STATE OF OUR ESTUARIES
2013

PREP
Piscataqua Region Estuaries Partnership

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LETTER FROM THE EXECUTIVE DIRECTOR

We all benefit from a clean, healthy estuary.

Each of us has an important role to play in ensuring that our waters continue to provide the essential benefits and services that our communities have come to rely upon.

Our two largest estuaries – The Great Bay Estuary and Hampton Seabrook Harbor – help define who we are as a region. Whether it's swimming in one of the many rivers of the estuary, going on a bird watch, or simply dining at one of our many local restaurants, these waters provide a profound sense of place for the tens of thousands who live and visit our region every year. Our economy – from our fishermen, to recreation, to the many businesses that call our region home – relies heavily upon a vibrant and healthy estuary system.

For those of us who live, work and play in the waters of the estuary, it is imperative that we monitor, study, report and educate ourselves on the challenges facing the estuary. And, we also need to identify solutions to the challenges we face that each of us can undertake – from policymakers to businesses to citizens – to keep our estuaries in balance. That is the purpose of the State of Our Estuaries Report: to provide you with information on the relative health of our estuaries as measured by 22 indicators, and ways that you can help make our waters healthier.

Scientists often say that estuaries are some of the most complicated ecosystems in the world to study – due to the dynamic nature of tides, human activity and the mixing of fresh and salt water. Through extensive monitoring and data collection, this State of Our Estuaries Report paints a complicated and dynamic picture of our estuarine ecosystem – one that is altered by the natural forces of weather and climate, and damaged by human activity such as pollution and loss of habitat.

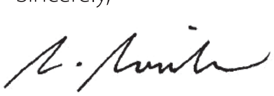
Even though our estuaries show troubling signs of decline, the news is not all bad. Through the work of many organizations, municipalities and individuals, about 90,000 acres in the estuary watershed have been permanently protected. Restoration projects have begun to rebuild lost oyster reefs, restore nearly 300 acres of saltmarsh, and re-open about 18 miles of our coastal rivers to migratory fish runs. You will read about many of these success stories in this report.

We hope that this report provides you with a sense of both hope and concern – because fundamentally, that is the story behind these dynamic estuary systems.

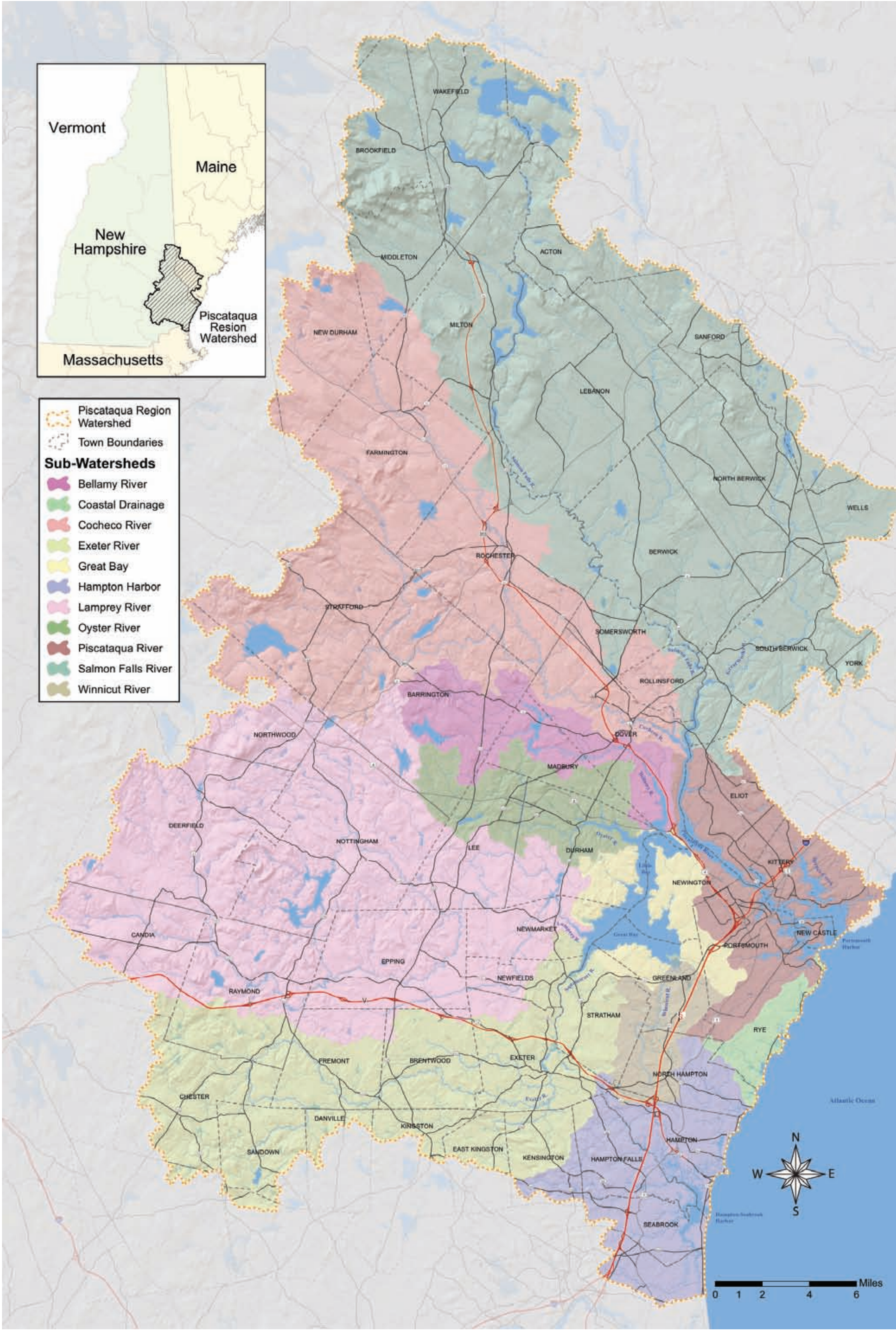
Perhaps most importantly, we have seen our communities come together to discuss the challenges facing our estuaries, and ways in which we can work together towards solutions. PREP remains committed to providing you with the information, data and research needed to make informed decisions that benefit our estuaries and the communities that rely upon them.

We hope that this report provides you with a sense of both hope and concern – because fundamentally, that is the story behind these dynamic estuary systems. But above all, we hope that this report better connects you with the place and with the community in which you live, work and play. Let's work together to improve our estuaries for today and for our future generations.

Sincerely,



Rachel Rouillard



PISCATAQUA REGION WATERSHED

Rivers flowing from 52 communities in New Hampshire and Maine converge with the waters of the Atlantic Ocean to form the Great Bay and Hampton-Seabrook estuaries. The watershed covers 1086 square miles. These bays provide critical wildlife habitat, nurseries for seafood production, buffering from coastal flooding, recreational enjoyment, and safe harbor for marine commerce. Our estuaries are part of the National Estuary Program, and recognized broadly as exceptional natural areas in need of focused study and protection.

EXECUTIVE SUMMARY OF THE STATE OF OUR ESTUARIES

We all benefit from keeping our estuaries healthy and clean. The Great Bay and Hampton-Seabrook estuaries are recognized as two premiere model systems in our nation for protection and study.

Every three years the Piscataqua Region Estuaries Partnership (PREP) produces this condition and environmental trends report in an effort to provide communities and citizens with an informed and comprehensive evaluation of what is being observed in our estuaries. This report presents our assessment of 22 key indicators of the health of our bays: 15 of which are classified as having cautionary or negative conditions or trends, while 7 show positive conditions or trends. The overall assessment shows that there is reason to be concerned about the health of our estuaries, and that increased efforts to study and restore our estuaries are needed. It also shows that there are effective efforts that can be made now to begin to reverse trends of concern.

We also recognize that the topic of nutrient levels in wastewater has become a publicly debated and contentious issue, but urge citizens and decision makers to examine all 22 indicators that together illustrate the wide-ranging challenges our system faces. While those challenges are many, this report also highlights the good work of many partners who are implementing solutions in their communities to address these environmental concerns, and perhaps most importantly, reaffirms our goals and priorities for future action.

What has been observed?

Indicators of Stresses on Our Estuaries

Our estuaries are complex and responsive to factors (stresses) both within and outside of our control. Changing climatic conditions resulting in more intense storms, polluted runoff from paved areas, human and animal waste, and excessive fertilizer application are examples of factors that can stress the ecological balance in our bays. There are two indicators that help us better understand these stresses.

- Impervious cover (paved parking lots, roadways and roofs) continued to increase throughout the region over the past three years. During rain storms and snow melt, water running over impervious areas carries pollutants which negatively impact the cleanliness of our rivers, lakes, streams and bays.
- While data has not been collected long enough to determine a long-term trend in nitrogen/nutrient loading to the Great Bay Estuary, this issue continues to be of concern. Traditional signs of nutrient-related problems such as loss of eelgrass habitat, periods of low oxygen in the water of the tidal rivers, and increases of nuisance seaweeds have been observed.

Indicators of Conditions in Our Estuaries

There are 14 indicators that help us understand more about the health and condition in the estuaries themselves. They provide a diverse picture of a number of key factors, integral to a healthy and productive system.

- Where measured in Great Bay, concentrations of the most reactive form of nitrogen, dissolved inorganic nitrogen, have increased significantly over the long term.
- Microalgae (phytoplankton) in the water have not shown a consistent long term trend in Great Bay. However, invasive and nuisance seaweed populations have increased.
- Dissolved oxygen levels in the water are at good levels in the bays and harbors, but are frequently too low in the tidal rivers with possible negative effects on marine life.

Stresses impacting the health of our estuaries are increasing, and there is reason to be concerned.

- The long term decline of eelgrass throughout most of the Great Bay Estuary is of continued concern. In spite of small increases in some areas, the total eelgrass coverage in all the bays and rivers shows a declining trend.
- Suspended sediment conditions, where measured in Great Bay, have increased over the long term which means that the water appears to be getting cloudier. Cloudy water can have adverse impacts on eelgrass, oysters, and fish.
- Bacterial contamination in Great Bay has declined substantially since 1989, but still contributes to shellfish harvest closures during rainy periods.
- The population status of oysters in the Great Bay Estuary and clams in the Hampton-Seabrook Estuary are in generally poor condition, falling well below recent historical abundances.
- Migratory fish populations exhibit cautionary trends, with high variability between years and among different rivers.
- Our region's beaches are almost always safe for swimming and the concentration of toxic chemicals in shellfish are almost all below levels deemed safe for human consumption.

Indicators of Progress on Conservation and Restoration of the Estuaries

- Gains have been made in overall land conservation, oyster bed restoration, and stream miles re-connected to the estuaries for migratory fish. However, many of the region's best natural areas are not being protected fast enough, and the results of eelgrass restoration efforts have been poor.
- Substantial progress has been made on restoring salt marshes since 2000, but there has been insufficient progress made on needed salt marsh enhancement work.

Where Do We Go From Here?

The conditions and trends documented here emphasize the need for both more research and action. In this report there are sections on emerging issues and research priorities that identify questions and target knowledge gaps in order to better inform our work over the next three to seven years. As a community of people who want to ensure a healthy environment and economy, we need to take action to:

- Expand the monitoring of our estuaries and fund additional research to address knowledge gaps.
- Protect important natural areas and waterways through land conservation and improved land use planning and development practices.
- Increase the pace and scale of restoration efforts for oysters, eelgrass, salt marsh, and migratory fish populations.
- Invest in clean water through appropriate infrastructure upgrades and reduce stormwater pollution from paved areas.

These priorities are part of the 2010 Piscataqua Region Comprehensive Conservation and Management Plan, which is a stakeholder-developed, 10-year strategy for protecting and restoring our estuaries. In addition, along with a number of public and private sector partners, PREP is building a Community for Clean Water movement to work together to make a difference. Join us at www.prep.unh.edu.

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ENVIRONMENTAL INDICATORS

END NOTES

INDICATOR TABLE

Indicator Organization

Indicators are things that we can measure to characterize the pressures on our estuaries, the conditions in our estuaries, and the steps we are taking to respond to challenges in our estuaries. This report is organized with pressure indicators first, followed by condition indicators, and ending with response indicators.

There are many, many more things that are being done to respond to challenges and to restore our estuary. Look for the "Success Stories" and "Case Studies" in the sidebars of the indicator spreads as well as in the "Citizens' Guide to the State of Our Estuaries" to learn more about what's being done and how you can help.

This list of indicators is not exhaustive and does not reflect every pressure, condition, or response that does or could exist for our estuaries. Several important indicators that are missing are harmful algal blooms, fishing pressure, and climate change. However, the list of indicators covers the major issues and provides a reasonably complete picture of the State of Our Estuaries.

Pressure Indicators

Pressure Indicators measure key human stresses on our estuaries

Condition Indicators

Condition indicators monitor the current conditions in our estuaries

Response Indicators

Response indicators track what we are doing to restore our estuaries

POSITIVE Demonstrates good or substantial progress toward the management goal.

CAUTIONARY Demonstrates moderate progress relative to the management goal.

NEGATIVE Demonstrates minimal progress relative to the management goal.

POSITIVE Demonstrates improving or generally good conditions or a positive trend.

CAUTIONARY Demonstrates a possibly deteriorating condition(s) or indicates concern given a negative trend.

NEGATIVE Demonstrates deteriorating conditions or generally poor conditions or indicates concern given a negative trend.

↑ **NEGATIVE INCREASE** Statistically significant trend over the full period of record.

↓ **NEGATIVE DECREASE** Statistically significant trend over the full period of record.

↓ **POSITIVE DECREASE** Statistically significant trend over the full period of record.

INDICATOR	STATUS	STATE OF THE INDICATOR	PAGE
PRESSURE INDICATORS: STRESSES ON THE ESTUARY			
Impervious Surfaces	↑	In 2010, 9.6% of the land area of the Piscataqua Region watershed was covered by impervious surfaces. Since 1990, the amount of impervious surfaces has increased by 120% while population has grown by 19%.	10
Nutrient Load		Total nitrogen load to the Great Bay Estuary in 2009-2011 was 1,225 tons per year. There appears to be a relationship between total nitrogen load and rainfall. Although typical nutrient-related problems have been observed, additional research is needed to determine and optimize nitrogen load reduction actions to improve conditions in the estuary.	12

INDICATOR	STATUS	STATE OF THE INDICATOR	PAGE
CONDITION INDICATORS: THE CURRENT STATE OF CONDITIONS IN THE ESTUARY			
Nutrient Concentration	↑	Between 1974 and 2011 data indicates a significant overall increasing trend for dissolved inorganic nitrogen (DIN) at Adams Point, which is of concern. When examining variability at other monitoring stations with shorter periods of data, no consistent patterns can be found. Recent data considered in the context of long-term data show no pattern or trend.	14
Microalgae		Microalgae (phytoplankton) in the water, as measured by chlorophyll-a concentrations, has not shown a consistent positive or negative trend in Great Bay between 1975-2011.	16
Macroalgae		Macroalgae, or seaweed, populations have increased, particularly nuisance algae and invasives.	16
Dissolved Oxygen (Bays)		State standards for dissolved oxygen are nearly always met in the large bays and harbors.	18
Dissolved Oxygen (Rivers)		State standards for dissolved oxygen in the tidal rivers are not met for periods lasting as long as several weeks each summer.	18
Eelgrass	↓	Data indicate a long-term decline in eelgrass since 1996 that is not related to wasting disease. Due to variability even recent gains of new eelgrass still indicate an overall declining trend.	20
Sediment Concentrations	↑	Suspended sediment concentrations at Adams Point in the Great Bay Estuary have increased significantly between 1976 and 2011.	22
Bacteria		Between 1989 and 2011, dry weather bacteria concentrations in the Great Bay Estuary have typically fallen by 50 to 92% due to pollution control efforts in most, but not in all, areas.	23
Shellfish Harvest Opportunities		Only 36% of estuarine waters are approved for shellfishing and, in these areas, periodic closures limited shellfish harvesting to only 42% of the possible acre-days in 2011. The harvest opportunities have not changed significantly in the last three years.	24
Beach Closures		Poor water quality prompted advisories extremely rarely in 2011. There are no apparent trends.	26
Toxic Contaminants	↓	The vast majority of shellfish tissue samples do not contain toxic contaminant concentrations greater than FDA guidance values. The concentrations of contaminants are mostly declining or not changing.	28
Oysters		The number of adult oysters decreased from over 25 million in 1993 to 1.2 million in 2000. The population has increased slowly since 2000 to 2.2 million adult oysters in 2011 (22% of goal).	30
Clams		The number of clams in Hampton-Seabrook Harbor is 43% of the recent historical average. Large spat or seed sets may indicate increasing populations in the future.	32
Migratory Fish		Migratory river herring returns to the Great Bay Estuary generally increased during the 1970-1992 period, remained relatively stable in 1993-2004, and then decreased in recent years.	34

INDICATOR	STATUS	STATE OF THE INDICATOR	PAGE
RESPONSE INDICATORS: WHAT WE'RE DOING TO RESTORE THE ESTUARY			
Salt Marsh Restoration		280.5 acres of salt marsh have been restored since 2000, and 30.6 acres of salt marsh have been enhanced since 2009, which is moderate overall progress towards PREP's goals.	35
Conservation Lands (General)		At the end of 2011, 88,747 acres in the Piscataqua Region watershed were conserved which amounted to 13.5% of the land area. At this pace, the goal of conserving 20% of the watershed by 2020 is likely to be reached.	36
Conservation Lands (Priority)		In 2011, 28% of the core priority areas in New Hampshire and Maine were conserved. At this pace, the goal of conserving 75% of these lands by 2025 is unlikely to be reached.	38
Oyster Restoration		A total of 12.3 acres of oyster beds have been created in the Great Bay Estuary, which is 61% of the goal. Mortality due to oyster diseases is a major impediment to oyster restoration.	40
Eelgrass Restoration		A total of 8.5 acres of eelgrass beds have been restored which is only 17% of the goal. Poor water quality is often the limiting factor for eelgrass transplant survival.	41
Migratory Fish Restoration		River herring access has been restored to 42% of their historical distribution within the mainstems of the major rivers in the Piscataqua Region. This represents substantial progress in meeting PREP's goal of restoring 50% of the historical distribution of river herring by 2020.	42

INDICATOR SUMMARY

There are 16 environmental indicators and 6 management indicators presented in this report:

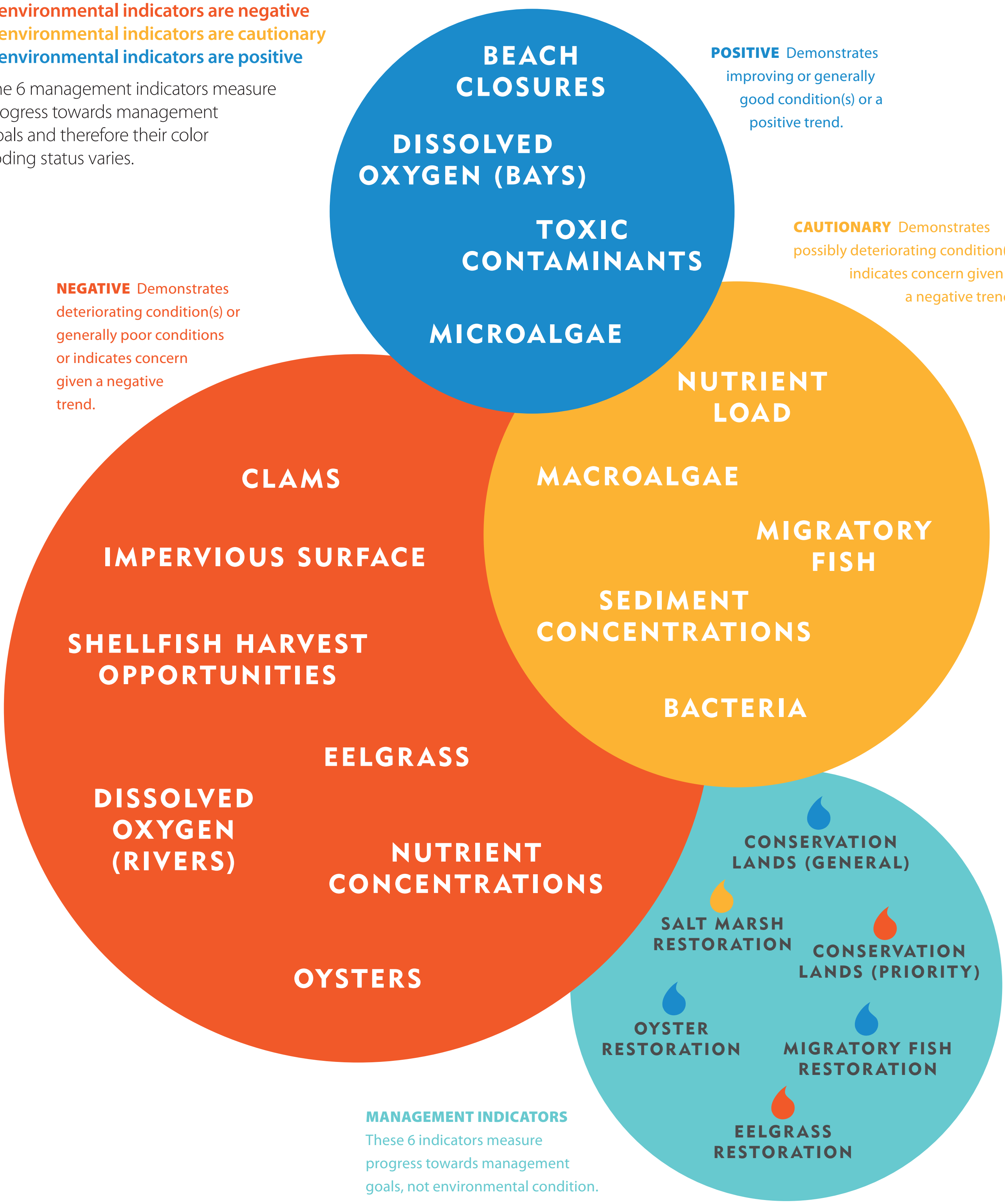
7 environmental indicators are negative
5 environmental indicators are cautionary
4 environmental indicators are positive

The 6 management indicators measure progress towards management goals and therefore their color coding status varies.

