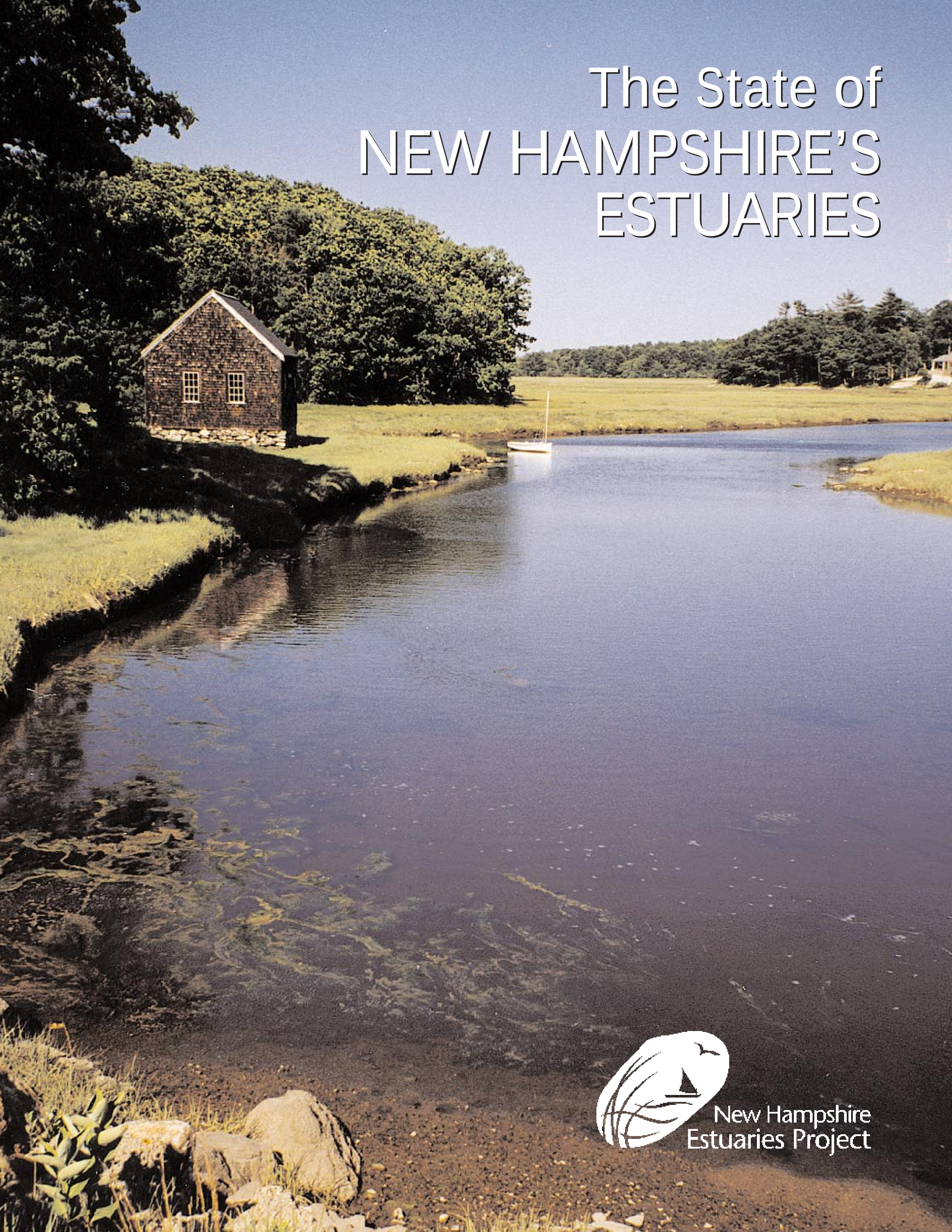
2000

State of New Hampshire's Estuaries

New Hampshire Estuaries Project

The State of NEW HAMPSHIRE'S ESTUARIES



New Hampshire Estuaries Project

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MANAGEMENT COMMITTEE

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Individuals who need auxiliary aids for effective communication in programs and services of the NH Estuaries Project are invited to make their needs and preferences known to the NH Estuaries Project Office, 152 Court Street, Portsmouth, NH 03801 (phone: 603/433-7187; fax: 603/431-1438). This notice is provided as required by Title II of the Americans with Disabilities Act of 1990.

PREFACE

In this State of the Estuaries Report, the New Hampshire Estuaries Project presents a snapshot of the environmental condition of the state's estuaries. The Report describes the region's valuable natural resources, and their essential links to the cultural and economic well-being of the Seacoast region and the state. It identifies challenges and problems that threaten the unique character and natural resource wealth of the estuaries.

The New Hampshire Estuaries Project is part of the U.S. Environmental Protection Agency's National Estuary Program (NEP). The NEP is a joint local, state, and federal program established under the Clean Water Act to promote the protection and enhancement of nationally significant estuaries. Each estuary project develops and implements a Management Plan to outline key environmental problems for the estuaries, and practical strategies to preserve, protect, and enhance these extraordinary natural resources.

Development of the NHEP *Management Plan* began with identifying the challenges to environmental quality in the New Hampshire estuaries. Environmental problems identified in *A Technical Characterization of Estuarine and Coastal New Hampshire** include poor water quality and declining natural resources, as well as management issues such as unchecked growth and development patterns, and inadequate enforcement of existing regulations, that can contribute to environmental degradation. Starting from this base of scientific information, along with a review of management and regulatory activities in the region, the NHEP and its public and private sector partners began to construct the *Management Plan* for New Hampshire's estuaries.

This State of the Estuaries Report summarizes the *Technical Characterization's* detailed assessment of the environmental condition of the estuaries, and describes in lay terms the scientific basis for the water quality, land use, and other natural resource management recommendations of the NHEP *Management Plan*.

* *A Technical Characterization of Estuarine and Coastal New Hampshire*, prepared for the NHEP by the University of New Hampshire Jackson Estuarine Laboratory, and edited by Dr. Stephen H. Jones.

THE STATE OF THE ESTUARIES

Estuaries are a vital component of the natural, aesthetic, and economic character of coastal New Hampshire. The cultural and natural history of the region has been shaped by the abundant resources of New Hampshire's estuaries. Archaeological evidence shows that long before European colonization, people were drawn to New Hampshire's estuaries to harvest the bountiful fish, shellfish, and game; to grow crops on the rich soils along the rivers; and to navigate the waterways.

