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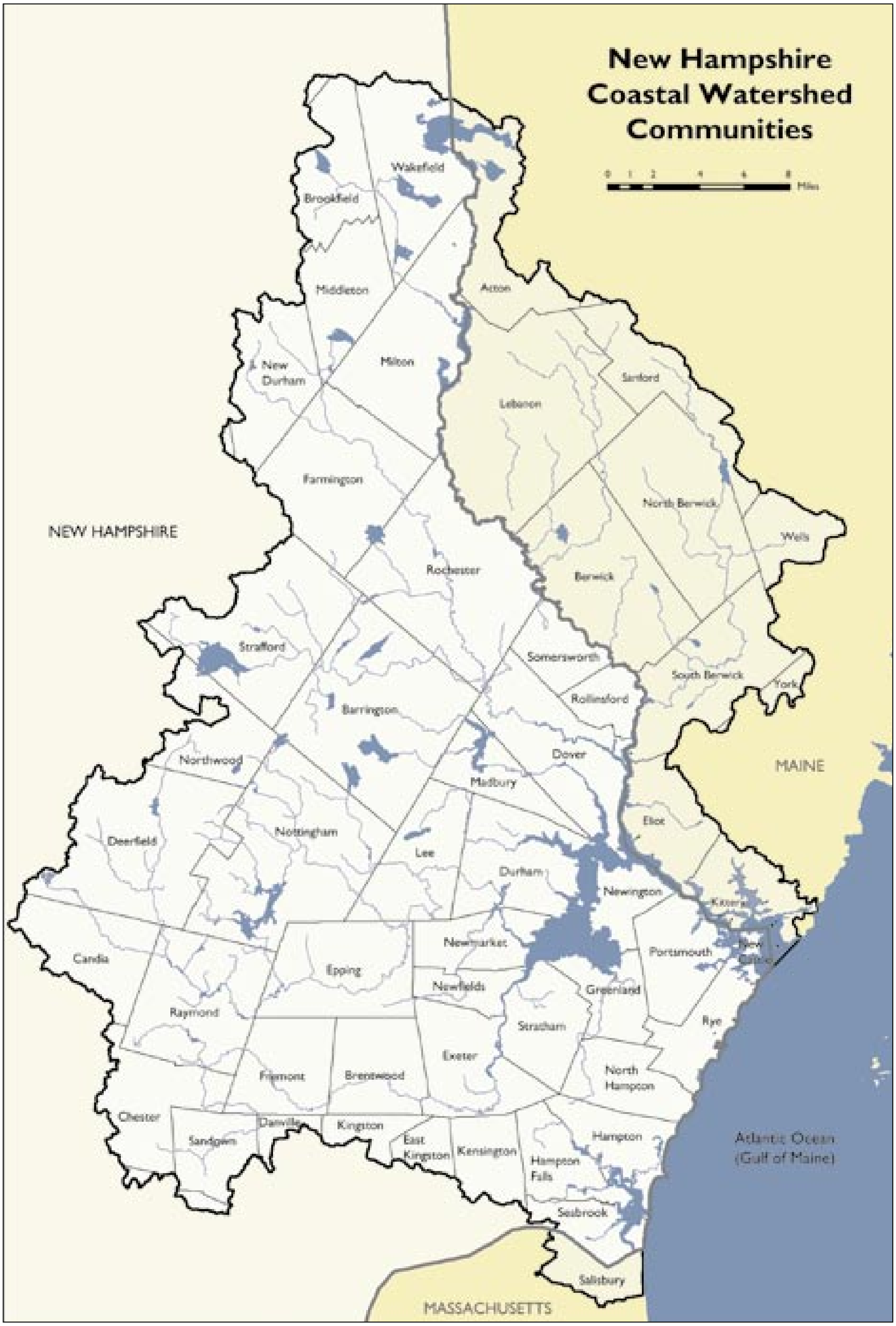
STATE OF THE ESTUARIES

2006

New Hampshire Estuaries Project


New Hampshire
Coastal Watershed
Communities
0 1 2 4 6 8
Miles
NEW HAMPSHIRE
MAINE
MASSACHUSETTS
Atlantic Ocean
(Gulf of Maine)
Wakefield
Brookfield
Middleton
Acton
New
Durham
Milton
Sanford
Lebanon
Farmington
North Berwick
Wells
Rochester
Berwick
Strafford
Somersworth
South Berwick
York
Rollinsford
Barrington
Dover
Northwood
Madbury
Eliot
Nottingham
Deerfield
Lee
Durham
Newington
Kittery
Newmarket
Portsmouth
New
Castle
Candia
Epping
Newfields
Greenland
Raymond
Stratham
Rye
Exeter
Fremont
Brentwood
North
Hampton
Chester
Danville
Sandown
Kingston
East
Kingston
Kensington
Hampton
Hampton
Falls
Seabrook
Salisbury

The New Hampshire Estuaries Project

The NHEP is part of the U.S. Environmental Protection Agency's (EPA's) National Estuary Program which is a joint local/state/federal program established under the Clean Water Act with the goal of protecting and enhancing nationally significant estuaries. The NHEP's Comprehensive Conservation and Management Plan for New Hampshire's estuaries was completed in 2000 and implementation is ongoing. The Management Plan outlines key issues related to management of New Hampshire's estuaries and proposes strategies that are expected to collectively preserve and protect the state's estuarine resources.

The NHEP's priorities were established by local stakeholders and include water quality improvements, shellfish resource enhancements, habitat protection, improved land development patterns, habitat restoration, and outreach activities to develop broad-based support and encourage involvement of the public, local governments, and other interested groups. The NHEP and its many partners undertake projects and activities to address these priorities in the New Hampshire coastal watershed. The coastal watershed that drains water into the state's major estuary systems – the Great Bay Estuary and Hampton-Seabrook Harbor – and other coastal waters via rivers and streams spans three states with approximately 80 percent of the area located in New Hampshire. The NHEP works with 42 New Hampshire communities that are entirely or partially located within the coastal watershed.

REPORT INTRODUCTION

The 2006 State of the Estuaries Report includes twelve indicators intended to report on the health and environmental quality of New Hampshire's estuaries.

The New Hampshire Estuaries Project (NHEP) developed and now implements a Monitoring Plan to track environmental indicators, inform management decisions, and report on environmental progress and status. The Monitoring Plan describes the methods and data for 34 indicators used to determine if the environmental goals and objectives of the Management Plan are being met. For each indicator, the Monitoring Plan defines the monitoring objective, management goal, data quality objectives, data analysis and statistical methods, and data sources. Just as implementation of the Management Plan for New Hampshire's estuaries involves the collaboration of many organizations and agencies, the NHEP Monitoring Plan relies on data compiled from organizations that are leaders in the management and protection of the state's estuaries and coastal watershed resources.

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

Prior to developing each State of the Estuaries report, the NHEP publishes four technical data reports ("indicator reports") that illustrate the status and trends of the complete collection of indicators tracked by the NHEP. Each report focuses on a different suite of indicators: Water Quality, Shellfish, Critical Habitats and Species, and Land Use and Development. These reports are available from the NHEP website, www.nhep.unh.edu.

The 2006 State of the Estuaries Report communicates the status of 12 out of the 34 environmental indicators tracked by the NHEP. For each of these key indicators it provides the reader with the associated NHEP management goal and an explanation of supporting data. For some of the 12 indicators, additional information from supporting or related indicators is presented to further explain trends or to provide context for the primary indicators.

The interpretations of the indicators in this report were peer reviewed by the 15 member NHEP Technical Advisory Committee and other experts in relevant fields, including university professors, researchers, and state and federal environmental managers from a variety of disciplines and perspectives. Therefore, the conclusions of this report represent the current scientific consensus regarding conditions in New Hampshire's estuaries.

FOCUS AREAS

Water Quality ☐
Shellfish ☐
Critical Habitats & Species ☐
Land Use & Development ☐

The environmental quality of New Hampshire's estuaries is good compared with estuaries across the country; but, conditions are changing. Some of the changes are positive, although more of the trends are troubling.

Several indicators of water quality show improvement.

- Bacteria concentrations in the water are decreasing during dry weather conditions.
- Toxic contaminant levels in the water and sediments are at levels of minimal concern. Mussels, clams, and oysters have decreasing toxic contaminant concentrations that are below national guidance values. Tests indicate that organisms living in the sediments are affected by toxic contaminants in only 0.3 percent of the estuary.

However, more indicators suggest that the ecological integrity of the estuaries is under stress or may soon be heading toward a decline.

- Oyster and clam populations are at or approaching the lowest levels ever recorded. Trends suggest that clam populations follow a cyclical boom-and-bust pattern, but the oyster populations appear to be experiencing a slow, steady decline.
- Impervious surfaces are being added to the watershed at an average rate of 1,185 acres per year. In 2005, eight percent of the watershed's land area was covered by impervious surfaces. Land consumption per person is increasing, which is an indicator of sprawling growth patterns.
- Nitrogen concentrations in Great Bay have increased by 59 percent in the past 25 years. Negative effects of excessive nitrogen, such as algae blooms and low dissolved oxygen levels, are not evident. However, the estuary cannot continue to receive increasing nitrogen levels indefinitely without experiencing a lowering of water quality and ecosystem changes.
- Eelgrass coverage in the Great Bay has declined slightly since 1996. During the same period, eelgrass biomass in Great Bay has experienced a more significant decrease. The causes of these declines are uncertain, but loss of water clarity, disease, excess nitrogen, and nuisance macroalgae are all contributing factors.
- Dissolved oxygen concentrations consistently fail to meet state water quality standards in the tidal tributaries to the Great Bay Estuary. So far, the dissolved oxygen levels in the larger embayments are not below state water quality standards.

In an attempt to counteract these trends, the NHEP and others have worked to conserve land, restore habitats, and eliminate pollution sources in the coastal watershed. Over the past three years, 12,037 acres in the coastal watershed have been permanently protected from development. Currently, 54,622 acres, or 10.7 percent of the watershed land area, are protected including 7,009 acres protected by the Great Bay Resource Protection Partnership. The New Hampshire Coastal Program has restored 279 acres of salt marsh in the past six years. The University of New Hampshire (UNH) has completed restoration projects for 3.18 acres of oyster beds and 1.75 acres of eelgrass. The NHEP, state agencies, watershed groups, and municipalities have identified and eliminated many sources of bacteria pollution, and as a result, more areas of the estuaries are open for shellfish harvesting.

Available environmental data indicate that New Hampshire's estuaries still retain many positive attributes and serve important ecological functions. However, the effects of human population growth and development on the estuaries are increasingly evident. Unfortunately, the potential impacts on future ecological integrity are poorly understood.

