EXHIBIT 19 (AR K.26)

STATE OF THE ESTUARIES

2009

WWW.PREP.UNH.EDU

PISCATAQUA REGION
Estuaries
Partnership

EXHIBIT 19 (AR K.26)

EXHIBIT 19 (AR K.26)

Every three years, PREP prepares a State of the Estuaries report that communicates the status and trends of a select group of environmental indicators for the coastal watershed and estuaries. The report provides PREP, natural resource managers, local officials, conservation organizations, and the public with information on environmental conditions and the effects of management decisions and actions.

The 2009 State of the Estuaries Report describes the status and trends of 12 primary indicators tracked by PREP. For each key indicator, the report provides the monitoring question and answer, PREP management goal, information on relevance, and an explanation of data analysis and interpretation. Additional information from other related indicators is presented to provide context or further explain trends. In total data from 28 different indicators are included in this report. About half of the indicators presented include data for Maine. Future reports will fully integrate the Maine portion of the PREP focus area.

Data for indicators presented in the 2009 State of the Estuaries Report are from PREP's 2009 Environmental Indicators Report, which is a technical, peer-reviewed document on the status and trends of all 42 indicators tracked by PREP, as defined by the Monitoring Plan. For each indicator, the PREP Monitoring Plan defines the monitoring objective, management goal, data quality objectives, data analysis and statistical methods, and data sources.

PREP's approach to implementing its Monitoring Plan and producing its environmental indicator reports relies largely on utilizing data compiled from a number of agencies and organizations involved in managing, protecting, and monitoring the region's estuaries and coastal watersheds. The interpretations of the indicators in this report were reviewed by PREP's Technical Advisory Committee and other experts in relevant fields, including university professors, researchers, and state and federal environmental managers. Therefore, the conclusions of this report represent the current scientific consensus regarding conditions in the region's estuaries and watersheds.

PISCATAQUA REGION ESTUARIES PARTNERSHIP

PREP (previously called the New Hampshire Estuaries Project) was formed in 1995, when New Hampshire's estuaries – the Great Bay Estuary and Hampton-Seabrook Estuary – were designated by the U.S. Environmental Protection Agency as "estuaries of national significance" and included in the agency's National Estuary Program. PREP is governed by a 27-person Management Committee comprised of representatives from municipalities, planning commissions, natural resource agencies, watershed groups, conservation organizations, energy producers, researchers, and anglers. Originally administered through New Hampshire agencies, the partnership moved to the University of New Hampshire in 2005.

At the end of 2007, the Management Committee voted unanimously to expand PREP's area of focus to the entire Great Bay Estuary watershed, including the 24 percent of the watershed in Maine. This shift was a critical step toward achieving the program's watershed-wide goals of improving water quality and protecting and restoring important habitats. PREP began expanding some of its programs and collaborating with Maine organizations on projects in 2008. The organization changed its name in 2009 to better reflect its focus area and approach.

PREP's original Comprehensive Conservation and Management Plan for New Hampshire's estuaries was developed through a collaborative process in 2000. For nearly 10 years, PREP and its partners implemented Management Plan actions, making progress in the areas of water quality improvement, land conservation, habitat restoration, and environmental monitoring. From 2000 to 2009, PREP spent over $4 million on projects to improve, protect, or monitor the health of the region's estuaries.

PREP currently is working with interested stakeholders to set priorities and define key actions for a new Management Plan to be released in early 2010. The updated plan lays the foundation for work over the next decade to meet new challenges in protecting and restoring the region's estuaries and coastal watersheds, so that they continue to sustain our economy, environment, and quality of life.

PISCATAQUA REGION WATERSHEDS

The watersheds of the Great Bay Estuary, Hampton-Seabrook Estuary, and the smaller New Hampshire Atlantic estuaries comprise the PREP focus area. This area covers 1,086 square miles and includes 52 towns in Maine and New Hampshire. It represents 9.4 percent of New Hampshire's land area and 0.8 percent of Maine. Twenty-two percent of the New Hampshire population and 14 percent of the combined population of New Hampshire and Maine lived in these coastal watersheds in 2005. The region's population grew from 109,861 in 1930 to 373,140 in 2005. Projected population growth rates for Rockingham and Strafford counties in New Hampshire and York County in Maine are among the highest within their respective states. Noted for its valuable water resources, cultural resources, and business and industry, the Piscataqua Region is very important to state and local economies.

EXHIBIT 19 (AR K.26)

SUMMARY OF THE STATE OF THE ESTUARIES

The environmental quality of the Piscataqua Region estuaries is declining. Eleven of the twelve environmental indicators show negative or cautionary trends. In the last State of the Estuaries Report in 2006, only seven of the twelve indicators were classified this way. There have been many successful land conservation and restoration projects, but these projects have not been able to keep pace with development and habitat loss.

The most pressing problems for the estuaries relate to population growth and the associated increases in nutrient loads and non-point source pollution.

- As the population of the watershed has grown, development has created new impervious surfaces at an average rate of nearly 1,500 acres per year. In 2005, there were 50,351 acres of impervious surfaces in the watershed, which is 7.5 percent of the watershed's land area. Nine of the 40 subwatersheds contained more than 10 percent impervious cover, which indicates the potential for degraded water quality and altered stormwater flow in these subwatersheds. Land consumption per person, a measure of sprawling growth patterns, continues to increase.
- The total nitrogen load to the Great Bay Estuary increased by 42 percent in the past five years, largely due to greater stormwater runoff and non-point source pollution loads during recent high rainfall years. In Great Bay, the concentrations of dissolved inorganic nitrogen, a major component of total nitrogen, have increased by 44 percent in the past 28 years. The negative effects of the increasing nutrient loads are evident. Water clarity has declined as shown by increasing concentrations of suspended solids and chlorophyll-a. Eelgrass habitat in the estuary has disappeared from the tidal rivers, Little Bay, and the Piscataqua River and is in steep decline in Great Bay, Portsmouth Harbor, and Little Harbor. Dissolved oxygen concentrations consistently fail to meet water quality standards in the tidal rivers.

The negative or cautionary trends for other indicators also are troubling.

- Oyster and clam populations have increased from historic lows a few years ago but are still depressed compared to historic abundance.
- Toxic contaminants affect nearly one-quarter of the estuarine sediments and concentrations of compounds associated with petroleum products are increasing in the tissues of shellfish from the Piscataqua River. The concentrations of other contaminants in shellfish tissue are declining.
- Anadromous fish returns to the estuaries are limited by various factors including water quality, passage around dams, and flooding.
- Bacteria concentrations are no longer declining and water quality standards for swimming and shellfishing are not being met in all areas.

In an attempt to counteract these trends, PREP and others have worked to conserve land, restore habitats, and eliminate pollution sources in the coastal watershed. Good progress has been made toward PREP goals for land conservation and salt marsh restoration. By the end of 2008, 76,269 acres in the coastal watershed (11.3 percent) had been permanently protected from development and 280 acres of salt marsh had been restored in New Hampshire. The PREP goals for these indicators are 15 percent and 300 acres, respectively. However, despite significant efforts, restoration goals for submerged habitats (oyster reefs and eelgrass) are not being achieved.

The Piscataqua Region estuaries retain many positive attributes and serve important ecological functions. Restoration of habitats and water quality still can be achieved. However, the increasing pressures of development in the watershed will need to be matched with increasing effort and awareness to reduce pollutant loads and protect habitats.

EXHIBIT 19 (AR K.26)

INDICATOR SUMMARY

Indicator	Question	Answer	Implication/ Trend
Dry weather bacteria concentrations	Have fecal coliform bacteria levels in the Great Bay Estuary changed over time?	Yes. Fecal coliform bacteria concentrations in Great Bay decreased significantly in the 1990s, but have not changed in the past 10 years. Water quality standards for swimming and shellfishing are not being met in all areas.	⚠
Toxic contaminants in shellfish tissue	Have concentrations of toxic contaminants in the tissues of shellfish changed over time?	Yes. The concentrations of polycyclic aromatic hydrocarbons, a component of petroleum products, have increased by 51% in Portsmouth Harbor and by 218% in the Piscataqua River over the past 16 years. The concentrations of other contaminants are declining.	⚠
Toxic contaminants in sediment	Do sediments in the estuaries contain toxic contaminants that might harm benthic organisms?	Yes. Contamination was found in 24% of estuarine sediment. However, organisms living in the sediments might be adversely affected by toxic contaminants in only 2.8% of the estuaries.	⚠
Nitrogen in Great Bay	Have nitrogen concentrations in Great Bay changed significantly over time?	Yes. The total nitrogen load to the Great Bay Estuary increased by 42% in the past five years. Dissolved inorganic nitrogen concentrations have increased in Great Bay by 44% in the past 28 years.	⊖
Dissolved oxygen	How often do dissolved oxygen levels in the Great Bay Estuary fall below state standards?	Rarely in the bays and harbors, but often in the tidal rivers.	⚠
Eelgrass	Has eelgrass habitat in the Great Bay Estuary changed over time?	Yes. Eelgrass cover in the Great Bay itself has declined by 37% between 1990 and 2008 and has completely disappeared from the tidal rivers, Little Bay, and the Piscataqua River.	⊖
Oysters	Has the number of adult oysters in the Great Bay Estuary changed over time?	Yes. The number of adult oysters fell by 95% in the 1990s. The population has increased slowly from a low point in 2000.	⊖
Clams	Has the number of adult clams in Hampton-Seabrook Harbor changed over time?	Yes. The current number of adult clams is 64% of the average level from 1971 to 2000.	⚠
Anadromous fish	Has the number of anadro-mous fish returning to Piscataqua Region coastal rivers changed over time?	Returning anadromous fish populations are limited by various factors including water quality, passage around dams, and flooding.	⚠
Habitat restoration	Are habitats being restored?	Yes for salt marsh, though oyster and eelgrass habitats have been restored at a slower rate.	⚠
Impervious surfaces	How much of the Piscataqua Region watershed is covered by impervious surfaces?	In 2005, 7.5% of the land area of the entire watershed was covered by impervious surfaces, and 9 subwatersheds had greater than 10% impervious surface cover.	⊖
Land conservation	How much of the Piscataqua Region watershed is protected from development?	At the end of 2008, 76,269 acres in the Piscataqua Region watershed were protected, which amounted to 11.3% of the land area.	⊕

Key to Implication/Trend Classifications:

⊕ **Positive**

The trend or status of the indicator demonstrates improving conditions, generally good conditions, or substantial progress relative to the management goal.

⚠ **Cautionary**

The trend or status of the indicator demonstrates possibly deteriorating conditions; however additional information or data are needed to fully assess the observed conditions or environmental response.

⊖ **Negative**

The trend or status of the indicator demonstrates deteriorating conditions, generally poor conditions, or minimal progress relative to the management goal.

EXHIBIT 19 (AR K.26)

Have fecal coliform bacteria levels in the Great Bay Estuary changed over time?

Yes. Bacteria levels in Great Bay decreased significantly in the 1990s but have not changed in the past 10 years. Water quality standards for swimming and shellfishing are not being met in all areas.

PREP GOAL

Achieve water quality in the Great Bay Estuary and Hampton-Seabrook Harbor that meets shellfish harvest standards by 2010.

WHY THIS IS IMPORTANT

Fecal coliform bacteria in surface waters may indicate the presence of pathogens due to sewage contamination. Pathogens, which are disease-causing microorganisms, pose a public health risk and are the primary reason why shellfish beds are closed to harvesting.

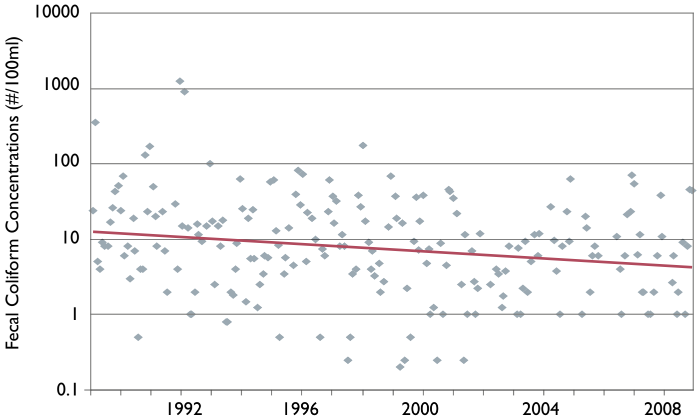
EXPLANATION

Dry weather fecal coliform contamination is an indication of sewage contamination from faulty septic systems, overboard marine toilet discharges, wastewater treatment facility failures, cross connections between sanitary sewer and stormwater systems, pet waste, livestock, wildlife, re-suspension of contaminated sediments, and residual stormwater-related pollution. At the three long-term water quality monitoring stations in the Great Bay and its tributaries, there has been a decrease in the fecal coliform bacteria concentrations during dry weather over the past 20 years. For example, in the middle of Great Bay at Adams Point, fecal coliform bacteria concentrations decreased by 66 percent between 1989 and 2008 (Figure 1). Even steeper declines were observed at stations in the tributaries. Waste-water treatment facility upgrades and removal of sewage inputs from stormwater sewer systems are likely major contributors to the long-term decreasing trend.