GBNERR

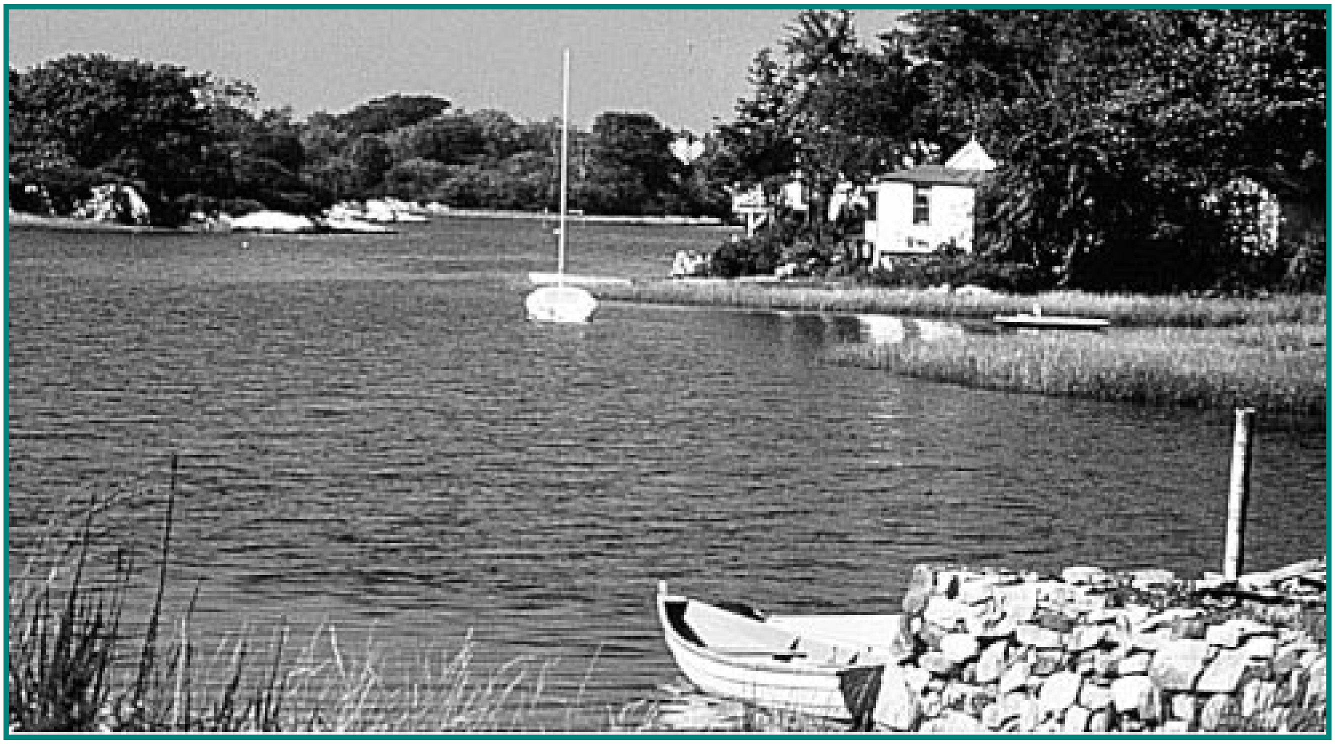
Crommet Creek

The first European settlements in New Hampshire were located at the waters' edge to take advantage of the extraordinary fisheries of the rich estuaries and the nearby Gulf of Maine. Cod, lobster, alewives, sturgeon, menhaden, clams, and oysters sustained the first Europeans and formed the foundation of the early colonial economy. Coastal New Hampshire's link to the estuaries was further strengthened when the forests of the Great Bay watershed were harvested to supply the growing needs of colonial ship-building as new boatyards sprang up along the tidewaters. Soon after, enterprising industrialists looked to the tidal rivers and creeks of coastal New Hampshire for waterpower to drive mills and factories. Industry prospered with the combination of abundant waterpower, plentiful natural resources, and access to world-wide markets afforded by tidewater locations.

definition: ESTUARY

(noun): a partially enclosed body of water where fresh water mixes with ocean salt water.

Today New Hampshire's estuaries still contribute to the economic, aesthetic, and environmental character of our state. Tourism, the second largest industry in the region, depends in many ways on a clean coastal environment. Both commercial and recreational fisheries make significant contributions to the



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Back Channel

Seacoast economy and are dependent on the environmental condition of the estuaries. However, by attracting more people and development, the very attractions of the New Hampshire Seacoast and its natural resource wealth pose a threat to the condition of the estuaries – and the region's prosperity and appeal.

New Hampshire's estuaries provide a coveted coastal atmosphere and setting for life along the coast, as they have throughout history. Located within an hour of Boston, Manchester, and Portland, this unique and beautiful land- and seascape attracts residents, businesses, and tourists, making the New Hampshire Seacoast one of the fastest-growing areas in New England and compounding the pressures of development on the estuaries.

definition: ESTUARINE NEW HAMPSHIRE

Great Bay; Little Bay; tidal portions of the Lamprey, Oyster, Bellamy, Cocheco, Salmon Falls rivers; Piscataqua River; Squamscott River; Little Harbor; Rye Harbor; Hampton-Seabrook Estuary; and smaller tidal tributaries.

New Hampshire's estuaries face threats from growth and development that imperil Seacoast traditions of fishing, shellfishing, and other water-dependent activities. Polluted stormwater runoff, overburdened septic systems, and wastewater treatment facility and industrial discharges, all threaten the environmental quality of our estuaries. These threats represent dangers to regional water quality, as well as to the host of living things that depend on New Hampshire's estuaries for their well-being.

The activities of area residents and visitors can have profound impacts on the estuarine system. Boats discharge oil and other pollutants in the water, disturb plant and animal life, and erode banks. Shoreline development removes protective plant cover, disturbs soils, increases runoff, and disrupts wildlife habitat and scenic views. Population growth and development throughout the region add to stormwater problems and burden wastewater treatment systems.

WHAT IS AN ESTUARY?

An estuary is a semi-enclosed embayment where freshwaters from rivers and streams mix with saltwater from the ocean. Estuaries are extraordinarily productive and diverse environments because of a unique set of conditions that create unusually nutrient-rich, protected waters. Many biologists consider estuaries among the most productive environments on earth.

With its Old Man of the Mountains icon, New Hampshire is more often associated with the White Mountains than with marine or estuarine habitat. However, New Hampshire has over 230 miles of sensitive tidal shoreline

MORRISON

JEL/UNH

Above: the Hampton-Seabrook Estuary

Left: The Piscataqua River with South and North Mill Ponds, Portsmouth

S. MIRICK

Aerial view of Great Bay

in addition to 18 miles of open-ocean coastline on the Gulf of Maine. New Hampshire's estuaries are a varied collection of bays, tidal rivers, and salt marsh systems. The largest distinct estuaries in New Hampshire are Great Bay and Hampton-Seabrook Estuary.

Great Bay

The Great Bay Estuary covers 17 square miles with nearly 150 miles of tidal shoreline. Great Bay is unusual because of its inland location, more than five miles up the Piscataqua River from the ocean**.** Consequently Great Bay's tidal exchange with the ocean is slow, requiring up to 18 days or 36 tide cycles for freshwater entering the head of the estuary to move to the ocean. With much of Great Bay's shorelines largely undeveloped, it has been called "the unknown treasure" of the New Hampshire Seacoast.

Great Bay's relatively undisturbed natural setting attracts scientists, researchers, and teachers interested in estuarine and marine processes. The University of New Hampshire, a land-grant, sea-grant, and space-grant university, is located in Durham within the Oyster River watershed of the Great Bay estuarine system. The University of New Hampshire with its New Hampshire Seacoast location has become a center for research, teaching, and development of practical applications of marine and estuarine science and technology.

Recognized as an estuarine system of national significance, Great Bay is the site of the Great Bay National Estuarine Research Reserve and the University of New Hampshire's Jackson Estuarine Laboratory. The National Oceanic and Atmospheric Administration recently joined with the University of New Hampshire to establish the Cooperative Institute for Coastal and Estuarine

Environmental Technology at UNH. The new Joint Hydrographic Center and the Center for Coastal and Ocean Mapping has drawn top researchers in this emerging field.

In Great Bay recreational shellfishers harvest oysters and clams; fishing enthusiasts pursue striped bass, bluefish, herring, or smelt; lobstering is a commercial and recreational activity; and eels are trapped for bait and for export. Birdwatchers come from all over the country and the world to view migratory birds against this picturesque backdrop. Great Bay is the state's principal waterfowl overwintering site, and is a focus area for the North American Waterfowl Management Plan.

Hampton-Seabrook Estuary

Hampton-Seabrook Estuary encompasses 0.75 square miles of water at high tide. Characterized by extensive salt marshes and separated from the ocean by a series of barrier beaches, this estuary represents a more typical estuarine system. The approximately 8 square miles of contiguous salt marsh within the Hampton-Seabrook Estuary make it by far the largest salt marsh in the state. Hampton-Seabrook Estuary provides the backdrop for Hampton Beach, one of the busiest tourist attractions and vacation spots in the state. It is also the site of the North Atlantic Energy Service Corporation's Seabrook Station, a nuclear-powered electric generation facility. Although surrounded by the busy seacoast communities of Seabrook, Hampton, Hampton Falls, and North Hampton, the Hampton-Seabrook Estuary hosts the best clamming in the state. Several thousand New Hampshire residents purchase shellfish licenses each year, most to dig the Hampton-Seabrook soft-shell or steamer clams.

The Hampton-Seabrook Estuary

MORRISON

ESTUARINE WATERSHEDS

New Hampshire's estuaries are linked to the surrounding upland areas by the freshwater that drains through the Great Bay and coastal watersheds. On its course to the ocean, water collects a variety of materials of both natural and human origin, with pronounced effects on the estuaries.

The forty-three cities and towns in the 930 square-mile Great Bay and coastal watersheds are linked by water. From rainwater to groundwater, puddles to tidal rivers, across municipal and political boundaries, water moves unerringly through these watersheds along its course to the ocean.

Definition: ESTUARINE WATERSHED COMMUNITIES

Barrington, Brentwood, Brookfield, Candia, Chester, Danville, Deerfield, Dover, Durham, East Kingston, Epping, Exeter, Farmington, Fremont, Hampstead, Hampton, Hampton Falls, Greenland, Kensington, Kingston, Lee, Middleton, Milton, New Castle, New Durham, Newington, Newmarket, Newfields, North Hampton, Northwood, Nottingham, Portsmouth, Raymond, Rochester, Rollinsford, Rye, Sandown, Seabrook, Strafford, Stratham, and Wakefield.

Each watershed resident has a role in safeguarding our mutual interest In the water and natural character of the area. Each urban, suburban, or rural resident anywhere within the watershed should strive to leave a positive environmental legacy and contribute to improving the environmental condition of New Hampshire's estuaries.