Indicator	Question	Answer	Implication/Trend
Dry weather bacteria concentrations *(page 6)*	Have fecal coliform bacteria levels in the Great Bay Estuary changed over time?	Yes. The bacteria concentrations in Great Bay have decreased by 73% over the past 16 years, but the trend has slowed recently.	⊕
Toxic contaminants in shellfish tissue *(page 8)*	Have concentrations of toxic contaminants in the tissues of shellfish changed over time?	Yes. The concentrations of several contaminants have decreased by 17% to 68% over the past 12 years and no concentrations have increased.	⊕
Toxic contaminants in sediments *(page 10)*	Do sediments in the estuaries contain toxic contaminants that might harm benthic organisms?	Yes, but rarely. Organisms living in the sediments might be adversely affected by toxic contaminants in only 0.3% of the estuaries.	⊕
Nitrogen in Great Bay *(page 12)*	Have nitrogen concentrations in Great Bay changed significantly over time?	Yes. Dissolved inorganic nitrogen concentrations have increased in Great Bay by 59% in the past 25 years.	⚠
Dissolved oxygen *(page 14)*	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.	⚠
Oysters *(page 16)*	Has the number of harvestable oysters in the Great Bay Estuary changed over time?	Yes. The number of harvestable oysters has declined 95% since 1993.	⊖
Clams *(page 18)*	Has the number of harvestable clams in Hampton-Seabrook Harbor changed over time?	Yes. The current number of harvestable clams is 31% of the average level and decreasing.	⊖
Eelgrass *(page 20)*	Has eelgrass habitat in Great Bay changed over time?	Yes. Eelgrass cover in the Great Bay has declined by 17% between 1996 and 2004.	⚠
Habitat restoration *(page 22)*	Are habitats being restored?	Yes for salt marsh, but oyster and eelgrass habitats have been restored at a slower rate.	⊕
Impervious surfaces *(page 24)*	How much of New Hampshire's coastal watershed is covered by impervious surfaces?	In 2005, 8% of the land area of the watershed was covered by impervious surfaces, and 10 subwatersheds had greater than 10% impervious surface cover.	⊖
Sprawling growth *(page 26)*	Is the coastal watershed experiencing "sprawl-type" development?	Yes. From 1990 and 2005, land consumption increased from 0.152 to 0.217 acres of impervious surface per person.	⊖
Land conservation *(page 28)*	How much of the coastal watershed is protected from development?	Currently, 54,622 acres in the watershed are protected, which amounts to 10.7% 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.

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

Yes. The bacteria concentrations in Great Bay have decreased by 73 percent over the past 16 years, but the trend has slowed recently.

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

At all four of the long-term water quality monitoring stations in the Great Bay Estuary, the trend has been a decrease in the fecal coliform concentrations during dry weather over the past 13 to 16 years. For example, in the middle of Great Bay at Adams Point, fecal coliform concentrations decreased by 73 percent between 1989 and 2004 (Figure 1). This result is encouraging because it indicates that the collective input from the Bay's many tributaries has decreased.

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, livestock, wildlife, re-suspension of contaminated sediments, and residual stormwater-related pollution. Wastewater treatment facility upgrades and removal of sewage inputs from stormwater sewer systems are likely major contributors to the decreasing trends.

It is important to note that fecal coliform concentrations have remained relatively constant in recent years, and there are still many closures of shellfish beds due to bacterial pollution, particularly after rain events. Moreover, long-term trend data are only available at four locations in the estuaries and these locations may not be representative of all areas.

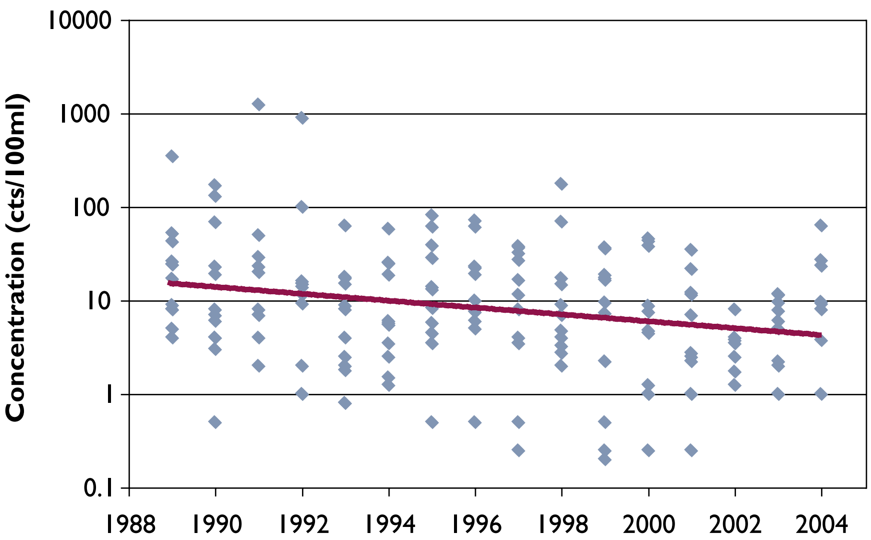
Water Quality

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

Pipe discharging water into Great Bay

NHEP

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



Data Source: UNH Jackson Estuarine Laboratory

KEEPING SEWAGE OUT OF THE ESTUARIES

Stormwater runoff is a major contributor to bacteria pollution. However, even during dry weather, certain bacteria pollution sources are problematic. Failing septic systems can be a constant source of bacteria pollution, as can illicit connections (or cross connections) between sanitary sewer systems and storm sewer systems. In some cases, pipes are misconnected to storm drainage systems, resulting in discharge of untreated sanitary waste to the estuaries. In others, sanitary waste leaches from old and leaky or broken pipes and is discharged to stormwater drainage that flows into surface waters.

The NHEP has supported the remediation of illicit connections in 16 seacoast communities, resulting in cleaner, safer waters. NHEP grant funds have supported the detection and elimination of more than 60 illicit connections in the last seven years. Detection usually begins with water testing of discharges from storm drainage outfalls during dry weather followed by smoke tests, dye tests, video surveillance, or other detection methods within the drain system to locate the illicit connections. After an illicit connection is detected, the sanitary sewer pipes are properly connected to the wastewater infrastructure so that waste is treated, rather than discharged into streams and estuaries.

TIDAL BATHING BEACH POSTINGS There is an increasing trend in the number of advisories issued at tidal beaches in the coastal watershed due to elevated bacteria levels. Between 1996 and 2002, there were no advisories issued for the tidal beaches. However, in the past three years, there has been at least one advisory per year at the tidal beaches. The increased number of advisories may be a result of a change in sampling protocols used by the NH Department of Environmental Services Beach Program or an increase in local bacterial sources. Regardless, beach advisories warrant attention because they indicate water quality problems.

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

Yes. The concentrations of several contaminants have decreased by 17 to 68 percent over the past 12 years and no concentrations have increased.

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 (GOMC's) Gulfwatch Program uses blue mussels (*Mytilus edulis*) as the indicator species for shellfish bioaccumulation of toxic contaminants. Between 1993 and 2004, none of the 13 mussel sampling stations in New Hampshire's estuaries registered toxic contaminant levels greater than U.S. Food and Drug Administration (FDA) guidelines. Mercury and polychlorinated biphenyls (PCBs) levels were well below FDA guidelines; however, lead levels approached the recommended limits in some locations. Since 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.

Mussel tissue samples from Portsmouth Harbor, Hampton-Seabrook Harbor, and Dover Point have been tested repeatedly between 1993 and 2004. Trends at these sites suggest that levels of PCBs, the pesticide DDT, lead, and zinc are declining (Figures 2a through 2d). The concentrations of DDT and PCBs decreased at two of the three stations by 33-35 percent and 39-68 percent, respectively. Lead concentrations have decreased by 23 percent in Portsmouth Harbor. At all three stations, the zinc concentrations have fallen between 17 percent and 28 percent. The decreasing PCB and DDT concentrations are probably due to decreased use of these chemicals following bans by the EPA in 1979 and 1972, respectively.

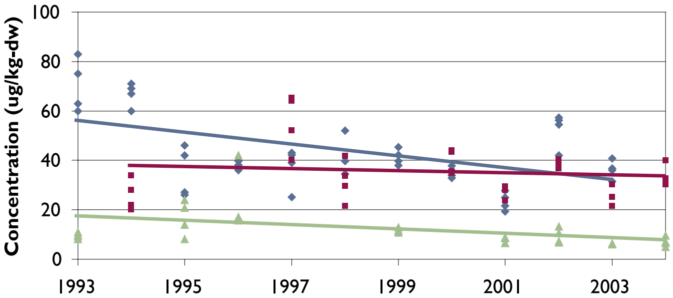
Water Quality

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

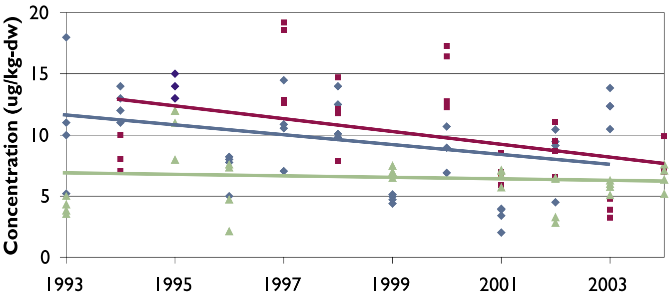
NHEP employee collects blue mussels at low tide that will be tested for contaminants

NHEP

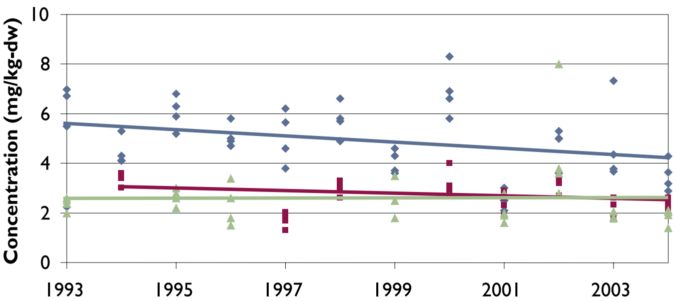
PCBs in mussel tissue (Figure 2a)



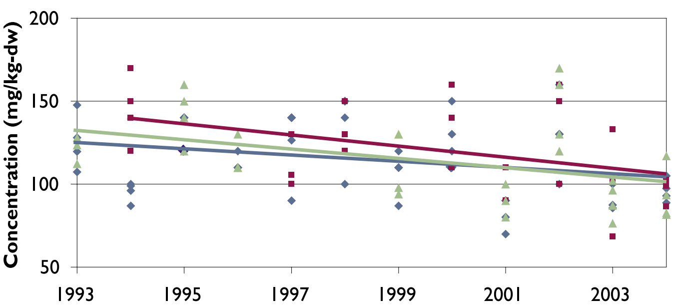
DDT in mussel tissue (Figure 2b)