POSITIVE Demonstrates improving or generally good condition(s) or a positive trend.

CAUTIONARY Demonstrates possibly deteriorating condition(s) or indicates concern given a negative trend.

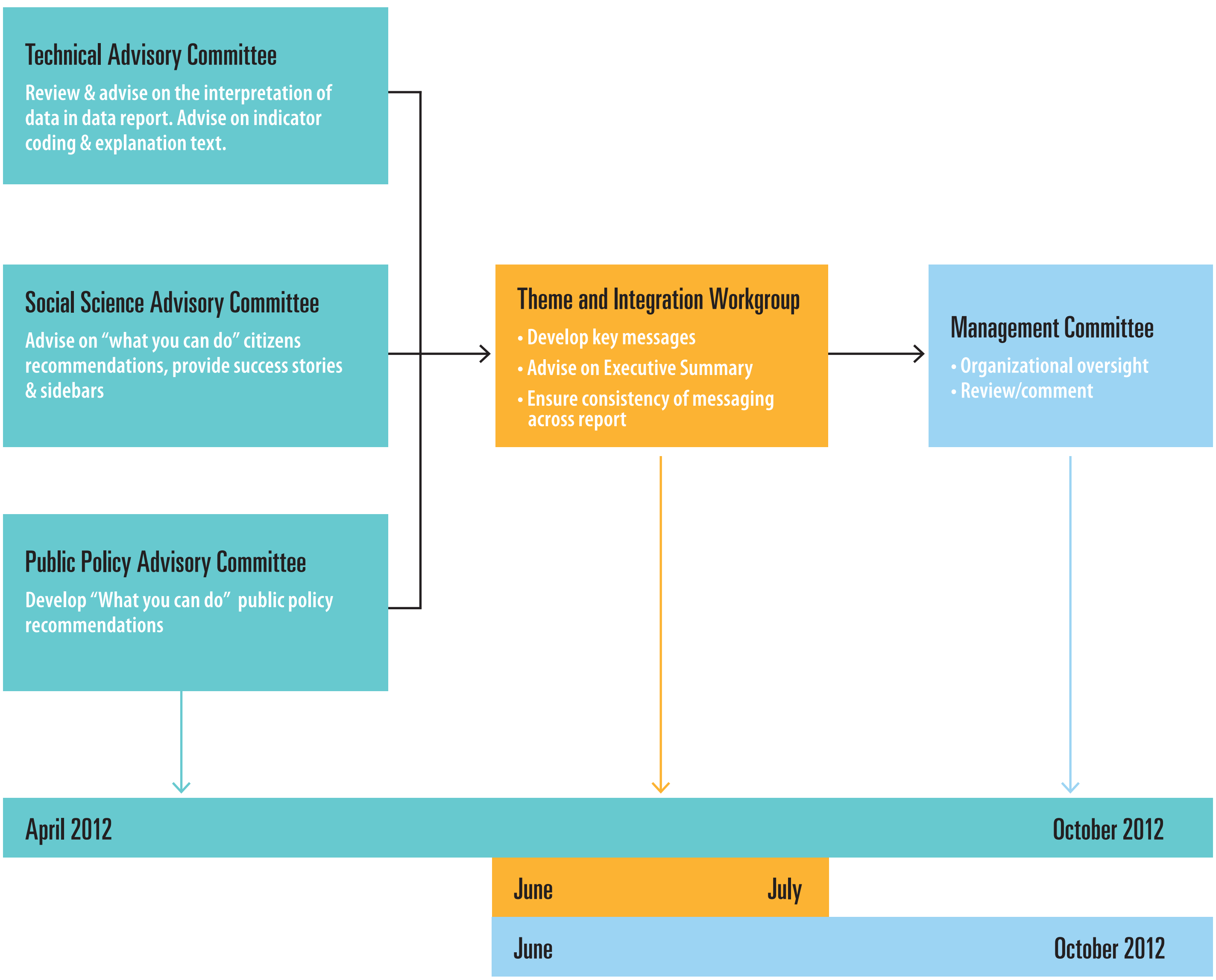
NEGATIVE Demonstrates deteriorating condition(s) or generally poor conditions or indicates concern given a negative trend.



MANAGEMENT INDICATORS These 6 indicators measure progress towards management goals, not environmental condition.

REPORT DEVELOPMENT PROCESS

This 2013 State of Our Estuaries report was developed somewhat differently than in previous years. Given the recent environmental and social changes in our watershed, it was important to construct a new, stakeholder driven process to inform the development of the report. As a science-based, stakeholder-driven organization, PREP maintained its Technical Advisory Committee (TAC) with the core function of reviewing and interpreting the data used in this report. The TAC is comprised of 24 independent scientists; 13 from University of New Hampshire and other partner groups including the US Environmental Protection Agency, The National Oceanic and Atmospheric Administration, NH Department of Environmental Services, The Nature Conservancy, NH Fish and Game Department, United States Geological Survey, Northeastern Regional Assoc. of Coastal & Ocean Observing Systems, Great Bay National Estuarine Research Reserve, and US Fish and Wildlife Service. In addition, PREP convened three other stakeholder groups to provide input during the process, as noted below. The purpose of these groups was to increase the diversity of feedback and perspectives from municipal, state, private, regional, public policy, and social science leaders and practitioners. A full listing of those who participated is noted on page 46 of this report in acknowledgement and appreciation of their dedication and efforts in helping to develop a comprehensive report that can be used by many as a resource over the next three years.



Impervious Surfaces

How much of the Piscataqua Region is currently covered by impervious surfaces and how has it changed over time?

Rain into a stormdrain in Portsmouth. Photo by D. Kellam

In 2010, 9.6% of the land area of the Piscataqua Region watershed was covered by impervious surfaces. Since 1990, the amount of impervious surfaces has increased by 120% while population has grown by 19%.

EXPLANATION The amount of impervious surface covering our land has grown from 28,695 acres in 1990 to 63,241 acres in 2010. On a percentage basis, 9.6% of the land in the watershed was covered by impervious surfaces in 2010 (Figure 1.1).

The impervious surfaces were not evenly spread out across the watershed. The percent of impervious surfaces in each of the Piscataqua Region subwatersheds in 2010 is shown in Figure 1.2. The watersheds with greater than 10 percent impervious surfaces are along the Atlantic Coast, Exeter River watershed and up the Route 16 corridor along the Cocheco River. The highest percent impervious values of 35 to 40 percent were found in the Portsmouth-New Castle area. Town-by-town information on impervious surfaces in 2010 is shown in Figure 1.3.

Between 1990 and 2005, impervious surfaces were added at an average rate of 1,441 acres per year. Between 2005 and 2010, the rate of new impervious surfaces nearly doubled to 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 between 1990 and 2010.

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.

Why This Matters

Impervious surfaces are paved parking lots, roadways, and roofs. During rain storms and snow melt, water running off of impervious surfaces carries pollutants and sediments into streams, rivers, lakes and estuaries. To keep waters clean, impervious surfaces should be a low percentage of the total amount of land area of the watershed basin.

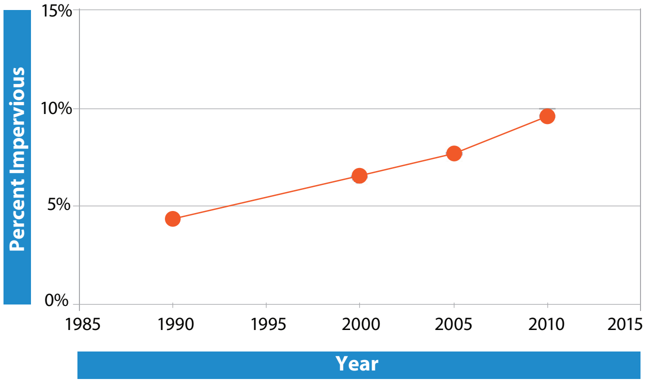
PREP GOAL No increases in the number of watersheds and towns with >10% impervious cover and no decreases in the number of watersheds and towns with <5% impervious cover.

Success Story

The Hodgson Brook Restoration Project in Portsmouth has worked to install over 7 residential rain gardens in neighborhoods across the city. Rain gardens help to soak up the rain and snow melt from impervious surfaces and let it seep into the ground where pollutants can be filtered out through the soil.

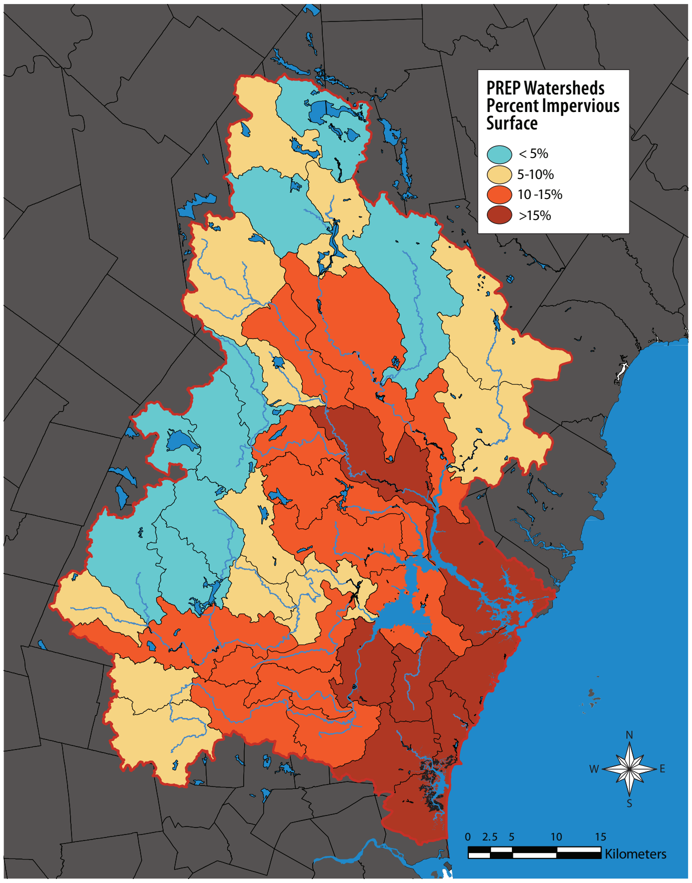
Residential rain garden. Photo by PREP

FIGURE 1.1 Percent of land area covered by impervious surfaces in the Piscataqua Region watershed, 1990-2010



Data Source: UNH Complex Systems Research Center

FIGURE 1.2 Impervious surface cover in Piscataqua Region subwatersheds



Data Source: UNH Complex Systems Research Center

FIGURE 1.3 Percent of land area covered by impervious surfaces for coastal municipalities, 1990-2010

		Percent Imperviousness (%)			
Town	Land Area (Acres)	1990	2000	2005	2010
Barrington, NH	29,718	2.6	4	4.7	6.3
Brentwood, NH	10,738	5	7.7	9.5	12.2
Brookfield, NH	14,593	1	1.3	1.4	1.8
Candia, NH	19,340	2.7	4.1	4.8	6.4
Chester, NH	16,618	2.5	4.3	5.1	6.8
Danville, NH	7,439	3.5	6	7.2	9.5
Deerfield, NH	32,584	1.5	2.4	3	4
Dover, NH	17,033	11	15.4	18.7	22.7
Durham, NH	14,252	4.7	7.2	7.7	9.9
East Kingston, NH	6,318	3.5	5.3	6.9	8.9
Epping, NH	16,465	4	6.5	7.8	10.3
Exeter, NH	12,549	7.5	10.9	12.4	15.6
Farmington, NH	23,218	3	4.2	4.7	6.1
Fremont, NH	11,035	3	4.9	6	7.9
Greenland, NH	6,722	6.7	10.5	12.5	15.7
Hampton, NH	8,017	14.7	20.1	21.5	25.6
Hampton Falls, NH	7,519	4.5	7.1	9.3	12
Kensington, NH	7,636	3.2	5	6.2	7.8
Kingston, NH	12,494	5.2	8.2	9.7	12.5
Lee, NH	12,686	3.7	5.8	6.6	8.8
Madbury, NH	7,399	3.4	5.3	5.3	7.2
Middleton, NH	11,559	1.8	2.5	3	4.1
Milton, NH	21,089	2.8	4	4.7	6.2
New Castle, NH	506	21.4	30.6	33.8	41
New Durham, NH	26,345	1.7	2.4	2.8	3.8
Newfields, NH	4,541	3.1	5.5	6.8	8.6
Newington, NH	5,216	13	17.9	20.1	23.8
Newmarket, NH	7,939	6	8.9	10.3	12.7
No. Hampton, NH	8,862	7.3	10.8	12.4	15.4
Northwood, NH	17,973	2.4	3.4	4	5.4
Nottingham, NH	29,874	1.5	2.3	2.8	3.8
Portsmouth, NH	10,002	21.4	27.3	30.6	35.1
Raymond, NH	18,439	5.3	8	9.3	11.8
Rochester, NH	28,322	8.5	11.7	13.9	17.4
Rollinsford, NH	4,681	5.7	8.2	9.3	11.9
Rye, NH	7,997	7.2	10.9	12.7	15.5
Sandown, NH	8,888	3.8	6.1	7.9	10.5
Seabrook, NH	5,215	15.4	23.1	29.5	34.7
Somersworth, NH	6,219	12.3	16.4	20.1	24.4
Strafford, NH	31,151	1.4	2	2.3	3.2
Stratham, NH	9,657	6.5	10.1	12.9	16.2
Wakefield, NH	25,264	3.5	4.8	5.6	7.4
Acton, ME	24,120	1.6	2.5	2.9	3.8
Berwick, ME	23,786	2.6	4.4	5.5	6.8
Eliot, ME	12,610	4.1	7.4	9.2	11.3
Kittery, ME	11,308	8.1	11.9	13.9	16.4
Lebanon, ME	35,055	1.8	3	3.7	4.7
North Berwick, ME	24,265	2.2	3.5	4.2	5.2
Sanford, ME	30,315	5.9	9.1	10.1	11.8
South Berwick, ME	20,469	2.4	3.9	4.7	5.9
Wells, ME	36,749	3.7	6	7.4	8.8
York, ME	34,908	4.3	7.1	8.3	9.9

Data Source: UNH Complex Systems Research Center

Nutrient Load

How much nitrogen is coming into the Great Bay Estuary and have nutrient-related problems been observed?

Sagamore Creek Panne, Portsmouth. Photo by D. Kellam

Total nitrogen load to the Great Bay Estuary in 2009-2011 was 1,225 tons per year. There appears to be a relationship between total nitrogen load and rainfall. Although typical nutrient-related problems have been observed, additional research is needed to determine and optimize nitrogen load reduction actions to improve conditions in the estuary.

EXPLANATION The load of all forms of nitrogen into the Great Bay Estuary in 2009-2011 was 1,225 tons per year (Figure 2.1). Nitrogen loads to the bay tend to be higher in years with more rainfall. Since 2003, when nitrogen loads began to be measured, the total nitrogen load to the bay was highest in 2005-2006. The increase appeared to be driven by higher amounts of nitrogen carried into the bay by rain runoff and river flow during years with heavy rainfall, especially 2005 and 2006 (Figure 2.2). In more recent years load has decreased, which again may be related to drier years with less rainfall. It is due to these fluctuations in data that no long or short term trends can be determined.

One important component of nitrogen needing consideration is the most reactive type called dissolved inorganic nitrogen (DIN). This type is known to cause faster plant and algae growth than other forms of nitrogen. Between 2009-2011, 597 of the 1,225 tons of nitrogen entering the bay was DIN.

Nitrogen enters the bay primarily in two ways. First, nitrogen from fertilizers from lawns and farms, septic systems, animal wastes, and air pollution from the whole watershed is carried into the bay through rain and snowmelt runoff, river flow, and groundwater flow. These sources account for 68% of the nitrogen entering our system (Figure 2.1). Second, there are 18 municipal sewer treatment plants that discharge treated wastewater out through pipes either into the bay or into rivers that flow into the bay. Wastewater discharges are concentrated sources of nitrogen, primarily in the reactive DIN form (Figure 2.1).

Regardless of the particular sources, the major contributors of nitrogen to the bay are related to population growth and associated building and development patterns. The PREP goal is to reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur. At this time the Great Bay Estuary exhibits many of the classic symptoms of too much nitrogen: low dissolved oxygen in tidal rivers, increased macroalgae growth, and declining eelgrass. Although the specific causal links between nitrogen load and these concerning symptoms have not yet been fully determined for Great Bay, global, national and local trends all point to the need to reduce nitrogen loads to the estuary.[3] Additional data collection and research is critical to a better understanding of these links and where the most effective reductions can be targeted.

Why This Matters

Nitrogen is a nutrient that is essential to life in the estuaries. However, scientific understanding of estuaries is that high levels of nitrogen may cause problems like the excessive growth of plants and algae.[1] When the plants die, oxygen needed by fish is pulled out of the water and can cause fish to suffocate. The rapid plant growth can also shade or smother underwater eelgrass meadows and other important habitats, limiting important functions such as providing food and shelter and cleaning the water. Excess nitrogen is a problem across the US and around the world.[2]

PREP GOAL **Reduce nutrient loads to the estuaries and the ocean so that adverse, nutrient-related effects do not occur.**

FIGURE 2.1 Nitrogen loads to the Great Bay Estuary from different sources, 2009-2011

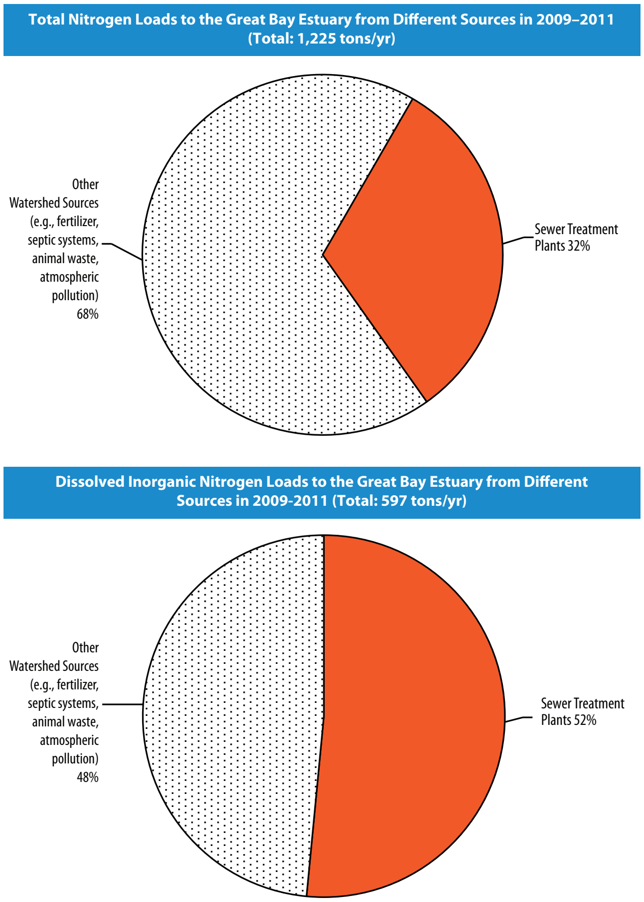


FIGURE 2.2 Trends in nitrogen loads and precipitation, 2003-2011

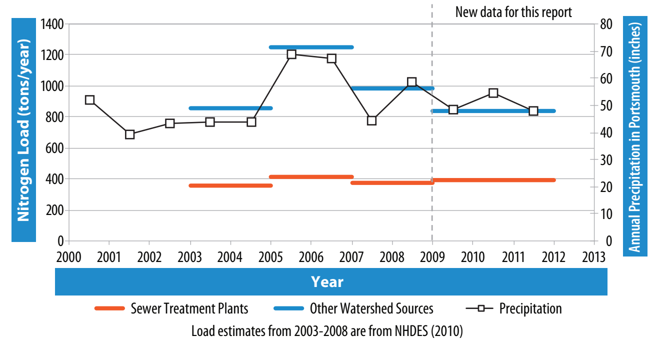
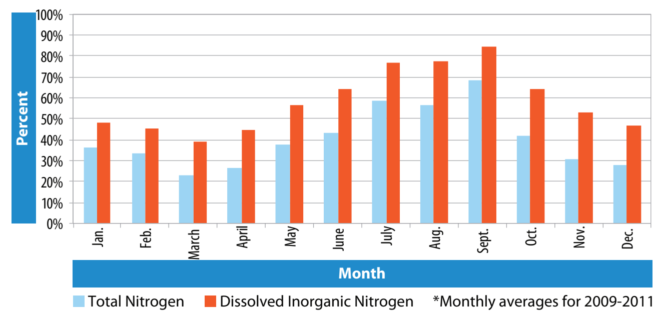


FIGURE 2.3 Percent of nitrogen load to the Great Bay Estuary from sewer treatment plants by month



The percent of the nitrogen load to the estuary from sewer treatment plants varies month-to-month over the course of the year. Sewer treatment plants contribute the majority of the nitrogen load during the warmer months when algae growth typically occurs.

