2003

State of Our Estuaries 2003

New Hampshire Estuaries Project

State of Our Estuaries 2003

2003

STATE OF THE ESTUARIES

New Hampshire Estuaries Project

About the New Hampshire Estuaries Project

The New Hampshire Estuaries Project (NHEP) is part of the U.S. Environmental Protection Agency's (EPA) National Estuary Program which is a joint local/state/federal program established under the Clean Water Act with the goal of protecting and enhancing nationally significant estuarine resources. The NHEP receives its funding from EPA and is administered by the New Hampshire Office of State Planning and Energy Programs.

The NHEP's *Comprehensive Conservation and Management Plan* for New Hampshire's estuaries was completed in 2000 and implementation has been ongoing. The *Management Plan* outlines key issues related to management of New Hampshire's estuaries and proposes strategies (Action Plans) that are expected to preserve, protect, and enhance the State's estuarine resources. The NHEP's priorities were established by local stakeholders and include water quality improvements, shellfish resource enhancements, land protection, and habitat restoration. Projects addressing these priorities are undertaken throughout New Hampshire's coastal watershed, which includes 42 communities.

The NHEP strives to:

- Improve the water quality and overall health of New Hampshire's estuaries
- Support regional development patterns that protect water quality, maintain open space and important habitat, and preserve estuarine resources
- Track environmental trends through the implementation of a long-term monitoring program to assess indicators of estuarine health
- Develop broad-based support for the *Management Plan* by encouraging involvement of the public, local government, and other interested parties in its implementation

New Hampshire's Estuaries

New Hampshire has over 230 miles of sensitive inland tidal shoreline in addition to 18 miles of open ocean coastline on the Gulf of Maine. New Hampshire's estuaries contain bays, tidal rivers, and salt marsh systems. The coastal watershed that drains water into New Hampshire's estuaries via rivers and streams spans three states and approximately 80% of it is located in New Hampshire. Forty-two New Hampshire communities are entirely or partially located within the coastal watershed. The largest estuaries in the system include Great Bay and Hampton-Seabrook Harbor. Other estuaries of importance in the State are Little Bay, Little Harbor, Rye Harbor and portions of tidal tributaries.

Great Bay – The Great Bay is a tidally dominated, complex embayment on the New Hampshire-Maine border. Estuarine tidal waters cover 17 square miles with nearly 150 miles of tidal shoreline. Land surrounding the Bay includes steep, wooded banks with rocky out-crops, cobble and shale beaches, and salt marshes. The estuary extends inland from the mouth of the Piscataqua River between Kittery, Maine and New Castle, New Hampshire to Great Bay proper, a distance of 15 miles. Great Bay's tidal exchange with the ocean generates rapid currents and keeps the estuary well mixed. Much of the land surrounding Great Bay is undeveloped, and groups such as the Great Bay Resource Protection Partnership are working to permanently protect land in the region from development.

Hampton-Seabrook Harbor – Hampton-Seabrook Harbor encompasses 480 acres of open water at high tide. Characterized by extensive salt marshes and separated from the ocean by a series of barrier beaches, the approximately 8 square miles of contiguous salt marsh within the Hampton-Seabrook Harbor is the largest salt marsh in the State. It is also one of the busiest tourist venues because of Hampton Beach and the productive clam flats in the harbor.

The 2003 State of the Estuaries Report: Trends of Key Environmental Indicators

New Hampshire's estuaries are dynamic, complex systems that greatly influence the Seacoast's economy, communities, quality of life and environment. To understand how these systems function and to gauge their relative health, the New Hampshire Estuaries Project (NHEP) tracks key environmental indicators and evaluates their status against a set of management goals. This report communicates the status of 12 of the 30 environmental indicators tracked by the NHEP. For each indicator it provides the reader with the associated NHEP management goal, explanation of supporting data, and some of the NHEP supported activities that help achieve the management goal.

It is important to recognize that the NHEP's goals for the indicators are long term. The NHEP strongly advises readers to not assume that positive trends, such as the decrease of fecal coliform bacteria, mean that no more work needs to be done. Positive trends only suggest that management efforts are working, not that the problem has been solved.

In addition to reporting on environmental indicators, this report also includes two case studies that illustrate how a variety of organizations' activities lead to the improvement of water quality and protection of estuarine resources.

Environmental Indicators

An environmental indicator is "a specific, measurable marker that helps assess the condition of the environment and how it changes over time."[1] In other words, an indicator is something that can be measured in the environment that is indicative of certain environmental conditions. For each environmental indicator, the NHEP has developed a numeric target based on the goals and objectives in the NHEP *Management Plan*. Some targets are fixed thresholds (e.g., water quality standards), while other targets are related to trends over time.

The NHEP currently tracks 30 different environmental indicators of water quality, shellfish resources, land use, and critical species and habitats. The NHEP also gathers and analyzes data on 20 other "supporting variables" that are used to understand the causes behind trends in the indicators.

The NHEP compiles and analyzes data from state, federal, regional and university monitoring programs to prepare four indicator reports for the NHEP's Technical Advisory Committee and the NHEP's Management Committee which cover the areas of water quality, shellfish, habitat and species, land use and development. These committees add interpretation and insight into the status and trends of the indicators and have selected the most compelling indicators that have sufficient data to be included in the *State of the Estuaries Report*.

Footnotes

[1]LISS (2001). Sound Health 2001: Status and trends in the health of Long Island Sound. Long Island Sound Study, U.S. Environmental Protection Agency, Stamford, CT.

COVER PHOTO: Jerry and Nancy Monkman/Ecophotography.com

Coastal Watershed Partnerships

The NHEP represents a collaborative effort of local, state, and federal interests involved in the stewardship of New Hampshire's estuaries. Coastal watershed communities and estuarine resources benefit immensely from the unique assemblage of resource management agencies, research institutions, and conservation organizations focused on the State's estuaries.

A notable partnership is the one between the NHEP and the Great Bay National Estuarine Research Reserve (GBNERR). The GBNERR is part of a national network of estuarine research reserves operated by the National Oceanic and Atmospheric Association. The objectives of the NHEP and the GBNERR are complementary and the estuary benefits from the coordinated efforts of these two organizations.

The NHEP has also formed partnerships with other groups to leverage efforts to protect the estuaries. Organizations such as the Great Bay Resource Protection Partnership and Great Bay Stewards have done much to protect critical land around Great Bay. Regional planning commissions and UNH Cooperative Extension have provided valuable technical assistance for towns' planning and resource protection efforts. Furthermore, the New Hampshire Coastal Program has restored over 200 acres of salt marsh habitat in the last five years. New Hampshire's estuaries also benefit greatly from UNH-based research conducted through the Cooperative Institute for Coastal and Estuarine Environmental Technology and the Jackson Estuarine Laboratory. Shellfish resources, as well as all other wildlife resources, are managed by New Hampshire Fish & Game Department, which relies on New Hampshire Department of Environmental Services programs to monitor and improve water quality - resulting in shellfish beds that are open to harvesting.

The NHEP's mission and *Management Plan* implementation are greatly advanced through the collective efforts of these and many other entities. These organizations strive to coordinate activities, and the NHEP has played a key role in facilitating this collaborative spirit.

Table of Contents

INDICATOR

1

QUESTION

Have fecal coliform bacteria levels changed in the last ten years in Great Bay?

ANSWER **Yes, they have decreased.**

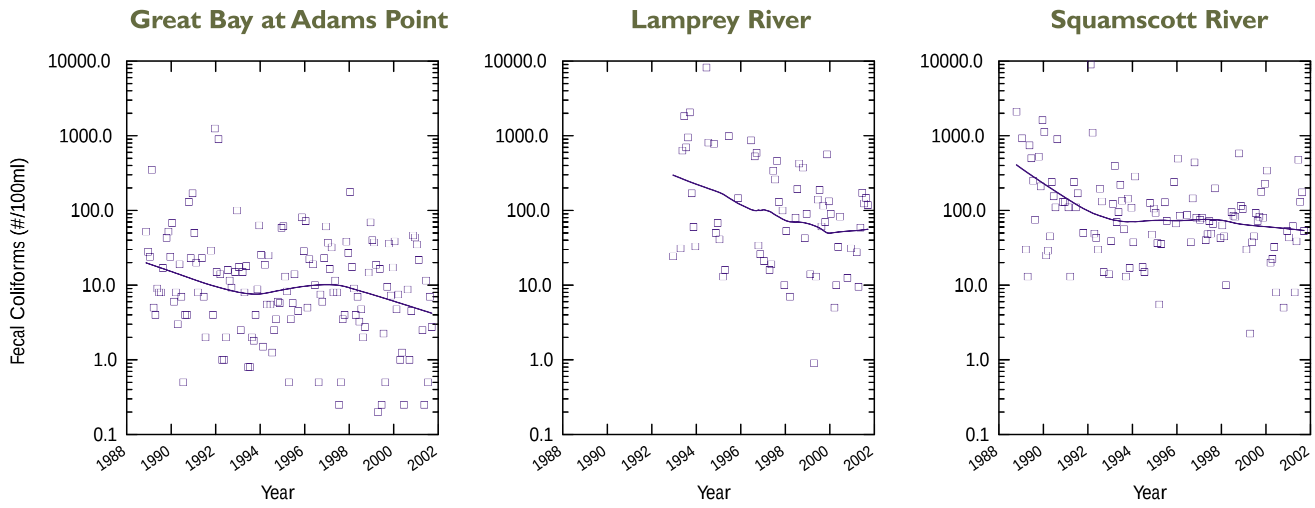
Why This Is Important

To estimate levels of fecal contamination in shellfish waters, scientists test for fecal coliforms, a group of bacteria that live in the gut of warm-blooded animals. The presence of fecal coliforms in surface water is a warning of sewage contamination, which may indicate the presence of disease-causing microorganisms. Because of this potential public health issue, elevated concentrations of fecal coliform bacteria in estuarine waters are the primary reason why shellfish beds are closed to harvesting.

Explanation

At all three long-term water quality monitoring stations in Great Bay, the trend has been a decrease in the concentrations of fecal coliforms during dry weather over the past ten years. Dry weather fecal coliform contamination is an indication of sewage contamination from faulty septic systems, overboard marine toilet discharges, wastewater treatment facility failures, and cross connections between sanitary sewer and stormwater systems as well as livestock, wildlife, resuspension of contaminated sediments, and residual stormwater-related pollution. In the middle of the Bay at Adams Point, fecal coliform concentrations have decreased by 30%. This result is encouraging because it indicates that the collective input from the Bay's many tributaries is decreasing. Stronger declining trends were found at the tributary sampling sites, where decreases of 75% have occurred during the same ten-year period. Despite these improvements, there are still many closures of shellfish beds due to bacterial pollution so the NHEP goal has not yet been fully met.