Lead in mussel tissue (Figure 2c)



Zinc in mussel tissue (Figure 2d)



◆ Portsmouth Harbor ▪ Dover Point ▲ Hampton-Seabrook Harbor

Data Source: GOMC and NHDES, Gulfwatch Program

GULFWATCH PROGRAM

For the past 13 years the GOMC has organized the Gulfwatch monitoring program to assess the types and concentrations of contaminants in blue mussels, *Mytilus edulis*, with the goal of providing baseline contaminant levels on which research questions and management decisions can be based. Mussels are collected annually from over three dozen locations throughout the Gulf of Maine – from Nova Scotia to Massachusetts – and are analyzed for the presence of over 50 types of toxic contaminants. The GOMC's general findings from Gulf-wide analysis of samples indicate that:

- Nearly all measured metal contaminants were detected in mussels from each of the sampling sites.
- Organic contaminants and certain metals were more concentrated in mussels collected near cities and large river mouths, particularly in the southern portion of the Gulf of Maine.
- Tissue concentrations for a few contaminants at some Gulfwatch sites were elevated compared to other regions of North America, although, except for lead in Boston Harbor, no contaminant concentrations exceeded any FDA federal action levels for human consumption.
- Analysis of five benchmark sites from 1991-1997 showed that most contaminants in mussels were decreasing or did not exhibit a trend.

More information on these findings and the Gulfwatch program is available on the GOMC's website: www.gulfofmaine.org/gulfwatch.

The GOMC Gulfwatch program collects and analyzes mussel tissue from two sites in New Hampshire each year. In addition, The NHEP organizes and funds the collection and analysis of mussels from two additional sites in the state each year, plus the collection and analysis of oysters and clams every three years. These additional sites and additional types of shellfish testing improve the coverage for New Hampshire's estuaries and allow better assessment of local sources of pollution.

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

Yes but rarely. Organisms living in the sediments might be adversely affected by toxic contaminants in only 0.3 percent of the estuaries.

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 of the estuaries.

Explanation

Approximately 12 percent of the estuarine sediments had at least one contaminant with concentrations greater than a screening value (Figure 3). Concentrations above screening values have the potential to pose a threat to organisms that live in the sediments. Elevated levels of contamination occur mainly in the tidal rivers, especially the Cocheco River. The chemicals that exceeded screening values were chromium, lead, silver, polycyclic aromatic hydrocarbons, and the pesticide DDT. Another important observation was the consistently low levels of almost all contaminants at sites in Little Harbor, Little Bay, Hampton-Seabrook Harbor, and in the outer portion of Portsmouth Harbor.

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 two locations out of 70 tested, or 0.3 percent of the estuary (Figure 4). The two locations were in the Cocheco River and the Lamprey River (Figure 5). Therefore, in most of the locations where toxic contaminants in sediments were above screening values, the organisms did not appear to be affected by the contamination.

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 significant 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 personal care products and pharmaceuticals.

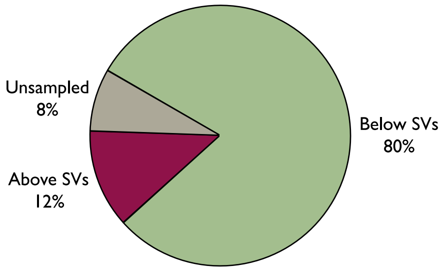
Water Quality

NHEP Goal: No impacts to benthic communities due to sediment contamination.

UNH technician preparing to collect a sediment sample from Great Bay

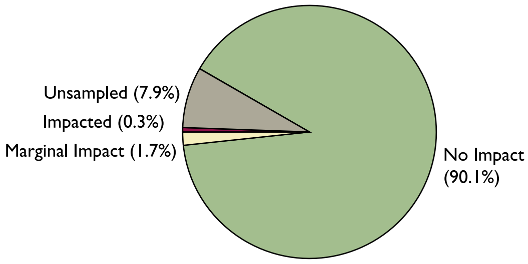
NHEP

Concentrations of toxic contaminants relative to screening values (SVs) (Figure 3)



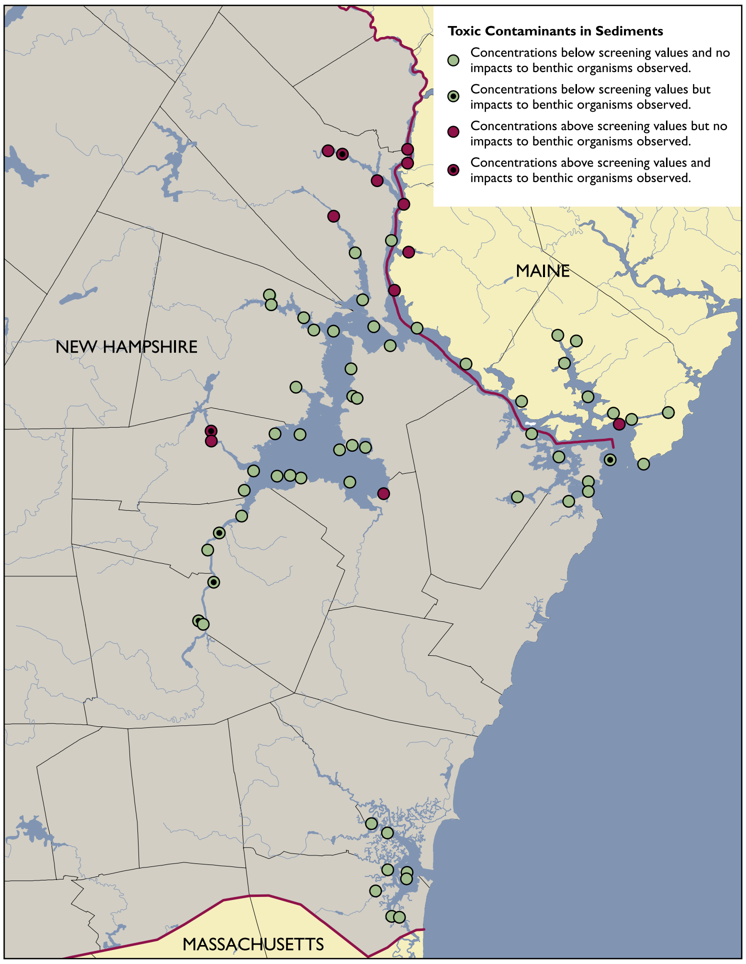
Data Source: EPA, NHDES, and UNH, National Coastal Assessment Survey (2000-2001)

Effects of toxic contaminants on benthic organisms (Figure 4)



Data Source: EPA, NHDES, and UNH, National Coastal Assessment Survey (2000-2001)

Locations of toxic contamination in sediments and impacts to benthic organisms (Figure 5)



Data Source: EPA, NHDES, and UNH, National Coastal Assessment Survey (2000-2001)

VOLUNTEERS CRITICAL IN MONITORING FRESHWATER RIVERS

The quality of freshwater river systems that eventually flow into the estuaries has a large impact on the overall condition of the estuaries. The NHDES Volunteer River Assessment Program (VRAP) organizes water quality monitoring by watershed organizations and other volunteers for freshwater streams and rivers in the coastal watershed. VRAP volunteers measure water quality parameters such as temperature, pH, dissolved oxygen, turbidity, and specific conductance. Recent VRAP water quality reports are available for the Bellamy, Cocheco, Isinglass, Lamprey, and Oyster rivers at www.des.nh.gov/wmb/VRAP.

The Coastal Volunteer Biological Assessment Program (CVBAP) was established in 2005 by the NHDES Biomonitoring Unit and the NH Coastal Program to educate the public about water quality issues as interpreted through biological data (aquatic macroinvertebrates), build a constituency of volunteers to practice sound water quality management at the local level, and supplement biological data collected by NHDES. The Cocheco River Watershed Coalition, Exeter River Local Advisory Committee, and Oyster River Watershed Association are participating in the program. Through CVBAP these groups' existing water quality monitoring efforts are expanded to include collection of biological data.

NHEP

NH DES technicians collecting aquatic invertebrates from the Oyster River

Have nitrogen concentrations in Great Bay changed significantly over time?

Yes. Dissolved inorganic nitrogen concentrations have increased in Great Bay by 59 percent in the past 25 years.

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

Dissolved inorganic nitrogen (DIN) has been monitored monthly in the estuary since 1991. Clear trends in DIN during this 15 year period are not evident. However, a comparison of historical and recent datasets shows that DIN concentrations have increased in Great Bay by 59 percent between the periods of 1974-1981 and 1997-2004 (Figure 6). During the same period, suspended solids concentrations increased by 81 percent (Figure 7). The change in suspended solids may be related to the nitrogen trend; however, many other factors might have caused the increased suspended solids including variability in rainfall, wind speed and tidal amplitude, localized erosion, recent loss of eelgrass, or loss of filter feeders such as oysters.

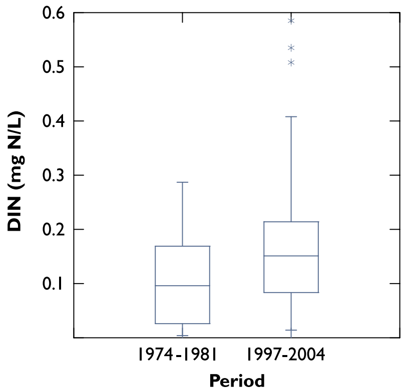
Researchers are still debating the possible effects of the increasing DIN concentrations on Great Bay because it is a unique system, both hydrodynamically and biologically, that may respond differently to excess nitrogen than other estuaries. So far, the typical effects of excess nitrogen have not been observed in Great Bay, although DIN concentrations in Great Bay are similar to concentrations in other estuaries where negative effects have been clearly observed. The only increasing trend for chlorophyll-*a*, a surrogate for algae, was observed at a station with very low concentrations. Low dissolved oxygen concentrations only have been found in the tributaries to the Bay, not the Bay itself. However, changes in other parts of the ecosystem, particularly eelgrass cover and biomass, have been observed. There also have been anecdotal reports of increasing populations of nuisance macroalgae in some areas of Great Bay. While a precise threshold for DIN effects is not known, it is certain that the estuary cannot continue to receive increasing nitrogen loads indefinitely without experiencing a lowering of water quality and ecosystem changes.

