calculate the "Sum PCB", "Sum DDT", and "Sum PAH" values. Only detected congeners were included in the sums.

Data Sources
The NH Gulfwatch Program provided the data on blue mussel, oyster, and clam tissue for this indicator.

Results

Between 1993 and 2011, 20 stations in the Piscataqua Region watershed have been tested for toxic contaminants in blue mussel tissue under the Gulfwatch Program (Figure TOX1-1). The stations cover all of the major shellfish growing areas in the estuaries. Most of the shellfish collected have been mussels; however, eight stations each have been monitored with clam and oyster tissue.

Table TOX1-1 shows that lead was the only compound with a maximum value above its FDA guidance value. This exceedence only occurred for mussels collected from station NHSM in South Mill Pond. The concentrations of contaminants in clam and oyster tissue were all below FDA guidance values.

Figure TOX1-2 shows all of the measurements of lead in mussels from station NHSM. There had been a steady increase in lead concentrations between 1999 and 2006, however in 2009 lead concentrations declined to 2003 levels, just above the FDA guidance value. Cadmium, zinc and aluminum concentrations have also decreased at this station between 2006 and 2009. One explanation for the increasing concentrations of metals is that a restoration project has increased tidal flushing in South Mill Pond in recent years. The increased flushing may have changed the geochemistry of the sediments resulting in the release of metals which were previously not bioavailable. The decrease in concentration seen in 2009 may indicate that the system has flushed out the bioavailable metals and returned to a state of equilibrium.

For the period between 1993 and 2011, mussel tissue has been analyzed 19, 15, and 15 years in Portsmouth Harbor, Dover Point and Hampton-Seabrook Harbor, respectively. The only increasing trends were for aluminum and iron in Hampton-Seabrook Harbor (Table TOX1-2, Figures TOX1-3 and TOX1-4). Aluminum and iron are not toxic so the increasing trends for these metals are not a concern. All of the other statistically significant trends for toxic contaminants were decreasing. The declining trends for PCBs, DDT, PAHs, chromium, lead, silver and mercury are shown in Figures TOX1-5 through TOX1-14. PCB concentrations have decreased by 70 to 83%. DDT concentrations have declined by 51% to 63%. Chromium concentrations have decreased by 43 to 46%. Lead concentrations have decreased by 48 to 67%. Silver concentrations have decreased by 7%, and zinc concentrations fell by 25 percent. Note that in Figure TOX3-9, the concentration reported for PCBs at NHHS in 2011 was zero. This is reflective of concentrations below detection limits for all analytes. These trends reflect the decreased usage of these contaminants due to product bans and pollution prevention programs.

EXHIBIT 36 (AR K.22)

Table TOX1-1: Maximum concentrations of toxic contaminants measured in clam, mussel and oyster tissue between 1993 and 2011

Parameter	Clam Tissue	Mussel Tissue	Oyster Tissue	FDA Screening Value	Units
ALUMINUM	2435	778	449		mg/kg-dw
CADMIUM	2.3	3.6	3.5	25	mg/kg-dw
CHROMIUM	7.1	24	3.1	87	mg/kg-dw
COPPER	26.6	15.1	178.8		mg/kg-dw
IRON	7501	1200	514		mg/kg-dw
LEAD	9.1	17.1	0.9	11.5	mg/kg-dw
MERCURY		0.4		6.7	mg/kg-dw
NICKEL	4.9	8.2	2.5	533	mg/kg-dw
SILVER	2.5	0.8	9.4		mg/kg-dw
ZINC	121.1	240	7056.8		mg/kg-dw
TOTAL PAHS	1217.1	1127.8	470.6		µg/kg-dw
SUM PCBS	9.1	93.8	106.7	13000	µg/kg-dw
TOTAL DDT	12	76.4	40.8	33000	µg/kg-dw

Source: NH Gulfwatch Program

1. Cells with results higher than the screening value are shaded.

2. FDA screening values were converted from wet-weight to dry-weight basis by dividing the value by 0.15 (the average fraction of solids in tissue samples).

Table TOX1-2: Trends in contaminant concentrations in mussel tissue in Portsmouth Harbor ("MECC"), Dover Point ("NHDP") and Hampton-Seabrook Harbor ("NHHS"), 1993-2011

Station	Parameter	Period	Trend	Regression Equation	Percent Change
MECC	ALUMINUM	1993 - 2011	No significant trend		
	CADMIUM	1993 - 2011	No significant trend		
	CHROMIUM	1993 - 2011	**Decreasing**	[CR] = -0.057*YEAR + 115.82	-46%
	COPPER	1993 - 2011	No significant trend		
	IRON	1993 - 2011	No significant trend		
	LEAD	1993 - 2011	**Decreasing**	[PB] = -0.151*YEAR + 306.64	-48%
	MERCURY	2003 - 2011	No significant trend		
	NICKEL	1993 - 2011	No significant trend		
	SILVER	2003 - 2011	No significant trend		
	ZINC	1993 - 2011	No significant trend		
	DDT, TOTAL	1993 - 2011	**Decreasing**	[DDT] = -0.433*YEAR + 875.27	-63%
	PAH, TOTAL	1993 - 2011	No significant trend		
	PCB, TOTAL	1993 - 2011	**Decreasing**	[PCB] = -2.16*YEAR + 4358.74	-70%
NHDP	ALUMINUM	1994 - 2011	No significant trend		
	CADMIUM	1994 - 2011	No significant trend		
	CHROMIUM	1994 - 2011	**Decreasing**	[CR] = -0.079*YEAR + 160.72	-43%
	COPPER	1994 - 2011	No significant trend		
	IRON	1994 - 2011	No significant trend		
	LEAD	1994 - 2011	**Decreasing**	[PB] = -0.099*YEAR + 199.92	-67%
	MERCURY	2003 - 2011	No significant trend		
	NICKEL	1994 - 2011	No significant trend		
	SILVER	2003 - 2011	**Decreasing**	[AG] = -0.004*YEAR + 8.44	-7%
	ZINC	1993 - 2011	**Decreasing**	[ZN] = -1.871*YEAR + 3862.94	-25%
	DDT, TOTAL	1993 - 2011	No significant trend		
	PAH, TOTAL	1993 - 2011	No significant trend		
	PCB, TOTAL	1993 - 2011	No significant trend		
NHHS	ALUMINUM	1993 - 2011	**Increasing**	[AL] = 11.83*YEAR - 23460.49	176%
	CADMIUM	1993 - 2011	No significant trend		
	CHROMIUM	1993 - 2011	No significant trend		
	COPPER	1993 - 2011	No significant trend		
	IRON	1993 - 2011	**Increasing**	[Fe] = 8.4*YEAR - 16490.95	60%
	LEAD	1993 - 2011	No significant trend		
	MERCURY	2003 - 2011	No significant trend		
	NICKEL	1993 - 2011	No significant trend		
	SILVER	2003 - 2011	No significant trend		
	ZINC	1993 - 2011	No significant trend		
	DDT, TOTAL	1993 - 2011	**Decreasing**	[DDT] = -0.216*YEAR + 438.13	-51%
	PAH, TOTAL	1993 - 2011	No significant trend		
	PCB, TOTAL	1993 - 2011	**Decreasing**	[PCB] = -0.736*YEAR + 1482.85	-83%

Source: NH Gulfwatch Program

EXHIBIT 36 (AR K.22)

Figure TOX1-1: Gulfwatch stations tested between 1993 and 2011

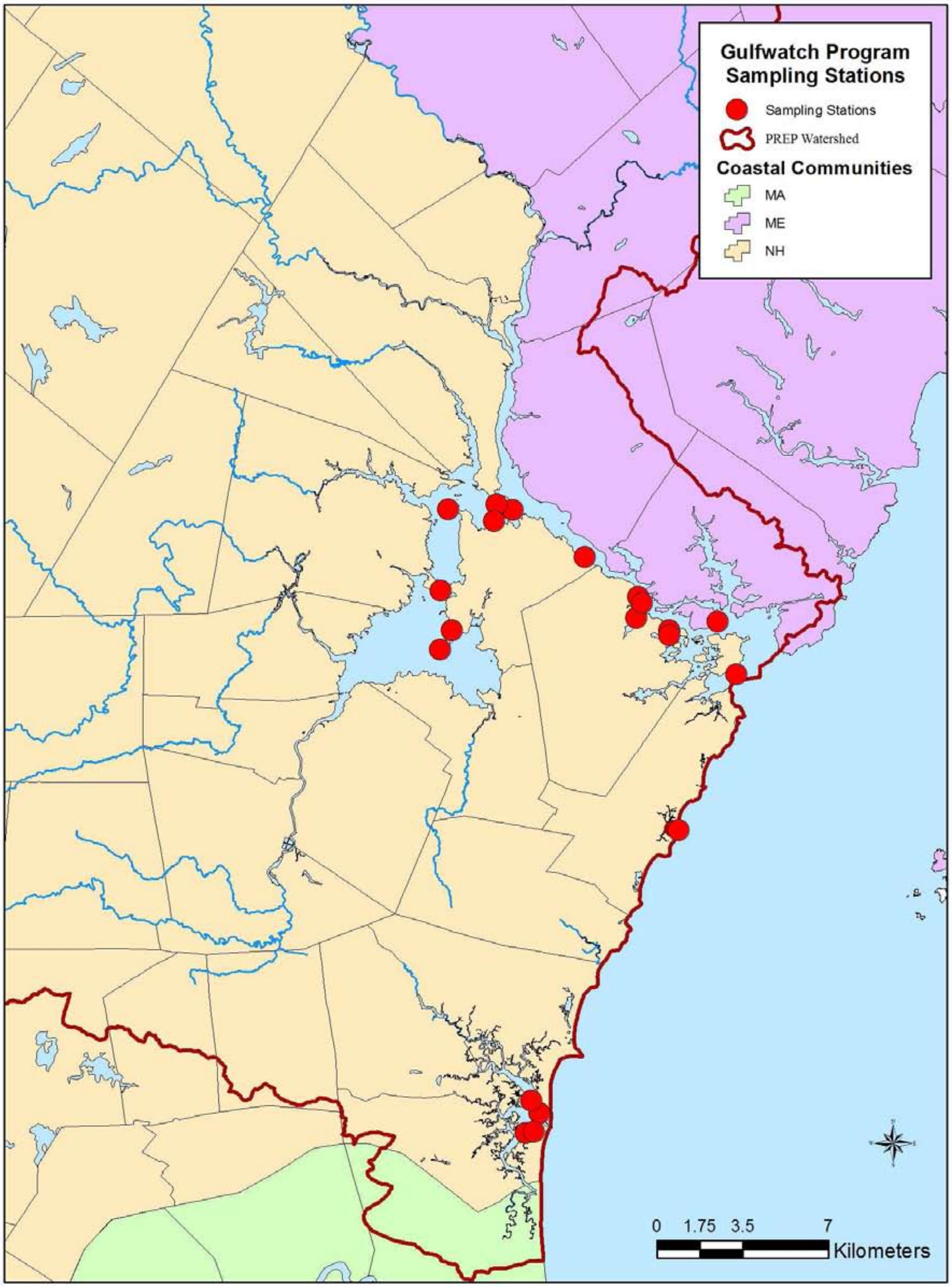

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Figure TOX1-2: Lead concentrations in mussel tissue from South Mill Pond

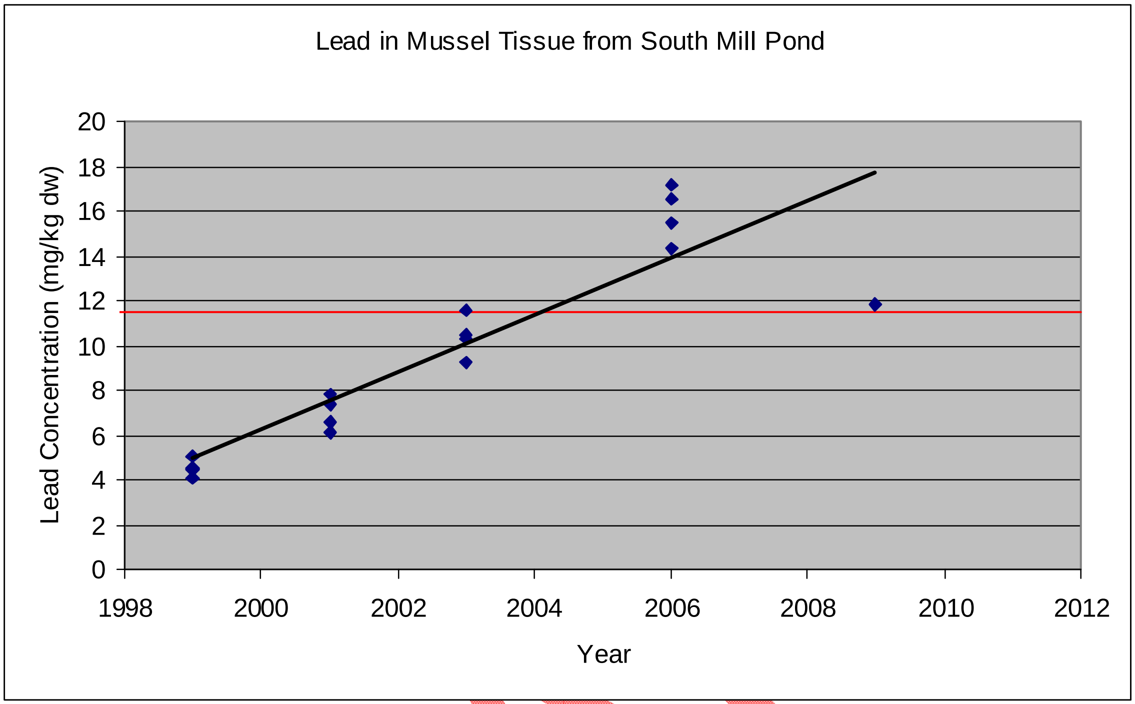

Figure TOX1-3: Aluminum concentrations in mussel tissue at station NHHS at Hampton-Seabrook Harbor

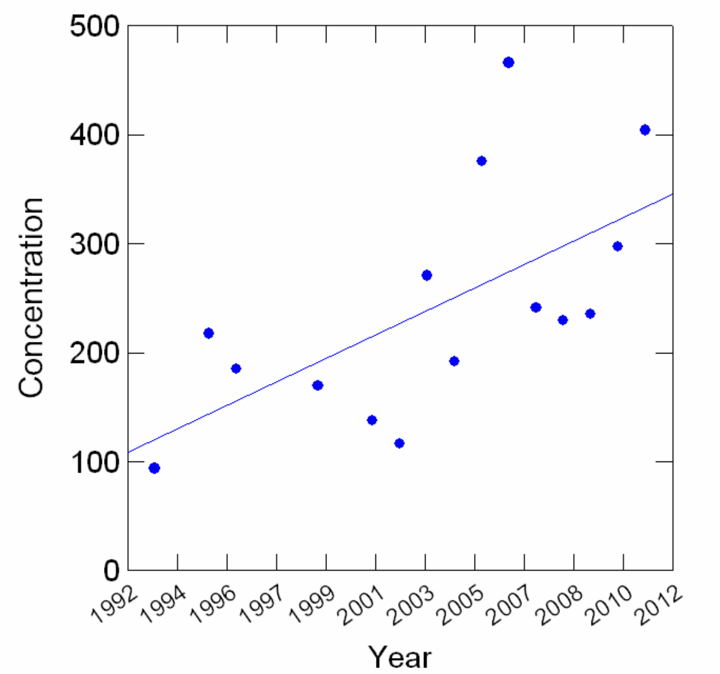

Figure TOX1-4: Iron concentrations in mussel tissue at station NHHS in Hampton-Seabrook Harbor

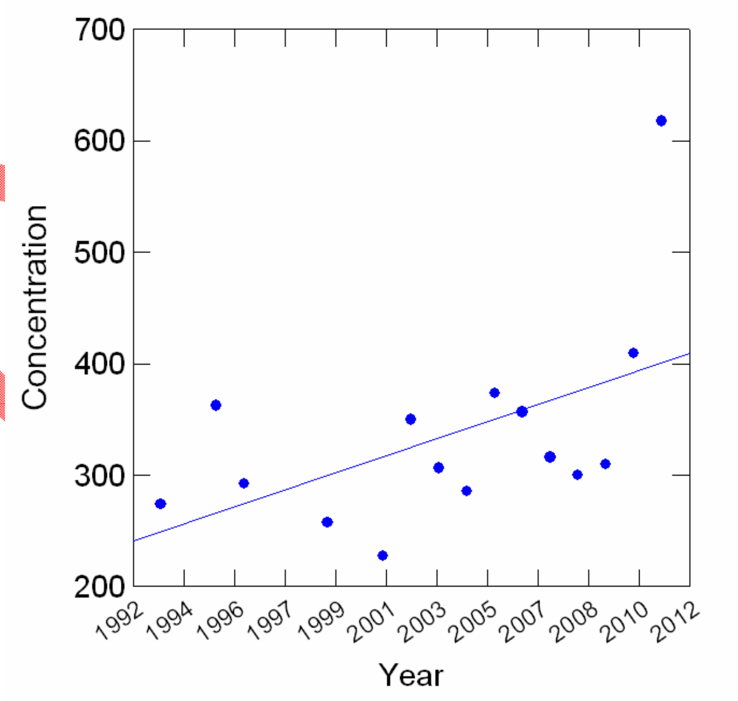

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Figure TOX1-5: Chromium concentrations in mussel tissue at station MECC in Portsmouth Harbor

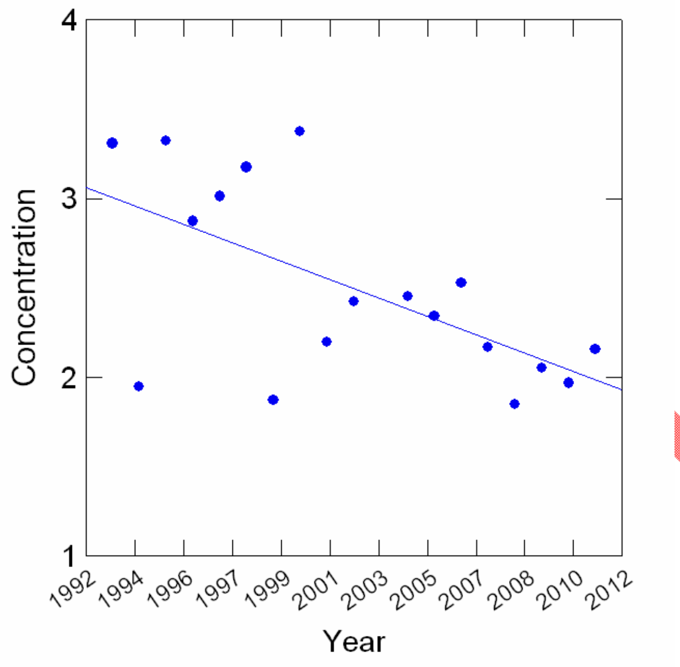


Figure TOX1-6: Chromium concentrations in mussel tissue at station NHDP at Dover Point

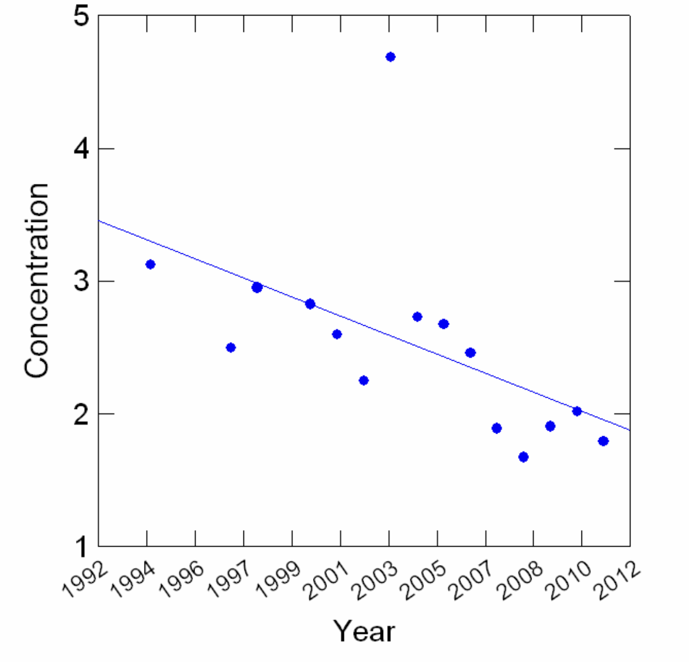


Figure TOX1-7: Lead concentrations in mussel tissue at station MECC in Portsmouth Harbor

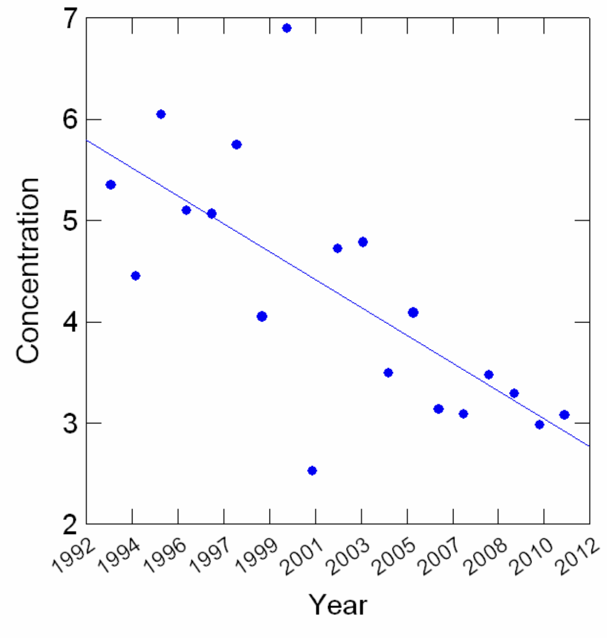


Figure TOX1-8: Lead concentrations in mussel tissue at station NHDP at Dover Point

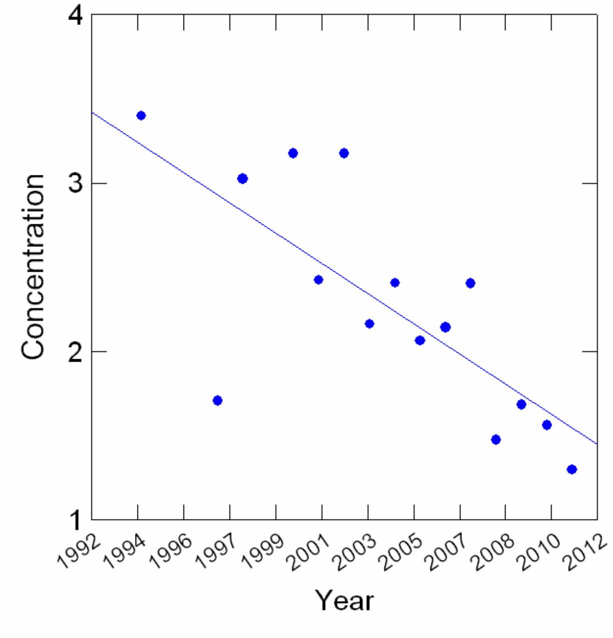


Figure TOX1-9: Silver concentrations in mussel tissue at station NHDP at Dover Point

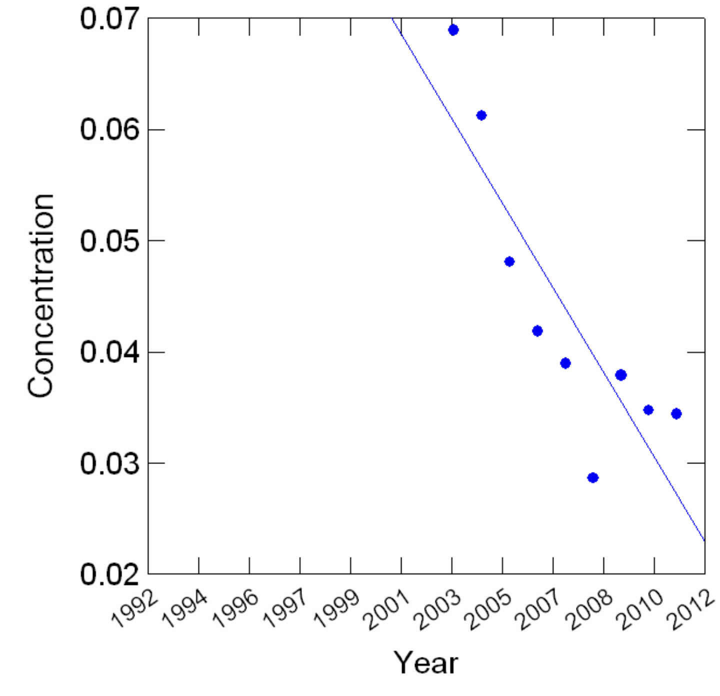


Figure TOX1-10: Total PCBs concentrations in mussel tissue at station MECC in Portsmouth Harbor

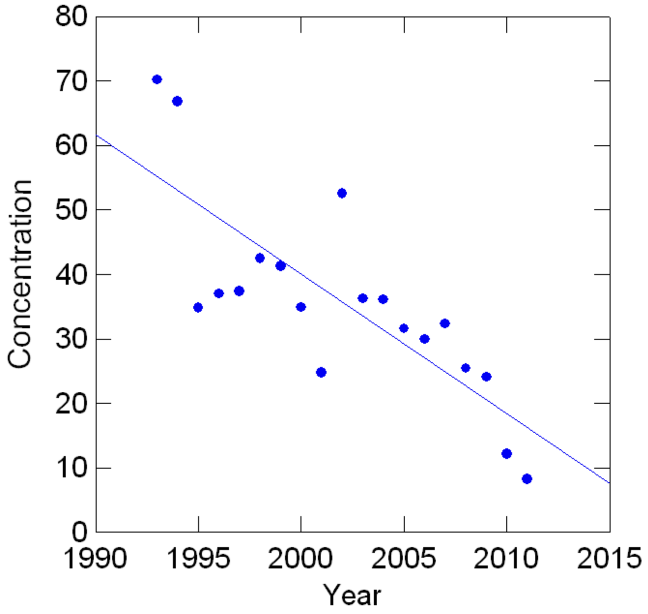


Figure TOX1-11: Total PCBs concentrations in mussel tissue at station NHHS in Hampton-Seabrook Harbor

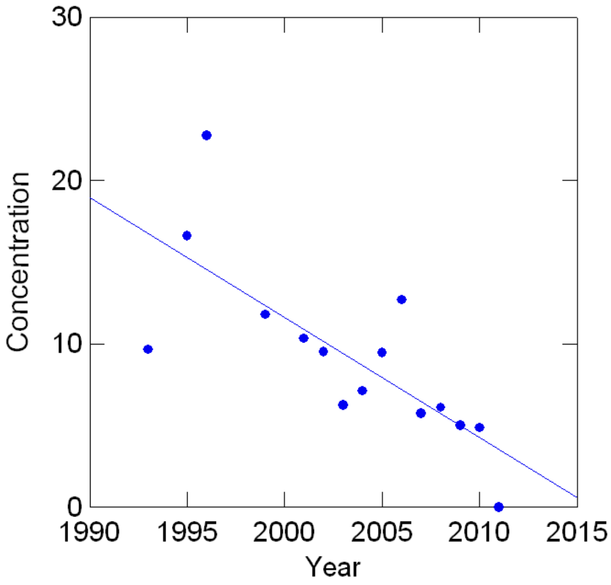


Figure TOX1-12: Total pesticide concentrations in mussel tissue at station MECC in Portsmouth Harbor

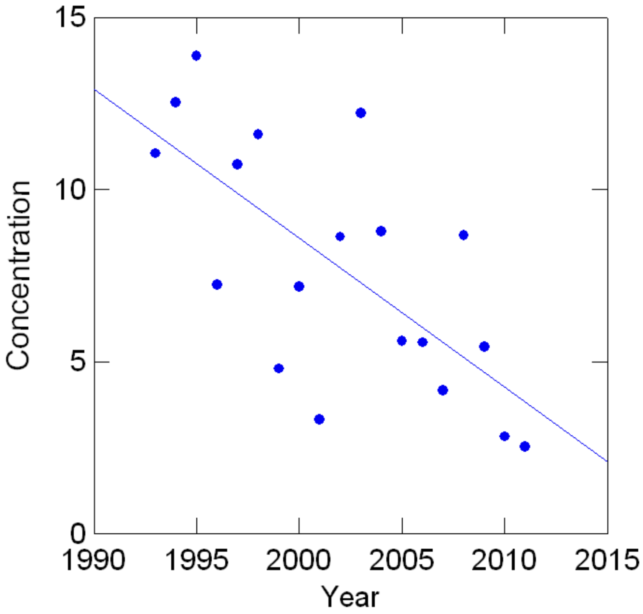


Figure TOX1-13: Zinc concentrations in mussel tissue at station NHDP at Dover Point

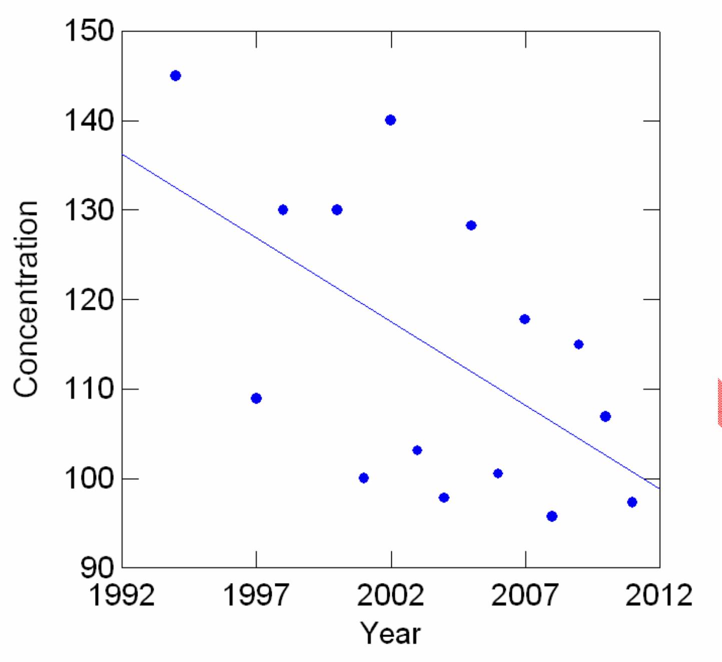
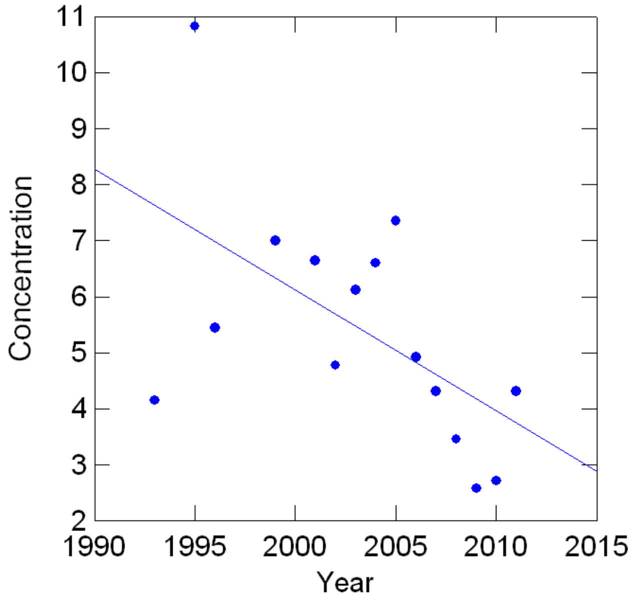


Figure TOX1-14: Total pesticide concentrations in mussel tissue at station NHHS in Hampton-Seabrook Harbor



Indicator: SHL5. Oysters in the Great Bay Estuary

Objectives

The primary objective of this indicator is to track to total number of adult oysters in the major oyster beds of the Great Bay Estuary. Oysters are excellent indicators of estuarine condition because they are relatively long-lived, stationary filter feeders that play important roles in nutrient cycling and water clarity. They also provide food and habitat for other species in the estuary. Harvesting and aquaculture farming of oysters can also provide economic benefits to local communities.

PREP Goal

Obj LR 1.1: Increase the abundance of adult oysters at the six documented beds in the Great Bay Estuary to 10 million oysters and restore 20 acres of oyster bed habitat by 2020.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The number of oysters was calculated by multiplying the size of each by the average density of adult oysters in the bed.

The most recent boundaries of the six major oyster beds in the Great Bay Estuary (Adams Point, Nannie Island, Oyster River, Piscataqua River, Squamscott River, and Woodman Point) were used to calculate current oyster bed areas. These areas were summed and compared to the sum of the areas of major oyster beds from 1997 (see following table).

Oyster Bed	Size in 1997 (acres)
Nannies Island	37.3
Woodman Point	6.6
Piscataqua River	12.8
Adams Point	4.0
Oyster River	1.8
Squamscott River	1.7
Total	64.2 +/- 4

A rigorous statistical test of this hypothesis was not possible. Instead, the error bars for the area estimate were used to establish an approximate “confidence interval” of possible values for the total area of oyster beds. To estimate the uncertainty, each bed area estimate was assumed to be accurate to +/-10%. The error in the total area of oyster beds in the estuary was estimated from the root mean square of the uncertainties in each bed. If the confidence intervals of the current area and the goal did not overlap, the difference was considered statistically significant.

For each of the major oyster beds, the average density of adult oysters (>80 mm shell height) was calculated and compared to 1997 levels (Langan, 1997). For each oyster bed in each year, the arithmetic mean and standard deviation of the number of oysters per quadrat with >80mm shell height was calculated. Only quadrats where oysters were found were included in the average density calcuation. The 95th percentile confidence limit of the average density was calculated by multiplying the standard deviation by a t-value of 2.776 and dividing by the square root of the number of quadrats used for the average. The average density for the year was compared to the average density measured in 1997 (the goal). If the goal fell outside the 95th percentile confidence limits for the annual density, the difference was considered statistically significant.

In addition, the average density of “spawning stock” oysters (>60 mm shell height) and oyster spat (<20 mm shell height) were also calculated. No formal goals have been set for these size classes of oyster and the 1997 densities were not recorded. The average densities for spawning stock oysters and oyster spat were tracked for illustrative purposes only.

The number of adult oysters in each bed was estimated by multiplying the average density of oysters >80mm for each bed by the most recent estimate of the bed size. If data on density or area are missing for a bed for a particular year, the closest other available data for that bed was used in the calculation. The number of adult oysters was summed for beds in areas open for harvesting and for all beds. The total for all beds was compared to the goal.

Data Sources
Baseline data from 1997 on the six major oyster beds in Great Bay was provided in Langan (1997). The baseline data were compared to more recent mapping completed using PREP funding or from other similar projects (NHF&G, 2002; Grizzle, 2004; Grizzle et al. 2008). The monitoring programs for this indicator should have an accuracy of ± 10% in the area estimate for each bed.

The NHF&G Oyster Resource Monitoring Program conducts a survey of the major oyster beds in the Great Bay Estuary every year to measure oyster density with quadrats and to collect samples for disease testing.

Maps of open and closed areas for shellfishing were provided by the DES Shellfish Program.

Results

Oyster Bed Areas

The six major oyster beds in the Great Bay Estuary were mapped in 1997 by Langan (1997). In 2001, New Hampshire Fish and Game (NHF&G) and the University of new Hampshire (UNH), with funding support from PREP, completed a new set of maps for the Adams Point, Nannie Island, Oyster River and Woodman Point oyster beds using a method that combined information from acoustic sonar, videography, and diver surveys (NHF&G, 2002). The Piscataqua River and Squamscott River oyster beds were mapped by UNH in 2003 using videography techniques (Grizzle, 2004). In 2004, the Nannie Island and Woodman Point oyster beds were mapped again (Grizzle, 2008). The Adams Point and Oyster River oyster beds were mapped most recently in 2006 (Grizzle, 2008). Table SHL1-1 contains the oyster bed areas as measured in 1997, 2001, 2003, 2004 and 2006.

The total area of oyster beds in Great Bay has not changed significantly since 1997. In 1997, the six oyster beds covered 64.2 acres in total (Table SHL5-1). Using the bed areas from 2003 through 2006, the bed areas summed to 70.5 acres. The difference between these two estimates is less than the uncertainty in either of the values. To estimate the uncertainty, each bed area estimate was assumed to be accurate to +/-10%. The root mean square of the uncertainties in each bed area resulted in errors of +/- 4 acres and +/- 4.5 acres for the 1997 and 2003-2006 totals, respectively. For individual beds, the size of the Nannie Island, Adams Point, Oyster River, and Squamscott River beds increased; while the Piscataqua River and Woodman Point beds have decreased. These changes may be the result of changes in the mapping methods or how these beds were defined.