Dry Weather Fecal Coliform Concentrations at Adams Point, Lamprey River and Squamscott River Stations



Source: Great Bay National Estuarine Research Reserve Monitoring Program

Possible Reasons

Wastewater treatment facility upgrades and removal of sewage inputs from stormwater sewers are likely major contributors to the decreasing trends (Jones, 2000).

NHEP GOAL

Achieve water quality in Great Bay and Hampton-Seabrook Harbor that meets shellfish harvest standards[1] by 2010.

NHEP-Funded Activities

Mapping of storm sewer infrastructure is an important but costly step municipalities must take to control illicit discharges of untreated wastewater that cause elevated levels of fecal coliform bacteria. The NHEP has contracted with the NH Department of Environmental Services to assist municipalities in creating storm sewer maps. Mapping projects have occurred in Hampton, Somersworth, Newmarket, Exeter, Seabrook, Portsmouth, and Rochester. Plans are in place to map the storm sewer systems of more towns and cities in the watershed. Another project supported by the NHEP is microbial source tracking work to build capacity for *Escherichia coli* ribotyping (commonly called DNA fingerprinting) to identify sources of fecal pollution.

Footnotes

[1] The water quality standards for shellfishing waters are the National Shellfish Sanitation Program (NSSP) standards for "approved" shellfish harvesting areas: a geometric mean for fecal coliforms of less than 14 MPN/100ml and a 90th percentile of less than 43 MPN/100ml. However, the NSSP classification guidelines include other factors besides attainment of these water quality standards (e.g., completion of shoreline sanitary surveys).

Reference to Indicator Report
A complete assessment of trends in dry-weather bacterial concentrations may be found in the NHEP Environmental Indicator Report: Water Quality, Indicator "BAC2"

Jones, S. Ed., (2000). A Technical Characterization of Estuarine and Coastal New Hampshire. New Hampshire Estuaries Project, Portsmouth, NH.

PHOTO CREDIT: NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

Sampling outfalls to detect illicit connections to storm sewer systems

INDICATOR

2

QUESTION

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

ANSWER **Yes, several have decreased and one has increased.**

Why This Is Important

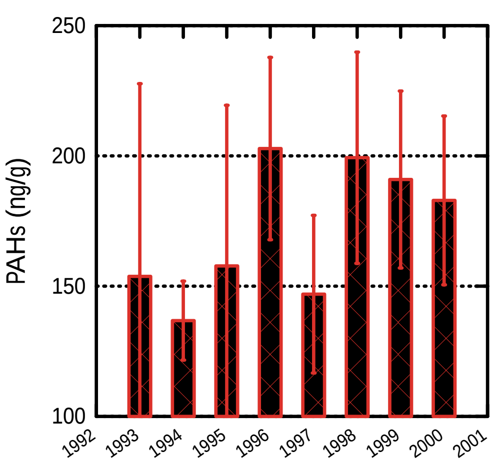
Mussels, clams, and oysters accumulate toxic contaminants from polluted water in their tissues. In addition to being a public health risk, contaminated shellfish tissue is also a natural long-term monitor of water quality in the estuaries.

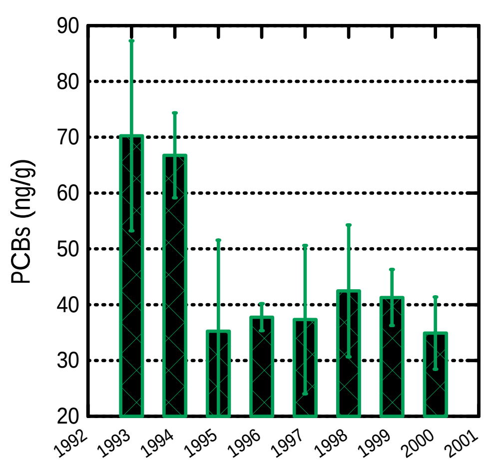
Explanation

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 2000, none of the 13 mussel sampling stations in the estuary have registered toxic contaminant levels greater than FDA guidelines. Mercury and polychlorinated biphenyls (PCBs)[1] levels were well below FDA guidelines, however, lead levels approached the recommended limits in some locations. Trends at the Portsmouth Harbor station suggest that levels of PCBs and the pesticide DDT[2] are declining while polyaromatic hydrocarbon (PAH)[3] levels are increasing.

In Portsmouth Harbor, mussel tissue has been analyzed annually from 1993 to 2000. The concentrations of PCBs and DDT in the blue mussels at this location have decreased by 49% and 37%, respectively, but concentrations of PAHs have increased by 30%. These trends were shown to be statistically significant. There were no significant trends for any metals in the blue mussel tissue, including mercury, which is a priority pollutant for the Gulf of Maine Council. 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. PAHs are constituents of petroleum and are residuals of the combustion of petroleum products and other organic compounds. Increased stormwater runoff from impervious surfaces (e.g. parking lots) and fuel spills into the estuary are two of many possible reasons for the increasing PAH concentrations in the blue mussel tissue.

Trends for Toxic Contaminants in Blue Mussel Tissue from Portsmouth Harbor





Source: Gulf of Maine Council Gulfwatch Program

Possible Reasons

The decreasing trends in PCBs and DDT are likely due to the bans placed on these chemicals in the 1970s. One explanation for the increasing PAH concentrations is that the growing amount of impervious surfaces in the Seacoast has caused more petroleum-polluted runoff to accumulate and then be washed into the estuary via stormwater conduits. Boat spills into the estuary is another possible explanation.[4]

NHEP GOAL

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

NHEP-Funded Activities

The NHEP is funding continued mussel tissue monitoring, which includes two additional sites for assessing trends in different portions of the estuary. The NHEP also funded testing of clam and oyster tissue for metals, pesticides, PCBs and PAHs in 2001 and 2002.

Footnotes

[1] PCBs: Polychlorinated Biphenyls are a group of toxic, persistent chemicals that were banned in 1979.

[2] DDT: Dichlorodiphenyltrichloroethane is a class of once popular pesticides that were banned in 1972.

[3] PAHs: Polynuclear aromatic hydrocarbons result from the burning of combustible material, most notably fossil fuels.

[4] Determination of toxic inputs was derived from *A Technical Characterization of Estuarine and Coastal New Hampshire*, which "provides a comprehensive compilation of information on key issues related to water quality and natural resources in the estuaries of New Hampshire" (Jones, 2000).

Reference to Indicator Report

A complete assessment of shellfish tissue contaminant concentrations may be found in the NHEP Environmental Indicator Report: Water Quality, Indicators "TOX1" and "TOX3"

Jones, S. Ed., (2000). A Technical Characterization of Estuarine and Coastal New Hampshire. New Hampshire Estuaries Project, Portsmouth, NH.

PHOTO CREDIT: NEW HAMPSHIRE ESTUARIES PROJECT

Tidal creek on Great Bay in Durham, NH

INDICATOR

3

QUESTION

Have nitrogen concentrations in Great Bay changed significantly over time?

ANSWER **Yes, they have increased.**

Why This Is Important

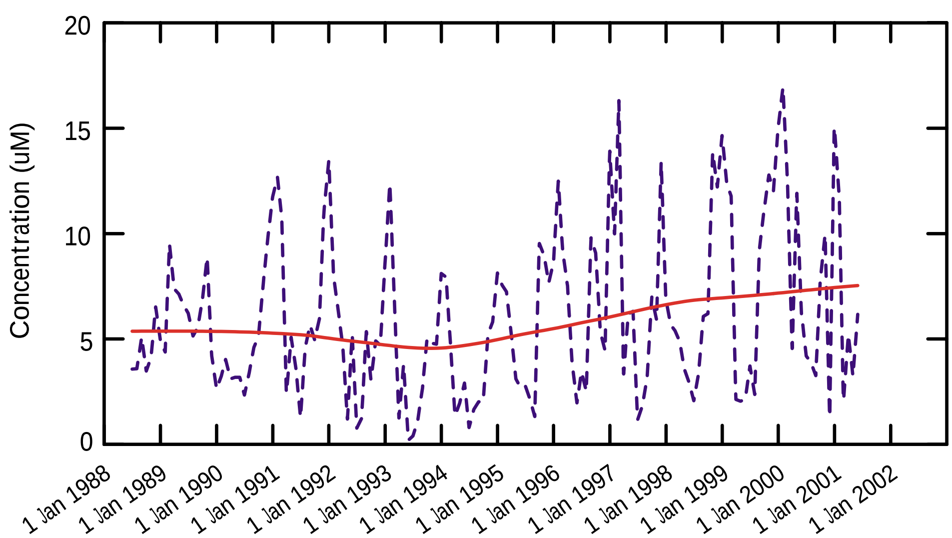
Increasing nitrogen concentrations in a body of water means an increasing amount nutrients are entering the system. Nitrogen and other nutrients are essential for life; however, it is possible to have too much of a good thing. Excessive nutrients can cause blooms of algae that change species composition of important habitats. Decomposition of algae can deplete coastal waters of dissolved oxygen. The critical, limiting nutrient in coastal waters is nitrogen, which comes from a variety of sources that are becoming more prevalent with increasing development. For this reason, it is important to monitor nutrient levels in New Hampshire's estuaries as a safeguard against nutrient pollution.

Explanation

Monthly measurements at three long-term water quality monitoring stations have documented the changes in nitrate+nitrate concentrations in the Great Bay between 1992 and 2001. Statistical tests have shown that nitrate+nitrite concentrations have increased at the stations at Adams Point in Great Bay and in the Lamprey River during this period. However, there were no statistically significant trends at the Squamscott River station.

Despite the increasing concentrations of nitrate+nitrite in the estuary, there have not been any significant trends for the typical indicators of eutrophication[1]: dissolved oxygen and chlorophyll-a concentrations. Therefore, the load of nitrate+nitrite to the bay appears to have not yet reached the level at which the undesirable effects of eutrophication occur.

Nitrate+Nitrite at Adams Point



Source: Great Bay National Estuarine Research Reserve Monitoring Program

Note: Dashed line equals measured contamination, solid line equals interpolated trend.

Possible Reasons

The major sources of nutrient contamination to the estuary are wastewater treatment facility effluent, lawn fertilizer residue, septic systems, atmospheric deposition, and runoff from urban and agricultural areas, which are all related to population growth and its associated land development patterns[2].

