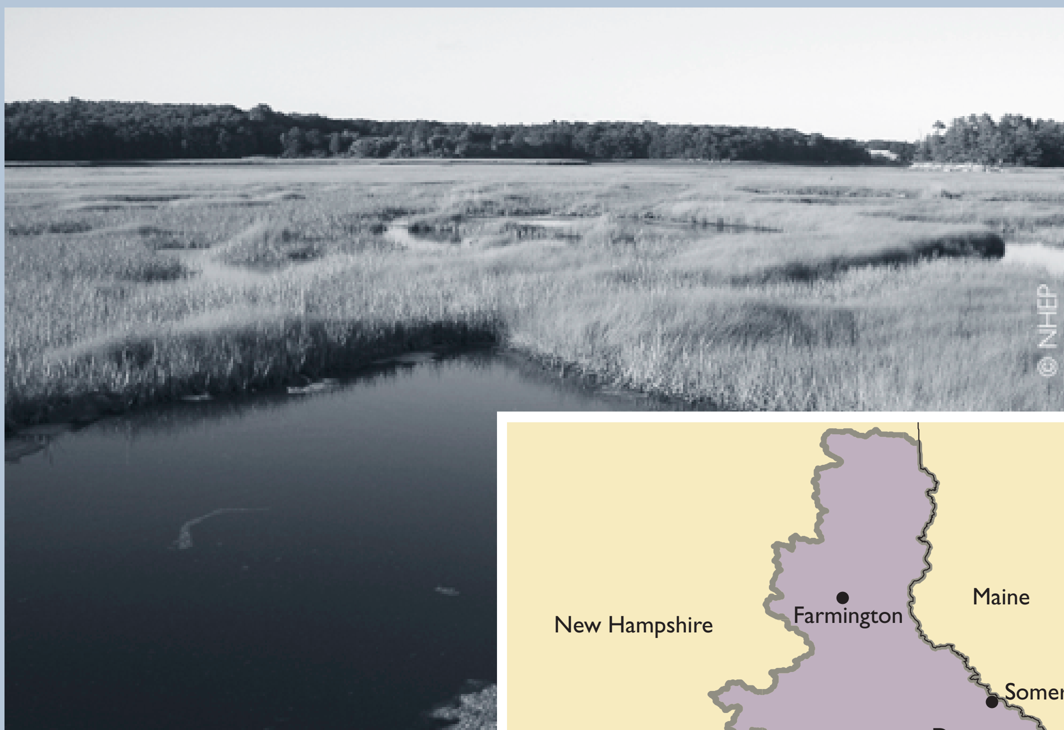
This document contains overall and specific condition of the New Hampshire Estuaries Project from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from ***http://www.epa.gov/owow/oceans/nepccr/index.html***

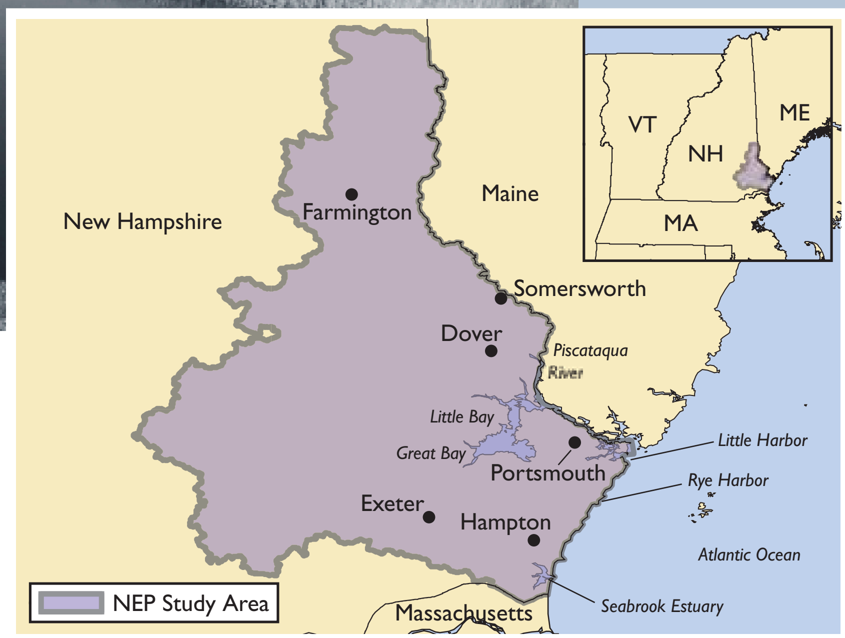
National Estuary Program Coastal Condition Report

Chapter 3: Northeast National Estuary Program Coastal Condition, New Hampshire Estuaries Project

June 2007

New Hampshire Estuaries Project





NewHampshire EstuariesProject

www.nhep.unh.edu

Background

New Hampshire has more than 230 miles of sensitive tidal shoreline, in addition to 18 miles of open-ocean coastline on the Gulf of Maine (NHEP, 2003). The Great Bay and Hampton-Seabrook estuaries are the largest distinct estuaries in New Hampshire. Other estuaries of importance are Little Bay, Little Harbor, and Rye Harbor, as well as portions of their tidal tributaries (NHEP, 2005).