Great Bay fringing marsh

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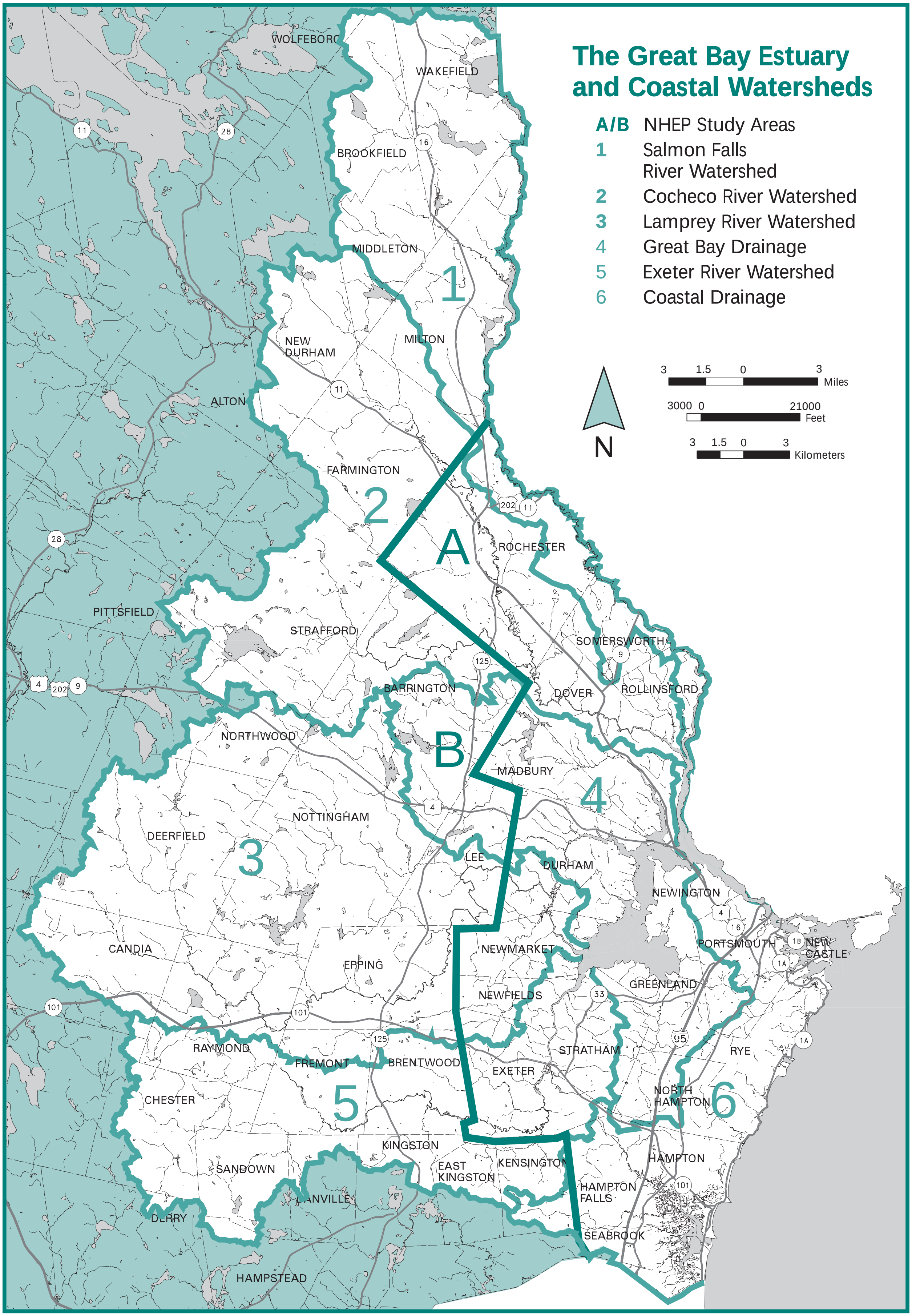


The NHEP Study Area included all 43 towns in the Great Bay and Seacoast watershed, however, much NHEP work was focused in Zone A (the 17 communities with tidal frontage plus Rochester and Somersworth.

THE COCHECO RIVER WATERSHED COALITION

The Cocheco River Watershed Coalition is a citizen conservation group dedicated to preserving and enhancing the Cocheco River and its watershed. The Coalition is committed to fostering community stewardship and appreciation of the river. Coalition concerns include the water quality of the Cocheco River, the health and sustainability of the fish populations, and securing public access to a clean river.

The Coalition grew out of citizen participation in educational activities provided by Strafford County UNH Cooperative Extension and Strafford Regional Planning Commission (SRPC) with NH Estuaries Project funding in 1997. NH DES funded an organization-building program for the Coalition in 1998. The group meets monthly with leadership and guidance from elected officers and an executive committee, a paid professional coordinator, bylaws, and a strategy for developing a watershed management plan. Community projects, water quality monitoring, explorations of the watershed, and management planning are focal points of Coalition activity.

- Members calling themselves "Cocheco River Watch" completed their first season monitoring water quality at numerous sites along the river for chemical, physical and biological properties. The City of Rochester, Strafford Regional Planning Commission, and the NH DES Volunteer River Assessment Program were all partners in the project.
- The Coalition completed a project in Rochester to prevent playground stormwater runoff from polluting the Cocheco River. The volunteers' many hours of hard work were acknowledged by the community, and rewarded with a cash prize from the Fleet Bank Allstars program.
- The Coalition has twice joined in the Coastal Cleanup program, working with community groups in each town on river cleanups in Dover, Rochester, and Farmington.
- To help fast-growing communities protect the integrity of wildlife habitat within the watershed, the Coalition is working with UNH Cooperative Extension and SRPC using grant funding and volunteers to map and assess habitat.
- As a Gulf of Maine Institute Without Walls site, the Coalition is partnering with Farmington High School and Spaulding High School in Rochester to enhance their watershed studies programs by providing opportunities to share research with each other, their communities, and the larger Gulf of Maine community.

New Hampshire has benefited from its close association with the estuaries, but the estuaries themselves have paid a dear price for this association. Rivers that once supported substantial runs of anadromous fish (species that live in saltwater but spawn in freshwater) such as Atlantic salmon, American shad, river herring, and alewives now host minimal returns or none at all. Over-harvest and poor estuarine water quality have contributed to declines of seasonal fish populations that depend on estuaries as spawning and nursery grounds.

For many years, our estuaries were used as convenient dumping grounds for sewage and industrial wastes. The industrial history of the Great Bay and Seacoast watersheds is now chronicled in the toxic materials trapped in sediments throughout the estuary. Dams that once ran mills and factories now restrict freshwater flow and collect sediments. Much of New Hampshire's valuable salt marsh habitat has been lost or degraded. Road construction and other development has resulted in filling, increased stormwater runoff, and reduced tidal exchange. Past ditching and draining activities, once thought to control mosquito problems, have further altered salt marsh habitat and functions. Today, we are responsible for dealing with both historic and present-day sources of estuarine contamination.

A REPORT CARD ON NEW HAMPSHIRE'S ESTUARIES

The good news is that our estuaries remain among New Hampshire's crown jewels as a natural and cultural resource treasure. The estuaries contain valuable and productive habitats that support diverse species, some rare or endangered. After a long history of sewage and industrial pollution, water quality has improved significantly over the last two decades.

NHEP

Upper Cocheco River

The bad news is that much work remains to be done. Cleaning up the estuaries' waters is critical to the health of shellfish and other living resources, and for people to use and enjoy estuarine resources. Priorities include stormwater management, outreach to local and regional planners, shellfish resource and sanitation management, land conservation, shoreland protection, and limiting sprawl development. The top living resource priorities include declining oyster populations, reduced clam densities, and degraded salt marshes. Improving water quality, improving and restoring habitats, and thoughtful resource management will help address most of these problems. In addition to solving existing problems, planning and preventive actions are needed to protect the estuaries from the increasing pressures of growth and development throughout their watersheds.

WATER QUALITY

Water quality is an important indicator of environmental health, and profoundly influences the condition of nearly all estuarine habitats, plants, and animals. Water transports and redistributes harmful bacteria, excess nutrients, and toxic materials. Stormwater runoff washes bacteria and toxic materials from roadways, parking lots, roofs, and residential and agricultural areas, contributing to degraded water quality and threatening many natural resources throughout the coastal watersheds.

Definition: IMPERVIOUS SURFACE

Any paved or compacted surface that limits the infiltration of water into the ground. Impervious surfaces often increase the volume, speed, and pollutant load (e.g. bacteria, nutrients, etc.) of stormwater runoff.

Pollution associated with stormwater runoff is called non-point source pollution (NPSP), because it does not come from a single point, such as a discharge pipe, but from a larger area. NH DES estimates that non-point sources cause over 90% of impairments to lakes, ponds, rivers, and streams in the state. Non-point sources are also believed to be significant contributors to estuarine water quality problems, especially bacterial contamination.


NHCP

Runoff can contain fecal bacteria, excess nutrients, oils and greases, toxic contaminants from pesticide and herbicide applications, toxic metals, and sediments eroded from shorelines and construction sites. Since these contaminants are collected, transported, and deposited via runoff, stormwater runoff must be considered as a potentially important source of these contaminants to New Hampshire's estuaries.

Point source pollution – which includes both permitted and illegal direct discharges – is a continuing threat to the environmental character of the coastal watersheds. Wastewater treatment facilities, industrial discharges, and power plants are the largest-volume point sources. While these discharges are closely monitored and regulated through state and federal permitting processes, the demands of regional economic and residential growth challenge wastewater treatment plant capacities, spur demand for electric power, and accelerate the production of industrial waste products. Point source pollution, often characterized by continual low level contaminant loading, tends to increase proportionally with regional growth.