NHEP GOAL

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

NHEP-Funded Activities

The NHEP is funding a study conducted by Department of Environmental Services (DES) and University of New Hampshire (UNH) to evaluate pollutant loading, including nutrients, from eleven wastewater treatment plants and determine impacts of effluent on estuarine systems. Another UNH study funded by the NHEP involves mapping groundwater discharge zones and groundwater nutrient loading in Hampton-Seabrook Harbor. The DES monthly monitoring program for nutrients in tributaries to Great Bay is also funded by the NHEP.

[1] Eutrophication is the process by which a body of water becomes enriched with organic material. This material is formed in the system by primary productivity (photosynthetic activity); and may be stimulated to harmful levels by the anthropogenic introduction of high concentrations of nutrients (nutrient over-enrichment) such as nitrogen and phosphorus (NRC, 2000).

[2] Determination of nutrient inputs was derived from *A Technical Characterization of Estuarine and Coastal New Hampshire*, which "provides a comprehensive compilation of information on key issues related to water quality and natural resources in the estuaries of New Hampshire" (Jones, 2000).

References to Indicator Report

A complete assessment of nutrient concentration trends may be found in the NHEP Environmental Indicator Report; Water Quality, Indicators "NUT2" and "NUT3."

Jones, S. Ed., (2000). A Technical Characterization of Estuarine and Coastal New Hampshire. New Hampshire Estuaries Project, Portsmouth, NH.

NRC, (2000). Clean Coastal Waters: Understanding and reducing the effects of nutrient pollution. National Research Council. National Academy Press, Washington, D.C.

PHOTO CREDIT: NEW HAMPSHIRE ESTUARIES PROJECT

Adams Point on Great Bay in Durham, NH

INDICATOR

4

QUESTION

How often do dissolved oxygen[1] levels in the estuary fall below State standards?

ANSWER **Not very often.**

Why This Is Important

Fish and many other aquatic organisms need dissolved oxygen in the water to survive. When dissolved oxygen levels are low, fish can be stressed or even die. Prolonged periods of low dissolved oxygen can alter aquatic ecosystems.

Explanation

The strong tidal flushing through the estuary and inflow from freshwater streams keep the water well mixed and oxygenated. Dissolved oxygen levels in Great Bay and the Squamscott River consistently meet the State standard. While the standard has been met at the Lamprey River sites 90% of the time, there have been a few instances where the standard was not met. More intensive measurements[2] are being made to confirm the frequency of these occurrences.

The Great Bay National Estuarine Research Reserve maintains instruments at several locations in the estuary to monitor the dissolved oxygen and other parameters every 30 minutes. The measurements are used to determine the average dissolved oxygen concentrations during the day. The results for Great Bay, the Lamprey River, and the Squamscott River are shown in the following table.

Daily Average Dissolved Oxygen Concentrations

Station	Year	# days with complete data in July, August, and September	# of days where measurements did not meet standards
Great Bay	1995	51	0
Great Bay	1996	58	0
Great Bay	1997	61	0
Great Bay	1998	71	0
Great Bay	1999	89	0
Great Bay	2000	60	0
Great Bay	2001	83	0
Lamprey River	1999	27	n/a
Lamprey River	2000	87	2
Lamprey River	2001	58	6
Squamscott River	1997	63	0
Squamscott River	1998	61	0
Squamscott River	1999	83	0
Squamscott River	2000	38	0
Squamscott River	2001	86	0

n/a: Data not available due to sensor error.

Source: Great Bay National Estuarine Research Reserve Monitoring Program

Possible Reasons

The causes of sporadic low dissolved oxygen concentrations are not known. Blooms of algae, respiration of benthic organisms, and oxygen demand from wastewater treatment facility effluent can deplete oxygen in the water. In some cases the low concentrations may be a natural phenomenon.

NHEP GOAL

No days with exceedences of the State standard for daily average dissolved oxygen (75% saturation).

NHEP-Funded Activities

In 2002 the NHEP funded the University of New Hampshire to deploy a datasonde with oxygen sensors in the Salmon Falls River and has provided $10,000 to maintain the system of datasondes throughout the estuary.

Footnotes

[1] Dissolved oxygen is the oxygen dissolved in water that is available for living organisms to use for respiration.

[2] The measurements are made using a piece of equipment called a datasonde which is installed in the water for up to two weeks. The datasonde sensors can become fouled during deployment so low dissolved oxygen readings should be verified by alternative methods in the field.

Reference to Indicator Report

A complete assessment of dissolved oxygen may be found in the NHEP Environmental Indicator Report: Water Quality, Indicators "NUT5" and "NUT6"

PHOTO CREDIT: NEW HAMPSHIRE ESTUARIES PROJECT

Great Bay shoreline in Stratham, NH

INDICATOR

5

QUESTION

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

ANSWER **Yes, it has declined dramatically.**

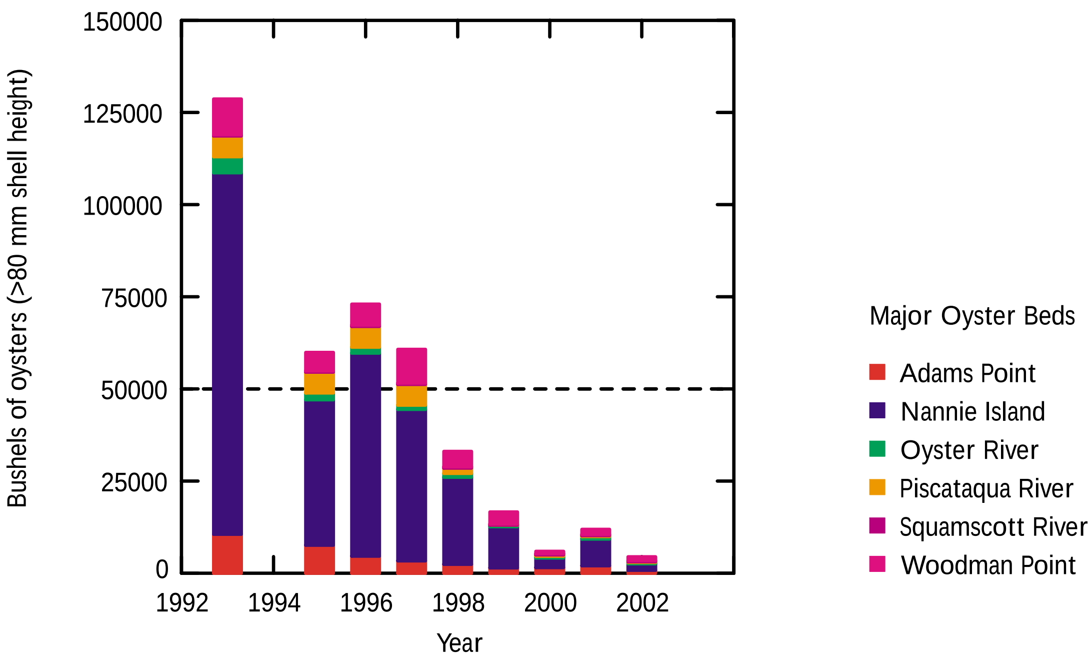
Why This Is Important

Oysters are economically important because they support valuable recreational fisheries and have tremendous potential as aquaculture species. They are also excellent bioindicators of estuarine condition because they are relatively long lived, stationary and filter large volumes of estuarine water to feed. Additionally, because they are filter feeders, they play an important role in nutrient cycling, improving water clarity, and removing significant quantities of nitrogen and phosphorus from the water.

Explanation

Since 1993 the oyster fishery in Great Bay has suffered a serious decline. In 2002 the standing stock[1] in beds open for harvesting was 3,579 bushels, about 7% of the goal of 50,000 bushels. Most of the remaining standing stock is in the Adams Point, Nannie Island, and Woodman Point beds in Great Bay.

Standing Stock of Harvestable-Size Oysters in Great Bay



Source: New Hampshire Fish and Game Department, Oyster Resource Surveys

Possible Reasons

The major cause of this 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.

NHEP GOAL

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

NHEP-Funded Activities

The NHEP funds the NH Fish and Game Department (NHFG) to monitor oyster disease organisms MSX and Dermo at selected beds. In 2001, the NHEP funded NHFG to map the dimensions of the major oyster beds to determine whether they had changed in size since they were last mapped in 1997. The NHEP has reserved $225,000 of funds for shellfish restoration projects. Projects for this funding will be selected in 2003.

Footnotes

[1] Standing stock is the number of oysters of harvestable size (> 80 mm shell height) in a designated area.

Reference to Indicator Report

A complete assessment of oyster populations may be found in the NHEP Environmental Indicator Report: Shellfish, Indicators "SHL5" and "SHL2"

PHOTO CREDIT: UNIVERSITY OF NEW HAMPSHIRE

Harvestable Oysters

INDICATOR

6

QUESTION

Has harvestable clam density in the Hampton-Seabrook Harbor flats changed over time?

ANSWER **Yes, current densities are lower than average.**

Why This Is Important

Soft shell clams are an 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

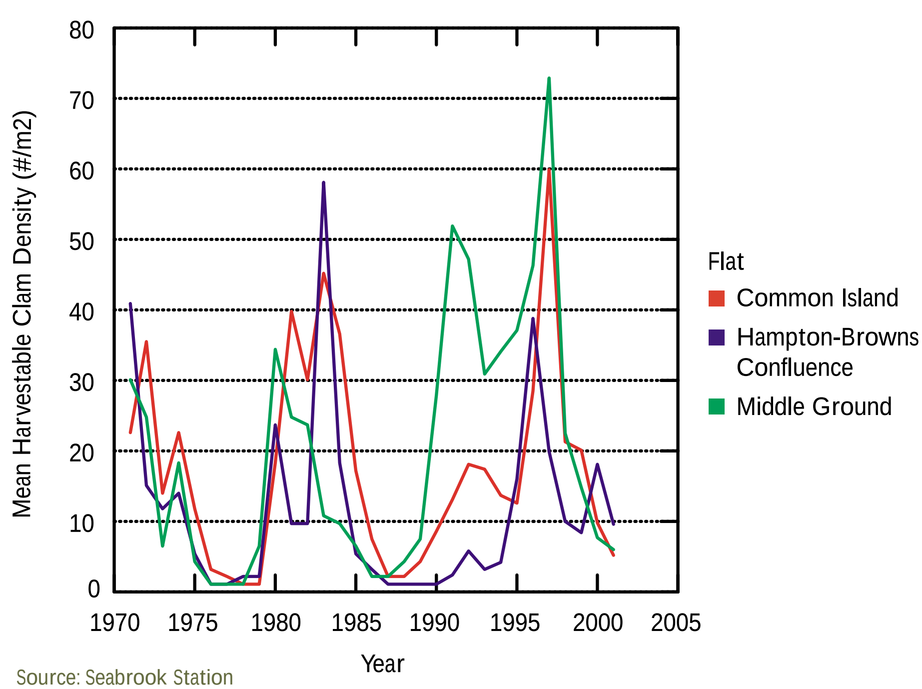
Densities in 2001 were well below the most recent 10 year average (1990-1999) and falling for all three main flats. The 2001 densities at Common Island and Middle Ground were also lower than the longer-term baseline densities recorded between 1974 and 1989.