In contrast to the long-term trend, fecal coliform concentrations have remained relatively constant in the past 10 years. The reasons why bacteria concentrations are no longer declining are not clear. The concentrations may be approaching background levels, bacteria source reduction efforts may be stalling, or there may be new loads that offset successful reduction efforts.

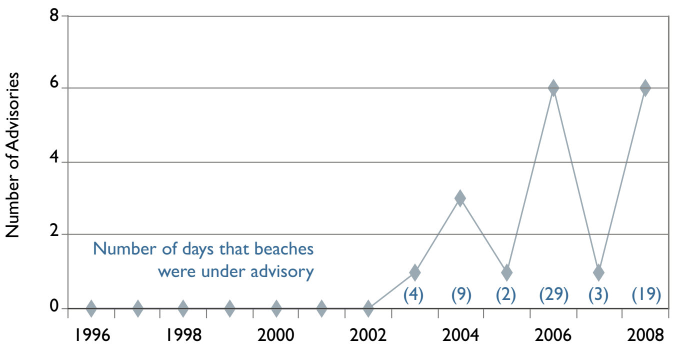
There are still many closures of shellfish beds due to bacterial pollution, particularly after rain events. In 2008, the different shellfish growing areas in New Hampshire were open to harvesting from 36 to 51 percent of the possible shellfish harvesting acre-days. Poor water quality prompted six advisories at four tidal beaches in New Hampshire for a total of 19 days in 2008 (Figure 2). Finally, in the 2006-2007 probabilistic survey for water quality, bacteria concentrations were greater than the water quality standard for swimming in 10 percent of the estuarine waters.

Fecal coliform bacteria concentrations during dry weather at Adams Point in Great Bay (Figure 1)



Data Source: UNH Jackson Estuarine Laboratory

Number of advisories at tidal beaches in New Hampshire 1996-2008 (Figure 2)



Data Source: NHDES Beach Program

OPTICAL BRIGHTENER DETECTION STUDY

The Spruce Creek estuary in Kittery and Eliot, Maine, has experienced chronic bacterial contamination from a number of sources, and this has restricted shellfish harvesting. Assessments have helped to identify some sources and efforts have been undertaken to remedy known sources. Through a PREP-funded project, the Spruce Creek Association and the Town of Kittery are performing additional studies to more accurately identify other suspected illicit discharges and sources of fecal contamination. The work is being coordinated with USEPA Region 1 and the Maine Healthy Beaches Program.

As part of their study, they will test for "optical brighteners" using state-of-the-art methods. Optical brighteners, which are used in laundry detergents, are fluorescent white dyes that absorb ultraviolet light and emit back visible blue light. This property makes optical brighteners effective at masking any yellowing that may be present in cotton fabrics. Optical brighteners generally are found in domestic waste water that has a component of laundry effluent. Optical brightener detection has become a useful method to identify human waste water discharges from faulty septic systems, leaking sewer pipes, and storm drain cross-connections and to differentiate between likely human and animal bacteria sources.

Later in 2009 a field crew organized by the Spruce Creek Association will use fluorometers to detect optical brighteners and associated pollution sources in their local waters. Identified sources will be addressed through the Town's "Spruce Creek Watershed Improvement Project," which is a comprehensive remediation program funded through the Maine Department of Environmental Protection's Nonpoint Source Pollution Program.

PREP

New Hampshire Department of Environmental Services staff sampling for bacteria in Hampton-Seabrook Harbor

EXHIBIT 19 (AR K.26)

Have concentrations of toxic contaminants in the tissues of shellfish changed over time?

Yes. The concentrations of PAHs have increased by 51 percent in Portsmouth Harbor and by 218 percent in the Piscataqua River over the past 16 years. Concentrations of other contaminants are declining.

PREP GOAL

Reduce toxic contaminant levels in indicator species to below FDA guidance values.

WHY THIS IS IMPORTANT

Mussels, clams, and oysters accumulate toxic contaminants from polluted water in their tissues. In addition to being a public health risk, the contaminant level in shellfish tissue is a long-term indicator of water quality in the estuaries.

EXPLANATION

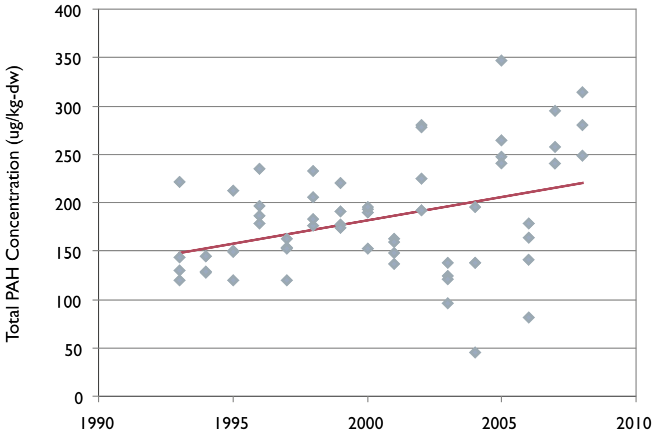
The Gulf of Maine Council's Gulfwatch Program uses blue mussels (*Mytilus edulis*) as the indicator species for shellfish bioaccumulation of toxic contaminants. Between 1993 and 2008, 20 stations in the Great Bay Estuary and Hampton-Seabrook Harbor have been tested at least once for toxic contaminants 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. Because shellfish collect toxic contaminants in their flesh when they feed by filtering water, the acceptable levels of contaminants in these creatures suggest that the concentrations of toxic contaminants in estuarine waters are of minimal concern in most of the estuary. The compound of concern in South Mill Pond is lead, which has been increasing in concentration since 1999. Cadmium, zinc and aluminum concentrations have also increased in South Mill Pond, although they still are below guidelines.

Mussel tissue samples from Portsmouth Harbor, Hampton-Seabrook Harbor, and Dover Point have been tested repeatedly between 1993 and 2008 to detect trends. The only increasing trends for a toxic contaminant were for polycyclic aromatic hydrocarbons (PAHs) at the stations in Portsmouth Harbor and at Dover Point. PAHs are components of petroleum products that may be introduced to the environment through fuel spills and combustion. In Portsmouth Harbor, the PAH concentrations have gradually increased by 51 percent between 1993 and 2008 (Figure 3). In contrast, PAH concentrations at Dover Point jumped to much higher concentrations in 2005 and 2007 (Figure 4). These peak concentrations appear to be from dredging that stirred up old contaminated sediments and fuel spills, respectively.

All of the other statistically significant trends for toxic contaminants were decreasing. Polychlorinated biphenyl concentrations have decreased by 52 to 57 percent. Concentrations of the pesticide DDT have declined by 36 to 50 percent. Lead concentrations fell by 29 to 38 percent. These trends reflect the decreased usage of these contaminants due to product bans and pollution prevention programs.

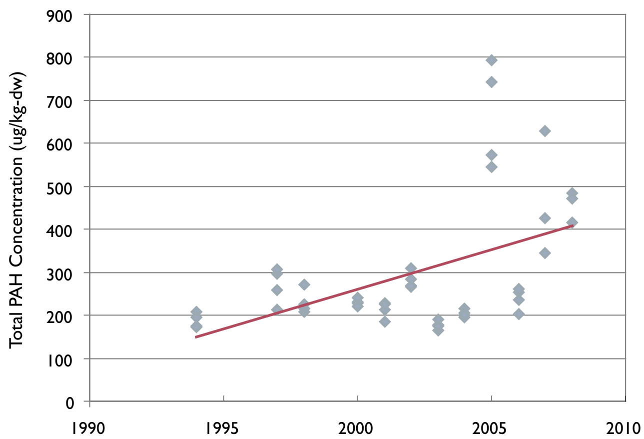
EXHIBIT 19 (AR K.26)

Total PAH concentrations in mussel tissue in Portsmouth Harbor (Figure 3)



Data Source: NH Gulfwatch Program

Total PAH concentrations in mussel tissue at Dover Point (Figure 4)



Data Source: NH Gulfwatch Program

PREP

Collection of blue mussels for testing

LEGACY POLLUTANTS AND EMERGING CONTAMINANTS

"Legacy pollutants" are chemicals, often used or produced historically by industry, which persist in the environment for long periods of time, frequently associated with sediments. They have the potential to bioaccumulate, meaning that they build up in animal tissues as they progress up the food web. Examples of legacy pollutants include lead, mercury, DDT, and PCBs. In many cases, use of these chemicals has been banned or significantly regulated now that their environmental impacts are better understood. The Gulf of Maine Council's Gulfwatch Program tests for a number of these legacy pollutants that previously were used, and to varying degrees, still persist throughout estuaries in the Gulf of Maine.

Scientists distinguish between legacy pollutants and "emerging contaminants" found in everyday products like pharmaceuticals and personal care products (PPCPs), herbicides, and pesticides. Pharmaceuticals, including prescription and over-the-counter drugs, are not fully absorbed by our bodies and make their way into discharges from septic systems and wastewater treatment facilities. In addition, unused medications often are flushed down the sink or toilet. Personal care products such as lotions, cosmetics, sunscreens, and house cleaning products are rinsed down the drain. Typical treatment systems are not designed to eliminate PPCPs from effluent.

Many PPCPs include persistent chemicals and compounds that remain biologically active after they leave the body or are disposed of in landfills and waters. Now ubiquitous in aquatic environments, at least in trace amounts, emerging contaminants pose potential threats to human and environmental health, although impacts are not fully documented and understood. Some organizations have initiated programs to provide better information on disposal options to consumers to prevent unused medications from going down the drain, however PPCP collection and disposal programs are uncommon.

EXHIBIT 19 (AR K.26)

Do sediments in the estuaries contain toxic contaminants that might harm benthic organisms?

Yes. Contamination was found in 24 percent of estuarine sediment. However, organisms living in the sediments might be adversely affected by toxic contaminants in only 2.8 percent of the estuaries.

PREP GOAL

No impacts to benthic communities due to sediment contamination.

WHY THIS IS IMPORTANT

Toxic contaminants accumulate in estuarine sediments, and therefore organisms living in the sediments are especially at risk of being impacted by these pollutants. Furthermore, toxic contaminant concentrations in sediments can provide information on both historical and current pollution in the estuaries.

EXPLANATION

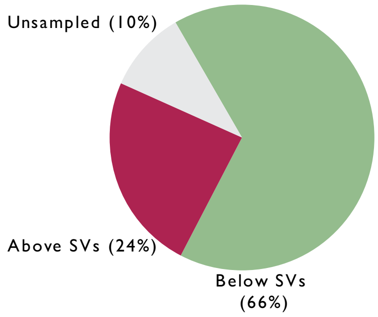
Approximately 24 percent of the estuarine sediments tested in 2002-2005 had at least one contaminant at a concentration greater than a screening value (Figure 5). Concentrations above screening values have the potential to pose a threat to organisms that live in the sediments. Elevated levels of contamination were found mainly in the tidal rivers. The chemicals that exceeded screening values were chromium, copper, mercury, lead, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls, and the pesticides DDT, lindane, and dieldrin. Of these compounds, PAHs, which are components of petroleum products and combustion, were the most common contaminants. The types of PAHs found in the sediments indicate that the source of the PAHs was not recent fuel spills, but rather combustion or historic contamination.

Screening values were set conservatively; therefore, concentrations above screening values do not necessarily mean that organisms in the sediments will be affected by the contaminants. Actual effects on benthic organisms were determined using sediment toxicity and benthic community surveys. These tests showed that the organisms in the sediments were affected by toxic contaminants in only 2.8 percent of the estuary (Figure 6). Impacts to benthic organisms were observed in the Lamprey River, Squamscott River, Spruce Creek, and Hampton-Seabrook Harbor (Figure 7). PAHs were the contaminant in the Lamprey River, Squamscott River, and Spruce Creek. The contaminant in Hampton-Seabrook Harbor was lindane (a pesticide).

The absence of apparent effects on organisms in the sediments does not necessarily mean all aquatic species are unaffected. First, the sediment toxicity and benthic community surveys are only capable of detecting large impacts to the benthic community. More subtle impacts might have been missed. Second, benthic organisms are just one of many possible aquatic species groups. For bioaccumulative compounds, such as mercury and PCBs, species in higher trophic levels could be at risk even if impacts to benthic organisms are not observed. Finally, the sediments have only been tested for the typical suite of toxic contaminants, not for new classes of chemicals which are emerging as possible threats, such as pharmaceuticals and personal care products.