New Hampshire's estuaries are also subject to contamination from the air. Atmospheric deposition from both outside and within the state's borders is now recognized as an important source of pollutants to surface waters across the state. Lead, mercury, and nitrogen compounds are deposited directly into surface waters or onto upland watershed areas and delivered to the estuaries in stormwater runoff.

Bacteria

Fecal coliform bacteria in water is a warning of sewage contamination and the presence of disease-causing organisms. Found throughout New Hampshire's estuaries, fecal bacteria come from a variety of sources: faulty septic systems, overboard-marine toilet discharges, wastewater treatment facility overflows, and sanitary sewer/stormwater system cross connections. Cross connections occur when sanitary sewers leak or are illegally connected into stormwater systems, causing discharge of sewage-contaminated stormwater directly into surface waters. Waterfowl, pet, and livestock waste can also contribute to bacterial contamination. Because

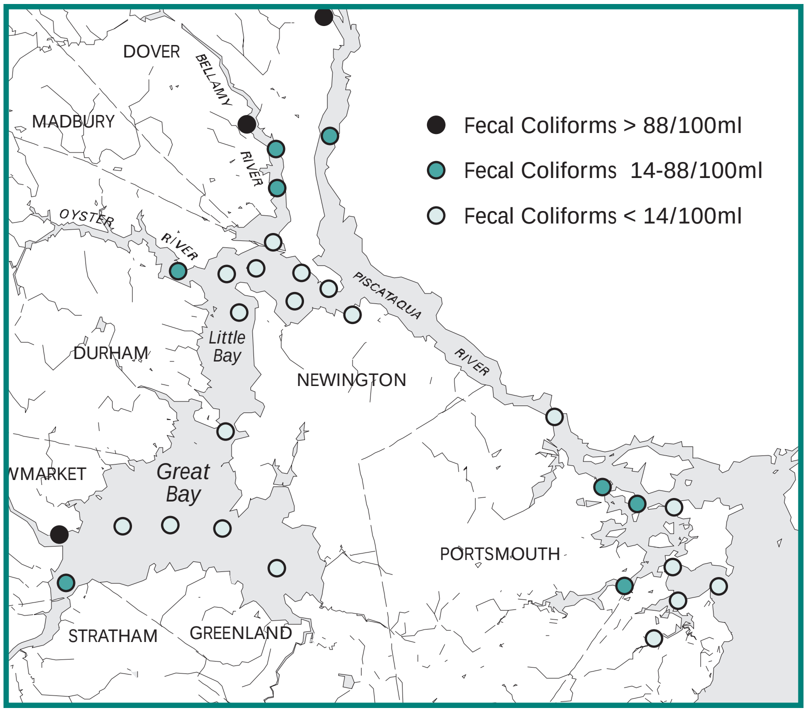
COASTAL AIR QUALITY

Air pollution presents health hazards to people and to wildlife, and pollutes surface water with atmospheric deposits. Still, citizens attending NHEP public meetings ranked air quality low in priority, perhaps because most Seacoast air pollution is beyond the reach of local control.

New Hampshire and other East Coast states affected by ozone pollution carried by air currents from other regions have joined together to form the Ozone Transport Assessment Group (OTAG) to study the problem and seek appropriate actions. Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react together in sunlight to produce low level, or tropospheric, ozone. The level of nitrogen oxides in the atmosphere governs the amount of tropospheric ozone produced. Of all the NO_x generated in New Hampshire, 63% is from mobile sources (motor vehicles) while 24% is from point sources and 13% is from area sources. OTAG data also indicates that the majority of New Hampshire's ozone results from NOx emissions that occur to the south and west, or 'upwind.' The NH DES has petitioned EPA to mitigate the upwind emissions of NO_x by requiring upwind sources to reduce their emissions of NO_x in an attempt to reduce New Hampshire's ambient tropospheric ozone concentrations.

The Ozone Transport Assessment Group (OTAG) has completed their policy recommendations and submitted them to EPA for their action. Based on OTAG's data, EPA has proposed new NO_x emissions figures directed at sources upwind of New Hampshire.

NH DES has also convened a Global Climate Change Workgroup representing a wide range of interests from virtually every sector throughout the state. Their aim is to suggest measures to NH DES to reduce emissions of greenhouse gases cost effectively and without detriment to the economy. There are currently no regulations at the state or federal level aimed specifically at controlling greenhouse gases.



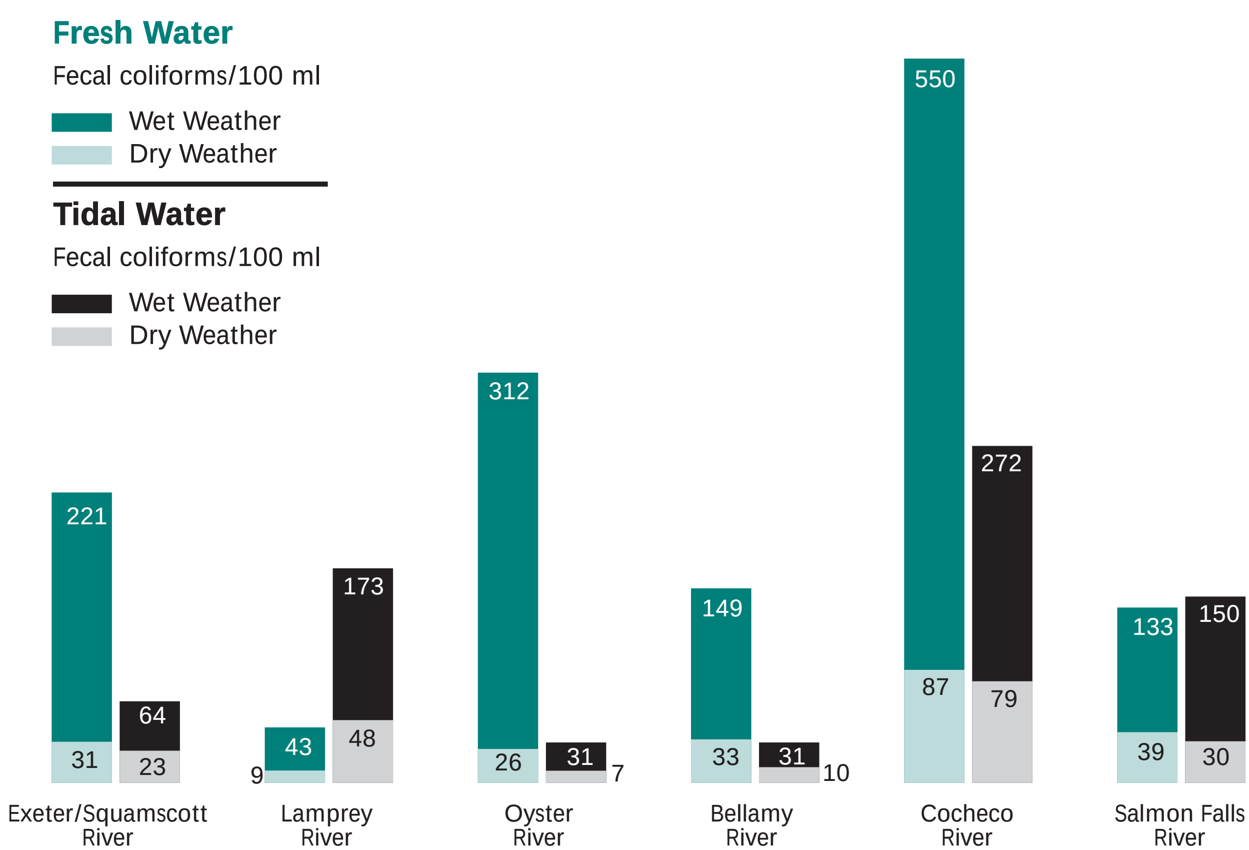
Average low tide fecal coliform levels 1988-98

of the public health risks associated with these bacteria, fecal coliform levels are routinely monitored throughout coastal New Hampshire in both wet and dry weather.

Bacterial concentrations in New Hampshire estuaries are highest during or immediately after rainfall, indicating that much of the bacterial pollution comes from contaminated stormwater runoff. Storm-associated bacterial pollution has been found in all the primary rivers in the Great Bay watershed, with the highest levels found in the Cocheco River.

High background concentrations of bacteria in the Cocheco River under dry-weather conditions suggest ongoing sewage pollution. Cross-connections that add untreated waste to stormwater systems through cracked pipes and illegal connections are the most likely sources of dry-weather bacterial pollution. Stormwater systems then deliver contaminated

Geometric mean fecal coliforms (colonies/100 ml) in water collected during wet and dry weather for three consecutive years in tributaries to the Great Bay Estuary: 1993-96.



water directly to the Cocheco River and streams flowing into Great Bay.