The general locations of the six major oyster beds that are being tracked by PREP are shown in Figure SHL5-1. Maps of the individual beds, showing the outlines from 1997 compared to the 2003-2006 boundaries are provided in Figures SHL5-2 through Figure SHL5-6.

Oyster Densities

The average adult (>80 mm shell height) oyster density in 2011 was significantly lower than 1997 levels at the Adams Point, Nannie Island, and Woodman Point beds (Table SHL5-2, Figure

SHL6-7). In contrast, the average densities in the Oyster River and Squamscott River beds had been higher than 1997 levels in recent years. Overall, the average density across all beds has declined by 58% compared to 1997. The cause for the decline largely has been attributed to the protozoan pathogens MSX and Dermo.

Spawning stock oysters (>60 mm shell height) show a similar trend (Table SHL5-3, Figure SHL5-8). The average density across all major beds has declined by 45% from 1996 or 1998 levels (densities > 60 mm shell height were not recorded in 1997). The average density has increased in the Piscataqua River and Squamscott River beds but declined at the four other major beds.

Number of Adult Oysters

Data from 1993 to 2011 illustrate that the oyster fishery in Great Bay has suffered a serious decline. The trends over time for adult oysters (>80 mm shell height) are shown in Table SHL5-5 and Figure SHL5-10. There was a precipitous fall from over 25 million adult oysters in 1993 to 1.2 million in 2000. The major cause of this decline is thought to be the protozoan pathogens MSX and Dermo which have caused similar declines in oyster fisheries in the Chesapeake and other mid-Atlantic estuaries. NHF&G reports that some of the decline at the Piscataqua River bed may be due to oily deposits. Since 2000, the adult oyster standing stock has grown slightly to 2.2 million with varying trends in the six major beds (Figure SHL5-11). The number of adult oysters in 2011 was 22% of the management goal of 10 million and 8% of 1993 levels.

In 2006, there was a large oyster spat set (SHL5-9). It was predicted that the adult oyster populations would increase starting in 2009 when this age class reached maturity. The predicted increase was not observed in the adult oysters but was evident in the spawning stock oysters (>60 mm shell height). Figure SHL5-12 and SHL5-13 show a peak of spawning size oysters in 2009 followed by lower levels in 2010 and 2011. Therefore, it appears that the large spat set from 2006 yielded oysters in the 60-80 mm shell height size but few oysters in the >80 mm shell height size class.

Table SHL5-1: Area (in acres) of the major oyster beds in the Great Bay Estuary

Year	Bed Area (acres)							Source	Comments
	Adams Point	Nannie Island	Oyster River	Piscataqua River	Squamscott River	Woodman Point	Total area		
1997	4	37.3	1.8	12.8	1.7	6.6	64.2	Langan (1997)	
2001	13.1	24.7	1.7			7.3	61.2	NHF&G (2002)	Total calculated using 2003 areas for the PR & SR
2003				12.5	1.9			Grizzle (2004) - high density area	
2004		41.8				6.1		Grizzle et al. (2008)	
2006	5.7		2.5				70.5	Grizzle et al. (2008)	Total calculated using 2003 areas for PR & SR, 2004 areas for NI & WP
Difference	1.7	4.5	0.7	-0.3	0.2	-0.5	6.3	Acreage change 1997 to 2003-2006	
	41%	12%	36%	-2%	12%	-7%	10%	% change 1997 to 2003-2006	

Table SHL5-2: Average density (in # per m^2) of adult oysters (>80 mm shell height) in the major Great Bay Estuary beds

Year	Adams Point	Nannie Island	Oyster River	Piscataqua River	Squamscott River	Woodman Point	Source
1993	120.0	119.3	109.5			66.4*	NHF&G
1995		48.0	46.7			34.3	NHF&G
1996	52.7	67.0	40.8			39.0	NHF&G
1997	38.0	50.0	29.0	20.0		63.0	Langan (1997)
1998	27.5	28.7	26.0	5.1	9.3	28.7	NHF&G
1999		13.6	10.4	0.0		22.4	NHF&G
2000	5.3	4.8	12.0	1.3		4.0	NHF&G
2001	7.0	13.3	17.6	1.0	8.0	8.6	NHF&G
2002	2.8	3.2	9.6	0.8		6.4	NHF&G
2003	13.6	7.2	10.4	0.8		10.4	NHF&G
2004	7.2	2.7	24.8	0.0		12.0	NHF&G
2005	33.6	4.0	28.8	4.0	**161.3**	8.8	NHF&G
2006	26.4	0.0	**29.6**	4.8		29.6	NHF&G
2007	8.8	5.6	**40.8**	20.0		4.0	NHF&G
2008	7.2	3.2	**79.2**	0.0	**44.0**	8.8	NHF&G
2009	7.2	8.8	**56.0**			8.8	NHF&G
2010	1.6	12.0	**36.0***	2.4	**32.0**	8.0	NHF&G
2011	18.4	3.2	23.2	6.0	**24.8**	12.8	NHF&G

1. Green cells are the PREP Management Goals for adult oyster density from Langan (1997). The density at the Squamscott River bed was not measured in 1997 so the 1998 value from NHF&G is the goal for this bed.
2. Yellow cells are statistically significant ($p<0.05$) decreases below management goals using a one sample, two-sided t-test.
3. Bold values indicate an increase above 1997 density

* Value for Woodman Pt in 1993 is from NHF&G summary reports. Raw data from quadrats were not available for this survey. Value for Oyster River in 2009 was measured using tongs, not quadrats.

EXHIBIT 36 (AR K.22)

Table SHL5-3: Average density (in # per m^2) of oyster spawning stock (>60 mm shell height) in the major Great Bay Estuary beds

Year	Adams Point	Nannie Island	Oyster River	Piscataqua River	Squamscott River	Woodman Point	Source
1993	228.7	223.3	145.1				NHF&G
1995		66.0	68.0	74.9			NHF&G
1996	72.7	123.0	70.4	119.0			NHF&G
1998	39.0	48.4	36.7	60.0	6.9	16.0	NHF&G
1999		23.2	15.2	30.4	0.8		NHF&G
2000	13.3	7.2	18.4	17.3	4.0		NHF&G
2001	10.0	42.7	49.6	29.7	10.0	18.7	NHF&G
2002	20.8	20.0	20.8	21.6	5.6		NHF&G
2003	30.4	24.8	27.2	19.2	6.4		NHF&G
2004	61.6	5.3	135.2	49.6	10.4		NHF&G
2005	85.6	4.0	98.4	18.4	30.0	401.3	NHF&G
2006	44.8	0.0	85.6	51.2	25.6		NHF&G
2007	24.0	26.4	81.6	22.4	40.0		NHF&G
2008	65.6	65.6	273.6	88.0	2.0	186.4	NHF&G
2009	54.4	102.4	204.0	99.2			NHF&G
2010	18.4	72.8	96.0	58.4	9.6	90.4	NHF&G
2011	24.8	37.6	51.2	40.8	14.0	56.0	NHF&G

Table SHL5-4: Average density (in # per m^2) of oyster spat (1-20 mm shell height) in the major Great Bay Estuary beds

Year	Adams Point	Nannie Island	Oyster River	Piscataqua River	Squamscott River	Woodman Point	Source
1993	0.0	0.7	0.0				NHF&G
1995		0.0	0.7			8.0	NHF&G
1996	0.0	1.0	0.0			1.0	NHF&G
1998	6.0	14.1	5.3	7.4	41.3	4.0	NHF&G
1999		11.2	31.2	32.8		65.6	NHF&G
2000	2.7	5.6	1.6	8.0		5.3	NHF&G
2001	0.0	0.7	2.4	0.0	20.0	1.1	NHF&G
2002	62.0	0.8	139.2	300.8		96.0	NHF&G
2003	4.0	3.2	9.6	4.8		1.6	NHF&G
2004	0.0	0.0	0.0	0.8		0.8	NHF&G
2005	0.0	0.0	2.4	0.0	29.3	1.6	NHF&G
2006	489.6	610.4	942.4	60.8		748.8	NHF&G
2007	141.6	62.4	149.6	52.0		45.6	NHF&G
2008	12.8	4.8	11.2	1.0	11.2	4.8	NHF&G
2009	11.2	8.8	12.0			4.8	NHF&G
2010	8.8	11.2	17.6	4.8	36.0	7.2	NHF&G
2011	36.0	11.2	3.2	0.0	16.8	6.4	NHF&G

EXHIBIT 36 (AR K.22)

Table SHL5-5: Standing stock of adult oysters (>80 mm) in the Great Bay Estuary

Year	Adams Point	Nannie Island	Oyster River	Piscataqua River	Squamscott River	Woodman Point	Total open beds	Total all beds
1993	2,115,360	19,616,145	868,259	1,128,192	69,924	1,931,324	23,662,828	25,729,204
1995	1,521,884	7,890,293	370,188	1,128,192	69,924	997,241	10,409,418	11,977,722
1996	928,408	11,013,534	323,650	1,128,192	69,924	1,134,362	13,076,304	14,598,070
1997	669,864	8,219,055	230,045	1,128,192	69,924	1,832,431	10,721,350	12,149,511
1998	484,770	4,724,435	206,248	290,107	69,924	833,804	6,043,009	6,609,287
1999	289,393	2,235,583	82,499	0	64,930	651,531	3,176,507	3,323,936
2000	94,016	789,029	95,191	75,213	64,930	116,345	999,390	1,234,724
2001	404,122	1,451,372	131,857	56,410	59,935	275,752	2,131,246	2,379,448
2002	161,649	348,329	71,922	45,128	634,314	205,895	715,873	1,467,237
2003	785,151	783,741	77,916	44,070	708,939	334,579	1,903,471	2,734,397
2004	415,668	491,563	185,799	0	708,939	322,910	1,230,141	2,124,879
2005	1,939,785	737,344	215,767	220,350	1,350,892	236,800	2,913,930	4,700,939
2006	658,163	0	320,378	264,420	859,659	796,511	1,454,673	2,899,130
2007	219,388	1,032,282	441,603	1,101,750	859,659	107,637	1,359,306	3,762,317
2008	179,499	589,875	857,228	0	368,425	236,800	1,006,175	2,231,828
2009	179,499	1,622,157	606,121	66,105	318,185	236,800	2,038,456	3,028,868
2010	39,889	2,212,032	389,649	132,210	267,946	215,273	2,467,194	3,256,999
2011	458,719	589,875	251,107	330,525	207,658	344,437	1,393,032	2,182,322

Notes:

Sources: Langan (1997) for 1997 values and NHF&G for all other years.

Most of the values on this table are approximate because the oyster density and oyster bed boundary were not measured in the same year. In 1997, the density and boundary were mapped by Langan (1997) for all the beds except for the Squamscott River bed. In 2001, the density and boundary were mapped for the Adams Point, Nannie Island, Oyster River, and Woodman Point beds. In 2003, only the boundaries were mapped for the Piscataqua River and Squamscott River beds. Boundaries from 1997 were used up until the year that the beds were remapped (2003 for the Squamscott and Piscataqua beds and 2001 for all others). For 2002 onwards, the most recent area for a bed was used starting with the year that the new map was made. This simplification requires the assumption that the bed sizes have not changed over 4-6 years, which may not be justified. The average adult oyster density for Woodman Point in 1993 was taken from NHF&G reports because raw data were not available to calculate this value independently.

Yellow cells indicate that oyster density measurements were not taken at that bed in that year and an assumption regarding the density of oysters was needed for the calculation. Either the closest value from another year or an average of two bracketing years was used.

Open beds include Adams Point, Nannie Island, and Woodman Point. Closed beds are: Oyster River, Piscataqua River, and Squamscott River.

Figure SHL1-1: Major oyster beds in the Great Bay Estuary

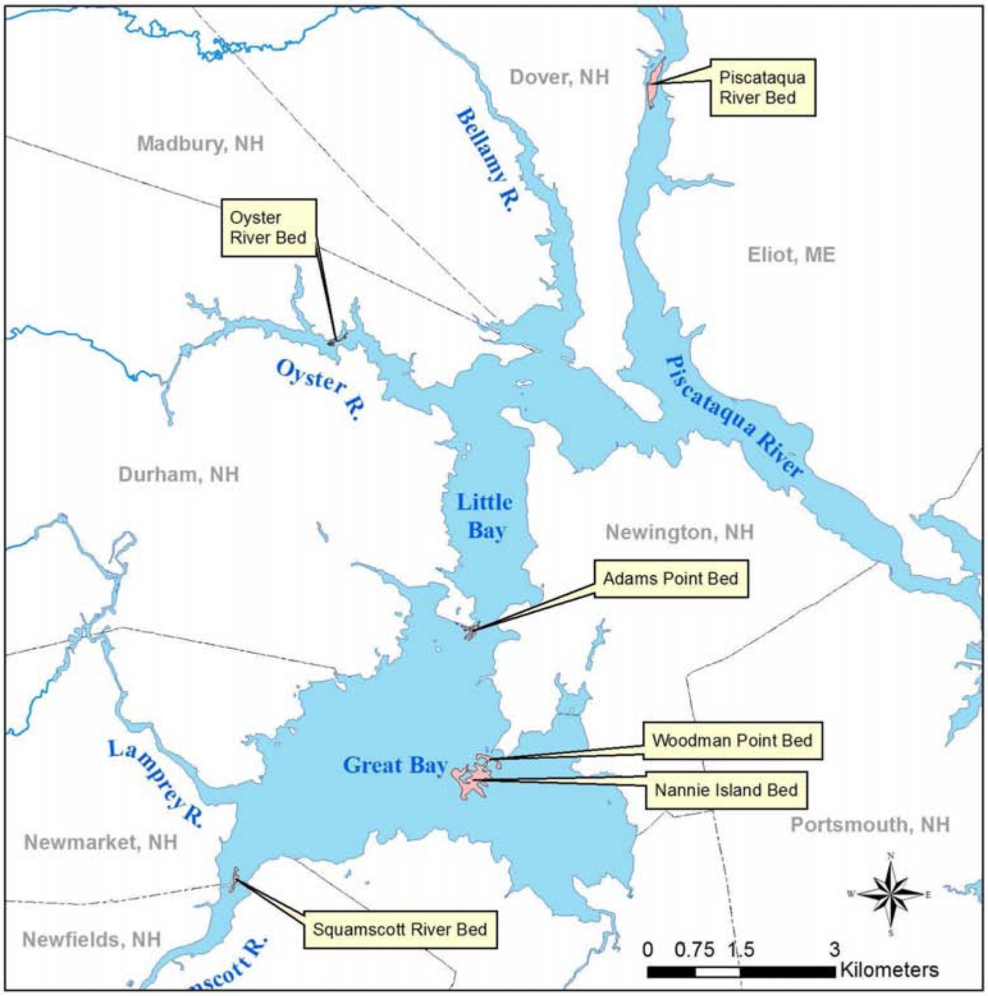


Figure SHL1-2: Boundaries of the Adams Point Oyster Bed

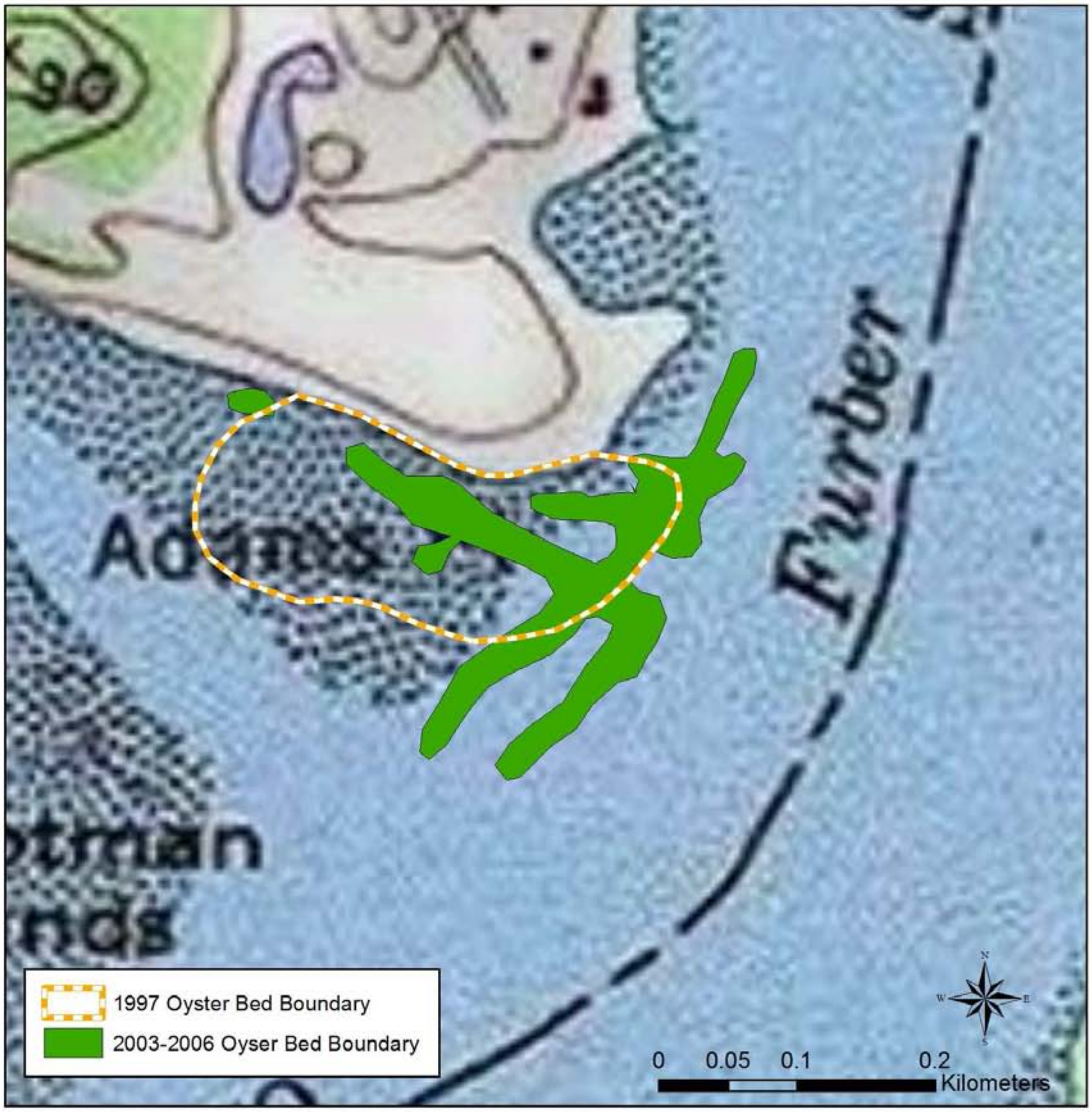


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Figure SHL1-3: Boundaries of the Nannie Island and Woodman Point Oyster Beds

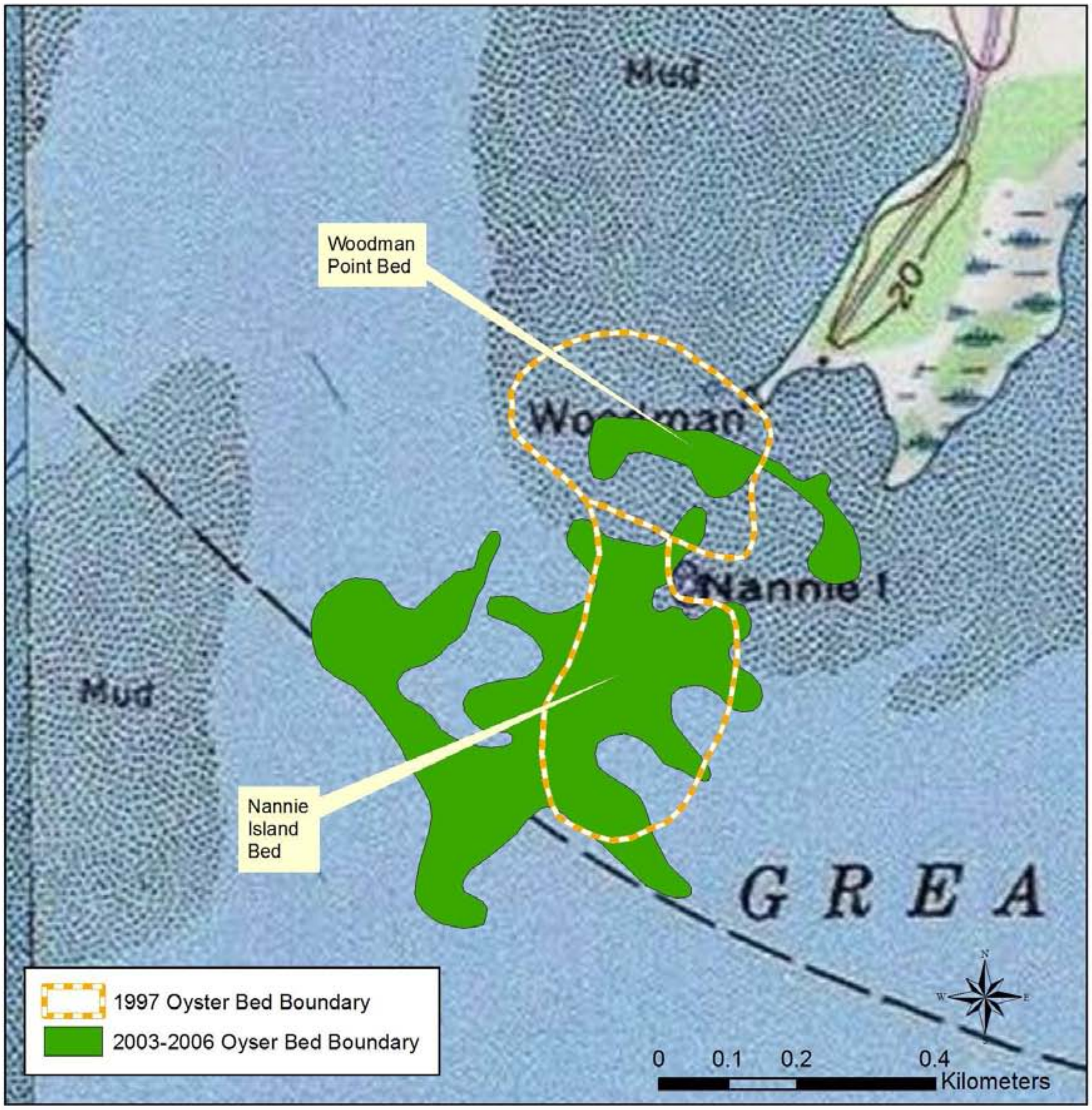


Figure SHL1-4: Boundaries of the Squamscott River Oyster Bed

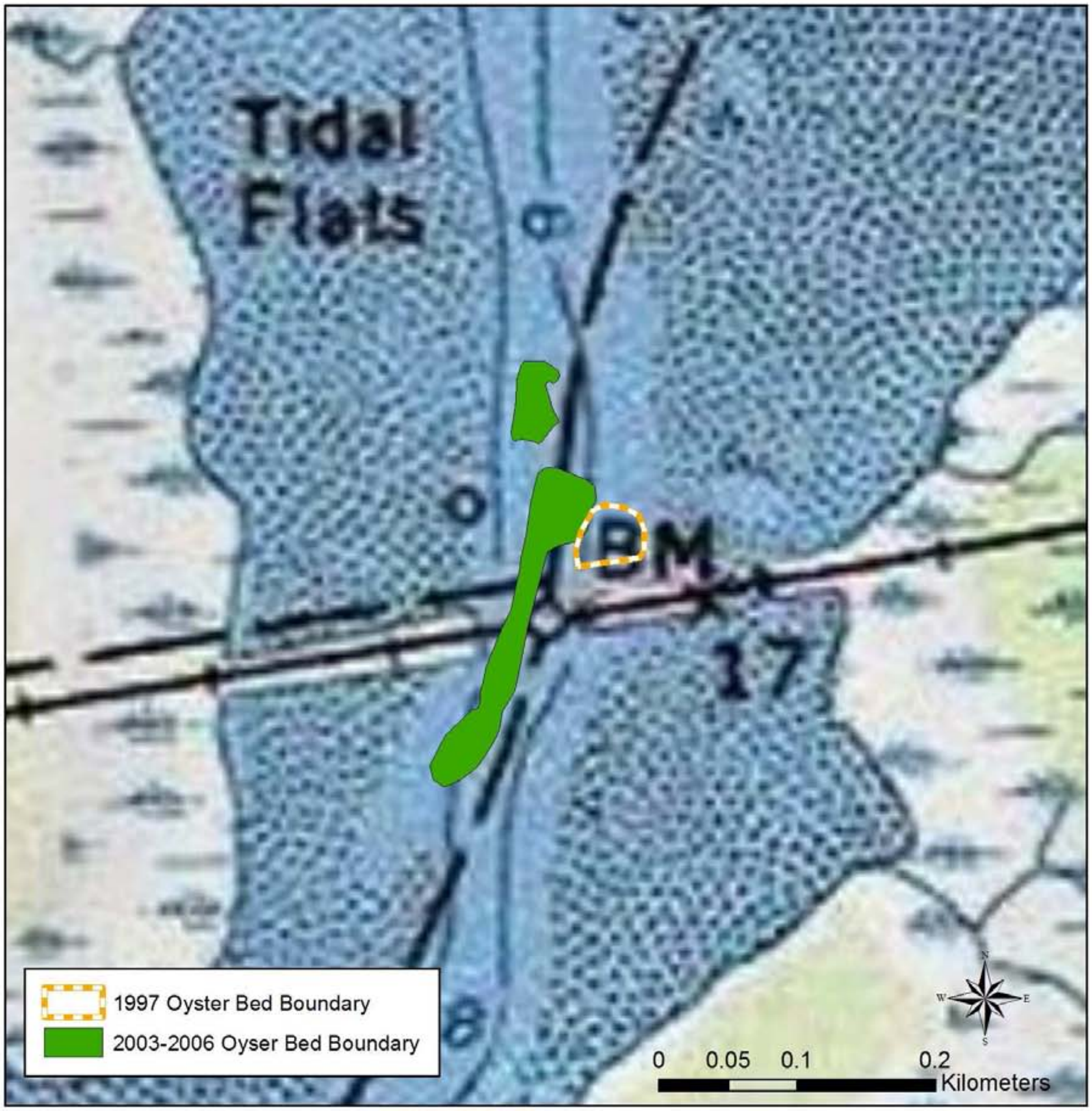


EXHIBIT 36 (AR K.22)

Figure SHL1-5: Boundaries of the Oyster River Oyster Bed

EXHIBIT 36 (AR K.22)

Figure SHL1-6: Boundaries of the Piscataqua River Oyster Bed

Figure SHL5-7: Average density of adult oysters in major Great Bay Estuary beds

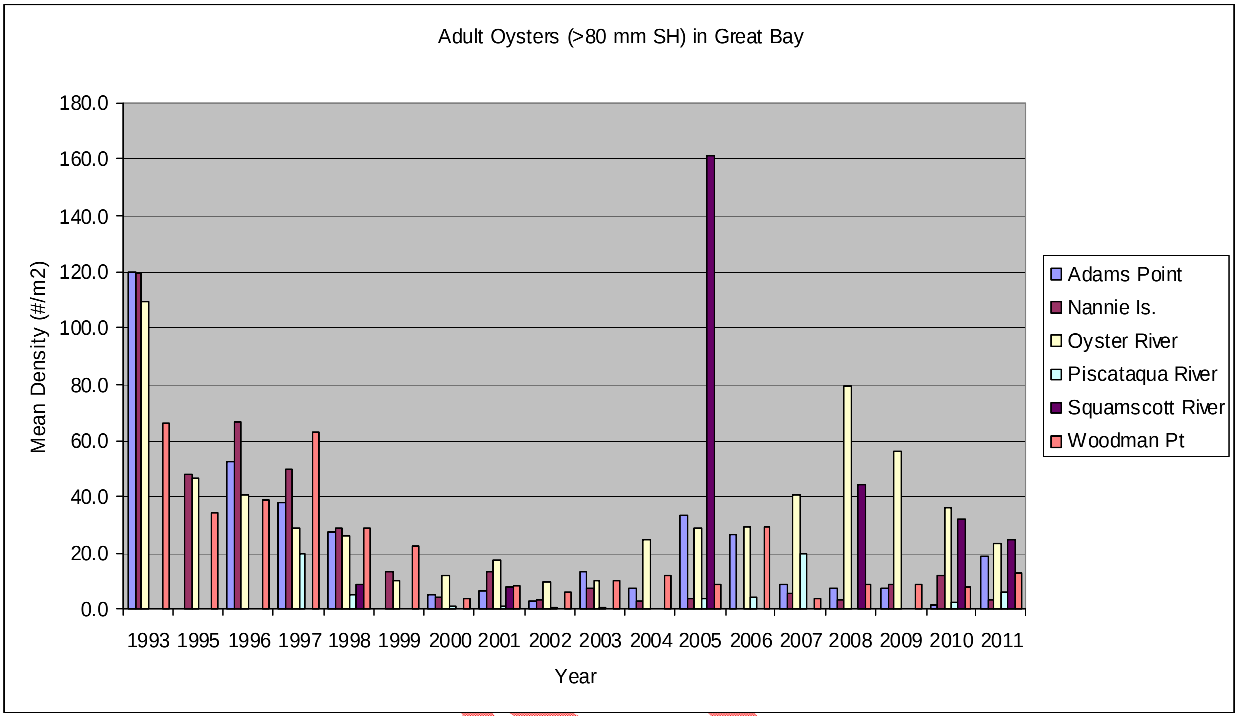


Figure SHL5-8: Average density of spawning stock oysters in major Great Bay Estuary beds

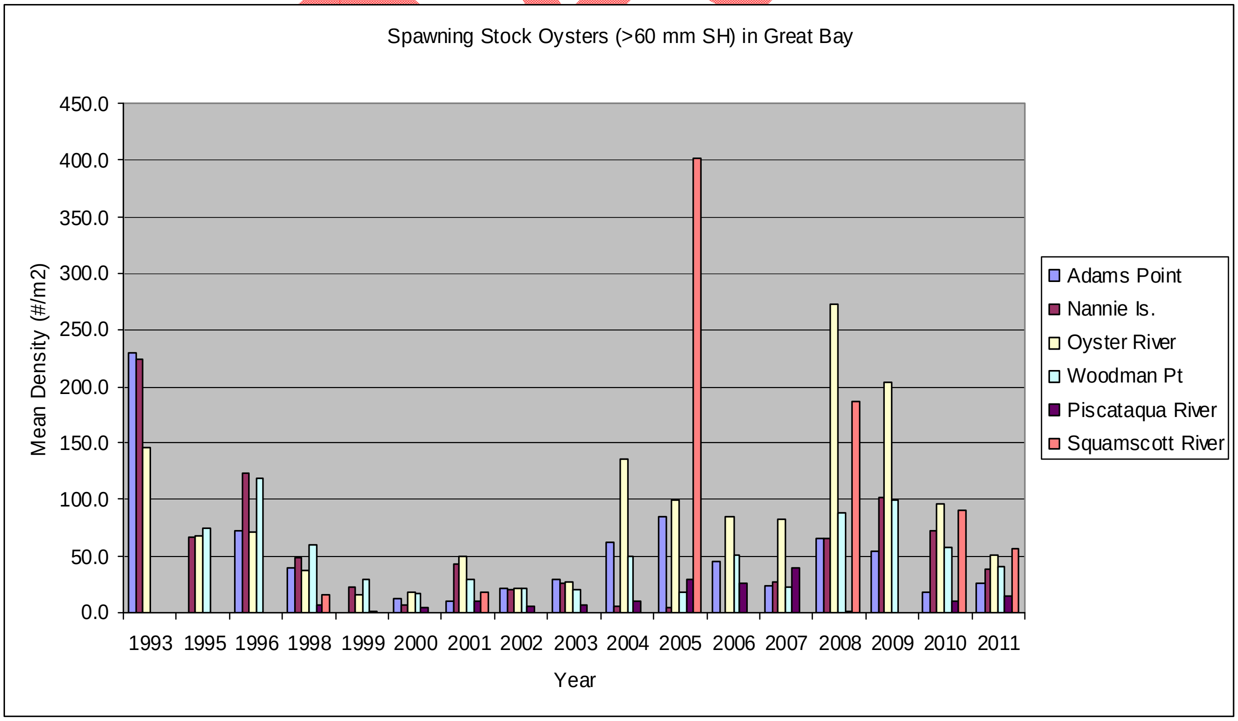


Figure SHL5-9: Average oyster spat density in the Great Bay Estuary

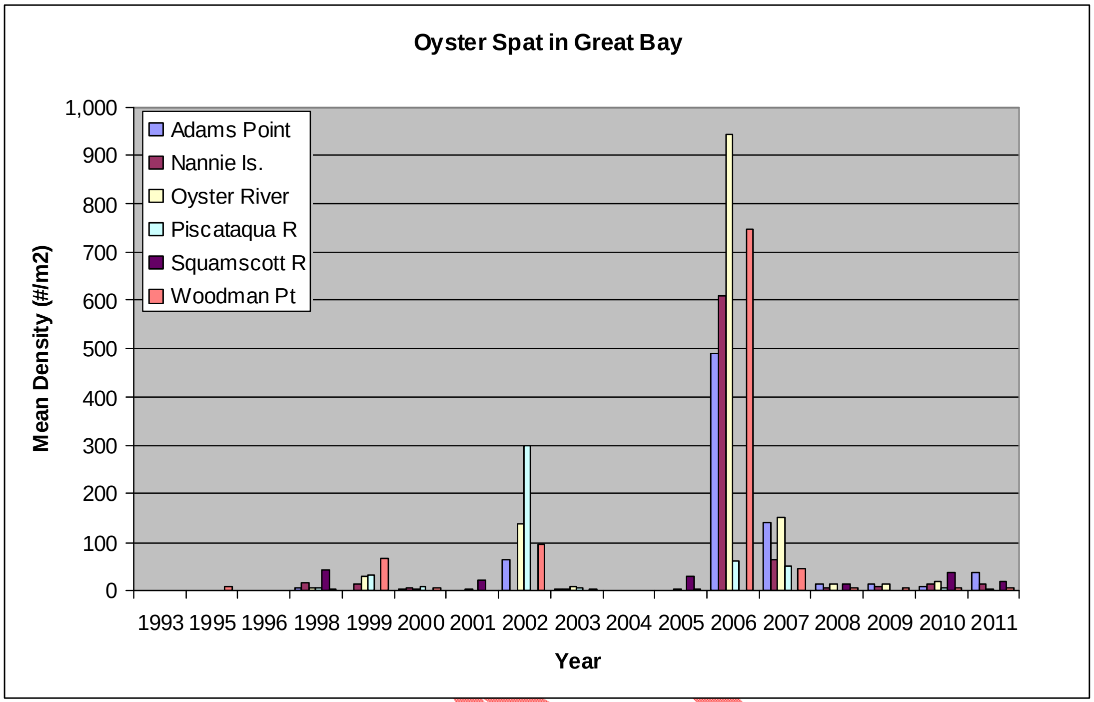


Figure SHL5-10: Number of adult oysters (>80 mm SH) in the Great Bay Estuary

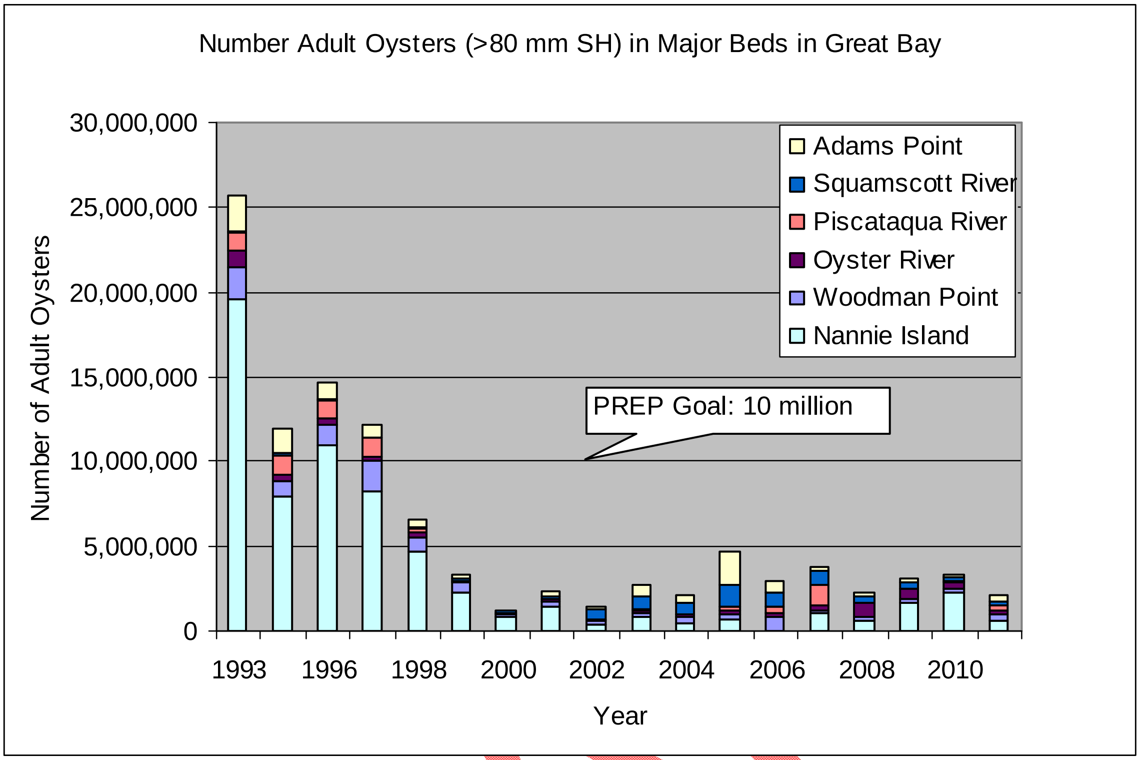


Figure SHL5-11: Number of adult oysters (>80 mm SH) in the Great Bay Estuary since 2000