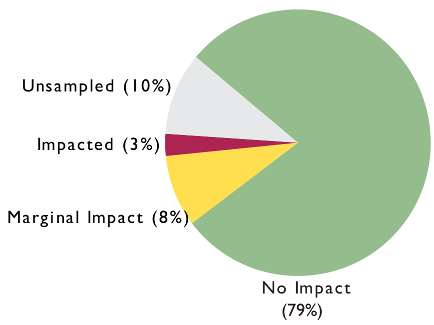
EXHIBIT 19 (AR K.26)

Concentrations of toxic contaminants relative to screening values (SVs) (Figure 5)



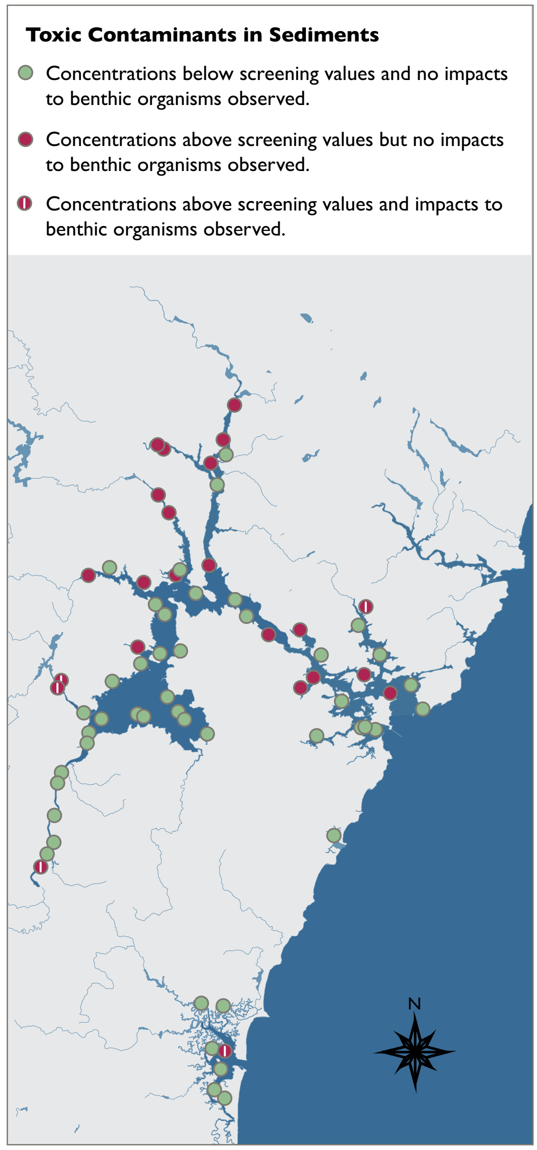
Data Source: NCA Survey (2002-2005) by EPA, NHDES, and UNH

Effects of toxic contaminants on benthic organisms (Figure 6)



Data Source: NCA Survey (2002-2005) by EPA, NHDES, and UNH

Locations of toxic contaminants in sediments and impacts to benthic organisms (Figure 7)



Data Source: NCA Survey (2002-2005) by EPA, NHDES, and UNH

NATIONAL COASTAL ASSESSMENT

The National Coastal Assessment (NCA) monitoring program, established by the U.S. Environmental Protection Agency, uses a probabilistic design to monitor ecological response and diagnostic indicators. Conducted across all the country's estuaries, the NCA provides nationally comparable data to determine the condition of our nation's ecosystems.

For the NCA sampling design, all estuarine waters in the Great Bay Estuary and the Hampton-Seabrook Estuary were covered by a grid of 82 equally sized hexagons. The grid of hexagons covered 21.7 square miles of estuarine waters in New Hampshire and Maine. Within each hexagon, one randomly determined sampling station was monitored. The location was randomly chosen with each subsequent round of sampling. The probabilistic survey allows data managers to extrapolate sampling results to all estuarine resources with measured confidence limits.

Parameters analyzed at each station include water physiochemistry (temperature, salinity, pH, dissolved oxygen, water clarity); water quality (nitrogen, phosphorus and silica species; total suspended solids, chlorophyll-a); sediment quality (toxic contaminants, sediment toxicity, total organic carbon, grain size); toxic contaminant concentrations in fish tissues; habitat (occurrence of submerged aquatic vegetation, macroalgae, others); and finfish abundance.

The survey was conducted by UNH and NHDES with financial support from USEPA annually from 2000 through 2006, after which time the agency moved to monitoring estuaries once every four to five years. From 2007 through 2009, PREP and NHDES supported the NCA monitoring program for water quality parameters to continue these long-term datasets so that important trends could be detected.

EXHIBIT 19 (AR K.26)

Have nitrogen concentrations in Great Bay changed significantly over time?

Yes. The total nitrogen load to the Great Bay Estuary increased by 42 percent in the past five years. Dissolved inorganic nitrogen concentrations have increased in Great Bay by 44 percent in the past 28 years.

PREP GOAL

Maintain inorganic nutrients in the Great Bay Estuary, Hampton-Seabrook Harbor, and their tributaries at 1998-2000 baseline levels.

WHY THIS IS IMPORTANT

Excessive nitrogen can cause algae blooms and change species composition of important habitats. Furthermore, decomposition of algae can deplete coastal waters of dissolved oxygen. Both of these effects will impair estuarine functions.

EXPLANATION

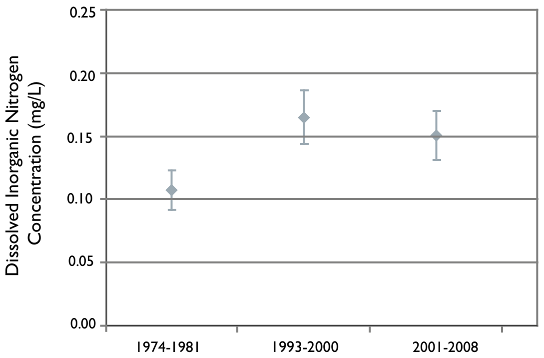
The long-term trends for nitrogen and other parameters in the estuary were determined by comparing monitoring data from 1974-1981 to data from 2001-2008. Dissolved inorganic nitrogen concentrations at Adams Point in Great Bay increased by 44 percent between these two periods (Figure 8). Suspended solids and chlorophyll-a concentrations also increased by 123 and 28 percent, respectively (Figures 9 and 10). Statistically significant increasing trends were also observed for nitrate/nitrite, suspended solids, and chlorophyll-a concentrations at Adams Point using the monthly samples that have been collected since 1988. The increases in suspended solids and chlorophyll-a are likely related to the nitrogen trend; however, other factors might have contributed to the increase including the loss of filter feeders such as oysters to disease in the mid-1990s.

The nitrogen load to the Great Bay Estuary was estimated to be 1,558 tons per year in 2006-2008 (Figure 11). Wastewater treatment facilities contributed 31 percent of the total amount. The largest component of the nitrogen load was non-point sources in the watershed tributaries and from the land adjacent to the estuary (65 percent). Non-point sources of nitrogen include lawn fertilizers, septic systems, animal wastes, and atmospheric deposition to land. Direct discharge from groundwater and direct atmospheric deposition represented relatively small overall contributions of nitrogen to the estuary. The major sources of nitrogen are all related to population growth and associated land development patterns.

The nitrogen load to the Great Bay Estuary increased by 42 percent from 1,097 tons per year in 2002-2004 to 1,558 tons per year in 2006-2008. The majority of this increase can be attributed to increased non-point source runoff due to higher rainfall in 2006-2008 than in 2002-2004. The rate of increased loading closely matches the observed changes in total nitrogen concentrations in the estuary. In the six years between 2003 and 2008, total nitrogen concentrations increased by 24 percent at Adams Point in Great Bay and 47 percent at the Coastal Marine Laboratory in Portsmouth Harbor.

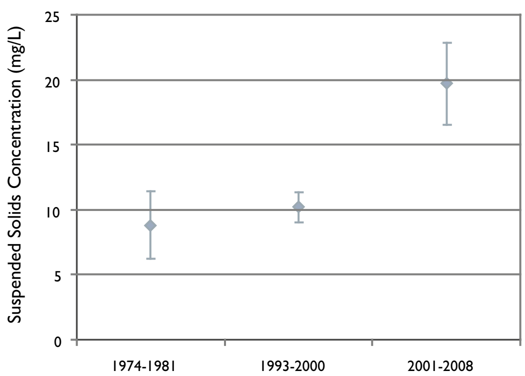
EXHIBIT 19 (AR K.26)

Dissolved inorganic nitrogen concentrations measured at Adams Point at low tide (Figure 8)



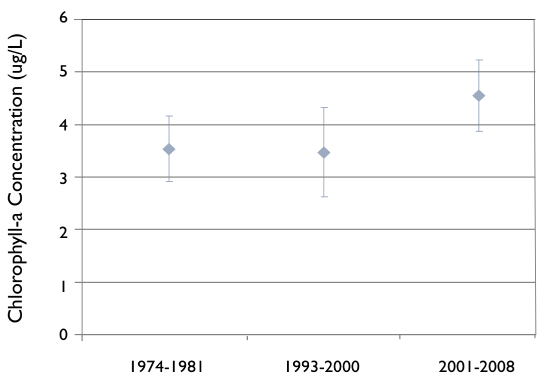
Data Source: UNH Jackson Estuarine Laboratory

Suspended solids concentrations measured at Adams Point at low tide (Figure 9)



Data Source: UNH Jackson Estuarine Laboratory

Chlorophyll-a concentrations measured at Adams Point at low tide (Figure 10)



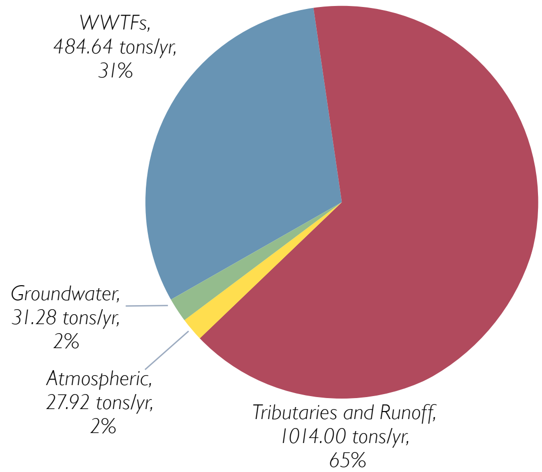
Data Source: UNH Jackson Estuarine Laboratory

Key to figures 8, 9, and 10:

◆ Average concentration for the period

I 95th percentile confidence interval

Total nitrogen loads to the Great Bay Estuary from different sources in 2006-2008 (Figure 11)



Data Source: PREP (2009)

NUTRIENT CRITERIA FOR THE GREAT BAY ESTUARY

There is consensus that the Great Bay Estuary is starting to experience the negative effects of excess nitrogen. Increasing chlorophyll-a concentrations indicate increased algae and phytoplankton populations. Nuisance macroalgae was found to have replaced eelgrass in 5.7 percent of the Great Bay in 2007. Dissolved oxygen concentrations in the tidal rivers consistently fall below state standards. Eelgrass cover and biomass are declining throughout the estuary. This suite of effects prompted the New Hampshire Department of Environmental Services (NHDES) to partner with PREP in 2005 to develop numeric water quality criteria for nitrogen for the estuary.

PREP staff and the PREP Technical Advisory Committee led this four-year effort, which culminated in proposed numeric criteria intended to protect eelgrass and prevent low dissolved oxygen levels. The numeric criteria will first be used for water quality assessments required by Section 305(b) of the Clean Water Act. Later, NHDES will promulgate these values as water quality criteria in the state's surface water quality regulations.

EXHIBIT 19 (AR K.26)

How often do dissolved oxygen levels in the Great Bay Estuary fall below state standards?

RARELY IN THE BAYS AND HARBORS, BUT OFTEN IN THE TIDAL RIVERS.

PREP GOAL

Reduce the number of days when dissolved oxygen concentrations violate state water quality standards to zero.

WHY THIS IS IMPORTANT

Fish and many other aquatic organisms need dissolved oxygen in the water to survive. Prolonged periods of low dissolved oxygen can alter aquatic ecosystems.