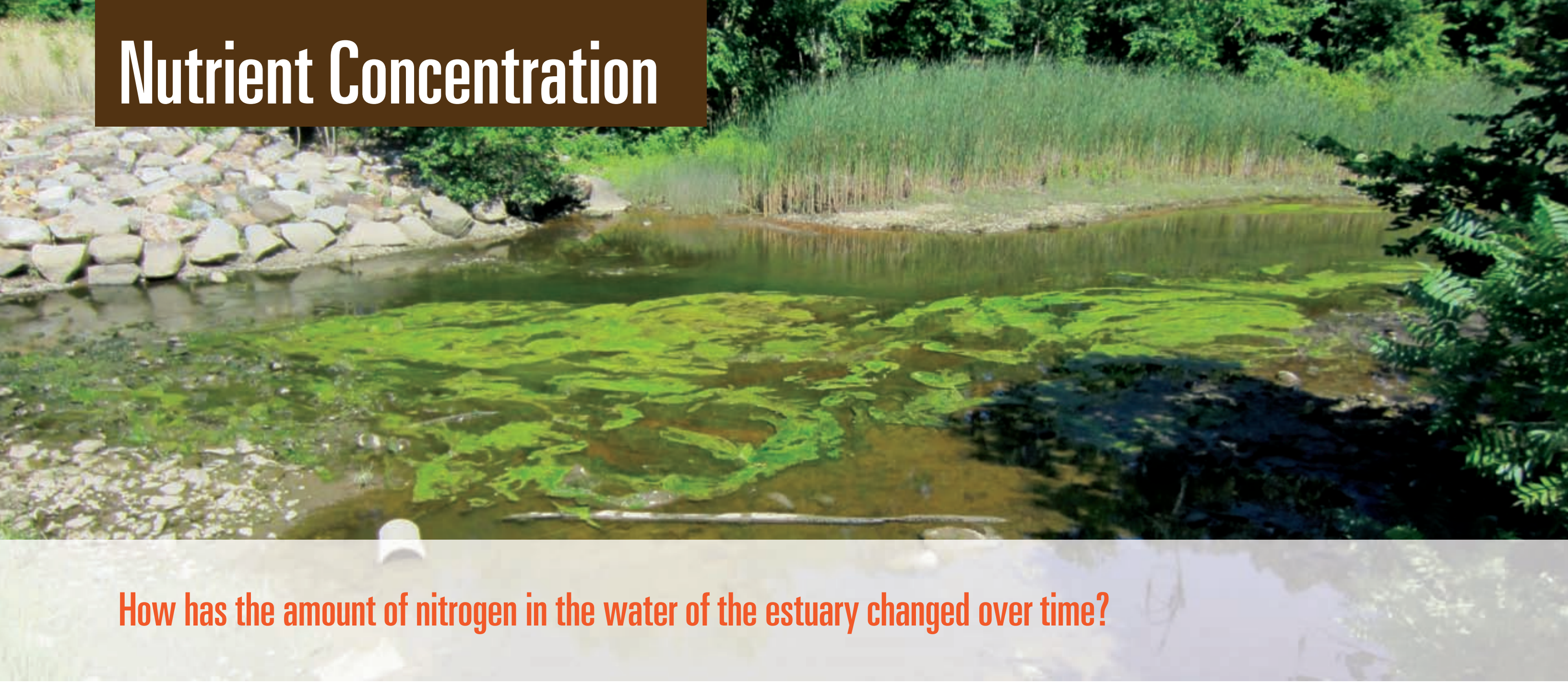
Success Story

York's Lawns to Lobsters

The Town of York, Maine has created a public education effort focused on environmentally sound lawn care practices focused on having a beautiful lawn without harming the rivers or the ocean from increased nutrients or pesticides. The program has spread around the coast of Maine and is now being adopted by the town of New Castle as well. The program has 10 tips every homeowner can practice visit www.lawns2lobsters.org to learn more.

Photo by PREP

Nutrient Concentration



How has the amount of nitrogen in the water of the estuary changed over time?

Algae growth in the Winnicut River below the fish ladder, Greenland, NH. Photo by S. Demers

Between 1974 and 2011 data indicates a significant overall increasing trend for dissolved inorganic nitrogen (DIN) at Adams Point, which is of concern. When examining variability at other monitoring stations with shorter periods of data, no consistent patterns can be found. Recent data considered in the context of long-term data show no pattern or trend.

EXPLANATION Total nitrogen measures all of the nitrogen in the water, both the nitrogen dissolved in the water and the nitrogen in floating algae. Total nitrogen concentrations in Great Bay have been monitored since 2003, but have not shown any consistent trends (Figure 3.1). The average concentration of total nitrogen in Great Bay in 2009-2011 was 0.38 mg/L.

Photo by PREP

However, as previously noted in this report, there is concern for the implications of dissolved inorganic nitrogen (DIN) as it is the most reactive form of nitrogen in the system. The long-term trend for all of the data collected between 1974 and 2011 shows an average increase of 68% for DIN (Figure 3.2). The DIN concentrations in the last three years fell below the average trend line to 0.116 mg/L. These levels are comparable to the DIN concentrations that were measured for some of the years in the 1970s.

The apparent conflict between the long-term increasing trend for DIN at Adams Point and recent overall low concentrations for DIN may be explained by the fact that DIN is highly variable. It is rapidly taken up into plants and removed from the water or converted to other forms of nitrogen. Total nitrogen concentrations are a better measure of overall nitrogen availability in the estuary.

In other areas of the estuary besides Great Bay, some trends for total nitrogen and other forms of nitrogen have been observed. Increasing trends for total nitrogen and total dissolved nitrogen were apparent in the Squamscott River, while decreasing trends for DIN were observed in the Oyster River.

The variety of results highlights the complexity of nitrogen cycling in the estuary. More data and study is needed to better understand these relationships.

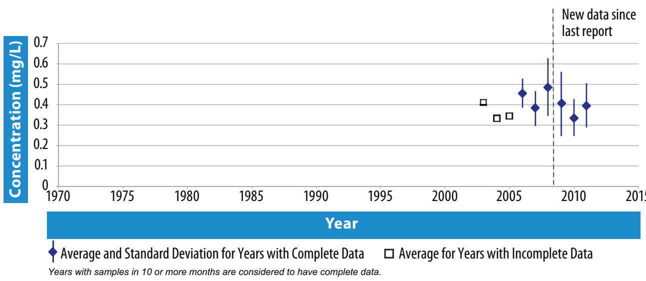
Why This Matters

Nitrogen is an essential nutrient to life in the estuaries. However, scientific understanding of estuaries is that high levels of nitrogen may cause problems from the excessive growth of plants and algae. The amount of nitrogen present in the water (the nitrogen "concentration") is an important indicator of nutrient availability for plants and algae[1] growth in the estuary. However, because nitrogen is rapidly removed from the water by plants, the nitrogen concentration in the water does not always reflect the amount of nitrogen that has been loaded into the estuary.

PREP GOAL **No increasing trends for any nitrogen or phosphorus species.**

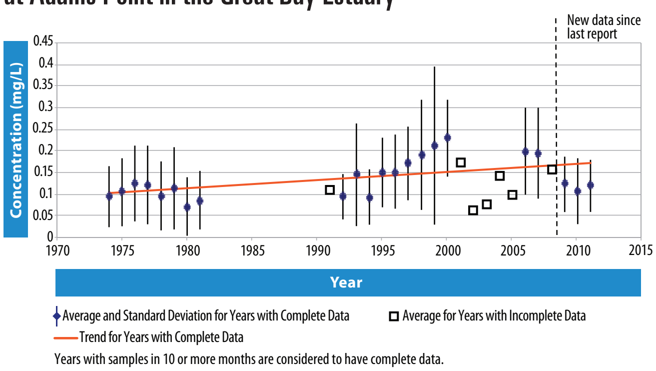
The long-term trend for all of the data collected between 1974 and 2011 shows an average nutrient concentration increase of 68%.

FIGURE 3.1 Total nitrogen concentration trends at Adams Point in the Great Bay Estuary

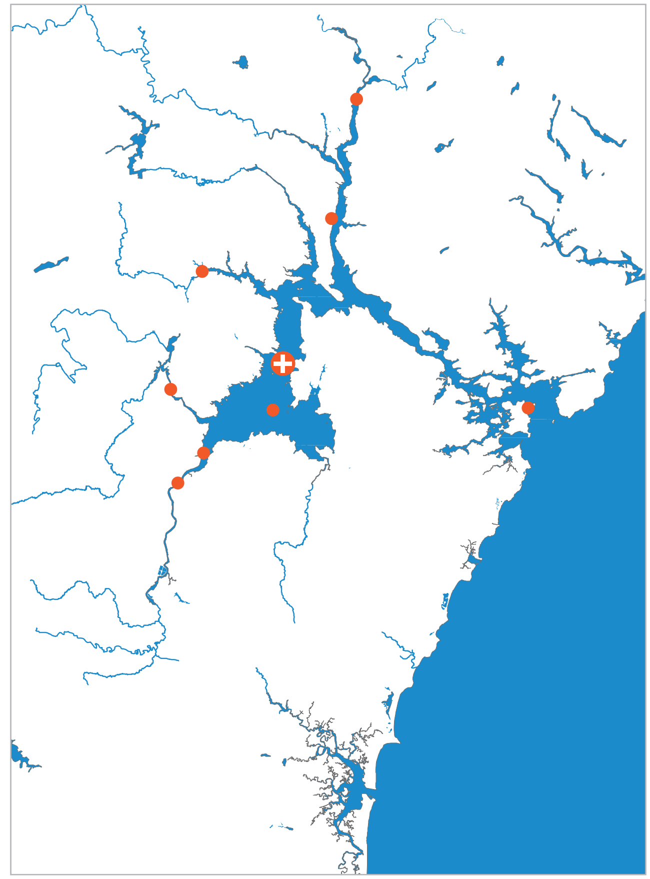


Data Source: UNH Jackson Estuarine Laboratory

FIGURE 3.2 Dissolved inorganic nitrogen concentration trends at Adams Point in the Great Bay Estuary



Data Source: UNH Jackson Estuarine Laboratory

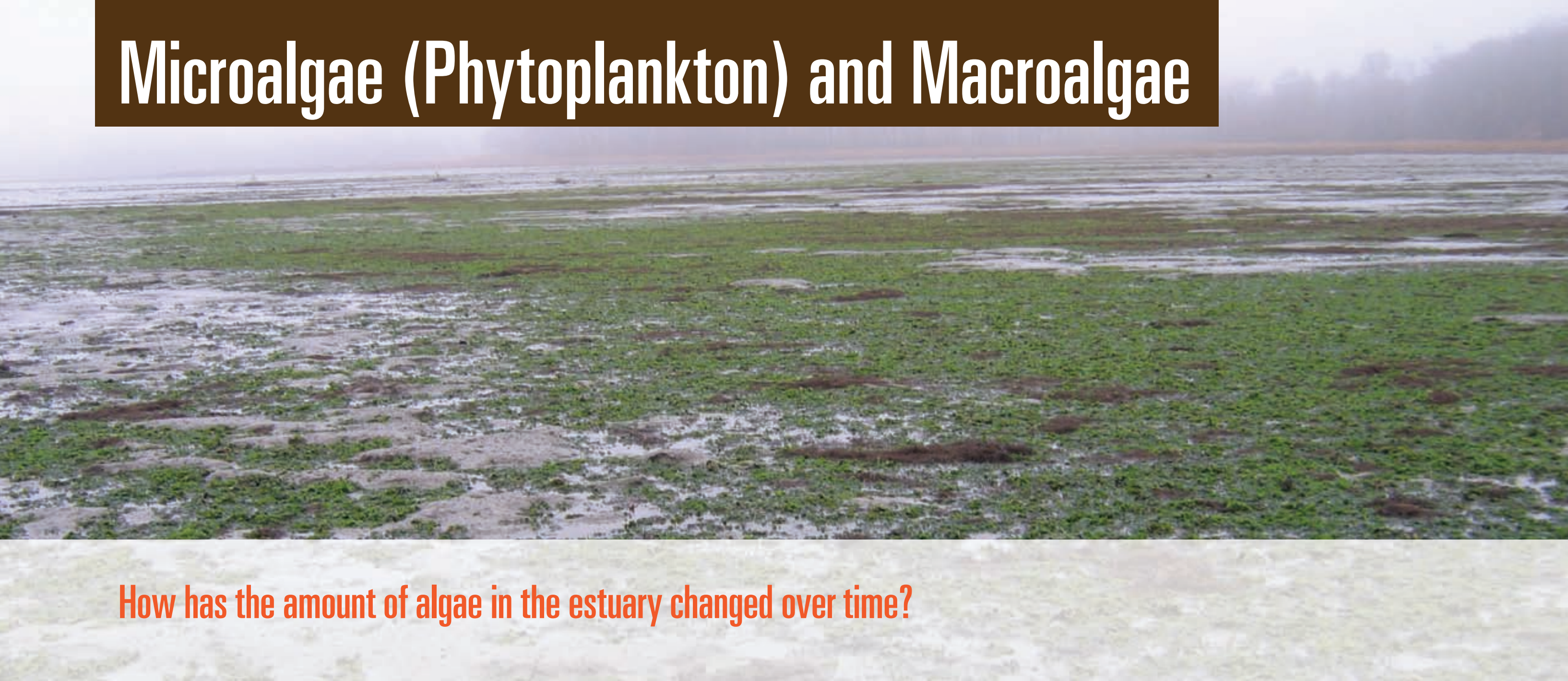


Monitoring location for Fig. 3.1 & 3.2 is marked by a red circle with a white plus sign. Other red dots indicate additional water quality monitoring locations.

Flooding in Newmarket, NH. Photo by PREP

Climatic trends, including extreme rain and snow events, can affect the delivery of nitrogen loads to our estuaries. The highest nitrogen loads calculated for the Great Bay Estuary appear to correlate with years of high annual precipitation (Figure 2.2). It appears that more nitrogen is "flushed" from the landscape during wet periods. New England is experiencing more frequent higher intensity rain storms, and this trend is anticipated to continue. Therefore additional research on how climate and weather affect the amount and timing of nitrogen delivery to the estuary is needed.

Microalgae (Phytoplankton) and Macroalgae



How has the amount of algae in the estuary changed over time?

Ulva Lactuca in Great Bay off of Portsmouth Country Club, Greenland,NH. Photo by J. Nettleton

Microalgae (phytoplankton) in the water, as measured by chlorophyll-a concentrations, has not shown a consistent positive or negative trend in Great Bay between 1975-2011.

Macroalgae, or seaweed, populations have increased, particularly nuisance algae and invasives.

EXPLANATION This is a new indicator for this year's report because of its known relationship to nutrients and the role algae plays in an estuarine system. Plant growth can take many forms in estuaries. There can be microscopic plants, called phytoplankton, that float in the water. The amount of chlorophyll-a present in the water is a measure of these microscopic plants. In addition, there can be larger rooted and un-rooted seaweeds, called macroalgae, that grow in the estuary. Of particular concern are certain types of nuisance macroalgae that grow quickly in high nutrient environments and crowd out or smother the slower growing eelgrass populations.[5]

Measurements of chlorophyll-a in the water in Great Bay since 1975 have not shown any consistent long-term trends, nor were there any short term changes in the last three years (Figure 4.1). Blooms of microscopic plants are episodic and variable in size depending on factors such as weather. As a result, it can be difficult to detect trends in chlorophyll-a based on a monthly monitoring program which is how monitoring is currently conducted.

For nuisance macroalgae, there is evidence that populations have increased. Baseline measurements of some macroalgae species at some locations were made by UNH researchers between 1972 and 1980.[7] In 2008-2010, these field studies were repeated using the same methods to document changes in populations.[7] 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."[8] For example, at a site in Lubberland Creek in the Great Bay, the mean percent cover of a common macroalgae, *Ulva lactuca,* had increased from 0.8% of the area covered in 1979-1980 to 39% of the area covered in 2008-2010. (Figure 4.2) Increases in macroalgae cover of up to 90% have been measured at some sites in the Great Bay Estuary on some dates. In 2007, another UNH field study[9] 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 4.3) and occupying areas formerly covered with eelgrass. Due to the variable nature of algae, more data collection and study is needed to gain a better understanding of the extent and causes of these increases.

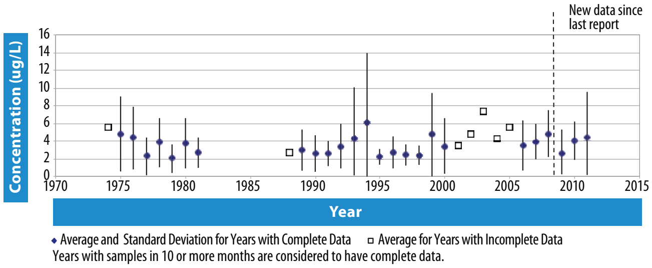
Why This Matters

Increasing nitrogen inputs to estuaries can stimulate plant growth. Excessive algae growth in the water and on the bottom can make the water cloudy, deplete dissolved oxygen in the water, or can entangle, smother and cause the death of important eelgrass habitat.[4]

PREP GOAL **No increasing trends for algae.**

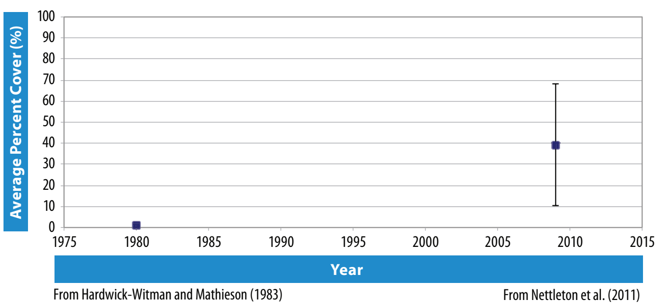
Nuisance macroalgae can grow quickly in high nutrient environments and crowd out the slower growing eelgrass populations.