The Great Bay Estuary covers 17 mi^2, with nearly 150 miles of tidal shoreline (NHEP, 2003). Great Bay is unusual because it is located inland, more than five miles up the Piscataqua River from the ocean. Due to this location, Great Bay's tidal exchange with the ocean is slow, requiring up to 18 days (or 36 tide cycles) for water entering the head of the Bay to move to the ocean (Jones, 2000). Oysters, clams, striped bass, bluefish, herring, smelt, lobsters, and eels are harvested from Great Bay for both recreational and commercial purposes. In addition, Great Bay is New Hampshire's principal waterfowl overwintering site and a focus area for the North American Waterfowl Management Plan (NHEP, 2005).

Hampton-Seabrook Harbor encompasses 480 acres of open water at high tide. This coastal estuary is characterized by extensive salt marshes and is separated from the ocean by a series of barrier beaches. The Harbor is surrounded by a 5,000-acre salt marsh, which is the largest contiguous salt marsh in the state, and Hampton Beach is one of the busiest tourist attractions in New Hampshire (NHEP, 2003). Several thousand residents purchase shellfish licenses each year, primarily to dig softshell or steamer clams locally.

Environmental Concerns

After a long history of industrial and sewage pollution, water quality in the New Hampshire Estuaries has shown significant improvements during the past two decades (Jones, 2000); however, bacterial and nutrient contamination, toxic contaminants, the loss or fragmentation of wildlife habitat, degraded salt marshes, and declines in oyster and clam populations continue to be high-priority problems for water quality, habitat, fish, and wildlife.

Population Pressures

The population of the 3 NOAA-designated coastal counties (Carroll, Rockingham, and Strafford) coincident with the New Hampshire Estuaries Project (NHEP) study area increased by more than 148% during a 40-year period, from 0.17 million people in 1960 to almost 0.43 million people in 2000 (Figure 3-17) (U.S. Census Bureau, 1991; 2001). This rate of population growth for the NHEP study area is almost 6 times the population growth rate of 24% for the collective NEP-coincident coastal counties of the Northeast Coast region. In 2000, the population density of these 3 NEP-coincident coastal counties was 216 persons/mi^2, almost 5 times lower than the population density of 1,055 persons/mi^2 for the collective NEP-coincident coastal counties of the Northeast Coast region (U.S. Census Bureau, 2001).

NCA Indices of Estuarine Condition—New Hampshire Estuaries

The overall condition of the New Hampshire Estuaries is rated fair based on the four indices of estuarine condition used by the NCA (Figure 3-18). Two of the assessed indices (sediment quality and fish tissue contaminants) received good to fair ratings for the New Hampshire Estuaries, whereas the other two indices (water quality and benthic) received fair ratings. Figure 3-19 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. This assessment is based on data from 76 NCA sites sampled in the NHEP estuarine area in 2000 and 2001. Please refer to Tables 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

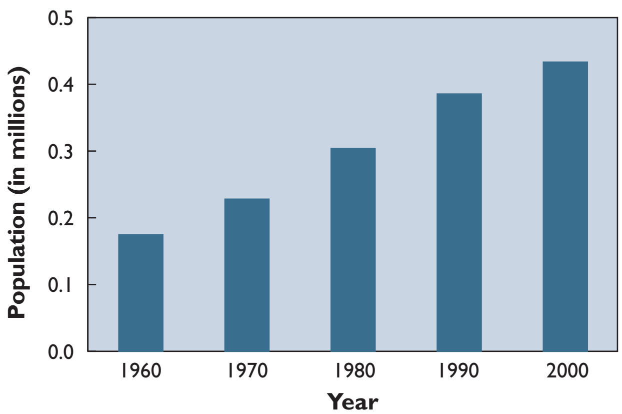


Figure 3-17. Population of NOAA-designated coastal counties of the NHEP study area, 1960–2000 (U.S. Census Bureau, 1991; 2001).

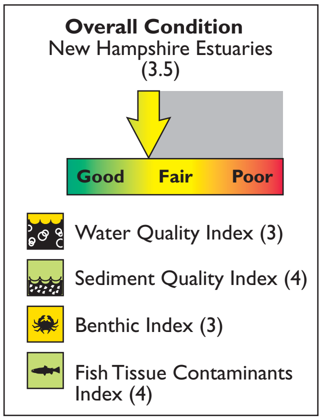


Figure 3-18. The overall condition of the NHEP estuarine area is fair (U.S. EPA/NCA).

New Hampshire Estuaries Project

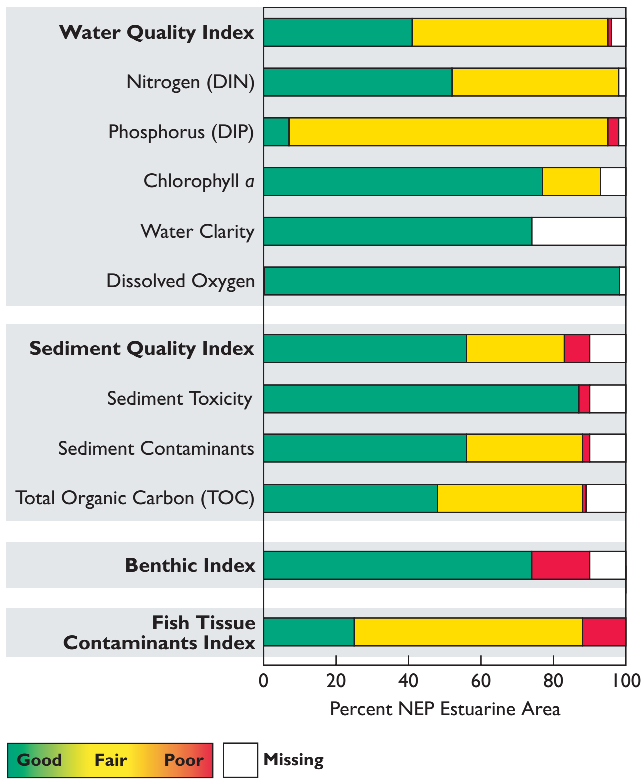


Figure 3-19. Percentage of NEP estuarine area achieving each rating for all indices and component indicators — New Hampshire Estuaries (U.S. EPA/NCA).