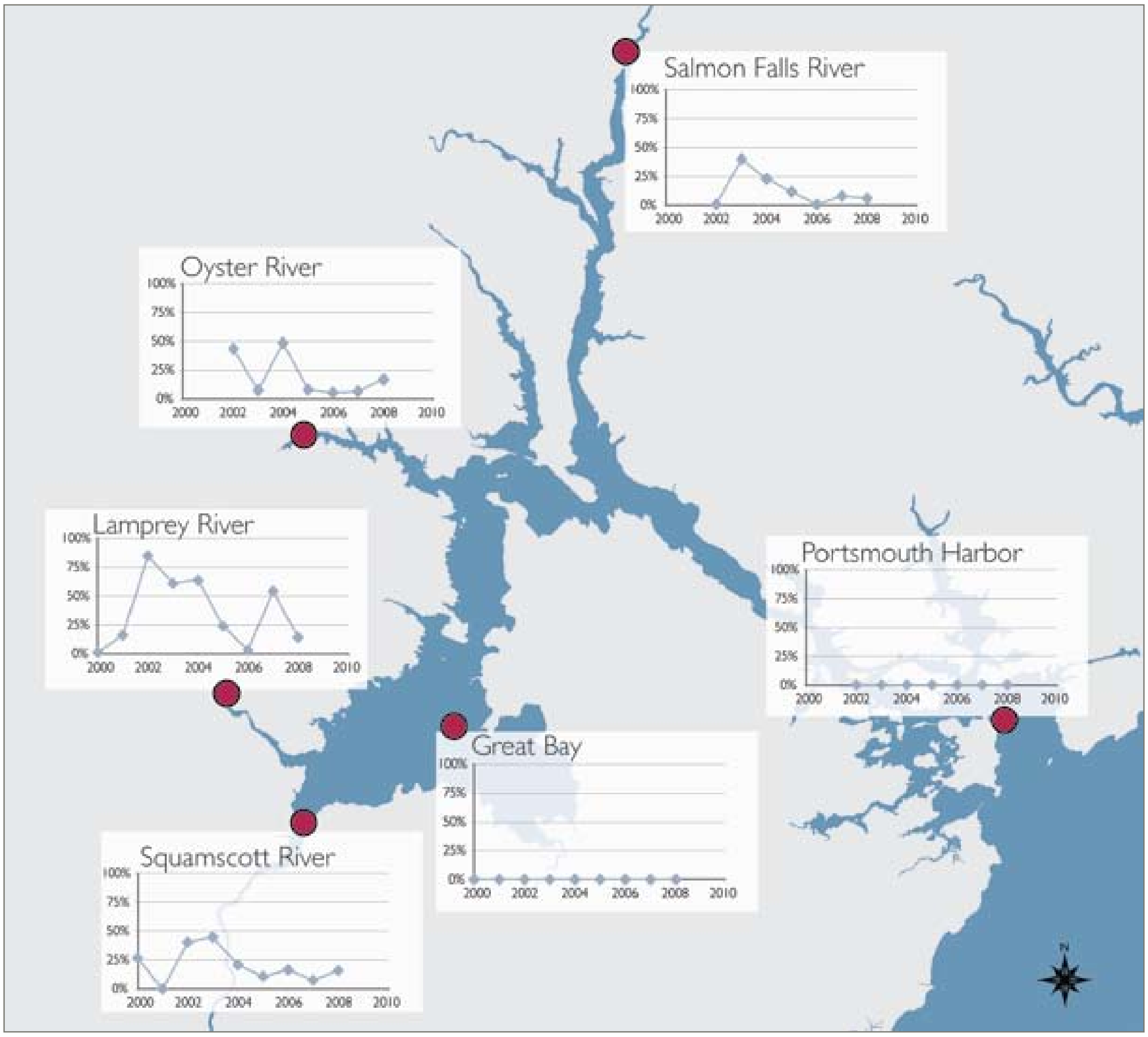
EXPLANATION

The Great Bay National Estuarine Research Reserve and PREP support the maintenance of instruments, called datasondes, at six locations in the Great Bay Estuary to monitor dissolved oxygen and other parameters every 15 to 30 minutes. The measurements are used to determine the daily minimum and daily average dissolved oxygen concentrations at each station. The sampling stations are located in the middle of Great Bay, Portsmouth Harbor, and in the tidal tributaries to the Great Bay Estuary. The dissolved oxygen concentrations in Great Bay and Portsmouth Harbor consistently meet state standards for both the daily minimum and daily average dissolved oxygen. In contrast, violations of both standards have been consistently observed at stations in the tidal tributaries (Figure 12). In 2008, the daily minimum dissolved oxygen at stations in tidal rivers fell below the standard (5 mg/L) on five to 16 percent of summer days. Likewise, the daily average dissolved oxygen at tidal river stations fell below the standard (75 percent saturation) on two to 13 percent of summer days in 2008. The most violations have been observed in the Lamprey River.

Strong tidal flushing through the estuary and inflow from freshwater streams appear to mix and oxygenate the water in the large embayments effectively. The causes of sporadic low dissolved oxygen concentrations in the tidal tributaries are unknown. Some possible explanations are algae blooms, benthic organism respiration, and oxygen demand from wastewater treatment facility effluent. In some cases low concentrations may be natural phenomena.

EXHIBIT 19 (AR K.26)

Datasonde stations and trends in the percent of summer days with minimum dissolved oxygen less than 5 mg/L at each datasonde station in the Great Bay Estuary (Figure 12)



Data Source: Great Bay National Estuarine Research Reserve, UNH Jackson Estuarine Laboratory

IMPOUNDED RIVER SYSTEMS

Tributary rivers to the region's estuaries are altered by a number of man-made freshwater impoundments created by dams. While some dams serve important functions by supplying water for human use and generating hydropower, all impede natural river flows and functions to varying degrees. Dams artificially impact water flow, sediment and nutrient transport, river morphology, and habitat connectivity. The water quality in many impoundments also is degraded. One problem in particular is low dissolved oxygen levels, especially for impoundments located in highly developed watersheds with high volumes of stormwater runoff.

Impoundments slow down water movement and increase the residence time for nutrients and other pollutants. The increased residence time makes it more likely for nutrients from the watershed to stimulate excessive growth of algae in the reservoirs. When algae die, the decay process uses up oxygen dissolved in the water. The turbidity caused by decomposing algae and suspended sediment can cause further problems for plants, fish, and other aquatic life. Dissolved oxygen problems are exacerbated by higher water temperatures of impoundments relative to free-flowing rivers. Water can hold less dissolved oxygen at higher temperatures.

Increases in temperature and decreases in dissolved oxygen affect the water quality of the impoundment and the quality of the river downstream. Low levels of dissolved oxygen in impoundments is one factor believed to be limiting migratory fish populations. Low dissolved oxygen and turbid conditions also can result in species shifts to often less desirable species that are more tolerant of poor water quality.

EXHIBIT 19 (AR K.26)

Has eelgrass habitat in the Great Bay Estuary changed over time?

Yes. Eelgrass cover in the Great Bay itself has declined by 37 percent between 1990 and 2008 and has completely disappeared from the tidal rivers, Little Bay, and the Piscataqua River.

PREP GOAL

Maintain habitats of sufficient size and quality to support populations of naturally occurring plants, animals, and communities.

WHY THIS IS IMPORTANT

Eelgrass (*Zostera marina*) is essential to estuarine ecology because it filters nutrients and suspended particles from water, stabilizes sediments, provides food for wintering waterfowl, and provides habitat for juvenile fish and shellfish, as well as being the basis of an important estuarine food web. Healthy eelgrass both depends on and contributes to good water quality. Excess nitrogen contributes to eelgrass loss by increasing phytoplankton blooms which decrease water clarity and by promoting the proliferation of macroalgae.

EXPLANATION

The UNH Seagrass Ecology Group has mapped the distribution of eelgrass every year from 1986 to 2008 in the Great Bay. The entire Great Bay Estuary was mapped by these researchers in 1996 and from 1999 through 2008. The eelgrass cover in 2008 is shown in Figure 13.

In 1989, there was a dramatic crash of the eelgrass beds in the Great Bay down to 300 acres (15 percent of normal levels). The cause of this crash was an infestation of a slime mold, *Labyrinthula zosterae*, commonly called "wasting disease" (Muehlstein et al., 1991). The eelgrass beds recovered following the infestation but have experienced a slow, steady decline since their recovery. Between 1990 and 2008, the eelgrass cover in Great Bay declined by 37 percent (Figure 14). In 2007 and 2008, no eelgrass was found in Little Bay. All of the eelgrass in the Winnicut River was lost between 1990 and 2008. Eelgrass has only been occasionally detected with low abundance in the other tributaries to Great Bay and Little Bay. However, historical maps indicate that eelgrass formerly existed in these rivers (NHDES, 2008).

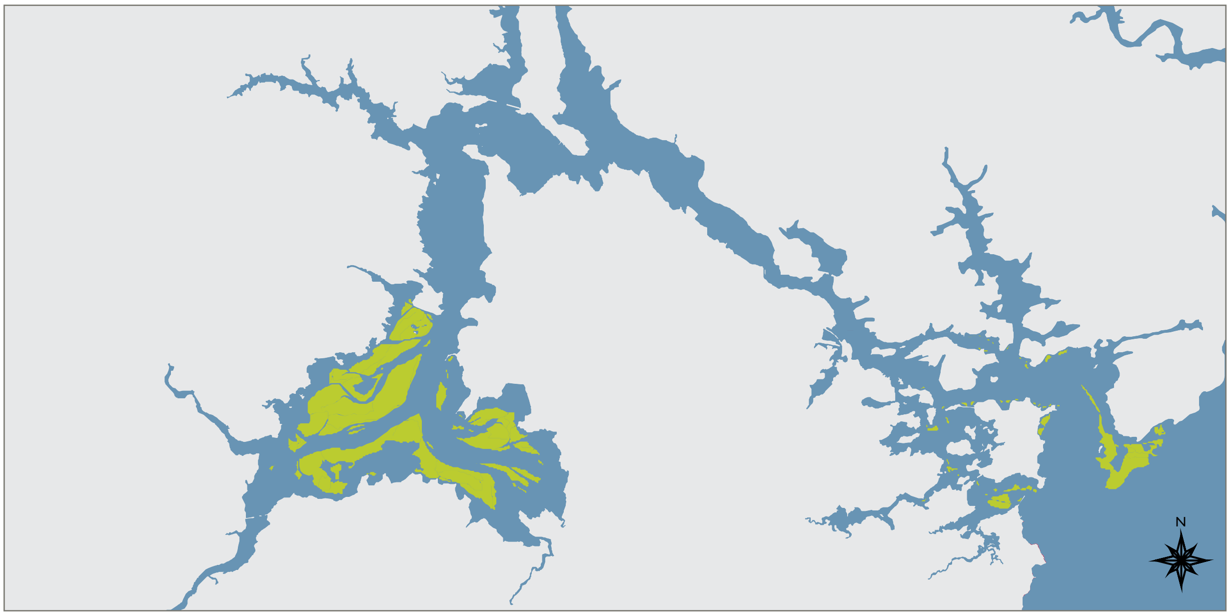
Another very troubling finding is that eelgrass cover in both Portsmouth Harbor and Little Harbor is also declining. The water quality in these areas is generally considered to be the best within the estuary. Nevertheless, the area of eelgrass beds in Portsmouth Harbor and Little Harbor declined by 24 percent and 30 percent, respectively, between 1996 and 2008.

The eelgrass populations in the upper and lower reaches of the Piscataqua River have also declined to nearly zero in 2008. The remaining beds are all near the mouth of the river, south of the Memorial Bridge (Route 1), near Seavey Island. Although high variability precludes the detection of statistically significant trends, the nearly complete loss of eelgrass from all the assessment zones in the Piscataqua River clearly indicates a declining trend for this area.

Eelgrass biomass has experienced a more significant decline than eelgrass cover (Figure 15). Biomass is the combined weight of eelgrass plants in the estuary. For example, between 1990 and 2008, the eelgrass biomass in Great Bay has declined by 64 percent.

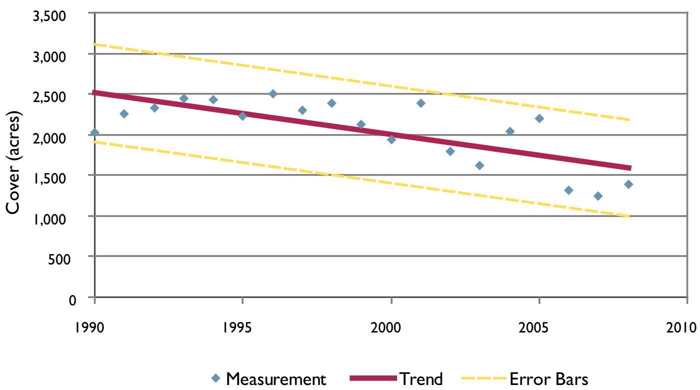
EXHIBIT 19 (AR K.26)

Eelgrass cover in the Great Bay Estuary in 2008 (Figure 13)



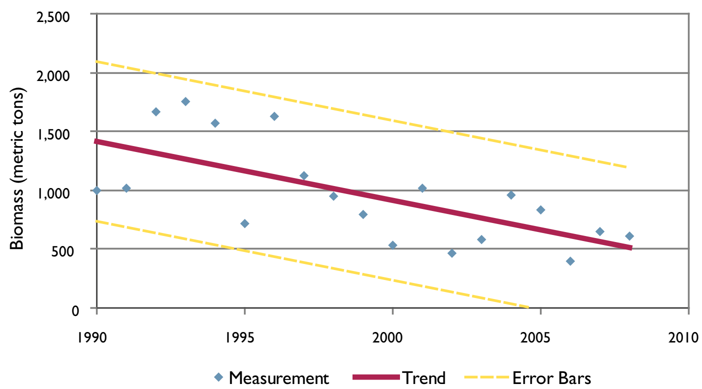
Data Source: UNH Jackson Estuarine Laboratory, Seagrass Ecology Group

Eelgrass cover in Great Bay (Figure 14)



Data Source: UNH Jackson Estuarine Laboratory, Seagrass Ecology Group

Eelgrass biomass in Great Bay (Figure 15)



Data Source: UNH Jackson Estuarine Laboratory, Seagrass Ecology Group

CONSERVATION MOORINGS

Docks, piers, and boats in coastal waters can affect underwater habitats in a number of ways – both directly by destroying or altering habitat and indirectly by shading and increasing turbidity. Eelgrass, in particular, is vulnerable to such impacts. Boat moorings can negatively impact eelgrass if the mooring is situated in or near an eelgrass bed.