Average Density of Harvestable[1] Sized Clams

Flat	Current Status (2001), #/m2	Latest 10-year Average (1990-1999), #/m2	Longer-Term Baseline (1974-1989), #/m2
Common Island	5.2	21.3	15.3
Hampton-Browns Confluence	9.6	11.0	9.8
Middle Ground	6.0	38.6	9.9

Clam densities have followed a cyclical pattern with a period of approximately 12 years. For instance, at Common Island, peak densities between 35.5 and 59.9 clams per square meter were observed in 1972, 1983, and 1997. Between these peaks, the harvestable clam density fell to 1-2 clams per square meter. The high densities in the 1990s coincided with a period when some or all of the flats were closed to harvesting due to bacterial pollution (1990-1997). However, densities have decreased since their peak in 1997 even though the harvest from the flats has been relatively low since 1998.

Density of Harvestable Clams in Hampton-Seabrook Harbor Flats



Source: Seabrook Station

Possible Reasons

The source 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 over-harvesting may contribute to the decline.

NHEP GOAL

Maintain or exceed the average density of harvestable clams in Hampton-Seabrook Harbor flats.

NHEP-Funded Activities

The NHEP funded a study by the University of Maine at Machias to examine the causes of mortality among juvenile clams in Hampton Harbor. The NHEP has reserved $225,000 for shellfish restoration projects. Projects for funding will be selected by the end of 2003.

Footnotes

[1] Harvestable clam size is >50mm shell length.

Reference to Indicator Report

A complete assessment of clam populations may be found in NHEP Environmental Indicator Report: Shellfish, Indicator "SHL3"

Beal, B. (2002). Juvenile clam mortality study at three intertidal flats in Hampton Harbor. New Hampshire Estuaries Project, Portsmouth, NH

NHEP (2000). Comprehensive Conservation and Management Plan. New Hampshire Estuaries Project, Portsmouth, NH

PHOTO CREDIT: NEW HAMPSHIRE COASTAL PROGRAM

Hampton-Seabrook Harbor in 1998

INDICATOR

7

QUESTION

Has eelgrass habitat in Great Bay changed over the past 10 years?

ANSWER **No, eelgrass cover has remained relatively constant.**

Why This Is Important

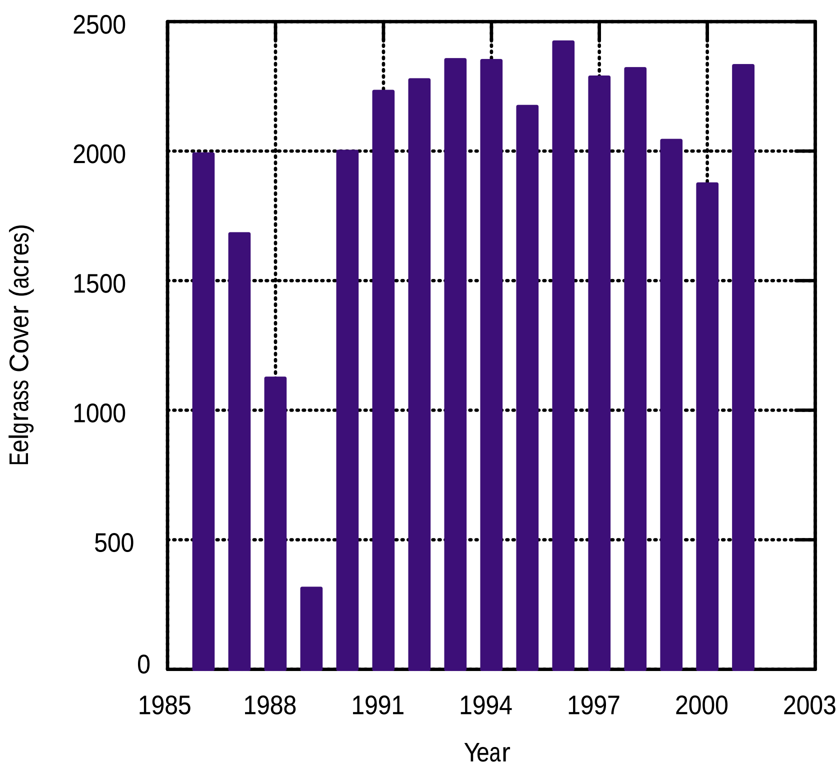
Eelgrass (*Zostera marina*) is an essential part the estuary's ecology because it provides food for wintering waterfowl and habitat for juvenile fish (Thayer et al., 1984).

Explanation

The University of New Hampshire (UNH) Seagrass Ecology Group has mapped the distribution of eelgrass in Great Bay every year from 1986 to 2001. The entire Great Bay estuary system (Great Bay, Little Bay, tidal tributaries, Piscataqua River, and Portsmouth Harbor) was mapped in 1996, 1999, 2000, and 2001.

Eelgrass cover in Great Bay has been relatively constant for the past 10 years at approximately 2,000 acres. In 1989, there was a dramatic decline in eelgrass to 300 acres (15% of normal levels). However, the eelgrass beds made a rapid recovery in the following year.

Eelgrass Coverage in Great Bay



Source: University of New Hampshire, Seagrass Ecology Group

Possible Reasons

Water clarity and water depth are the main factors affecting the presence of eelgrass. However, eelgrass can be affected by other factors, such as disease, on a rapid temporal scale. For example, the dramatic density decline in 1989 was caused by an infestation of a slime mold *Labryrinthula zosterae*, commonly called "wasting disease" (Muehlstein et al., 1991).

NHEP GOAL

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

NHEP-Funded Activities

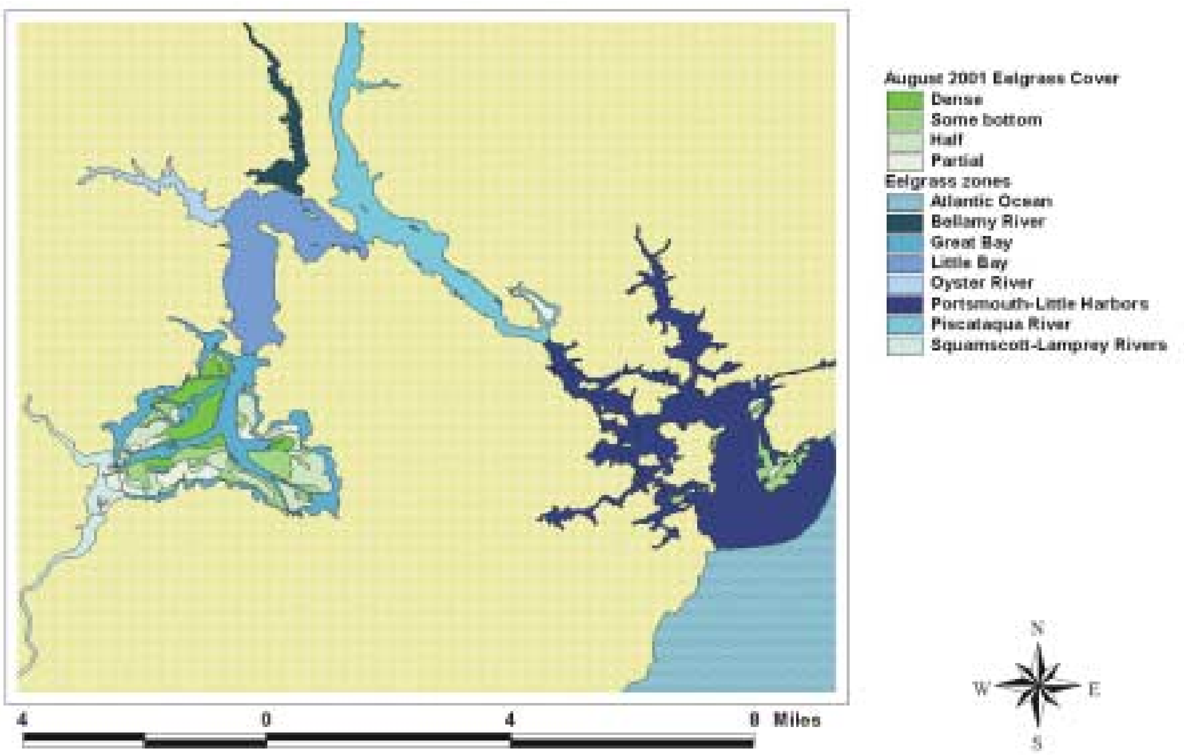
In 2002, the UNH Jackson Estuarine Laboratory completed work on an eelgrass mapping project that created digital maps from aerial photos of Great Bay from 1999, 2000, and 2001. The NHEP-funded project provided a valuable tool for understanding trends in eelgrass populations. The NHEP began funding annual surveys of eelgrass beds by UNH researchers in 2002.

Reference to Indicator Report
A complete assessment of eelgrass distribution may be found in the NHEP Environmental Indicator Report: Species and Habitat, Indicator "HAB2"

Thayer GW, Kenworthy WJ, Fonseca MS (1984). The ecology of eelgrass meadows of the Atlantic coast: a community profile. US Fish and Wildlife Service, FWS/OBS0-84/02, 147pp.

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.

Eelgrass Coverage in Great Bay Estuary



Source: University of New Hampshire, Seagrass Ecology Group

INDICATOR

8

QUESTION

How much of the coastal watershed is protected[1] from development?