Water Quality

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

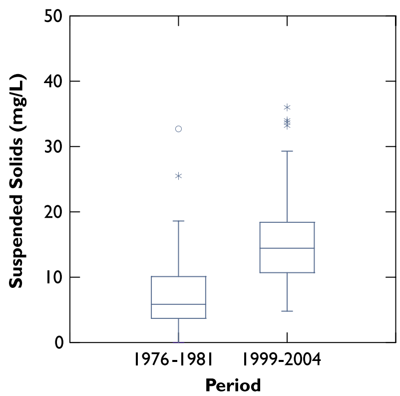
Dissolved inorganic nitrogen concentrations measured at Adams Point at low tide (Figure 6)

Data Source: UNH Jackson Estuarine Laboratory



Suspended solids concentrations measured at Adams Point at low tide (Figure 7)

Data Source: UNH Jackson Estuarine Laboratory



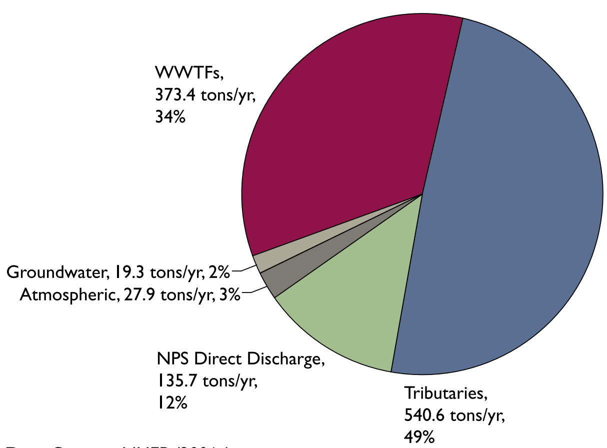
Key to understanding a box and whisker plot: The box and whisker plots in Figures 6 and 7 show the distribution of concentrations measured at the same location during two different periods. The horizontal line in the middle of each box marks the median concentration measured for that period. The lower and upper walls of the box mark the 25th and 75th percentile concentrations, respectively. The lower and upper ends of the "whiskers" (the vertical lines extending from the box) approximate the 5th and 95th percentile concentrations, respectively. Points beyond the whiskers are measurements which are much lower or higher than the rest of the distribution.

NUTRIENT CRITERIA FOR NEW HAMPSHIRE'S ESTUARIES

Excess nutrients are a major concern for water quality and ecological integrity in estuaries. The EPA requires states to develop water quality criteria for estuarine waters which would set limits on nutrients or the negative effects of excess nutrients. The NHEP agreed to lead the effort to develop nutrient criteria for New Hampshire's estuaries because of its technical expertise and strong stakeholder ties. Data from NHEP indicators on dissolved oxygen, chlorophyll-*a*, total suspended solids, eelgrass biomass, and other input and response indicators are being reviewed to better understand nutrient dynamics and impacts in the Great Bay Estuary. The outcome of this analysis will be recommendations to the State Water Quality Standards Advisory Committee for specific criteria to protect the water quality and ecology of New Hampshire's estuaries from excess nutrients.

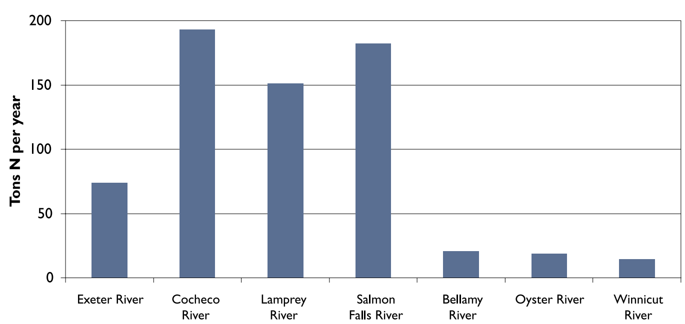
NITROGEN LOAD TO THE GREAT BAY ESTUARY The NHEP estimated that 1,097 tons of nitrogen entered the Great Bay/ Upper Piscataqua Estuary in 2002 (Figure 8). Wastewater treatment facilities (WWTFs) contributed 34 percent of the total amount. The largest component of the nitrogen load was nonpoint sources in the watershed tributaries (49 percent) and from the land adjacent to the estuary (12 percent). Nonpoint sources of nitrogen include lawn fertilizers, septic systems, animal wastes, and atmospheric deposition to land. Direct discharge to the Bay from groundwater and direct atmospheric deposition to the Bay represented relatively small overall contributions of nitrogen. The major sources of nitrogen are all related to population growth and associated land development patterns. Figure 9 shows the annual average nitrogen load that was measured for the 2002-2004 period at the head of tide dam for each tributary. The Cocheco, Salmon Falls, and Lamprey rivers supplied the largest nitrogen loads compared with the other tributaries.

Nitrogen loads to the Great Bay and Upper Piscataqua River Estuary in 2002 (Figure 8)



Data Source: NHEP (2006c)

Total nitrogen loads from Great Bay watersheds in 2002-2004 (Figure 9)



Data Source: NHEP (2006c)

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.

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 the NHEP support the maintenance of instruments, called datasondes, at six locations in the Great Bay Estuary to monitor dissolved oxygen and other parameters every 30 minutes. The measurements are used to determine the average dissolved oxygen concentrations during the day. The sampling stations are located in the middle of Great Bay, Portsmouth Harbor, and in the tidal tributaries to the Great Bay Estuary (Figure 10).

The dissolved oxygen concentrations in Great Bay and Portsmouth Harbor consistently meet the 75 percent saturation standard, while exceedences of the standard have been observed in the tidal tributaries (Figure 11). The most exceedences have been observed in the Lamprey River (56 percent of the summer season on average in 2002-2004). Relatively few exceedences of the standard have been observed in the Squamscott, Oyster, and Salmon Falls rivers.

Strong tidal flushing through the estuary and inflow from freshwater streams appear to mix and oxygenate the water well in the large embayments. 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.

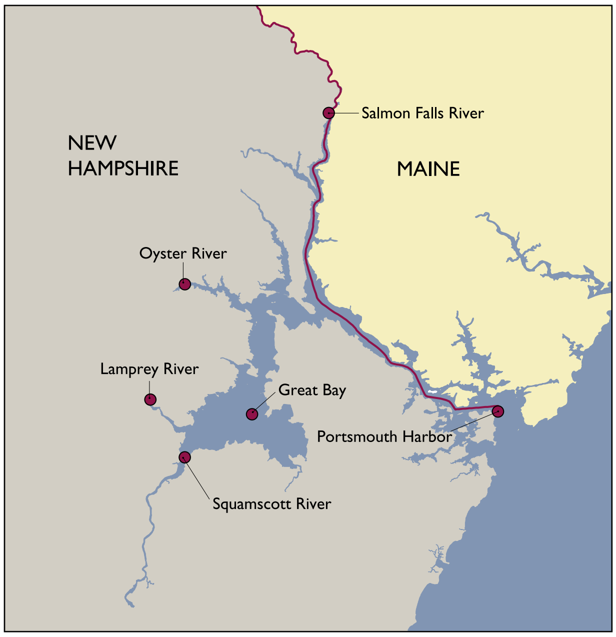
Water Quality

NHEP Goal: No days that exceed the state standard for daily average dissolved oxygen (75 percent saturation).

Datasonde buoy on Great Bay

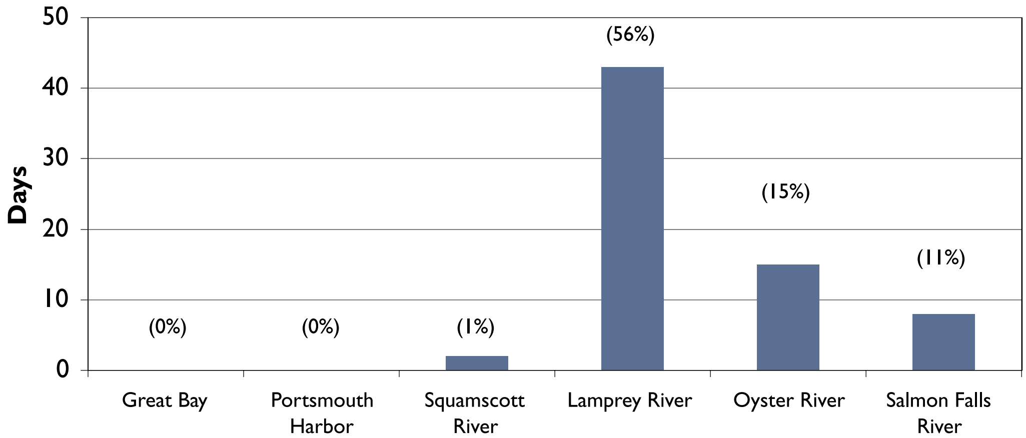
Bridget Finnegan

Datasonde stations in the Great Bay Estuary (Figure 10)



Data Source: UNH Jackson Estuarine Laboratory

Number of summer season days in 2002-2004 with daily average dissolved oxygen less than 75 percent saturation (Figure 11)



Numbers in parentheses are the percent of daily average dissolved oxygen measurements less than 75%.

Data Source: UNH Jackson Estuarine Laboratory, Great Bay National Estuarine Research Reserve System Wide Monitoring Program

DATASONDES

Datasondes are automated monitoring instruments programmed to obtain measurements of specific conductivity, salinity, dissolved oxygen, percent saturation, pH, temperature, water level, and turbidity every half hour. The instruments are deployed continuously during ice-free seasons, except for brief periods when they are removed for cleaning, maintenance, and recalibration. Datasondes are deployed approximately one meter from the bottom and recovered for data download every two to four weeks depending upon the time of year. Deployment and operation of the network of datasondes throughout the Great Bay Estuary is made possible through a partnership between the Great Bay National Estuarine Research Reserve, the NHEP, and the UNH Jackson Estuarine Laboratory.

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

Yes. The number of harvestable oysters has declined 95 percent since 1993.