In a traditional mooring system, the chain drags and scours seagrass as the boat swings from wind and wave action. In extreme cases, circles devoid of any vegetation appear in mooring fields around the anchor sites. Additionally, turbidity may be increased from chain scour and affect nearby eelgrass.

Newer designs for moorings that are often labeled "conservation" moorings are intended to have a lesser impact on the estuary bottom. Conservation moorings eliminate the chain and have no moving parts that contact the seabed floor thereby eliminating scour. The design of one type of conservation mooring includes heavy-duty elastic polyurethane bands attached to a post deeply anchored on the bottom and connected to a mooring buoy. The elastic line never touches the bottom.

The potential for reducing impacts from moorings is significant. In New Hampshire there are more than 1,500 moorings in 29 mooring fields registered with the Division of Ports and Harbors. However, more information is needed about conservation moorings and the potential of eelgrass to recover and thrive if conservation moorings are used in new locations or if traditional moorings are replaced. Several demonstration projects currently being conducted in New England may provide quantifiable data in the near future.

EXHIBIT 19 (AR K.26)

Has the number of adult oysters in the Great Bay Estuary changed over time?

YES. THE NUMBER OF ADULT OYSTERS FELL BY 95 PERCENT IN THE 1990S. THE POPULATION HAS INCREASED SLOWLY FROM A LOW POINT IN 2000.

PREP GOAL

50,000 bushels of adult oysters (>80 mm) in the major beds of the Great Bay Estuary.

WHY THIS IS IMPORTANT

Oysters are a keystone species in the estuarine ecosystem. They are relatively long-lived, stationary filter feeders that play important roles in nutrient cycling and water clarity. They also provide food and habitat for other species in the estuary. They are economically important because they support valuable recreational fisheries and have potential as an aquaculture species.

EXPLANATION

The New Hampshire Fish and Game Department (NHFGD) has monitored the oyster populations in the six major reefs in New Hampshire since 1993. Data on oyster populations in Maine tidal waters were not available in time for this report.

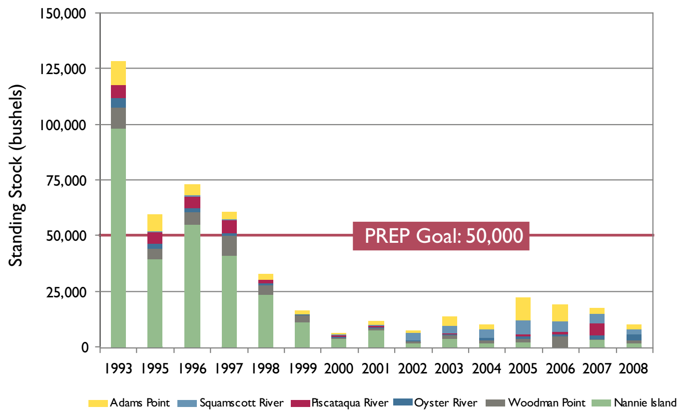
Data from 1993 to 2008 illustrate that the oyster fishery in Great Bay has suffered a considerable decline (Figure 16). The 2008 standing stock of adult oysters (>80 mm) is approximately 20 percent of the management goal of 50,000 bushels of adult oysters. There was a precipitous fall from over 125,000 bushels in 1993 to 6,174 bushels in 2000. The major cause of this decline is thought to be the protozoan pathogens MSX and Dermo which have caused similar declines in oyster fisheries in the Chesapeake and other mid-Atlantic estuaries. Since 2000, the adult oyster standing stock has grown slightly to 10,044 bushels.

NHFGD has monitored the prevalence of the diseases MSX and Dermo in oysters from the Great Bay every year since 1995. There has been no apparent trend in MSX infection rates since the disease was first detected (Figure 17). Approximately 27 percent of the oysters in Great Bay were infected with MSX at some level in 2008. However, starting in 2002, the prevalence of Dermo infections has increased from zero to greater than 60 percent (Figure 17). The increase in Dermo prevalence may be the result of warming water temperatures or acclimatization of the parasite to local conditions. These two diseases, in combination with other factors, limit the survival of oysters into adult size classes.

It is expected that the adult oyster populations will increase starting in 2009. In 2006, there was a large oyster spat set, which is when oyster larvae in the water attach themselves to oyster beds. This was followed the next year with another good set. Some of the spat from 2006 and 2007 have survived and become juvenile oysters on beds in the Great Bay Estuary. These juvenile oysters may approach the adult size (>80 mm) for the 2009 survey. The 2006 spat set is already contributing to increased numbers of spawning oysters greater than 60 mm in size (Figure 18).

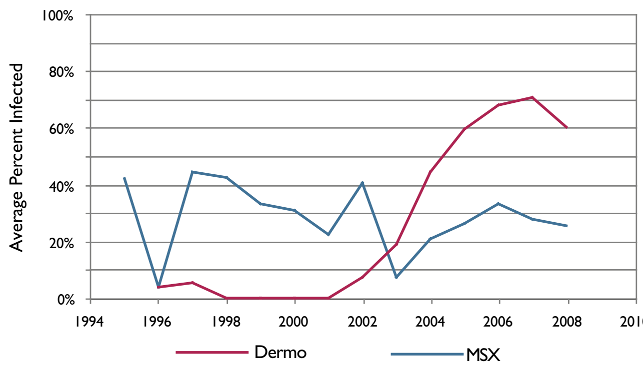
EXHIBIT 19 (AR K.26)

Standing stock of adult oysters (>80 mm) in the Great Bay Estuary (Figure 16)



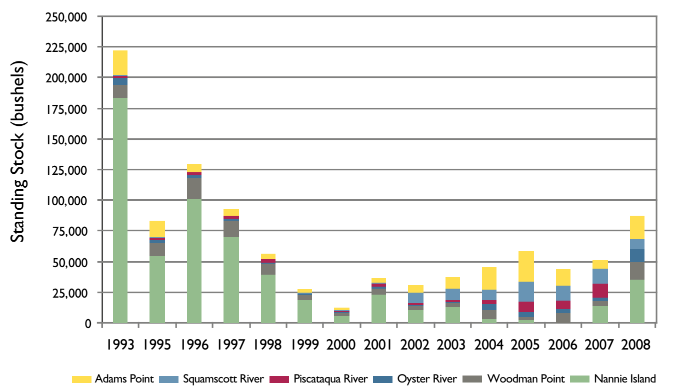
Data Source: NH Fish and Game Department

Average MSX and Dermo infection prevalence in Great Bay oysters at all beds (Figure 17)



Data Source: NH Fish and Game Department

Standing stock of spawning oysters (>60 mm) in the Great Bay Estuary (Figure 18)



Data Source: NH Fish and Game Department

OYSTER REEF RESTORATION

Healthy oyster populations provide significant water quality benefits, due to an oyster's filtering capacity of 20-30 gallons of water per day under optimum conditions. Oyster reefs also are an important habitat for other estuarine species. Reefs provide large surface areas and form a complex ecosystem within which other creatures can attach, forage, and hide.

With funding from PREP and the New Hampshire Coastal Program, the University of New Hampshire conducted a project to restore oyster habitat and evaluate impacts on other estuarine species. A total of 1.2 million oyster spat placed on recycled oyster shells were used to construct 12 mini-reefs, each 5-7 meters in diameter, in a 1.75-acre area just north of Nannie Island in Great Bay in August 2007. Oyster densities and other species' use of the restored reefs and two adjacent natural reefs were evaluated over an 18-month period.

The Nannie Island area, in general, experienced increased oyster densities over the project period due in large part to the exceptional 2006 natural recruitment observed throughout Great Bay. The oyster densities on the restored reef area were about 35 percent greater than on the natural reef areas at the conclusion of the sampling in May 2009. The enhanced oyster densities resulted in improved habitat for other species. Total species richness was similar in all three areas, averaging about 20 total species of plants, invertebrates and fish present on reefs in each area. However, macroalgal biomass typically was two to four times greater on the restored mini-reefs compared to the natural reefs. Invertebrate densities and biomass also were substantially greater on the mini-reefs.

OYSTER BED MAPPING IN MAINE

In 2008 the University of New Hampshire conducted a PREP-funded study to characterize and map the boundaries of oyster bottom in portions of the Upper Piscataqua River, Sturgeon Creek, and Spruce Creek. Most of these areas had not been surveyed since the 1970s. Underwater video in conjunction with GIS technology was used to map areas of significant "shell bottom." Video footage of nearly 7.5 miles identified several areas containing oyster shells and one sizeable active bed at the mouth of Sturgeon Creek in Eliot, Maine. This bed is 15.6 acres and ranks third in size relative to other oyster beds in the Piscataqua region.

EXHIBIT 19 (AR K.26)

Has the number of adult clams in Hampton-Seabrook Harbor changed over time?

Yes. The current number of adult clams is 64 percent of the average number from 1971 to 2000.

PREP GOAL

Maintain or exceed the 1971 to 2000 average standing stock of 8,500 bushels of adult clams (>50 mm) in Hampton-Seabrook Harbor flats.

WHY THIS IS IMPORTANT

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 New Hampshire's economy (PREP, 2000).

EXPLANATION

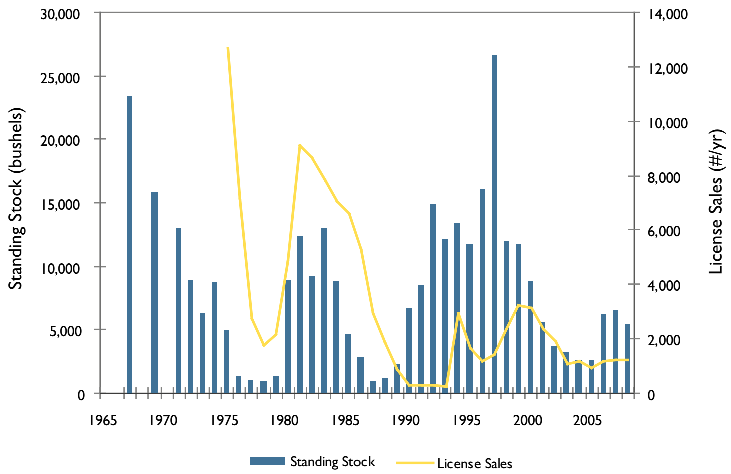
The number of adult clams (>50 mm) in Hampton-Seabrook Harbor, also known as standing stock, has been monitored by Seabrook Station over the past 38 years (Figure 19). The standing stock has undergone several 12-15 year cycles of growth and decline. Peak standing stocks of approximately 23,000, 13,000, and 27,000 bushels occurred in 1967, 1983, and 1997, respectively. Between the peaks, there have been crashes of the fishery in 1978 and 1987, with standing stock less than 1,000 bushels. From 1997 to 2004, the standing stock dropped once again to 2,600 bushels. In the last three years, however, the population has rebounded to 5,432 bushels (64 percent of the goal).

A PREP-funded study in 2001-2002 concluded that predation of juvenile clams by green crabs and strong currents in the harbor were potential factors limiting soft-shell clam populations (Beal, 2002). Recreational harvest is another possible factor. Clam harvest license sales are a good indication of harvest pressure. The oscillations in license sales generally follow similar patterns as the clam standing stock (Figure 19). This relationship indicates that recreational clam harvesting pressure can get high enough to limit clam populations. For example, the number of license sales reached peak values of greater than 9,000 before the two major crashes of the fishery in the late 1970s and late 1980s. Clam populations rebounded during the period from 1989 to 1994 when harvest was prohibited because of water quality concerns. Clam standing stock has grown under the current level of harvest pressure. The number of license sales in 2003-2008 has stabilized at approximately 1,100. Harvest is further limited by restrictions enacted in 2003 by the New Hampshire Fish and Game Department which only allow clam harvesting on Saturdays.