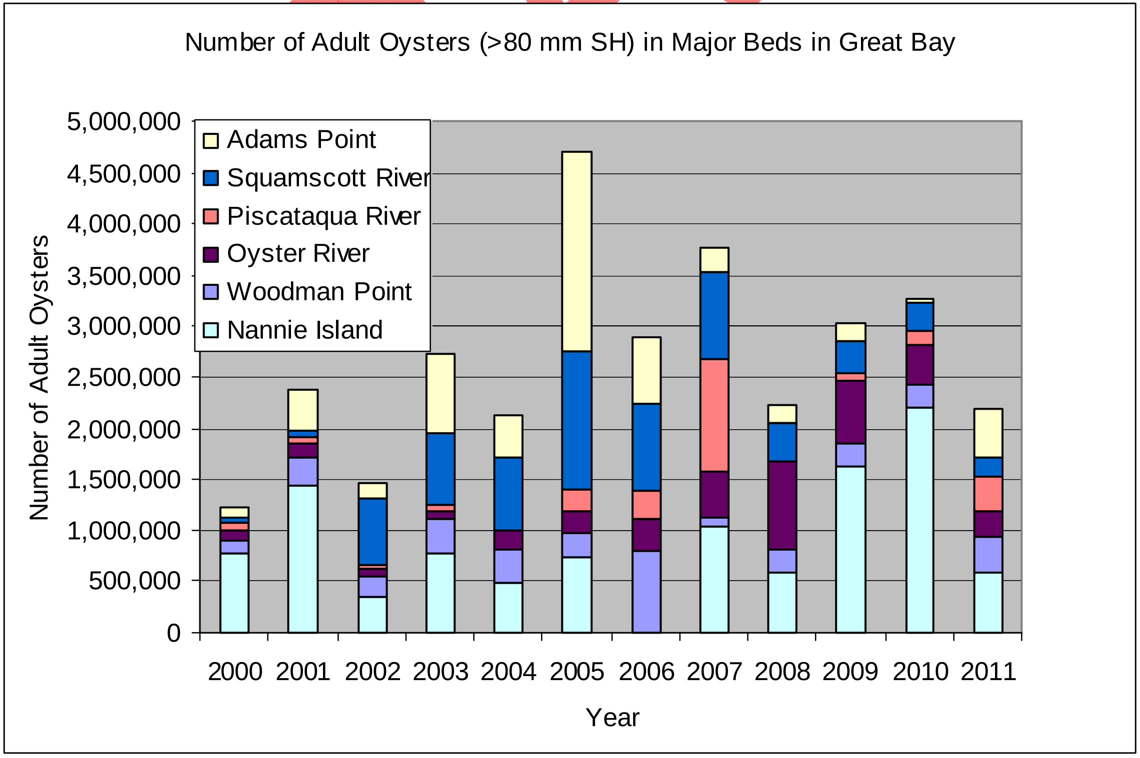


Figure SHL5-12: Number of spawning stock oysters (>60 mm SH) in the Great Bay Estuary

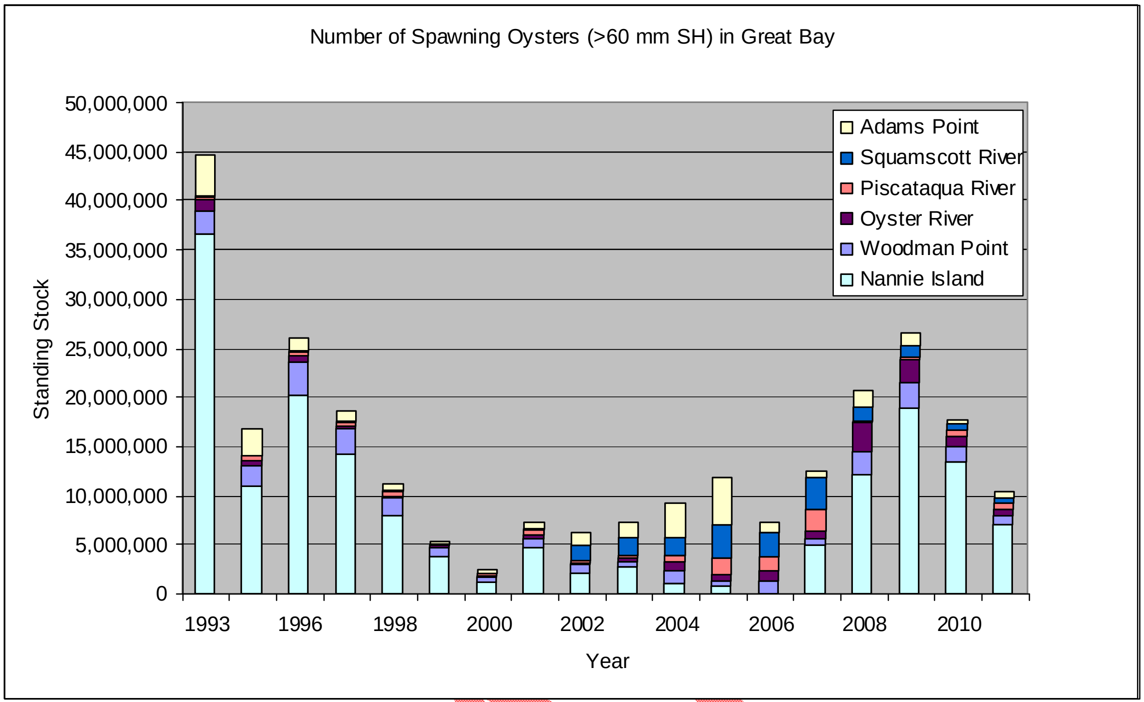
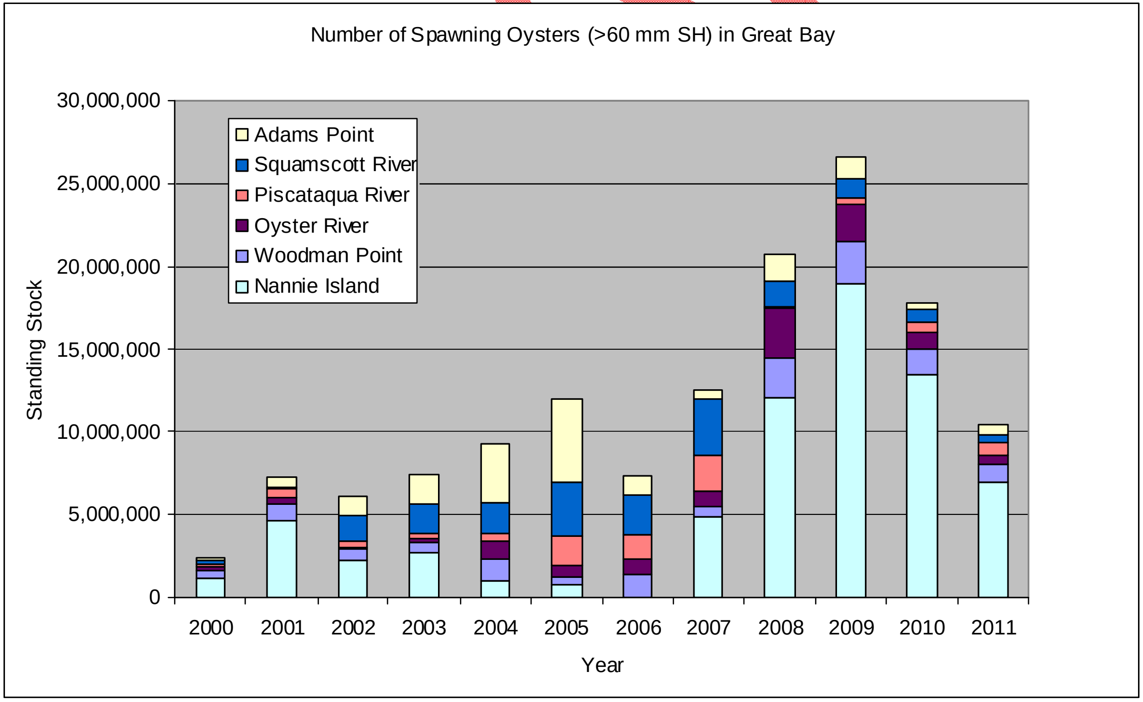


Figure SHL5-13: Number of spawning stock oysters (>60 mm SH) in the Great Bay Estuary since 2000



Indicator: SHL6. Clams in Hampton-Seabrook Harbor

Objective

The objectives of this indicator are to estimate the total number and mean density of adult clams in Hampton-Seabrook Harbor (i.e., clams >50 mm shell length). This is important because soft shell clams are an important economic, recreational, cultural, and natural resource for the Seacoast region. Recreational shellfishing in Hampton-Seabrook Harbor is estimated to contribute more than $3 million a year to the State economy (NHEP, 2000).

PREP Goal

Obj LR 1.2: Increase the number of adult clams in the Hampton-Seabrook Estuary to 5.5 million clams by 2020.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

For each flat, the arithmetic mean densities for clam spat, juveniles, and adults were calculated by summing the mean densities for the 1-25mm, 26-50mm, and >50mm size classes, respectively, using data tables in the Seabrook Station Annual Data Reports. The arithmetic mean density for adult clams, juvenile, and clam spat were compared to the average density for each flat in 1974-1989. The 1974-1989 period was chosen because it represents pre-operational conditions for Seabrook Station and because the standing stock of adult clams during this period was approximatly equal to the PREP goal of 5.5 million adult clams. Clam density is an important component of clam standing stock. In order to achieve the PREP goal for standing stock, the clam densities must also equal or exceed 1974-1989 levels. In previous reports, PREP used the average density in 1974-1989 as a target for spat, juvenile, and adult clams.

The standing stock of adult clams was calculated by multiplying the average density of adult clams in each flat in each year by the most recent estimate of the size of the flat. Clam densities have been measured annually since 1971 but flat boundaries have only been monitored seven times between 1977 and 2002. For the years when the flat boundaries were not surveyed, it was assumed that the most recent boundary for that flat was still accurate. This assumption introduces some uncertainty into the estimates for these years. The standing stock in the three major flats was summed to estimate the total standing stock in Hampton-Seabrook Harbor.

Data Sources

The Seabrook Station Soft Shell Clam Monitoring Program, implemented by Normandeau Associates, conducts annual surveys of clam densities in the three major flats in Hampton-Seabrook Harbor.

Results

Adult clam densities in 2011 were 4.3, 4.9, and 5.4 $\#/m^2$ in the Common Island, Confluence, and Middle Ground flats, respectively (Table SHL6-1). Historically, adult clam densities have been much higher. The 2011 densities were 28 to 54% of the average densities from 1974-1989 during the Seabrook Station pre-operational period. Figure SHL6-1 illustrates the trends in adult clam densities over the last 41 years with peak densities in 1972, 1983, and 1997 followed by crashes of the fishery. All the flats were closed to harvesting due to bacterial pollution in 1989. The Common Island, Confluence, and Middle Ground flats were reopened in 1994, 1995, and 1998, respectively. The high clam densities in the 1990s occurred during this period. There was a small peak of adult clam density in 2006, during which the density reached 15.9 $\#/m^2$ in the Common Island flat. However, adult clam densities have decreased since then.

The expected population of adult clams in the future depends on the population of juvenile clams and spat. Figure SHL6-2 illustrates that large clam spatfalls occurred in the late 1970s and early

1980s. After an unusually low spatfall in 2006, the spatfalls in 2008-2011 have rebounded to be some of the highest on record. In 2011, the average spat densities were 1523, 1274, and 2411 #/m^2 in the Common Island, Confluence, and Middle Ground flats, respectively. These densities were 146 to 225% of historical averages (Table SHL6-3). In contrast, juvenile clam densities in 2011 were only 1 to 2% of historical averages (Table SHL6-2). These data indicate the adult clam densities may increase as the 2011 spat mature, depending on the survival of this year class.

Table SHL6-4 and Figure SHL6-3 show the acreages of the three major clam flats mapped during 7 surveys. The latest available data on flat areas are from 2002. These data do not indicate any long-term trends in clam flat areas. However, in 2004-2005, the U.S. Army Corps of Engineers completed a large dredging operation in Hampton-Seabrook Harbor. The operation filled in a channel between the Middle Ground flat and the Town of Seabrook shoreline, reinforced the edge where the Blackwater River passes by the Middle Ground flat and dredged a channel through the northern edge of the Middle Ground flat. It is important to note that sand flats that are exposed during low tide do not guarantee the presence of clams. Clams may colonize only a portion of this habitat. The clam flat boundaries are being updated in 2012.

Adult clam densities were combined with clam flat areas to estimate the standing stock of adult clams over the past 41 years (Table SHL6-5, Figure SHL6-4). The standing stock has undergone several cycles of growth and decline. Peak standing stocks of approximately 18 million and 27 million occurred in 1983 and 1997, respectively. Between the peaks, there have been crashes of the fishery in 1978 and 1987, with standing stock less than 1 million. From 1997 to 2004, the standing stock dropped to 1.9 million. By 2006 the population had rebounded to 5.1 million (93% of the PREP goal). However, in the last five years, the population has declined to 2.4 million (43% of the PREP goal).

EXHIBIT 36 (AR K.22)

Table SHL6-1: Yearly average density (in # per m2) of adult clams (>50mm) in Hampton-Seabrook Harbor

Year	Common Island Flat	Confluence Flat	Middle Ground Flat
1971	22.6	40.9	30.1
1972	35.5	15.1	24.8
1973	14.0	11.8	6.5
1974	22.6	14.0	18.3
1975	11.8	5.4	4.3
1976	3.2	1.1	1.1
1977	2.2	1.1	1.1
1978	1.1	2.2	1.1
1979	1.1	2.2	6.5
1980	18.3	23.7	34.4
1981	39.8	9.7	24.8
1982	30.1	9.7	23.7
1983	45.2	58.1	10.8
1984	36.6	18.3	9.7
1985	17.2	5.4	6.5
1986	7.5	3.2	2.2
1987	2.2	1.1	2.2
1988	2.2	1.1	4.3
1989	4.3	1.1	7.5
1990	8.6	1.1	27.9
1991	13.1	2.4	51.9
1992	18.1	5.8	47.2
1993	17.4	3.2	30.9
1994	13.7	4.2	34.1
1995	12.6	16.0	37.1
1996	28.5	38.8	46.3
1997	59.9	19.9	72.9
1998	21.3	10.0	22.5
1999	20.1	8.4	14.8
2000	9.8	18.1	7.7
2001	5.2	9.6	6.0
2002	3.0	5.3	7.5
2003	3.0	4.0	7.0
2004	5.1	2.7	3.9
2005	3.7	3.2	6.0
2006	15.9	6.6	9.0
2007	14.5	3.6	9.3
2008	12.3	4.9	4.9
2009	6.0	7.6	3.6
2010	6.6	2.6	5.1
2011	4.3	4.9	5.4
1974-1989 Average	15.3	9.8	9.9
% of '74-'89 Ave	28%	50%	54%

Table SHL6-2: Yearly average density (in # per m2) of juvenile clams (26-50mm) in Hampton-Seabrook Harbor

Year	Common Island Flat	Confluence Flat	Middle Ground Flat
1971	73.2	51.7	189.4
1972	87.2	23.7	114.1
1973	26.9	40.9	40.9
1974	39.8	14.0	30.1
1975	8.6	0.0	3.2
1976	1.1	1.1	1.1
1977	1.1	0.0	1.1
1978	15.1	42.0	180.8
1979	327.2	37.7	390.7
1980	775.0	42.0	508.0
1981	481.1	10.8	531.7
1982	141.0	2.2	132.4
1983	227.1	47.4	30.1
1984	66.7	9.7	10.8
1985	15.1	1.1	3.2
1986	2.2	1.1	2.2
1987	1.1	1.1	3.2
1988	3.2	1.1	9.7
1989	8.6	1.1	11.8
1990	5.4	1.1	33.4
1991	16.9	2.5	22.3
1992	8.3	1.1	19.1
1993	3.3	0.3	5.5
1994	21.6	40.8	33.6
1995	96.5	34.2	46.0
1996	39.1	14.5	38.6
1997	9.9	0.9	36.0
1998	1.2	0.1	1.4
1999	0.5	0.1	1.2
2000	1.5	0.8	1.5
2001	0.0	0.3	1.0
2002	1.3	0.4	1.6
2003	1.6	0.4	3.0
2004	1.8	0.5	3.1
2005	3.9	1.2	2.2
2006	6.7	0.6	5.3
2007	1.8	0.5	2.5
2008	0.5	0.0	0.9
2009	0.6	0.11	0.8
2010	0.11	0.0	0.2
2011	0.9	0.2	1.0
1974-1989 Average	132.1	13.3	115.6
% of ‘74-‘89 Ave	1%	2%	1%

EXHIBIT 36 (AR K.22)

Table SHL6-3: Yearly average density (in # per m2) of clam spat (1-25 mm) in Hampton-Seabrook Harbor

Year	Common Island Flat	Confluence Flat	Middle Ground Flat
1971	517	979	1,141
1972	1,184	1,636	1,485
1973	474	1,464	194
1974	22	0	32
1975	334	54	420
1976	6,243	2,131	5,113
1977	4,704	527	2,637
1978	2,250	86	1,851
1979	431	334	1,044
1980	969	2,723	1,033
1981	484	5,586	2,540
1982	65	75	258
1983	226	205	484
1984	614	269	883
1985	54	226	172
1986	97	97	129
1987	75	140	129
1988	32	22	65
1989	118	269	377
1990	1,227	431	1,044
1991	62	86	38
1992	59	41	70
1993	298	542	392
1994	956	235	275
1995	36	200	25
1996	279	289	304
1997	267	359	123
1998	336	153	171
1999	605	1,016	654
2000	514	261	291
2001	271	225	282
2002	253	201	99
2003	117	41	85
2004	231	98	68
2005	640	223	212
2006	45	139	27
2007	83	53	58
2008	1,591	568	1,148
2009	509	285	418
2010	714	554	1,276
2011	1,523	1,274	2,411
1974-1989 Average	1044.7	796.5	1073.0
% of ‘74-‘89 Ave	146%	160%	225%

Table SHL6-4: Area (in acres) of major clam flats in Hampton-Seabrook Harbor

Year	Common Island Flat	Confluence Flat	Middle Ground Flat	Total
1977	54.9	27.2	49.7	131.8
1979	54.8	26.7	53.5	135.0
1981	54	24.7	50.8	129.5
1983	52.7	26.4	49.9	129.0
1984	50	21.7	47.9	119.6
1995	45.7	26.4	47.3	119.4
2002	36.9	23.4	57.8	118.1

Table SHL6-5: Standing stock of adult clams in Hampton-Seabrook Harbor

Year	Standing Stock (millions)
1971	15.59
1972	14.53
1973	5.71
1974	10.24
1975	4.09
1976	1.05
1977	0.81
1978	0.69
1979	1.87
1980	14.07
1981	14.76
1982	12.42
1983	18.03
1984	10.89
1985	5.21
1986	2.23
1987	0.95
1988	1.36
1989	2.43
1990	7.25
1991	12.92
1992	13.32
1993	9.80
1994	9.74
1995	11.15
1996	18.28
1997	27.17
1998	9.31
1999	7.46
2000	5.22
2001	3.13
2002	2.71
2003	2.46
2004	1.92
2005	2.26
2006	5.11
2007	4.67
2008	3.46
2009	2.45
2010	2.41
2011	2.37

Figure SHL6-1: Average density of adult clams in Hampton-Seabrook Harbor

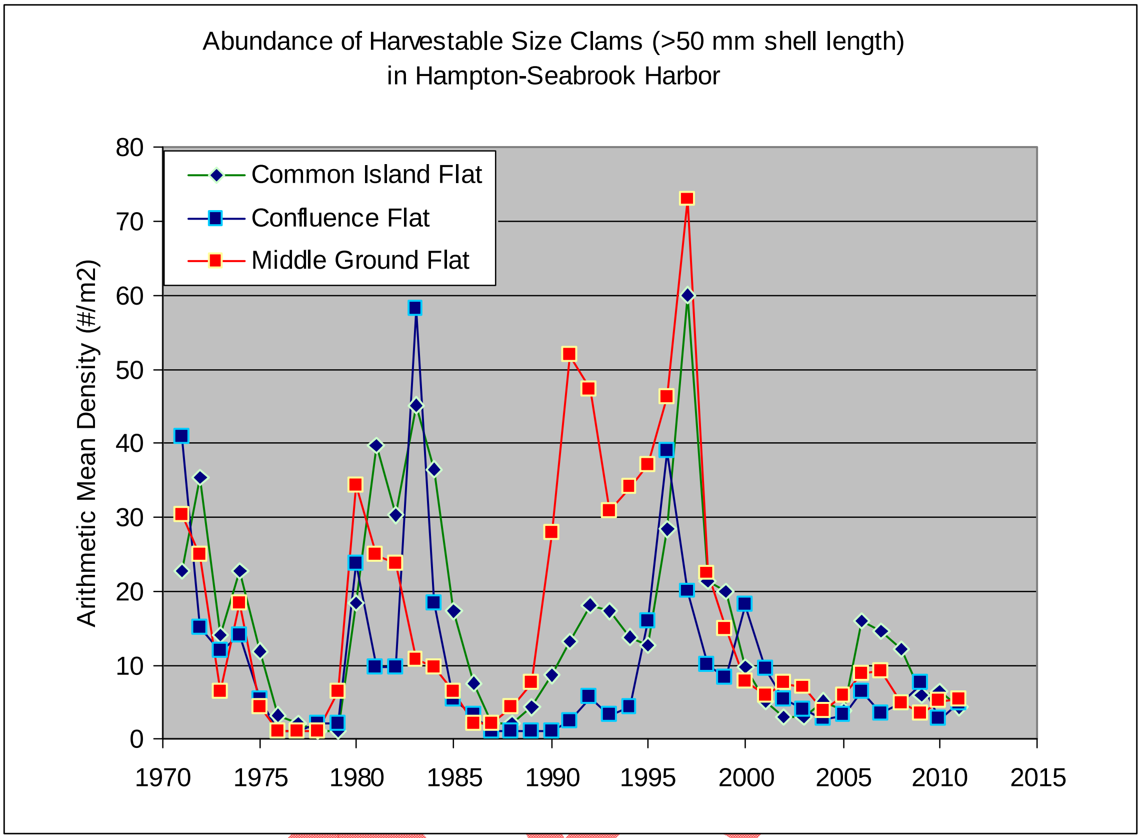


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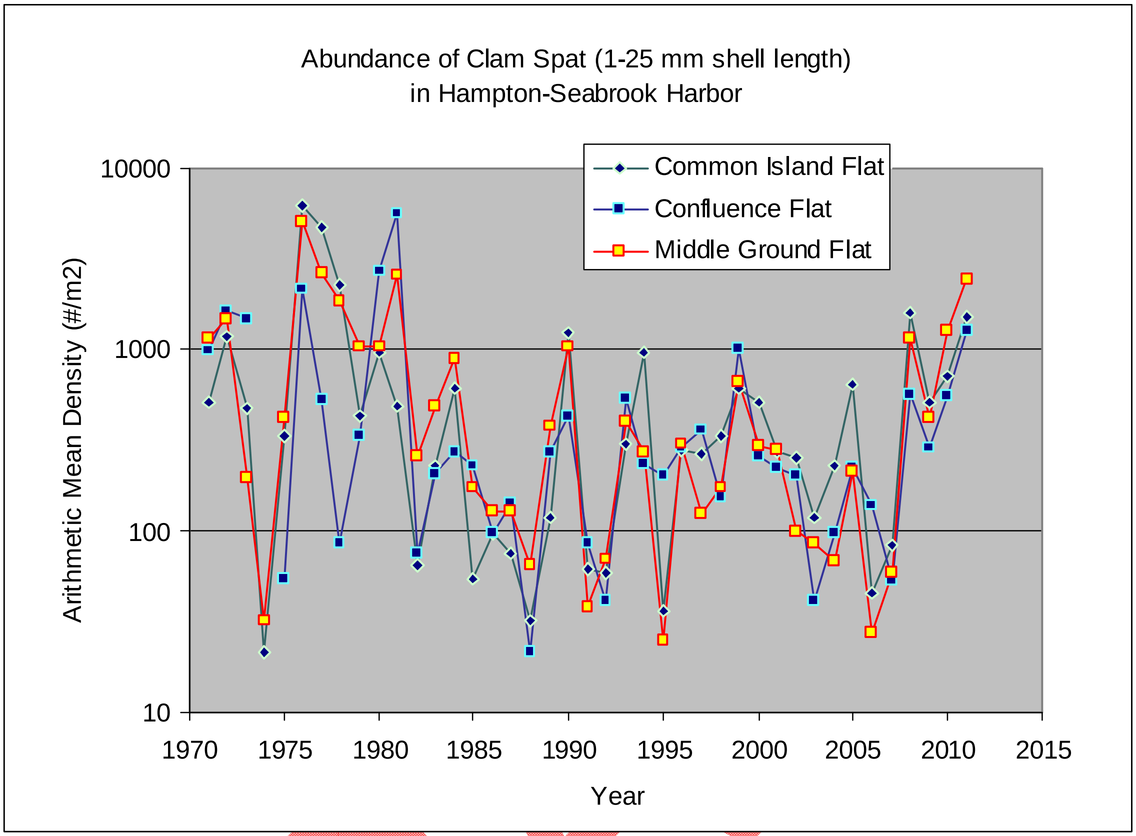
Figure SHL6-2: Average clam spat density in Hampton-Seabrook Harbor



PREP
Piscataqua Region Estuaries Partnership

Figure SHL6-3: Area of clam flats in Hampton-Seabrook Harbor

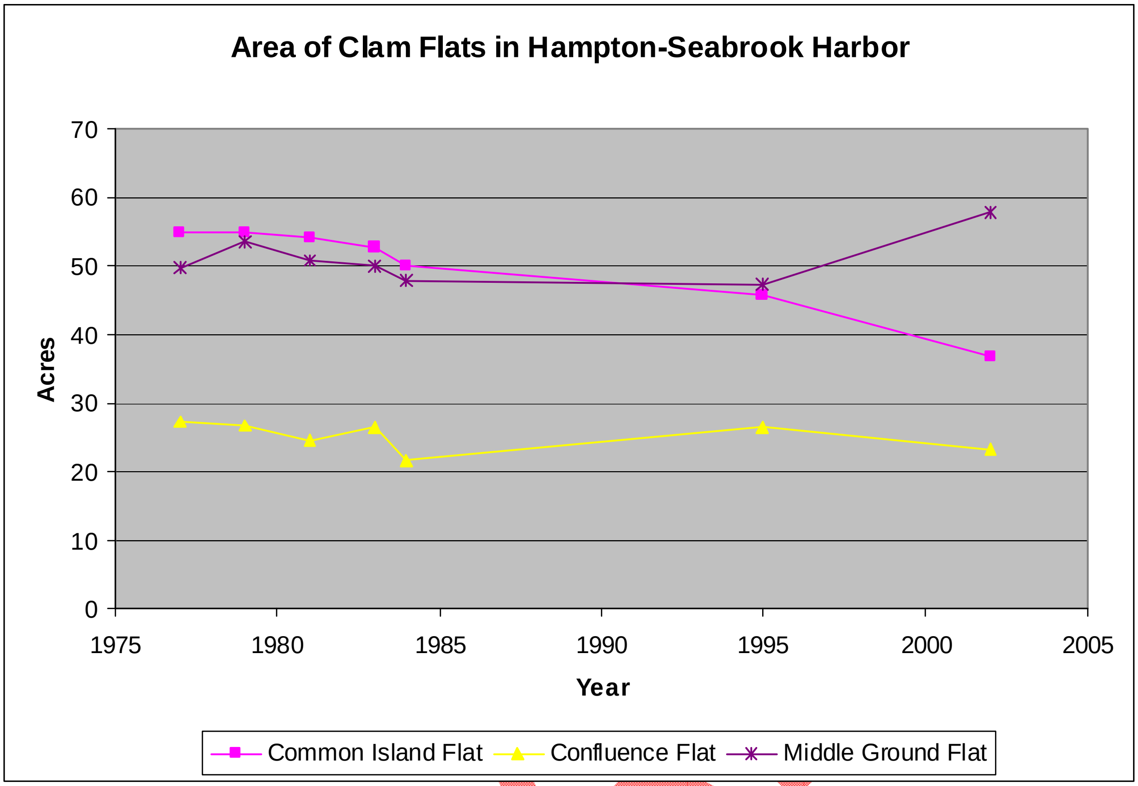


EXHIBIT 36 (AR K.22)

Figure SHL6-4: Standing stock of adult clams in Hampton-Seabrook Harbor

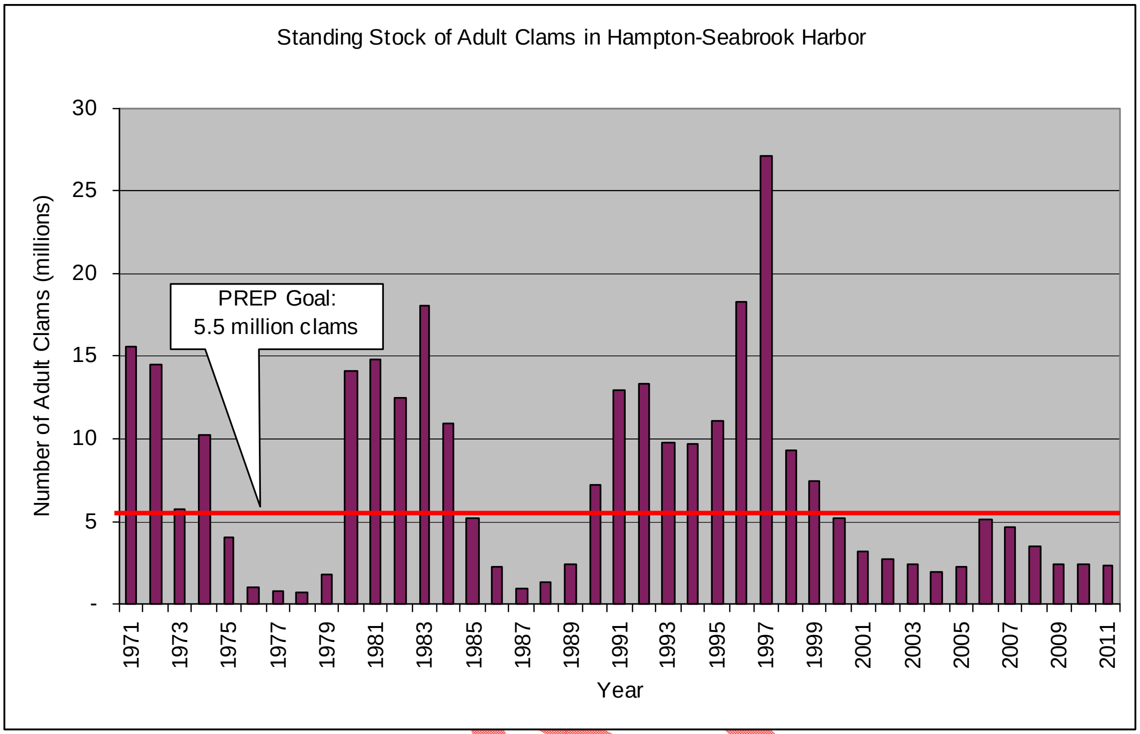


EXHIBIT 36 (AR K.22)

HAB8. Migratory fish returns

Objective

As a subset of the adult finfish, diadromous fish returns are indicative of barriers to migration and conditions in the upper watershed. The juvenile fish need suitable habitat in impoundments, rivers, and streams to thrive, adults need passage through barriers (e.g., dams, culverts, etc.) and suitable upstream, estuarine, or ocean habitat to spawn. Therefore, annual changes in the diadromous fish returns to New Hampshire coastal rivers could be due to many factors. Despite the complexity of this indicator, tracking the returns of river herrings is a useful indicator of ecological conditions in the Piscataqua Region watershed so long as consideration is given to other factors that might affect fish returns (e.g., condition of the fish ladders, floods, etc.).

PREP Goal

Obj LR 1.4: Restore native diadromous fish access to 50 percent of their historical mainstem river distribution range by 2020, and improve habitat conditions encountered throughout their life cycle. For the 2013 SOOE Report, this objective will be evaluated based on migratory fish access to historical mainstem river miles, not actual returns of migratory fish.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

Measurements of abundance for three diadromous fish species were tracked for each year using data from the NH Fish and Game Department (NHF&G). Abundance was measured by counts of fish passing through fish ladders in the spring. Abundance was plotted versus year to illustrate the trend in returns over time. The results were annotated with any pertinent information such as the dates of fish ladder improvements. The species tracked were:

Species	Abundance Measure	Location	Source
Herring (*Alosa pseudoharengus* and *Alosa aestivalis*)	Passage through fish ladders (# of fish/yr)	Exeter, Lamprey, Oyster, Cocheco, Winnicut, and Taylor rivers	NHF&G F-61-R report Table 2-5
Shad (*Alosa sapidissima*)	Passage through fish ladders (# of fish/yr)	Exeter, Lamprey, and Cocheco rivers	NHF&G F-61-R report, Table 1-3

NHF&G also has tracked abundance of five other diadromous fish: Atlantic salmon, sea lamprey, American eel (young-of-year), brown trout, and striped bass. Very few Atlantic salmon have returned to rivers in the Piscataqua River in the past decade, making this species an insensitive indicator. Between 1992 and 2003, only 44 fish were recorded in fish ladders. NHF&G discontinued the Atlantic salmon stocking and monitoring programs in 2004. The abundance of brown trout and striped bass were tracked by voluntary reports from anglers rather than designed surveys implemented by NHF&G staff. Therefore, the abundance results for these species were not included in this indicator.

Data Sources

NH Fish and Game Anadromous Fish Monitoring Programs provided data for this indicator.

Results

Many factors influence the returns of diadromous fish. Each species has its own life cycle history and has different habitat needs as larvae, juvenile and adults. The following comments are simply summaries of the reported data. A more in-depth analysis of the data was not performed.

Data on river herring returns are shown in Figure HAB8-1. One of the most important observations regarding river herring returns is that high water conditions during the spawning runs affect fish ladder efficiency thereby dramatically reducing the number of returns as noted in all rivers from 2005 through 2007. Once the river herring population in the Cocheco River became established after construction of a fish ladder, herring returns have improved but are subjected to lows likely due to high water conditions and availability of effective downstream passage over dams. Following the construction of a fish ladder in the Exeter River, the herring runs have been relatively low due to sea lamprey inundation, harvest pressure, inadequate downstream passage over dams, and water quality issues such as low dissolved oxygen in the upstream impoundment (NHF&G 2005). Once the herring population was established after ladder construction in the Oyster River, a carrying capacity population of above ~50,000 fish has been noted. Recent lows in returns to the Oyster River are likely due to degraded water quality conditions and, as noted above, flood conditions. In the Lamprey River, herring passage appears to follow a cyclical pattern with a period of approximately 20 years. The Taylor River, in Hampton-Seabrook Harbor, had the highest recorded returns of herring. However, this population has declined dramatically due to issues such as water quality degradation and harvesting. River herring returns to the rivers of the Great Bay Estuary have been combined in Figure HAB8-2. This figure illustrates growth of the returns during the 1970s and 1980s with the installation of and improvements in fish ladders, followed by a period of relative stability in the 1990s. There has been a general decline in river herring returns in recent years. This decline is due to a combination of natural fluctuations in populations, realization of a river's carrying capacity, fish passage inefficiencies, possible overharvest, water quality degradation, and high water conditions. Returns can be improved through ladder improvements as shown in the Exeter and Winnicut (in 2001) however those improvements do not compensate for poor water quality within upstream impoundments.