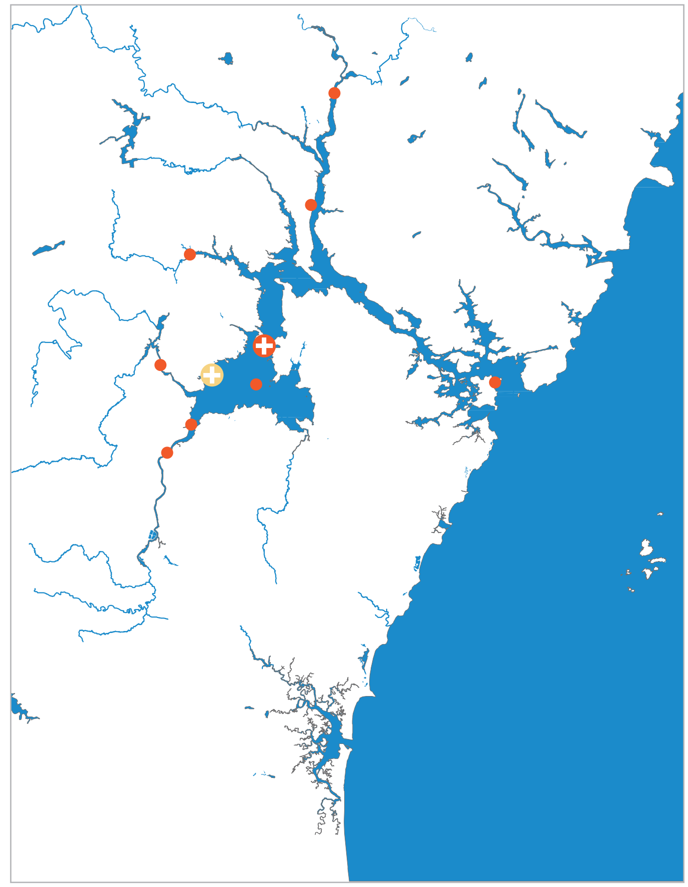
FIGURE 4.1 Chlorophyll-a trends at Adams Point in the Great Bay Estuary



Data Source: UNH Jackson Estuarine Laboratory

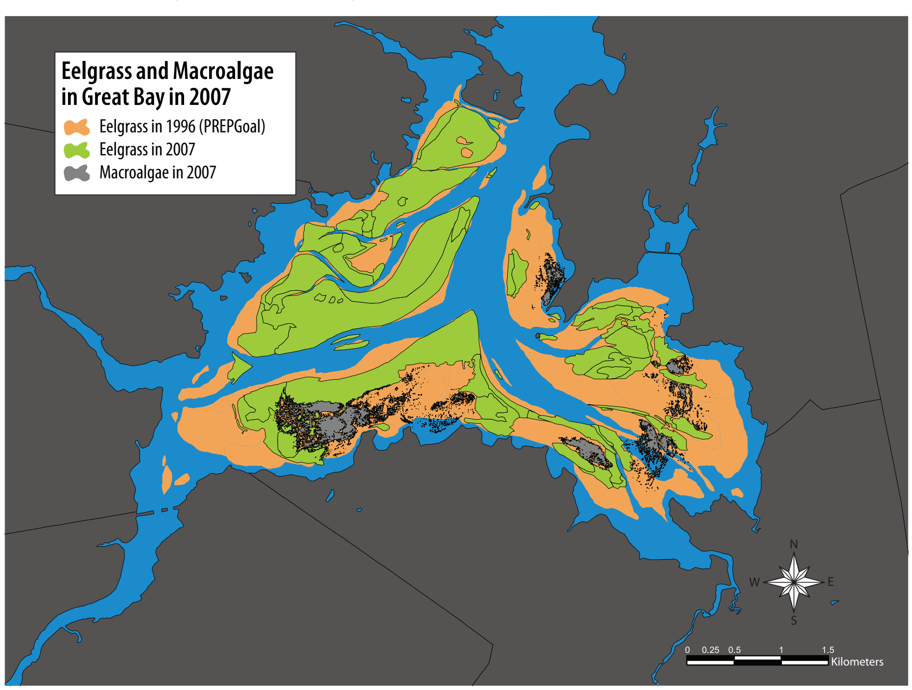
FIGURE 4.2 Macroalgae percent cover at the Lubberland Creek site in Great Bay in 1979-1980 and 2008-2010



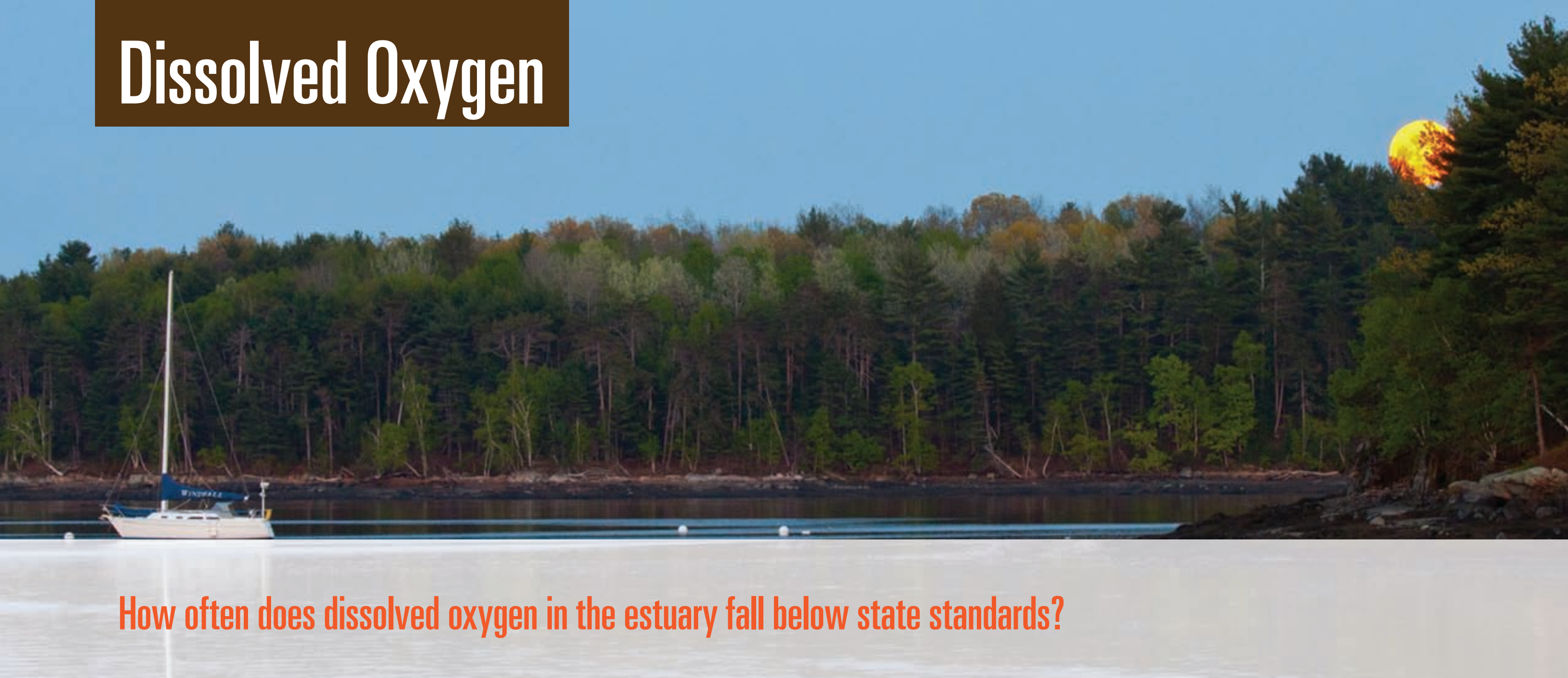


Monitoring location for Fig. 4.1 is marked by a red circle with a white plus sign. Monitoring location for Fig. 4.2 is marked by a yellow circle with a white plus sign. Other red dots indicate water quality monitoring locations.

FIGURE 4.3 Eelgrass and macroalgae in Great Bay in 2007



Data Source: Eelgrass data provided by UNH Seagrass Ecology Laboratory Macroalgae data from Pe'eri et al. (2008)



Dissolved Oxygen

How often does dissolved oxygen in the estuary fall below state standards?

Moon over Great Bay. Photo by C. Keeley

State standards for dissolved oxygen are nearly always met in the large bays and harbors.
State standards for dissolved oxygen in the tidal rivers are not met for periods lasting as long as several weeks each summer.

EXPLANATION The most accurate measurements of dissolved oxygen (DO) are made using datasonde instruments (see figure 5.1) that are installed in the water to collect measurements every 15 minutes. The six locations where datasondes are deployed are shown on Figure 5.2. The figure also contains charts summarizing the number of days in the summer when the DO fell below the water quality standard (5 mg/L) at each station (Figure 5.3).

The dissolved oxygen concentrations in Great Bay in the summer have never been measured below 5 mg/L. In Portsmouth Harbor there has been only one day with dissolved oxygen less than 5 mg/L (in 2010). Based on these data, the well mixed areas of Great Bay and Portsmouth Harbor typically meet the water quality standard for DO.

In contrast, there have been persistent and numerous violations of the dissolved oxygen standards at stations in the tidal rivers that flow into the estuaries. The number of summer days with violations varied over time at the stations. 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 negative effects in areas where the state standard is not attained.

The most exceedences and the lowest dissolved oxygen concentrations have been observed in the tidal rivers, particularly the Lamprey River. UNH 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.[12]

Similarly, the Great Bay Municipal Coalition hired HydroQual to conduct a study of dissolved oxygen in the Squamscott River in 2011.[13] The study confirmed that dissolved oxygen concentrations in the river periodically exceeded the state standard and that algae discharged in the wastewater from the Exeter sewer treatment plant was a factor affecting dissolved oxygen levels. Overall, the relationship between nutrients, dissolved oxygen and algae growth is a complex one and more data/study is needed to specifically understand those linkages in our system.

Why This Matters

Low dissolved oxygen (DO) concentrations in bays are a common impact of excessive nitrogen in estuaries.[10] Fish and many other aquatic organisms need dissolved oxygen in the water to survive. Prolonged periods of low dissolved oxygen are harmful or lethal to aquatic life.[11] There are state water quality standards for dissolved oxygen to protect against these effects. Other factors besides nutrients may cause or contribute to periods of low DO.

PREP GOAL **Zero days with exceedences of the state water quality standard for dissolved oxygen.**

FIGURE 5.1 Datasonde buoy deployed in Great Bay

The most exceedences and the lowest dissolved oxygen concentrations have been observed in the tidal rivers, particularly the Lamprey River.

FIGURE 5.2 Locations of Datasondes in the Piscataqua Region Estuaries

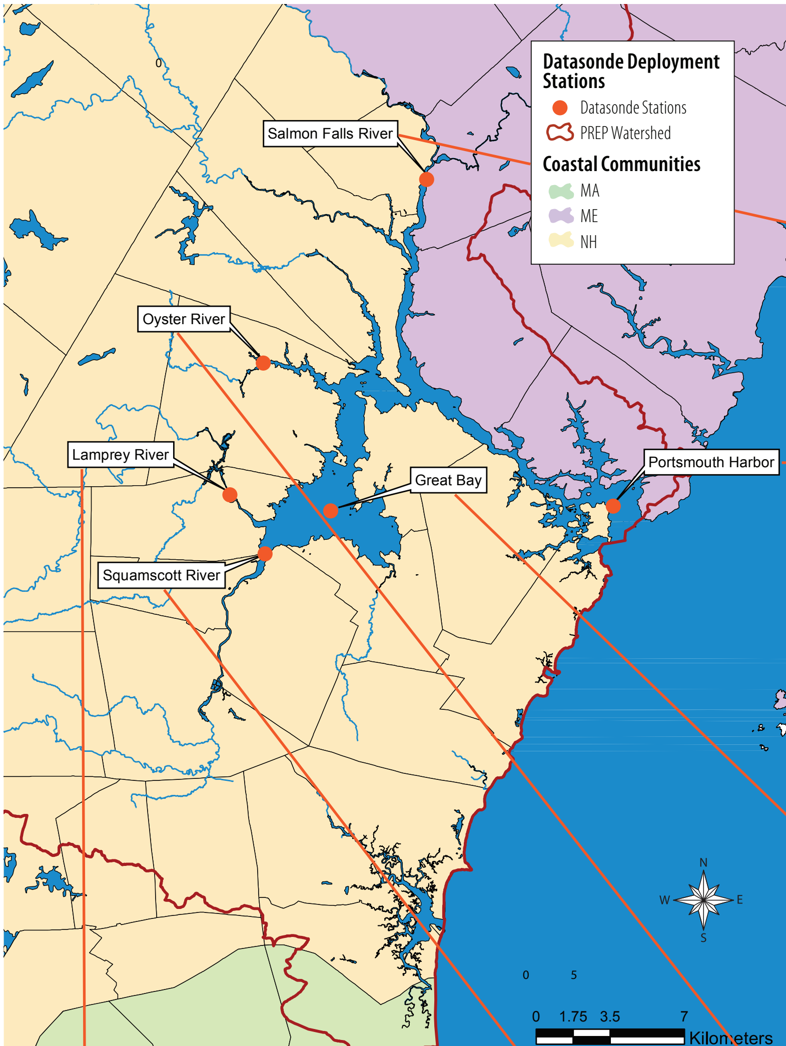
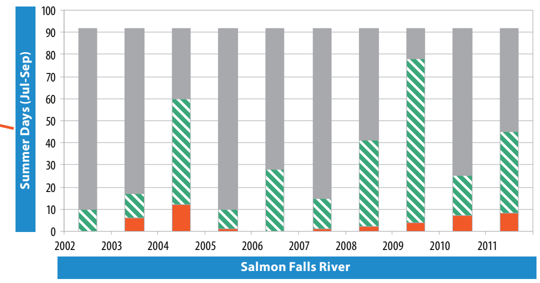
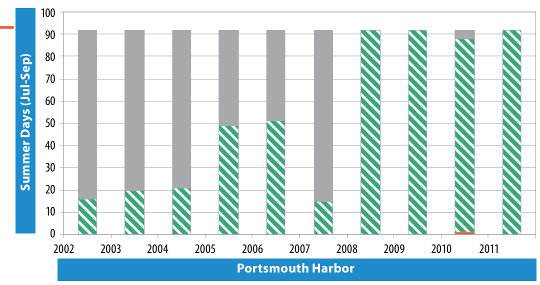
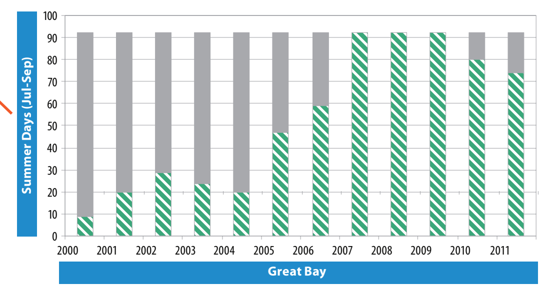
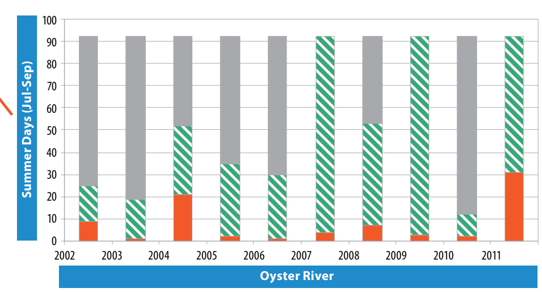


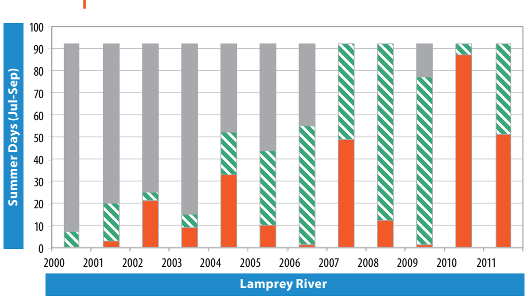
FIGURE 5.3 Number of days during summer months of each year when datasondes measured violations of state standards for dissolved oxygen (less than 5 mg/L)

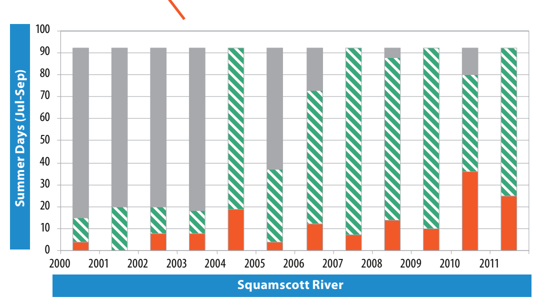












No Data   No Violations   Violations

Data Source: UNH Jackson Estuarine Laboratory

Eelgrass

How much eelgrass habitat is in the Great Bay Estuary and how has it changed over time?

Eelgrass on the bottom of Little Bay. Photo by J. Carroll

Data indicate a long-term decline in eelgrass since 1996 that is not related to wasting disease. Due to variability even recent gains of new eelgrass still indicate an overall declining trend.

EXPLANATION The total eelgrass cover in the entire Great Bay Estuary for years with complete data is plotted in Figure 6.1. 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 acreage 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. There are also indications, based on estimates of the density of the eelgrass beds, that the remaining beds contain fewer plants and, therefore, provide less habitat.

The majority of the eelgrass in the estuary is in the Great Bay itself. Eelgrass in this important area has been mapped each year. The data show that, since 1990, there has been a statistically significant, 38% decline of eelgrass in Great Bay (Figure 6.2). Statistically significant declines of eelgrass have also been observed in other sections of the estuary: the Winnicut River, Little Harbor, Portsmouth Harbor, and the Piscataqua River. However, the total amount of eelgrass lost in these areas is much smaller than the losses in Great Bay.

The actual location and connectivity of the remaining eelgrass in the estuary is important. Figures 6.3, 6.4, and 6.5 show the 2011 eelgrass maps relative to the 1996 eelgrass maps. These figures show that: (1) the loss of eelgrass in the Piscataqua River disrupts the connectivity of eelgrass between Portsmouth Harbor and Great Bay, (2) eelgrass is absent from the tidal rivers, and (3) the new eelgrass bed in Little Bay is larger than the one that was mapped in 1996.

The new eelgrass bed in Little Bay may be a positive sign. 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 shows the variability of eelgrass recovery. Data from 2012 and future years are needed to determine if this bed will persist showing an improving trend in Little Bay.

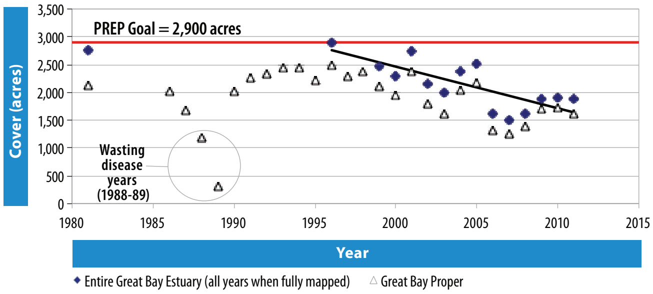
Why This Matters

Eelgrass (*Zostera marina*) is at the base of the estuarine food web in the Great Bay Estuary. Healthy eelgrass beds filter water and stabilize sediments[14] and provide habitat for fish and shellfish.[15] While eelgrass is only one species in the estuarine community, the presence of eelgrass is critical for the survival of many species.

PREP GOAL Increase the aerial extent of eelgrass cover to 2,900 acres and restore connectivity of eelgrass beds throughout the Great Bay Estuary by 2020.

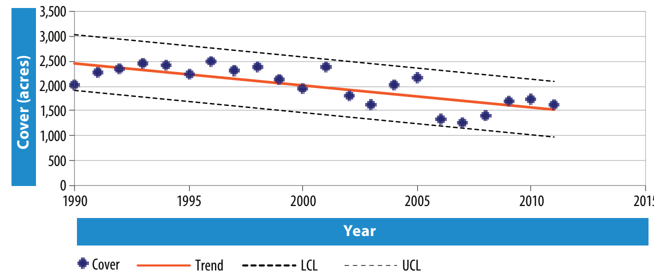
There are indications that remaining beds contain fewer plants and, therefore, provide less habitat.