"Clam spatfall" refers to the event when clam larvae settle out of the water column to the sediments. It is critical to have good spatfalls on a clam flat in order to recruit new clams which can then grow into adults. Figure 20 illustrates that clam spatfall in Hampton-Seabrook Harbor has fluctuated on approximately four year intervals over the past 30 years. Very large spatfalls occurred in the late 1970s and early 1980s. After an unusually low spatfall in 2006, the spatfall in 2008 rebounded to one of the highest on record.

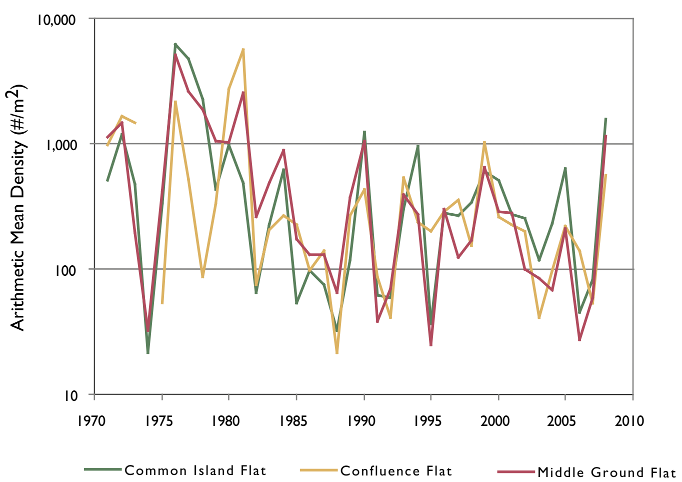
EXHIBIT 19 (AR K.26)

Clam standing stock in Hampton-Seabrook Harbor and harvest license sales in New Hampshire (Figure 19)



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

Average clam spat density in Hampton-Seabrook Harbor (Figure 20)



Data Source: NextEra Energy Seabrook Station

CLAM NEOPLASIA

Another factor affecting clam populations may be Sarcomatous neoplasia (neoplasia), which is a form of leukemia in soft-shell clams. The disease is normally fatal in clams, although some lightly infected clams can recover. It is harmless to humans and other creatures that consume infected clams. Within a clam, the disease causes an increased number of malformed blood cells that, in turn, increases its need for oxygen. During warmer months when oxygen in the water is at its lowest levels, diseased clams can suffocate in the mud. Clammers cannot tell if a clam has neoplasia simply by looking at it. Sometimes, but not always, an infected clam will be lethargic and slow to withdraw into its shell when handled. For a definitive diagnosis, a clam blood sample must be analyzed in a laboratory.

In 1986, neoplasia was first discovered in clams from Hampton-Seabrook Harbor. Monitoring conducted by Seabrook Station indicated that by 1989, 80 percent of the clams from one of the major flats had neoplastic cells. Between 2002 and 2008, the prevalence of any neoplasia infection typically ranged from 50 to 75 percent of clams.

Researchers at the University of New Hampshire currently are examining the prevalence of neoplasia throughout the region's estuaries. They are collecting and testing hundreds of clams from numerous areas in New Hampshire and Maine with the goal of understanding the extent of the disease and to see if there is a correlation between the disease and contaminated sediments.

PREP

Digging clams in the Hampton-Seabrook Estuary

EXHIBIT 19 (AR K.26)

Has the number of anadromous fish returning to Piscataqua Region coastal rivers changed over time?

Returning anadromous fish populations are limited by various factors including water quality, passage around dams, and flooding.

PREP GOAL

Maintain habitats of sufficient size and quality to support populations of naturally occurring plants, animals, and communities.

WHY THIS IS IMPORTANT

Anadromous fish migrate from the ocean to fresh water to spawn. These species need suitable spawning and rearing habitat in the rivers and streams to thrive, and both upstream and downstream passage past dams. Therefore, anadromous fish returns are dependent on environmental conditions of watershed =streams and barriers to both upstream and downstream migration.

EXPLANATION

Several species of anadromous fish return to the rivers of the Piscataqua Region watersheds to spawn. The New Hampshire Fish and Game Department (NHFGD) has monitored returns of river herring (*Alosa pseudoharengus, Alosa aestivalis*), American shad (*Alosa sapidissima*), and Atlantic salmon (*Salmo salar*) to rivers in the New Hampshire portion of the watershed. Data on returns to the Maine portion of the watershed were not available in time for this report.

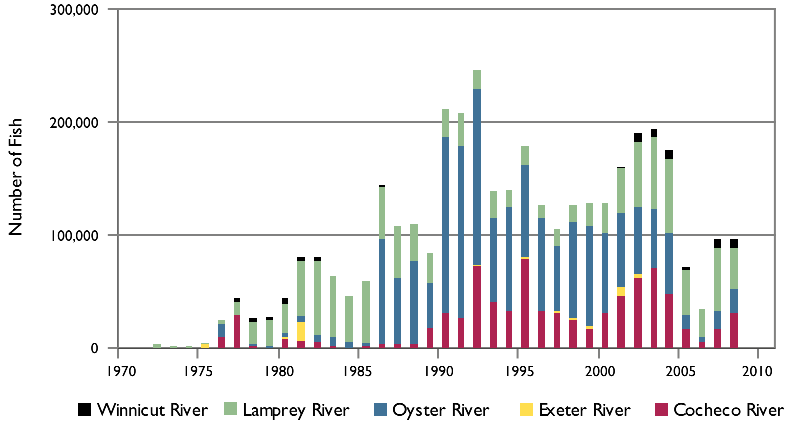
The largest remaining runs of anadromous fish are for river herring. River herring returns to the rivers of the Great Bay Estuary have been combined in Figure 21. This figure illustrates growth of the returns during the 1970s and 1980s with the installation of and improvements in fish ladders, followed by a period of relative stability in the 1990s. There has been a general decline in river herring returns in recent years. This decline is likely due to a combination of natural fluctuations in populations, realization of a river's carrying capacity, fish passage inefficiencies, possible over-harvest in some river systems, water quality degradation, and high water conditions. Returns can be improved through ladder improvements as shown in the Exeter and Winnicut, however, those improvements do not compensate for poor water quality within upstream impoundments. The Taylor River, in Hampton-Seabrook Harbor, has had the highest recorded returns of herring (Figure 22). However, this population has declined dramatically. The decline is most likely due to a combination of water quality deterioriation and habitat degradation.

American shad returns to the Exeter River have been decreasing since 2001. Returns to the Lamprey and Cocheco Rivers have been minimal as well leaving only a small residual spawning stock. Only 11 shad returned to New Hampshire rivers in 2008. Similar to river herring, the declines in shad returns are likely due to flood waters, impoundment water quality degradation, and lack of downstream passage.

Very few Atlantic salmon are currently returning to rivers in New Hampshire. Between 1992 and 2003, only 44 salmon were recorded returning to fish ladders. NHFGD discontinued Atlantic salmon fry stocking programs in 2004.

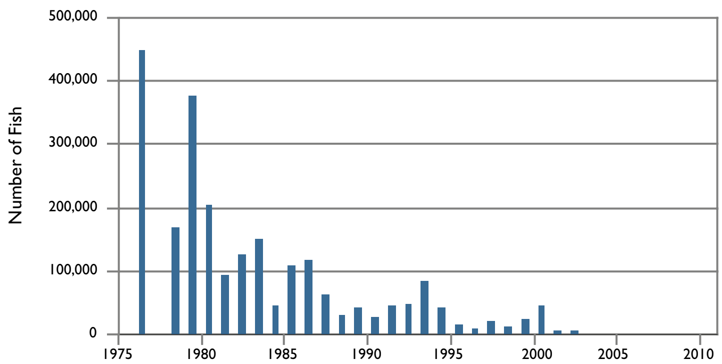
EXHIBIT 19 (AR K.26)

Returns of river herring to fish ladders in the Great Bay Estuary (Figure 21)



Data Source: NH Fish and Game Department

Returns of river herring to the fish ladder on the Taylor River (Figure 22)



Data Source: NH Fish and Game Department

DAM REMOVAL

Authors of the Great Bay Estuary Restoration Compendium identified the historic and current distributions of seven migratory fish species and habitat miles that could be accessed with barrier removal or improved fish passage at dams. One hundred ninety (190) dams on Great Bay Estuary tributary rivers and streams were identified. Prior to dam construction, river herring (alewife and blueback herring) were most likely present in nearly every stream connected to the estuary except where natural barriers or inadequate streamflow prevented access. The Compendium notes significant differences between historic and current distributions of river herring for the Bellamy, Oyster, and Lamprey River watersheds, in particular.

Head-of-tide dams are found on all the major river systems draining to the Great Bay Estuary. These dams, along with upstream dams and culverts, can block access to fish habitat. Fish ladders, which are used on some dams, provide upstream access to habitat for some fish species during certain flow conditions.

The removal of the Winnicut River dam in Greenland will eliminate the only dam on the main stem of the river. This project was one of 50 selected nationally to receive American Recovery and Reinvestment Act stimulus funds through the National Oceanic and Atmospheric Administration habitat restoration program. Led by the NH Coastal Program and the NH Fish and Game Department, the project involves removing the Winnicut Dam and installing a fish passage structure upstream under the Route 33 bridge. Scheduled for late summer 2009, the project will reopen access to nearly 40 miles of habitat for migratory fish like alewife, blueback herring, and American eel.

B. Gratwicke

River herring have been excluded from many historic spawning areas by dams and culverts

EXHIBIT 19 (AR K.26)

Are habitats being restored?

Yes for salt marsh, though oyster and eelgrass habitats have been restored at a slower rate.

PREP GOAL

Restore 300 acres of salt marsh through tidal restriction removal, 20 acres of oyster beds, and 50 acres of eelgrass beds by 2010.

WHY THIS IS IMPORTANT

Historic data suggest that salt marshes, oyster beds, and eelgrass habitats in the region's estuaries have been degraded or destroyed over time. Restoration efforts attempt to restore the function of these critical habitats.

EXPLANATION

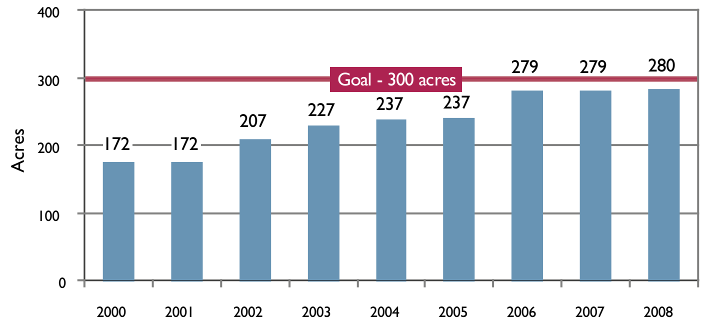
There has been significant progress toward the goal of restoring 300 acres of salt marsh by 2010 (Figure 23). The current tally of salt marsh restoration projects by tidal restriction removal since January 1, 2000 is 280 acres (93 percent of the goal). This indicator tracks restoration effort in terms of acres for which restoration was attempted. The area of functional habitat created by restoration projects has not been determined and may be lower.

Habitat restoration projects for oyster beds and eelgrass also have been completed, although many additional acres are needed to meet the PREP management goals of 20 acres and 50 acres, respectively. Eight oyster restoration projects have been implemented in the Great Bay Estuary and have resulted in a total of 6.6 restored acres of oyster bed, which is 33 percent of the PREP goal (Figure 24). Since 2000, 8.1 acres of eelgrass restoration projects have been completed, which is 16 percent of the goal (Figure 25). As with salt marsh restoration, these indicators track restoration effort in terms of acres for which restoration was attempted. The area of functional habitat created by restoration projects may be lower.

The restoration totals listed above are only for New Hampshire projects. Data on restoration projects in Maine were not available in time for this report.

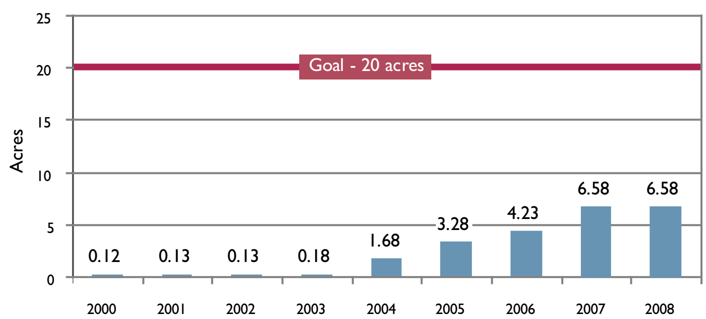
EXHIBIT 19 (AR K.26)

Cumulative acres of salt marsh restoration through tidal restriction removal (Figure 23)



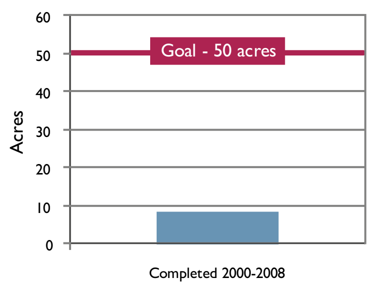
Data Source: PREP (2009)

Cumulative acres of oyster bed restoration (Figure 24)



Data Source: PREP (2009)

Cumulative acres of eelgrass bed restoration (Figure 25)



Data Source: PREP (2009)

RESTORATION PARTNERSHIP

In 2007, PREP, in coordination with The Nature Conservancy and the NH Coastal Program, began the process of developing a collaborative partnership to increase the pace and scale of restoration to improve the sustainability of the region's estuaries. Two years later, the Partnership to Restore New Hampshire's Estuaries achieved a milestone of garnering official support from nine parties through the signing of a Memorandum of Understanding.