Returns of American shad are shown in Figure HAB8-3. Shad returns to the Exeter River have been decreasing since 2001. Similar to river herring, the declines in shad returns are likely due to flood waters, impoundment water quality degradation, lack of downstream passage, and lack of supplemental stocking since 2009. Returns to the Lamprey and Cocheco Rivers have been minimal as well, largely because restoration efforts (supplemental stocking) have focused on the Exeter River since 1989, leaving only a small residual returning spawning stock.

EXHIBIT 36 (AR K.22)

Figure HAB8-1 Returns of river herring to fish ladders on Piscataqua Region rivers

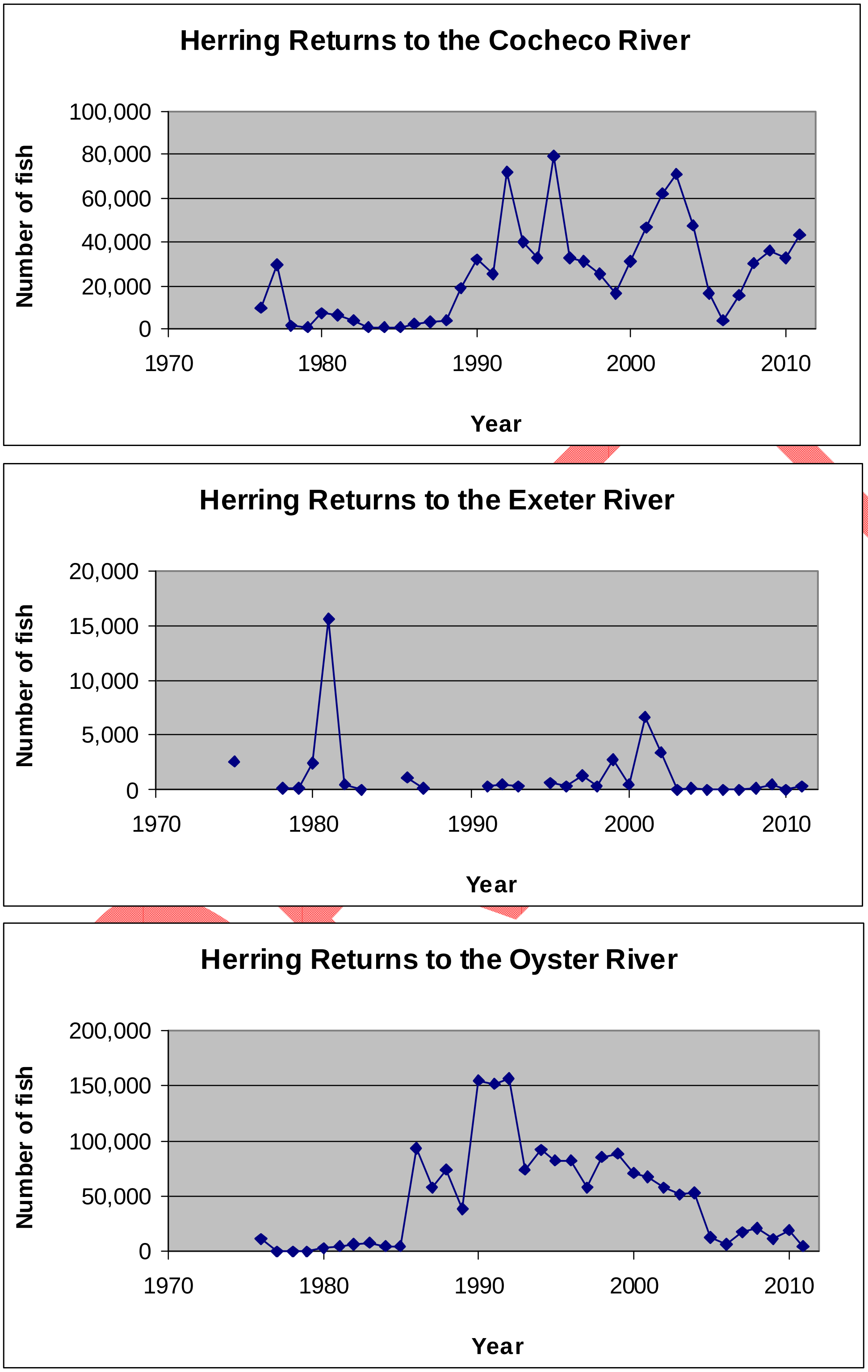
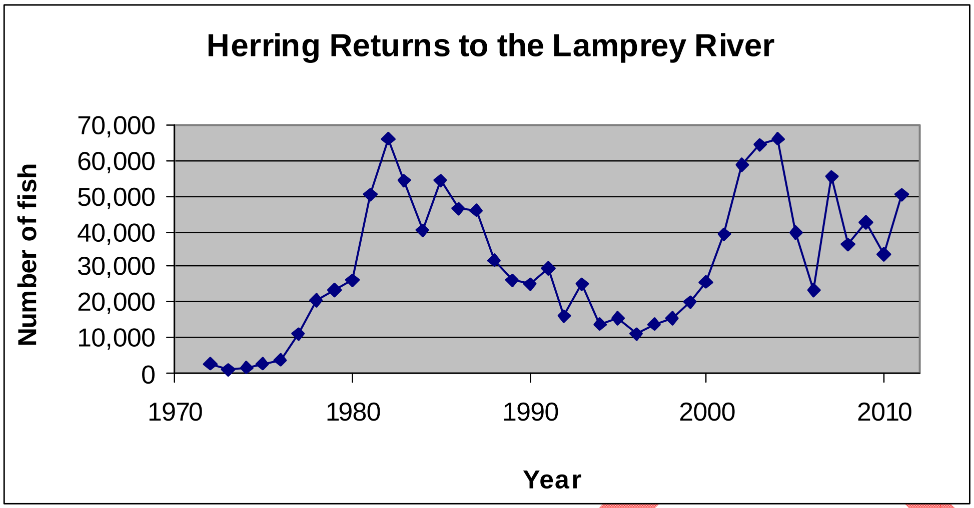
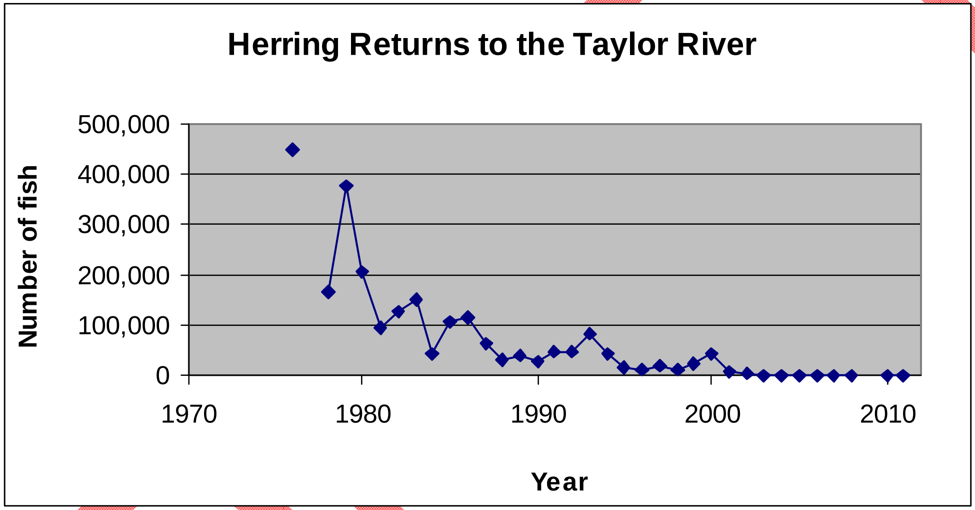


EXHIBIT 36 (AR K.22)

Figure HAB8-1 Returns of river herring to fish ladders on Piscataqua Region rivers (Continued)





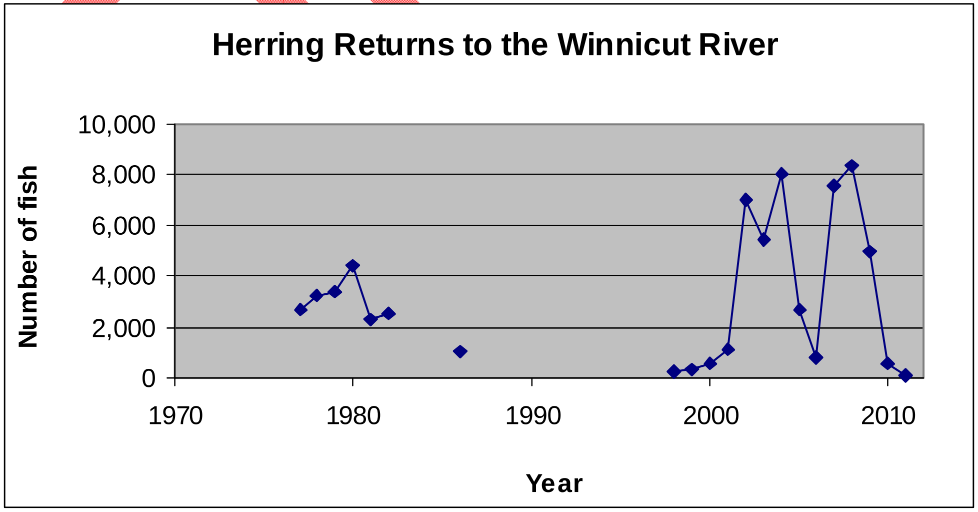


EXHIBIT 36 (AR K.22)

Figure HAB8-2: Returns of river herring to fish ladders in the Great Bay Estuary

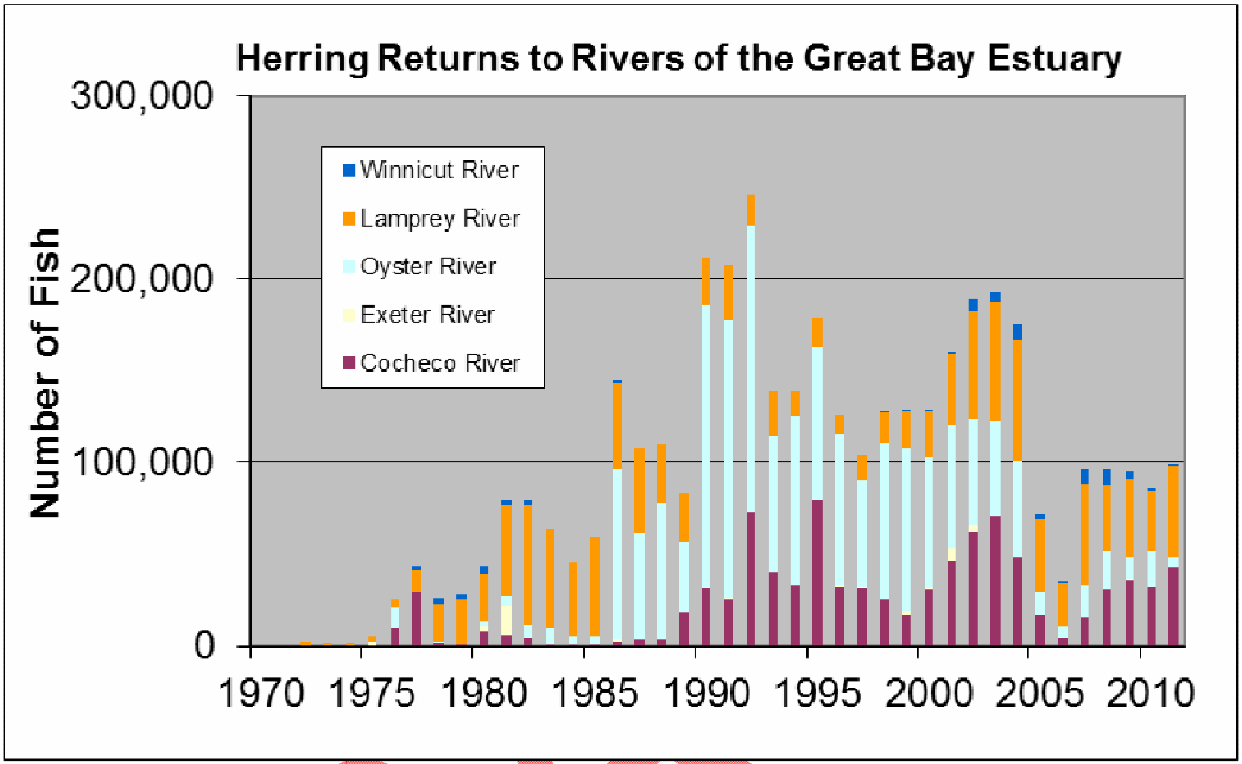
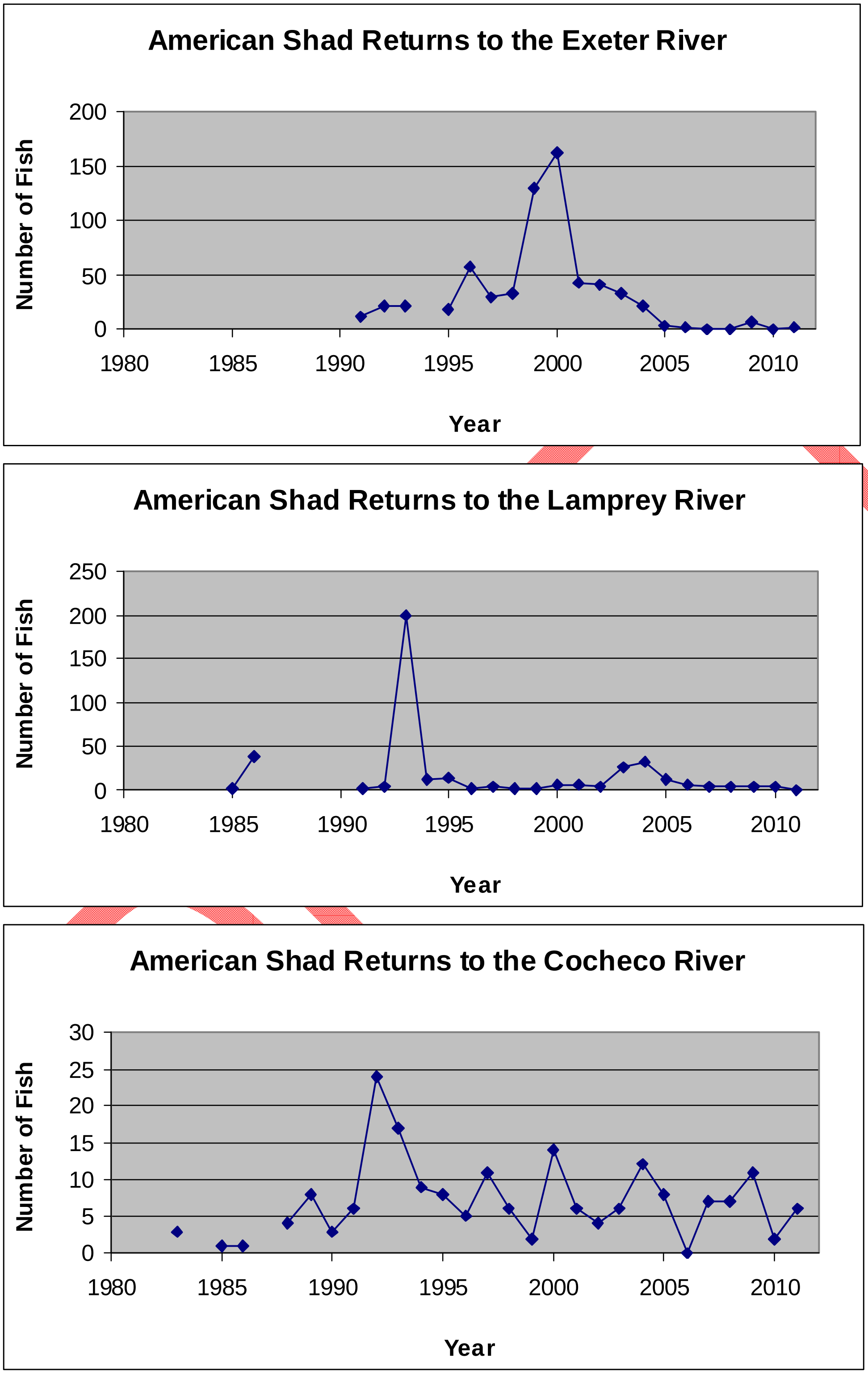


EXHIBIT 36 (AR K.22)

Figure HAB8-3: American shad returns to fish ladders on Great Bay tributaries.



PREP
Piscataqua Region Estuaries Partnership

II. Indicators for the State of Our Estuaries Report

C. Management Response Indicators

Indicator: HAB6. Conservation lands in the Piscataqua Region

Objective

The objective of this indicator is to report on the total acres of lands protected from development in the Piscataqua Region watershed. Development of land for residential, commercial, industrial, and other uses can eliminate or disrupt habitats and increase stormwater runoff and other sources of water pollution. Permanently protecting key areas from development will maintain the ecosystem benefits provided by healthy, natural landscapes.

PREP Goal

Obj LU 3.1: Work with landowners to permanently protect land and water through conservation easements and fee acquisitions, particularly associated with Conservation Focus Areas. AP LU-14: "PREP has adopted a new goal of protecting 20% of the watershed by 2020" (in text).

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The most recent ArcGIS coverage of conservation lands from the Wells National Estuarine Research Reserve for the Maine towns and The Nature Conservancy for the New Hampshire towns were the primary data source for this indicator. The database was queried to identify the conservation lands within the Piscataqua Region watershed (HUC8 01060003). Lands were grouped into categories representing the level of protection and management status. The total acres of public and private conservation lands in the Piscataqua Region watershed and the 22 coastal communities were calculated by summing the areas of individual conservation polygons within these two zones.

The land area was calculated by subtracting the areas of surface waters from the town boundary polygon. To determine the area of surface waters, DES combined the relevant National Hydrograph Dataset Waterbody features (with FType = 390 “LakePond”, 436 “Reservoir”, and 493 “Estuary”) and Area features (with FType = 336 “CanalDitch”, 364 “Foreshore”, 403 “Inundation Area”, 431 “Rapids”, 445 “SeaOcean”, 455 “Spillway”, and 460 “StreamRiver”). The percentage of the Piscataqua Region watershed that is conserved was calculated by dividing the total acres of conservation land by the total land area of the watershed. The same method was used to determine the percent of conservation lands in the 22 coastal communities.

Data Sources

The Conservation/Public Lands geographic datalayer were the basis for this indicator. Conservation lands were grouped into “permanent”, “unofficial”, and “recreational” categories using the protection level fields from NH GRANIT and Wells NERR. Permanent conservation lands were Level 1 in both databases. Unofficial conservation lands were Levels 2 and 3 in both databases. Recreational lands (e.g., parks, fields) were Level 4 in both databases.

Results

Table HAB6-1 summarizes the acres of conservation lands in the Piscataqua Region watershed in both New Hampshire and Maine. By the end of 2011, there were 88,747 acres of protected land in the watershed. This amount is equivalent to 13.5% of the land area, which is still below the PREP goal of 20% by 2020. Eighty-six percent of the conservation lands have permanent protection status. The remaining lands are “unofficial” conservation lands, water supply lands, or recreational parks and fields. Parcels in Maine and New Hampshire make up 10.3 and 89.7% of the total conservation lands, respectively.

There are 22 municipalities in the PREP study area which have tidal shorelines, 17 in New Hampshire and 5 in Maine (Table HAB6-2). In these coastal communities, there was a total of 48,370 acres of conservation land in 2010 (19% of the total land area in these towns). This amount is just below the PREP goal of 20%. However, only 74.2% of these conservation lands have permanent protection. Three of the towns showed a decrease in conservation land between the 2008 and 2011. All of these changes were less then 1% of the total conservation area. These decreases in conservation land are due to small boundary differences between the 2008 and 2011 datasets.

The conservation lands database for 2008 and 2011 was updated by Wells National Estuarine Research Reserve for the Maine towns and The Nature Conservancy for the New Hampshire towns. The combination of these two datasets provides watershed-wide information on conservation lands for the Piscataqua Region. In the Piscataqua Region watershed the total amount of conservation lands has grown from 68,010 in 2008 (10.3%) to 88,747 in 2011 (13.5%). The rate of growth of conservation lands in the Piscataqua Region watershed has been approximately 7,000 acres per year. In order to reach the PREP goal of protecting 20% of the entire Piscataqua Region watershed by 2020, an additional 42,944 acres of conservation lands are still needed. If the current pace of conservation is maintained, the PREP goal will be achieved.

The percentage of land area that is protected in each PREP municipality is shown in Table HAB6-2 and on Figure HAB6-1. Figure HAB6-1 illustrates that great progress toward the PREP goals has been made in the towns around Great Bay, near the coast, in the vicinity of the Bear Brook and Pawtuckaway State Parks, and in the Mt. Agamenticus to the Sea area. In contrast, there is a lower percentage of protected land in the Salmon Falls River and Cocheco River watersheds.

EXHIBIT 36 (AR K.22)

Table HAB6-1: Conservation lands in the Piscataqua Region watershed in 2011

Type	New Hampshire	Maine	Total	% of Total
Permanent	68,635	7,701	76,336	86.0%
Recreational	1,383		1,383	1.6%
Unofficial	9,545	1,484	11,029	12.4%
Total	79,563	9,185	88,747	100%
% of Total	89.7%	10.3%	100%	

Table HAB6-2: Conservation lands in PREP municipalities in 2002, 2005, 2008 and 2011

Town Name (*=coastal community)	Conservation Lands - 2002 (ac)	Conservation Lands - 2005 (ac)	Conservation Lands - 2008 (ac)	Conservation Lands - 2011 (ac)	Percent Conservation 2011
BARRINGTON, NH	2,551	2,734	3,157	4,094	13.8%
BRENTWOOD, NH	460	1,474	2,571	2,782	25.9%
BROOKFIELD, NH	1,813	1,845	2,461	2,480	17.0%
CANDIA, NH	1,891	2,046	2,110	2,261	11.7%
CHESTER, NH	1,320	1,312	1,311	1,312	7.9%
DANVILLE, NH	458	557	567	620	8.3%
DEERFIELD, NH	5,332	5,582	6,034	6,704	20.6%
DOVER, NH*	1,589	1,529	2,259	2,860	16.8%
DURHAM, NH*	3,401	4,326	5,010	6,157	43.2%
EAST KINGSTON, NH	156	670	847	902	14.3%
EPPING, NH	498	1,367	1,441	2,795	17.0%
EXETER, NH*	2,447	3,496	3,689	3,713	29.6%
FARMINGTON, NH	1,146	1,242	1,574	2,025	8.7%
FREMONT, NH	209	231	574	574	5.2%
GREENLAND, NH*	727	899	1,328	1,321	19.6%
HAMPTON, NH*	631	630	763	778	9.7%
HAMPTON FALLS, NH*	483	633	664	991	13.2%
KENSINGTON, NH	626	1,548	1,549	1,722	22.5%
KINGSTON, NH	1,067	1,376	1,473	2,035	16.3%
LEE, NH	1,239	2,340	2,336	3,021	23.8%
MADBURY, NH*	1,641	1,328	1,390	1,682	22.7%
MIDDLETON, NH	398	488	2,316	2,302(4)	19.9%
MILTON, NH	2,568	2,553	2,672	3,417	16.2%
NEW CASTLE, NH*	106	106	106	111	21.9%
NEW DURHAM, NH	1,754	1,753	1,753	1,910	7.3%
NEWFIELDS, NH*	394	784	784	1,263	27.8%
NEWINGTON, NH*	1,216	1,307	1,307	1,307	25.1%
NEWMARKET, NH*	761	1,330	1,512	1,904	24.0%
NORTH HAMPTON, NH*	481	718	903	931	10.5%
NORTHWOOD, NH	2,150	2,381	2,476	2,761	15.4%
NOTTINGHAM, NH	5,676	5,860	8,112	8,806	29.5%
PORTSMOUTH, NH*	1,107	1,103	1,117	1,407	14.1%
RAYMOND, NH	1,075	1,017	1,247	1,419	7.7%

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Town Name (*=coastal community)	Conservation Lands - 2002 (ac)	Conservation Lands - 2005 (ac)	Conservation Lands - 2008 (ac)	Conservation Lands - 2011 (ac)	Percent Conservation 2011
ROCHESTER, NH	436	436	1,013	1,222	4.3%
ROLLINSFORD, NH*	411	409	633	632(4)	13.5%
RYE, NH*	1,246	1,495	1,532	1,608	20.1%
SANDOWN, NH	336	591	591	801	9.0%
SEABROOK, NH*	285	451	451	485	9.3%
SOMERSWORTH, NH	221	221	299	408	6.6%
STRAFFORD, NH	3,646	5,261	6,275	6,410	20.6%
STRATHAM, NH*	671	1,025	1,098	1,461	15.1%
WAKEFIELD, NH	284	397	691	905	3.6%
ACTON, ME	NA	NA	432	432	1.8%
BERWICK, ME	NA	NA	944	893	3.8%
ELIOT, ME*	NA	NA	583	588	4.7%
KITTERY, ME*	NA	NA	1,567	1,595	14.1%
LEBANON, ME	NA	NA	923	997	2.8%
NORTH BERWICK, ME	NA	NA	635	735	3.0%
SANFORD, ME	NA	NA	2,587	2,562(4)	8.5%
SOUTH BERWICK, ME*	NA	NA	3,475	3,689	18.0%
WELLS, ME*	NA	NA	5,266	5,780	15.7%
YORK, ME*	NA	NA	7,631	8,109	23.2%
TOTAL:	**54,909**	**66,852**	**104,038**	**117,680**	**14.0%**
TOTAL Coastal Communities:	**17,598**	**21,570**	**43,069**	**48,370**	**19.0%**

(1) Data source for conservation lands in 2011: The Nature Conservancy (NH towns), Wells NERR (ME towns)

(2) Results are for the whole town. PREP also reports on conservation lands in the Piscataqua Region watershed. Some towns are only partially in the watershed. Therefore, there are some discrepancies between the totals on this table and the totals for the whole watershed.

(3) The dates of conservation lands are approximate and reflect the date when the parcel was reported with sufficient metadata, not the date of an easement or other instrument.

(4) Decrease in total conservation land between 2008 and 2011. Middleton, Rollinsford and Sanford showed decreases of 13, one and 24 acres, respectively. These decreases in conservation land were due to small boundary differences between the 2008 and 2011 datasets.

EXHIBIT 36 (AR K.22)

Figure HAB6-1: Percent of land area that is protected in each PREP municipality in 2011

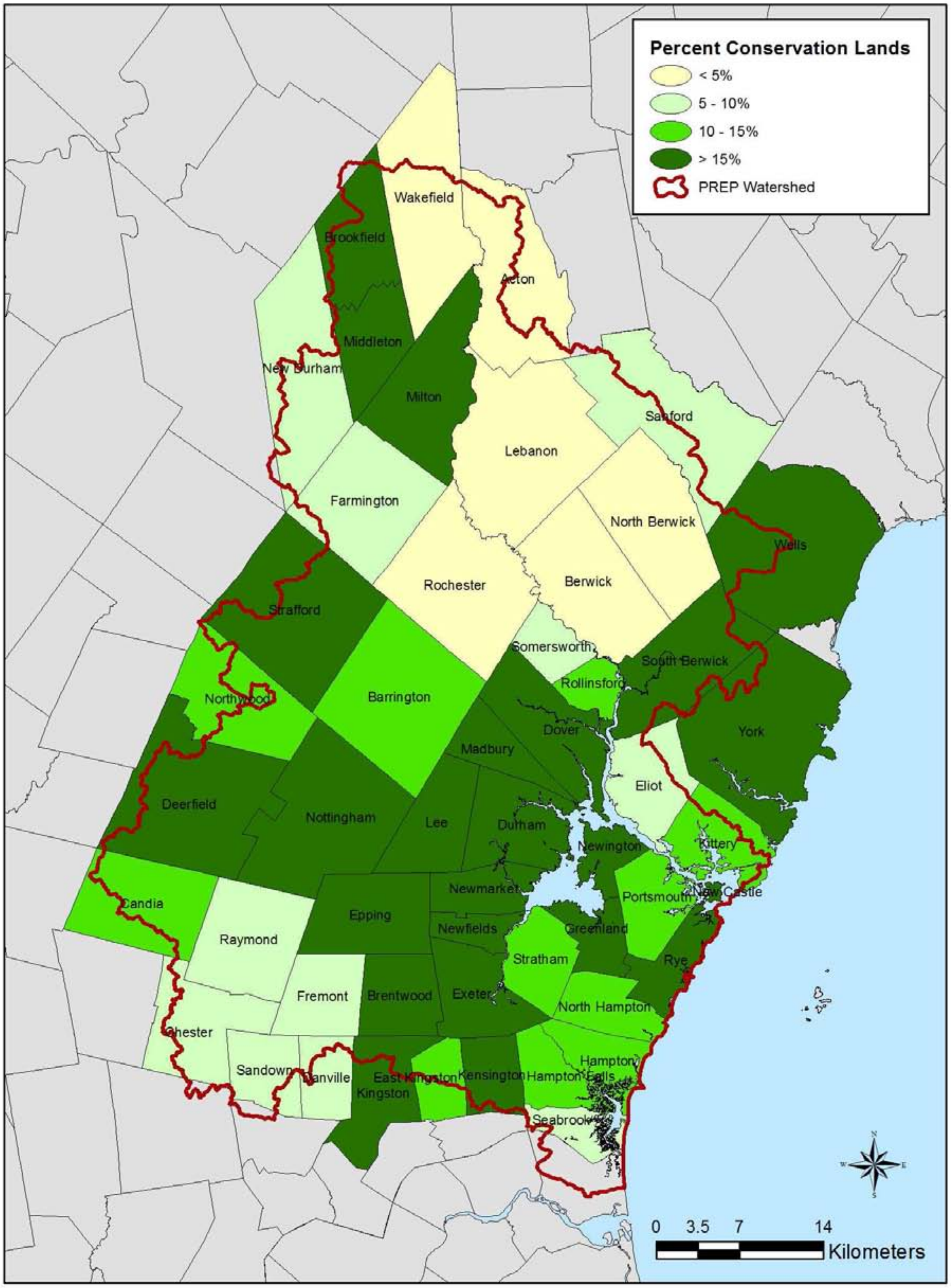

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EXHIBIT 36 (AR K.22)

Indicator: HAB5. Conservation Focus Areas in the Piscataqua Region

Objective

The objective for this supporting variable is to track the percentage of conservation focus areas in the Piscataqua Region watershed that are already protected from development. The Land Conservation Plan for New Hampshire's Coastal Watersheds (TNC, 2006) identified 75 Conservation Focus Areas in the New Hampshire portion of the Piscataqua Region watershed. Fifteen conservation focus areas have been delineated in the Maine side (Walker et al, 2010). These focus areas are priorities for conservation because of their high habitat values.

PREP Goal

Obj LU 3.1: Implement the Land Conservation Plan for New Hampshire's Coastal Watersheds and the Land Conservation Plan for Maine's Piscataqua Region Watersheds, and protect 75% of lands identified as Conservation Focus Areas by 2025. PREP goal set by Obj LU 3.1.

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The most recent ArcGIS coverage of conservation lands and conservation focus areas, available through NH GRANIT and Wells NERR were the data sources for this indicator. ArcGIS software was used to calculate the intersection of the conservation lands coverage and conservation focus areas coverage within the Piscataqua Region watershed (HUC8 01060003). Only core areas for conservation focus areas were used for this analysis. Conservation lands were grouped into "permanent", "unofficial", and "recreational" categories using the protection level fields. Permanent conservation lands were Level 1 in both databases. Unofficial conservation lands were Levels 2 and 3 in both databases. Recreational lands (e.g., parks, fields) were Level 4 in both databases. The indicator was the percentage of conservation focus areas in the Piscataqua Region watershed that intersect the conservation lands coverage.

Data Sources

The geographic datalayers of the conservation focus areas and the conservation/public lands, available through NH GRANIT and Wells NERR, were used for this analysis. Conservation focus area boundaries were obtained from TNC (2006) and Walker et al. (2010). The total area of conservation lands in the conservation focus areas is slightly different from the totals reported in 2008. This difference is due to; 1) the New Hampshire data layers used in 2008 were not clipped to the PREP watershed boundaries; and 2) overlaps between Maine and New Hampshire polygons were removed, which resulted in the addition of one CFA in Maine.

Results

The updated database of conservation lands was merged with the locations of conservation focus areas in the Piscataqua Region watershed to determine how much of each focus area was protected from development. The total area of conservation lands in the conservation focus areas is slightly different from the totals reported in 2008. This difference is due to; 1) the New Hampshire data layers used in 2008 were not clipped to the PREP watershed boundaries; and 2) overlaps between Maine and New Hampshire polygons were removed, which resulted in the addition of one CFA in Maine.

Table HAB5-1 shows the total area of conservation land in all of the focus areas. Overall, 45,869 acres of conservation land fall within the core focus areas, which amount to 28% of the combined area of the focus areas. In 2008, 42,046 acres of the core focus areas were protected. Therefore, 3,823 acres were protected over 3 years at an average rate of 1,274 acres per year. In order to reach the PREP goal of 125,000 acres of focus areas protected by 2025 an additional 79,131 acres need to be protected. This goal will not be achieved by 2025 at the current rate of land protection in focus areas.

The percent of conservation lands varies across the focus areas. Twenty-three of the 90 focus areas have less than 10% of the core land area protected. In contrast, there are 14 focus areas with greater than 50% coverage by conservation lands. The percentage of conservation lands in each focus area is shown in Tables HAB5-2 and HAB5-3 and on Figure HAB5-1. Fourteen of the conservation focus areas showed a decrease in conservation land between the 2008 and 2011. The majority of these changes were less then 5% of the total conservation area with the exception of Thurston Pond/Hartford Brook, Brave Boat Harbor and Gerrish Island, Cranberry Meadow and Sanford Ponds, which showed a decrease greater than 20% in total conservation area. These decreases in conservation land are due to areas outside of the PREP watershed not removed from the calculations in 2008 and/or boundary modifications between the 2008 and 2011 datasets.

In general, there are a higher percentage of conservation lands in conservation focus areas than in the watershed as a whole. Indicator HAB6 showed that 13.5% of the Piscataqua Region watershed was protected from development. In contrast, 61 of the 90 focus areas have at least 14% coverage by conservation lands and cumulatively 27% of the focus areas are covered by conservation lands.