FIGURE 6.1 Eelgrass Cover in the Great Bay Estuary



Data Source: UNH Seagrass Ecology Laboratory

FIGURE 6.2 Eelgrass cover in Great Bay proper



Data Source: UNH Seagrass Ecology Laboratory Statistically significant trend

FIGURE 6.3 Eelgrass cover in Great Bay and its tributaries in 1996 and 2011

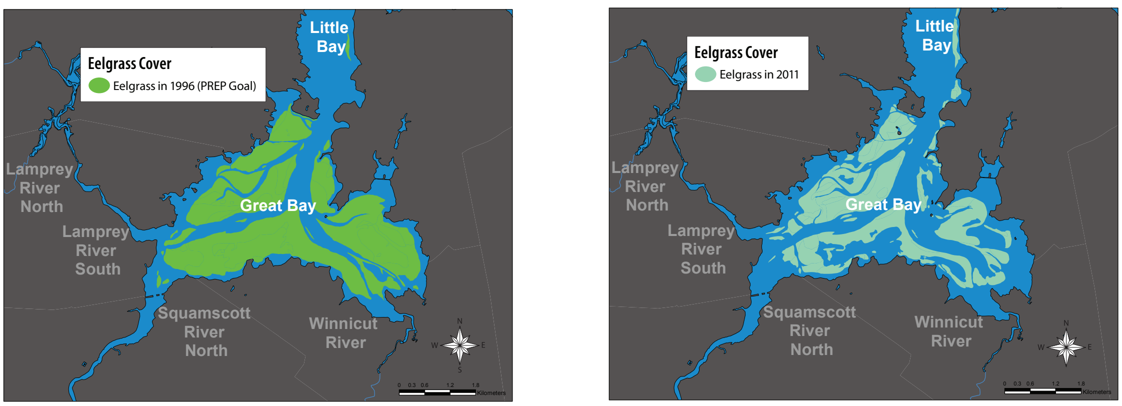


FIGURE 6.4 Eelgrass cover in Little Bay and its tributaries in 1996 and 2011

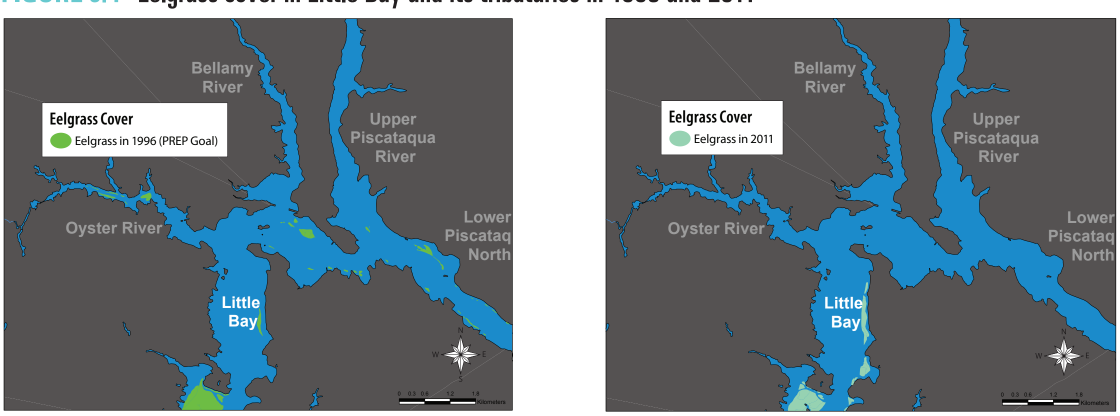
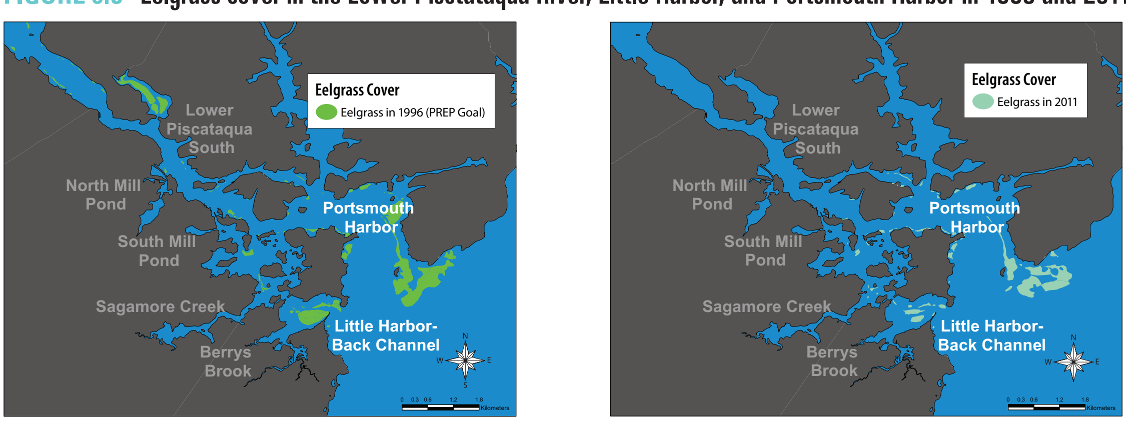


FIGURE 6.5 Eelgrass cover in the Lower Pisctataqua River, Little Harbor, and Portsmouth Harbor in 1996 and 2011



Data Source: UNH Seagrass Ecology Laboratory

EELGRASS

Sediment Concentrations

How has the amount of sediment in the water of the estuary changed over time?

Oyster River Reservoir, Durham, NH. Photo by D. Kellam

Suspended sediment concentrations at Adams Point in the Great Bay Estuary have increased significantly between 1976 and 2011.

EXPLANATION Suspended sediments have been measured at Adams Point in Great Bay since 1976. At this station, the concentrations of suspended sediment have increased by 122% between 1976 and 2011 (Figure 7.1).

Suspended sediment concentrations are important because a UNH study found that non-algal particles contributed significantly to light availability for the underwater eelgrass in the vicinity of the Great Bay Coastal Buoy in 2007.[16] Increased suspended sediments are expected in estuaries where eelgrass has been lost. Eelgrass stabilizes the sediments in the estuary. When this habitat is lost,[17] the sediments are more easily stirred up by wind and waves.

Why This Matters

Suspended sediments are soil and plant particles that hang in the water and cause the water to look cloudy. This cloudiness blocks sunlight from entering the water which can inhibit eelgrass growth and can also smother eelgrass and oysters. Soil and plant particles mostly get into the water from turbulent mixing that carries bay sediments up from the bottom into the water or rain and snow melt running off from developed land.

PREP GOAL **No increasing trends for suspended sediments.**

FIGURE 7.1 Suspended sediment trends at Adams Point in the Great Bay Estuary

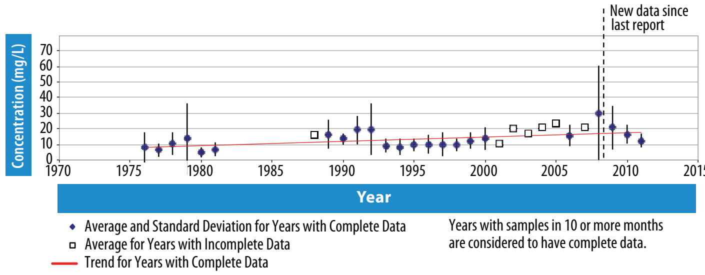
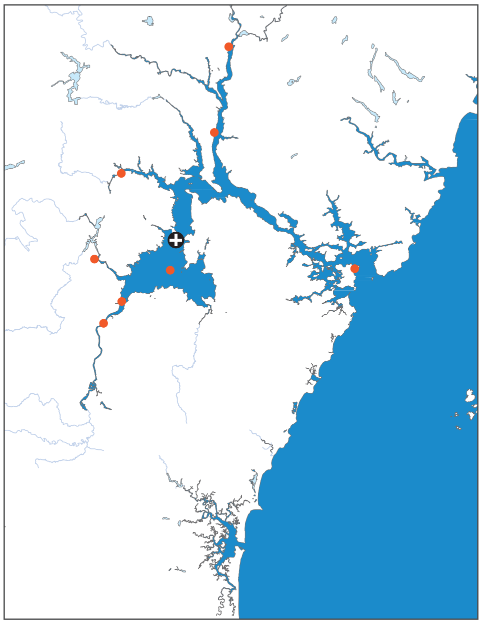
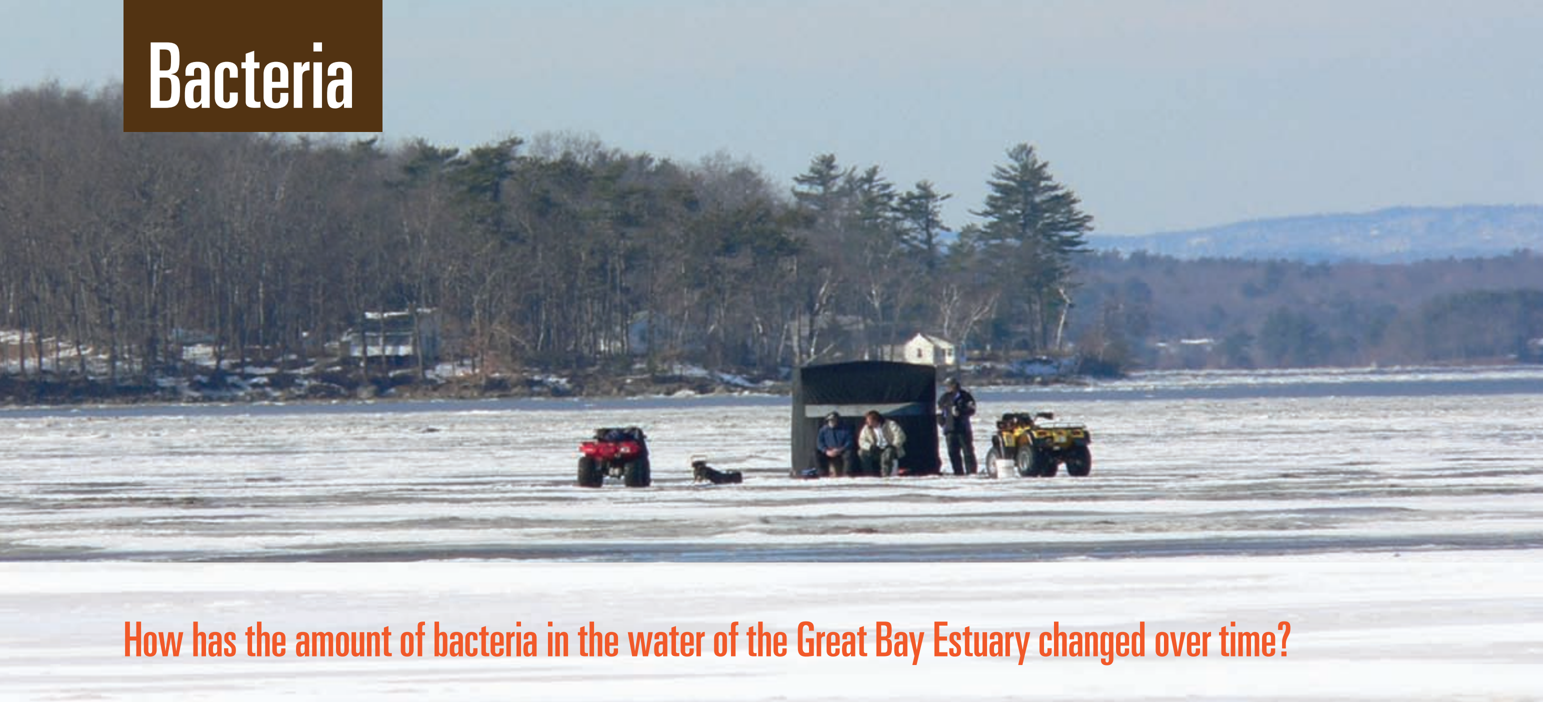


FIGURE 7.2 Monitoring site for sediment concentration is marked by a black dot with a white cross.



Bacteria



How has the amount of bacteria in the water of the Great Bay Estuary changed over time?

Smelt Fishing on Great Bay. Photo by D. Kellam

Between 1989 and 2011, dry weather bacteria concentrations in the Great Bay Estuary have typically fallen by 50 to 92% due to pollution control efforts in most, but not in all, areas.

EXPLANATION High amounts of fecal coliform bacteria, which is found in human and animal waste, is an indication of sewage pollution from leaking septic systems, overboard marine toilet discharges, sewer treatment plant overflows, cross connections between sewers and stormdrain systems, farm animals and wildlife waste, polluted mud on the estuary floor being stirred up, and polluted water running off from paved surfaces. PREP uses fecal coliform bacteria measurements from days without signficant rainfall for this indicator because storm runoff can cause large spikes of pollution. Data on this indicator is only available for the Great Bay Estuary.

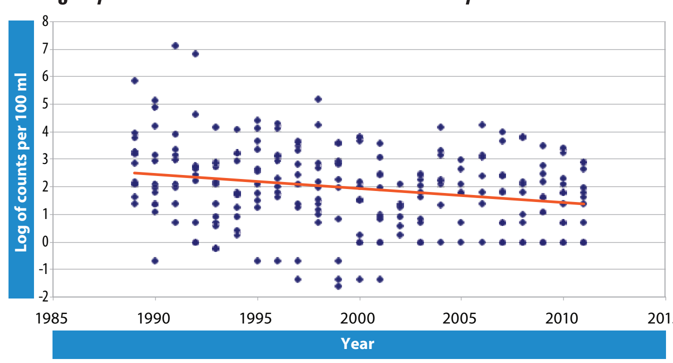
At all four long-term water pollution monitoring stations in the estuary, there has been a decrease in fecal coliform bacteria during dry weather over the past 23 years. For example, in the middle of Great Bay at Adams Point, fecal coliform bacteria decreased by 68 percent between 1989 and 2011 (Figure 8.1). Sewer treatment plant upgrades and removal of sewage flowing into cities' and towns' storm drain systems are likely major contributors to the long-term decreasing trend. In the most recent 10 years, bacteria levels have mostly remained the same. The observed trends may have been driven by large decreases in the late 1980s and early 1990s. Alternatively, continued population growth in the Piscataqua Region watershed may be counteracting the ongoing pollution control efforts. It should be noted that not all trends were decreasing. Concentrations of enterococcus, a different type of bacteria, increased in the Squamscott River but did not show any trends in other locations.

Why This Matters

Increased amounts of bacteria in bay waters often indicate the presence of pathogens due to sewage pollution or other sources. Pathogens, which are disease-causing microorganisms, pose a public health risk and are the primary reason why shellfish beds and public beaches can be closed.

PREP GOAL **No increasing trends for any bacteria species.**

FIGURE 8.1 **Fecal coliform bacteria concentrations at low tide during dry weather at Adams Point in Great Bay**



Source: UNH Jackson Estuarine Laboratory

Shellfish Harvest Opportunities

How much of our estuaries are open for shellfish harvesting and how has it changed over time?

NH Dept. of Environmental Services measuring shellfish size. Photo by PREP

Only 36% of estuarine waters are approved for shellfishing and, in these areas, periodic closures limited shellfish harvesting to only 42% of the possible acre-days in 2011. The harvest opportunities have not changed significantly in the last three years.

EXPLANATION There are still many closures of shellfish beds due to bacterial pollution, particularly after it rains. In 2011, the most recent year with data, 64% of the shellfish growing areas were closed to harvesting on a year-round basis (Figure 9.1). The major open areas are in Hampton-Seabrook Harbor, Great Bay, Little Bay, and Little Harbor (Figure 9.2). None of the Piscataqua Region estuary waters in Maine are open for harvesting. In 2000 and 2001, approximately 29 to 31% of the estuarine waters were classified as open for shellfishing by NH Department of Environmental Services and Maine Department of Environmental Protection shellfish programs. The percentage of waters in these open categories grew to 38% in 2003 and then remained relatively constant from 2004 to 2011, ranging from 35 to 36%. In the areas where harvesting was allowed, the shellfish beds were closed at least 50 percent of the time in 2011 due to water pollution after rain storms (Figure 9.3).

Why This Matters

Shellfish beds are closed to harvesting when there are high amounts of bacteria or other pollution in the water. The closures can be permanent or temporary. Therefore, the amount of time that shellfish beds are open for harvest is an indicator of how clean the water is in the estuary. Shellfishing aquaculture provides a living for some area fishermen and brings in money for the Seacoast region through retail sales.

PREP GOAL **100% of possible acre-days in estuarine waters open for harvesting.**

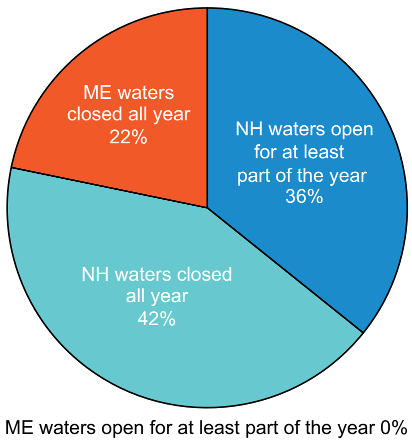
Success Story

Septic-sniffing dogs

FB Environmental Associates recently hired Environmental Canine Services LLC to help collect data on fecal bacteria sources in Kittery, ME. Hailing from Michigan, Environmental Canine Service (ECS) is a K-9 illicit discharge detection unit made up of animal handlers, scientists and two furry data collectors, Sable and Logan. By sniffing outflow pipes and areas where stormwater or wastewater discharges into rivers, estuaries, and beaches, they can tell if it's contaminated with harmful bacteria and then Kittery officials can work to identify and correct the sources.

In 2011, the most recent year with data, 64% of the shellfish growing areas were closed to harvesting on a year-round basis.

FIGURE 9.1 Shellfish harvest classifications for Piscataqua Region estuaries, 2011

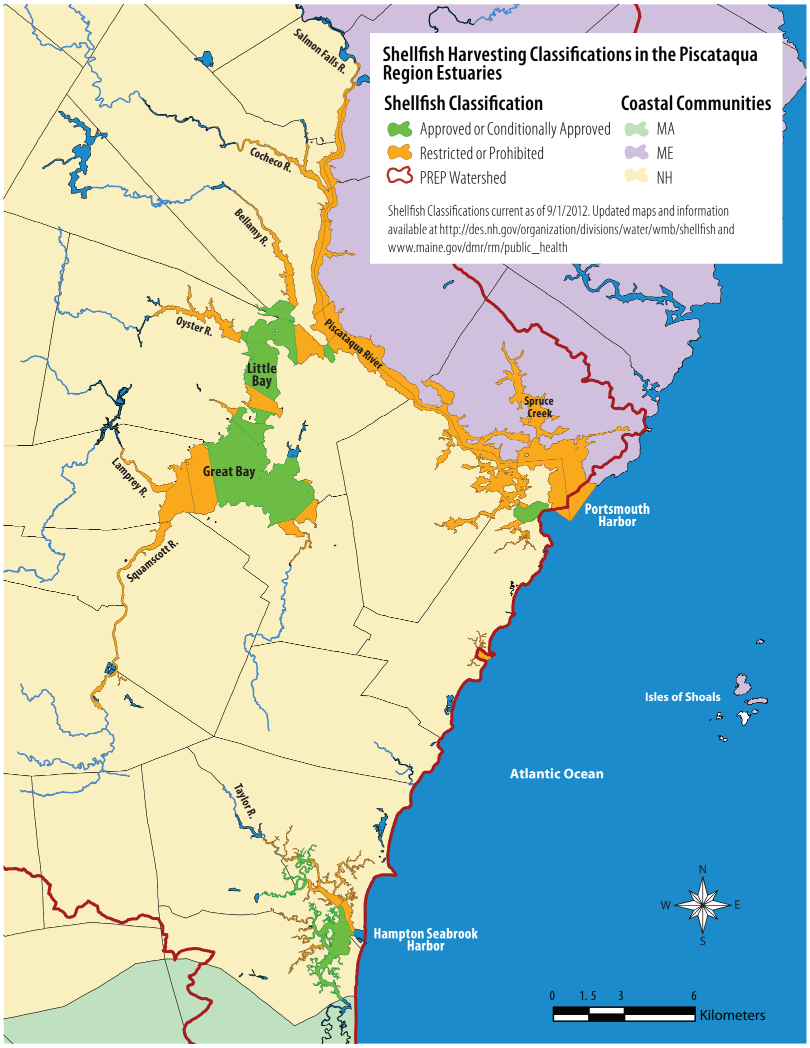


Data Source: NH Dept. of Environmental Services and Maine Dept. of Marine Resources

Success Story

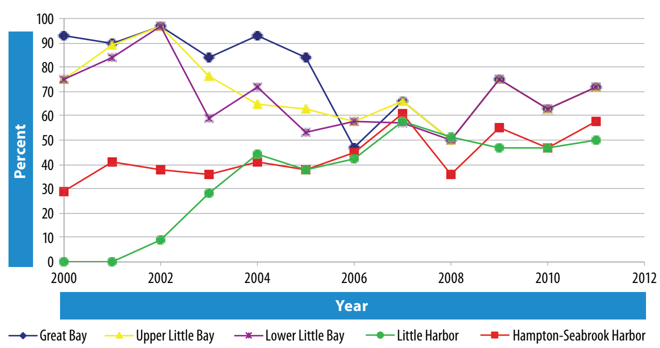
Will Carey of Little Bay Oyster Company Oysters are a model for the importance of a healthy ecosystem that in turn supports a healthy economy. Will Carey of The Little Bay Oyster Company grows oysters in his "underwater vineyard" off of Fox Point in Newington, NH. Enterprises like the Little Bay Oyster Co. represent an opportunity to reintroduce a natural resource as part of local business and stimulate the NH economy. Today Little Bay Oyster Company is now one of about six commercial growers and part of a growing movement of local economies based on a healthy ecosystem, valuable natural resources and clean water.

FIGURE 9.2 Shellfish Harvesting Classifications in the Piscataqua Region Estuaries



Data Source: NH Dept. of Environmental Services and Maine Dept. of Marine Resources

FIGURE 9.3 Shellfish harvesting opportunities in open areas as a percent of the maximum possible per year



Data Source: NH Dept. of Environmental Services

SHELLFISH HARVEST OPPORTUNITIES

Beach Closures

How often are tidal bathing beaches closed due to bacteria pollution and how has it changed over time?

Hampton Beach on a crowded Summer day. Photo by C. Keeley

Poor water quality prompted advisories extremely rarely in 2011. There are no apparent trends.

EXPLANATION Tidal beaches in the Piscataqua Region are mostly located along the Atlantic coast, not in the estuaries (Figure 10.1). At these beaches, between 1 and 11 advisories have been issued per year between 2003 and 2011 (Figure 10.2). The advisories have resulted in very few beach closures as a percent of the total beach days in the summer. 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).

Jenness Beach, Rye, NH. Photo by J. Carroll

Why This Matters

If the concentrations of bacteria in the water at a beach do not meet state standards for swimming, the state agencies may recommend that an advisory be posted at the beach. Therefore, the number of postings at tidal beaches is a good indicator of bacteria pollution at important recreational areas. Recreational beach visitors supply tourist dollars for our region's economy giving local businesses like hotels, restaurants and beachfront shops a boost.