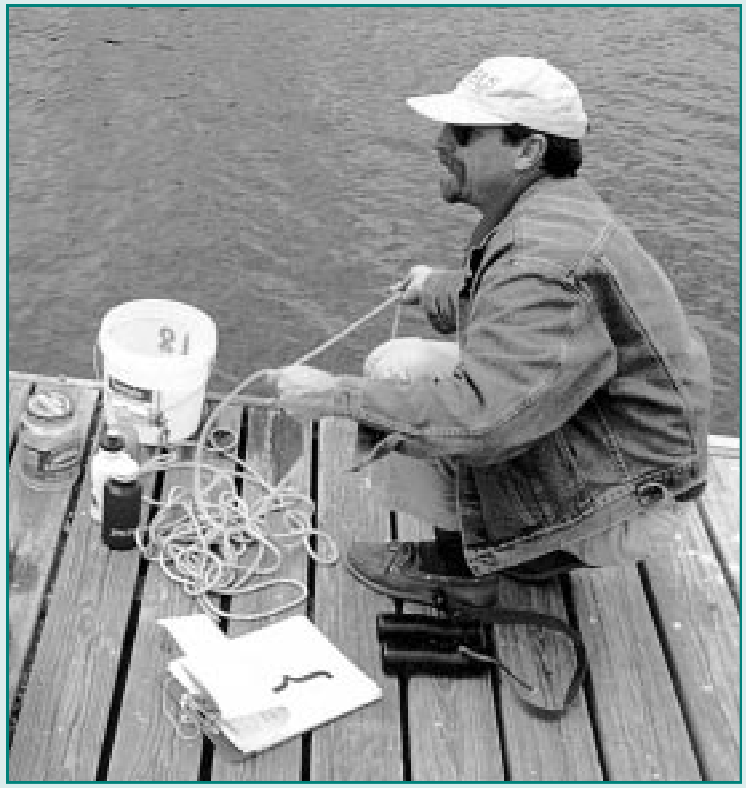
Despite significant improvements in recent decades, Seacoast wastewater treatment facilities still do not meet their required treatment standards 100% of the time. Factors affecting plant performance include waste stream changes, equipment problems, operational changes, operator errors, and storm events. The most severe incidences of bacterial contamination follow rainfall runoff events and treatment process interruptions at wastewater treatment facilities. While dramatic reduction in coliform counts has occurred in tidal rivers like the Squamscott since 1960, water quality sampling throughout the Great Bay Estuary tracks a pattern of elevated counts coming from urban runoff and wastewater treatment plants, with some plants causing more problems than others.

Nutrients

Estuarine systems are especially sensitive to excess nitrogen. Nitrogen is a naturally occurring nutrient essential for plants and algae. But too much nitrogen can promote unrestrained growth of nuisance algae. As these algae blooms die and decompose, they rob the water of oxygen, harming or killing estuarine and marine life.

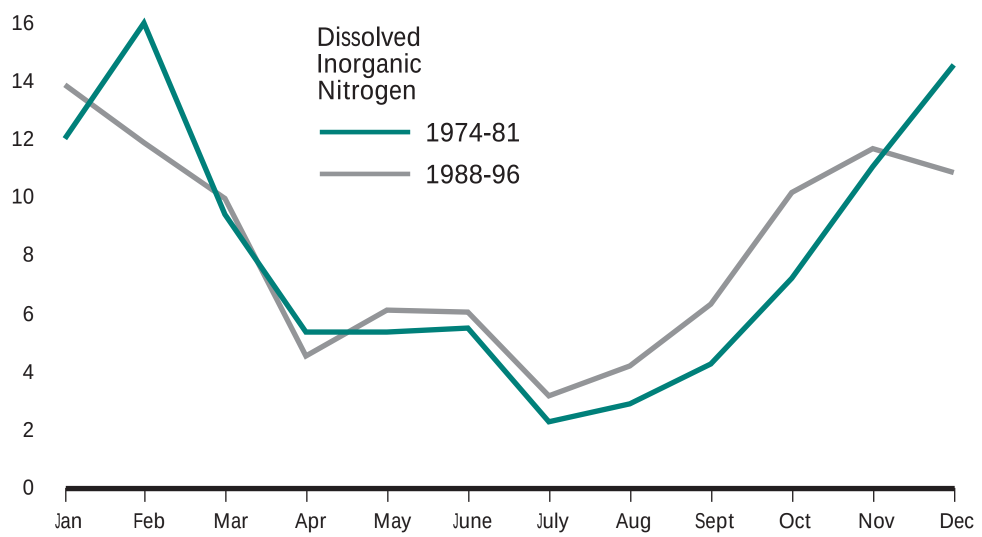
Nutrient loading is the continual addition of nutrients from natural and human sources. The nutrient load to Great Bay from the tributary rivers comes from both point and non-point sources, and from atmospheric deposition. Nutrient loading occurs throughout New Hampshire's estuaries and their tributaries. Evidence suggests that nutrient concentrations within the

GREAT BAY COAST WATCH


A.REID

Great Bay Coast Watch is New Hampshire's largest and most wide-ranging program for citizen monitoring of estuarine waters. Lay-people, retirees, environmental professionals, students, and teachers all participate in monitoring activities designed to protect New Hampshire's valuable estuarine resources. The Watch was founded in 1990 in response to the Great Bay National Estuarine Research Reserve Management Plan's call for a citizens' estuarine monitoring program. Today Great Bay Coast Watch routinely tests water quality at sites throughout Great and Little Bays, the Exeter, Lamprey, Bellamy, Cocheco, Salmon Falls, and Piscataqua rivers, plus Portsmouth's North and South Mill ponds and the Hampton/Seabrook estuarine system.

Great Bay Coast Watch has assisted the NH Estuaries Project and the NH Department of Health and Human Services with pollution source identification, sanitary surveys, and shoreline habitat surveys. Volunteer monitoring has extended the reach of the state's pollution source identification work; made faster, more targeted, clean-up activities possible; and provided interested citizens with an active role in stewardship of the coastal environment.

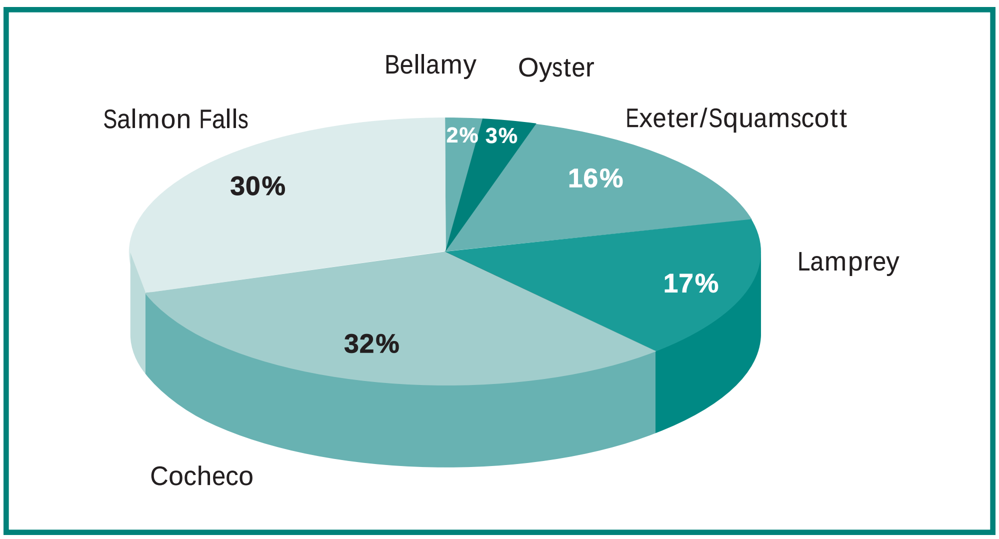


Monthly mean dissolved inorganic nitrogen (in micromoles per liter) at Adams Point in Great Bay for the years 1973-81 and 1988-96

main area of Great Bay have not changed significantly over the past twenty years. No widespread eutrophication effects have been observed. However, local isolated incidents of reduced oxygen levels and intense phytoplankton blooms have been observed in some freshwater tributaries of the Great Bay Estuary. Documented effects of phytoplankton blooms in other areas are rare. Thus, eutrophication and related impacts do not appear to be an imminent widespread problem.

However, sources of nutrient contaminants such as wastewater treatment facility effluent, lawn fertilizer residue, septic systems, and runoff from impervious surfaces, will increase with human population growth and development pressures. For this reason, it is important to continue to monitor nutrient levels in New Hampshire's estuaries as a safeguard against nutrient contamination.

Both routine and storm-related effluent nutrient contribution varies with individual wastewater treatment facilities. Based on total nitrogen



Nitrogen loading to the Great Bay Estuary from fluvial (riverine) sources calculated from plant reports, the largest nitrogen contributors to the Great Bay Estuary are, in descending order, the Portsmouth, Rochester, Dover, Exeter, Berwick, and Kittery facilities.