Water Quality Index

Based on data collected by the NCA surveys, the water quality index for the New Hampshire Estuaries is rated fair. This index was developed using NCA data on five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. About half of the estuarine area of the New Hampshire Estuaries was rated fair for water quality, and less than 1% was rated poor (Figure 3-20). Nutrient concentrations were moderately high, particularly for DIP, and 16% of the estuarine area had moderate chlorophyll *a* concentrations, primarily in the tributaries. The water quality condition of the New Hampshire Estuaries was relatively poor as compared to other NEPs in the Acadian Province, from Massachusetts to Maine. The larger of the New Hampshire Estuaries, the Great Bay and Piscataqua River system, formed as a drowned river valley and therefore displays different characteristics from other, more oceanic-influenced systems in the Acadian Province. There were no indications of dissolved oxygen depletion or poor water clarity in the New Hampshire Estuaries during the NCA assessment period (2000–2001).

Dissolved Nitrogen and Phosphorus | The New Hampshire Estuaries are rated good for DIN concentrations because 52% of the estuarine area was rated good and 46% of the area was rated fair for this component indicator. None of the NHEP estuarine area was rated poor for DIN concentrations. The Estuaries are rated fair for DIP concentrations, with 7% of the estuarine area rated good, 88% of the area rated fair, and 3% of the area rated poor for this component indicator.

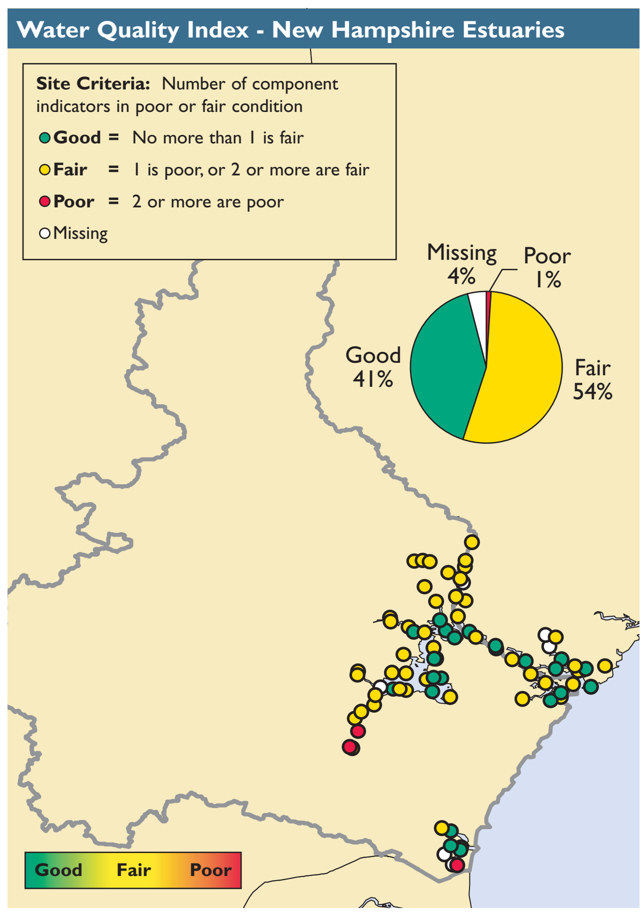


Figure 3-20. Water quality index data for the New Hampshire Estuaries, 2000–2001 (U.S. EPA/NCA).

Chlorophyll a | The New Hampshire Estuaries are rated good for chlorophyll *a* concentrations. Of the estuarine area assessed, 77% and 16% was rated good and fair, respectively, and none of the area was rated poor. NCA data on chlorophyll *a* concentrations were unavailable for 7% of the NHEP estuarine area.

Water Clarity | Water clarity in the New Hampshire Estuaries is rated good. None of the estuarine area was rated poor for water clarity, and 74% of the area was rated good; however, NCA data on water clarity were unavailable for 26% of the NHEP estuarine area.

Dissolved Oxygen | The New Hampshire Estuaries are rated good for dissolved oxygen concentrations. Ninety-eight percent of the estuarine area was rated good for dissolved oxygen concentrations, and none of the area was rated poor. NCA data on dissolved oxygen concentrations were unavailable for 2% of the NHEP estuarine area.

Sediment Quality Index

The sediment quality index for the New Hampshire Estuaries is rated good to fair, with 7% of the estuarine area rated poor, 27% rated fair, and 56% rated good for sediment quality (Figure 3-21). This index was developed using NCA data on three component indicators: sediment toxicity, sediment contaminants, and sediment TOC. One site in Portsmouth Harbor proved to be toxic to amphipods; however, sediments were sandy at this site, which may have contributed to the low amphipod survival. Most of the survey sites characterized as impaired had sediments with moderate to high concentrations of metals, PAHs, and DDT, and nearly all of the contaminated sites also had moderate levels of TOC.