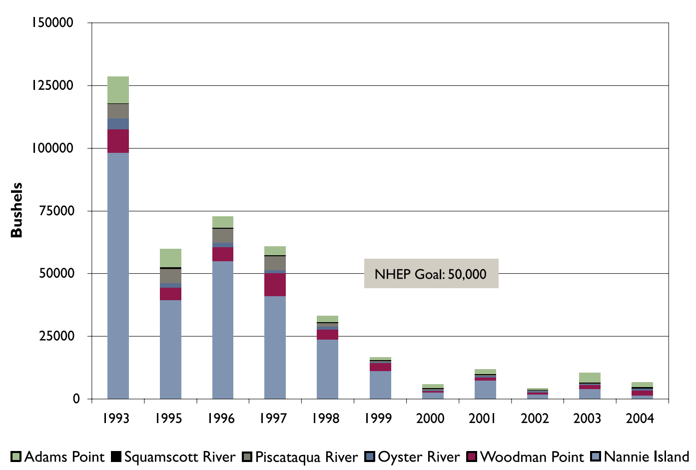
Why this is important

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

Explanation

Since 1993 the oyster fishery in the Great Bay Estuary has suffered a serious decline (Figure 12). Harvestable oyster standing stock in 2004 was only 11 percent of the NHEP goal of 50,000 bushels and only five percent of the maximum observed standing stock in 1993. Most of the remaining standing stock is in the Nannie Island and Woodman Point beds in Great Bay. The major cause of the decline is thought to be the protozoan pathogens MSX and Dermo that have caused similar declines in oyster fisheries in the Chesapeake and other mid-Atlantic estuaries. There is some uncertainty in the standing stock estimates because, while the oyster densities are typically measured each year, the sizes of the beds have been monitored less frequently.

Oyster standing stock in the Great Bay Estuary (Figure 12)



Data Source: NH Fish and Game Department

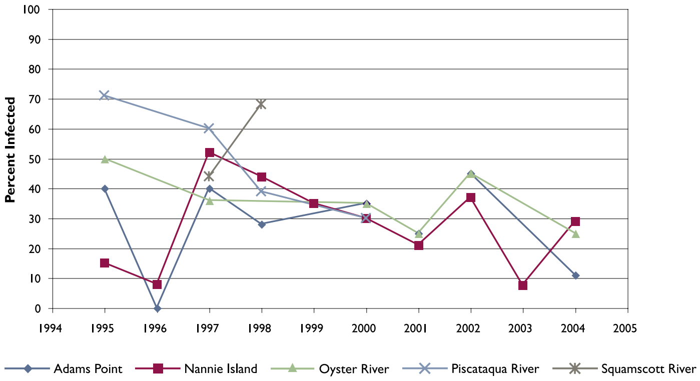
Shellfish

NHEP Goal: Triple the standing stock of harvestable oysters from 1999 levels to 50,000 bushels.

UNH researchers building an experimental oyster reef in Great Bay

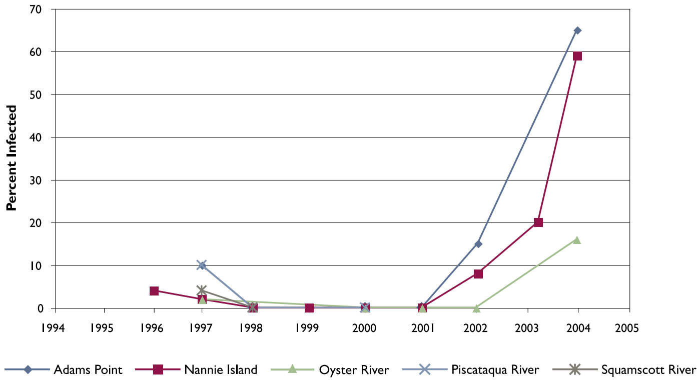
UNH

MSX infection prevalence in Great Bay Estuary oyster beds (Figure 13)



Data Source: NH Fish and Game Department

Dermo infection prevalence in Great Bay Estuary oyster beds (Figure 14)



Data Source: NH Fish and Game Department

RESTORING OYSTER REEFS

Oyster restoration projects are attempting to reverse the declining trends in the number of harvestable oysters by addressing some factors believed to be responsible for their dramatic decline. UNH, with funding and support from the NHEP, Natural Resources Conservation Service, The Nature Conservancy, and the City of Dover, has several active projects. All of the restoration projects use a disease-resistant fast-growth strain of oyster larvae to counteract the effects of the oyster diseases.

For one of the projects, UNH researchers are studying reef structure alternatives in an area near Nannie Island in Great Bay where two reef designs were built and are being evaluated. One design mimics a large reef, while the other imitates a series of smaller reefs clustered together. The researchers are studying each design and evaluating which one best promotes spat abundance, survival, and growth. The reefs were built with crushed granite mounded up eight inches and then seeded with about 200 young oysters per square yard. The research study also compares natural spat density on the constructed reefs to density on natural reefs. Lessons learned from this project will help create a blueprint for future oyster restoration projects. For more information on New Hampshire oyster restoration projects, visit www.oyster.unh.edu.

OYSTER DISEASES There are two diseases that are known to be affecting oysters in the Great Bay Estuary. The disease MSX, which is caused by the protozoa *Haplosporidium nelsoni,* was detected in the Piscataqua River in 1983. The first oyster mortality from the disease was observed in 1995 following a severe drought (Barber et al., 1997). The disease Dermo is caused by the protozoa *Perkinsus marinus.* The NH Fish and Game Department and NHEP have monitored the prevalence of MSX and Dermo in oysters from the Great Bay Estuary every year since 1995 (Figures 13 and 14). No statistically significant change in MSX infection rates at Nannie Island has occurred since the disease was first detected. Approximately 20 percent of the oysters in the Great Bay Estuary are currently infected with MSX. The infection prevalence of Great Bay Estuary oysters by Dermo was low or zero until recently. Between 2002 and 2004, the prevalence of Dermo infection in the Nannie Island and Adams Point oyster beds shot up from approximately 10 percent to 60 percent. The cause of the increased prevalence of Dermo in these beds is not known.

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

Yes. The current number of harvestable clams is 31 percent of the average level and decreasing.

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 the local and State economy (NHEP, 2000).

Explanation

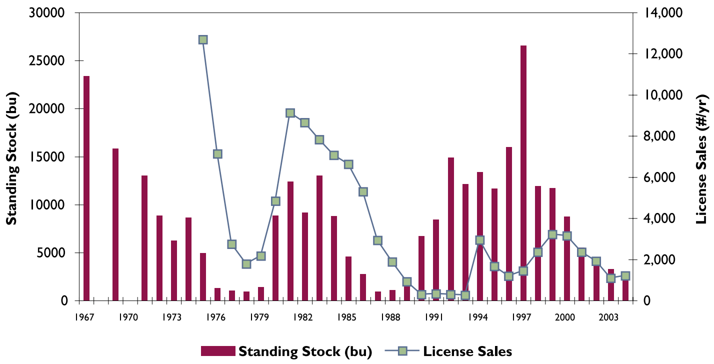
The amount of clams of harvestable size in Hampton-Seabrook Harbor, also known as standing stock, has been monitored by FPL Energy Seabrook Station over the past 38 years (Figure 15). The standing stock has undergone several 12-15 year cycles of growth and decline. Peak standing stocks of approximately 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. Since 1997, the standing stock has been dropping once again, but the 2004 levels have not yet reached the levels observed during the crashes in 1978 and 1987. The standing stock in 2004 was 2,630 bushels which is 31 percent of the NHEP management goal of 8,500 bushels.

The cause of the current decline in harvestable clam populations is unknown. A NHEP study in 2001-2002 concluded that predation of juvenile clams by green crabs and strong currents in the harbor were potential factors in the decline (Beal, 2002). Other observers have expressed concern that harvesting, which appears to be correlated with clam standing stock (Figure 15), may contribute to the decline.

Shellfish

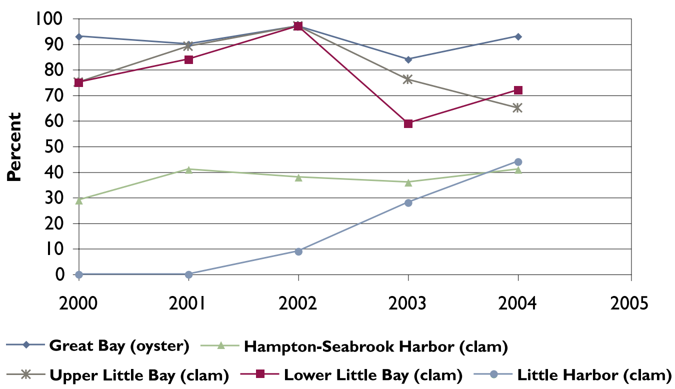
NHEP Goal: Maintain or exceed the average standing stock of harvestable clams in Hampton-Seabrook Harbor flats (8,500 bushels).

Clam standing stock in Hampton-Seabrook Harbor and recreational clamming license sales (Figure 15)



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

Percent of possible shellfish harvesting acre-days (Figure 16)



Data Source: NHDES Shellfish Program

NHDES SHELLFISH PROGRAM: PROTECTING PUBLIC HEALTH

The NHDES Shellfish Program determines which areas meet standards for shellfish harvesting and consumption. Staff regularly collect water samples from over 75 locations in state tidal waters and shellfish meat samples from 15 locations. Water and shellfish samples are sent to state labs in Concord where they are tested for bacterial contamination. In addition, the program monitors concentrations of the paralytic shellfish poison toxin, commonly referred to as "red tide."

To determine if shellfish growing areas meet standards for harvesting and consumption, the NHDES Shellfish Program conducts indepth environmental studies called sanitary surveys. Surveys involve intensive water monitoring and shoreline inspections coupled with an analysis of the impacts of wastewater treatment plants, private septic systems, development, boating, and other activities that affect shellfish growing areas because of pollution. To date the program has completed sanitary surveys for approximately 85 percent of the estuarine areas. Most of the approved shellfish harvesting areas are open on a conditional basis, meaning that certain conditions, such as rainfall or sewage releases from wastewater treatment plants, will close areas to harvest until the NHDES Shellfish Program determines that the area meets standards for consumption.

The NHEP has supported the NHDES Shellfish Program activities since they began in the late 1990s by providing funding to complete sanitary surveys and more recently to support laboratory analysis of water and shellfish tissue samples. As a result of these efforts, the NHDES Shellfish Program was officially recognized as being compliant with the National Shellfish Sanitation Program by the U.S. Food and Drug Administration in October 2002.

SHELLFISH HARVESTING OPPORTUNITIES The NHDES Shellfish Program measures the opportunities for shellfish harvesting using "acre-days," which is the product of the acres of shellfish growing waters and the number of days that these waters are open for harvest. The acre-days indicator is reported as the percentage of the total possible acre-days of harvesting for which the shellfish waters are actually open. In most cases, poor bacterial water quality restricts harvesting, making the acre-day indicator a good integrative measure of the degree to which water quality in the estuary is meeting fecal coliform standards for shellfish harvesting. Shellfishing opportunities in the open portions of the estuaries vary by location (Figure 16). In Great Bay, the shellfishing acre-days were nearly 90 percent of the possible amount in 2000-2004. In Hampton-Seabrook Harbor and Little Harbor, the acre-day percentage was only slightly above 40 percent for the same period. In both of these harbors, poor water quality due to elevated bacteria concentrations occurs after even small rain storms causing closures. However there has been an improving trend in the Little Harbor growing area. This area was closed to shellfishing before 2001. By 2004, it was open 44 percent of the possible acre-days. The areas in Upper and Lower Little Bay were closed more often in 2003 and 2004 than previously because of heavy rainfall, wastewater treatment facility overflows, and the extended presence of boats in the mooring fields.