PREP GOAL **Less than 1% of summer beach days over the summer season affected by closures due to bacteria pollution.**

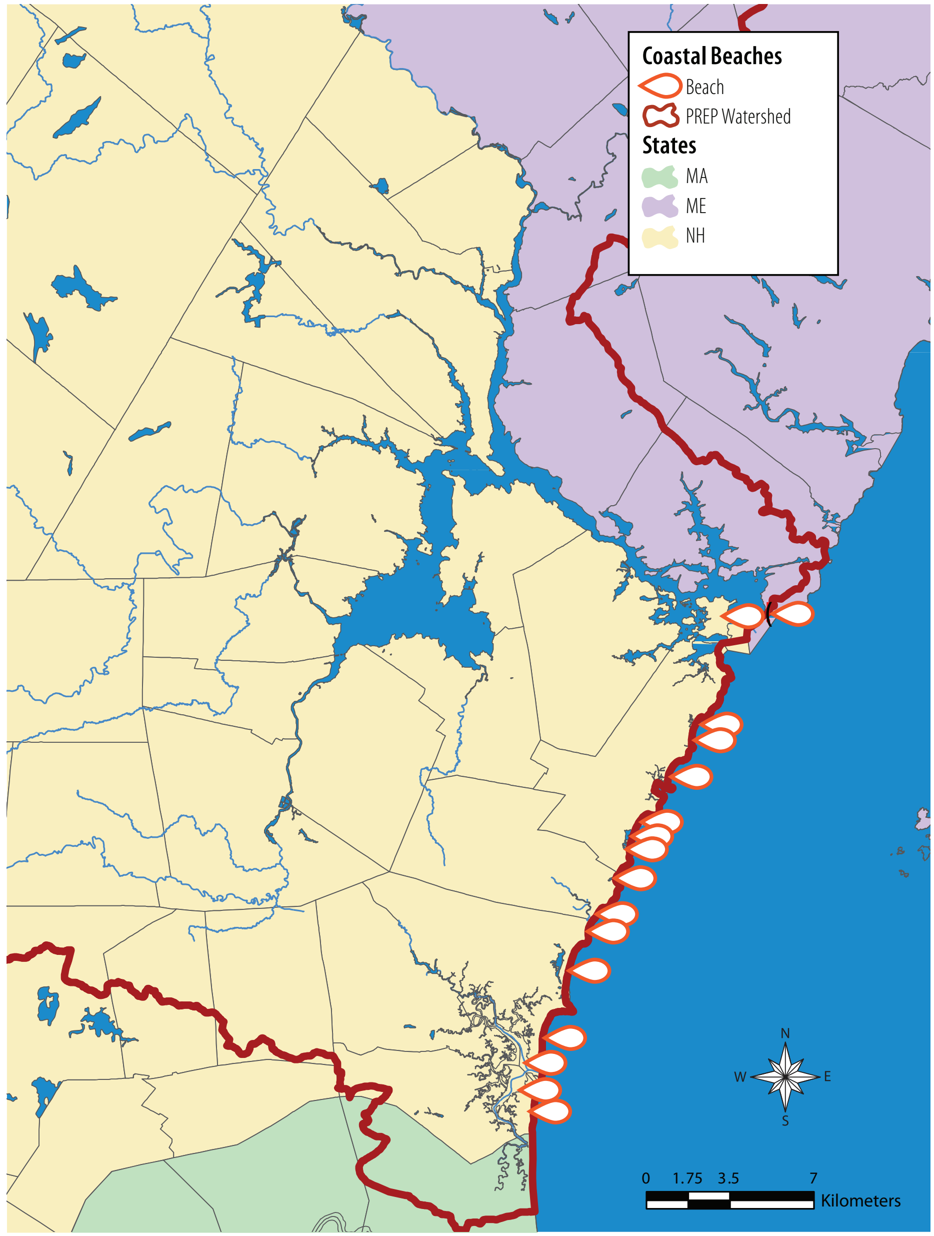
The beaches with the most advisories are the New Castle Town Beach, the North Hampton State Beach, and Fort Foster in Maine.

Success Story

New Hampshire's 5 Star Beaches

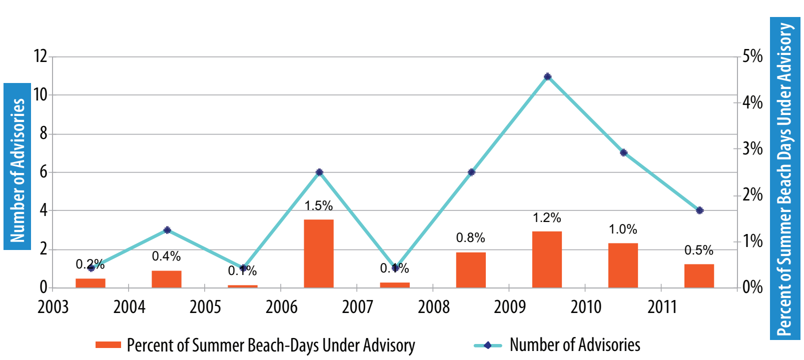
The Natural Resource Defense Council publishes an annual guide to water quality for US beaches. Two of New Hampshire's beaches were once again rated as "5-Star," standing out from over 200 beaches rated from across the country. Hampton Beach State Park and Wallis Sands in Rye were recognized for exceptionally low violation rates and strong testing and safety practices.

FIGURE 10.1 Coastal Beaches



Data Source: NH Dept. of Environmental Services and Maine Dept. of Environmental Protection

FIGURE 10.2 Advisories at tidal beaches in the Piscataqua Region, 2003-2011



Data Source: NH Dept. of Environmental Services and Maine Dept. of Environmental Protection

Toxic Contaminants

How much toxic contamination is in shellfish tissue and how has it changed over time?

Wrack on the shore in New Castle, NH. Photo by D. Kellam

The vast majority of shellfish tissue samples do not contain toxic contaminant concentrations greater than FDA guidance values. The concentrations of contaminants are mostly declining or not changing.

EXPLANATION Shellfish collect toxic contaminants in their flesh when they feed by filtering water. The Gulf of Maine Council's Gulfwatch Program uses blue mussels (*Mytilus edulis*) for measuring the accumulation of toxic contaminants in their flesh. Between 1993 and 2011, 20 stations in the Great Bay Estuary and Hampton-Seabrook Harbor have been tested at least once for toxic contaminants in blue mussel tissue. The concentrations of toxic contaminants in mussel tissue have been less than U.S. Food and Drug Administration guidelines at all of the sites except for South Mill Pond in Portsmouth and shellfish harvesting is not permitted in this area. The acceptable levels of contaminants in these creatures suggest that the amount of toxic contaminants in estuarine waters are of minimal concern in most of the estuary.

Samples of mussel flesh from three locations (Portsmouth Harbor, Hampton-Seabrook Harbor, and Dover Point as shown in Figure 11.1) have been tested repeatedly between 1993 and 2011 to detect trends. The trends for toxic contaminants were decreasing (Figures 11.2, 11.3, 11.4) or remaining stable in these locations. These trends reflect that people are using less of the products containing these contaminants due to product bans and pollution prevention programs. While declining trends are a good sign, the amount of some toxic contaminants are still elevated. Research by Sunderland et. al. (2012) reported that the amount of mercury in the muddy bottom of the Piscataqua Region estuaries was similar to Boston Harbor and other estuaries located close to cities.

Why This Matters

Mussels, clams, and oysters accumulate toxic contaminants from polluted water in their flesh. In addition to being a public health risk, the contaminant level in shellfish flesh is a long-term indicator of how clean the water is in the estuaries. If toxic pollution does not appear in the flesh of the mussels, then the amount of toxic pollution in the water is likely very low.

PREP GOAL **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 contaminants.**

Frog photo by PREP

FIGURE 11.1 Gulfwatch Program Sampling Stations

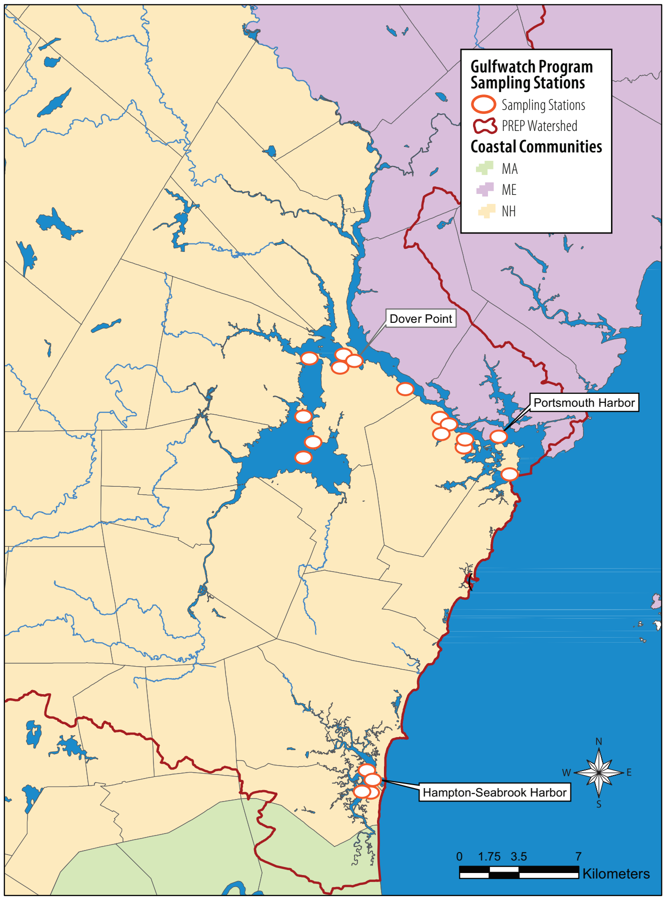
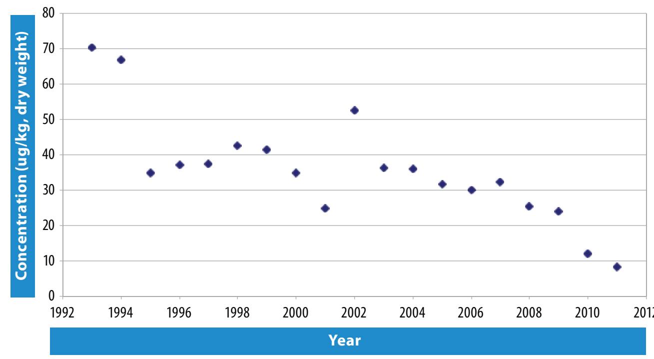
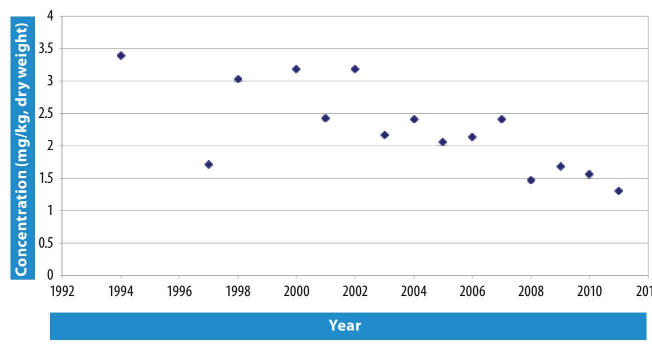


FIGURE 11.2 Total PCBs in Mussel Tissue in Portsmouth Harbor



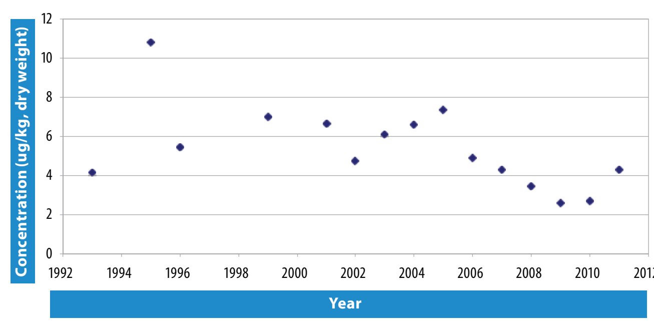
Data Source: NH Gulfwatch Program

FIGURE 11.3 Lead in Mussel Tissue at Dover Point



Data Source: NH Gulfwatch Program

FIGURE 11.4 Total DDT Pesticides in Mussel Tissue in Hampton-Seabrook Harbor



Data Source: NH Gulfwatch Program

Newt photo by NH Fish & Game

Digging Deeper

PCBs (Polychlorinated Biphenyls) belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned by the US EPA in 1979. They were used in hundreds of industrial and commercial applications. Since being banned in 1979 the presence of PCBs in the environment has dramatically dropped.

In 1972 after the publication of Rachel Carson's *Silent Spring* the use of the pesticide DDT (dichloro-diphenyl-trichloroethane) was also banned. Although it is no longer used or produced in the United States, we continue to find DDT in our environment. Other parts of the world continue to use DDT in agricultural practices and in disease-control programs. Therefore, atmospheric deposition is the current source of new DDT contamination in soils, fish & shellfish.

PAHs are Polycyclic Aromatic Hydrocarbons. PAHs are created when products like coal, oil, gas, and garbage are burned but the burning process is not complete.

Source: US EPA

TOXIC CONTAMINANTS

Oysters

How many oysters are in the Great Bay Estuary and how has it changed over time?

Oyster spat, or seed, set on an oyster shell. Photo by R. Grizzle

The number of adult oysters decreased from over 25 million in 1993 to 1.2 million in 2000. The population has increased slowly since 2000 to 2.2 million adult oysters in 2011 (22% of goal).

EXPLANATION The New Hampshire Fish and Game Department monitors the oyster populations in the six major reefs in the Great Bay Estuary (Figure 12.1).

Data from 1993 to 2011 show that the oysters in Great Bay have been declining considerably (Figure 12.2). There was a steep 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 diseases MSX and Dermo which have caused similar declines in oysters in the Chesapeake and other mid-Atlantic estuaries. Since 2000, the number of adult oysters has grown slightly to 2.2 million. The 2011 number of adult oysters is approximately 22% of the PREP goal of 10 million adult oysters. Biologists hoped for a large increase in oysters when the 2006 oyster seed, called spat, reached maturity in 2009. A small amount of mature oysters (>60 mm) did appear in 2009 but they did not grow to the typical adult size (>80 mm). Overall, the average amount of adult and mature oysters in the major beds is 58% and 45% lower than 1997 levels, respectively.

The New Hampshire Fish and Game Department has monitored the prevalence of the diseases MSX and Dermo in oysters from the Great Bay every year since 1995 (Figure 12.3). There has been no apparent trend in MSX infection rates since the disease was first detected. Approximately 21% of the oysters in Great Bay were infected with MSX at some level in 2011. However, starting in 2002, the prevalence of Dermo infections has increased from zero to greater than 90%. The increase in Dermo may be the result of warming water temperatures or adjustment of the parasite to local conditions. These two diseases, in combination with other factors, limit the survival of oysters into adult size. Recreational harvest of oysters has been declining for 30 years and is not thought to be affecting the size of the population.

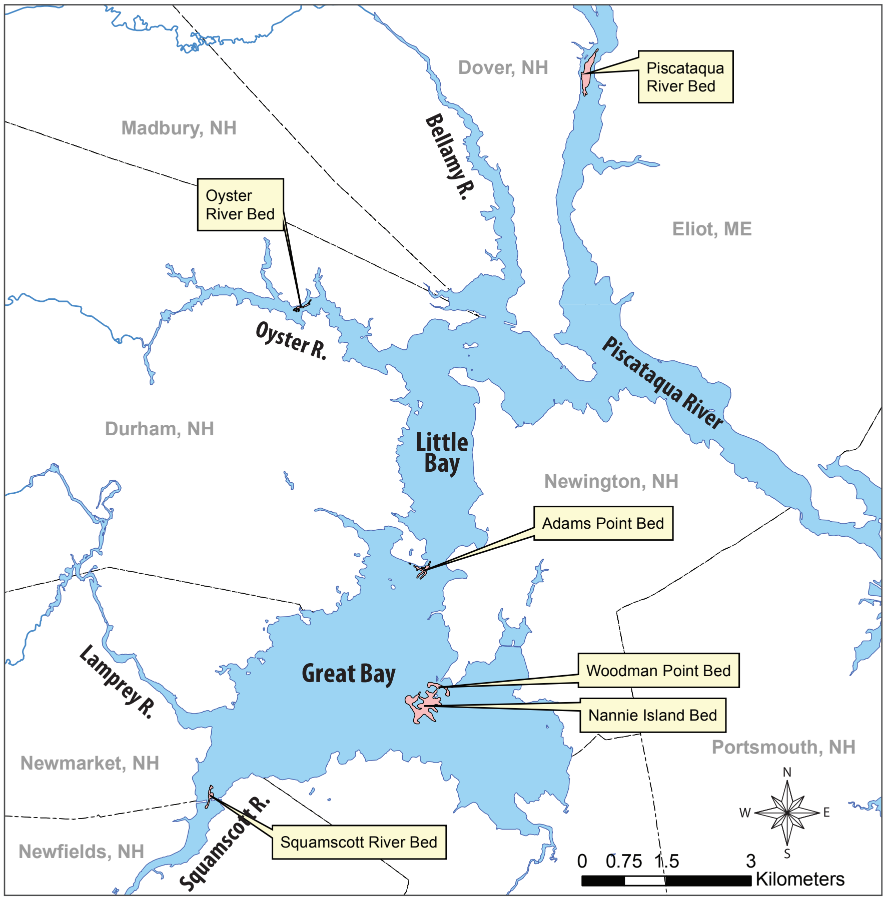
Why This Matters

Oysters are filter feeders that take in the water around them, filter out some of the pollutants and sediment, and then release cleaner water. Harvesting and aquaculture farming of oysters provide economic benefits to local communities and businesses. Oyster shell reefs also create important habitat for other creatures in the estuary.

PREP GOAL **Increase the abundance of adult oysters at the six documented beds in the Great Bay Estuary to 10 million oysters by 2020.**

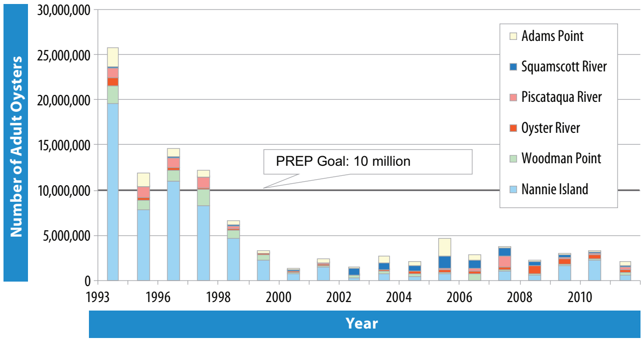
The 2011 number of adult oysters is approximately 22% of the PREP goal of 10 million adult oysters.

FIGURE 12.1 Major oyster beds in the Great Bay Estuary



Data Source: NH Dept. of Environmental Services

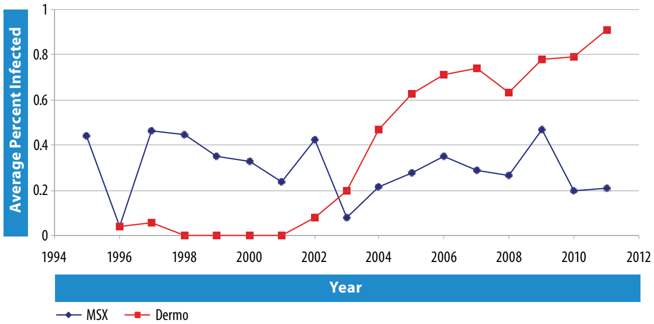
FIGURE 12.2 Number of adult oysters* in major Piscataqua Region beds



* Shell height greater than 80 mm

Data Source: NH Fish and Game Department

FIGURE 12.3 Average MSX and Dermo infection prevalence in Piscataqua Region oysters from all beds



Data Source: NH Fish and Game Department

Success Story

Oyster Conservationists Homeowners are helping Ray Konisky of the Nature Conservancy rebuild oyster reefs at the mouths of the tributary rivers of Great Bay. Through the Oyster Conservationist program, people with waterfront property can take care of baby oysters until they are ready to join the big oysters at the restoration sites around the Bay. In the 2011 season, 39 families helped grow oysters for restoration. More oyster parents are always needed, contact Kara McKeton (kmcketon@tnc.org) if you're ready to help raise baby oysters!

Clams

How many clams are in Hampton-Seabrook Harbor and how has it changed over time?

Digging for clams in Hampton Harbor. Photo by PREP

The number of clams in Hampton-Seabrook Harbor is 43% of the recent historical average. Large spat or seed sets may indicate increasing populations in the future.

EXPLANATION The largest clam flats in the Piscataqua Region estuaries are in Hampton-Seabrook Harbor (Figure 13.1). The number of adult clams in these flats has been monitored by NextEra Energy/Seabrook Station over the past 41 years (Figure 13.2). The number of adult clams has undergone several cycles of growth and decline. Peak clam numbers of approximately 18 million and 27 million occurred in 1983 and 1997, respectively. Between the peaks, there have been crashes in 1978 and 1987, with the number of adult clams totalling less than 1 million. From 1997 to 2004, the number of adult clams dropped to 1.9 million. By 2006 the population had rebounded to 5.1 million (93% of the goal). However, in the last five years, the population has declined to 2.4 million (43% of the goal).