Dissolved Oxygen

One reason for concern about nutrient over-enrichment is reduced dissolved oxygen in water. When the excess plant material of blooms spurred by nutrient over-enrichment dies, the bacteria that break it down often use up oxygen in the water. Dissolved oxygen may be reduced or completely removed to levels that adversely affect marine and estuarine organisms, threatening the vitality of aquatic ecosystems.

Dissolved oxygen in the Great Bay Estuary, including the Salmon Falls, Oyster, Lamprey, Squamscott/Exeter, Cocheco, and Upper Piscataqua rivers, has been monitored in numerous studies over the past thirty years. The Great Bay Estuary does not generally exhibit low dissolved oxygen conditions in tidal waters. However, the freshwater portions of the Exeter and Salmon Falls Rivers have experienced low dissolved oxygen conditions during summer low flow periods. Biological impacts associated with these low dissolved oxygen conditions are unknown at this time.

Although the data are limited, studies in the Hampton-Seabrook Estuary have found no low dissolved oxygen conditions within the estuary. This likely results from the nearly complete tidal exchange – 88% of the estuary's volume – with well-oxygenated ocean water in each tide cycle.

ADVOCATES OF THE NORTH MILL POND

S.MILLER

The Advocates of North Mill Pond neighborhood association was formed in 1997 to protect, conserve, and enhance the North Mill Pond and the surrounding neighborhood. The neighborhood group considers the pond an asset to the City of Portsmouth. The ANMP stated mission includes:

- Encourage appropriate revitalization that will complement and encourage the stability of the tidal pond ecosystem, while enabling the community to utilize the surrounding areas;
- Foster appreciation of the historical and cultural resources of the pond and the surrounding area;
- Encourage stewardship of the pond through activities such as community clean-ups, water quality monitoring, and remediation programs; and
- Provide a forum that will keep the neighborhoods informed of all issues that may impact the North Mill Pond and surrounding area.

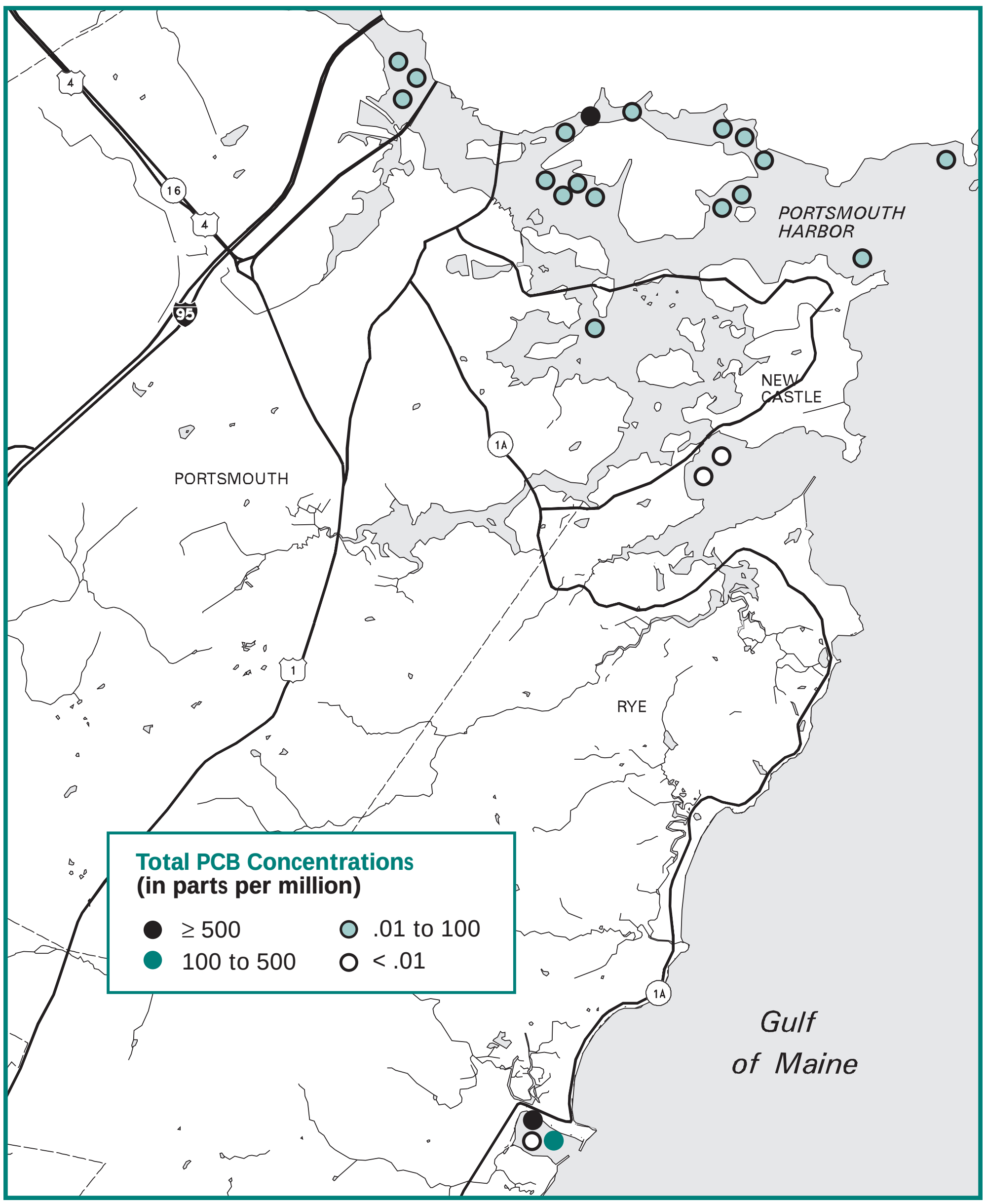
Located on Portsmouth's north side, North Mill Pond is a 46-acre saltwater pond, fed by the tidal waters of the Piscataqua River and by the freshwater flow of Hodgson Brook. Though little appreciated in the recent past, the pond played an integral role in the city's historical development. The surrounding neighborhoods reflect Portsmouth's diversity – ranging from heavy industry to residential neighborhoods, to serene salt marsh. A recent ANMP study funded by the NH Estuaries Project shows that the pond provides critical habitat for fish and wildlife, and an important resting and feeding area for migratory birds.

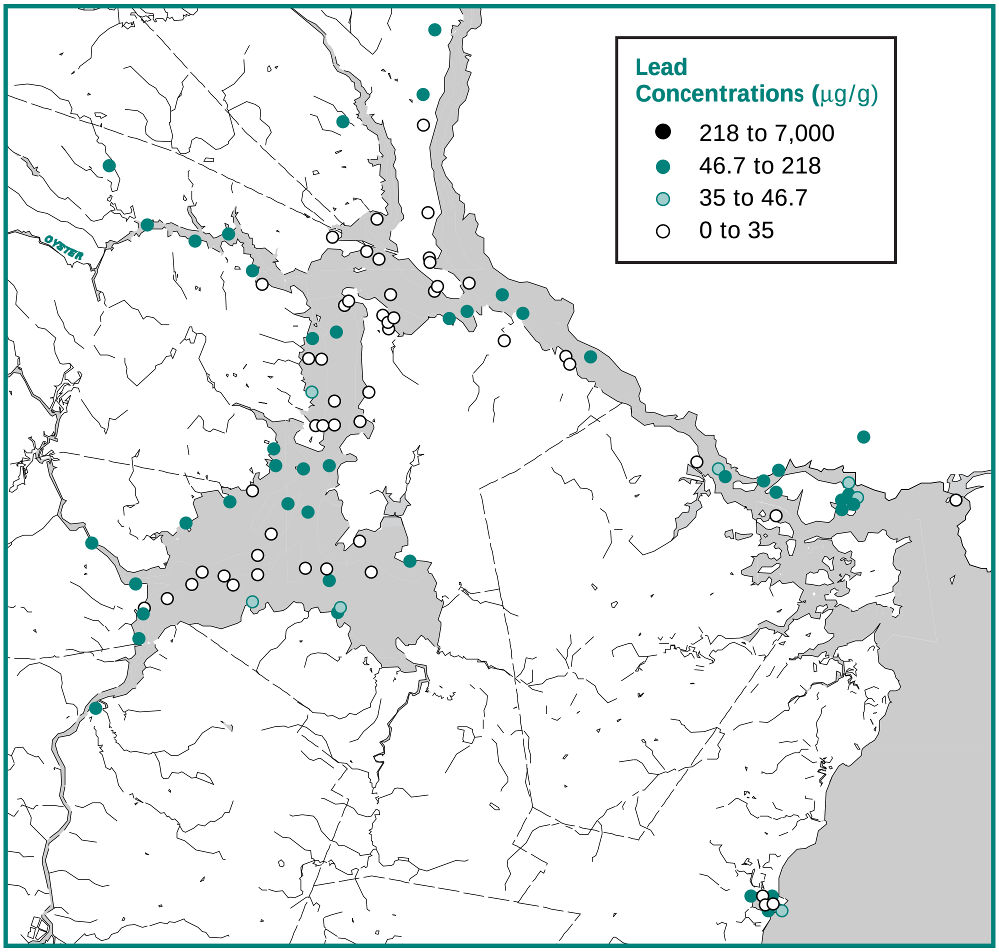
TOXIC MATERIALS

Heavy metal and toxic organic compounds are found throughout New Hampshire's estuaries. The Portsmouth Naval Shipyard, the former Pease Air Force Base, and a few other locations exhibit particularly elevated concentrations of some toxic contaminants. The most common toxic contaminants are chromium, lead, mercury, copper, zinc, and PCBs. DDT and other organic pollutants are present at elevated levels at some sites, but not at concentrations of concern to humans and other living things.