Sediment Toxicity | The New Hampshire Estuaries are rated good for sediment toxicity, with only 3% of the estuarine area rated poor for this component indicator. NCA data on sediment toxicity were unavailable for 10% of the NHEP estuarine area.

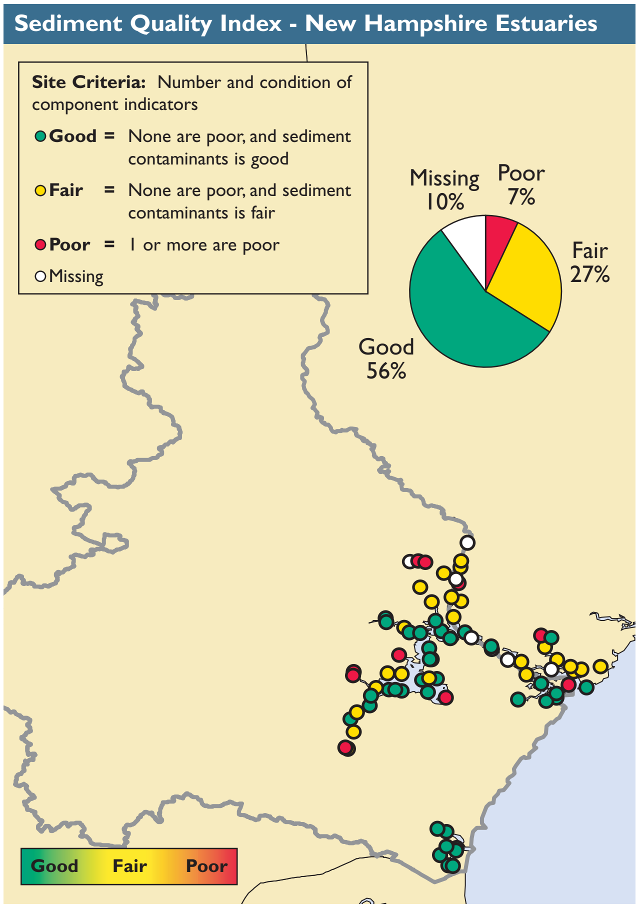


Figure 3-21. Sediment quality index data for the New Hampshire Estuaries, 2000–2001 (U.S. EPA/NCA).

Sediment Contaminants | The New Hampshire Estuaries are rated good for sediment contaminant concentrations. Approximately 2% of the estuarine area was rated poor for sediment contamination, and 32% of the area was rated fair.

Total Organic Carbon | Another measure of sediment quality is sediment TOC, and the New Hampshire Estuaries are rated good for this component indicator. Forty-eight percent of the estuarine area was rated good for TOC concentrations, and 40% of the area was rated fair. Only 1% of the estuarine area was rated poor, and NCA data on sediment TOC concentrations were unavailable for 11% of the NHEP estuarine area.

Benthic Index

The benthic index for the New Hampshire Estuaries is rated fair, with 16% of the estuarine area showing poor benthic condition as measured by the Shannon-Weiner Diversity Index (Figure 3-22). This rating indicates a level of diversity comparable with other NEP estuaries in the Northeast Coast region. Most of the sites with a poor benthic index rating also had moderate or high concentrations of sediment contaminants. In addition, some of the low diversity sites occurred in waters where salinity was relatively fresh (less than 20 ppt), which indicates a site where natural salinity fluctuations could be a natural stressor, causing a reduction in benthic species diversity.

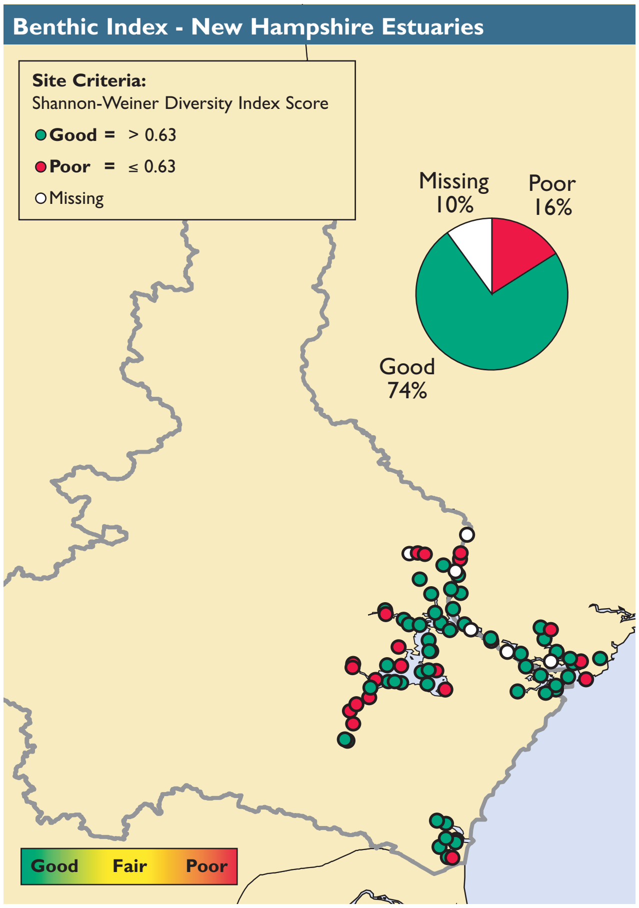


Figure 3-22. Benthic index data for the New Hampshire Estuaries, 2000–2001 (U.S. EPA/NCA).