Table HAB5-1: Conservation lands in all conservation focus areas in the Piscataqua Region watershed in 2011

Type	New Hampshire	Maine	Total	% of Total
Permanent	38,393.24	3,704.01	42,097.25	91.78%
Unofficial	2,887.93	684.52	3,572.45	7.79%
Recreational	199.33	0.00	199.33	0.43%
Total	41,480.50	4,388.53	45,869.03	100.00%
% of Total	90.43%	9.57%	100.00%	

Table HAB5-2: Conservation lands in individual conservation focus areas in New Hampshire in 2011

Focus Area	Area of Core CFA (acres)	Permanent Conservation Land (acres)	Unofficial Conservation Land (acres)	Active Recreational Land (acres)	Total Conservation Lands (acres)	Percent of Core CFA Area
Awcomin Marsh	885.02	250.29	83.79	0.00	334.09*	37.7%
Bailey Brook	564.20	86.78	28.96	0.00	115.74	20.5%
Bayside Point	333.12	120.73	0.00	0.00	120.73*	36.2%
Bellamy River	796.03	529.44	0.00	0.00	529.44	66.5%
Birch Hill Road Lowlands	57.74	0.00	0.00	0.00	0.00	0.0%
Bloody and Dudley Brooks	552.78	361.16	0.00	0.00	361.16*	65.3%
Blue Hills	16,878.93	2,848.21	46.53	0.00	2,894.74	17.2%
Bumfagging Hill	2,361.06	478.87	0.00	0.00	478.87	20.3%
Candia Road	549.16	0.00	0.00	0.00	0.00	0.0%
Cocheco Headwaters	1,691.08	173.54	0.00	0.00	173.54	10.3%
Coldrain Pond	906.25	129.54	0.00	0.00	129.54	14.3%
Cooper Cedar Woods	379.52	130.91	0.00	0.00	130.91	34.5%
Creek Pond Marsh	671.19	608.95	23.60	0.00	632.55	94.2%
Crommet and Lubberland Creeks	3,798.66	2,201.49	0.00	0.00	2,201.49	58.0%
Davis and Oak Hill	1,337.31	38.77	0.00	0.00	38.77	2.9%
Dogtown Swamp	164.06	35.79	0.00	0.00	35.79*	21.8%
Dumplingtown Hill	364.87	113.89	0.00	4.83	118.72	32.5%
Exeter River	620.35	431.98	4.50	0.00	436.48	70.4%
Fabyan Point	1,071.64	787.64	0.00	10.18	797.82	74.4%
Fordway Brook Headwaters	941.39	118.29	0.00	0.00	118.29	12.6%
Fresh Creek	325.92	0.00	0.00	0.00	0.00	0.0%
Garvin Brook	82.76	36.96	0.00	0.00	36.96	44.7%
Great Bog	989.21	645.41	0.00	0.00	645.41	65.2%
Great Meadows	1,400.23	142.18	674.52	0.00	816.70	58.3%
Hampton Marsh	7,470.01	578.73	69.46	21.35	669.54	9.0%
Hart Brook / Mt. Tenneriffe	3,502.95	409.38	355.34	0.00	764.72	21.8%
Johnson and Bunker Creeks	747.57	174.12	0.00	3.93	178.04	23.8%
Kennard Hill	1,294.59	0.00	0.00	0.00	0.00	0.0%
Lamprey River	1,722.16	509.29	27.35	0.00	536.64	31.2%
Langley and Cyrus Ponds	1,027.81	0.00	0.00	0.00	0.00	0.0%
LaRoche and Woodman Brooks	444.11	111.07	224.27	15.21	350.55	78.9%
Lower Berry's Brook	270.17	58.44	0.00	0.00	58.44	21.6%
Lower Cocheco River	485.50	107.16	0.00	0.00	107.16	22.1%
Lower Fordway Brook	1,679.10	201.49	0.00	0.00	201.49	12.0%
Lower Isinglass River	1,260.85	207.48	0.00	16.85	224.33	17.8%
Lower Lamprey River	1,228.13	355.58	180.16	0.00	535.74	43.6%
Lower Little River	195.85	76.76	0.00	0.00	76.76	39.2%
Lower Lubberland Creek	239.13	189.09	0.00	0.00	189.09	79.1%
Lower Piscassic River	3,027.23	1,175.39	9.62	23.27	1,208.28	39.9%
Lower Winnicut River	229.02	55.62	0.00	5.74	61.36	26.8%
Middle Isinglass River	504.35	0.00	0.00	0.00	0.00	0.0%

EXHIBIT 36 (AR K.22)

Focus Area	Area of Core CFA (acres)	Permanent Conservation Land (acres)	Unofficial Conservation Land (acres)	Active Recreational Land (acres)	Total Conservation Lands (acres)	Percent of Core CFA Area
Middle Little River	595.15	9.21	86.28	0.00	95.49	16.0%
Middle Piscassic River	2,281.29	1,200.74	0.00	14.85	1,215.59	53.3%
Middle Winnicut River	163.91	36.77	0.00	0.00	36.77	22.4%
Moose Mountains	8,788.70	3,556.67	81.69	0.00	3,638.36*	41.4%
Muddy Pond	156.29	17.39	44.04	0.00	61.43	39.3%
North River / Rollins Brook	813.85	29.90	0.00	3.76	33.66	4.1%
Northeast Pond	1,385.22	703.02	0.00	0.00	703.02*	50.8%
Oyster River	2,691.06	218.33	531.39	0.22	749.94	27.9%
Packer Bog	815.15	394.12	0.00	0.00	394.12	48.4%
Parkman Brook	547.25	74.54	0.00	0.00	74.54	13.6%
Pawtuckaway Mountains	23,142.47	10,293.54	0.00	0.00	10,293.54	44.5%
Pawtuckaway River	748.98	424.85	0.00	0.00	424.85	56.7%
Pike Brook	2,338.66	30.63	0.00	26.79	57.42*	2.5%
Preston Pond	342.52	110.23	0.00	0.00	110.23	32.2%
Rochester Heath Bog	1,024.03	49.15	0.00	0.00	49.15	4.8%
Rochester Neck	1,605.23	347.94	6.58	0.00	354.53	22.1%
Saddleback Mountain	3,342.88	1,399.24	259.02	0.00	1,658.27	49.6%
Seavey Creek / Fairhill Swamp	633.45	439.78	0.00	0.00	439.78*	69.4%
Spruce Swamp	1,854.53	427.50	10.87	14.47	452.83	24.4%
Squamscott River	2,023.56	617.68	18.43	1.98	638.09	31.5%
Stonehouse Brook	726.47	0.00	0.00	0.00	0.00	0.0%
Taylor River and The Cove	2,421.88	693.01	0.00	0.00	693.01	28.6%
Thurston Pond / Hartford Brook	2,474.71	382.87	0.00	0.00	382.87*	15.5%
Union Meadows	985.90	43.93	0.00	0.00	43.93	4.5%
Upper Berry's Brook	1,460.64	288.11	38.76	0.00	326.87	22.4%
Upper Exeter River	3,011.24	359.41	0.00	35.91	395.32	13.1%
Upper Great Brook	543.54	185.93	0.00	0.00	185.93*	34.2%
Upper Isinglass River	853.75	203.55	0.00	0.00	203.55	23.8%
Upper Little River	326.56	86.67	0.00	0.00	86.67*	26.5%
Upper North Branch River	2,879.91	960.68	65.03	0.00	1,025.70	35.6%
Upper Taylor River	438.99	107.83	0.00	0.00	107.83	24.6%
Upper Winnicut River	289.58	49.33	0.00	0.00	49.33	17.0%
Wallis Marsh	310.88	125.26	12.36	0.00	137.62	44.3%
Winnicut River / Cornelius Brook	329.43	45.02	5.37	0.00	50.38	15.3%
Total	135,398.66	38,393.24	2,887.93	199.33	41,480.50	30.6%

* Awcomin Marsh, Bayside Point, Bloody and Dudley Brooks, Dogtown Swamp, Upper Great Brook and Upper Little River showed decreases in total conservation land (<6 acres) between 2008 and 2011. These decreases in conservation land were due to small boundary differences between the 2008 and 2011 datasets. Moose Mountains, Northeast Pond, Pike Brook, Seavey Creek / Fairhill Swamp and Thurston Pond / Hartford Brook showed decreases in total conservation land (<1-170 acres) between 2008 and 2011. These decreases in conservation land were due the data layers used in 2008 not being clipped to the PREP watershed boundary.

EXHIBIT 36 (AR K.22)

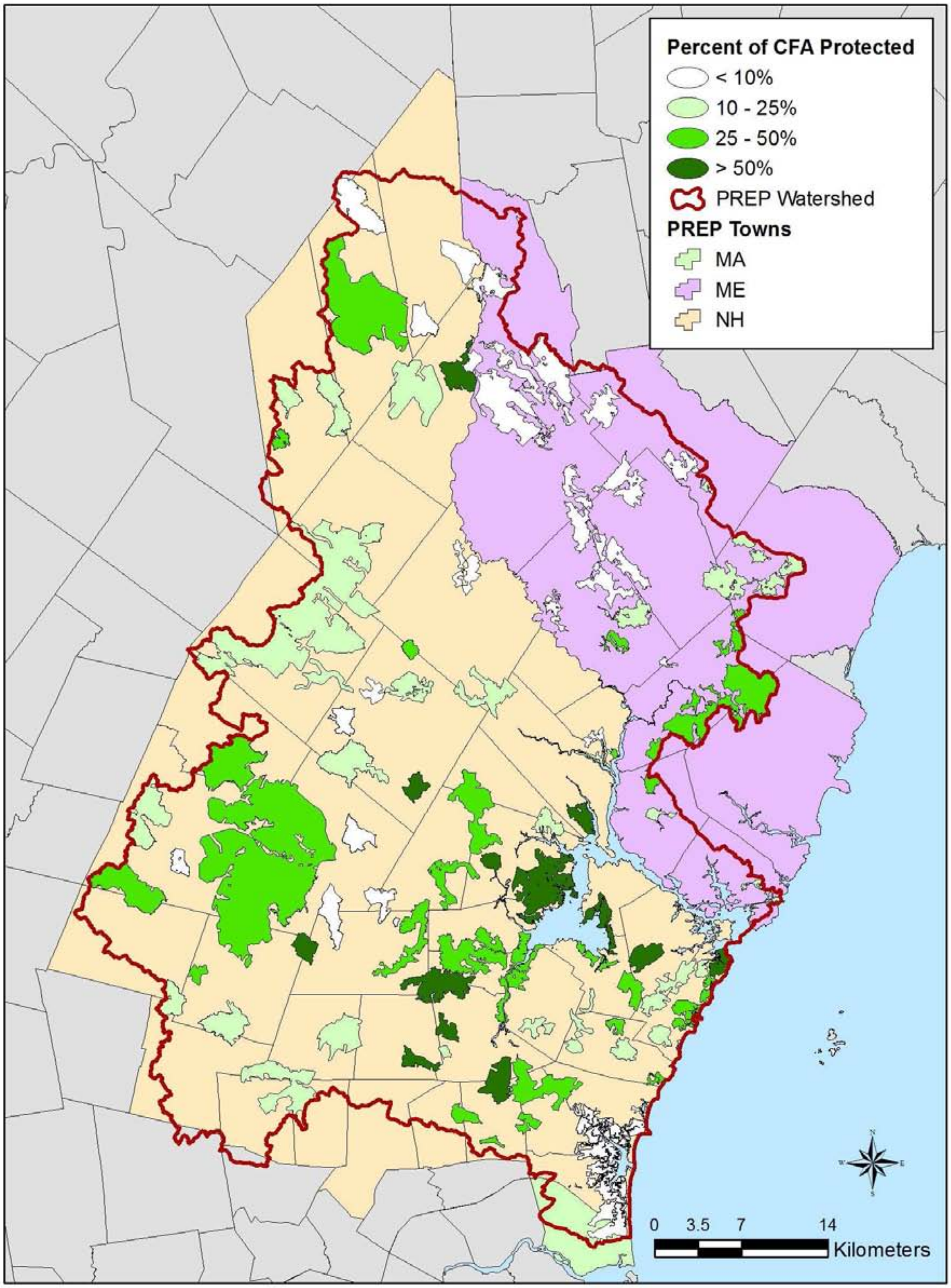
Table HAB5-3: Conservation lands in individual conservation focus areas in Maine in 2011

Focus Area	Area of Core CFA (acres)	Permanent Conservation Land (acres)	Unofficial Conservation Land (acres)	Active Recreational Land (acres)	Total Conservation Lands (acres)	Percent of Core CFA Area
Bauneg Beg Mountain	1,572.20	0.00	0.00	0.00	0.00	0.0%
Beaver Dam Heath	1,051.74	120.87	0.00	0.00	120.87	11.5%
Brave Boat Harbor and Gerrish Island	347.95	78.35	4.02	0.00	82.37*	23.7%
Cranberry Meadow	426.70	126.70	0.00	0.00	126.70*	29.7%
Gerrish Mountain	1,282.71	32.76	0.00	0.00	32.76	2.6%
Knights Pond	113.54	0.00	0.00	0.00	0.00	0.0%
Little River East	4,373.50	0.00	0.00	0.00	0.00	0.0%
Little River West	476.93	32.69	0.00	0.00	32.69	6.9%
Merriland River Wetlands	3,257.17	57.92	283.45	0.00	341.36	10.5%
Mount Agamenticus and York River Headwaters	6,851.18	2,855.35	242.92	0.00	3,098.27	45.2%
Northeast Pond	418.08	4.36	0.00	0.00	4.36	1.0%
Sanford Ponds	907.76	26.86	35.68	0.00	62.54*	6.9%
Shapleigh Pond	72.00	0.00	0.00	0.00	0.00	0.0%
South Acton Swamps	8,063.57	318.86	105.90	0.00	424.76	5.3%
Sturgeon Creek	295.97	49.29	0.00	0.00	49.29	16.7%
West Sanford Swamps	1,256.58	0.00	12.55	0.00	12.55	1.0%
Total	30,767.59	3,704.01	684.52	0.00	4,388.53	14.3%

* Brave Boat Harbor and Gerrish Island, Cranberry Meadow, and Sanford Ponds showed decreases in total conservation land (25-40 acres) between 2008 and 2011. These decreases in conservation land were due to boundary differences between the 2008 and 2011 datasets.

EXHIBIT 36 (AR K.22)

Figure HAB5-1: Percent of land area that is protected in each core conservation focus area in 2011



Indicator: RST1. Restored salt marsh

Objective

The objective of this indicator is to track the cumulative acres of salt marsh with tidal restrictions that have been restored or enhanced since PREP implementation began (2000). Historic data suggests that salt marshes, oyster beds, and eelgrass habitats in the Piscataqua Region watershed have been degraded or lost over time (Odell et al., 2006; Eberhardt and Burdick, 2009). Restoration efforts attempt to restore the function of these critical habitats.

PREP Goal

Obj LR 1.10: Restore or enhance an additional 300 acres of salt marsh by 2020 through removal of tidal restrictions or invasive species management. The original objective from the 2000 PREP Management Plan was to restore 300 acres of salt marsh by removing tidal restrictions. The 2010 PREP Management Plan added an additional objective to enhance 300 more acres of salt marsh by 2020 through improved management practices. Therefore, PREP has two complementary goals for salt marsh restoration: to restore 300 acres of salt marsh and to enhance another 300 acres of salt marsh by 2020.

Methods and Data Sources

Data Analysis and Statistical Methods

The total acres of salt marshes that have been restored since January 1, 2000 was recalculated each year and compared to the goal of 300 total acres. The total acres of salt marshes that have been enhanced since January 1, 2010 was recalculated each year and compared to the goal of 300 total acres. The salt marsh areas were considered “restored” at the conclusion of the restoration project. The total area of restored or enhanced salt marsh was determined by the restoration project manager. No statistical tests were applied.

Data Sources

The most recent summary of salt marsh restorations in the Piscataqua Region watershed were obtained from the inventory maintained by the NH Coastal Program and by querying other practicing restoration partners active in the region. The quality of the information for this indicator depends on the accuracy of the reported area restored for each project. The total restored or enhanced area for a project is important to restoration project managers. Therefore, the information reported by restoration project managers will be considered to be sufficiently accurate for this indicator.

Results

There has been significant progress toward the goal of restoring 300 acres of salt marsh (Figure RST1-1). The current tally of salt marsh restoration projects by tidal restriction removal since January 1, 2000 is 280.5 acres (93% of goal).

Limited progress has been made toward the goal of enhancing 300 acres of salt marsh. There has been 30.6 acres of marsh enhancement work completed, representing 10% of the goal.

This indicator tracks restoration effort in terms of acres for which restoration was attempted. The area of functional habitat created by restoration projects may be lower.

Figure RST1-1: Cumulative acres of salt marsh restoration and enhancement since 2000.

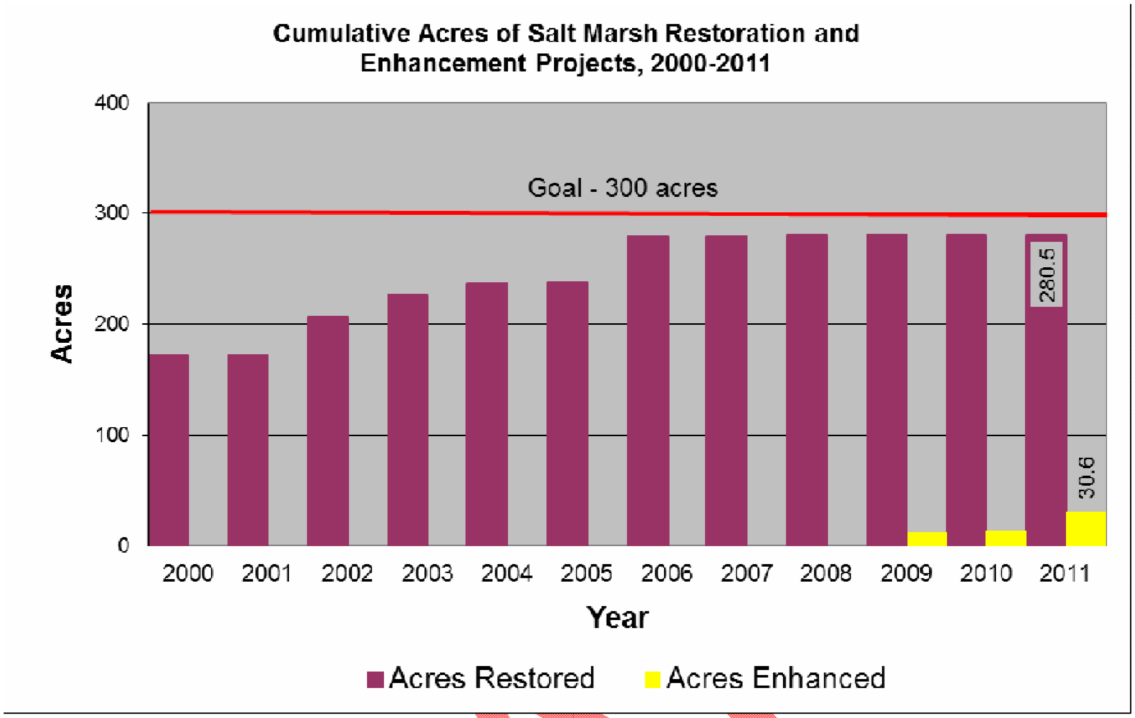


EXHIBIT 36 (AR K.22)

Indicator: RST2. Restored eelgrass beds

Objective

The objective of this indicator is to track the cumulative acres of eelgrass beds that have been restored since PREP implementation began (2000). Historic data suggests that salt marshes, oyster beds, and eelgrass habitats in the Piscataqua Region watershed have been degraded or lost over time (Odell et al., 2006; Eberhardt and Burdick, 2009). Restoration efforts attempt to restore the function of these critical habitats.

PREP Goal

LR 1.3: Increase the aerial extent of eelgrass cover to 2900 acres and restore connectivity of eelgrass beds throughout the Great Bay Estuary by 2020. Consistent with previous PREP reports, the numeric target for active eelgrass habitat restoration will be 50 acres.

Methods and Data Sources

Data Analysis and Statistical Methods

The total acres of eelgrass beds that have been restored since January 1, 2000 were recalculated each year and compared to the goal. The eelgrass beds were considered “restored” at the conclusion of the restoration project. Only projects that actively plant eelgrass in areas were considered restoration projects. Expanded eelgrass coverage due to improving water quality was not considered active eelgrass restoration. The total area of restored eelgrass bed was determined by the restoration project manager. No statistical tests were applied.

Data Sources

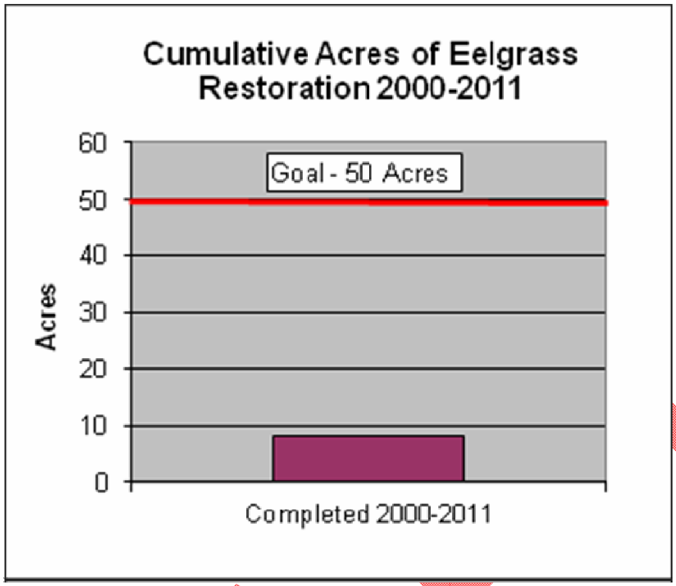
Data for this indicator was obtained from records of eelgrass restoration projects compiled by the UNH Seagrass Ecology Group. The quality of the information for this indicator depends on the accuracy of the reported area restored for each project. The total restored area for a project is important to restoration project managers. Therefore, the information reported by restoration project managers will be considered to be sufficiently accurate for this indicator.

Results

Several eelgrass planting projects have been completed since January 1, 2000. A small, community-based project was attempted in North Mill Pond in 2000. Eelgrass was transplanted in over twenty frames (0.25 m^2/frame). The total area covered by the project was 0.5 acres. None of the transplants survived due to inadequate water quality. In 2001, an eelgrass mitigation project for the US Army Corps of Engineers was completed in Little Harbor. Eelgrass was transplanted over 5.5 acres. The restoration was monitored for one year following the transplant and found to be successful. However, because the impetus for this project was to replace eelgrass beds that were destroyed, it was not counted toward the PREP goal. In 2005, eelgrass was transplanted to locations in the Bellamy River (1 ac.) and Portsmouth Harbor (0.25 ac.). In 2006-2008, a total of 6.8 acres of eelgrass was restored in the Bellamy River. The project was funded by the Natural Resource Conservation Service. Therefore, since 2000, 8.5 acres of eelgrass restoration projects have been completed (16% of the goal). Prior to 2005, no state or federal money was available for eelgrass restoration.

This indicator tracks restoration effort in terms of acres for which restoration was attempted. The area of functional habitat created by restoration projects may be lower.

Figure RST2-1: Cumulative acres of eelgrass bed restoration



Indicator: RST3. Restored oyster beds

Objective

The objective of this indicator is to track the cumulative acres of oyster beds that have been restored since NHEP implementation began (2000). Historic data suggests that salt marshes, oyster beds, and eelgrass habitats in the Piscataqua Region watershed have been degraded or lost over time (Odell et al., 2006; Eberhardt and Burdick, 2009). Restoration efforts attempt to restore the function of these critical habitats.

PREP Goal

LR 1.1: Increase the abundance of adult oysters at the six documented beds in the Great Bay Estuary to 10 million oysters and restore 20 acres of oyster reef habitat by 2020. Specific goal is 20 acres of oyster reef restoration in 2011-2020 per Action Plan LR-1).

Methods and Data Sources

Data Analysis and Statistical Methods

The total acres of oyster beds that have been restored since January 1, 2000 was recalculated each year and compared to the goal. The oyster beds were considered “restored” at the conclusion of the restoration project. Only projects that actively transplant oysters to reefs or otherwise enhance oyster populations were considered restoration projects. The total area of each restored oyster bed was determined by the restoration project manager. No statistical tests were applied.

Data Sources

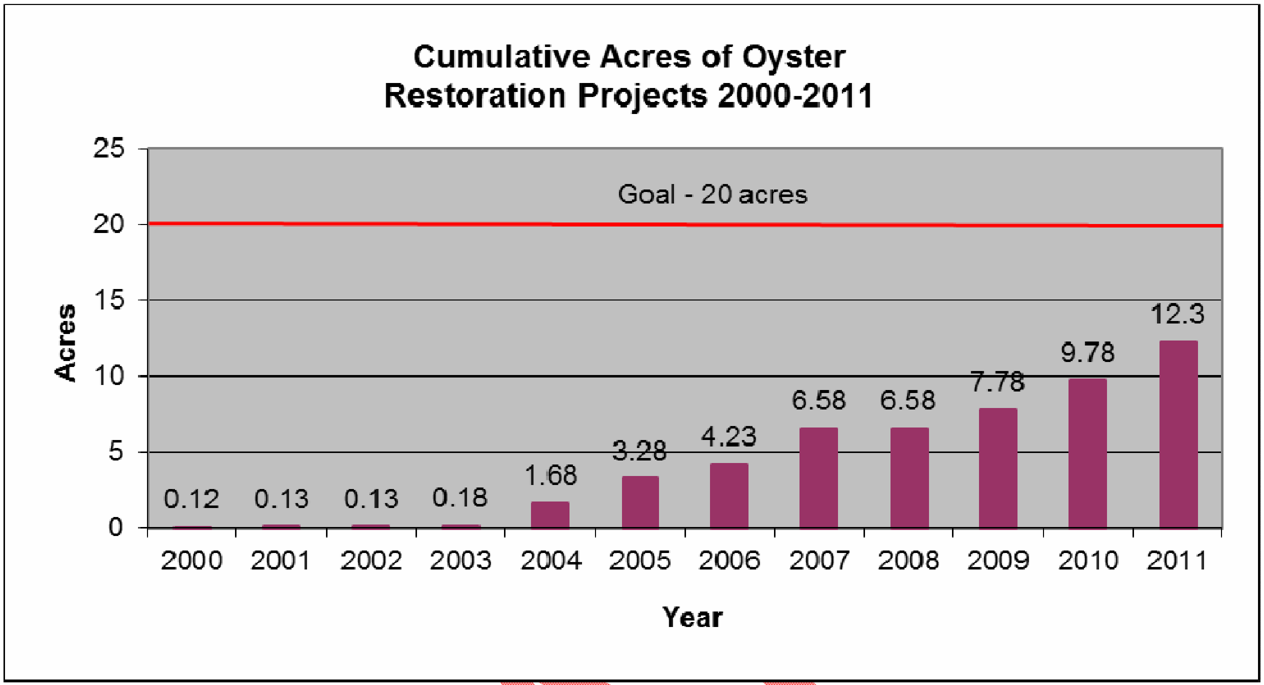
Data on oyster restoration projects was gathered from The Nature Conservancy and the UNH Jackson Estuarine Laboratory staff leading oyster restoration work in the Great Bay estuary. The quality of the information for this indicator depends on the accuracy of the reported area restored for each project. The total restored area for a project is important to restoration project managers. Therefore, the information reported by restoration project managers will be considered to be sufficiently accurate for this indicator.

Results

Nine oyster restoration projects have been implemented in the Piscataqua Region watershed since January 1, 2000. As a result of these projects, a total of 12.3 acres of oyster bed has been restored, representing 61% of the goal of 20 acres (Figure RST3-1). All of the projects involved remote setting of disease-resistant spat followed by introduction of the settled spat to an artificial reef. High mortality was reported for some of the restoration sites. However, the restoration work still created oyster habitat by installing cultch or other materials on which spat could settle. Additional information about oyster restorations in New Hampshire is available from www.oyster.unh.edu. A major impediment to oyster restoration efforts in the Great Bay estuary is the ongoing oyster mortality due to MSX and Dermo infections in native oysters. Inconsistent year spatfall is another limiting factor.

This indicator tracks restoration effort in terms of acres for which restoration was attempted. The area of functional habitat created by restoration projects may be lower.

Figure RST3-1: Cumulative acres of oyster bed restoration



HAB 9. Stream miles accessible to migratory fish returns

Objective

Restoring access to suitable freshwater habitat that has been blocked by dams and culverts is critical in order to recover large sustainable migratory fish populations. The objective of this indicator is to compare the historically available miles of mainstem river herring habitat of major rivers with the currently accessible stream miles in the Piscataqua Region. The indicator is intended to track incremental progress over time in restoring upstream habitat access to migratory herring.

PREP Goal

Obj LR 1.4: Restore native diadromous fish access to 50 percent of their historical mainstem river distribution range by 2020, and improve habitat conditions encountered throughout their life cycle.

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

The cumulative mainstem river miles restored to date was calculated and compared to the historical river mileage baseline estimate of 114.5 miles. Restored river miles within the mainstem were divided by the historic mileage and reported as a percent completed. No statistical tests were applied.

Historical distribution of river herring along the mainstem portions of the region's major rivers was estimated and reported in the Great Bay Estuary Restoration Compendium (Odell et al., 2006) and Hampton-Seabrook Estuary Restoration Compendium (Eberhardt and Burdick, 2009) reports. These reports summarized data about the location of mainstem dams and the status of fish passage at these dams. Estimates of mainstem river miles were adjusted such that the location of head-of-tide was treated as river mile zero. This was done to acknowledge that herring have unobstructed access to the tidal portions of the rivers (which are part of the estuary), and to ensure that "upstream" river miles are reported as strictly the freshwater portions of the major rivers above head-of-tide. The historical distribution estimates are treated as the baseline mileage against which future improvements in fish passage around dams will be measured against. This indicator does not tally stream miles opened along tributary streams and does not account for obstructions to passage from dams and culverts located along tributaries or non-major river segments. This indicator considers dams with fish ladders to provide access for migratory fish although access is limited by the presence of the dam.

Data Source

Data on upstream mainstem river miles restored for river herring access are obtained by PREP from NHF&G, the NH Coastal Program, and other fish passage restoration practitioners in the coastal watershed that have completed work on the mainstem segments of the major rivers.

The quality of the information for this indicator depends on the accuracy of the river mileage estimates reported for both historical distribution extent of river herring as well as the estimate for river mileage restored for upstream passage of river herring. The historical distribution estimates from Odell et al. (2006) and Eberhardt and Burdick (2009) are considered the best available estimates. These estimates are likely conservative in some cases, especially with regard to the historical extent of river herring within the Salmon Falls and Great Works river systems. The mileage estimates of upstream mainstem river miles for a project are important to restoration project managers. Therefore, the information reported by restoration project managers will be considered to be sufficiently accurate for this indicator after cross-referencing with the established mileage estimates in the restoration compendium reports.

Results

Major efforts are underway to restore river herring access to their historical freshwater ranges in order to support recovery of their populations. Figure HAB9-1 shows the miles of freshwater habitat in the main branch of each major river that was historically available to herring, and how many miles of that habitat are currently accessible. Fish ladders on the Exeter and Cocheco rivers provide access to the historically available habitat, but still likely pass far fewer fish than if the dams were not present. In 2010, the only major dam on the Winnicut River was removed, restoring access to 10 miles of upstream habitat on the main branch of the river, representing 100% of the historical distribution in that river. In 2011 a fish ladder was completely on the Wiswall Dam on the Lamprey River, allowing herring access to 7.8 miles of habitat that has been blocked for over 200 years. Changes in accessible stream miles over time are shown in Figure HAB9-2.

Figure HAB9-1: Mainstem stream miles accessible to river herring by river

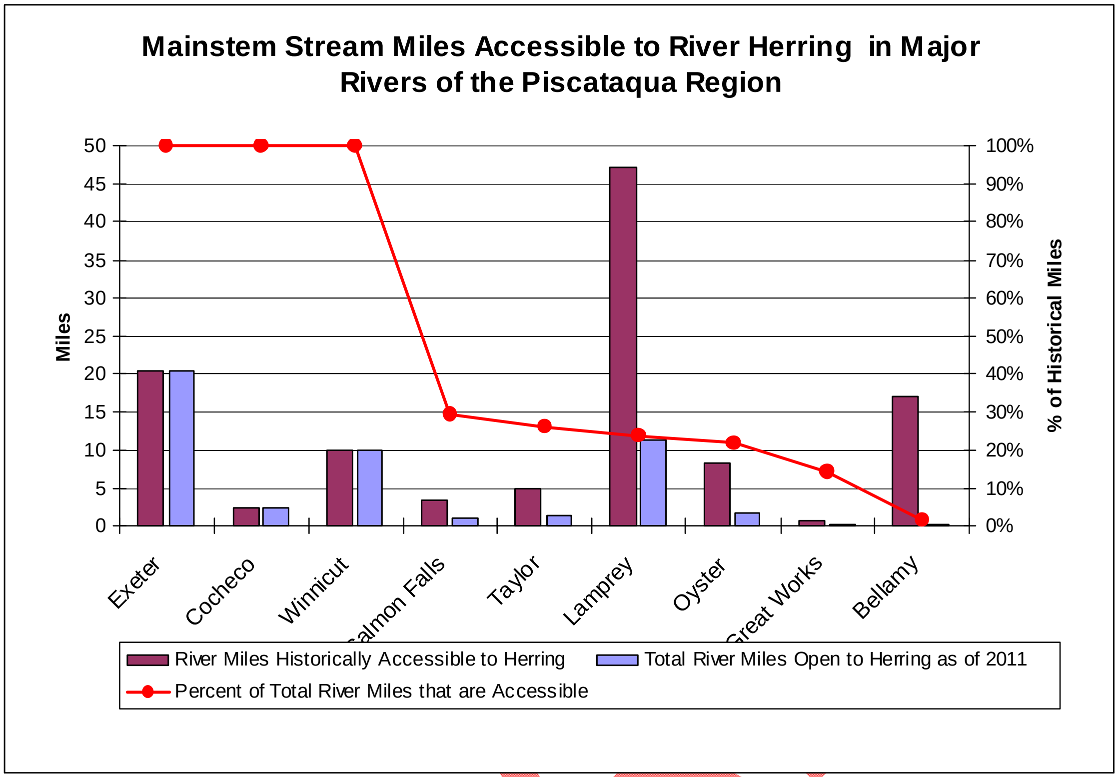
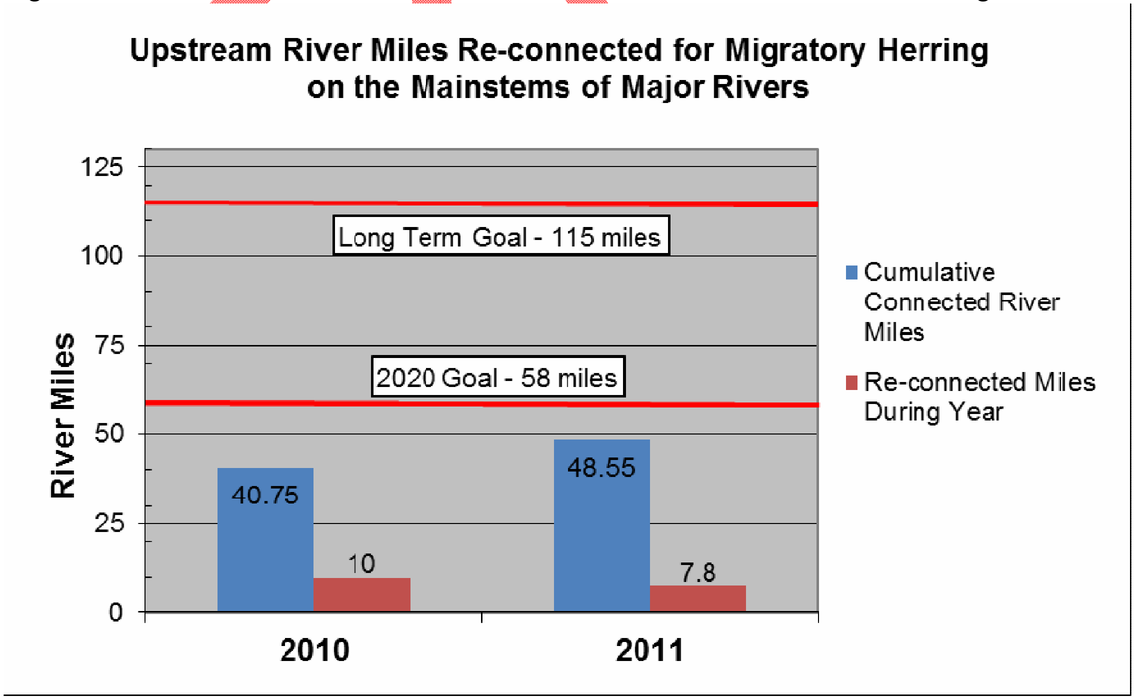


Figure HAB9-2: Cumulative mainstem stream miles accessible to river herring over time



PREP
Piscataqua Region Estuaries Partnership

III. Supplemental Information

EXHIBIT 36 (AR K.22)

Supplemental Information POP1: Population in the Piscataqua Region

Objective

The objective of this section is to compile relevant information on the population in the Piscataqua Region which can be used as supplemental information when evaluating the other indicators.

PREP Goal

None

PREP Goal

No goal

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

Population totals for the 52 towns in the Piscataqua Region in NH and Maine were compiled for every U.S. Census. Mid-decade population projections were also compiled for the most recent estimates.

Data Sources

Data from the U.S. Census Bureau were used for this indicator.

Results

The population for each of the 52 municipalities in the Piscataqua Region between 1930 and 2010 are listed in Table POP1-1. Changes in the total population for the region over time are shown in Figure POP1-1.