From colonial times mills, tanneries, and factories were built on the banks of our coastal rivers for their waterpower, shipping access, and easy waste disposal. Their legacy of toxic contamination remains stored in the fine-grained sediments dispersed throughout the estuaries. Currently small doses of toxins enter the estuaries from permitted and monitored discharges, pesticides, atmospheric deposition, and occasional oil spills. Other suspected sources include municipal discharges, stormwater runoff, and groundwater contaminated with leachate from hazardous waste disposal sites.

PCB concentrations in sediments: 1973-94





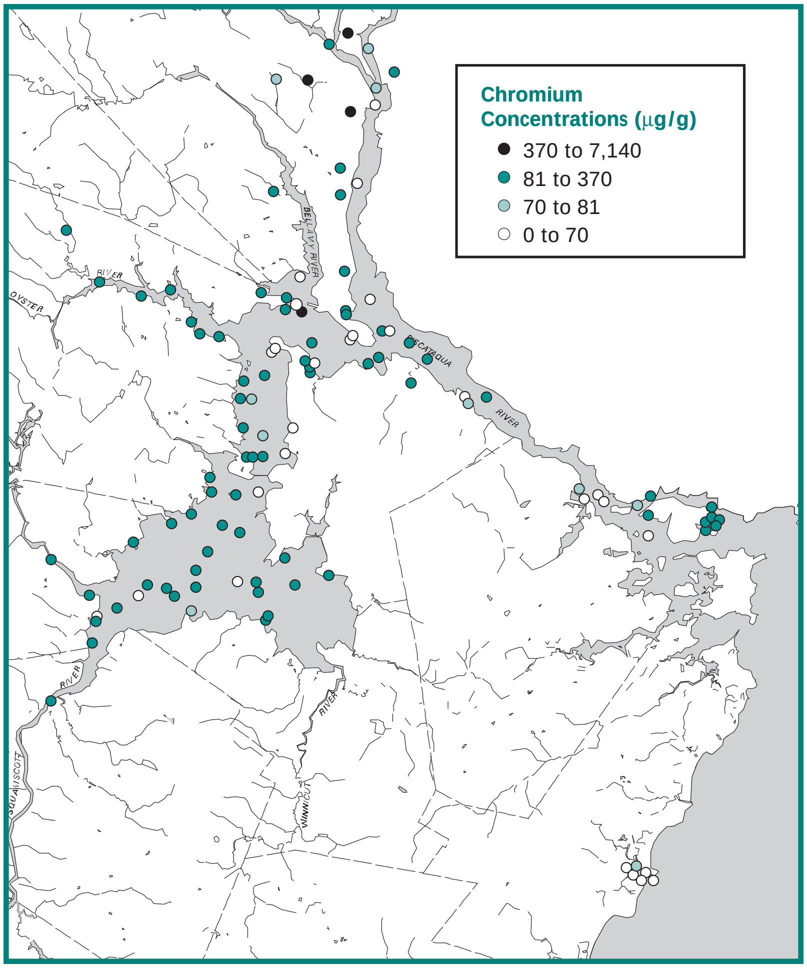
Lead concentrations in sediments: 1973-94

NOAA has designated ER-M = 110 µg/g. Effects range-median (ER-M) is the concentration at which biological effects are likely to occur.

Oil Spills

Many oil spills of a wide range of volumes have occurred in coastal New Hampshire waters. From 1975-79, there were 103 spills in public waters. While most of those incidents were of small volumes, the nine spills of greater than 500 gallons accounted for 95% of total oil spilled. The most recent large spill was the July 1, 1996 spill of approximately 1,000 gallons of #6 fuel oil from the vessel *Provence* into the Piscataqua River. The # 6 fuel oil involved in the *Provence* spill has both floating and sinking components. The sinking portion was difficult to contain and reached the sediments. Some of the oil residue was redistributed in the lower Great Bay Estuary. Investigators are still studying the impacts of this spill. Several preventable oil spills have occurred because of vessels that leaked due to poor condition or maintenance, dock line failure, or pump connection failure.

In 1998 the NH DES joined efforts with the Gulf of Maine Council-sponsored Gulfwatch to expand the use of blue mussel tissue for monitoring toxic contaminants in New Hampshire waters. One goal of this program is to establish baseline data for use in monitoring recovery from any future oil spill. Since Portsmouth and Newington serve as the oil shipping center for the region, port activities require continued attention. Collaborative efforts like the Piscataqua River Cooperative Oil Spill Response Team increase the margin of safety for the estuaries by developing and re-evaluating spill containment and cleanup techniques suited to the specific conditions of the Piscataqua River and coastal New Hampshire.



Sediments

Sediments suspended in the water can influence the overall water quality of an estuary. Suspended sediments in an estuary typically come from three sources: marine deposits, riverine inflows, and resuspension from wind, wave, tidal action, and boating activities. Reduced water clarity limits light penetration, often resulting in stress to submerged aquatic vegetation. Declines in the numbers of juvenile oysters and overall success of oyster beds result when sediments settle on the shells of mature oysters and impede the recruitment of oyster larvae from the water. Suspended sediments in the water also absorb energy from sunlight, resulting in warmer water temperatures and reduced capacity to hold dissolved oxygen.

Most freshwater river tributaries of the estuary have been dammed since industrial development in the 1800s, so much of their sediment remains trapped in the stillwater impoundments behind the dams. Today most of the suspended sediments in the Great Bay estuary result from the perpetual action of wind and tide. These forces re-suspend sediment particles and redistribute

Chromium concentrations in sediments: 1973-94. ER-M = 145 µg/g.

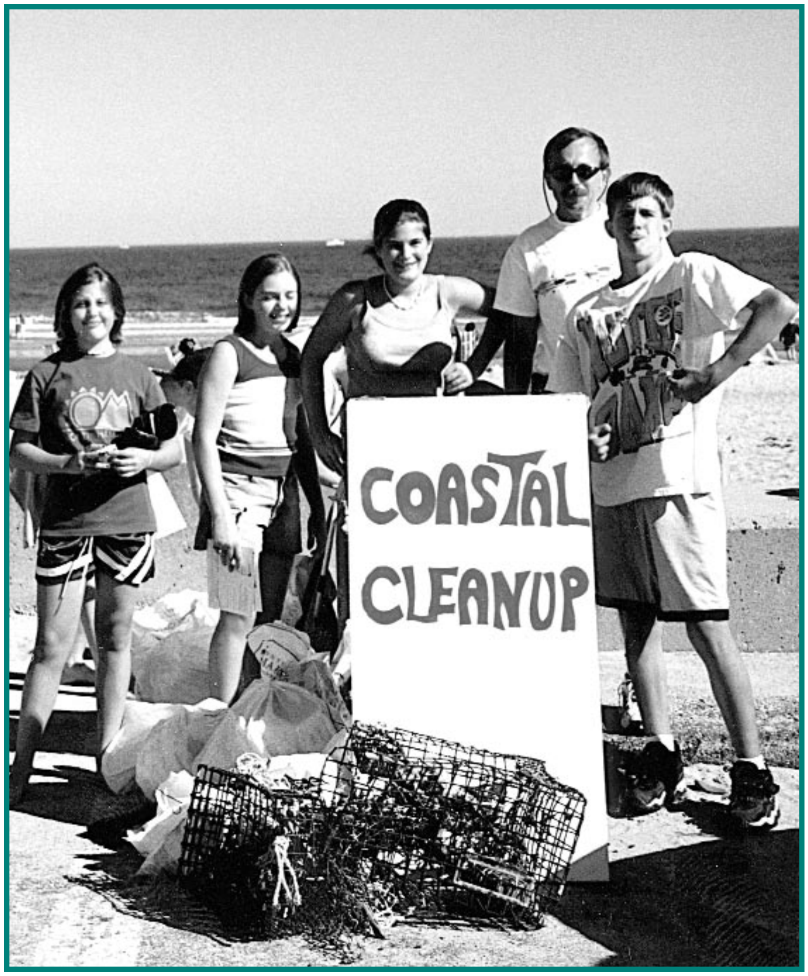
Sediment sampling, North Mill Pond

ANMP

them within the estuary. Sediment-borne contaminants such as heavy metals and other toxics are often redistributed as well. Chromium – a waste product of the early tannery industry located primarily on the Cocheco and Salmon Falls rivers – is distributed throughout the Great Bay system, providing evidence of this process.