Participating organizations include the National Oceanic and Atmospheric Administration National Marine Fisheries Service, New Hampshire Department of Environmental Services through its Coastal Program and Watershed Assistance Section, New Hampshire Fish and Game Department through its Marine Division and Great Bay National Estuarine Research Reserve, Piscataqua Region Estuaries Partnership, The Nature Conservancy, University of New Hampshire Marine Program, U.S.D.A. Natural Resources Conservation Service, and U.S. Fish and Wildlife Service's Fisheries Program and Partners for Fish & Wildlife Program.

The Restoration Partnership brings together a broad base of expertise, capacity, and local knowledge to advance restoration goals and better coordinate activities and resources. The group is in the process of developing baseline information for a number of potential restoration sites, setting priorities, and developing action plans. The Restoration Partnership will implement and provide technical assistance for restoration projects as well as foster peer review of project designs.

PREP

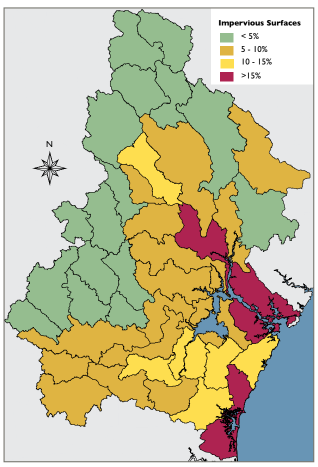
In the last nine years, 280 acres of salt marsh have been restored by tidal restriction removal

EXHIBIT 19 (AR K.26)

How much of the Piscataqua Region watershed is covered by impervious surfaces?

In 2005, 7.5 percent of the land area of the watershed was covered by impervious surfaces, and 9 subwatersheds had greater than 10 percent impervious surface cover.

Impervious surface cover in Piscataqua Region subwatersheds (Figure 26)



Data Source: UNH Complex Systems Research Center

PREP GOAL

Keep the coverage of impervious surfaces in coastal watersheds less than 10 percent.

WHY THIS IS IMPORTANT

Impervious surfaces such as paved parking lots, roadways, and building roofs increase the pollutant load, sediment load, volume, and velocity of stormwater flowing into the estuaries. Studies conducted in other regions of the country have demonstrated water quality deterioration where impervious surfaces cover greater than 10 percent of the watershed area (CWP, 2003). In 2005, a study in New Hampshire demonstrated the percent of urban land use in stream buffer zones and the percent of impervious surface in a watershed can be used as indicators of stream quality (Deacon et al., 2005).

EXPLANATION

The percent of impervious surfaces in each of the Piscataqua Region subwatersheds in 2005 is shown in Figure 26. The subwatersheds with greater than 10 percent impervious surfaces are along the Atlantic Coast and up the Route 16 corridor along the Cocheco River.

Overall, the area of impervious surfaces has grown from 28,710 acres in 1990 to 42,618 acres in 2000 to 50,351 acres in 2005. On a percentage basis, 4.3 percent, 6.3 percent, and 7.5 percent of the land area in the watershed was covered by impervious surfaces in 1990, 2000, and 2005, respectively (Figure 27). The number of watersheds with greater than 10 percent impervious surface cover was two in 1990, eight in 2000, and nine in 2005. In 2005, 16 of the 52 municipalities in the watershed had greater than 10 percent impervious surface cover.

Between 1990 and 2000, 13,908 acres of impervious surfaces were added to the watershed (1,391 acres per year). Impervious surfaces were added at a slightly higher rate between 2000 and 2005 (1,547 acres per year). All of these summary statistics show that impervious surfaces continue to be added to the watershed at a steady rate of nearly 1,500 acres per year, which amounts to 0.2 percent of the land area in the watershed each year.

The median imperviousness per capita for the 52 municipalities in the watershed grew from 0.128 acres per person in 1990 to 0.172 acres per person in 2000 to 0.188 acres per person in 2005 (Figure 28). The median value for 2005 was higher than the median of the PREP goals for the individual municipalities (0.169 acres per person). These statistics are clear evidence that land consumption per person in the Piscataqua Region watersheds is still increasing. Town-by-town information on impervious surfaces for 1990, 2000, and 2005 is shown in Figure 29.

Watershed summary statistics presented is this report differ from those in the 2006 State of the Estuaries Report due to the addition of the Maine portion of the watershed.

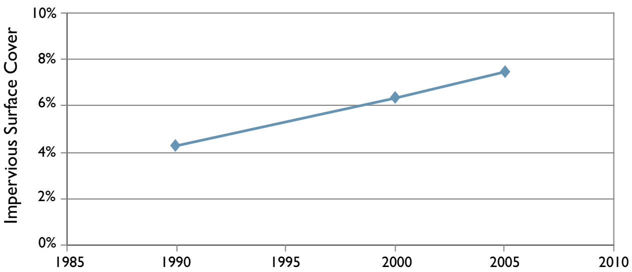
EXHIBIT 19 (AR K.26)

Percent of land area covered by impervious surfaces and impervious surfaces per capita for coastal municipalities in 1990, 2000, and 2005 (Figure 29)

Town	Percent Imperviousness			Imperviousness per Capita (acres per person)			
	1990	2000	2005	1990	2000	2005	Goal
Acton	1.5	2.5	2.9	0.217	0.278	0.305	0.269
Barrington	2.6	4.0	4.7	0.124	0.159	0.170	0.154
Berwick	2.6	4.4	5.4	0.103	0.166	0.178	0.157
Brentwood	5.0	7.7	9.5	0.205	0.259	0.277	0.238
Brookfield	1.0	1.3	1.4	0.269	0.316	0.300	0.297
Candia	2.7	4.1	4.8	0.149	0.203	0.224	0.197
Chester	2.5	4.3	5.1	0.157	0.190	0.184	0.174
Danville	3.5	6.0	7.2	0.103	0.111	0.122	0.110
Deerfield	1.5	2.4	3.0	0.157	0.209	0.236	0.198
Dover	11.0	15.4	18.6	0.075	0.098	0.112	0.098
Durham	4.7	7.2	7.7	0.057	0.081	0.083	0.082
East Kingston	3.5	5.3	7.0	0.164	0.188	0.197	0.170
Eliot	4.1	7.4	9.2	0.098	0.157	0.181	0.153
Epping	4.0	6.5	7.8	0.127	0.196	0.213	0.186
Exeter	7.5	11.0	12.4	0.075	0.098	0.106	0.098
Farmington	3.0	4.2	4.7	0.120	0.167	0.170	0.160
Fremont	3.0	4.9	5.9	0.128	0.153	0.165	0.147
Greenland	6.7	10.5	12.5	0.164	0.222	0.250	0.216
Hampton	14.2	19.3	20.6	0.096	0.107	0.112	0.107
Hampton Falls	4.4	6.9	9.1	0.227	0.285	0.345	0.272
Kensington	3.2	5.0	6.2	0.149	0.200	0.230	0.193
Kingston	5.2	8.2	9.7	0.116	0.174	0.195	0.169
Kittery	8.1	11.8	13.8	0.098	0.141	0.151	0.137
Lebanon	1.8	3.0	3.7	0.147	0.210	0.235	0.200
Lee	3.7	5.8	6.6	0.125	0.179	0.191	0.174
Madbury	3.4	5.3	5.3	0.179	0.261	0.237	0.247
Middleton	1.8	2.5	3.0	0.173	0.197	0.208	0.183
Milton	2.8	4.0	4.7	0.162	0.215	0.227	0.203
New Castle	21.4	30.7	33.9	0.129	0.153	0.166	0.152
New Durham	1.7	2.4	2.8	0.232	0.283	0.297	0.266
Newfields	3.1	5.5	6.8	0.160	0.162	0.194	0.160
Newington	13.2	18.0	20.2	0.694	1.214	1.305	1.167
Newmarket	5.9	8.8	10.1	0.067	0.088	0.089	0.089
North Berwick	2.2	3.5	4.2	0.139	0.198	0.212	0.187
North Hampton	7.3	10.8	12.4	0.178	0.225	0.241	0.216
Northwood	2.4	3.4	4.0	0.136	0.168	0.181	0.162
Nottingham	1.5	2.3	2.8	0.152	0.187	0.193	0.174
Portsmouth	21.3	27.3	30.5	0.082	0.131	0.148	0.131
Raymond	5.3	8.0	9.3	0.112	0.153	0.170	0.151
Rochester	8.5	11.7	13.9	0.090	0.116	0.132	0.115
Rollinsford	5.7	8.1	9.3	0.100	0.144	0.167	0.145
Rye	7.3	11.0	12.8	0.127	0.169	0.196	0.169
Sandown	3.8	6.1	7.9	0.083	0.106	0.123	0.105
Sanford	5.8	9.0	10.0	0.087	0.132	0.142	0.131
Seabrook	14.1	21.3	27.1	0.123	0.152	0.183	0.149
Somersworth	12.3	16.4	20.2	0.068	0.089	0.107	0.089
South Berwick	2.3	3.9	4.7	0.082	0.119	0.132	0.117
Strafford	1.4	2.0	2.3	0.146	0.176	0.183	0.169
Stratham	6.5	10.1	12.9	0.127	0.154	0.176	0.149
Wakefield	3.5	4.8	5.6	0.287	0.288	0.302	0.272
Wells	3.8	6.0	7.4	0.177	0.233	0.268	0.224
York	4.3	7.1	8.3	0.153	0.192	0.217	0.188

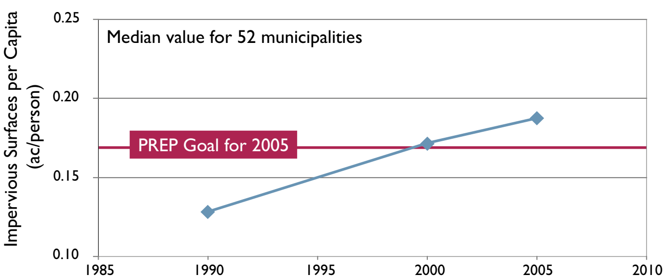
Data Source: UNH Complex Systems Research Center

Percent of land area covered by impervious surfaces in the Piscataqua Region watershed in 1990, 2000 and 2005 (Figure 27)



Data Source: UNH Complex Systems Research Center

Impervious surfaces per capita, median for municipalities in the Piscataqua Region watershed (Figure 28)



Data Source: UNH Complex Systems Research Center

CULVERT INFRASTRUCTURE ASSESSMENT

PREP received a grant from the U.S. EPA's "Climate Ready Estuaries" initiative to assess climate change impacts on roads and streams in the Oyster River watershed. With climate change, the frequency of extreme rainfall events is increasing. At the same time, watersheds are being altered by impervious surfaces associated with development. Both factors contribute to greater stormwater runoff and increase the chance for damaging floods.

To address these challenges PREP organized a team to complete a climate adaptation project that identified specific culverts likely to fail under expected changes in precipitation patterns and watershed development. Staff from PREP, the Town of Durham, NH Fish and Game Department, and Strafford Regional Planning Commission assessed and mapped 110 culverts in the watershed. Data on culvert capacity, vegetation, slope, soils, permeability, roads, and land use were compiled into a model that calculated runoff volumes for current and projected future precipitation patterns.

Results indicate that six percent of the culverts currently are undersized to accommodate a "25-year" storm event under existing conditions. When climate change model predictions of future storm intensities are considered, 13-22 percent of culverts are estimated to be undersized for a 25-year storm event. With watershed build-out and future storm intensities, 20-24 percent of culverts are predicted to fail with flows associated with the 25-year storm. Later in 2009 the project team will provide recommendations to municipalities for infrastructure improvements based on risk, cost, and infrastructure lifespan considerations.

EXHIBIT 19 (AR K.26)

How much of the Piscataqua Region watershed is protected from development?

At the end of 2008, 76,269 acres in the Piscataqua Region watershed were protected, which amounted to 11.3 percent of the land area.

PREP GOAL

Increase the acres of protected private and public lands from baseline levels to 15 percent by 2010.

WHY THIS IS IMPORTANT

Development of land for residential, commercial, industrial, and other uses can eliminate or disrupt habitats and increase stormwater runoff and other sources of water pollution. Permanently protecting key areas from development will maintain the ecosystem benefits provided by healthy, natural landscapes.