In 2010, there were 377,427 people living the Piscataqua Region municipalities, which is an 8% increase from 2000 levels.

Table POP1-1: Population for Piscataqua Region municipalities, 1930-2010

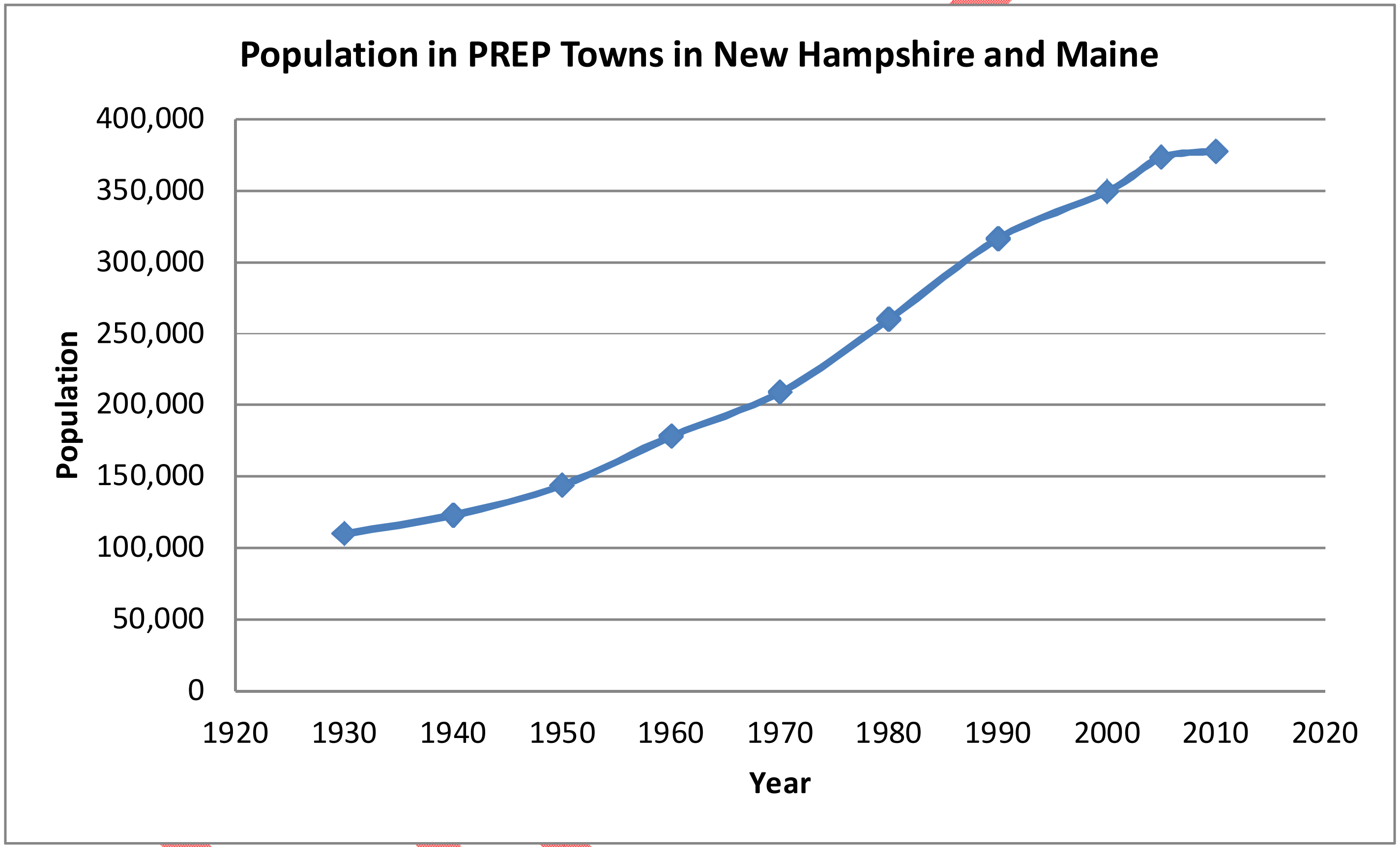
Town	County	State	1930	1940	1950	1960	1970	1980	1990	2000	2005	2010
Barrington	Strafford	NH	613	780	1,052	1,036	1,865	4,404	6,164	7,475	8,145	8,576
Brentwood	Rockingham	NH	725	720	819	1,072	1,468	2,004	2,590	3,197	3,692	4,486
Brookfield	Carroll	NH	166	142	159	145	198	385	518	604	661	712
Candia	Rockingham	NH	812	965	1,243	1,490	1,997	2,989	3,557	3,911	4,154	3,909
Chester	Rockingham	NH	653	702	807	1,053	1,382	2,006	2,691	3,792	4,639	4,768
Danville	Rockingham	NH	406	457	508	605	924	1,318	2,534	4,023	4,381	4,387
Deerfield	Rockingham	NH	635	749	706	714	1,178	1,979	3,124	3,678	4,103	4,280
Dover	Strafford	NH	13,573	14,990	15,874	19,131	20,850	22,377	25,042	26,884	28,383	29,987
Durham	Strafford	NH	0	1,533	4,770	5,504	8,869	10,652	11,818	12,664	13,276	14,638
East Kingston	Rockingham	NH	347	424	449	574	838	1,135	1,352	1,784	2,225	2,357
Epping	Rockingham	NH	1,672	1,618	1,796	2,006	2,356	3,460	5,162	5,476	6,072	6,411
Exeter	Rockingham	NH	4,872	5,398	5,664	7,243	8,892	11,024	12,481	14,058	14,665	14,306
Farmington	Strafford	NH	2,698	3,095	3,454	3,287	3,588	4,630	5,739	5,774	6,426	6,786
Fremont	Rockingham	NH	571	634	698	783	993	1,333	2,576	3,510	3,975	4,283
Greenland	Rockingham	NH	577	696	719	1,196	1,784	2,129	2,768	3,208	3,373	3,549
Hampton	Rockingham	NH	1,507	2,137	2,847	5,379	8,011	10,493	12,278	14,937	15,394	14,976
Hampton Falls	Rockingham	NH	481	493	629	885	1,254	1,372	1,503	1,880	2,026	2,236
Kensington	Rockingham	NH	438	458	542	708	1,044	1,322	1,631	1,893	2,044	2,124
Kingston	Rockingham	NH	1,017	1,002	1,283	1,672	2,882	4,111	5,591	5,862	6,225	6,025
Lee	Strafford	NH	376	481	575	931	1,481	2,111	3,729	4,145	4,405	4,330
Madbury	Strafford	NH	358	401	489	556	704	987	1,404	1,509	1,656	1,771
Middleton	Strafford	NH	176	236	255	349	430	734	1,183	1,440	1,686	1,783
Milton	Strafford	NH	1,206	1,279	1,510	1,418	1,859	2,438	3,691	3,910	4,344	4,598
New Castle	Rockingham	NH	378	542	583	823	975	936	840	1,010	1,031	968
New Durham	Strafford	NH	448	433	463	474	583	1,183	1,974	2,220	2,449	2,638
Newfields	Rockingham	NH	376	417	469	737	843	817	888	1,551	1,584	1,680
Newington	Rockingham	NH	381	418	494	1,045	798	716	990	775	809	753
Newmarket	Rockingham	NH	2,511	2,640	2,709	3,153	3,361	4,290	7,157	8,027	9,153	8,936
North Hampton	Rockingham	NH	695	818	1,104	1,910	3,259	3,425	3,637	4,259	4,570	4,301
Northwood	Rockingham	NH	872	873	966	1,034	1,525	2,175	3,124	3,640	3,969	4,241
Nottingham	Rockingham	NH	451	468	566	623	952	1,952	2,939	3,701	4,360	4,785

EXHIBIT 36 (AR K.22)

Town	County	State	1930	1940	1950	1960	1970	1980	1990	2000	2005	2010
Portsmouth	Rockingham	NH	14,495	14,821	18,830	26,900	25,717	26,254	25,925	20,784	20,620	21,233
Raymond	Rockingham	NH	1,165	1,340	1,428	1,867	3,003	5,453	8,713	9,674	10,096	10,138
Rochester	Strafford	NH	10,209	12,012	13,776	15,927	17,938	21,560	26,630	28,461	29,945	29,752
Rollinsford	Strafford	NH	1,409	1,463	1,652	1,935	2,273	2,319	2,645	2,648	2,616	2,527
Rye	Rockingham	NH	1,081	1,246	1,982	3,244	4,083	4,508	4,612	5,182	5,225	5,298
Sandown	Rockingham	NH	229	292	315	366	741	2,057	4,060	5,143	5,701	5,986
Seabrook	Rockingham	NH	1,666	1,782	1,788	2,209	3,053	5,917	6,503	7,934	8,411	8,693
Somersworth	Strafford	NH	5,680	6,136	6,927	8,529	9,026	10,350	11,249	11,477	11,696	11,766
Strafford	Strafford	NH	617	714	770	722	965	1,663	2,965	3,626	3,971	3,991
Stratham	Rockingham	NH	552	634	759	1,033	1,512	2,507	4,955	6,355	7,080	7,255
Wakefield	Carroll	NH	1,186	1,158	1,267	1,223	1,420	2,237	3,057	4,252	4,654	5,078
Acton	York	ME	449	392	473	501	697	1,228	1,727	2,145	2,269	2447
Berwick	York	ME	1,961	1,971	2,166	2,738	3,136	4,149	5,995	6,353	7,337	7246
Eliot	York	ME	1,462	1,932	2,509	3,133	3,497	4,948	5,329	5,954	6,404	6204
Kittery	York	ME	4,400	5,374	8,380	10,689	11,028	9,314	9,372	9,543	10,447	9490
Lebanon	York	ME	1,148	1,452	1,499	1,534	1,983	3,234	4,263	5,083	5,552	6031
North Berwick	York	ME	1,540	1,455	1,655	1,844	2,224	2,878	3,793	4,293	4,795	4576
Sanford	York	ME	13,392	14,886	15,177	14,962	15,812	18,020	20,463	20,806	21,673	20798
South Berwick	York	ME	2,650	2,546	2,646	3,112	3,488	4,046	5,877	6,671	7,291	7220
Wells	York	ME	2,047	2,144	2,321	3,528	4,448	8,211	7,778	9,400	10,073	9589
York	York	ME	2,532	3,283	3,256	4,663	5,690	8,465	9,818	12,854	13,409	12 529
NH population			78,280	87,597	103,696	131,491	156,874	195,712	241,989	266,333	283,890	291,297
ME Population			31,581	35,435	40,082	46,704	52,003	64,493	74,415	83,102	89,250	86,130
Total Population			109,861	123,032	143,778	178,195	208,877	260,205	316,404	349,435	373,140	377,427
NH State Population			463,898	491,320	533,110	606,400	737,578	920,475	1,109,117	1,235,550	1,303,112	1,316,470
ME State Population			797,423	847,226	913,774	969,265	992,048	1,124,660	1,227,928	1,274,923	1,312,222	1,328,361

EXHIBIT 36 (AR K.22)

Figure POP1-1: Total population in the Piscataqua Region, 1930-2010



Supplemental Information: HAB12. Eelgrass biomass in the estuary

Objectives

The objective of this section is to compile relevant information on eelgrass biomass which can be used as supplemental information when evaluating the HAB2 indicator (eelgrass cover).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods and Hypothesis

The method for eelgrass mapping in the Great Bay Estuary is described for the HAB2 indicator.

In addition to mapping eelgrass bed boundaries, each eelgrass bed was assigned a density based on visual observation: partial (10-30% cover), half (30-60% cover), some bottom (60-90% cover) and dense (90-100% cover) (UNH, 2010). The ArcGIS Identity tool was used to calculate the area of eelgrass coverage in each density class in the different sections of the Great Bay Estuary. The biomass of eelgrass was calculated by assuming a shoot density for each density class: partial (25 g/m^2); half (55 g/m^2); some bottom (85 g/m^2); and dense (250 g/m^2). The total area of eelgrass in each density class was multiplied by the shoot density for the class to calculate the biomass for that class. The total biomass (in units of metric tons or 1000 kilograms) was calculated by summing the biomass from each density class of eelgrass.

The biomass of eelgrass in each segment of the estuary was calculated using the GIS files provided by UNH and the ArcGIS Identity tool. Trends in the eelgrass biomass in each segment versus year were identified using linear regression with $p<0.05$ defined as the level of significance. The trend analysis for the Great Bay and its tributaries (Winnicut River, Squamscott River, and Lamprey River) used data from 1990 to present. In 1988-1989, there was a wasting disease event that affected eelgrass populations (Muehlstein et al., 1991).The trends since 1990 reflect changes in the eelgrass population in these areas after it had recovered from this wasting disease event. In the rest of the estuary, trend analysis used data from the earliest year of the existing monitoring program (1996) to present. The change in eelgrass between two dates evaluated for trends was defined as the difference between the value of the statistically significant regression equation at the ending and beginning date.

Total eelgrass biomass in the whole estuary was plotted for years when the whole estuary was mapped.

Data Sources

Data on eelgrass cover and density in the estuary is provided by the UNH Seagrass Ecology Group, with funding from the PREP. The monitoring protocols are described in the Quality Assurance Project Plan (UNH, 2010).

Results

Since 1990, there have been statistically significant declining trends in eelgrass biomass in the Great Bay and Winnicut River (Figure HAB12-1). In the Great Bay, there has been a 72% decline with 1,008 metric tons lost (these numbers reflect the long-term regression equation, not the actual measurements of eelgrass biomass in 1990 and 2011). In the Winncut River, 100% of the eelgrass biomass has been lost (7 metric tons, based on the regression). Trends in the Squamscott and Lamprey Rivers could not be evaluated because eelgrass has not been found in these segments since 1990 except for a few acres at the mouth of the Lamprey River in two years.

In other areas of the estuary, there has been a statistically significant declining trend in eelgrass biomass since 1996 in Little Harbor (Figure HAB12-1). The eelgrass losses since 1996 in Little Harbor (expressed as both percents and acres based on the regressions) were -85% and -20 metric tons.

The total eelgrass biomass in the entire Great Bay Estuary for years with complete data is plotted in Figure HAB12-2. In 2011, the total eelgrass cover in the estuary was 446 metric tons and falling. In 1996, the total eelgrass biomass was 1,807 metric tons.

In 2009, UNH obtained 1981 aerial photographs of the estuary and used this information to map eelgrass in most of the estuary for that year (UNH, 2009). The eelgrass biomass for the estuary from 1981 was 1,456 metric tons and this value is included on Figure HAB12-2. One reason why the 1981 total eelgrass biomass was less that the 1996 level (1,807 acres) is because the 1981 dataset was incomplete. Eelgrass in some portions of the estuary could not be mapped because the imagery had glare in some areas. The interference affected mapping in the Oyster River, Lower Piscataqua River, Portsmouth Harbor, and Little Harbor. As a result, the 1981 values on Figure HAB12-2 and Table HAB12-1 underestimate actual eelgrass biomass in 1981. The 1981 data were included in Table HAB12-1 and Figure HAB12-2 to provide a historical perspective because this was prior to the wasting disease event in the late 1980s.

Information on eelgrass biomass is used as supplemental information because there is an unknown amount of uncertainty associated with assuming a shoot density for each eelgrass density class on the eelgrass maps in order to calculate the biomass.

EXHIBIT 36 (AR K.22)

Table HAB12-1: Eelgrass biomass in the Great Bay Estuary

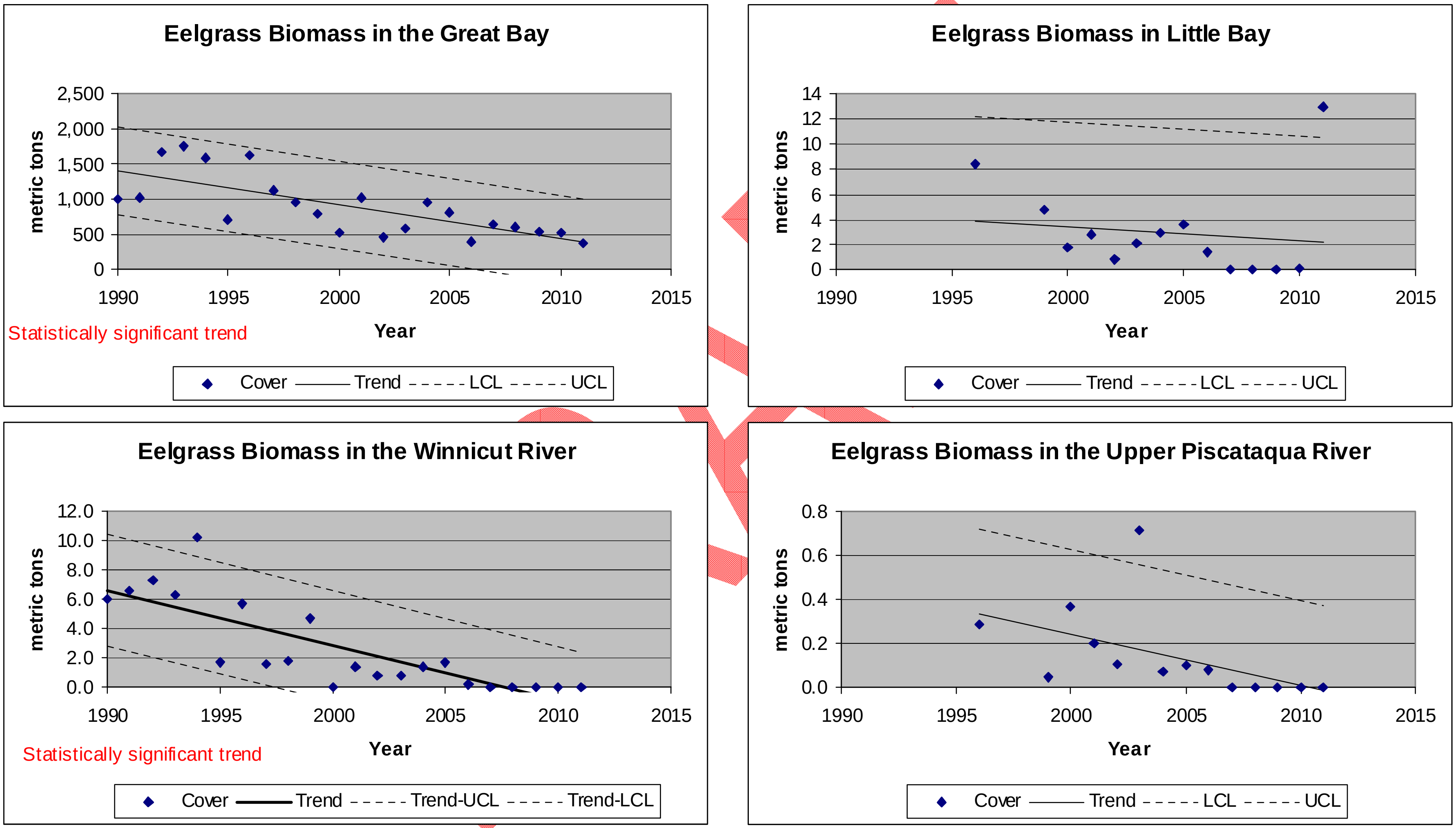
Year	Winnicut River	Squamscott River	Lamprey River	Oyster River	Bellamy River	Great Bay	Little Bay	Upper Piscataqua River*	Lower Piscataqua River North*	Lower Piscataqua River South*	Portsmouth Harbor*	Little Harbor	Sagamore Creek
1981	0.0	0.0	0.0	a	1.0	1168.7	82.9	0.1	15.9	0.7	171.7	14.9	0.4
1990	6.0	0.0	0.0	a	a	996.6	a	a	a	a	a	a	a
1991	6.6	0.0	0.0	a	a	1013.8	a	a	a	a	a	a	a
1992	7.3	0.0	0.0	a	a	1669.1	a	a	a	a	a	a	a
1993	6.3	0.0	0.0	a	a	1756.2	a	a	a	a	a	a	a
1994	10.2	0.0	0.0	a	a	1573.0	a	a	a	a	a	a	a
1995	1.7	0.0	0.0	a	a	717.2	a	a	a	a	a	a	a
1996	5.7	0.0	0.0	2.0	0.0	1624.3	8.4	0.3	4.6	4.7	131.0	24.9	0.7
1997	1.6	0.0	0.0	a	a	1121.6	a	a	a	a	a	a	a
1998	1.8	0.0	0.0	a	a	952.2	a	a	a	a	a	a	a
1999	4.7	0.0	0.0	0.0	0.0	794.5	4.8	0.0	1.6	1.7	83.3	23.2	0.8
2000	0.0	0.0	0.0	0.0	0.0	531.1	1.7	0.4	1.4	3.0	151.4	16.1	0.1
2001	1.4	0.0	0.0	0.0	0.0	1019.0	2.8	0.2	5.1	3.7	89.4	12.9	0.5
2002	0.8	0.0	0.0	0.0	0.0	463.8	0.9	0.1	2.6	1.7	97.8	20.6	0.7
2003	0.8	0.0	0.6	0.0	0.0	586.0	2.1	0.7	14.1	2.5	89.0	11.0	0.6
2004	1.4	0.0	0.0	0.0	0.1	955.0	2.9	0.1	8.4	3.1	161.2	12.2	0.6
2005	1.7	0.0	0.0	0.0	0.0	817.5	3.7	0.1	6.1	3.0	192.3	10.5	1.5
2006	0.2	0.0	0.0	0.0	0.0	394.0	1.4	0.1	3.1	5.1	149.3	11.2	0.2
2007	0.0	0.0	0.0	0.0	0.0	651.8	0.0	0.0	0.1	1.9	101.2	6.3	0.1
2008	0.0	0.0	0.0	0.0	0.0	609.1	0.0	0.0	0.0	1.1	55.0	6.3	0.4
2009	0.0	0.0	0.0	0.0	0.0	538.8	0.0	0.0	0.0	1.5	42.5	5.4	0.1
2010	0.0	0.0	0.0	0.0	0.0	518.2	0.1	0.0	0.0	1.1	35.3	7.6	0.0
2011	0.0	0.0	0.1	0.0	0.0	382.8	13.0	0.0	0.0	1.6	43.2	5.3	0.2

Units = Metric tons (1 metric ton = 1000 kg)   a = not mapped

* The biomass estimates for 1981, 1996-2008 include beds from both the NH and ME sides of the Piscataqua River but not the tidal creeks along the Maine shore.

EXHIBIT 36 (AR K.22)

Figure HAB12-1: Eelgrass biomass in segments of the Great Bay Estuary



* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

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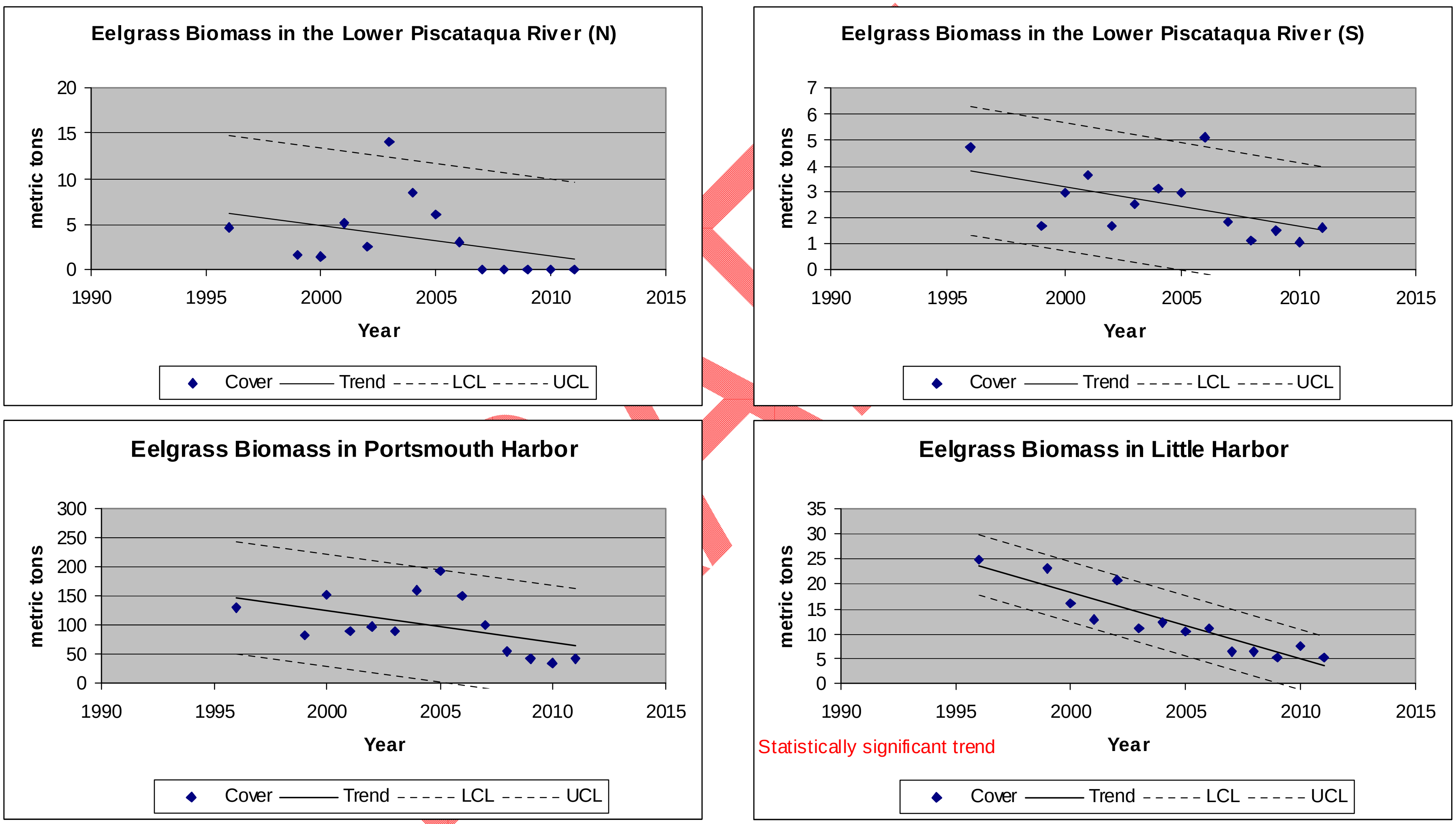
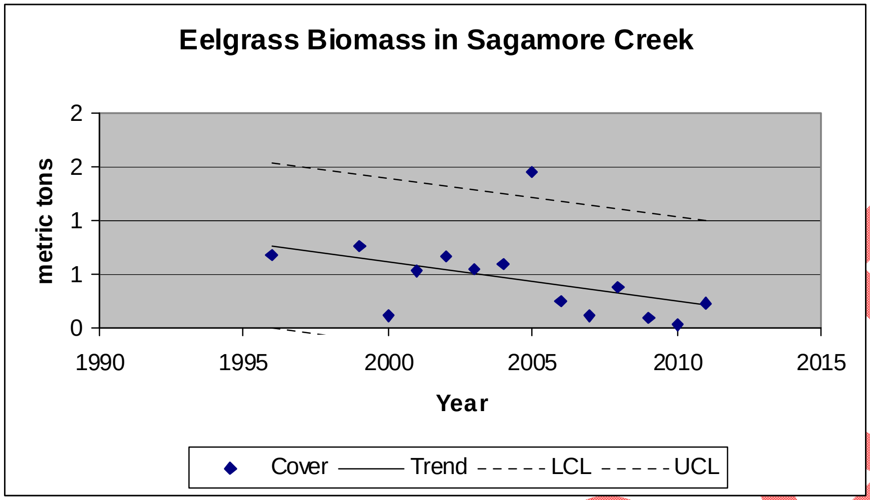
Figure HAB12-1: Eelgrass biomass in segments of the Great Bay Estuary (cont.)



Statistically significant trend

* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

Figure HAB12-1: Eelgrass biomass in segments of the Great Bay Estuary (cont.)



* Trend UCL and Trend LCL refer to the upper and lower confidence limits (95th percentile) of the trend line

Figure HAB12-2: Total eelgrass biomass in the Great Bay Estuary

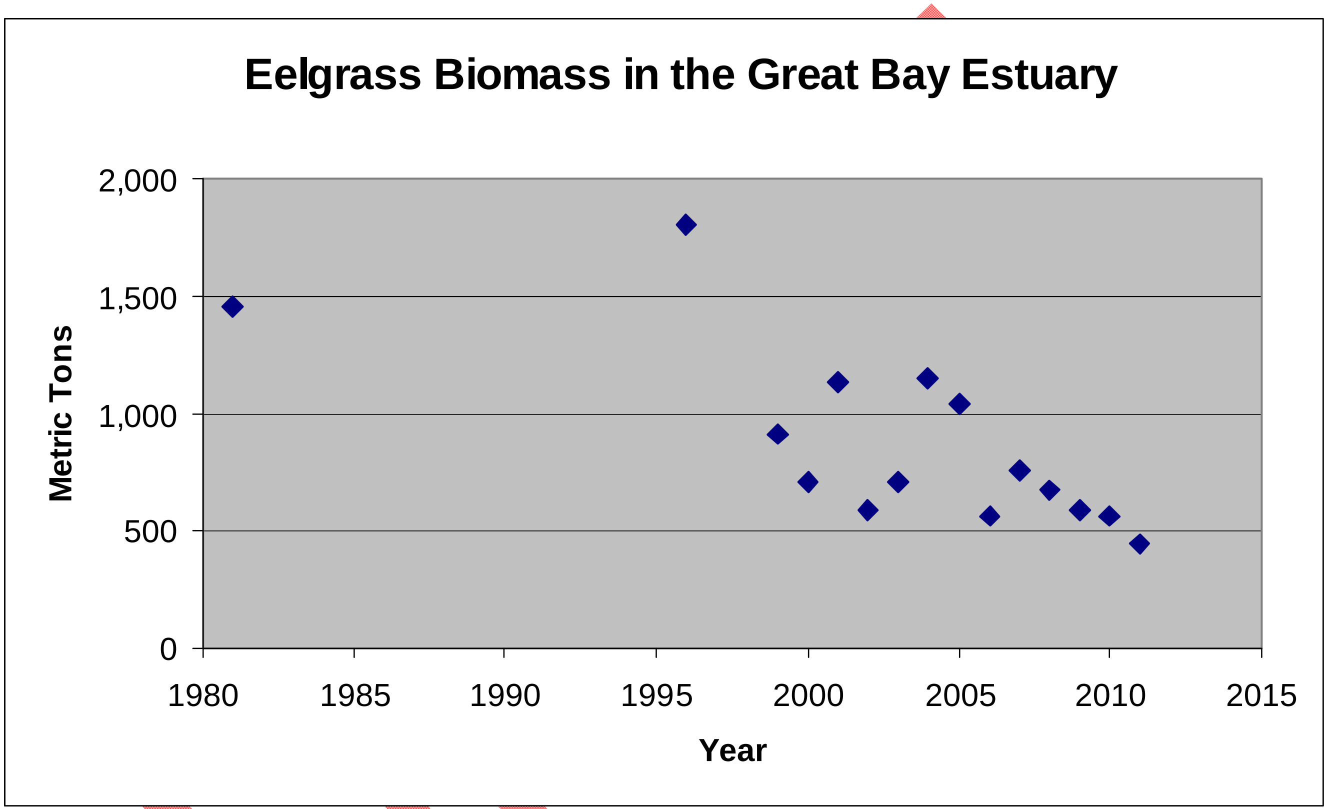


EXHIBIT 36 (AR K.22)

Supplemental Information: SHL9. Recreational harvest of oysters

Objective

The objective of this section is to compile relevant information on the recreational harvest of oysters which can be used as supplemental information when evaluating the SHL5 indicator (number of adult oysters).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The number of oyster licenses sold per year was compiled to illustrate trends in harvest pressure for oysters. Estimates of actual recreational harvest from Manalo et al. (1991) and NHF&G (1997) were paired with estimates of adult standing stock for the same year.

Data Sources

The number of oyster licenses sold per year was provided by NH Fish and Game (603-271-6832).

Results

In Table SHL9-1, the historical record of recreational harvest license sales has been combined with the available estimates of oyster harvest. For the years when estimates of oyster harvest were made, the results have been compared to oyster standing stock estimates from indicator SHL-5.

The limited available data indicate a progressive decline in license sales and a proportional decline in total harvest. License sales fell 93% between 1981 and 2011 (Figure SHL9-1). In 1996, the total harvest amounted to approximately 4% of the number of adult oysters. Only 143 oyster harvesting licenses were sold in 2011. The declining trend in license sales is assumed to reflect declining harvest as well. However, there is no recent information on actual harvest to confirm this assumption.

In 2008, the New Hampshire Fish and Game Department reduced the daily limit for recreational harvest of oysters from one bushel to one-half bushel.

Table SHL9-1: Recreational oyster harvest license sales and harvest estimates

Year	License Sales*	Harvest (bushels)	Standing Stock (bushels)	Harvest as a Percent of Standing Stock
1975	1532			
1976	1460			
1977	1479			
1978	1440			
1979	1553			
1980	1961			
1981	2109			
1982	1522			
1983	1426			
1984	1373			
1985	1582			
1986	1358			
1987	1285			
1988	1157			
1989	992	>4,000	128,646 (1)	3.1%
1990	932			
1991	1001			
1992	907			
1993	847			
1994	1009			
1995	971			
1996	661	2,727	72,990 (2)	3.7%
1997	582			
1998	579			
1999	545			
2000	506			
2001	406			
2002	344			
2003	253			
2004	262			
2005	270			
2006	293			
2007	325			
2008	221			
2009	197			
2010	168			
2011	143			

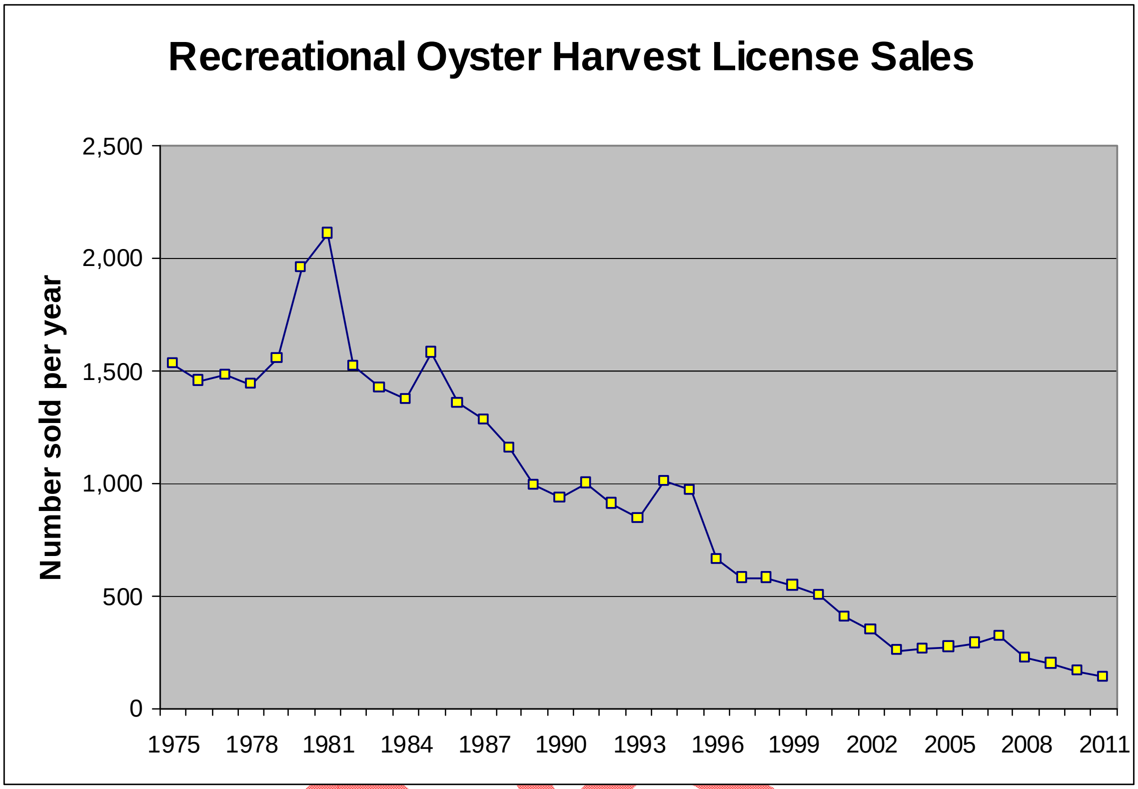
Source: Oyster harvest license sales provided by NHF&G

(1) Using earliest standing stock estimate (1993) from indicator SHL-5 to represent the "late 1980s". Harvest estimate is from Manalo et al. (1991).