Fish Tissue Contaminants Index

The fish tissue contaminants index for the New Hampshire Estuaries is rated good to fair (Figure 3-23). Seventeen fish and six shellfish (e.g., lobster) samples from the New Hampshire Estuaries were analyzed for chemical contaminants. Twelve percent of the samples had high concentrations of at least one toxicant and were rated poor, and 63% had moderate levels of contaminants and were rated fair.

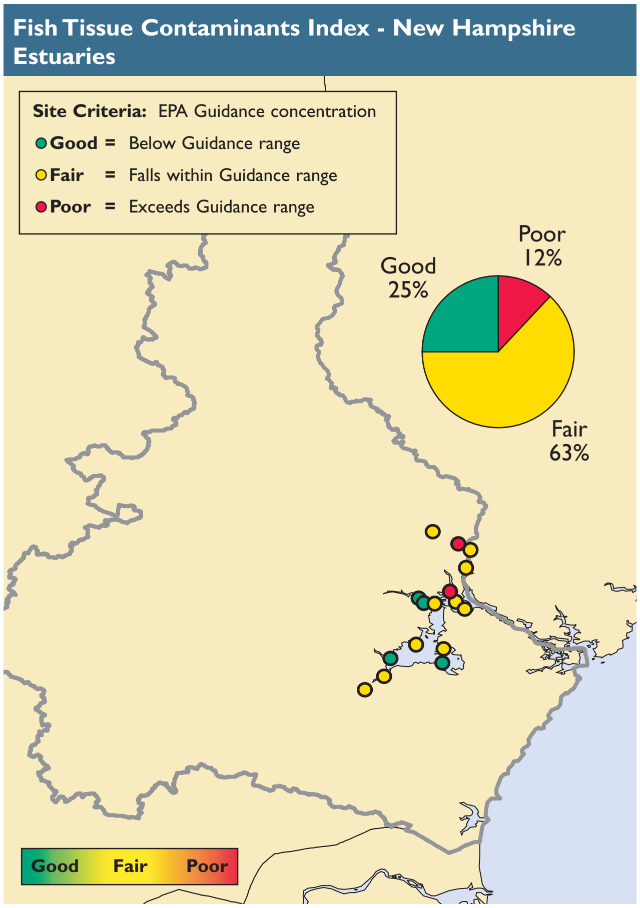


Figure 3-23. Fish tissue contaminants index data for the New Hampshire Estuaries, 2000–2001 (U.S. EPA/NCA).

New Hampshire Estuaries Project Indicators of Estuarine Condition

The NHEP tracks the health of the New Hampshire Estuaries through 34 environmental indicators that are defined in the *NHEP Monitoring Plan 2004, Version 4* (Townbridge, 2004). Every three years, the NHEP produces a report that highlights results from the key environmental indicators. The most recent report (NHEP, 2003) was issued in 2003, coincident with a State of the Estuaries conference. The 12 indicators identified in the *2003 State of the Estuaries* report are summarized in the sections below. The full report and conference proceedings are available at http://www.nhep.unh.edu.

Some of the NHEP indicators are based on data from the NCA's 2000–2001 probabilistic survey, which were used for the EPA National Indicators of Estuary Condition and will be included in the *2006 State of the Estuaries* report. The NHEP uses different standards or analysis methods for some indicators than EPA; therefore, the NHEP's conclusions will differ from the EPA report. For example, the NHEP evaluates sediment quality using a triad approach with sediment toxicity, sediment chemistry, and benthic community data, whereas EPA calculates the sediment quality index using data on sediment contaminants, sediment toxicity, and TOC. The New Hampshire Department of Environmental Services and the University of New Hampshire (UNH) have analyzed the 2000–2001 NCA data to calculate NHEP indicators and document other observations (NHDES, 2005).

Water and Sediment Quality

The NHEP reported on four indicators of water quality: bacteria concentrations, toxic contaminants in mussel tissue, nitrogen concentrations, and violations of the dissolved oxygen standard. Overall, these four indicators show that water and sediment quality in the New Hampshire Estuaries is generally good; however, there is concern about rising nitrogen concentrations.

Dry-weather fecal coliform contamination is used as an indicator of sewage contamination in the New Hampshire Estuaries. In the middle of Great Bay at Adams Point, fecal coliform concentrations decreased by 30% between 1992 and 2002 (Figure 3-24). Stronger declining trends were found at the tributary sampling sites, where decreases of 75% were observed for the same period. Despite these improvements, many shellfish bed closures still exist due to bacterial pollution (NHEP, 2003).

Blue mussels (*Mytilus edulis*) are used as a water quality indicator species for toxic contaminants from polluted waters because these shellfish accumulate contaminants in their tissues. Between 1993 and 2000, none of the samples collected from the 13 mussel-sampling sites in the New Hampshire Estuaries had toxic contaminant levels greater than U.S. Food and Drug Administration (FDA) guidelines. Levels of PCBs and the pesticide DDT are declining at the Portsmouth Harbor station, and PAH levels are increasing. The decreasing PCB and DDT concentrations are probably due to the decreased use of these chemicals following an EPA ban enacted in 1979 and 1972, respectively. PAHs are present as petroleum constituents and as 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 Estuaries are two of many possible reasons for the increasing PAH concentrations in blue mussel tissues (NHEP, 2003).