ANSWER **8.4%**

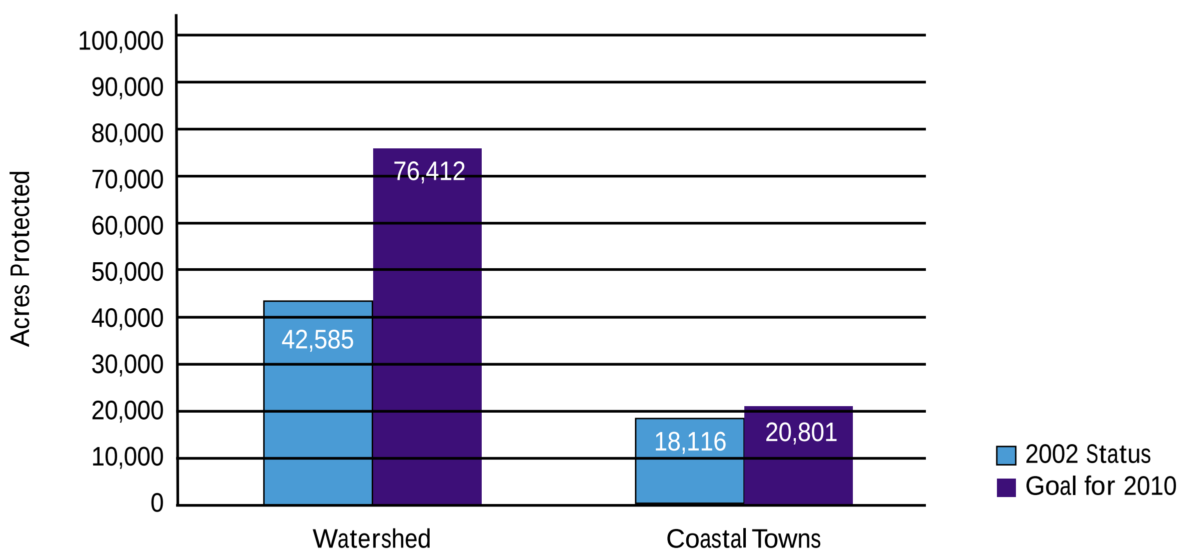
Why This Is Important

Development of land for residential, commercial, industrial, and other uses can eliminate or disrupt habitats and increase stormwater runoff and other sources of estuarine water pollution.

Explanation

As of 2002, there were 42,585 acres of protected land in New Hampshire's coastal watershed, which represented 8.4% of the entire watershed land area. In coastal communities 18,116 acres were protected lands in 2002, which is 13.1% of the total area of these communities. In order to reach NHEP goal of protecting 15% of the watershed land area by 2010 an additional 33,827 acres need to be protected in the watershed, including at least 2,685 acres in the 17 coastal communities.

Conservation Lands in the Coastal Watershed



Source: GRANIT Conservation Lands Data Layer (October 2002)

Possible Reasons

Many municipalities, land trusts, and conservation organizations are working to protect lands from rapidly increasing development in the Seacoast region. A collaborative of organization that has done a great deal to protect land from development is the Great Bay Resource Protection Partnership, which consists of the Audubon Society of New Hampshire, Ducks Unlimited, Great Bay National Estuarine Research Reserve, NH Fish and Game, The Nature Conservancy, Society for the Protection of NH Forests, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and the U.S. Natural Resources Conservation Service. The Partnership has facilitated the protection of 4,062 acres of land in the Great Bay region from January 1995 to March 2003.

NHEP GOAL

Increase the acres of protected private and public lands from baseline levels to 15% of the coastal watershed and 15% of the coastal communities by 2010.

NHEP-Funded Activities

The NHEP is funding the Coastal Watershed Land Protection Transaction Fund, which is administered by the Center for Land Conservation Assistance. Through the Fund, land conservation organizations and municipalities can apply for up to $3,000 to cover the transaction costs associated with permanent land protection projects. Expenses such as survey costs, attorneys' fees, consultants' fees and other costs are eligible for funding. The NHEP is also supporting efforts of Bear-Paw Regional Greenways, Moose Mountains Regional Greenways, Rockingham Land Trust, and Seacoast Land Trust to promote land protection across the watershed.

Footnotes

[1] GRANIT, New Hampshire's statewide GIS data storage and distribution center, maintains a digital record of parcels of land of two or more acres that are mostly undeveloped and are protected from future development. Protection is usually in the form of a conservation easement that limits development in perpetuity.

Reference to Indicator Report

A complete assessment of conservation land may be found in the NHEP Environmental Indicator Report: Species and Habitats, Indicator "HAB6"

PHOTO CREDIT: OFFICE OF STATE PLANNING AND ENERGY PROGRAMS

Conservation land in Rollinsford, NH

INDICATOR

9

QUESTION

Are there large, protected, unfragmented land blocks in New Hampshire's coastal watershed?

ANSWER **Yes, but very few.**

Why This Is Important

The fragmentation of open lands due to new roads and sprawling patterns of development can have significant consequences on habitat and hydrologic functions within the coastal watershed.

Explanation

As of 2001, there were 282 unfragmented blocks greater than 250 acres in the coastal watershed. The majority of the blocks were less than 1,000 acres. There were only 4 blocks greater than 5,000 acres. Only ten percent (10%) of the blocks are currently protected from development.

Number, Acreage, and Protection Status of Unfragmented Forest Blocks in the Coastal Watershed

	UNFRAGMENTED BLOCK SIZE (ACRES)					
	250 to 500	500 to 1,000	1,000 to 2,500	2,500 to 5,000	5,000 to 10,000	Total
Number of unfragmented blocks	112	95	60	11	4	**282**
Acres of unfragmented blocks	40,486	65,629	87,751	40,202	28,019	**262,087**
Protected lands in blocks greater than 250 acres						**25,236**
Percent of unfragmented blocks that are protected						**9.6%**

Source: 2001 land cover with fragmentation analysis by the Society for the Protection of New Hampshire Forests[1] and the October 2002 conservation lands data layer from GRANIT[2]

PHOTO CREDIT: NEW HAMPSHIRE ESTUARIES PROJECT

PHOTO CREDIT: NEW HAMPSHIRE COASTAL PROGRAM

Open space in Durham and Newmarket, NH

Possible Reasons

Rapid development, especially sprawl-type development, in the coastal watershed results in the loss of unfragmented lands through road building and subdivisions.

The unfragmented blocks were predominantly located in the western portion of the watershed. The following table summarizes the percent of each town in the watershed that is covered by unfragmented blocks of 250 acres or greater.

Fraction of Land Area in Coastal Towns Covered by Unfragmented Forest Blocks in 2001

Town	Town Area (acres)			Acres of Unfragmented Blocks >250 acres	Percent of Land Area in Unfragmented Blocks >250 acres
Name	**Land**	**Water**	**Total**		
MIDDLETON	11,560	283	11,843	8,102	70.09%
NOTTINGHAM	29,880	1,116	30,997	20,478	68.53%
MILTON	21,099	836	21,935	13,585	64.39%
FARMINGTON	23,221	419	23,640	14,525	62.55%
BARRINGTON	29,719	1,398	31,117	18,434	62.03%
NEWFIELDS	4,542	105	4,647	2,812	61.90%
BROOKFIELD	14,593	287	14,880	8,729	59.81%
FREMONT	11,036	107	11,143	6,543	59.29%
DEERFIELD	32,587	762	33,349	18,699	57.38%
EPPING	16,468	308	16,776	9,186	55.78%
BRENTWOOD	10,742	121	10,862	5,725	53.30%
MADBURY	7,403	396	7,799	3,809	51.45%
STRAFFORD	31,153	1,626	32,779	15,874	50.95%
NORTH HAMPTON	8,865	57	8,922	4,168	47.01%
RAYMOND	18,448	495	18,944	8,328	45.14%
NORTHWOOD	17,976	1,380	19,356	7,564	42.08%
HAMPTON FALLS	7,719	358	8,077	3,240	41.98%
EXETER	12,553	261	12,814	5,175	41.23%
KENSINGTON	7,637	31	7,668	3,091	40.47%
CANDIA	19,342	215	19,557	7,774	40.19%
CHESTER	16,620	98	16,718	6,652	40.02%
ROCHESTER	28,331	750	29,081	11,274	39.79%
STRATHAM	9,672	228	9,901	3,734	38.60%
NEWMARKET	8,073	1,007	9,080	3,102	38.42%
DURHAM	14,308	1,543	15,852	5,367	37.51%
WAKEFIELD	25,264	3,452	28,716	9,357	37.04%
RYE	7,997	426	8,424	2,872	35.91%
NEW DURHAM	26,347	1,707	28,054	9,127	34.64%
SANDOWN	8,889	343	9,232	2,921	32.86%
ROLLINSFORD	4,682	161	4,843	1,506	32.17%
GREENLAND	6,780	1,744	8,524	2,053	30.28%
EAST KINGSTON	6,319	62	6,381	1,843	29.17%
LEE	12,680	248	12,928	3,338	26.33%
HAMPTON	8,317	754	9,071	2,034	24.45%
SOMERSWORTH	6,220	179	6,399	1,249	20.08%
DOVER	17,094	1,498	18,592	3,336	19.51%
SEABROOK	5,669	491	6,160	1,079	19.03%
DANVILLE	7,439	131	7,569	1,341	18.02%
PORTSMOUTH	10,001	762	10,763	1,687	16.87%
KINGSTON	12,495	955	13,450	1,263	10.11%
NEWINGTON	5,215	2,701	7,916	242	4.65%
NEW CASTLE	504	843	1,348	0	0%

Source: 2001 land cover with fragmentation analysis by the Society for the Protection of New Hampshire Forests[1]

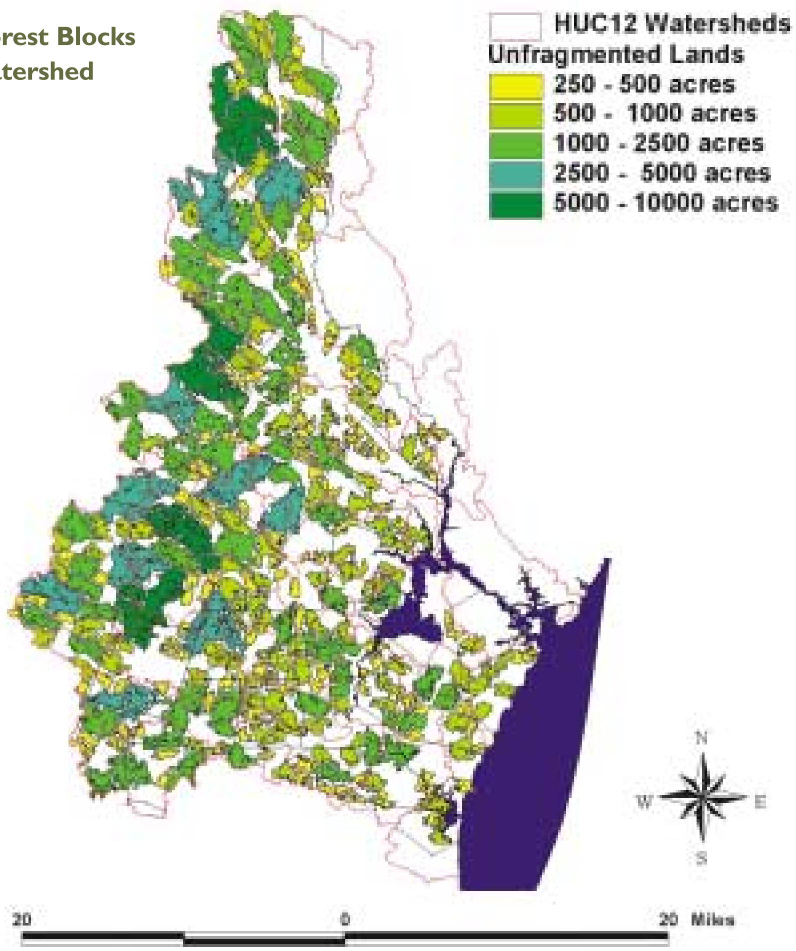
NHEP GOAL

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

NHEP-Funded Activities

In 2003 the NHEP granted funds to the Seacoast Land Trust to work on a cooperative project with the University of New Hampshire's Cooperative Extension Service and the Society for the Protection of New Hampshire Forests to create co-occurrence habitat maps for the town of Greenland and to communicate the results of this mapping project through public workshops. Co-occurrence maps highlight priority resource features, including unfragmented habitats, to assist in targeting land protection efforts.