EXPLANATION

By the end of 2008, there were 76,269 acres of protected land in the watershed (Figure 30). This amount is equivalent to 11.3 percent of the land area, which is still below the PREP goal of 15 percent. Eighty-five 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 percentage of land area that is protected in each town is shown in Figure 31. This map illustrates that great progress toward the PREP goals has been made in the towns around Great Bay, near the coast, in the vicinity of the Bear Brook and Pawtuckaway State Parks, and in the Mt. Agamenticus to the Sea area. In contrast, there is a lower percentage of protected land in the Salmon Falls River and Cocheco River watersheds.

The updated database of conservation lands in Maine and New Hampshire was merged with the locations of conservation focus areas in the Piscataqua Region watersheds to determine how much of each focus area was protected from development. Overall, 42,046 acres of conservation land fell within the core areas of the conservation focus areas, which amounts to 25 percent of the combined area of the core areas (Figure 32). This statistic demonstrates that the conservation focus areas have been a priority for land conservation efforts but that the majority of these areas are still unprotected.

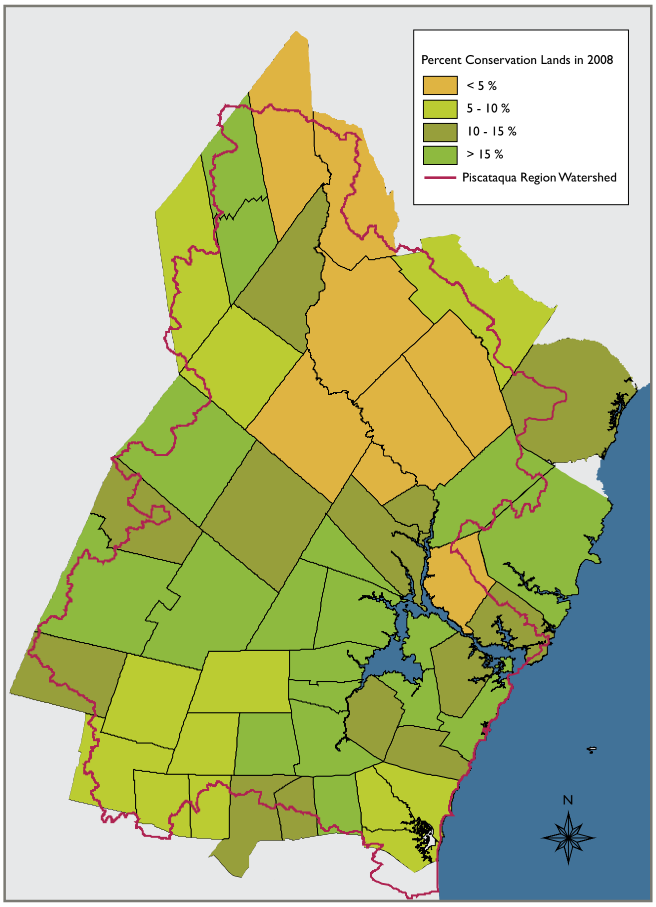
EXHIBIT 19 (AR K.26)

Acres of conservation land in the Piscataqua Region watershed in 2008 (Figure 30)

Type	New Hampshire	Maine	Total
Permanent	57,549	7,331	64,880
Unofficial	9,269	1,475	10,743
Recreational	645	0	645
Total	**67,463**	**8,806**	**76,269**

Data Source: The Nature Conservancy and Wells National Estuarine Research Reserve

Percent of land area that is protected in each watershed municipality in 2008 (Figure 31)



Data Source: The Nature Conservancy and Wells National Estuarine Research Reserve

Protected status of core areas of conservation focus areas (CFAs) in the Piscataqua Region (Figure 32)

	New Hampshire	Maine	Total
Area of Core CFAs (acres)	136,551	30,469	167,020
Conservation Lands in Core CFAs (acres)	37,746	4,300	42,046
Percent of Core CFAs Protected	27.6%	14.1%	25.2%

Data Source: The Nature Conservancy, Wells National Estuarine Research Reserve, and Maine Department of Inland Fisheries and Wildlife

CONSERVATION FOCUS AREAS

The Land Conservation Plan for New Hampshire's Coastal Watersheds identified Conservation Focus Areas (CFAs) that are areas of exceptional significance for protecting living resources and water quality. Seventy-five CFAs, totaling 190,300 acres (36 percent of the total area), were identified throughout New Hampshire's coastal watersheds. Each CFA is comprised of a core area, which in some cases is surrounded by a supporting natural landscape area that provides additional buffering and habitat connectivity for the core area. The Plan provides a systematic, science-based approach to identify critical conservation areas and strategies at a watershed scale to support local and regional efforts.

In 2008 PREP sought to develop a similar conservation plan for the Maine part of the Great Bay Estuary watershed. PREP partnered with the Maine Department of Inland Fisheries and Wildlife's Beginning with Habitat Program, Wells National Estuarine Research Reserve, and Southern Maine Regional Planning Commission to produce a plan for watershed areas in southernmost Maine. The group modeled their approach after the process used to develop the New Hampshire plan and relied on input from many local and regional conservation experts to rank different resource features and delineate boundaries of conservation areas.

Through this process,15 CFAs, totaling 55,541 acres (35 percent of the total area), were identified in the Maine portion of the Great Bay Estuary watershed. With support from the New Hampshire Charitable Foundation-Piscataqua Region and the Maine Coastal Program, project partners are finalizing the plan and will work with towns, land trusts, and other conservation organizations to integrate the data and protection priorities into local conservation efforts.

CFAs are a priority for PREP's conservation efforts and funding. Through its Land Protection Transaction Grants Program, PREP funded project transaction costs leading to the protection of 605 acres located in CFAs in 2008 and 865 acres in CFAs in 2009. Projects protecting lands in Maine CFAs will be eligible for funding through the program in 2010.

EXHIBIT 19 (AR K.26)

ACKNOWLEDGEMENTS

The creation of the 2009 State of the Estuaries Report would not have been possible without the collaborative work of many partnering organizations and committed individuals. Special recognition goes to the following organizations and individuals for sharing data and coordinating efforts to help understand the status of the Piscataqua Region watersheds.

Great Bay National Estuarine Research Reserve
Gulf of Maine Council Gulfwatch Program
Maine Department of Inland Fisheries and Wildlife
New Hampshire Coastal Program
New Hampshire Department of Environmental Services
New Hampshire Fish and Game Department
NextEra Energy Seabrook Station
The Nature Conservancy
University of New Hampshire
U.S. Environmental Protection Agency
Wells National Estuarine Research Reserve

PREP MANAGEMENT COMMITTEE MEMBERS

Peter Britz, City of Portsmouth
Jeannie Brochi, US Environmental Protection Agency
Cynthia Copeland, Strafford Regional Planning Commission
Mel Cote, US Environmental Protection Agency
Steve Couture, NH Rivers Management & Protection Program
Paul Dest, Wells National Estuarine Research Reserve
Ted Diers, NH Coastal Program
Dick Dumore, Public Service of New Hampshire
Sue Foote, Town of Seabrook
Phyllis Ford, Spruce Creek Association
Dave Funk, Great Bay Stewards
Brian Giles, Lamprey River Local Advisory Committee
Doug Grout, NH Fish and Game Department
Don Kale, Maine Department of Environmental Protection
Mitch Kalter, Great Bay Trout Unlimited & Coastal Conservation Association
Peter Lamb, New Hampshire Charitable Foundation
Rich Langan, University of New Hampshire
Al Legendre, NextEra Energy Seabrook Station
Jonathan Pennock, University of New Hampshire
Christine Perron, NH Department of Transportation
Betsy Sanders, Exeter River Local Advisory Committee
Paul Schumacher, Southern Maine Regional Planning Commission
Brad Sterl, Maine resident
Graham Taylor, US Fish and Wildlife Service
Peter Tilton, Jr., Defiant Lobster
Theresa Walker, Rockingham Planning Commission
Peter Wellenberger, Great Bay National Estuarine Research Reserve
Mark Zankel, The Nature Conservancy

PREP TECHNICAL ADVISORY COMMITTEE MEMBERS

Tom Ballestero, University of New Hampshire
Jeannie Brochi, US Environmental Protection Agency
Dave Burdick, University of New Hampshire
Gregg Comstock, NH Department of Environmental Services
Paul Currier, NH Department of Environmental Services
Ted Diers, NH Coastal Program
Michele Dionne, Wells National Estuarine Research Reserve
Brian Giles, Lamprey River Advisory Committee
Ray Grizzle, University of New Hampshire
Jennifer Hunter, Piscataqua Region Estuaries Partnership
Steve Jones, University of New Hampshire
Mitch Kalter, Great Bay Trout Unlimited & Coastal Conservation Association
Ray Konisky, The Nature Conservancy
Rich Langan, University of New Hampshire
Kevin Lucey, NH Coastal Program
Bill McDowell, University of New Hampshire
Kathy Mills, Great Bay National Estuarine Research Reserve
Ru Morrison, University of New Hampshire
Chris Nash, NH Department of Environmental Services
Jonathan Pennock, University of New Hampshire
Robert Roseen, University of New Hampshire
Fay Rubin, University of New Hampshire
Fred Short, University of New Hampshire
Bruce Smith, NH Fish and Game Department
Derek Sowers, Piscataqua Region Estuaries Partnership
Phil Trowbridge, Piscataqua Region Estuaries Partnership

REFERENCES

Beal (2002) Juvenile clam mortality study at three intertidal flats in Hampton Harbor. University of Maine at Machias, Machias, ME. Published online: http://www.prep.unh.edu/resources/pdf/juvenileclammortality-um-03.pdf.

CWP (2003) Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph Number 1. Center for Watershed Protection, Ellicott City, MD. March 2003. Available from: www.stormwatercenter.net.

Deacon, J.R., Soule, S.A., and Smith, T.E. (2005) Effects of urbanization on stream quality at selected sites in the Seacoast region in New Hampshire, 2001-03: U.S. Geological Survey Scientific Investigations Report 2005-5103, 18 p.

Muehlstein LK, Porter D, Short FT (1991) Labyrinthula zosterae sp. Nov, the causative agent of wasting disease of eelgrass, Zostera marina. Mycologia 83: 180-191.

NHDES (2008) New Hampshire 2008 Section 305b and 303d Surface Water Quality Report: Appendix 5 (Eelgrass Assessment Methodology). New Hampshire Department of Environmental Services, Water Division, Concord, NH. Published online: http://des.nh.gov/organization/divisions/water/wmb/swqa/2008/index.htm.

Odell, J., A. Eberhardt, D. Burdick, P. Ingraham (2006) Great Bay Estuary Restoration Compendium. The Nature Conservancy and University of New Hampshire. Published online: http://www.prep.unh.edu/resources/pdf/great_bay_restoration-tnc-06.pdf.

PREP (2000) Management Plan. Piscataqua Region Estuaries Partnership, University of New Hampshire, Durham, NH (formerly the New Hampshire Estuaries Project). Published online: http://www.prep.unh.edu/resources/pdf/nhepmanagementplan-PREP-05.pdf.

PREP (2008) Monitoring Plan. Piscataqua Region Estuaries Partnership, University of New Hampshire, Durham, NH (formerly the New Hampshire Estuaries Project). Published online: http://www.nhep.unh.edu/resources/pdf/prep_monitoring_plan-nhep-08.pdf.

PREP (2009) Environmental Indicators Report. Piscataqua Region Estuaries Partnership, University of New Hampshire, Durham, NH. Published online: http://www.prep.unh.edu/resources/pdf/environmental_indicators_report-prep-09.pdf.

Zankel, M., C. Copeland, P. Ingraham, J. Robinson, C. Sinnott, D. Sundquist, T. Walker, and J. Alford (2006) The Land Conservation Plan for New Hampshire's Coastal Watersheds. The Nature Conservancy, Society for the Protection of New Hampshire Forests, Rockingham Planning Commission, and Strafford Region Planning Commission. Published online: http://www.prep.unh.edu/resources/pdf/the_land_conservation-tnc-06.pdf.

EXHIBIT 19 (AR K.26)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

UNIVERSITY *of* NEW HAMPSHIRE

Public Service of New Hampshire

The Northeast Utilities System

This report was funded in part by the U.S. Environmental Protection Agency through an agreement with the University of New Hampshire and by Public Service of New Hampshire through a generous contribution to PREP as part of the company's ongoing commitment to environmental stewardship.

EXHIBIT 19 (AR K.26)

Piscataqua Region Estuaries Partnership
University of New Hampshire
Nesmith Hall, 131 Main Street
Durham, NH 03824-2601

NON PROFIT ORG.
U.S. POSTAGE PAID
DURHAM, NH
PERMIT NO. 2

WWW.PREP.UNH.EDU