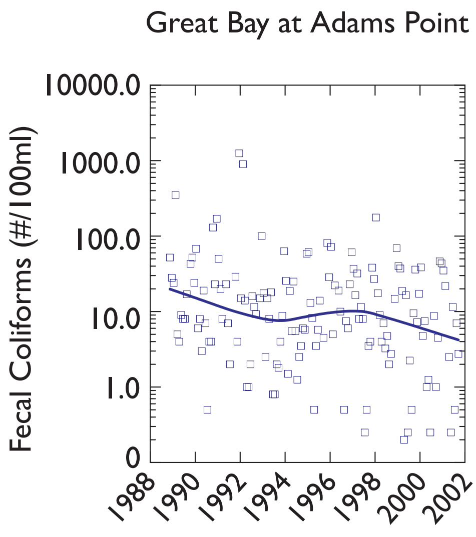


Figure 3-24. Fecal coliform concentrations between 1988 and 2002 in Great Bay at Adams Point (NHEP, 2003).

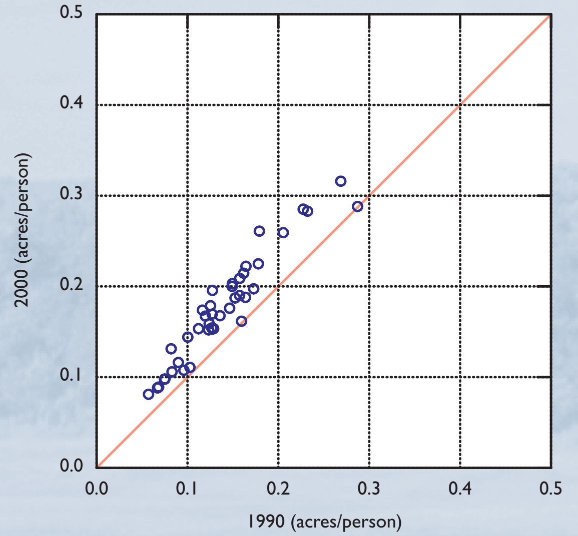
New Hampshire Estuaries Project

Mapping Impervious Surfaces in New Hampshire's Coastal Watershed

Stormwater runoff from pavement and other impervious surfaces is a major factor that affects water quality in the New Hampshire Estuaries. Shellfish beds are often closed after rain storms due to bacteria that have been washed into the Estuaries via impervious surfaces, which are a marker for high-impact human development in the watershed. To address this issue, the NHEP set out to obtain a watershed-wide map of impervious surfaces to better understand the extent of impervious surface and the possible water quality impacts.

The NHEP contracted with the UNH Complex Systems Research Center to generate maps of impervious surfaces in 1990 and 2000 from satellite imagery (Justice and Rubin, 2002). UNH used a subpixel analysis routine on Landsat Thematic Mapper data, coupled with ground-truthing surveys, to generate the maps. The NHEP totaled the area of impervious surfaces in each of the 42 coastal towns located within the NHEP study area and calculated the percent of land area covered by impervious surfaces. The map on the next page shows the 42 coastal watershed towns and their percent of imperviousness in 2000.

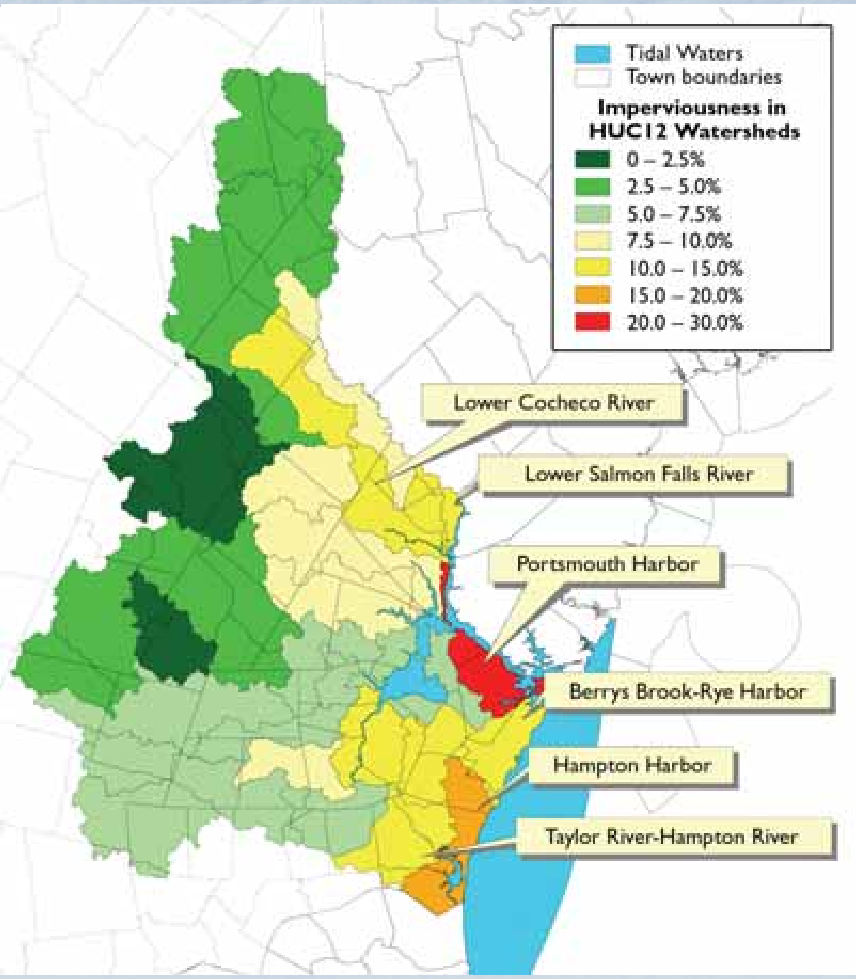
Eleven of the 42 towns had more than 10% of their land area covered by impervious surfaces. Studies conducted in other regions of the country have demonstrated water quality deterioration where impervious surfaces cover greater than 10% of the watershed area (Schueller, 1995); therefore, it is the goal of the NHEP to keep the coverage of impervious surfaces in the coastal subwatersheds to less than 10% (Townbridge, 2003). However, additional factors, such as the proximity of the impervious surfaces to waterbodies and the extent of buffer, may be more important than percent imperviousness.