Unfragmented Forest Blocks in the Coastal Watershed



Source: 2001 land cover with fragmentation analysis by the Society for the Protection of New Hampshire Forests[1] and the October 2002 conservation lands datalayer from GRANIT[2].

Footnotes

[1] SPNHF had processed 2001 land cover data from GRANIT using the roads datalayers to identify blocks of unfragmented lands in southeastern New Hampshire. Blocks were permitted to straddle town boundaries.

[2] GRANIT, New Hampshire's statewide GIS data storage and distribution center, maintains a digital record of parcels of land of two or more acres that are mostly undeveloped and are protected from future development. Protection is usually in the form of a conservation easement that limits development in perpetuity.

Reference to Indicator Report

A complete assessment of unfragmented forest blocks may be found in the NHEP Environmental Indicator Report: Land Use and Development, Indicator "LUD4" and in the NHEP Environmental Indicator Report: Species and Habitats, Indicator "HAB4"

INDICATOR

10

QUESTION

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

ANSWER **6.8%, but it is not evenly distributed.**

Why This Is Important

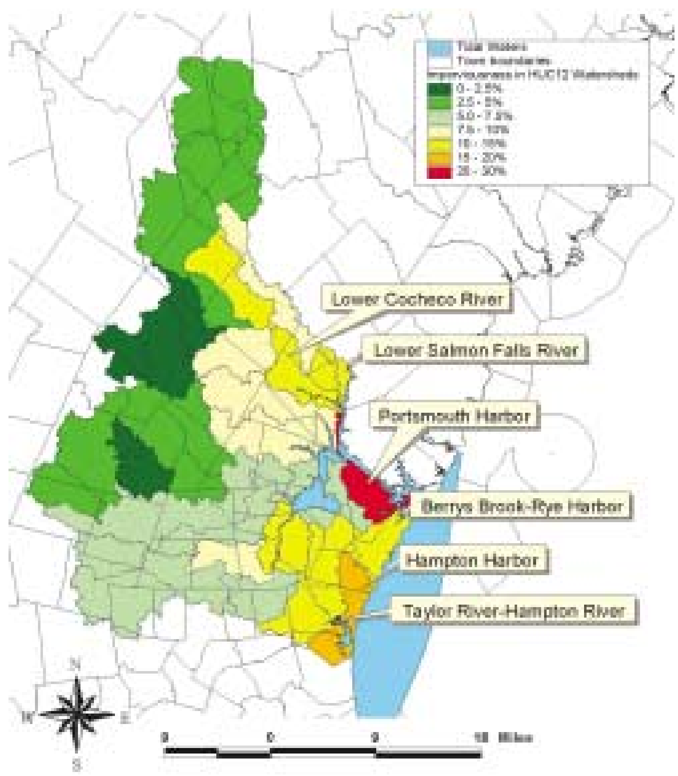
Paved parking lots, roadways, and building roofs are all examples of impervious surfaces. Precipitation cannot pass through the surface and infiltrate into the ground so all the water from storms runs off across the surface, often accumulating pollutants as it flows. Impervious surfaces add to the volume and velocity of stormwater, sending more pollutants and sediments through drains and tributaries or directly into the estuaries.

Studies conducted in other regions of the country have demonstrated water quality deterioration where impervious surfaces cover greater than 10% of the watershed area (Shueller, 1995). However, additional factors, such as the proximity of the impervious surfaces to water bodies and the extent of buffer may be more important than percent imperviousness.

Explanation

For the coastal watershed as whole, there were 24,349 and 35,503 acres of impervious surfaces in 1990 and 2000, respectively. These acreages amount to 4.7% and 6.8% of the watershed land area. However, the surfaces were not evenly distributed across the watershed. Six (6) of the 37 subwatersheds of the coastal watershed had impervious surface cover >10% in 2000. Most of these subwatersheds are adjacent to the coast or along the Route 16 corridor. The Hampton Harbor subwatershed had between 15% and 20% impervious cover. The Portsmouth Harbor subwatershed had between 20% and 30% impervious cover.

Percent of Impervious Surface Cover in NH's Coastal Watershed in 2000



Source: University of New Hampshire, Complex Systems Research Center

Possible Reasons

Development creates impervious surface in the form of new buildings, new roadways, new driveways, and new parking lots. Sprawl-type development, such as commercial strip development with large parking lots and dispersed low-density residential development with long roadways and driveways, typically creates more impervious surface than compact development and redevelopment activities.

Eleven (11) of the 42 towns in the coastal watershed have more than 10% of their land area covered by impervious surfaces. The town with the highest percent impervious cover is New Castle, which has approximately 30% impervious surfaces. Portsmouth and Seabrook both have impervious values between 20% and 30%. Impervious surfaces cover between 15% and 20% of Dover, Hampton, Newington, and Somersworth. Exeter, North Hampton, Rochester, and Rye have percent impervious values between 10% and 15%. The following table shows the percent of land area covered by impervious surfaces in the 42 coastal watershed towns.

Mapped Areas, Impervious Surface in Acres and Percentage of Coastal Watershed Towns

Town	Mapped Area (acres)			Impervious Surface (acres)		Impervious Surface (percent*)	
Name	Land	Water	Total	1990	2000	1990	2000
NEW CASTLE	504	843	1,348	108	155	21%	31%
PORTSMOUTH	10,001	762	10,763	2,128	2,726	21%	27%
SEABROOK	5,669	491	6,160	802	1,206	14%	21%
HAMPTON	8,317	754	9,071	1,179	1,605	14%	19%
NEWINGTON	5,215	2,701	7,916	687	941	13%	18%
SOMERSWORTH	6,220	179	6,399	768	1,021	12%	16%
DOVER	17,094	1,498	18,592	1,873	2,626	11%	15%
ROCHESTER	28,331	750	29,081	2,395	3,304	8%	12%
RYE	7,997	426	8,424	587	878	7%	11%
EXETER	12,553	261	12,814	937	1,376	8%	11%
NORTH HAMPTON	8,865	57	8,922	647	958	7%	11%
GREENLAND	6,780	1,744	8,524	455	713	7%	10%
STRATHAM	9,672	228	9,901	628	979	6%	10%
NEWMARKET	8,073	1,007	9,080	480	707	6%	9%
KINGSTON	12,495	955	13,450	651	1,019	5%	8%
ROLLINSFORD	4,682	161	4,843	266	381	6%	8%
RAYMOND	18,448	495	18,944	977	1,484	5%	8%
BRENTWOOD	10,742	121	10,862	532	829	5%	8%
DURHAM	14,308	1,543	15,852	675	1,026	5%	7%
HAMPTON FALLS	7,719	358	8,077	342	536	4%	7%
EPPING	16,468	308	16,776	658	1,071	4%	6%
SANDOWN	8,889	343	9,232	337	544	4%	6%
DANVILLE	7,439	131	7,569	260	445	4%	6%
LEE	12,680	248	12,928	468	740	4%	6%
NEWFIELDS	4,542	105	4,647	142	251	3%	6%
MADBURY	7,403	396	7,799	251	394	3%	5%
EAST KINGSTON	6,319	62	6,381	221	335	4%	5%
KENSINGTON	7,637	31	7,668	243	378	3%	5%
FREMONT	11,036	107	11,143	329	538	3%	5%
WAKEFIELD	25,264	3,452	28,716	878	1,225	4%	5%
CHESTER	16,620	98	16,718	423	720	2%	4%
FARMINGTON	23,221	419	23,640	687	966	3%	4%
CANDIA	19,342	215	19,557	531	794	3%	4%
BARRINGTON	29,719	1,398	31,117	763	1,187	3%	4%
MILTON	21,099	836	21,935	597	839	3%	4%
NORTHWOOD	17,976	1,380	19,356	424	610	2%	3%
MIDDLETON	11,560	283	11,843	204	284	2%	2%
NEW DURHAM	26,347	1,707	28,054	458	628	2%	2%
DEERFIELD	32,587	762	33,349	492	768	2%	2%
NOTTINGHAM	29,880	1,116	30,997	448	693	2%	2%
STRAFFORD	31,153	1,626	32,779	434	638	1%	2%
BROOKFIELD	14,593	287	14,880	139	191	1%	1%

*Percent of land area
Source: UNH Complex Systems Research Center

NHEP GOAL

Keep the coverage of impervious surfaces in coastal subwatersheds less than 10%.

NHEP-Funded Activities

The University of New Hampshire's Complex Systems Research Center was funded by the NHEP to estimate impervious surface acreage for the coastal watershed for the years 1990 and 2000 using Landsat satellite imagery and sub-pixel processing.

Reference to Indicator Report
A complete assessment of impervious surfaces may be found in the NHEP Environmental Indicator Report: Land Use and Development, Indicator "LUD1"

Schueller (1995). The importance of imperviousness. Watershed Protection Techniques, 1(3): 100-111.