"Clam spatfall" refers to the event when clam larvae fall out of the water and settle onto the muddy bottom. It is critical to have good spatfalls on a clam flat in order to recruit new clams which can then grow into adults. Figure 13.3 illustrates that clam spatfall in recent years has been higher than historical averages, which may mean more adult clams in the future.

Why This Matters

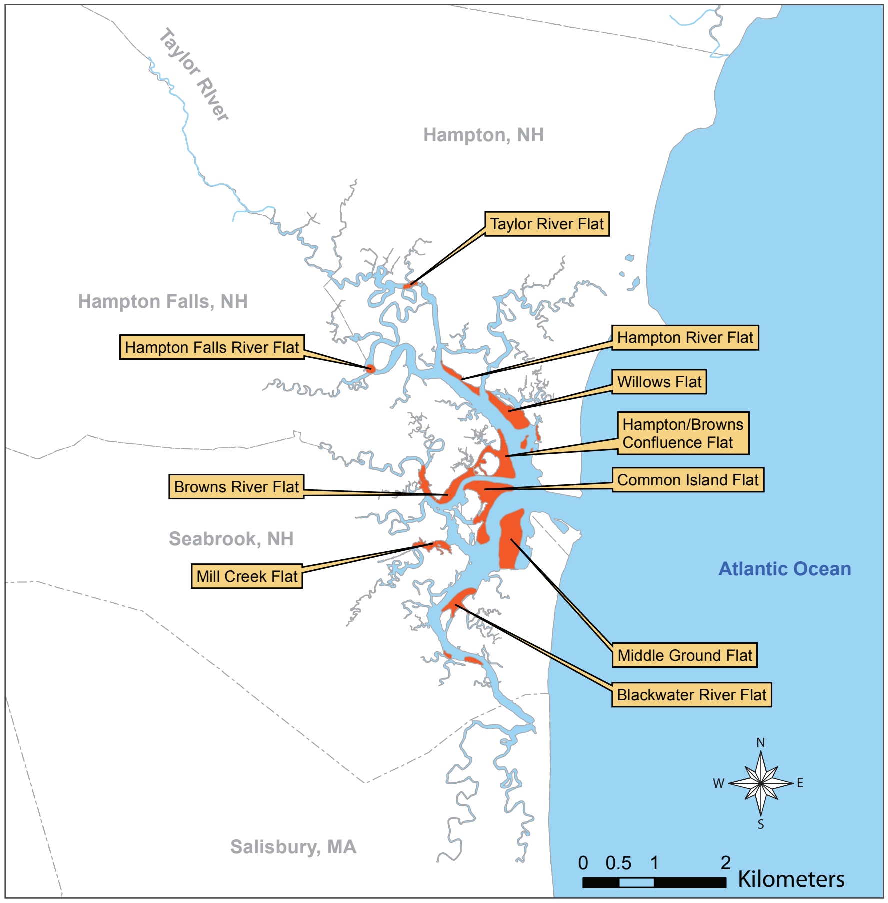
Soft shell clams are an important economic, recreational, cultural, and natural resource for the Seacoast region. Recreational shellfishing in Hampton-Seabrook Harbor is estimated to contribute more than $3 million a year to the New Hampshire economy.

Father and daughter clamming. Photo by PREP

PREP GOAL **Increase the number of adult clams in the Hampton-Seabrook Estuary to 5.5 million clams by 2020.**

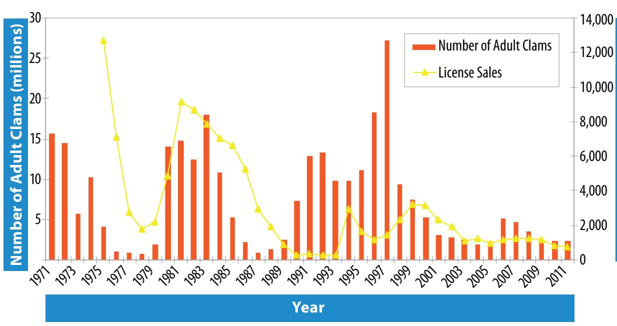
In the last five years, the population of clams has declined to 2.4 million (43% of the goal).

FIGURE 13.1 Major clam flats in the Hampton-Seabrook Estuary



Data Source: NH Dept. of Environmental Services

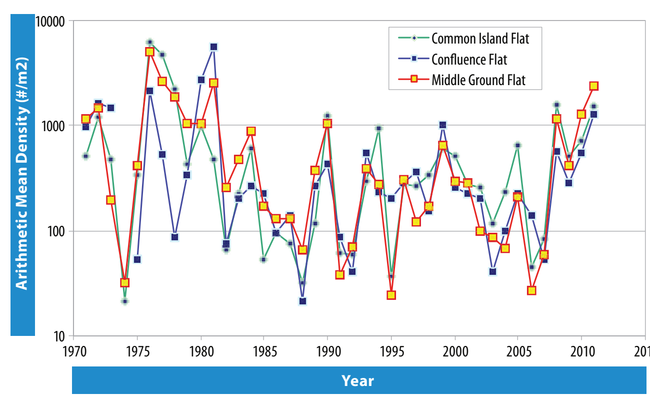
FIGURE 13.2 Number of adult clams* in Hampton-Seabrook Harbor and recreational clam harvest license sales



*Shell length greater than 50 mm

Data Source: NextEra Energy Seabrook Station and NH Fish and Game Department

FIGURE 13.3 Average clam spat* density in Hampton-Seabrook Harbor



*Young clams with shell length between 1-25mm

Data Source: NextEra Energy Seabrook Station

Success Story

The New Hampshire Shellfish Program

The New Hampshire Department of Environmental Services (NHDES) Shellfish Program ensures that shellfish harvested from the state's tidal waters are safe to eat. In order to provide this service, the program regularly monitors bacteria levels in seawater from over 75 locations in New Hampshire's tidal waters and evaluates weekly samples of mussels to ensure that shellfish are not contaminated with Paralytic Shellfish Poison (PSP) toxin from "red tide" events.

Migratory Fish

How have migratory fish returns to the Piscataqua Region changed over time?

Fish ladder on the Lamprey River, Newmarket, NH. Photo by PREP

Migratory river herring returns to the Great Bay Estuary generally increased during the 1970-1992 period, remained relatively stable in 1993-2004, and then decreased in recent years.

EXPLANATION Major rivers of the Piscataqua Region historically had very large populations of migratory fish including Atlantic salmon, river herring, American shad, and American eels. Today, only river herring and American eels still return regularly in substantial numbers to the rivers and are the focus of current migratory fish restoration efforts.

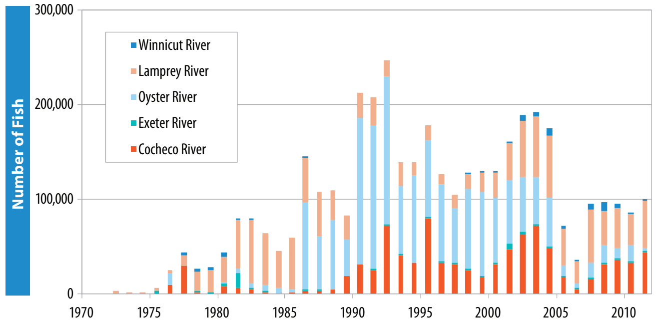
River herring returns to the major rivers of the Great Bay Estuary have been combined in Figure 14.1. This figure illustrates that river herring returns to the Great Bay estuary generally increased during the 1970-1992 period, remained relatively stable 1993-2004, then decreased in recent years. This decline is likely due to a combination of losses while the herring are in the sea-going portions of their lifecycle, limited freshwater habitat quantity/quality, difficulty getting up fish ladders that are installed over dams, safe downstream passage over dams, possible over-fishing in some river systems, water pollution, and flood events during upstream migrations. The Taylor River, in Hampton-Seabrook Harbor, has had the highest recorded returns of herring (Figure 14.2). However, this population has declined dramatically. The decline is most likely due to poor water quality in the Taylor River reservoir upstream of the dam.

Why This Matters

River herring are migratory fish, which means they travel from the ocean upstream to freshwater streams, marshes, and ponds to reproduce. Herring are eaten by other species and therefore sustain important commercial and recreational fisheries and other wildlife.

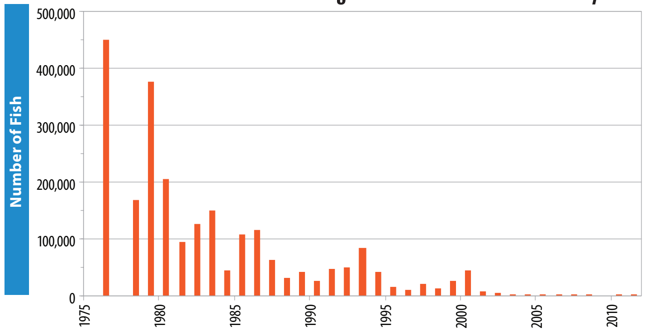
PREP GOAL No goal.

FIGURE 14.1 Returns of river herring to fish ladders in the Great Bay Estuary



Data Source: NH Fish and Game Department

FIGURE 14.2 Returns of river herring to the fish ladder on the Taylor River



Data Source: NH Fish and Game Department

Salt Marsh Restoration

How much salt marsh restoration has been done?

Pickering Brook, Greenland, NH. Photo by D. Kellam

280.5 acres of salt marsh have been restored since 2000 and 30.6 acres of salt marsh have been enhanced since 2009, which is moderate overall progress towards PREP's goals.

EXPLANATION Salt marshes are coastal wetlands connected to the ebb and flow of the tides. Salt marshes serve as a critical base of the food web in the estuary, provide essential breeding, feeding, and rearing places for birds, fish, and other wildlife, filter pollutants, and protect our communities from coastal flooding. Historically, many salt marshes were filled for development, blocked off from the tides for hay fields, or impacted with ditches to try to drain them. Restoration of salt marshes involves undoing these past harmful alterations, while enhancement usually involves removing invasive plants and re-establishing native plant communities.

PREP has two complementary goals for salt marsh restoration: to restore 300 acres of salt marsh and to enhance an additional 300 acres of salt marsh by 2020. Tracking of enhancement acres is a new indicator and began in 2009. There has been significant progress toward the goal of restoring 300 acres of salt marsh (Figure 15.1), with 280.5 acres restored (93% of goal).

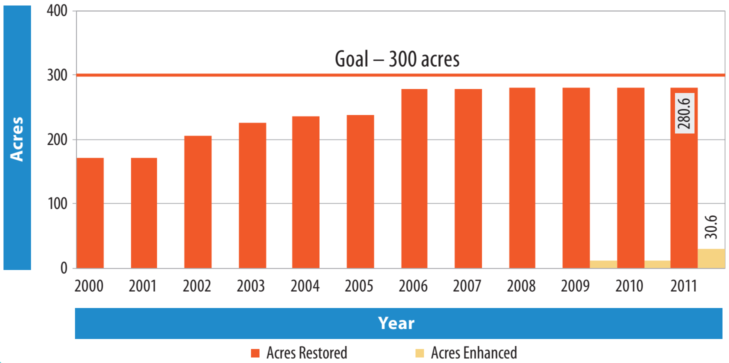
Limited progress has been made toward the goal of enhancing 300 acres of salt marsh. There has been 30.6 acres of marsh enhancement work completed since 2009, representing 10% of the goal.

Why This Matters

Salt marshes are among the most productive ecosystems in the world.[18] In the past few centuries, many of the salt marshes in the Piscataqua Region watershed have been degraded or lost over time. Restoration efforts attempt to restore the function of these critical habitats.

PREP GOAL **Restore 300 acres of salt marsh and enhance an additional 300 acres of salt marsh by 2020.**

FIGURE 15.1 Cumulative acres of salt marsh restoration and enhancement projects, 2000-2011



Conservation Land (General)

How much of the Piscataqua Region is permanently conserved in its natural state?

Evans Mountain Overlooking Bow Lake, Strafford, NH. Photo by D. Sperduto

At the end of 2011, 88,747 acres in the Piscataqua Region watershed were conserved which amounted to 13.5% of the land area. At this pace, the goal of conserving 20% of the watershed by 2020 is likely to be reached.

EXPLANATION By the end of 2011 there were 88,747 acres of conserved, protected land in the watershed (Figure 16.1). This amount is equivalent to 13.5% of the land area, which is 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. The rate of growth of conservation lands in the Piscataqua Region Watershed has been approximately 7,000 acres per year. If this pace is maintained, the PREP goal to conserve 20% of the entire Piscataqua Region watershed by 2020 will be achieved.

The percentage of land area that is protected in each town is shown in Figure 16.2. This map illustrates that significant progress 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 watershed areas.

Photo by C. Keeley

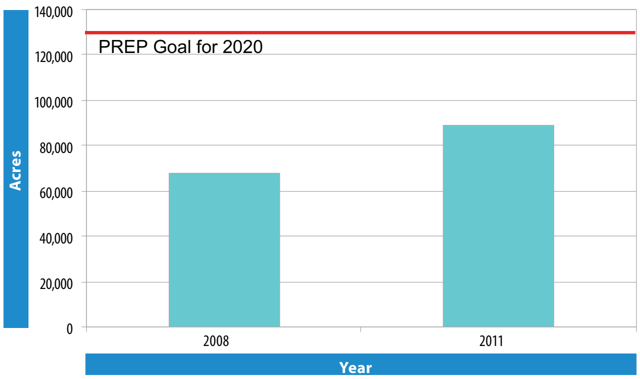
Why This Matters

Our region is under pressure from rapid population growth and land development. Conserving a network of undeveloped natural lands in our region is critical in order to maintain clean water, support healthy wildlife populations, minimize flood damages, and provide quality recreational opportunities.

PREP GOAL **Conserve 20% of the watershed by 2020.**

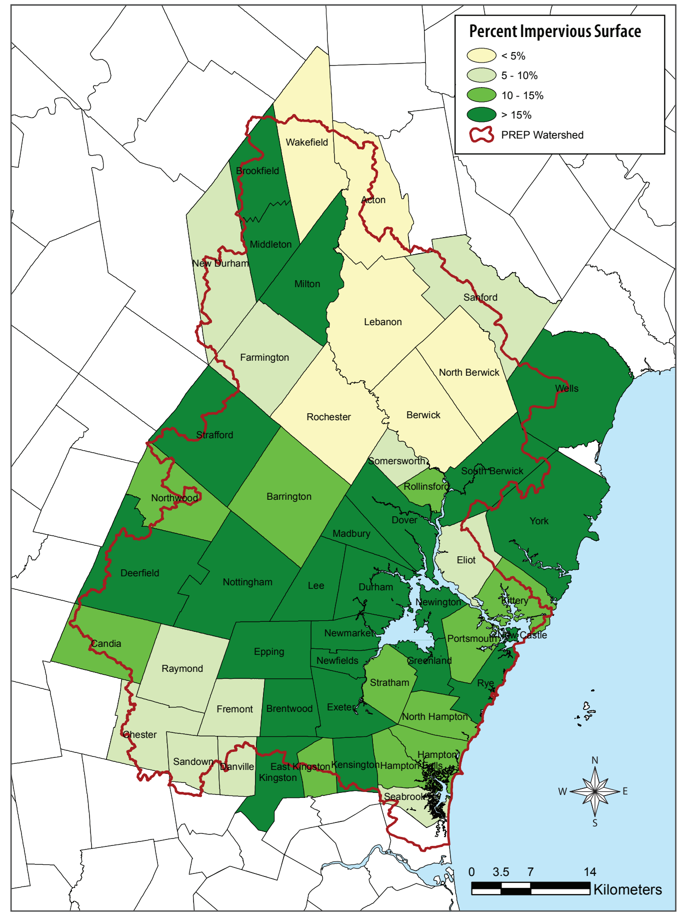
By the end of 2011 there were 88,747 acres conserved that is 13.5% of the land area of the Piscataqua Region.

FIGURE 16.1 Conservation lands in the Piscataqua Region watershed



Data Source NH GRANIT & Wells National Estuarine Research Reserve

FIGURE 16.2 Percent Conservation Lands



Data Source NH GRANIT & Wells National Estuarine Research Reserve

Success Story

Protecting A Mountain Where A Coastal River Begins In 2011, the local land trust Bear-Paw Regional Greenways permanently protected 1,015 acres on Evans Mountain, an area in the Town of Strafford from which the Isinglass and Cocheco Rivers begin their journey to the Great Bay Estuary. This project conserves clean streams, highest quality wildlife habitats, and large forestlands perfect for outdoor recreation and educational opportunities such as hiking, hunting, and snowmobiling.

Mist at sunrise, Milton, NH. Photo by V. Long

Conservation Land (Priority)

How much of the top priority areas in the Piscataqua Region are permanently conserved in their natural state?

Spruce Swamp, a Conservation Focus Area in Fremont, NH. From the Fremont Prime Wetland Designation Study by West Environmental

In 2011, 28% of the core priority areas in New Hampshire and Maine were conserved. At this pace, the goal of conserving 75% of these lands by 2025 is unlikely to be reached.

EXPLANATION *The Land Conservation Plan for New Hampshire's Coastal Watersheds* and *The Land Conservation Plan For Maine's Piscataqua Region Watersheds* are two key science-based regional conservation plans that identified 90 Conservation Focus Areas in the Piscataqua Region watershed. These areas represent the highest priority lands to conserve in order to protect clean water and highest quality wildlife habitat. PREP has established a goal of permanently protecting 75% of the lands in these focus areas by 2025. Of the 88,747 acres of existing conservation lands, more than half (45,869 acres) fall within the high-priority conservation focus areas. Overall, 28% of the focus areas have been conserved. This statistic demonstrates that the conservation focus areas have been a priority for land protection efforts but that the majority of these areas are still unprotected.

In recent years, less than one-in-five of the new conservation lands have been in high priority focus areas. The goal to conserve 75% of the focus areas will not be met unless the pace of conservation in these special areas increases.

Why This Matters

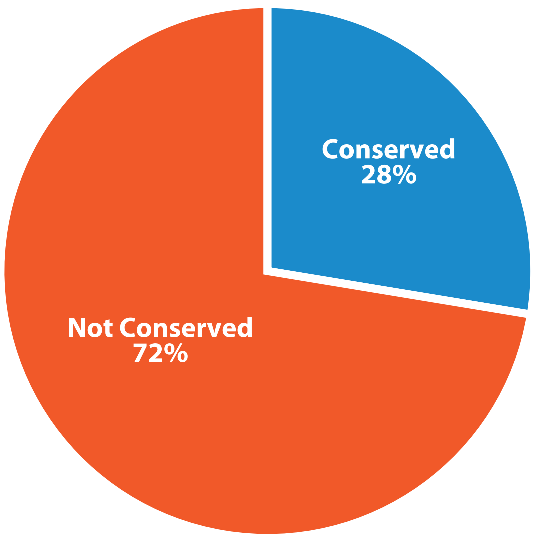
Our region still contains exceptional unfragmented natural areas that support critical wildlife populations and maintain high water quality. There is a small window of time to protect these areas in order to ensure these benefits remain for future generations.

PREP GOAL Conserve 75% of lands identified as Conservation Focus Areas by 2025.

Goose in Marsh. Photo by C. Keeley

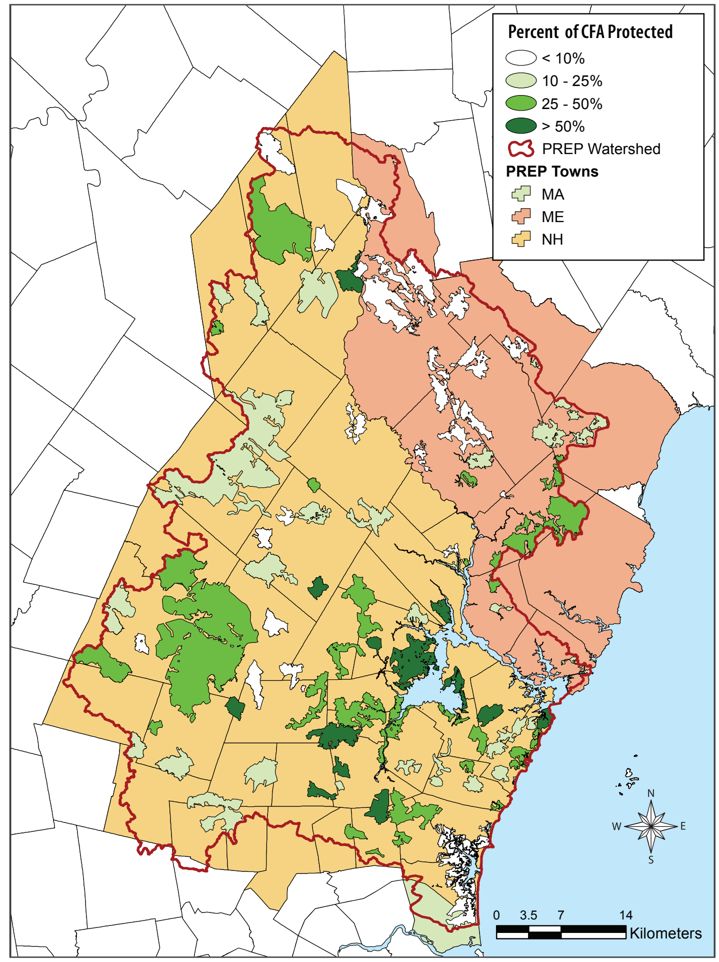
Of the 88,747 acres of existing conservation lands, more than half (45,869 acres) fall within the high-priority conservation focus areas.