Comparison of imperviousness per capita in 1990 to 2000 (Townbridge, 2003).

The impervious surface data was also used to study the pattern of "sprawl-type" development in the coastal watershed. A commonly accepted definition of sprawl is increasing rates of land consumption per person. Using the impervious surface data from 1990 and 2000, the NHEP was able to show that all of the 42 towns used more impervious surface per person in 2000 than in 1990 (the difference was statistically significant for 25 of the 42 towns). On average, the acres of impervious surface for each person in the towns increased from 0.15 acres/person in 1990 to 0.20 acres/person in 2000 (Townbridge, 2003). The figure above shows the general increase in imperviousness per capita for each town in 1990 versus 2000. All of the towns are plotted above the red line, which shows that imperviousness per capita is increasing in all the towns, even if the change is not statistically significant.

After the NHEP presented the impervious surface data at the 2003 State of the Estuaries Conference, many town officials requested detailed information for their towns. As a result, the NHEP produced a customized map of impervious surfaces and water resources for each of the 42 towns. The towns also received a fact sheet summarizing what is known about the effects of impervious surfaces on water quality. The NHEP distributed this information at a workshop for conservation commissions and planning boards in October 2004. The NHEP plans to update these impervious surface maps in 2005 and again in 2010.



Percent impervious surface in New Hampshire's coastal watershed in 2000 (NHEP, based on data from UNH Complex Systems Research Center).

Excessive nitrogen concentrations in estuaries can cause blooms of algae that change the species composition of important habitats. Monthly measurements at three long-term water quality monitoring sites have documented changes in nitrogen (as nitrate+nitrite) concentrations in the Great Bay between 1992 and 2001. Statistical tests have shown that nitrate+nitrite concentrations have increased during this period at the sites at Adams Point in Great Bay and in the Lamprey River; however, there were no statistically significant trends at the Squamscott River station. Despite the increasing concentrations of nitrate+nitrite in the New Hampshire Estuaries, there have not been any significant trends observed in the typical indicators of eutrophication (e.g., dissolved oxygen and chlorophyll *a* concentrations); therefore, the load of nitrate+nitrite to the Great Bay appears to have not yet reached the level at which the undesirable effects of eutrophication occur. The major sources of nutrient contamination to the Estuaries are WWTP effluents, malfunctioning septic systems, atmospheric deposition, and runoff from urban and agricultural areas, which are all related to population growth and the associated land development patterns (NHEP, 2003).

Fish and many other aquatic organisms need dissolved oxygen in the water to survive. The strong tidal flushing through the Estuaries and inflow from freshwater streams keeps the water well mixed and oxygenated. Dissolved oxygen levels in Great Bay and the Squamscott River consistently meet state standards. Although the standard has also been met at the Lamprey River sites 90% of the time, there have been a few instances where the standard was not met. The causes of these sporadic hypoxic events are not known. Blooms of algae, respiration of benthic organisms, and oxygen demand from WWTP effluent can deplete oxygen in the water; however, in some cases, these low concentrations may be a natural phenomenon (NHEP, 2003).

Habitat Quality

The NHEP tracks six indicators to determine habitat quality: eelgrass abundance, unfragmented forest blocks, salt marsh restoration, protected lands, impervious surfaces, and sprawl-type growth. Only the first two of these indicators are presented in this section. The other four indicators are discussed in the *Current Projects, Accomplishments, and Future Goals* section of this profile and in the NHEP Highlight article.

Eelgrass (*Zostera marina*) is an essential part of the Estuaries' ecology because it provides food for wintering waterfowl and habitat for juvenile fish (Thayer et al., 1984). The UNH Seagrass Ecology Group has mapped the distribution of eelgrass in Great Bay every year from 1986 to 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 85% decline in eelgrass acreage to 300 acres; however, the eelgrass beds made a rapid recovery the following year. Water clarity and water depth are the main factors affecting the presence of eelgrass, although eelgrass can also be affected by other factors (e.g., disease) on a rapid temporal scale (NHEP, 2003). 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).

The fragmentation of open lands due to new roads and sprawling patterns of development can have significant consequences for habitat and hydrologic functions within the coastal watershed. As of 2001, there were 282 unfragmented blocks greater than 250 acres in the coastal watershed, the majority of which were less than 1,000 acres. In addition, there were only 4 blocks greater than 5,000 acres, and only 10% of the remaining blocks are protected from development (NHEP, 2003).