PHOTO CREDIT: NEW HAMPSHIRE COASTAL PROGRAM

Little River in North Hampton, NH

INDICATOR

11

QUESTION

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

ANSWER **Yes.**

Why This Is Important

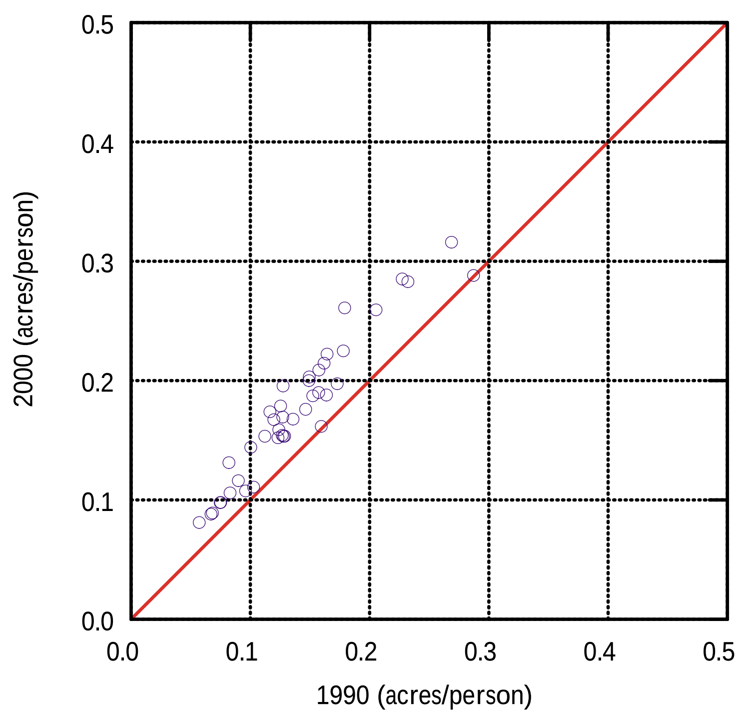
Increasing rates of land consumption per person is an indicator of sprawl-type development. Undeveloped land is at a premium in New Hampshire's coastal watershed. Accelerated consumption of this land is a threat to the habitats, health, and aesthetic quality of the watershed.

Explanation

Between 1990 and 2000, 11,154 acres of impervious surface were added in the coastal watershed. More than half of the 42 towns in the coastal watershed had significantly increasing land consumption per person between 1990 and 2000 (25 of 42 towns)[1]. On average, the acres of impervious surfaces for each person in the towns increased by 0.05 acres/person over ten years, from 0.15 acres/person in 1990 to 0.20 acres/person in 2000. The towns with the largest increases were Newington, Madbury, and Epping where the imperviousness per capita increased by 0.52, 0.08, and 0.07 acres per person, respectively. The high ratio for Newington was likely caused by the loss of population between 1990 and 2000 following the closure of Pease Air Force Base.

The following figure illustrates the general increase in imperviousness per capita by plotting the ratio for each town in 1990 versus its ratio in 2000. All of the towns plot above the red 45 degree line, which shows that imperviousness per capita is increasing in all the towns even if the change is not statistically significant.

Impervious Acres per Person - 1990 vs. 2000



Note: Values for Newington not shown on figure.
Source: University of New Hampshire Complex Systems Research Center

Possible Reasons

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.

NHEP GOAL

No towns in the coastal watershed having increasing rates of land consumption per person as measured by impervious surface creation.

NHEP-Funded Activities

The NHEP supports the Natural Resources Outreach Coalition (NROC), which assists communities with planning for growth while protecting natural resources. NROC helps communities identify priorities, provides technical assistance, and funds community implementation projects through grants. NROC activities have been conducted in the towns of Barrington, Dover, Exeter, Stratham, and Newfields. Activities in 2003 are being conducted in Somersworth, Candia, and Nottingham.

The NH Office of State Planning, with NHEP support, completed "Achieving Smart Growth in New Hampshire," a resource to assist communities integrating smart growth principles into planning activities. The report provides examples of smart growth in New Hampshire and presents the planning process undertaken by three communities through case studies.

Footnotes

[1] An increase in ratios was considered statistically significant if the amount of the increase was greater than the uncertainty in the estimates.

Reference to Indicator Report

A complete assessment of per capita land consumption may be found in the NHEP Environmental Indicator Report: Land Use and Development, Indicator "LUD2"

PHOTO CREDIT: NEW HAMPSHIRE ESTUARIES PROJECT

Tidal creek in Durham, NH

INDICATOR

12

QUESTION

Have restoration efforts resulted in more tidal wetland acres?

ANSWER **Yes.**

Why This Is Important

Filling, ditching, draining and restricting tidal flow degrade salt marshes. These impacts disrupt the marsh ecology and can result in mosquito problems, flooding, and reduced biological diversity. Restoration efforts seek to remedy these problems by improving tidal hydrology and reestablishing healthy marsh habitats.

Explanation

The NHEP has a goal to restore 300 acres of tidal wetlands through tidal restriction removal. Since January 2000, 176.5 acres of salt marsh has been restored through tidal restriction removal (59% of goal). The NH Coastal Program is currently planning another 129 acres of salt marsh restoration by tidal restriction removal, which, if completed, will surpass the NHEP goal of restoring 300 acres.

Possible Reasons

Over time much of the salt marsh area in the State has been degraded due to tidal restrictions (e.g. undersized culverts and/or filling), hydrology modifications (e.g. ditching), and increased freshwater inputs from impervious surfaces. However in the last decade, over 600 acres of salt marsh habitat have been restored in the State as a result of strong leadership from local communities and state and federal agencies including the NH Coastal Program, NH Department of Transportation, and the USDA Natural Resources Conservation Service.

NHEP GOAL

Restore 300 acres of salt marsh through tidal restriction removal by 2010.

PHOTO CREDIT: GREAT BAY NATIONAL ESTUARINE RESEARCH RESERVE

Salt marsh habitat and a great blue heron

NHEP-Funded Activities

The NHEP has funded salt marsh restoration activities in the towns of Hampton and North Hampton. Currently, the NHEP is supporting the New Hampshire Chapter of Ducks Unlimited in cooperation with the NH Coastal Program to restore the Pickering Brook salt marsh in Greenland that has been degraded due to ditching.

Reference to Indicator Report

A complete assessment of salt marsh restoration may be found in the NHEP Environmental Indicator Report: Species and Habitats, Indicator "RST1"

CASE STUDY 1

Protecting Critical Habitat around Great Bay

by Matt Craig,
NHEP Planning Technician

PHOTO CREDIT: NH ESTUARIES PROJECT

Protected land along Great Bay in Newmarket, NH

The Great Bay Resource Protection Partnership (GBRPP) plays an integral role in the identification and protection of key undeveloped lands and habitat around Great Bay. The Partnership was conceived in 1994 by a coalition of organizations that shared the objective of protecting critical habitat. GBRPP's nine principal partners, the Audubon Society of New Hampshire, Ducks Unlimited, Great Bay National Estuarine Research Reserve, New Hampshire Fish and Game Department (NHFG), The Nature Conservancy, Society for the Protection of New Hampshire Forests, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Natural Resources Conservation Service, first came together to protect 500 acres of significant wetlands and associated uplands in the Crommet Creek area of Durham.

The success of the Crommet Creek project led to the development of a plan for identifying and protecting additional important habitat. Since then, GBRPP has been awarded four North American Wetland Conservation Act (NAWCA) grants, funded through the Duck Stamp program, for a total of nearly $3.2 million, which was matched by over $5.7 million in local funding. Furthermore U. S. Senator Judd Gregg has been instrumental in securing nearly 25 million dollars in federal funding for the Partnership's land protection activities. Today, with support from a uniquely diverse array of federal, state, and local stakeholders, the Partnership has succeeded in protecting over 4,100 acres of important habitat in the Lamprey River, Piscassic River, and Crommet Creek watersheds through purchases of land and conservation easements, most of which will ultimately be under the management of the NHFG.

The NHEP's *Management Plan* rates support of the GBRPP as among its Highest Priority Action Plans. As such, the NHEP has consistently funded the Partnership's habitat protection efforts through staff support and through support of resource assessment projects that identify and recommend conservation action priorities.

As a tributary to the Lamprey River with tracks of rural forested land ripe for new development, the Piscassic River Watershed was a logical region in which to continue habitat inventory and assessment work. With NHEP funding, the Partnership recently completed *An Assessment of Natural Communities and Significant Wildlife Habitat in Selected Focus Areas in the Piscassic River Watershed*. This study, a potential prototype for studies of other tributaries to Great Bay, is comprised of two complementary components: a technical report, which applies GIS technology to developing a habitat modeling protocol, and a field-based resource assessment, which inventories significant ecological communities.

Findings from the assessment demonstrate that a remarkable level of diversity occurs in the Piscassic River Watershed. Within the 2,500 acres inventoried as part of the assessment, 60 natural community types were recorded and 358 plant species were identified – nearly 18 percent of the documented native and naturalized plant species found in the State. The assessment identified three parcels as priority areas for conservation action, including a wetland/floodplain forest community, a large intact forested block with interspersed open field, river corridor, and riparian habitats, and a riverside tract within which three turtle species deemed of "special management concern" were confirmed to occur. Based on the Piscassic study, the Partnership submitted an application in March 2003 for $1 million in NAWCA funds to protect these important habitats. Of 44 proposals received, the application ranked second in the Atlantic Coast region based in part on the strength, thoroughness, and currency of its assessment. In July 2003 the proposal was approved by the NAWCA Council and the completed assessment and mapping will provide an important baseline of data from which to develop resource management plans. In the meantime, GBRPP intends to continue to inventory sites and implement habitat protection strategies throughout the Great Bay area, building on its already considerable success.

CASE STUDY 2

Managing Shellfish Waters in Hampton-Seabrook Harbor

Shellfish harvesting is a popular recreational activity in the estuaries of New Hampshire and is a tradition for many Seacoast families. In addition to their value as a recreational resource, shellfish serve as an indicator of overall water quality and estuarine health. In the 1980s and early 1990s, closure of clam flats due to bacterial contamination left many residents frustrated and was the impetus for action by the New Hampshire Estuaries Project (NHEP). In conjunction with other state agencies, the University of New Hampshire (UNH) and the surrounding communities, the NHEP facilitated the development of programs designed to evaluate water quality, identify and remediate pollution sources, classify shellfish growing waters, and enhance opportunities for shellfish harvesting.

Using the NHEP *Management Plan* as a framework for improving water quality and shellfish resources, the NHEP and its partners have implemented a variety of monitoring, assessment, and restoration programs. Monitoring activities include classifying shellfish waters, sampling stormdrain and wastewater treatment facility discharges, and tracking pollution sources. Research projects, pollution source assessment, and monitoring activities have helped managers make informed decisions about shellfish harvesting, such as classification and opening of additional clam flats to harvesting and delineation of areas around wastewater plants and marinas that are permanently closed to harvesting.

Program activities supported by the NHEP are described below.

Determining Safe Shellfishing Conditions

Since its inception in 1995 the NHEP has supported sanitation monitoring to ensure safe shellfish harvesting. The NHEP was instrumental in establishing the New Hampshire Department of Environmental Services (DES) Shellfish Program and obtaining certification from the FDA for a commercial shellfish program in 2002. The DES Shellfish Program, with continued support from the NHEP, pursues a goal of completing sanitary surveys of all shellfish growing waters by the end of 2005. Sanitary survey reports describe water quality status and trends in shellfish growing areas, outline future activities to improve water quality, and ultimately expand harvesting opportunities.