Has eelgrass habitat in Great Bay changed over time?

Yes. Eelgrass cover in the Great Bay has declined by 17 percent between 1996 and 2004.

Why this is important

Eelgrass (*Zostera marina*) is essential to estuarine ecology because it filters water, stabilizes sediments, provides food for wintering waterfowl, and provides habitat for juvenile fish and shellfish. Healthy eelgrass habitat both depends on and contributes to good water quality.

Explanation

Throughout the 1990s, the total eelgrass cover in Great Bay was relatively constant at approximately 2,000 acres (Figure 17). In 1988 and 1989, there was a dramatic crash of the eelgrass beds down to 300 acres (15 percent of normal levels). The cause of this crash was an infestation of a slime mold, *Labryrinthula zosterae*, commonly called "wasting disease" (Muehlstein et al., 1991). The greatest extent of eelgrass was observed in 1996 (2,421 acres) after recovery from the wasting disease. The current (2004) extent of eelgrass in Great Bay is 2,008 acres, which is 17 percent less than the maximum extent observed in 1996.

The biomass of eelgrass in Great Bay has experienced a more significant decline relative to the levels observed in 1996 (Figure 17). Biomass is the combined weight of eelgrass plants in the bay. In 1990, 1991, and 1995, the biomass was low due to wasting disease events. Superimposed on these rapid events has been a gradual, decreasing trend in eelgrass biomass that does not appear to be related to wasting disease. The current eelgrass biomass level for Great Bay is 948 metric tons, which is 41 percent lower than the biomass observed in 1996.

The specific cause of the decline in eelgrass cover and biomass is unclear, but appears to be related to a reduction in the amount of light reaching the plants. Eelgrass is sensitive to water quality, especially water clarity. The observed changes in eelgrass cannot be linked directly to a water quality trend in Great Bay, although increasing concentrations of suspended solids have been observed at Adams Point. The effects of the wasting disease are easily observed on the plants and the gradual decline of the past decade is not consistent with a wasting disease event. There have been anecdotal reports of increasing populations of nuisance macroalgae and epiphytic growth on eelgrass leaves, which may be related to increasing nitrogen concentrations in the Bay. Macroalgae can compete with and smother eelgrass, and heavy epiphyte loads can decrease eelgrass growth, reducing eelgrass biomass and cover.

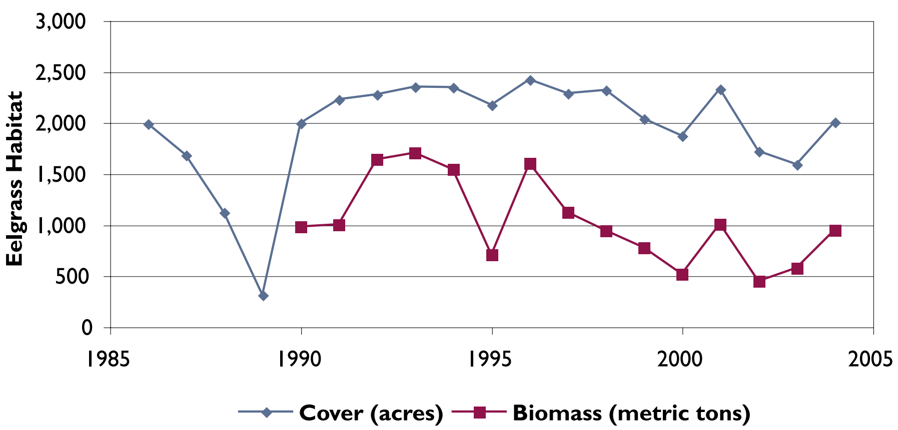
Critical Habitats & Species

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

Eelgrass plays a vital role in the ecology of Great Bay

NHEP

Eelgrass cover and biomass in the Great Bay (Figure 17)



Data Source: UNH Seagrass Ecology Group

GLOBAL DECLINE OF SEAGRASS

Eelgrass trends observed in New Hampshire mirror trends in seagrass health across the world, although declines may be caused by different factors. SeagrassNet, a global monitoring program initiated in 2001, monitors seagrass at 48 sites in 18 countries. Findings indicate that seagrass is declining at nearly all the sites monitored. Causes of declines include diseases, increased sedimentation from land use disturbance activities, decreased water clarity from water pollution, dredging and other physical disturbances, and many other anthropogenic impacts.

Eelgrass loss (as well as loss of other types of seagrasses) affects water quality because the root systems of plants help stabilize sediments to prevent erosion, and the plants themselves filter nutrients and particulates from the water column. Other species such as shellfish, fish, and waterfowl that depend on these important aquatic habitats for food and shelter are in turn affected by eelgrass loss.

Information about the Global Seagrass Monitoring Network can be found at www.seagrassnet.org.

NHEP

An eelgrass experiment at UNH Jackson Estuarine Laboratory examines the relationship between eelgrass and turbidity

Are habitats being restored?

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

Why this is important

Historical data suggests that salt marshes, oyster beds, and eelgrass habitats in New Hampshire'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 18). The current tally of salt marsh restoration projects by tidal restriction removal since January 1, 2000 is 279 acres (93 percent of the goal). The NH Coastal Program is planning additional salt marsh restoration by tidal restriction removal, which, if completed, would surpass the NHEP 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 NHEP management goals. Five oyster restoration projects have been implemented in the Great Bay Estuary and have resulted in a total of 3.18 restored acres of oyster bed (16 percent of the NHEP goal). Since 2000, 1.75 acres of eelgrass restoration projects have been completed (3.5 percent of the goal). 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.

Critical Habitats & Species

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

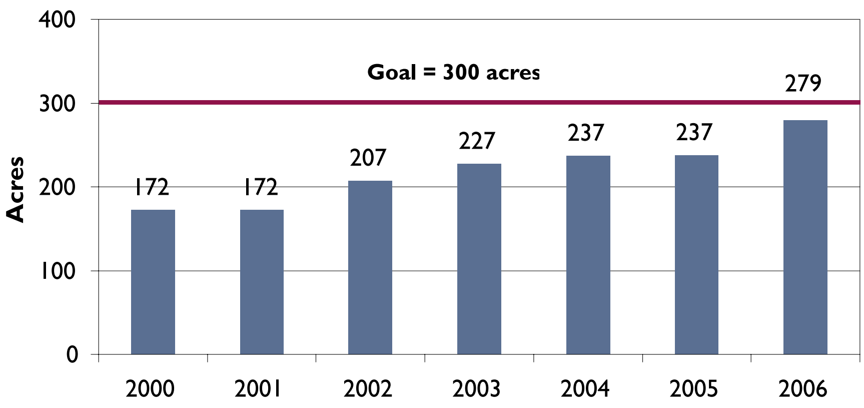
Restored Pickering Brook salt marsh

NHEP

HABITAT RESTORATION OPPORTUNITIES

The Great Bay Estuary Restoration Compendium, recently completed by The Nature Conservancy with funding from the NHEP and the NH Coastal Program, identifies ecological restoration opportunities in and around Great Bay. The compendium is the first comprehensive look at restoration priorities in Great Bay that includes multiple habitats and species, such as oyster reefs, soft-shell clam beds, salt marshes, eelgrass, shoreline buffers, and diadromous fish. Sites were identified by comparing historic and current distributions of habitats and species, identifying specific areas of loss, and using models to estimate which of these areas represented realistic restoration opportunities based on current environmental conditions. Final selection of the most promising areas was based on expert review and the potential for multiple habitat projects. The resulting compendium of historic, modern, and desired future conditions also includes information on appropriate restoration techniques. The compendium will be used by the NHEP, NH Coastal Program, and others as a guide for future restoration efforts in the coastal watershed area. The restoration compendium is available on the NHEP website: www.nhep.unh.edu.

Cumulative area of salt marsh restoration projects (Figure 18)



Data Source: NH Coastal Program

AWCOMIN SALT MARSH RESTORATION PROJECT

A celebration held in April 2006 highlighted five years of work by many organizations, led by the Town of Rye, Natural Resources Conservation Service, and the NH Coastal Program, to restore the 30-acre Awcomin Marsh in Rye, New Hampshire. The marsh was long ago degraded by filling of dredged materials that changed the elevation, hydrology, and plant composition of the marsh. The embattled marsh lacked pools and pannes and was overrun with invasive plants. Restoration of the marsh has occurred in several phases starting in 1991, when the NH Coastal Program and its partners removed old berms and excavated new channels and creeks on the site. The latest restoration effort, which began in 2001, aimed to remove dredge spoils (totaling about 9,000 dump truck loads), recreate the tidal creek system and open water habitat, and restore native vegetation. After more than five years of planning, construction, and revegetation activities, the latest phase of restoration was complete. An ongoing monitoring program organized by the NH Coastal Program tracks changes in salinity, water level, vegetation, and fish communities to assess the long-term success of the restoration effort. A boardwalk and two viewing platforms were installed to provide recreational opportunities and access to this marsh system. In the future, additional restoration work to control invasive species and mosquito habitat may be needed at this site.

NHEP

Third grade students and teachers plant switchgrass seedlings for a NHEP-funded revegetation project at Awcomin Marsh

How much of New Hampshire's coastal watershed is covered by impervious surfaces?

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

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

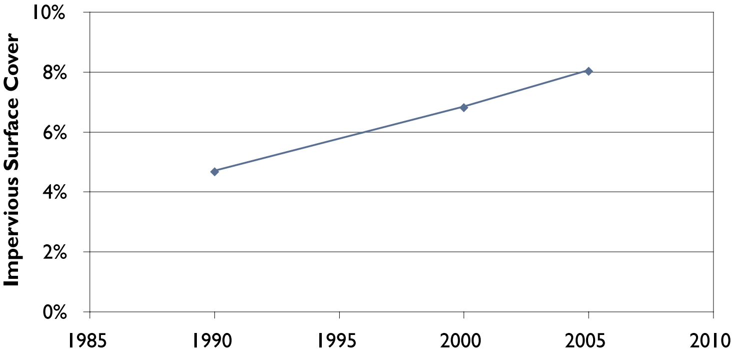
Overall, the area of impervious surfaces in the coastal watershed has grown from 24,349 acres in 1990 to 35,503 acres in 2000 to 41,784 acres in 2005. On a percentage basis, 4.7 percent, 6.8 percent, and 8.0 percent of the land area in the watershed was covered by impervious surfaces in 1990, 2000, and 2005, respectively (Figure 19). The number of watersheds with greater than 10 percent impervious surface cover was two in 1990, six in 2000, and 10 in 2005. Between 1990 and 2000, 11,154 acres of impervious surfaces were added to the watershed (1,115 acres per year). Impervious surfaces were added at a slightly higher rate between 2000 and 2005 (1,256 acres per year). All of these summary statistics show that impervious surfaces have been added to the watershed at an average rate of 1,185 acres per year over the past 15 years.