(2) Using standing stock estimate for 1996 from indicator SHL-5. Harvest estimate is from NHF&G (1997).

EXHIBIT 36 (AR K.22)

Figure SHL9-1: Recreational oyster harvest license sales



Supplemental Information: SHL11. Prevalence of oyster disease

Objective

The objective of this section is to compile relevant information on the prevalence of the oyster diseases, MSX and DERMO, which can be used as supplemental information when evaluating the SHL5 indicator (number of adult oysters).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

Data from NHF&G and Rutgers University on MSX and Dermo prevalence in oyster samples were compiled for each major oyster bed for each year. The average prevalence across all beds was calculated. The Mann-Kendall Test was used to determine whether the average prevalence had increased significantly since 1996.

Data Sources

Data for this indicator are provided by the NHF&G Oyster Disease Monitoring Program. The methods and data quality objectives for this program are described in the Quality Assurance Project Plan (NHF&G, 2011).

Results

The disease MSX was first detected in Delaware Bay in 1957 and since then has spread throughout the Atlantic coast. The protozoa that causes MSX (*Haplosporidium nelsoni*) is mainly controlled by salinity. The protozoa cannot survive in low salinity water (<10 ppt), has limited virulence at salinities between 10 and 20 ppt, and is fully infectious at salinities >20 ppt (Haskin and Ford, 1982). Therefore, droughts tend to increase the prevalence of MSX infections and allow for expansion of the protozoa's range.

Unspeciated haplosporidian plasmodia were observed in the Piscataqua River as early as 1979 by Maine Department of Marine Resources. The presence of MSX in Great Bay was first conclusively determined in 1983. However the first oyster mortality from the disease was observed in 1995 following a severe drought (Barber et al., 1997).

The NH Fish and Game Department has monitored the prevalence of MSX in oysters from the Great Bay Estuary every year since 1995. There is no apparent trend in MSX infection rates since the disease was first detected (Table SHL11-1, Figures SHL11-1 and SHL11-2) Approximately 21% of the oysters in the Great Bay Estuary were infected with MSX at some level in 2011. The rate of systemic infection (2% on average in 2011) is also important because systemic infection is a portent of imminent death, whereas oysters with low grade infections will often survive for at least another year. There has been no significant trend in average MSX infection prevalence since 1996.

The other major oyster disease present in the Great Bay Estuary is Dermo which is caused by the protozoa *Perkinsus marinus*. The NH Fish and Game Department has monitored the prevalence of Dermo in oysters from the Great Bay Estuary every year since 1996. The infection prevalence of Great Bay Estuary oysters by Dermo has been less severe than MSX until recently. In 1997, only 10% of oysters from any bed were infected with the disease. Between 1998 and 2001, Dermo was not found in New Hampshire waters except at the Salmon Falls River bed (not shown). In 2002, oysters from Adams Point, Nannie Island, and the Salmon Falls River were found to be infected with Dermo again. By 2004, the prevalence of Dermo infection was approximately 60% in the Nannie Island and Adams Point oyster beds. And by 2011, the average prevalence of infection has reached 91% with 20% of the oysters heavily infected. The average infection prevalence for Dermo has increased significantly since 1996 based on a Mann-Kendall test with a significance level of $p<0.05$.

EXHIBIT 36 (AR K.22)

Table SHL11-1: MSX infection prevalence in Great Bay Estuary oysters

Date	Year	Location	Number Tested	Percent Infected	Percent with Systemic Infection	Notes
11/06/95	1995	Adams Point	20	40%	15%	(3)
05/27/96	1996	Adams Point	10	0%	0%	
11/17/97	1997	Adams Point	25	40%	20%	
12/09/98	1998	Adams Point	25	28%	8%	
11/04/00	2000	Adams Point	20	35%	25%	
11/04/01	2001	Adams Point	20	25%	20%	
10/14/02	2002	Adams Point	20	45%	0%	
10/14/02	2002	Adams Point	20	45%	0%	
11/19/04	2004	Adams Point	19	11%	5%	
11/14/05	2005	Adams Point	20	35%	10%	
11/22/06	2006	Adams Point	20	5%	0%	
12/07/07	2007	Adams Point	20	25%	5%	
10/08/08	2008	Adams Point	20	5%	0%	
11/06/09	2009	Adams Point	20	45%	25%	
10/19/10	2010	Adams Point	20	25%	20%	
10/21/11	2011	Adams Point	20	30%	5%	
11/06/95	1995	Nannie Island	20	15%	5%	(3)
05/27/96	1996	Nannie Island	40	8%	0%	(1)
11/17/97	1997	Nannie Island	25	52%	28%	
12/09/98	1998	Nannie Island	25	44%	8%	
10/21/99	1999	Nannie Island	20	35%	30%	
11/04/00	2000	Nannie Island	20	30%	25%	
10/10/01	2001	Nannie Island	24	21%	17%	
10/31/02	2002	Nannie Island	24	37%	17%	
10/31/02	2002	Nannie Island	24	37%	17%	
10/28/03	2003	Nannie Island	26	8%	0%	
11/18/04	2004	Nannie Island	17	29%	6%	
12/07/06	2006	Nannie Island	20	20%	0%	
11/21/07	2007	Nannie Island	20	25%	5%	
10/22/08	2008	Nannie Island	20	15%	5%	
11/12/09	2009	Nannie Island	20	55%	25%	
10/20/10	2010	Nannie Island	20	10%	0%	
11/04/11	2011	Nannie Island	20	20%	0%	
12/18/95	1995	Oyster River	20	50%	30%	(3)
11/17/97	1997	Oyster River	25	36%	8%	
11/15/00	2000	Oyster River	20	35%	10%	
11/04/01	2001	Oyster River	20	25%	20%	
10/14/02	2002	Oyster River	20	45%	5%	
10/14/02	2002	Oyster River	20	45%	5%	
10/27/04	2004	Oyster River	24	25%	4%	
11/06/05	2005	Oyster River	20	35%	5%	
11/01/06	2006	Oyster River	20	40%	5%	
10/23/07	2007	Oyster River	20	35%	15%	
10/10/08	2008	Oyster River	20	40%	10%	

Date	Year	Location	Number Tested	Percent Infected	Percent with Systemic Infection	Notes
11/04/09	2009	Oyster River	20	50%	35%	
10/21/10	2010	Oyster River	20	10%	0%	
10/26/11	2011	Oyster River	20	20%	0%	
10/27/95	1995	Piscataqua River	45	71%	33%	(2) (3)
11/17/97	1997	Piscataqua River	25	60%	20%	
12/09/98	1998	Piscataqua River	18	39%	17%	
11/04/00	2000	Piscataqua River	20	30%	15%	
10/31/06	2006	Piscataqua River	20	55%	10%	
10/16/07	2007	Piscataqua River	20	35%	5%	
10/23/08	2008	Piscataqua River	10	50%	0%	
12/08/09	2009	Piscataqua River	20	45%	20%	
10/26/10	2010	Piscataqua River	17	41%	18%	
09/08/97	1997	Squamscott River	25	44%	20%	
12/09/98	1998	Squamscott River	25	68%	28%	
11/17/05	2005	Squamscott River	20	30%	15%	
11/07/06	2006	Squamscott River	40	60%	15%	
10/27/08	2008	Squamscott River	10	30%	0%	
11/16/10	2010	Squamscott River	20	20%	15%	
11/07/11	2011	Squamscott River	20	20%	5%	
11/16/05	2005	Woodman Point	20	10%	0%	
11/02/06	2006	Woodman Point	20	30%	5%	
10/24/07	2007	Woodman Point	20	25%	15%	
10/09/08	2008	Woodman Point	20	20%	15%	
11/13/09	2009	Woodman Point	20	40%	15%	
10/18/10	2010	Woodman Point	20	15%	0%	
10/28/11	2011	Woodman Point	20	15%	0%	

Source: NHF&G except where noted

(1) Combination of 30 samples taken 4/12/96 and 10 samples taken 5/27/96

(2) Combination of 25 oysters tested on 9/5/95 and 20 oysters tested on 10/27/95. Samples taken at "summer bed".

(3) Source: Barber et al. (1997)

EXHIBIT 36 (AR K.22)

Table SHL11-2: Dermo infection prevalence in Great Bay Estuary oysters

Date	Year	Location	Number Tested	Percent Infected	Percent Heavily Infected	Source	Notes
11/17/97	1997	Adams Point	50	10%	0%	NHF&G	
12/09/98	1998	Adams Point	25	0%	0%	NHF&G	
11/04/00	2000	Adams Point	20	0%	0%	NHF&G	(1)
11/04/01	2001	Adams Point	20	0%	0%	NHF&G	(1)
10/14/02	2002	Adams Point	20	15%	0%	NHF&G	(1)
11/19/04	2004	Adams Point	20	65%	20%	NHF&G	(1)
11/14/05	2005	Adams Point	20	90%	10%	NHF&G	
11/22/06	2006	Adams Point	20	100%	30%	NHF&G	
12/07/07	2007	Adams Point	20	55%	20%	NHF&G	
10/08/08	2008	Adams Point	20	80%	30%	NHF&G	
11/06/09	2009	Adams Point	20	90%	35%	NHF&G	
10/19/10	2010	Adams Point	20	90%	30%	NHF&G	
10/21/11	2011	Adams Point	20	85%	10%	NHF&G	
12/16/96	1996	Nannie Island	25	4%	0%	NHF&G	
11/17/97	1997	Nannie Island	50	2%	0%	NHF&G	
12/09/98	1998	Nannie Island	25	0%	0%	NHF&G	
10/21/99	1999	Nannie Island	20	0%	0%	NHF&G	
11/04/00	2000	Nannie Island	20	0%	0%	NHF&G	
10/10/01	2001	Nannie Island	25	0%	0%	NHF&G	
10/31/02	2002	Nannie Island	24	8%	0%	NHF&G	
10/28/03	2003	Nannie Island	25	20%	8%	NHF&G	
11/18/04	2004	Nannie Island	17	59%	6%	NHF&G	
12/07/06	2006	Nannie Island	20	60%	5%	NHF&G	
11/21/07	2007	Nannie Island	20	35%	10%	NHF&G	
10/22/08	2008	Nannie Island	20	40%	10%	NHF&G	
11/12/09	2009	Nannie Island	20	80%	0%	NHF&G	
10/20/10	2010	Nannie Island	20	75%	20%	NHF&G	
11/4/11	2011	Nannie Island	20	90%	5%	NHF&G	
11/17/97	1997	Oyster River	50	2%	0%	NHF&G	
11/15/00	2000	Oyster River	20	0%	0%	NHF&G	
11/04/01	2001	Oyster River	20	0%	0%	NHF&G	
10/14/02	2002	Oyster River	20	0%	0%	NHF&G	
10/27/04	2004	Oyster River	25	16%	0%	NHF&G	
11/06/05	2005	Oyster River	20	65%	10%	NHF&G	
11/01/06	2006	Oyster River	20	80%	30%	NHF&G	
10/23/07	2007	Oyster River	20	100%	35%	NHF&G	
10/10/08	2008	Oyster River	20	85%	15%	NHF&G	
11/04/09	2009	Oyster River	20	100%	40%	NHF&G	
10/21/10	2010	Oyster River	20	95%	20%	NHF&G	
10/26/11	2011	Oyster River	20	100%	35%	NHF&G	
11/17/97	1997	Piscataqua River	50	10%	2%	NHF&G	
12/09/98	1998	Piscataqua River	18	0%	0%	NHF&G	
11/04/00	2000	Piscataqua River	20	0%	0%	NHF&G	
10/31/06	2006	Piscataqua River	20	75%	20%	NHF&G	

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Date	Year	Location	Number Tested	Percent Infected	Percent Heavily Infected	Source	Notes
10/16/07	2007	Piscataqua River	20	90%	30%	NHF&G	
10/23/08	2008	Piscataqua River	10	30%	0%	NHF&G	
12/08/09	2009	Piscataqua River	20	45%	0%	NHF&G	
10/26/10	2010	Piscataqua River	17	64%	6%	NHF&G	
09/08/97	1997	Squamscott River	25	4%	0%	NHF&G	
12/09/98	1998	Squamscott River	25	0%	0%	NHF&G	
11/17/05	2005	Squamscott River	20	5%	0%	NHF&G	
11/07/06	2006	Squamscott River	39	13%	0%	NHF&G	
10/27/08	2008	Squamscott River	10	50%	10%	NHF&G	
11/16/10	2010	Squamscott River	20	55%	0%	NHF&G	
11/7/11	2011	Squamscott River	20	80%	15%	NHF&G	
11/16/05	2005	Woodman Point	20	90%	10%	NHF&G	
11/02/06	2006	Woodman Point	20	100%	5%	NHF&G	
10/24/07	2007	Woodman Point	20	90%	40%	NHF&G	
10/09/08	2008	Woodman Point	20	95%	35%	NHF&G	
11/13/09	2009	Woodman Point	20	75%	25%	NHF&G	
10/18/10	2010	Woodman Point	20	95%	40%	NHF&G	
10/28/11	2011	Woodman Point	20	100%	35%	NHF&G	

(1) Combination of 25 oysters taken 8/14/97 and 25 oysters taken 11/17/97

Figure SHL11-1: MSX infection prevalence in Great Bay Estuary oysters

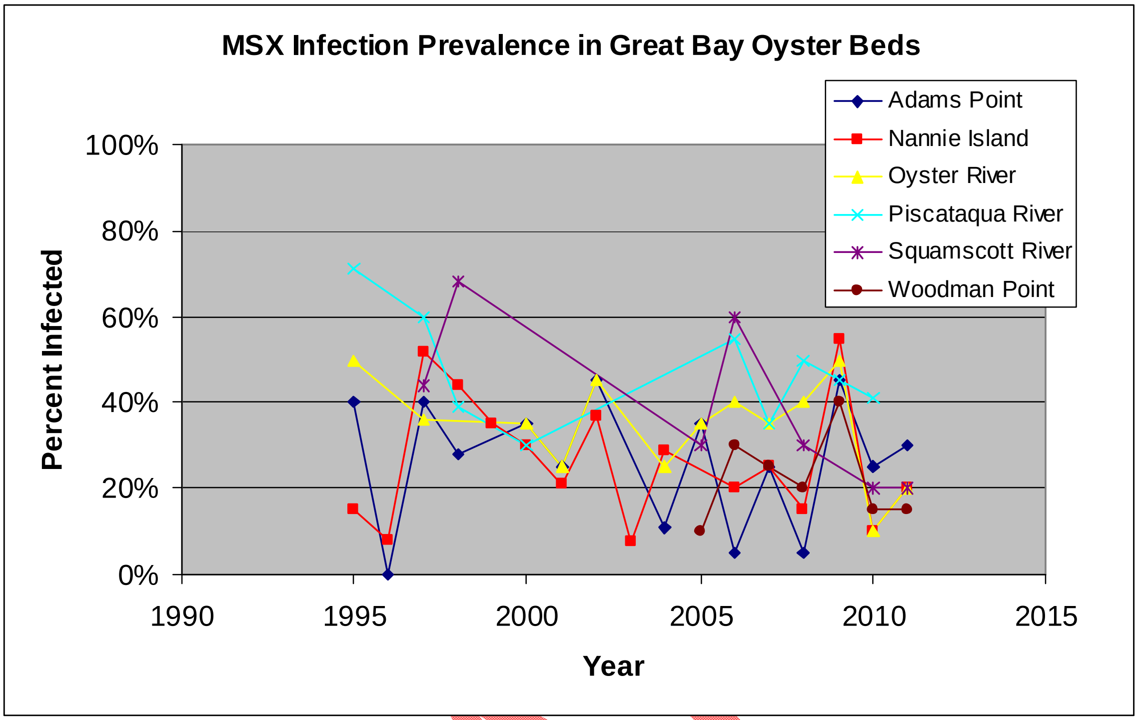


Figure SHL11-2: MSX systemic infection prevalence in Great Bay Estuary oysters

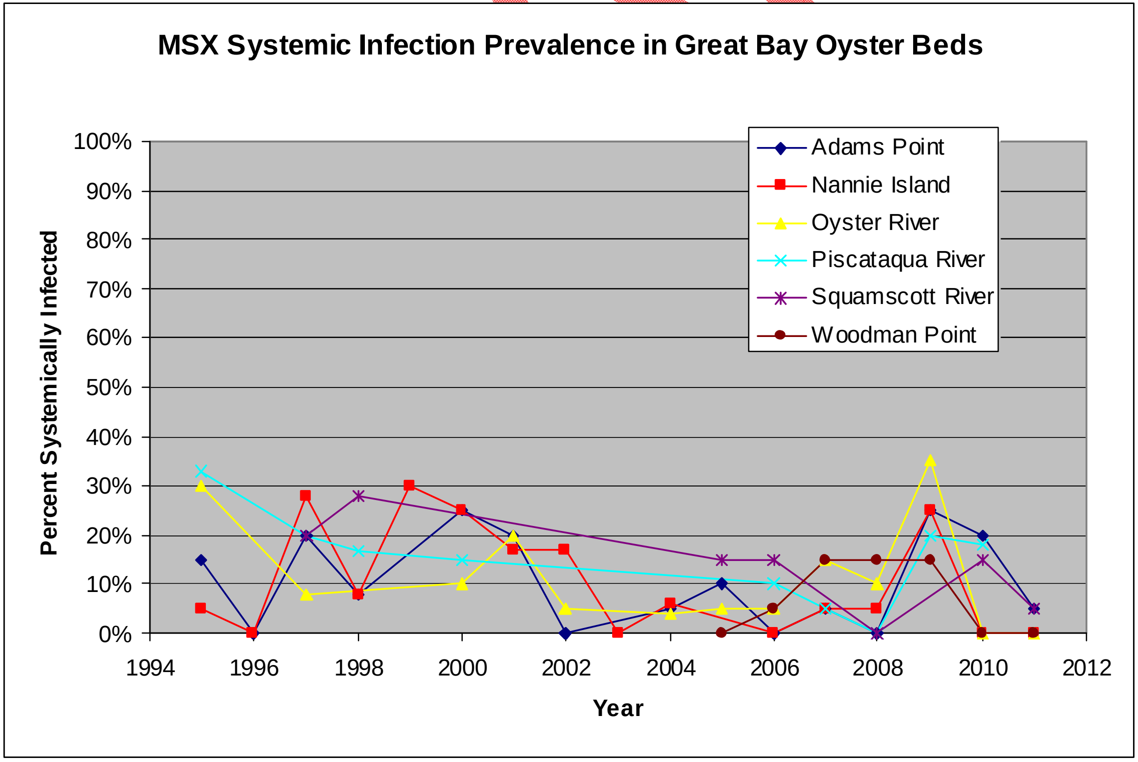


Figure SHL11-3: Dermo infection prevalence in Great Bay Estuary oysters

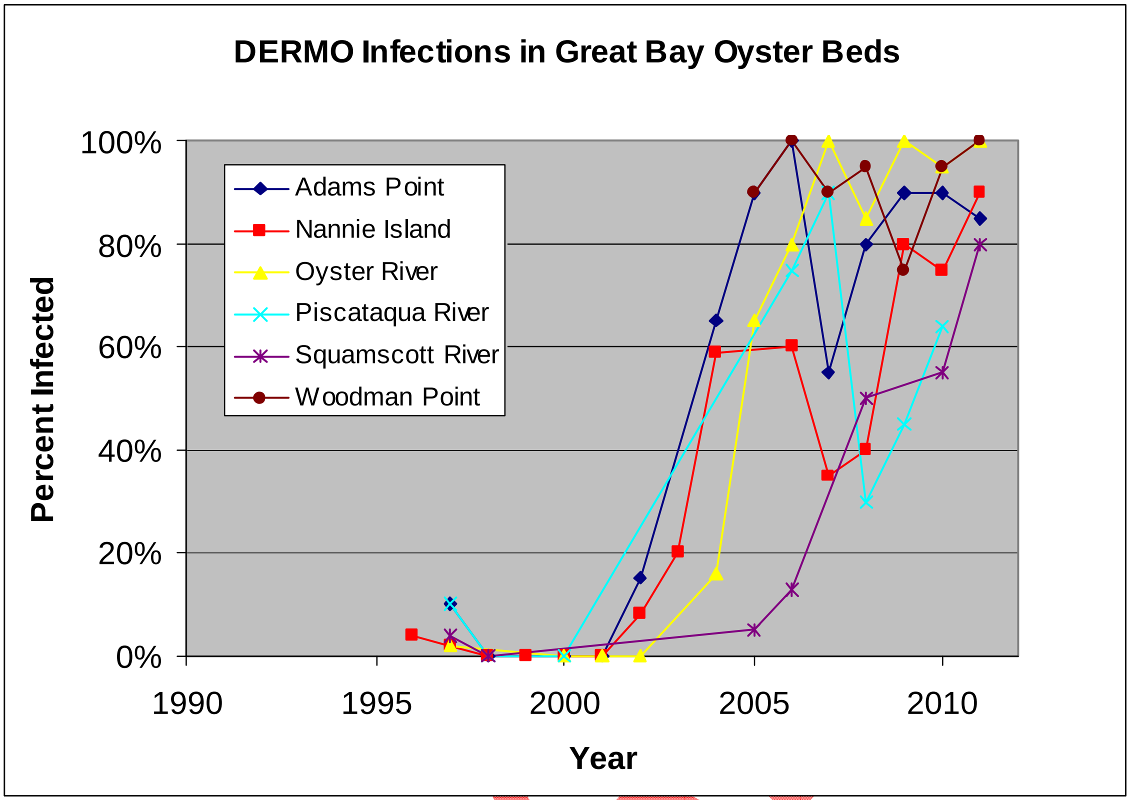
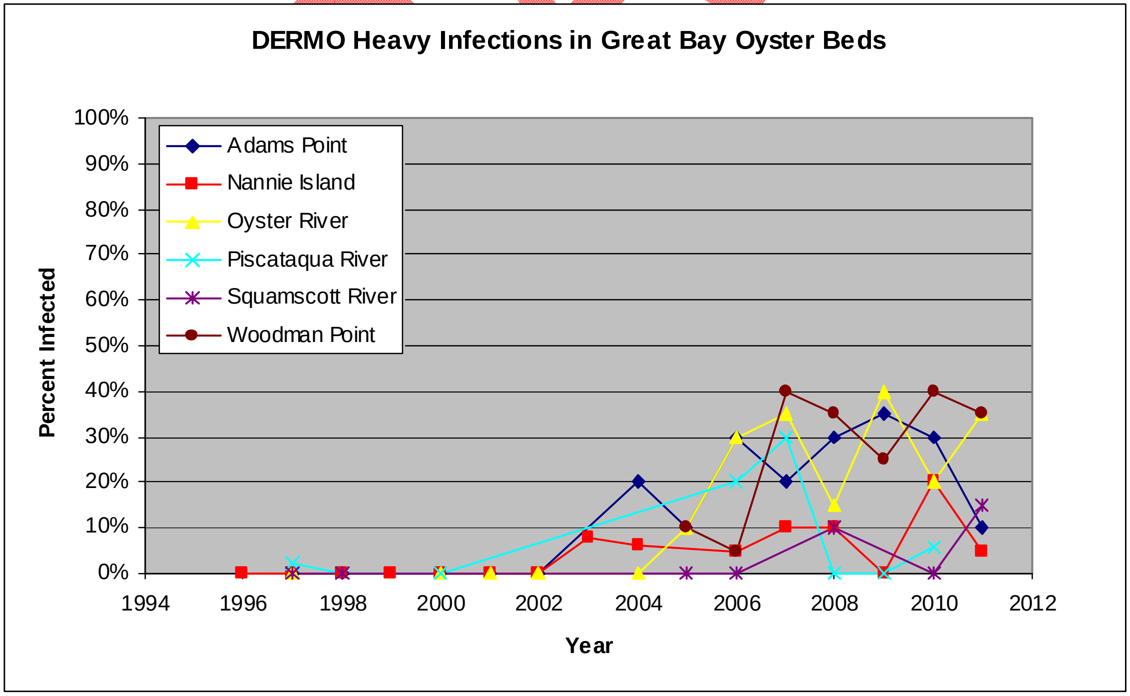


Figure SHL11-4: Dermo heavy infections in Great Bay Estuary oysters



Supplemental Information: SHL7. Abundance of Clam Predators

Objective

The objective of this section is to compile relevant information on the abundance of shellfish predators which can be used as supplemental information when evaluating the SHL6 indicator (Clams in Hampton-Seabrook Harbor).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The monthly catch-per-unit-effort (CPUE) of green crabs in Hampton-Seabrook Harbor were charted versus time. The time series was evaluated using the Mann Kendall test for trends.

Data Sources

The Seabrook Station Soft Shell Clam Monitoring Program provided a time series of green crab abundance in Hampton-Seabrook Harbor.

Results

The green crab (*Carcinus maenus*) is an invasive species which was introduced from Europe and currently exists along the Atlantic coast from Nova Scotia to Delaware. Beal (2006) determined that predation by green crabs is a major factor limiting the population of adult clams in Hampton-Seabrook Harbor. Time series data on green crab abundance in Hampton-Seabrook Harbor are shown in Figure SHL7-1. There is no statistically significant trend in the abundance values over time. Green crabs prey on juvenile clams. Figure SHL7-2 shows that juvenile clam populations are low during years with high crab abundance and rebound when the crab abundance drops. Therefore, predation by green crabs may limit the abundance of adult clams.

EXHIBIT 36 (AR K.22)

Figure SHL7-1: Green crab abundance in Hampton-Seabrook Harbor

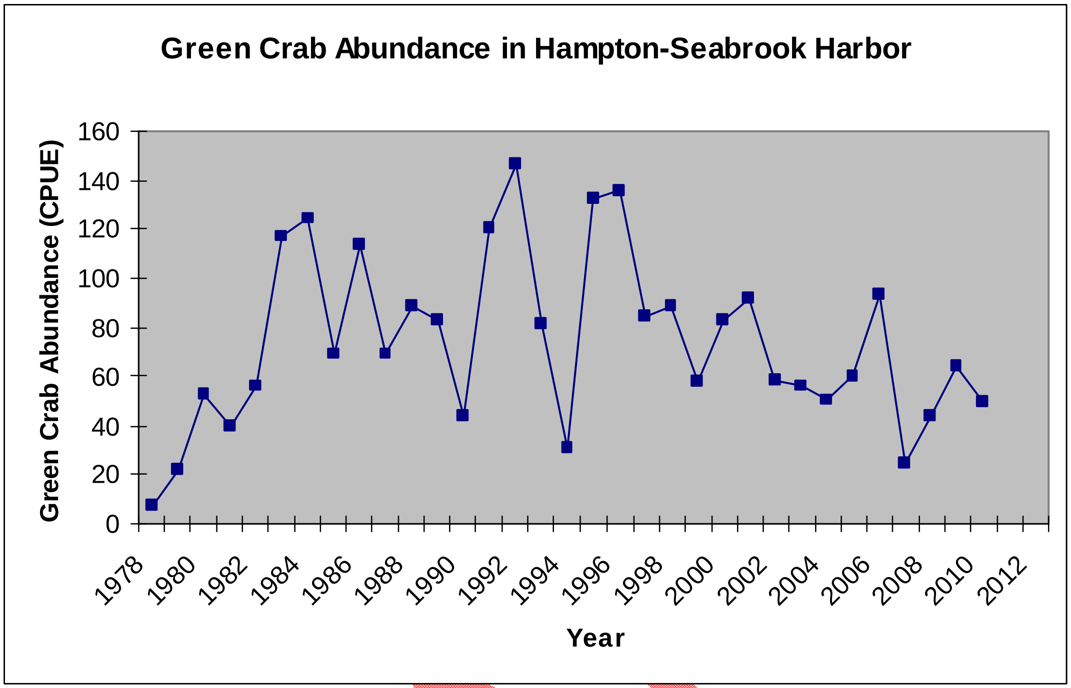


Figure SHL7-2: Green crab and juvenile clam abundance in Hampton-Seabrook Harbor

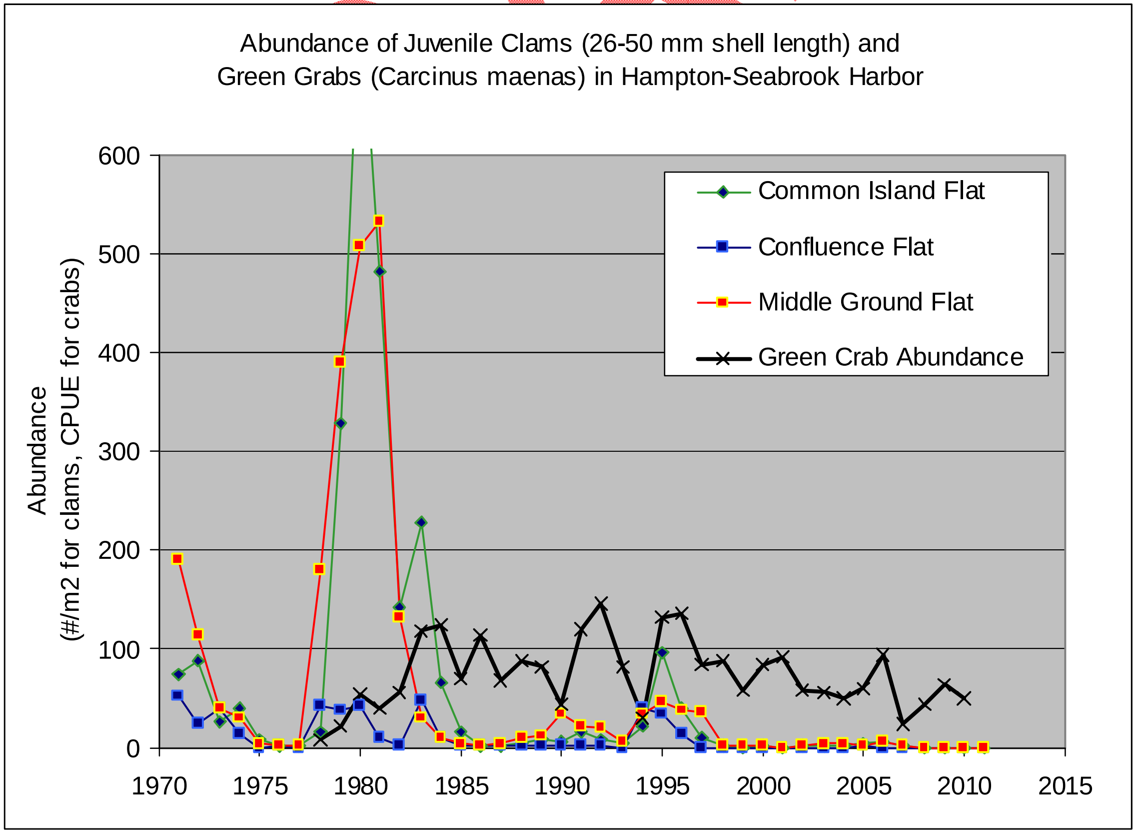


EXHIBIT 36 (AR K.22)

Supplemental Information: SHL10. Recreational harvest of clams

Objective

The objective of this section is to compile relevant information on recreational harvest of clams which can be used as supplemental information when evaluating the SHL6 indicator (Clams in Hampton-Seabrook Harbor).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The clam harvest license sales were used as the indicator of harvest pressure. For previous PREP reports, a regression equation between actual harvest and license sales was used based on observations between 1980 and 2002 when digging was allowed on Fridays and Saturdays. Starting in 2003, the regulations changed such that digging was only allowed on Saturdays. Therefore, the regression equation was no longer accurate which prompted the change to license sales, a surrogate for harvest pressure. Trends in license sales were compared to trends in standing stock. No statistical tests were applied.

Data Sources

The number of clamming licenses sold per year was provided by the NH Fish and Game Department (603-271-6832).

Results

Figure SHL10-1 shows that clam harvest license sales have ranged from peak values greater than 9,000 in 1975 and 1981 to less than 320 in 1990-1993. The oscillations in license sales generally followed similar patterns in the clam standing stock (Figure SHL10-2). This relationship indicates that recreational clam harvest pressure has been high enough to limit clam populations at times through actual harvest, clams damaged by digging, and physical disturbance of clam habitat. For example, the number of license sales reached peak values greater than 9,000 before the two major crashes of the fishery in the late 1970s and late 1980s. Clam populations rebounded during the period from 1989 to 1994 when harvest was prohibited because of water quality concerns. The number of license sales in 2007-2009 was approximately 1,200 per year. In 2010 and 2011, the license sales were approximately 800 per year. At this level of harvest pressure, the clam standing stock has declined from 5.1 to 2.4 million.

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Figure SHL10-1: Clam harvest license sales in New Hampshire

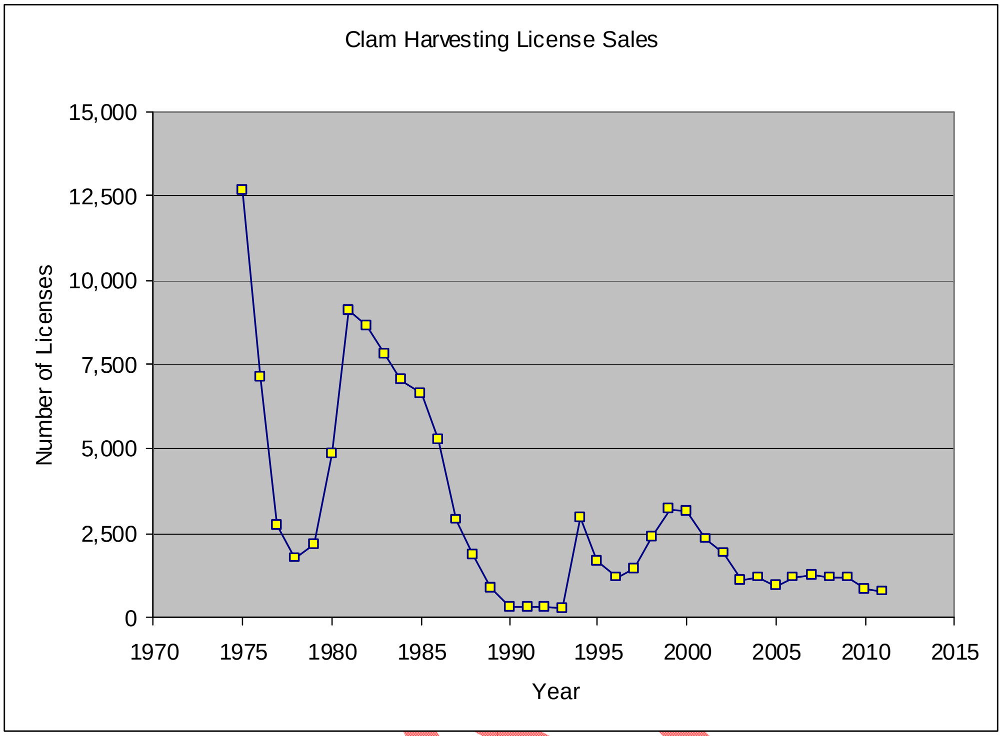


Figure SHL10-2: Clam standing stock in Hampton-Seabrook Harbor and harvest license sales in New Hampshire

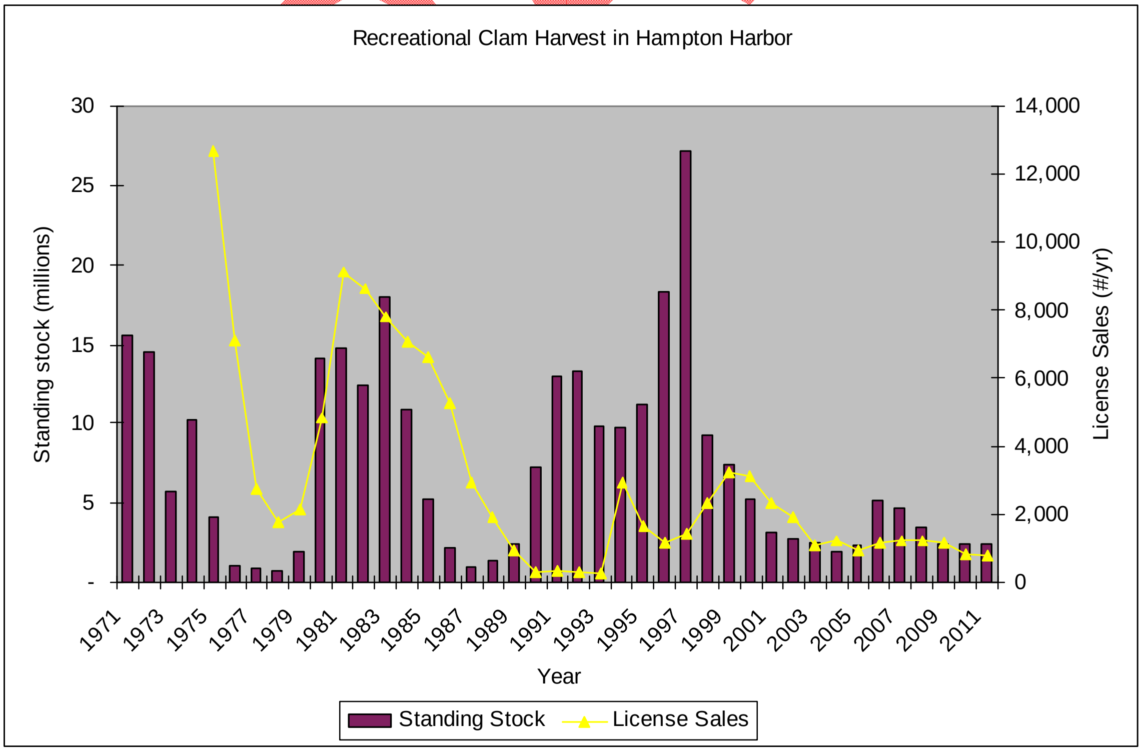


EXHIBIT 36 (AR K.22)

Supplemental Information: SHL12. Prevalence of Clam Disease

Objective

The objective of this section is to compile relevant information on the prevalence of clam disease (sarcomastic neoplasia) which can be used as supplemental information when evaluating the SHL6 indicator (Clams in Hampton-Seabrook Harbor).