A key function of the DES Shellfish Program is the collection of data to inform the decision to reopen shellfishing beds that have been closed due to an influx of harmful bacteria, such as a wastewater treatment plant failure. In February of 2003, a discharge of improperly disinfected sewage was released from the Hampton wastewater treatment facility and the popular clamming flats in Hampton-Seabrook Harbor were immediately closed. Shellfish tissue sampling conducted by the DES Shellfish Program accurately monitored the bacterial levels in the shellfish and provided the necessary information to determine when to reopen the flats. Without this testing the closure may have continued for days after bacteria levels had reached safe levels.

The DES Shellfish Program benefits from the assistance of Great Bay Coast Watch volunteers, whose activities are supported by grants from the NHEP. These volunteers provide field support to the program by assisting with water quality and meat tissue sample collection.

Studying Juvenile Clam Mortality

In the past 30 years the Hampton-Seabrook Harbor flats have experienced dramatic peaks and valleys in its clam populations ranging from a high of 27,000 bushels in 1997 to lows less than 1,000 bushels in 1978 and 1987. Overharvesting was suspected as the cause of these crashes, however, NHEP-funded research suggests that there may be more to the story.

In 2001, University of Maine at Machias researcher Dr. Brian Beal was contracted by the NHEP to examine the causes of juvenile soft-shell clam mortality in the Hampton-Seabrook Harbor. He conducted a series of manipulative field experiments at three clam flats in the harbor from November 2001to July 2002. Dr. Beal placed hatchery-reared, juvenile clams into six-inch plastic plant pots that were filled with sediments from each flat and buried to their rims. Half the pots were stocked with a high density of clams to determine whether crowding affected survival. To assess the effects of predation, Dr. Beal placed flexible plastic netting over

CASE STUDY

2

Managing Shellfish Waters in Hampton-Seabrook Harbor *(continued)*

some of the pots to exclude predators. He collared other pots with netting that extended about 1 inch above the rim to contain clams dislodged by sediment erosion. In total Dr. Beal's research team placed 720 pots in the harbor. The carefully crafted design also addressed potential differences in clam growth and survival with respect to tidal height.

The results of Dr. Beal's work suggested that sediment erosion by tidal and wind currents and predation by crustaceans, primarily green crabs *(Carcinus maenas L.)*, were significant factors that increased juvenile clam mortality. The NHEP is using these results to develop strategies and additional projects to address declining clam populations.

PHOTO CREDIT: UNIVERSITY OF MAINE AT MACHIAS

Experimental units placed in Hampton-Seabrook Harbor clam flats

Improving Shellfish Harvesting Opportunities

The DES Shellfish Program with support from the NHEP has improved shellfish harvesting opportunities in Hampton-Seabrook Harbor through a variety of activities. From 1999 to 2002, the Program conducted a sanitary survey of the Hampton Falls River and Taylor River that led to the conditional opening of 87 acres of growing waters to harvest, thus bringing the total open area in Hampton-Seabrook to 44 percent of the total 1,068 acres. The DES Shellfish Program also re-evaluated the rainfall closure criterion and determined in 2003 that the closure threshold could be raised to 0.25 inches for the late fall, winter, and spring harvesting seasons. This change is expected to open 10 percent more weekends to clam harvesting. In order to ensure that closures are issued only when necessary, DES conducts a post-rainfall sampling program that in 2002 identified four of the seven weekend storms sampled as not warranting clam flat closures. Without this direct sampling of bacteria levels, 25 percent of the available weekends in 2002 would have been closed to clam harvesting.

Tracking Pollution Sources

The NHEP funded a study by the DES in conjunction with UNH that utilized a new high-tech DNA analysis technique called ribotyping (commonly referred to as DNA fingerprinting) to track down the source of bacteria *(Escherichia coli)* in Hampton-Seabrook Harbor.

Beginning in 2000, water samples were collected for one year, twice a month, from ten sites in Hampton-Seabrook Harbor during both dry and wet weather conditions. UNH researchers then matched the collected bacteria's DNA signatures with signatures from a genetic library of bacteria from many different animals, including humans. During the study 236 of the 391 isolates collected between August 2000 and October 2001 were matched with a source species. Of the total 391 isolates 26 percent came from humans, 15 percent from wildlife, 8 percent from livestock, 7 percent from wild birds, 4 percent from pets, and 40 percent were unidentified. Results will help managers make informed decisions to control pollution from specific sources and target additional studies to further refine source identification.

Setting Pollution Load Limits

The DES is currently developing a bacteria Total Maximum Daily Load (TMDL) for Hampton-Seabrook Harbor in accordance with the Clean Water Act requirements. A TMDL determines the amount of pollution a body of water can receive and still meet water quality standards. Hampton-Seabrook Harbor was

CASE STUDY

2 Managing Shellfish Waters in Hampton-Seabrook Harbor *(continued)*

PHOTO CREDIT: SEABROOK STATION

Hampton-Seabrook Harbor in 2000

a priority for TMDL development because of bacteria concentrations that exceed State surface water quality standards for the consumption of shellfish. The goal of the TMDL is for the water quality in the harbor to meet standards set for shellfish growing waters by the National Shellfish Sanitation Program.

The NHEP contributed to the TMDL development by funding two rounds of wet weather sampling in 2002 in and around Hampton-Seabrook Harbor. The study characterized the bacterial loading to the harbor from 23 major storm drains and tributaries and also showed the effects of the stormwater discharges on water quality. This information was used to prioritize pollution sources as part of the Hampton-Seabrook Harbor bacteria TMDL and it will be useful to managers prioritizing pollution mitigation efforts for the storm drain systems.

Managing Stormwater

Communities are required to address stormwater pollution, a major threat to water quality and estuarine resources such as shellfish. The NHEP has helped the towns of Hampton and Seabrook, in addition to other seacoast communities, meet this challenge through projects to understand and manage stormwater runoff. Through a grant program administered by DES, the NHEP provides funds to communities to map their storm sewer systems, including underground and aboveground storm drainage systems, catch basins, and outfalls, as well as flow direction. The electronic maps generated are valuable tools to communities to monitor stormwater pollution and maintain stormwater management infrastructure. The mapping projects have assisted Hampton and Seabrook with meeting a requirement of the federal Stormwater Management Phase II Regulations to map stormwater infrastructure.

NHEP-supported activities have also involved the public in stenciling community stormdrains. Painted messages adjacent to stormdrains remind people that anything going into a drain flows directly into our waterways and estuaries. An NHEP-funded project, coordinated by the New Hampshire Sea Grant Program and several seniors from Winnicunnett High School, involved students from Hampton Academy Junior High stenciling over 100 stormdrains in Hampton in 2002.

Summary

Much work has been done by the NHEP to monitor contamination, and identify and eliminate sources of bacteria and nutrients to Hampton-Seabrook Harbor. The NHEP, in partnership with other organizations, is planning to take further action to enhance shellfish resources, improve the Harbor's water quality, and protect open space throughout the Hampton/Seabrook watershed.

Much of the information appearing in this case study is adapted from "Managing Shellfish Waters in Hampton Harbor Using a Watershed Approach" by the following authors:

Natalie Landry, NH Department of Environmental Services
Phil Trowbridge, NH Department of Environmental Services
Chris Nash, NH Department of Environmental Services
Dr. Stephen Jones, University of New Hampshire, Jackson Estuarine Laboratory

Acknowledgements

The creation of the *2003 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 for sharing data and coordinating their efforts to help understand the status of New Hampshire's estuaries:

Great Bay National Estuarine Research Reserve
Gulf of Maine Council Gulfwatch Program
New Hampshire Coastal Program
New Hampshire Department of Environmental Services
(Watershed Bureau and Shellfish Program)
New Hampshire Department of Transportation
New Hampshire Fish and Game Department
New Hampshire Heritage Bureau
Seabrook Station
Society for the Protection of New Hampshire Forests
University of New Hampshire
(in particular the Jackson Estuarine Laboratory and Complex Systems Research Center)
U.S. Environmental Protection Agency

Special recognition also must go to the following individuals for their work with the NHEP and for their assistance during the creation of this report:

NHEP Management Committee:
Cynthia Belowski, Audubon Society of New Hampshire
Peter Britz, City of Portsmouth
Jean Brochi, US EPA
Ed Cournoyer, New Hampshire Fish and Game
Brian Doyle, University of New Hampshire Sea Grant
Dick Dumore, Public Service of New Hampshire
Taylor Eighmy, University of New Hampshire
Dave Funk, Great Bay Stewards
Brian Giles, Strafford Regional Planning Commission
Rep. Tom Gillick, Town of Hampton
Dave Hartman, New Hampshire Coastal Program
Natalie Landry, New Hampshire Department of Environmental Services
Rich Langan, CICEET/University of New Hampshire
Wendy Lull, Seacoast Science Center
Dean Peschel, City of Dover
Paul Raiche, New Hampshire Department of Health and Human Services
Jimmy Reynolds, Great Bay National Wildlife Refuge, US Fish & Wildlife Service
Ron Sher, Seabrook Station
Brian Smith, New Hampshire Fish and Game/Great Bay National Estuarine Research Reserve
Brad Sterl, State of Maine (retired)
Peter Tilton, Defiant Lobster Company
Ian Walker, Aquaculture Resource Development
Theresa Walker, Rockingham Planning Commission
Mark Zankel, The Nature Conservancy

NHEP Technical Advisory Committee:
Tom Ballestero, University of New Hampshire
Gregg Comstock, New Hampshire Department of Environmental Services
Paul Currier, New Hampshire Department of Environmental Services
Ted Diers, New Hampshire Coastal Program
Jennifer Hunter, New Hampshire Estuaries Project
Steve Jones, University of New Hampshire
Natalie Landry, New Hampshire Department of Environmental Services
Rich Langan, CICEET/University of New Hampshire
Steve Mirick, Audubon Society of New Hampshire
Chris Nash, New Hampshire Department of Environmental Services
Chris Neefus, University of New Hampshire
Jonathan Pennock, University of New Hampshire
Fay Rubin, University of New Hampshire
Fred Short, University of New Hampshire
Brian Smith, New Hampshire Fish and Game/GBNERR
Sally Soule, New Hampshire Coastal Program
Phil Trowbridge, New Hampshire Estuaries Project

This report was designed by IDEA Outfitters of Portsmouth, NH, and coordinated by Dave Kellam of the New Hampshire Estuaries Project.

NewHampshire EstuariesProject

152 Court Street, Suite 1
Portsmouth, New Hampshire 03801
www.state.nh.us/nhep

printed on recycled paper