The percent of impervious surfaces in each coastal watershed in 2005 is shown in Figure 20. The watersheds with greater than 10 percent impervious surfaces are along the Atlantic Coast and up the Route 16 corridor along the Salmon Falls River and the Cocheco River. Town-by-town information for 1990, 2000, and 2005 is shown in Figure 21.

Land Use & Development

NHEP Goal: Keep the coverage of impervious surfaces in coastal subwatersheds less than 10 percent.

Percent of land area covered by impervious surfaces in the coastal watershed in 1990, 2000, and 2005 (Figure 19)



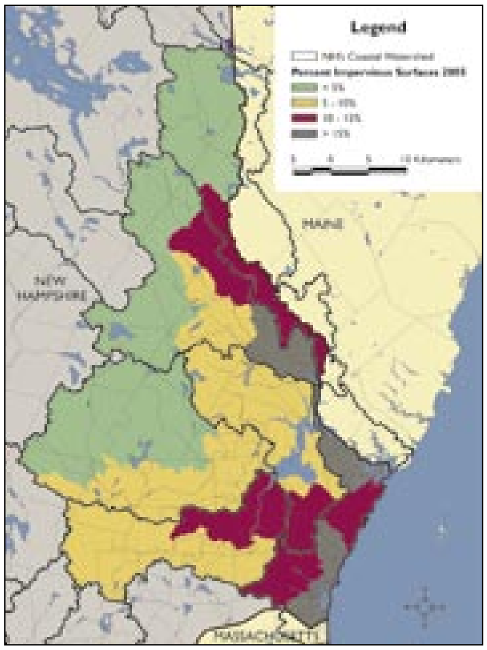
Data Source: UNH Complex Systems Research Center

Percent of land area covered by impervious surface in 1990, 2000, and 2005 (Figure 21)

Town	Land Area (acres)	Percent Imperviousness		
		1990	2000	2005
BARRINGTON	29,719	2.6%	4.0%	4.7%
BRENTWOOD	10,742	5.0%	7.7%	9.5%
BROOKFIELD	14,593	1.0%	1.3%	1.4%
CANDIA	19,342	2.7%	4.1%	4.8%
CHESTER	16,620	2.5%	4.3%	5.1%
DANVILLE	7,439	3.5%	6.0%	7.2%
DEERFIELD	32,587	1.5%	2.4%	3.0%
DOVER	17,094	11.0%	15.4%	18.6%
DURHAM	14,308	4.7%	7.2%	7.7%
EAST KINGSTON	6,319	3.5%	5.3%	7.0%
EPPING	16,468	4.0%	6.5%	7.8%
EXETER	12,553	7.5%	11.0%	12.4%
FARMINGTON	23,221	3.0%	4.2%	4.7%
FREMONT	11,036	3.0%	4.9%	5.9%
GREENLAND	6,780	6.7%	10.5%	12.5%
HAMPTON	8,317	14.2%	19.3%	20.6%
HAMPTON FALLS	7,719	4.4%	6.9%	9.1%
KENSINGTON	7,637	3.2%	5.0%	6.2%
KINGSTON	12,495	5.2%	8.2%	9.7%
LEE	12,680	3.7%	5.8%	6.6%
MADBURY	7,403	3.4%	5.3%	5.3%
MIDDLETON	11,560	1.8%	2.5%	3.0%
MILTON	21,099	2.8%	4.0%	4.7%
NEW CASTLE	504	21.4%	30.7%	33.9%
NEW DURHAM	26,347	1.7%	2.4%	2.8%
NEWFIELDS	4,542	3.1%	5.5%	6.8%
NEWINGTON	5,215	13.2%	18.0%	20.2%
NEWMARKET	8,073	5.9%	8.8%	10.1%
NORTH HAMPTON	8,865	7.3%	10.8%	12.4%
NORTHWOOD	17,976	2.4%	3.4%	4.0%
NOTTINGHAM	29,880	1.5%	2.3%	2.8%
PORTSMOUTH	10,001	21.3%	27.3%	30.5%
RAYMOND	18,448	5.3%	8.0%	9.3%
ROCHESTER	28,331	8.5%	11.7%	13.9%
ROLLINSFORD	4,682	5.7%	8.1%	9.3%
RYE	7,997	7.3%	11.0%	12.8%
SANDOWN	8,889	3.8%	6.1%	7.9%
SEABROOK	5,669	14.1%	21.3%	27.1%
SOMERSWORTH	6,220	12.3%	16.4%	20.2%
STRAFFORD	31,153	1.4%	2.0%	2.3%
STRATHAM	9,672	6.5%	10.1%	12.9%
WAKEFIELD	25,264	3.5%	4.8%	5.6%

Data Source: UNH Complex Systems Research Center

Impervious surface cover in coastal watersheds (Figure 20)



Data Source: UNH Complex Systems Research Center

UNH STORMWATER CENTER

The treatment and management of stormwater becomes increasingly important with the growing amounts of impervious surface cover in New Hampshire's coastal watershed. The UNH Stormwater Center, with support from the Cooperative Institute for Coastal and Estuarine Environmental Technology, serves as a resource to communities and managers for information on stormwater treatment devices and management practices. The Center's field facility tests a dozen different treatment systems, including manufactured devices, conventional structures such as ponds and swales, and newer designs often referred to at "low impact development" technologies such as bioretention systems and gravel wetlands. The Center monitors each treatment type for its ability to remove water pollution constituents typically found in stormwater and control stormwater peak flow and flow volume through storage and/or infiltration. In workshops conducted by UNH at the field site, stormwater managers, regulators, and land use decision-makers view how the structures function first hand, and they review monitoring data collected for each treatment type.

Results from the first year of facility operation indicated low impact development treatment systems typically performed well at removing many pollutants and reducing peak flow. Systems that included infiltration, filtration, biological treatment, and/or storage capacities tended to be the best performers. The most commonly used stormwater treatment and management systems – stone swales – had relatively low performance. The effectiveness of manufactured devices varied, with those that included filtration or infiltration components performing better than those that did not include these components.

For the latest information on the UNH Stormwater Center and its reports, visit www.unh.edu/erg/cstev or www.ciceet.unh.edu.

Is the coastal watershed experiencing "sprawl-type" development?

Yes. From 1990 and 2005, land consumption increased from 0.152 to 0.217 acres of impervious surface per person.

Why this is important

Increasing rates of land consumption per person is an indicator of sprawl-type development. Undeveloped land is at a premium in New Hampshire's coastal watershed. Accelerated consumption of this land is a threat to the habitats, health, and aesthetic quality of the watershed. Sprawl is a regional issue of concern as population in the Seacoast region continues to increase. If development is poorly planned, it can result in creation of unnecessary impervious surface cover with impacts to water quality, wildlife, and other natural resources.

Explanation

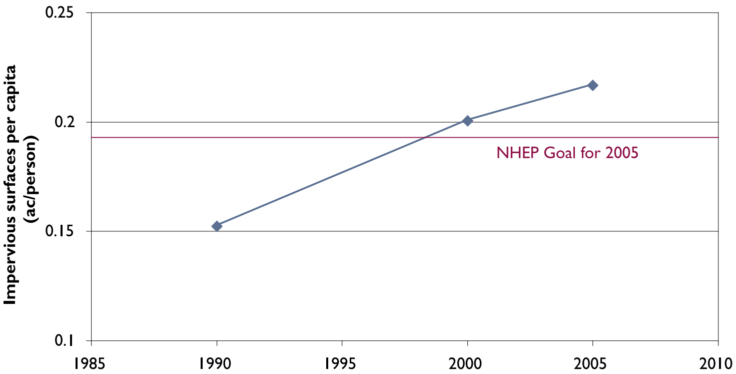
Overall, the average imperviousness per capita for the 42 municipalities grew from 0.152 acres per person in 1990 to 0.201 acres per person in 2000 to 0.217 acres per person in 2005 (Figure 22). The average value for 2005 was higher than the average of the NHEP goals for the individual towns (0.193 acres per person). Only 15 of the 42 municipalities met the NHEP goals for imperviousness per capita (Figure 23). These statistics clearly demonstrate that land consumption per person in the coastal watershed is still increasing and that sprawl-type development is still occurring.

While the average values indicate an overall problem with sprawling growth, the imperviousness per capita varied between municipalities (Figure 24). There was a marked difference in imperviousness per capita between municipalities with populations less than 10,000 people (0.207 acres/person) and municipalities with more than 10,000 people (0.120 acres/person). Of the 27 municipalities that did not meet the NHEP goal in 2005, only one was a municipality with greater than 10,000 people (Somersworth). As municipalities approach build out, population growth results in development of smaller lots and in multi-storied buildings which create less impervious surface per person than typical single family homes. The linear relationship between population and imperviousness may only be applicable to smaller towns with abundant undeveloped land.

Land Use & Development

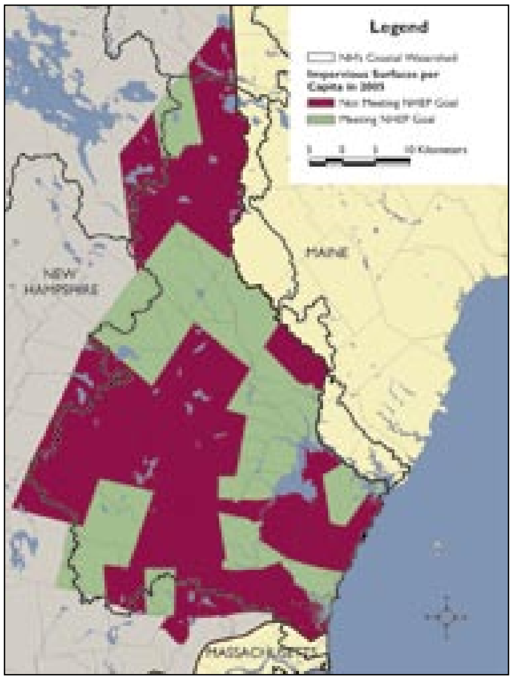
NHEP Goal: New development in coastal watershed towns between 2000 and 2010 should add no more than 0.1 acres of impervious surfaces per new resident.