Living Resources

The NHEP reported on two wildlife indicators—oyster and clam populations—in the *2003 State of the Estuaries* report, citing both species as declining in the New Hampshire Estuaries.

Oysters are economically important because they support valuable recreational fisheries and have tremendous potential as an aquaculture species. They are also excellent bioindicators of estuarine condition because they are relatively long lived, remain stationary, and filter large volumes of estuarine water to feed. Additionally, as filter feeders, oysters play an important role in cycling nutrients, improving water clarity, and removing significant quantities of nitrogen and phosphorus from the water (NHEP, 2003). Since 1993, the oyster harvest in Great Bay has suffered a serious decline (Figure 3-25). In 2002, the standing stock 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. The major cause of this decline is thought to be the protozoan pathogens MSX and Dermo, which have caused similar declines in oyster fisheries in Chesapeake Bay and other mid-Atlantic estuaries (NHEP, 2003).

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 economies (Jones, 2000). Soft shell clam densities in 2001 were well below the most recent 10-year average (1990–1999) and were declining in all three main clam flats. The 2001 densities at Common Island and Middle Ground were also lower than the long-term baseline densities recorded between 1974 and 1989. The source of the current decline in harvestable clam populations is unknown (NHEP, 2003); however, an 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 juvenile clam population decline (Beal, 2002). Other observers have expressed concern that over-harvesting may also be contributing to the decline.

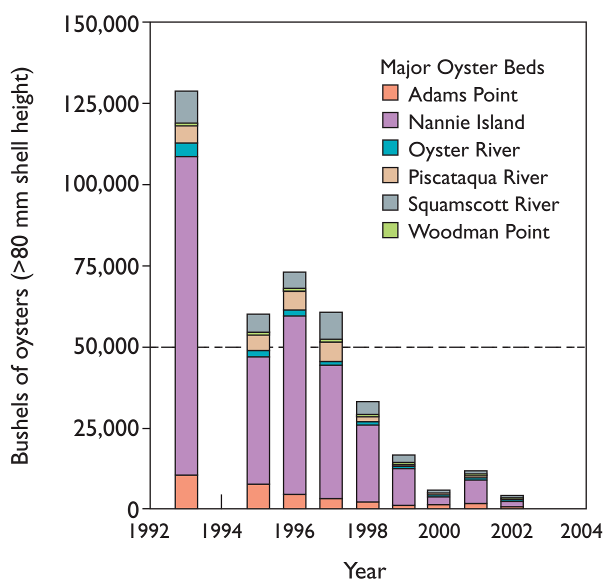


Figure 3-25. Standing stock of harvestable-size oysters in Great Bay between 1992 and 2004 (NHEP, 2003).

Current Projects, Accomplishments, and Future Goals

The NHEP has been successful at implementing many projects to protect and enhance the New Hampshire Estuaries. Data from two environmental indicators show that the NHEP has achieved on-the-ground results for land conservation and salt marsh restoration.

For the past five years, the NHEP has supported the Great Bay Resource Protection Partnership to conserve land in the coastal watershed. 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 (Figure 3-26). 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 the NHEP's 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 (NHEP, 2003).

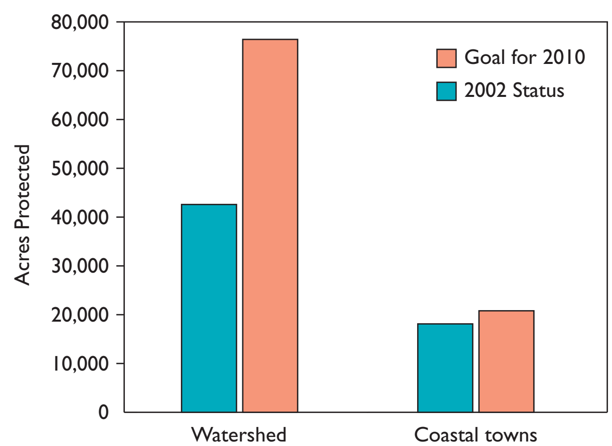


Figure 3-26. Acres of protected lands in New Hampshire's coastal watershed and coastal towns (NHEP, 2003).

New Hampshire Estuaries Project

Filling, ditching, draining, and restricting tidal flow degrades salt marshes, which can 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. The NHEP has a goal to restore 300 acres of tidal wetlands through tidal restriction removal. Through the leadership of the New Hampshire Coastal Program (NHCP), 176.5 acres of salt marsh have been restored through tidal restriction removal (59% of the goal) since January 2000. The NHCP is currently planning another 129 acres of salt marsh restoration by tidal restriction removal, which, if completed, will surpass the NHEP goal (NHEP, 2003).

Conclusion

In the *2003 State of the Estuaries* report, the NHEP concluded that the New Hampshire Estuaries are in generally good condition. During the past decade, water quality has improved and land conservation efforts and salt marsh restoration projects have been successful; however, shellfish resources are declining in the Estuaries, and development pressures are growing throughout the watershed. In contrast, the overall condition of the New Hampshire Estuaries is rated fair, based on NCA data from 76 sites surveyed in 2000–2001.

Prescott Park and Fishermen's cooperative along the Piscataquog River in Portsmouth, NH (NHEP).