PREP Goal

None

Methods and Data Sources

Data Analysis, Statistical Methods, and Hypothesis

The average prevalence of neoplasia infection (both total and heavily infected) were tracked over time. No statistical tests are applied.

Data Sources

Neoplasia has been monitored at the major clam flats in Hampton-Seabrook Harbor using consistent methods since 2002 by the Seabrook Station Soft Shell Clam Monitoring Program, implemented by Normandeau Associates.

Results

Sarcomatous neoplasia (neoplasia) is a lethal form of leukemia in soft-shell clams. In 1986, neoplasia was first discovered in clams from Hampton-Seabrook Harbor. By 1989, 80% of the clams from the Confluence flat had neoplastic cells (FPL, 2004). A consistent monitoring program for neoplasia was put in place by FPL Seabrook Station starting in 2002. Between 2002 and 2010, the prevalence of any neoplasia infection typically ranged from 50 to 80% of clams (Table SHL12-1, Figure SHL12-1). Infection here is defined as clams having anywhere from 1 to 100% neoplastic cells. No trend in the prevalence rate is apparent. The disease is normally fatal in clams, although some lightly infected clams can recover (Brousseau and Baglivo, 1991). Clams with a high degree of infection (90-100% neoplastic cells) are expected to have a 92% mortality rate (Farley, 1989).

EXHIBIT 36 (AR K.22)

Table SHL12-1: Percent of clams with any neoplasia infection in Hampton-Seabrook Harbor

YEAR	FLAT 1	FLAT 2	FLAT 3	FLAT 4	FLAT 5	Average*
2002	79	84	73	79	86	79.3
2003	50	50	30	54	42	43.8
2004	53	64	59	43	43	50.5
2005	46	51	43	49	72	51.3
2006	54	63	53	56	54	55.6
2007	29	56	52	67	62	52.3
2008	80	76	77	74	83	77.8
2009	49	53	64	56	50	53.5
2010	58	65	71	58	74	64.8

* Average calculated as the total number of infected clams from all flats divided by the total number of clams tested from all flats.

Figure SHL12-1: Average prevalence of neoplasia infection in clams from Hampton-Seabrook Harbor

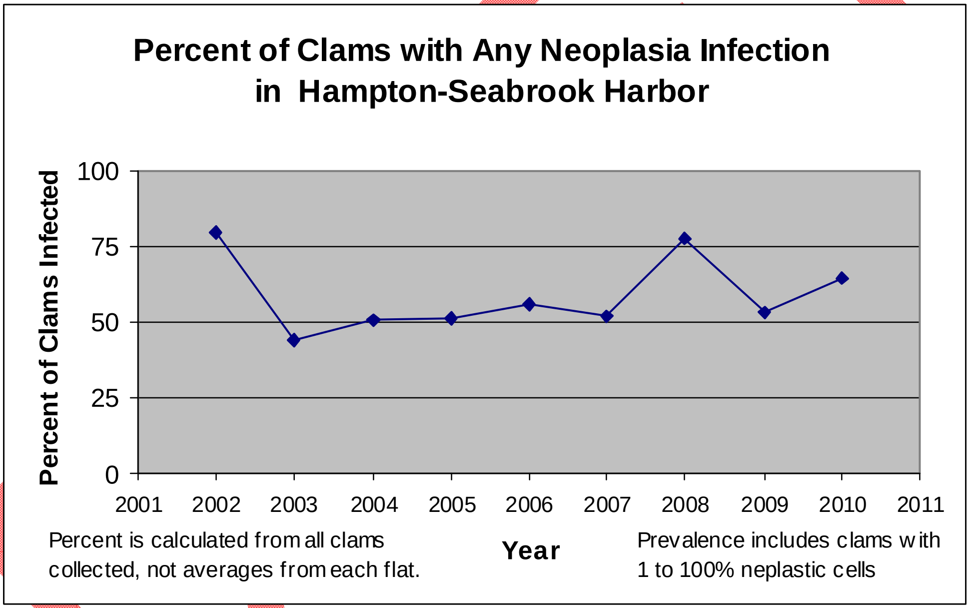
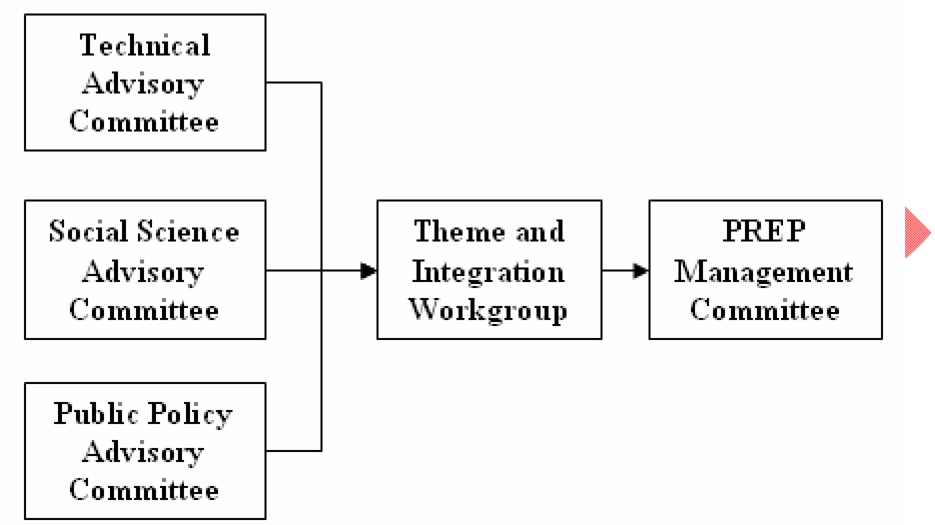


EXHIBIT 36 (AR K.22)

IV. Public Comment Responsiveness Summary

Introduction

For the 2013 State of Our Estuaries report, PREP developed a public engagement process to ensure transparency and stakeholder participation. Four different advisory committees plus the PREP Management Committee provided comments and feedback on drafts of the report. The following figure shows the structure of the overall engagement process.



The PREP Technical Advisory Committee (TAC) was responsible for reviewing the draft Data Report. The timeline for TAC meetings and comments on the draft Data Report is summarized below.

- May 24, 2012: Draft Data Report content released to TAC for review
- May 30, 2012: TAC meeting
- June 15, 2012: TAC subcommittee meeting on nutrients, eelgrass, and dissolved oxygen indicators
- June 22, 2012: Deadline for initial comments on draft Data Report
- June 25, 2012: TAC subcommittee on stoplight coding
- July 13, 2012: Deadline for additional comments on draft Data Report
- July 16, 2012: Draft Final Data Report released for final review (draft includes responses to comments received)
- July 19, 2012: TAC meeting
- July 26, 2012: Deadline for final comments on Data Report
- TBD: Content for Data Report finalized. However, the report will not be published until December 2012 coincident with the State of Our Estuaries report.

TAC Members

In 2012, the following individuals were members of the TAC.

University of New Hampshire
- Steve Jones (Chair)
- Tom Ballestero
- Dave Burdick
- Ray Grizzle
- Rich Langan
- Arthur Mathieson
- Bill McDowell
- Jonathan Pennock
- Robert Roseen
- Andy Rosenberg
- Fay Rubin
- Fred Short
- Alison Watts

NH Dept. of Environmental Services
- Gregg Comstock
- Steve Couture
- Ted Diers
- Chris Nash

Maine Dept. of Environmental Protection
- Wendy Garland

NH Fish and Game Department
- Bruce Smith
- Michael Dionne

Great Bay National Estuarine Research Reserve
- Paul Stacey

Wells National Estuarine Research Reserve
- Michele Dionne

Northeast Regional Assoc. of Coastal and Ocean Observing Systems
- Ru Morrison

Coastal Conservation Association
- Mitch Kalter

Normandeau Associates
- Paul Geoghegan

The Nature Conservancy
- Ray Konisky

PREP Management Committee
- Brian Giles

Southeast Watershed Alliance
- Candace Dolan

U.S. Environmental Protection Agency
- Jean Brochi, EPA

National Oceanic and Atmospheric Administration
- Dwight Trueblood

U.S. Geological Survey
- Keith Robinson

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TAC Meetings

Between May 30, 2012 and July 19, 2012, the full TAC met twice and subcommittees of the TAC met twice to discuss the draft indicators. PREP also invited the Great Bay Municipal Coalition and other stakeholders to participate in the TAC meetings and to submit written comments. The following individuals participated in PREP TAC meetings and subcommittee meetings.

May 30, 2012

TAC Members
Steve Jones, UNH (Chair)
Brian Giles
Paul Stacey, GBNERR
Rich Langan, UNH
Jonathan Pennock, UNH
Bruce Smith, NHF&G
Ted Diers, NH DES
Alison Watts, UNH SC
Michelle Daley, UNH
Ray Konisky, TNC
Jeannie Brochi, EPA
Rob Roseen, UNH SC

Guests
Corey Riley, GBNERR
Dean Peschel, GBMC
Peter Rice, GBMC
Candace Dolan, SWA
Mike Trainque, SWA
Matt Wood, DES

PREP Staff
Rachel Rouillard
Philip Trowbridge
Derek Sowers
Jeff Edelstein (Facilitator)
Jill Farrell
Colin Lentz

June 15, 2012 (Nutrients/eelgrass/dissolved oxygen subcommittee meeting)

TAC Members
Steve Jones, UNH (Chair)
Brian Giles
Paul Stacey, GBNERR
Rich Langan, UNH
Jonathan Pennock, UNH
David Burdick, UNH
Ted Diers, NH DES

Guests
Corey Riley, GBNERR
Dean Peschel, GBMC
John Hall, GBMC
Tom Gallagher, GBMC
Mike Trainque, SWA
Peter Wellenberger, CLF

PREP Staff
Rachel Rouillard
Philip Trowbridge
Derek Sowers
Jeff Edelstein (Facilitator)

June 25, 2012 (Stoplight subcommittee meeting)

TAC Members
Steve Jones, UNH (Chair)
Rob Roseen, UNH
Steve Couture, NH DES
Rich Langan, UNH
Corey Riley, GBNERR

Guests

PREP Staff
Rachel Rouillard
Jeff Edelstein (Facilitator)

July 19, 2012

TAC Members
TBD

Guests

PREP Staff

TAC Written Comments

Written comments were received from the following:

- Bruce Smith, NHF&G (June 7, 2012)
- Art Mathieson, UNH (June 11, 2012)
- Dean Peschel, Great Bay Municipal Coalition (June 22, 2012)
- Cheri Patterson & Kevin Sullivan, NHF&G (June 5, 2012)

PREP Responses to TAC Comments

PREP staff reviewed the input provided at the meetings and in writing The approach of the PREP staff in developing responses to comments and input was to:

- Determine where the comment was best addressed: in the Data Report, the State of Our Estuaries Report, and/or referred to the Theme and Integration Workgroup for policy consideration.
- Ensure that text/graphics represent factual statements relevant to indicator questions.
- Strive for consistency with previous PREP Management Plan (PREP, 2010), Monitoring Plan (PREP, 2008), previous Data Reports (PREP, 2009a), and previous State of Our Estuaries reports (PREP, 2009b), when possible.
- Develop connections/linkages between indicators, if warranted, only in theme or executive summary statements, not in the individual indicator write ups. The indicators were developed to illustrate status and trends in the estuary, not to prove or disprove cause and effect.
- Ensure that State of Our Estuaries content is understandable by a non-scientist audience.

All of the comments received are listed in the following table. Specific responses to comments are provided in the table. Comments that could not be addressed because they were beyond the scope of the Data Report and the State of Our Estuaries report are shaded in gray.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

Comments that cannot be addressed in the Data Report or the SOOE report are shaded.

Topic	Comment	To Be Address In…	To Be Addressed By…	Response
General	Consider using a pressure-state-response model for the report. Link state variables to pressures.	Data Report, SOOE Outline	TIWG	PREP staff will present a Pressure-State-Response outline for the report to the TIWG.
General	Condition and trends are different indicators. There should be two questions: What is the condition (concentration)? What is the trend? The answer should be specific to the question. The time scale for the questions should be clearer and consistent. Are trends long-term or since last report?	Data Report, SOOE Q&A	PREP staff	A common Q&A format will be used: What was the current level (concentration or load or amount) and how has it changed over time? If sufficient data are available, both long-term changes and changes since the last SOOE report will be mentioned in the answer.
General	Add "theme summaries" for groups of indicators: nutrients/DO/eelgrass, land use, oyster/clam/fish, etc.	SOOE Executive Summary	TIWG	The TIWG will develop language that "bundles" different indicators. For the 2013 SOOE, the bundling is expected to be qualitative. For future SOOE reports, more quantitative analyses may be completed, as appropriate.
General	Linkages between nutrients, DO, eelgrass, and macroalgae should be explained. The linkages should either cite local data or literature.There should be a way to link the graphs from the different nutrient-related indicators.	SOOE Executive Summary	PREP Staff, TIWG	Indicator graphics will be prepared using consistent time scales as much as possible. Text discussion of linkages between the indicators will be developed by the TIWG.
General	SOOE short answer should link directly to first figure. All SOOE text should connect directly to figures.	SOOE Q&A	PREP staff	PREP staff will ensure that Q&A statements are clearly linked to figures.
General	Need for better synthesis statements in the "Why This Matters" text that uses local data and literature reports to justify statements.	SOOE and Data Report "Why This Matters" text	PREP staff	The "Why This Matters" text will be expanded in the Data Report with more local information and literature citations. The text will be simplified for the SOOE report to conform to the audience.
General	How should new information be handled?		PREP staff	Information that is specifically relevant to PREP indicators will be included in the report either directly or by reference.
General	Lack of funding has limited the number of research projects on different areas of the estuary.	SOOE Research Priorities	TIWG	Funding shortfalls will be considered by the TIWG for inclusion in the SOOE Research Priorities section.
General	What is the TAC's role in assessing/backing data?		PREP staff	The TAC serves as an advisory committee. Many members of the TAC are also responsible for providing data for the PREP indicators.
Stoplight	The green-yellow-red color coding should be based on the "state" of each indicator, with red indicating "unhealthy/bad", green indicating "healthy/good", and yellow indicating somewhere in between.	SOOE	PREP Staff, TIWG	The definitions of green, yellow, and red color coding will be editted.
Stoplight	In order to determine the state of an indicator, there should be two primary components: the measurement of the state and the benchmark. The benchmark can be state regulations, PREP goals/objectives, information from local research, and information from research in general. If the state exceeds all four benchmarks, the color code will likely be red. If the state does not exceed all four benchmarks, then the color will likely be green. If there is a mixture, then the color may be yellow.	SOOE	PREP Staff, TIWG	PREP will develop a matrix for each indicator that summarizes the available information for each of the benchmark options.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

Comments that cannot be addressed in the Data Report or the SOOE report are shaded.

Topic	Comment	To Be Address In…	To Be Addressed By…	Response
Stoplight	As a secondary level of assessment of the color coding, each indicator will be assessed for trends, the degree to which the status diverges from the benchmark, the degree of uncertainty/consensus with the scientific community. The secondary assessment may provide a basis for shifting an indicator from yellow to either green or red and/or it may inform the section of the SOOE reoprt that identifies emerging issues and next steps or the section on public policy responses.	SOOE	PREP Staff, TWG	PREP staff and the TWG will consider the secondary level of assessment when setting color codes.
Stoplight	An indicator will only be included in the SOOE report if PREP believes sufficient information exists for an accurate assessment. If insufficient information exists, the indicator might be identified for inclusion in the next SOOE report, if sufficent data can be gathered over the next three years.	Data Report, SOOE	PREP staff	The SOOE report will have a Research Priorities section which will include any important indicators that do not have sufficient information to be included in the 2013 report. The Data Report will have a section for Supplemental Information.
Stoplight	Show short and long term trends as consistently as possible.	Data Report, SOOE	PREP staff	A trend line based on annual data will be used to show trends. Long term trends will be shown with a regression line. Short term trends will be show by highlighting the last three years of data relative ot the long term trend and other yearly points.
Dissolved Oxygen	Are the causes of dissolved oxygen violations actually known? If not, should caveat explanation. It would be better to represent chlorophyll-a as a contributing factor, not the sole cause of DO problems. Report should say whether impacts to aquatic life have actually occurred (e.g., fish kills).	Data Report "Why It Matters" Text	PREP staff	Text will be modified to include literature citations.Citations to detailed studies in the Lamprey (Pennock) and Squamscott (HydroQual) will be added. Text related to observed fish kills (information from NHFG) and other impacts will be added to the report.
Dissolved Oxygen	The PREP report must reference studies by Pennock (2005), Jones (2007), and Hydroqual (2011) in discussing the causes of dissolve oxygen criteria excursions in the different areas of the estuary. The report should conclude that low dissolved oxygen levels are not a direct function of elevated phytoplankton chlorophyll-a concentration. Phytoplankton chlorophyll-a levels are specifically no the cause of low dissolved oxygen in the Lamprey River. Further investigation is needed on this issue.	Data Report		The requested citations will be added to the text as stated above. Regarding conclusions about causes of low dissolved oxygen, PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Dissolved Oxygen	Explain variance in violations of the DO standard between years.	Data Report Graphics, SOOE Graphics	PREP staff	DO violation graphs will be changed to show data availability, which explains much of the variance.
Dissolved Oxygen	Graphs should show the magnitude, frequency, and duration of violations of the state standard.	Data Report	PREP staff	A table with the duration below different DO levels in the summer season will be added. Frequency of low DO episodes was included in the 2006 Data Report. There is not enough time to repeat that analysis.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

Comments that cannot be addressed in the Data Report or the SOOE report are shaded.

Topic	Comment	To Be Address In…	To Be Addressed By…	Response
Dissolved Oxygen	Can it be shown that dissolved oxygen in the tidal rivers is related to chlorophyll-a? Plot algae data on the same graph as the DO data.			Chlorophyll-a and dissolved oxygen data are colleced on very different time scales. It would be inappropriate to compare the 3 grab samples for chlorophyll-a collected at each station in the summer to the 8000 dissolved oxygen datasonde readings collected in the same season. Moreover, PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Dissolved Oxygen	The PREP report must reference studies by Pennock (2005), Jones (2007), and Hydroqual (2011) in discussing the causes of dissolve oxygen criteria excursions in the different areas of the estuary. The report should conclude that low dissolved oxygen levels are not a direct function of elevated phytoplankton chlorophyll-a concentration. Phytoplankton chlorophyll-a levels are specifically no the cause of low dissolved oxygen in the Lamprey River. Further investigation is needed on this issue.			The requested citations will be added to the text as stated above. Regarding conclusions about causes of low dissolved oxygen, PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Dissolved Oxygen	Claims that low dissolved oxygen levels in the Oyster River are due to nutrients stimulating algal growth are misplaced. Data on dissolved oxygen criteria excursions shows that the number of excursions increased when algae chlorophyll-a levels in the river were low and decreased when chlotophyll-a levels were elevated.			Chlorophyll-a and dissolved oxygen data are colleced on very different time scales. It would be inappropriate to compare the 3 grab samples for chlorophyll-a collected at each station in the summer to the 8000 dissolved oxygen datasonde readings collected in the same season. Moreover, PREP indicators were not intended to prove causative linkages.
Dissolved Oxygen	Graphs should show seasonality of violations.			The indicator is already indexed to the summer growing season. Most of the violations occur during this season. No changes are needed.
Eelgrass	It is confusing to measure trends starting in 1990 but to mention data from 1986 or earlier.	Data Report, SOOE	PREP staff	Text will be modified to use consistent dates as much as possible. Trend calculations will all be done using data since 1990 to avoid complications from wasting disease event in 1988-1989.
Eelgrass	Eelgrass biomass should have error bars.	SOOE	PREP Staff, TWG	Data needed to determine error bars is not available. This topic will be discussed in the Data Report and will be considered for inclusion in the SOOE Research Priorities section by the TWG.

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Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

Comments that cannot be addressed in the Data Report or the SOOE report are shaded.

Topic	Comment	To Be Address In…	To Be Addressed By…	Response
Eelgrass	It is confusing to switch between eelgrass cover and biomass. / References to eelgrass biomass should be eliminated from the PREP report because these measurements are considered unreliable at this time.	SOOE	PREP staff	To avoid confusion and acknowledging the uncertainty in the biomass measurement, the eelgrass biomass indicator will be not be included in the SOOE report. The indicator will be replaced with qualitiative discussion of thinning beds.
Eelgrass	Is is appropriate to use 1996 levels as the goal for eelgrass biomass?	Data Report, SOOE	PREP staff	Eelgrass biomass will not be included as in indicator in the SOOE report. Eelgrass biomass will be included in the Data Report as supplemental information. The Data Report will contain an assessment of trends in biomass, not a comparison to a numeric goal.
Eelgrass	It is difficult to see the eelgrass on the map provided. Use solid color. Blow up Portsmouth Harbor area.	Data Report, SOOE Graphics	PREP staff	Simplified graphics with blow-ups will be created.
Eelgrass	Remove statements about "eelgrass entirely lost from tidal rivers"	Data Report, SOOE Q&A	PREP staff	Loss of eelgrass from the tidal rivers is a statement of fact based on historic maps from Great Bay Estuarine Restoration Compendium and recent maps. The Q&A wording will be reviewed to ensure accuracy.
Eelgrass	Should report acres lost in addition to percent change for different areas.	Data Report, SOOE Text	PREP staff	Change will be made.
Eelgrass	Eelgrass restoration targets in the estuary need to be individually specified for different areas that make up the estuary (i.e., tidal rivers, Great Bay, Little Bay, the Piscataqua River, and the Harbor). These individual targets should be specified based on average conditions that have previously been considered acceptable (e.g., Great Bay eelgrass coverage - 2100 acres +/-20%).	Data Report, SOOE Graphics	PREP staff	Eelgrass graphic will be changed to a map showing the PREP goal (1996 distribution) and current (2011) distribution of eelgrass in all areas. This graphic will address the comment that trends in all areas should be shown and will tie into the PREP management goal to restore connectivity between eelgrass beds. Furthermore, the Data Report will continue to contain individual graphs of the trends in eelgrass cover in different areas of the estuary.
Eelgrass	Wasting disease discussion is not relevant to current situation.	Data Report, SOOE Text	PREP staff	Wasting disease is an important issue but there is too much text in the current drafts. The text will be shortened.
Eelgrass	The draft PREP report indicates that eelgrass coverage in Little Bay was essentially zero acres for the four year period from 2007-2010. In 2011, eelgrass coverage in Little Bay increased to 48 acres, the highest level reported in 20 years. This increase is unusual and suggests that the coverage for the prior four years may be in error and should be verified. This significant improvement in eelgrass coverage should be noted and the "negative" trend revised.	Data Report	PREP staff	Eelgrass is the estuary is mapped using consistent methods year after year. The change in eelgrass cover in Little Bay in 2011 does not invalidate the previous results. The change in eelgrass cover in Little Bay will be discussed in the text of the Data Report.
Eelgrass	Where did the PREP goal of 2900 acres of eelgrass cover come from? If using the highest level as the goal, the goal will never be achieved.	Data Report, SOOE "Goal" Text	PREP staff	Text will explain that the CCMP set a goal to restore eelgrass to 1996 levels (2900 acres in whole system) and to restore connectivity between beds.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

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Topic	Comment	To Be Address In…	To Be Addressed By…	Response
Eelgrass	NHF&G divers find eelgrass in areas where it was not mapped by the UNH aerial surveys.			The data used for the indicator have been collected using aerial photography using consistent methods to cover the entire estuary. Therefore, the data used for the indicator is appropriate for the indicator. Observations of eelgrass by divers during site-specific studies does not invalidate the indicator.
Eelgrass	Eelgrass restoration in the tidal rivers (i.e., the Lamprey River, the Squamscott River) is not possible due to habitat considerations and water quality due to natural conditions (CDOM, tubidity). Other areas, such as the Piscataqua River have a limited ability for eelgrass restoration due to transparency limitations associated with water color and turbidity. (This question was interpreted as meaning that eelgrass restoration goals may not be possible due to poor water quality in some areas of the estuary.)			PREP management goals for eelgrass habitat and restoration have been established in the CCMP based on mapped eelgrass as recently as 1996. It is beyond the scope of the Data Report or SOOE to change these goals.
Eelgrass	The Morrison and DES reports evaluating factors influencing transparency in the estuary must be referenced in the PREP report. These reports concluded that color, not phytoplankton chlorophyll-a was the controlling factor influencing transparency. The report should speify [sic] that eelgrass loss is not a nutrient issue. Elevated flows entering the estuary convey excess color and influence of this factor on light transmission and eelgrass coverage needs to be recognized.			PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Eelgrass	The PREP report needs to include a conclusion that TN increased at most caused minor changes in phytoplankton chlorophyll-a concentrations and these changes do not significantly affect light transparency in Great Bay, Little Bay, or the Piscataqua River.			PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE.
Nutrients	It is confusing to have nitrogen load and nitrogen concentrations in the same indicator. Which one is the indicator? Load is a better indicator because concentration reflects what is left over.	SOOE	PREP staff	Nitrogen load and nitrogen concentrations will be separated because the load will be a "pressure" indicator and concentration will be "state" indicator.
Nutrients	Add better explanation for changes in nitrogen loads over time. Use the same methods across all periods. Pie chart of nitrogen sources is valuable but also need to show how the pie chart has changed over time.	SOOE Graphics, Data Report	PREP staff	Replace nitrogen loads from 2006 and 2009 SOTE reports with loads from DES Nitrogen Loading Analysis which used the same methods as the latest SOOE. Include annual precipitation on the graph for reference.
Nutrients	Changes in nitrogen loads should be linked to population and impervious surface growth.	Data Report, SOOE Report	PREP staff	PREP staff will explored including historical nitrogen loads (from models) and population growth to provide context to the nitrogen load indicator. Without published reports on the historical models, it was deem inappropriate to include these results. A population growth indicator was added to the Data Report.

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Topic	**Comment**	**To Be Address In…**	**To Be Addressed By…**	**Response**
Nutrients	The nitrogen load indicator needs a goal. / The PREP report should eliminate nutrient load reduction targets as no information has been provided to substantiate any such targets. If targets are established, pre-2000 DIN levels should be sufficient to address macroalgae growth.	Data Report, SOOE	PREP staff, TAC, TIWG	The goal in the CCMP is: "Reduce nutrient loads to the estuaries and ocean so that adverse, nutrient-related effects do not occur." For this SOOE, PREP will use this narrative standard rather than setting a numeric threshold. Observations of low dissolved oxygen, declining eelgrass, or increasing algae will be interpretted as meaning that the nitrogen load to the estuary is still higher than the PREP goal. PREP staff will also explore adding normalized loading thresholds for estuaries from the scientific literature.
Nutrients	Effects of weather should be considered.	Data Report, SOOE Report	PREP staff	Annual precipitation will be added to the nitrogen load graphic.Graphing rainfall along with the nitrogen load indicator makes sense because runoff is the dominant factor in non-point source nitrogen loads. For other indicators (e.g., nitrogen concentrations), rainfall is one of many factors affecting the indicator. Therefore, it does not make sense to graph this factor and not the others.

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Topic	**Comment**	**To Be Address In…**	**To Be Addressed By…**	**Response**
Nutrients	Nutrient trends should be assessed using shorter bin size than 8-years to show more variability. Ideally, yearly data should be shown.	Inidicator Report, SOOE	PREP staff	For nutrient indicators, PREP will graph the annual mean and standard deviation at Adams Point for years with samples in 10 or more months starting in 1974 and ending in 2011. Only low-tide samples will be used to best reflect estuarine conditions (minimal dilution by ocean water). The trend will be calculated using linear regression of all of the monthly datapoints in years with complete data in ensure enough statistical power to detect trends. The percent change and absolute value change in concentration will be calculated from the trend line (if significant at p<0.05) using the first and last year of complete data. The average concentration for years without enough samples will be shown on the graph but not used in the trend calculation. Data from other stations besides Adams Point will be presented in the same manner and plotted on a map to illustrate spatial variability.
Nutrients	Macroalgae proliferation should be included in the report. Based upon observations and scientific data, eutrophication is creating an unstable and negative situation within the GBES, which needs to be quickly rectified. The green and red (Graciliaria) algal blooms are typical of stressed estuarine systems like those found within Waquoit Bay, MA, Narragansett Bay, RI, and the middle Atlantic coastal estuaries with Delaware, Maryland, and Virginia.	Data Report, SOOE	PREP staff	Chlorophyll-a and macroalgae will be combined into a new indicator group. Changes in macroalgae prevalence in Great Bay as documented by Nettleton will be shown on a graph.
Nutrients	The PREP report should note that increasing levels of DIN may be stimulating macroalgae growth in Great Bay, however the level of DIN necessary to limit macroalgae growth has not been determined. Macroalgae are not a concern in the tidal rivers or the Piscataqua River where tidal currents are too high to allow their proliferation.	Data Report, SOOE	PREP staff	Chlorophyll-a and macroalgae will be combined into a new indicator group. Changes in macroalgae prevalence in Great Bay as documented by Nettleton will be shown on a graph.
Nutrients	Should chlorophyll-a be its own indicator? It is currently lumped with nutrients.	Data Report, SOOE	PREP staff	Chlorophyll-a and macroalgae will be combined into a new indicator group.
Nutrients	Chlorophyll-a trends should be expressed as both absolute values and percent changes. A large percent change of a small number is still a small number.	Data Report, SOOE	PREP staff	Trends will be expressed in absolute and relative terms.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

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Topic	Comment	To Be Address In…	To Be Addressed By…	Response
Nutrients	Figure 2. What is the purpose of this graph? Have you linked summer DIN load to algae response?	SOOE Report	TIWG	Figure 2 will be retained in the Data Report. The TIWG will consider whether this graphic should be included in the SOOE.
Nutrients	"Troublesome" is not a very technical term. DIN is only troublesome if it causes algae blooms. Should not refer to "nutrient pollution" or "safe levels" in the Q&A.	SOOE Text	PREP staff	Editorial changes.
Nutrients	"Why This Matters" text should caveat link between nutrients and algal growth ("may cause"…)	SOOE "Why it matters" Text	PREP staff	Editorial changes.
Nutrients	Should the DES decision to impair sections of the Great Bay Estuary for nitrogen be included?	SOOE "Why it matters" Text	TIWG	TIWG will consider this comment.
Nutrients	Changes in nitrogen concentrations should be attributed to changes in eelgrass cover because eelgrass removes nitrogen from the water column.	SOOE Executive Summary	TIWG	Linkages between nutrient indicators will be addressed by the TIWG.
Nutrients	The PREP report must state that increases in TN and DIN between 1990 and 2011 did not result in significant changes in phytoplankton chlorophyll-a concentrations in any areas of the estuary.	SOOE	TIWG	Linkages between nutrient indicators will be addressed by the TIWG.
Nutrients	Report should account for natural variation and sampling error.	Data Report	PREP staff	All data used in the report has undergone QA checks. Natural variability is expressed using error bars.
Nutrients	Should add text explaining that additional studies are needed.	SOOE Research Priorities	TIWG	
Nutrients	Chlorophyll-a concentrations in the Great Bay are low relative to other estuaries.			The focus of the SOOE report is the Great Bay Estuary and the Hampton-Seabrook Estuary not other estuaries.
Nutrients	Consider using NCCR as a model for the report.			The focus of the SOOE report is the Great Bay Estuary and the Hampton-Seabrook Estuary. The indicators have not been designed for comparisons to other estuaries or national averages using the NCCR model.
Nutrients	The report does not have process data to link nitrogen with algal growth. / The PREP report needs to indicate that phytoplankton chlorophyll-a/nutrients are not the primary factors controlling light transparency in the estuary.			PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Nutrients	Language of SOOE report will be used by regulatory agencies and needs to address what level of nitrogen removal is necessary at WWTFs.			This comment is beyond the scope of the SOOE report. PREP is not a regulatory agency and answering regulatory questions is not the purpose of the report.
Nutrients	Fundamental, technical questions about algae, nitrogen, DO, and eelgrass need to be addressed. Has nitrogen been proven to be the cause of these effects?			PREP indicators were not intended to prove causative linkages. Addressing this comment is beyond the scope and objectives of the PREP Data Report and SOOE. Findings from any site-specific studies relevant to this question will be included in the report discussions.
Sediment	Provide more information on suspended sediment trends		PREP staff	Suspended sediment trends will be analyzed in the same manner as the nutrient and chlorophyll-a trends.

Summary of Comments on May 24, 2012 Draft Data Report and SOOE Content

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Topic	**Comment**	**To Be Address In…**	**To Be Addressed By…**	**Response**
Sediment	Sediment load is underestimated	SOOE and Data Report	PREP staff	This indicator will be deleted until a more suitable monitoring design is funded.
Beach closures	Beach closures should be expressed as a percent of the total possible days	SOOE Graphics	PREP staff	Change will be made.
Shellfish harvesting	Shellfish closures due to safety zones should be removed	Data Report, SOOE	PREP staff	For the acre-days of shellfish harvesting indicator, safety zones are already excluded, so no change is needed. For the acres in each classification indicator, Maine does not officially designate safety zones in the Piscataqua River so any attempt to remove safety zones will exclude Maine waters. It was deemed more appropriate to leave the indicator unchanged.
Bacteria	Positive trend for enterococcus should be be explained better.	SOOE Text	PREP staff	The increasing trend for enterococcus in the Squamscott River will be used to say that the trends for bacteria in the estuary are "mixed".
Impervious Surfaces	Need to clarify text about 10% threshold because conditions do not dramatically change between 9% and 11%. Need a clear PREP goal.	SOOE Q&A	PREP staff	Additional text was added clarifying that the there is a range of IS% values for which effects have been observed (7-14%).
Conservation Lands	Put conservation lands goal into context with impervious surface growth	SOOE Q&A	PREP staff	The PREP goals for conservation lands will be clarified.
Oysters	Change "oyster reef" text to "oyster bed"	Data Report, SOOE	PREP staff	Editorial change will be made.
Oysters	Consider mentioning oily deposition on Piscataqua River oyster bed as a contributor to oyster losses.	Data Report	PREP staff	Change will be made.
Clams	Change refernces to FPL to new name, NextEra Energy and Normandeau	Data Report, SOOE	PREP staff	Change will be made.
Clams	Clam license sales "have not stabilized at 1000" as stated in the report. The number of license sales was 778 in 2011.	Data Report	PREP staff	Change will be made.
Diadromous Fish	Fish returns in 2011 s hould be added to the graphs.	Data Report	PREP staff	Change will be made.
Diadromous Fish	Change references to "dam passage" to "barrier passage".	Data Report	PREP staff	Change will be made.
Diadromous Fish	Delete or clarify statement that lamprey return data are only available on the Cocheco River.	Data Report	PREP staff	Sentence will be deleted.

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