Average impervious surfaces per capita in coastal municipalities (Figure 22)



Data Source: UNH Complex Systems Research Center

Coastal watershed towns with impervious surfaces per capita greater than NHEP goals (Figure 23)



Data Source: UNH Complex Systems Research Center

Impervious surfaces per capita (Figure 24)

Town	Imperviousness per Capita (ac/person)			
	1990	2000	2005	Goal
BARRINGTON	0.124	0.159	0.172	0.154
BRENTWOOD	0.205	0.259	0.251	0.225
BROOKFIELD	0.269	0.316	0.298	0.296
CANDIA	0.149	0.203	0.225	0.197
CHESTER	0.157	0.190	0.187	0.175
DANVILLE	0.103	0.111	0.121	0.110
DEERFIELD	0.157	0.209	0.231	0.196
DOVER	0.075	0.098	0.110	0.098
DURHAM	0.057	0.081	0.082	0.082
EAST KINGSTON	0.164	0.188	0.222	0.179
EPPING	0.127	0.196	0.218	0.188
EXETER	0.075	0.098	0.107	0.098
FARMINGTON	0.120	0.167	0.167	0.159
FREMONT	0.128	0.153	0.164	0.147
GREENLAND	0.164	0.222	0.248	0.215
HAMPTON	0.096	0.107	0.111	0.107
HAMPTON FALLS	0.227	0.285	0.347	0.273
KENSINGTON	0.149	0.200	0.227	0.191
KINGSTON	0.116	0.174	0.195	0.170
LEE	0.125	0.179	0.193	0.175
MADBURY	0.179	0.261	0.225	0.239
MIDDLETON	0.173	0.197	0.211	0.184
MILTON	0.162	0.215	0.228	0.203
NEW CASTLE	0.129	0.153	0.164	0.152
NEW DURHAM	0.232	0.283	0.299	0.267
NEWFIELDS	0.160	0.162	0.187	0.158
NEWINGTON	0.694	1.214	1.330	1.187
NEWMARKET	0.067	0.088	0.089	0.090
NORTH HAMPTON	0.178	0.225	0.243	0.218
NORTHWOOD	0.136	0.168	0.184	0.163
NOTTINGHAM	0.152	0.187	0.201	0.177
PORTSMOUTH	0.082	0.131	0.145	0.131
RAYMOND	0.112	0.153	0.165	0.150
ROCHESTER	0.090	0.116	0.130	0.115
ROLLINSFORD	0.100	0.144	0.163	0.143
RYE	0.127	0.169	0.194	0.168
SANDOWN	0.083	0.106	0.123	0.105
SEABROOK	0.123	0.152	0.182	0.149
SOMERSWORTH	0.068	0.089	0.106	0.089
STRAFFORD	0.146	0.176	0.183	0.169
STRATHAM	0.127	0.154	0.179	0.149
WAKEFIELD	0.287	0.288	0.299	0.270
AVERAGE	0.152	0.201	0.217	0.193

Data Source: UNH Complex Systems Research Center

COMMUNITIES PROTECTING NATURAL RESOURCES

Sprawling patterns of growth, which are typically associated with increases in impervious surfaces, affect water quality and other natural resources. A study conducted by the US Geological Survey and NH Coastal Program in the coastal watershed found that water quality parameters and macroinvertebrate populations were negatively impacted by various indicators of development. The amounts of urban land use in stream buffer areas and the amounts of impervious surface in subwatersheds have a direct bearing on water quality.

Assistance is available for communities to develop and implement plans to protect natural resources in the face of increasing development and growth. The Natural Resources Outreach Coalition (NROC) works with two to three communities each year to help identify important natural resources and facilitate town-initiated activities to protect them. As of 2006, over 15 towns in the coastal watershed have benefited from the NROC assistance. Community-initiated projects have resulted in improved ordinances, land protection projects, open space plans, successful town votes for land conservation funding, habitat inventories, and increased involvement of citizens in conservation activities.

Another resource is the NHEP's Community Technical Assistance Program (CTAP) that provides consulting services to communities to assist with regulatory and nonregulatory approaches to natural resources protection. Assistance is available for projects related to land conservation planning, stormwater management, and buffer protections. During the first year of this program, eleven communities have received customized technical assistance. For information on NROC or CTAP, contact the NHEP at Contact.NHEP @unh.edu or visit www.nhep.unh.edu.

How much of the coastal watershed is protected from development?

Currently, 54,622 acres in the watershed are protected, which amounts to 10.7 percent of the land area.

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

As of 2005, there were 54,622 acres of protected land in New Hampshire's coastal watershed, which represented 10.7 percent of the entire watershed land area (Figure 25). Over the past three years, 12,037 acres in the coastal watershed have been permanently protected from development (4,012 acres per year on average). In order to reach the NHEP goal of protecting 15 percent of the watershed land area by 2010, an additional 21,790 acres need to be protected in the watershed. The rate of land protection will need to increase in order to meet the NHEP goal.

The percentage of land area that is protected in each town is shown in Figure 26. This map shows that progress toward the NHEP goals has been good in the towns around Great Bay, near the coast, and in the vicinity of the Bear Brook and Pawtuckaway State Parks. In contrast, there is a lower percentage of protected land in the Salmon Falls River and Cocheco River watersheds.

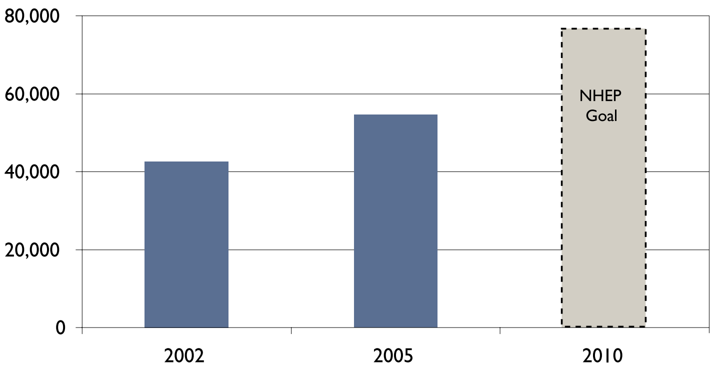
Many municipalities, land trusts, and conservation organizations are working to protect lands from rapidly increasing development. One especially successful effort is guided by the Great Bay Resource Protection Partnership (GBRPP), which is a collaborative group of nine conservation organization and agencies. As of December 2005, the GBRPP has facilitated the protection of over 7,000 acres of land in the Great Bay region.

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

Protected by The Nature Conservancy, Lubberland Creek Preserve covers 120 acres adjacent to Great Bay

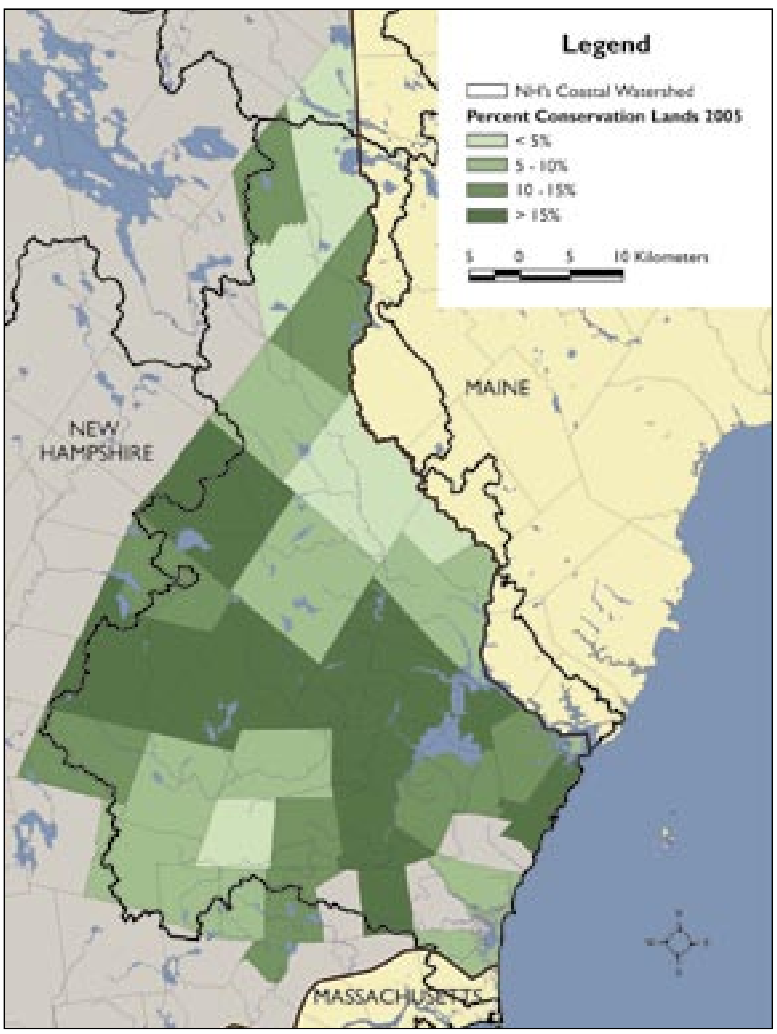
TNC

Conservation lands in the coastal watershed (Figure 25)



Data Source: UNH Complex Systems Research Center

Coverage of conservation lands in municipalities in the coastal watershed (Figure 26)



Data Source: UNH Complex Systems Research Center

LAND CONSERVATION PLAN FOR NEW HAMPSHIRE'S COASTAL WATERSHEDS

To maintain healthy coastal ecosystems, ecologically valuable land needs to be protected from development. The recently completed Land Conservation Plan for New Hampshire's Coastal Watersheds identifies 75 conservation focus areas totaling over 230,000 acres that are key targets for land protection activities. The areas identified in the plan are important for the protection and maintenance of ecosystem functions and ecological integrity throughout the coastal watershed. The conservation focus areas were selected for their importance in protecting water quality and aquatic resources, promoting large forested habitat blocks, and supporting critical habitats and species that are valued in the seacoast region. The plan is intended to serve as a scientifically defensible guide to support habitat protection activities – both through traditional conservation approaches (e.g., fee ownership and conservation easements) and regulatory approaches that limit development in high priority areas and encourage conservation practices. The NH Coastal Program will use the plan as the foundation for the State's Coastal and Estuarine Land Conservation Program (CELCP). For more information on the plan, go to www.nhep.unh.edu.

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Society for the Protection of New Hampshire Forests
University of New Hampshire
US Environmental Protection Agency

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