FIGURE 17.1 Percent of core priority areas in the Piscataqua Region that are conserved in their natural state



Data Source: NH GRANIT and Wells National Estuarine Research Reserve

FIGURE 17.2 Percent of each Core Priority Area in the Piscataqua Region that is conserved in its natural state



NH GRANIT & Wells National Estuarine Research Reserve

Isinglass River, Strafford, NH. Photo by D. Sowers

Success Story

Conserving Top Priority Conservation Land and Building a Town Forest The Town of Fremont, NH is working to add 76 more precious acres to their existing 313 acre Glen Oakes Town Forest while permanently protecting the Spruce Swamp Conservation Focus Area. This area contains highest quality wildlife habitat in the state and exceptional trails for public access. Protection of this special natural area will ensure that the wetlands there continue to provide clean water to both the Lamprey and Exeter Rivers that flow to the Great Bay Estuary.

Oyster Restoration

How much oyster restoration has been done?

Imported clam shell is deposited to settle on the bottom and make a reef for new oysters to grow on at the mouth of the Oyster River. Photo by D. Kellam

A total of 12.3 acres of oyster beds have been created in the Great Bay Estuary, which is 61% of the goal. Mortality due to oyster diseases is a major impediment to oyster restoration.

EXPLANATION Nine oyster restoration projects have been completed 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 18.1). Restoration projects start by the setting of disease-resistant oyster seed called spat then planting the settled spat to an artificial reef on the estuary floor. High mortality was reported for some of the restoration sites. However, the restoration work still created an oyster reef structure by installing cultch or other materials on which spat could settle. Additional information about oyster restoration 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 successful, functioning habitat created by restoration projects may be lower.

Why This Matters

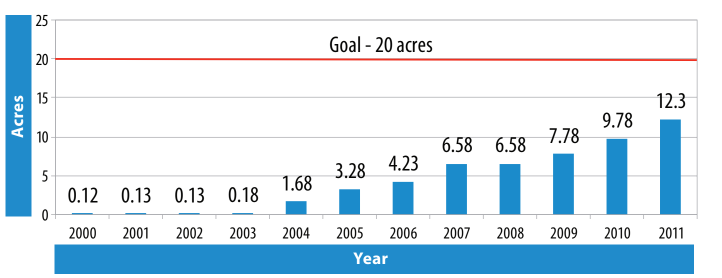
Oysters grow in concentrated groups, called beds, in areas with hard bottom. Historic data has documented that the amount and size of oyster beds in the Piscataqua Region watershed have been decreasing or lost over time. Restoration efforts attempt to restore the abundance and function of these critical habitats.

PREP GOAL **Restore 20 acres of oyster reef habitat by 2020.**

Success Story

Oyster Shell Recycling The Coastal Conservation Association of NH works with eight area restaurants to help restore oysters to Great Bay. Weekly, CCA volunteers pickup discarded oyster shells after they've been happily slurped by customers. Shells are then recycled back to the bottom of Great Bay to give growing oyster spat or seed a place to grow at restoration sites.

FIGURE 18.1 Cumulative acres of oyster restoration projects, 2000-2011



Eelgrass Restoration

How much eelgrass restoration has been done?

Measuring eelgrass height at a restoration site in Great Bay. Photo by J. Carroll

A total of 8.5 acres of eelgrass beds have been restored which is only 17% of the goal. Poor water quality is often the limiting factor for eelgrass transplant survival.

EXPLANATION 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 wooden planting frames. The total area covered by the project was 0.5 acres. None of the transplants survived due to the water not being clean enough. In 2001, an eelgrass replacement project for the US Army Corps of Engineers was completed in Little Harbor. Eelgrass was transplanted and covered 5.5 acres. The restoration was monitored for one year following the transplant and found to be successful. However, because the purpose of 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) (Figure 19.1). Prior to 2005, no state or federal money was available for eelgrass restoration.

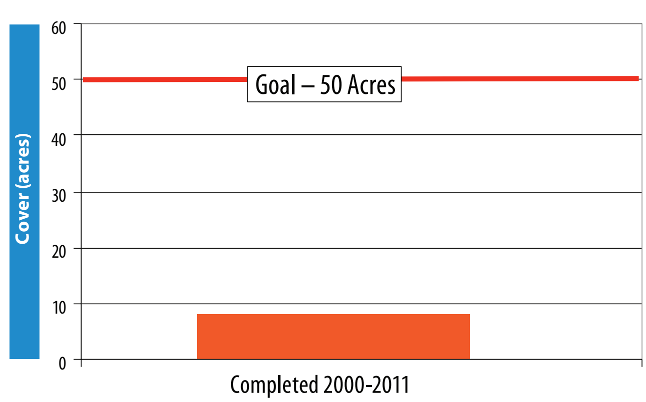
This indicator tracks restoration effort in terms of acres for which restoration was attempted. The area of successful, functioning habitat created by restoration projects may be lower.

Why This Matters

Eelgrass grows in meadows on the floor of the estuary and provides important habitat for young fish, lobsters and mussels. Historic data suggests that eelgrass meadows in the Piscataqua Region watershed have been thinning or lost over time. Restoration efforts attempt to restore the coverage and function of this critical habitat.

PREP GOAL **Restore 50 acres of eelgrass habitat by 2020.**

FIGURE 19.1 **Cumulative acres of eelgrass restoration 2000-2011**



Migratory Fish Restoration

How much river restoration for migratory fish has been done?

Alewife photo by: B. Gratwicke www.dcnature.com

River herring access has been restored to 42% of their historical distribution within the mainstems of the major rivers in the Piscataqua Region. This represents substantial progress in meeting PREP's goal of restoring 50% of the historical distribution of river herring by 2020.

EXPLANATION Major efforts are underway to restore river herring access to their historical freshwater streams and ponds in order to support recovery of their populations. Figure 20.1 shows the miles of freshwater in the main branch of each major river that was historically accessible to herring, and how many miles of that habitat are currently accessible. There is 100% access to main-stem sections of the Winnicut, Exeter, and Cocheco Rivers but less than 30% access in all other rivers. Overall, river herring access has been restored to 42% of their historical distribution within the main stems of the region's major rivers (Figure 20.2). This represents substantial progress in meeting PREP's goal of restoring 50% of the historical distribution of river herring by 2020.

Winnicut River Fish Passage, Greenland, NH. Photo by: C. Lentz.

Why This Matters

Dams and road crossings of streams often block migratory fish from swimming upstream to reproduce and safely downstream to grow in the estuary and ocean, limiting their populations.

PREP GOAL **Restore native diadromous fish access to 50 percent of their historical mainstem river distribution range by 2020.**

There is 100% access to main-stem sections of the Winnicut, Exeter, and Cocheco Rivers but less than 30% access in all other rivers.

FIGURE 20.1 Mainstem stream miles accessible to river herring in major rivers of the Piscataqua Region

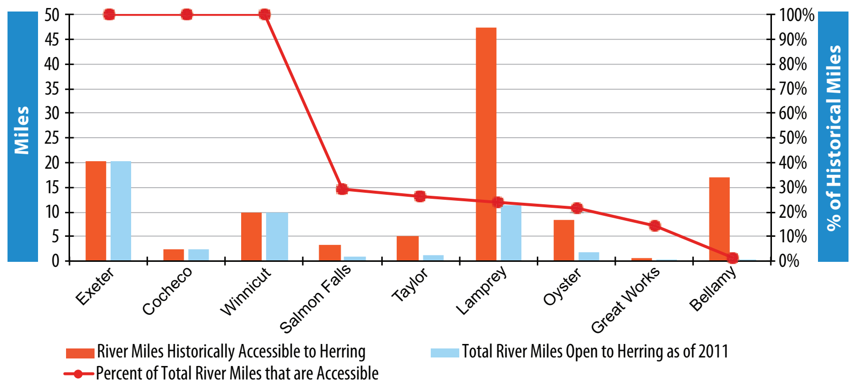
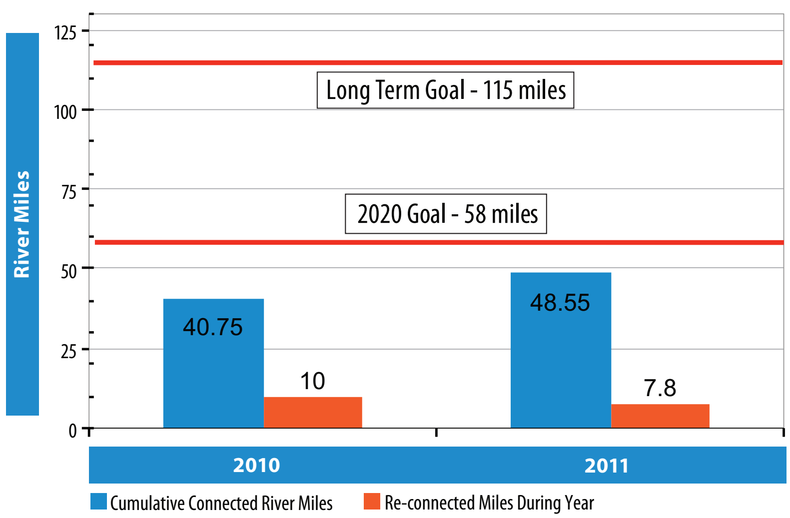


FIGURE 20.2 Upstream river miles re-connected for migratory herring on the mainstems of major rivers



Newly installed Wiswall Fish Ladder on the Lamprey River, Durham, NH. Photo by D. Cedarholm

Success Story

Returning Fish after 200 Years

Thanks to leadership from the Town of Durham, the USDA Natural Resource Conservation Service, and the New Hampshire Fish and Game Department, migratory fish from the Great Bay Estuary are now swimming upstream to habitat in the Lamprey River that they have been blocked from reaching for over 200 years. Access to at least 7.8 miles of the Lamprey River was restored by constructing a fish passage ladder over the Wiswall Dam in Durham, with initial estimates of 14,000-26,000 fish getting past the ladder in the first year.

EMERGING ISSUES & CHANGING CONDITIONS

Estuaries are complex and responsive to factors both within, and outside of, our control. By definition, an environmental indicators report is not intended to determine cause and effect. The causes of some environmental changes can be numerous, and directed research is sometimes required to better understand how the estuaries respond to stresses like pollution and losses of key habitats.

This report provides a summary of results from an extensive suite of environmental monitoring data collected and analyzed by PREP and its partner organizations. However, PREP also recognizes that there are emerging issues not fully described in this report or reflected in our current indicators that are likely to impose additional challenges to the health of our estuaries. This section of the report acknowledges some of these pressing emerging issues that are likely to need more research, monitoring, and analysis attention in the near future.

Weather and Climate

The most influential emerging issue is the fact that New England's climate is changing, and the best available scientific information indicates that climate change impacts such as sea level rise, temperature increases, and more frequent severe storm events are highly likely to continue to increase throughout the next century. These major changes to climate and weather events will substantially affect water quality, wildlife habitat, and human communities in unprecedented ways. One of the implications is that more erratic and extreme weather is to be expected and that assessing the health of our estuaries based on assumptions of historical weather and climate patterns can be misleading. Climate change impacts are likely to contribute additional stress to coastal habitats that we are working to conserve and restore. For instance, increased rainfall can transport additional contaminants such as sediments and nutrients into our estuaries. Climate change is also likely to substantially change the temperature, saltiness, and acidity in our estuaries and thereby modify many of the natural chemical and biological processes in the bays. Exactly how these changes will affect coastal habitats, shellfish, water quality, and human health is uncertain – but it is certain that they will have an important influence over the future State of Our Estuaries. To learn more about these issues refer to the 2011 report "Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future" (www.carbonsolutionsne.org).

Autumn Marsh. Photo by C. Keeley

Macroalgae

Recent major research efforts have been completed to inventory the types of macroalgae present in the Great Bay estuary, assess their abundance, and map their coverage in the bay. These efforts have led to recognition that a substantial increase in the abundance of nuisance macroalgae is an emerging problem for the bay and that increased monitoring and research effort is needed to better understand this issue.

Aquaculture

There is substantial interest in the region about the potential to responsibly develop shellfish and algae aquaculture within or adjacent to our estuaries as a way to help remove excess nutrients from the water column while also producing valuable commodities. The environmental, social, and economic costs and benefits of aquaculture scenarios is a topic of current and ongoing research interest.

Pharmaceuticals and Personal Care Products

Thousands of chemicals from pharmaceuticals and personal care products used by humans (such as prescription drugs and cosmetics) end up in sewage waste, are insufficiently removed by conventional treatment systems, and inevitably enter our nation's waterways. These chemicals have been documented in many waterways that have been studied, and some research suggests that certain chemicals may cause ecological harm. Potential negative impacts on our region's waterways are largely unknown at this time.

Did You Know

The US Drug Enforcement Administration has hosted five successful National Drug Take-Back Days over the last two years. The most recent event in September 2012 resulted in 244 tons of prescription medication being safely disposed. Citizens are able to return unused or expired prescription drugs to their local police station or other location to be sure they are disposed of properly keeping them out of our environment.

Visit www.deadiversion.usdoj.gov/drug_disposal/takeback to find out when the next take-back day is scheduled.

LOOKING AHEAD: DATA, MONITORING, AND RESEARCH NEEDS

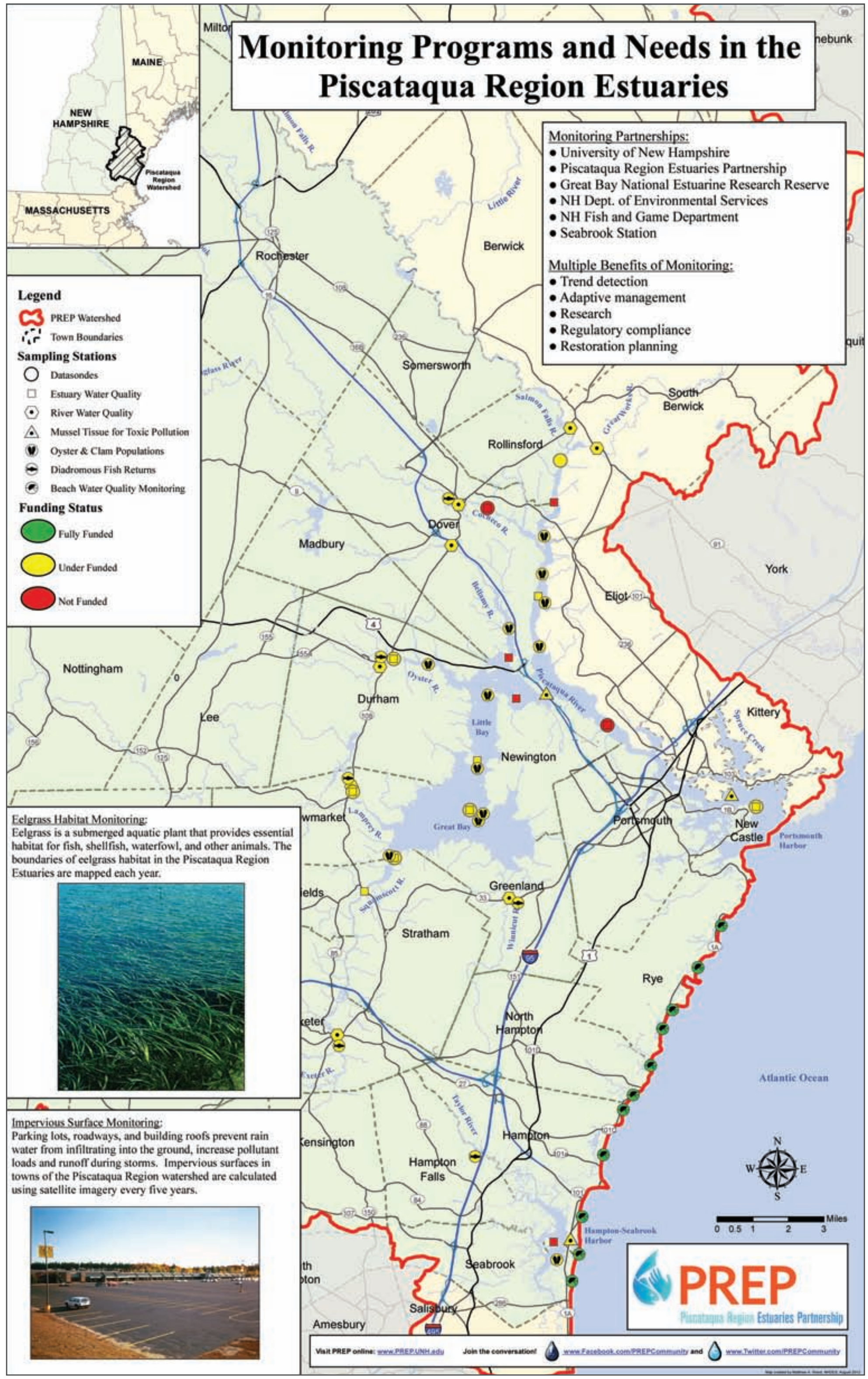
Both prior to and during the development of this report, one theme that emerged was the critical need for more data collection and research on critical topics. As we work closely with our municipal, state, private, and university partners on collecting and analyzing data, it is well understood that more data is needed to help inform some of the critical questions that are being asked about our estuaries today. PREP has worked hard since the program began in 1995 to develop and implement a diverse Monitoring Plan that synthesizes and analyzes data about our estuaries. PREP is committed to working with our partners on securing resources to address data and research gaps in an effort to provide researchers, managers and the public with accurate scientific information needed to make management decisions pertaining to the health of our estuaries.

Monitoring Needs (Data Collection)

The Piscataqua Region estuaries have been monitored by the University of New Hampshire researchers, government programs, and volunteers for decades. However, at this crucial juncture the programs that monitor the health of the estuaries need to be upgraded to answer new questions and help inform management decisions. The current system of monitoring is a mosaic of programs with shrinking funds from different federal and state sources. There is an immediate need to add stations in a number of areas throughout the system.

Research Priority Themes

Over the next three to seven years there are a number of high priority research areas needing additional work. Given how a number of indicators interrelate with one another, themes that have been identified as priority include:



- **Oyster restoration and other economically beneficial, nutrient extractive technologies**
- **Integration and expansion of stormwater management strategies**
- **Macroalgae, including its extent, new invasive species, and relationship to nutrient-uptake**
- **Nutrient and other pollutant loads and concentration variations throughout the system**
- **Changes in climatic conditions and storm events, and their impact on pollutant loading, species shifts, marsh migration, coastal resiliency, and flooding**
- **Impacts of dams and other factors on anadromous fish**
- **Sediment concentrations, sources, transport and resuspension, and ecosystem impacts**
- **Ecosystem services within and surrounding the estuaries**
- **Emerging bacterial pathogens and toxin-producing microogranisms**

A commitment to, and the required support for, increased data collection and focused research will be critical to our collective success in answering important questions about the challenges in our estuaries.

CREDITS & ACKNOWLEDGEMENTS

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END NOTES

1. See CBP (2000), Cloern (2001), Bricker et al. (2007), Burkholder et al. (2007), and CENR (2010)
2. See Bricker et al. (2007) and Diaz and Rosenberg (2008)
3. See Bricker et al. (2007), Diaz and Rosenberg (2008), and Nixon et al. (2005)
4. See Cloern (2001), Bricker et al. (2007), CERN (2010), Mathieson (2012), Valiela et al. (1997), Hauxwell et al. (2001), and McGlathery (2001)
5. See Fox et al. (2008) and Pedersen and Borum (1996)
6. See Chock and Mathieson (1983) and Hardwick-Witman and Mathieson (1983)
7. See Nettleton et al. (2011)
8. See Nettleton et al. (2011), page 82
9. See Pe'eri et al (2008)
10. See NRC (2000), Cloern (2001), Bricker et al. (2007), EPA (2001), Diaz and Rosenberg (2008)
11. See Diaz and Rosenberg (2008), Cloern (2001), and Bricker et al. (2007)
12. See Pennock (2005)
13. See HydroQual (2012)
14. See Short and Short (1984)
15. See Duarte (2001) and Heck et al. (2003)
16. See Morrison et al. (2008)
17. See Burkholder et al. (2007)

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A short guide for municipal leaders and legislators that provides a short list of priority policy options for consideration and model efforts from our own communities.

A short guide for citizens that has examples and tips on simple things everyone can do to help prevent pollution and protect the places we love.

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