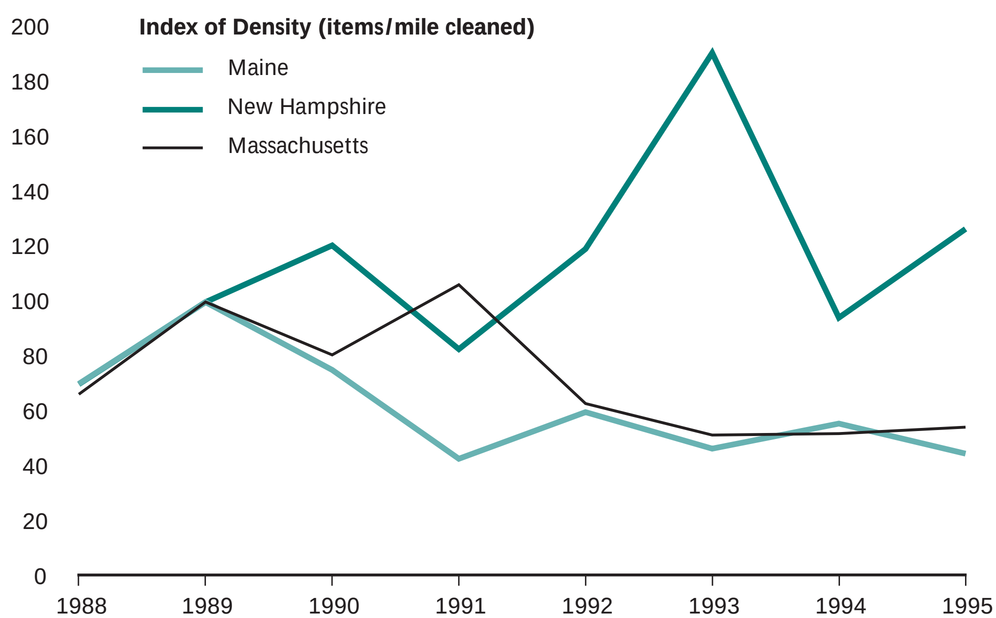
Marine Debris

New Hampshire, northern Massachusetts, and parts of Nova Scotia have relatively high densities of near-shore marine debris compared to Maine and southern Massachusetts. Since 1989 both Maine and Massachusetts had slight reductions in beverage container debris while New Hampshire showed no reduction. Onshore sources accounted for 80 to 85% of all debris, with much less coming from offshore sources such as commercial fishing gear. Each September the New Hampshire Coastal Program of the NH Office of State Planning sponsors a coast-wide cleanup effort, which removes tons of accumulated trash and debris from the region's shorelines and beaches.



NHCP

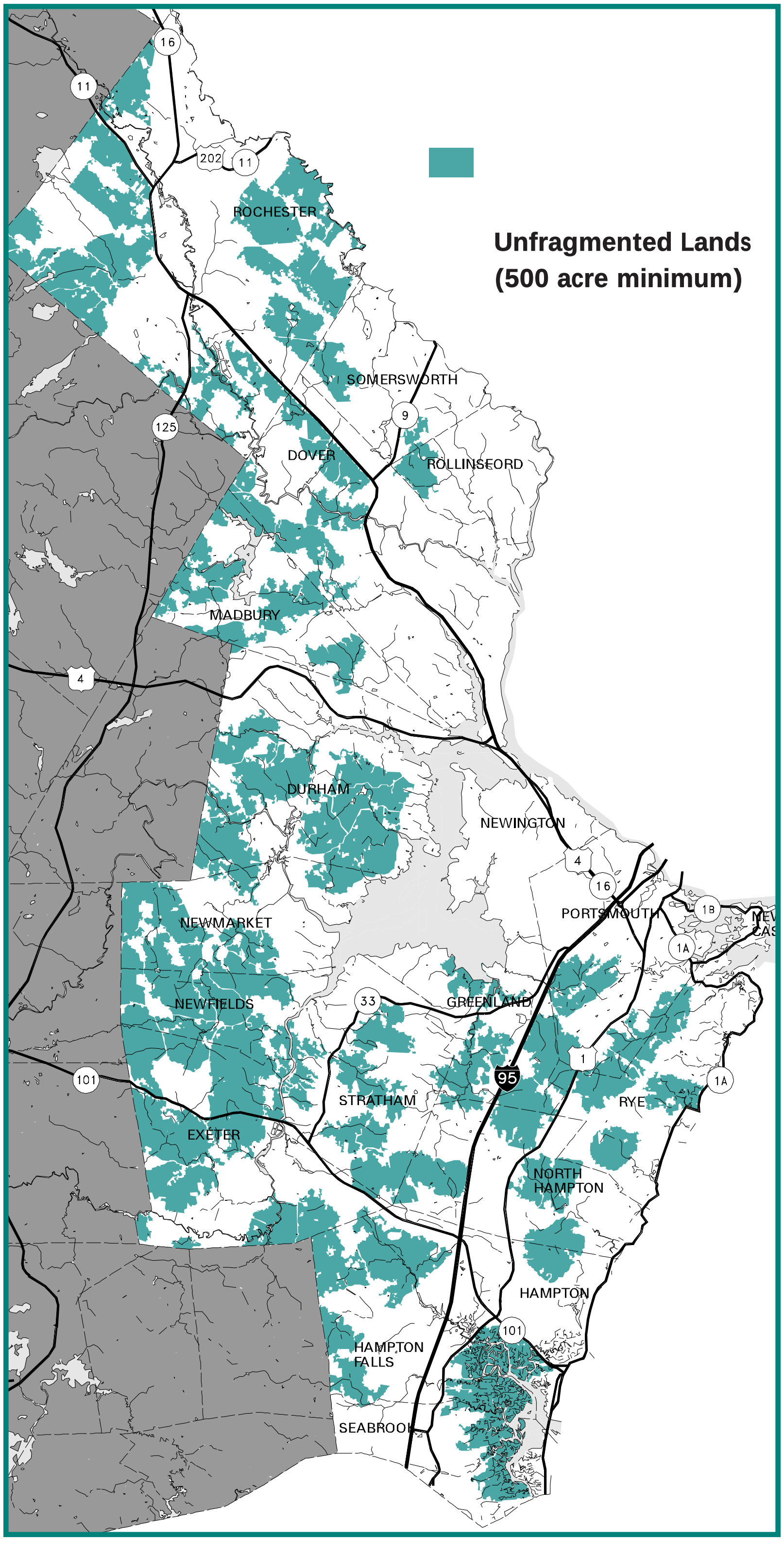
Coastal Cleanup volunteers



Index of bottles and associated items in marine debris from Maine, New Hampshire and Massachusetts, based on Coastal Marine Cleanup data

LAND USE AND REGIONAL GROWTH

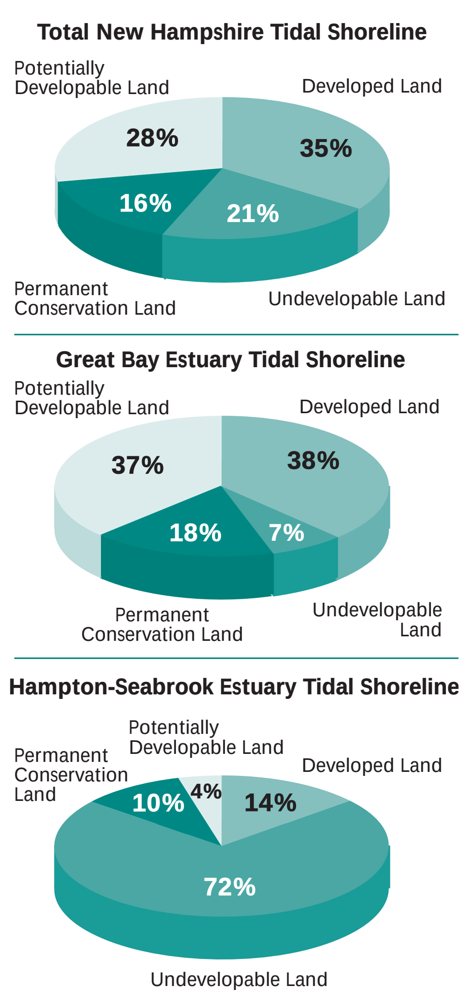
Many threats to the environmental character of our estuaries are the direct result of human activities, including development of land for residential, commercial, industrial, and other uses. The population of Rockingham and Strafford counties is projected to grow 17% from 1998 to 2005. Pressure to develop land for residential, commercial, industrial and other uses will intensify as population in the region grows. Continued population growth and development in the coastal region will add more impervious surfaces – paved areas, buildings, etc., increasing the potential for stormwater-related non-point source pollution. Negative impacts on water quality and living resources can be reduced through careful planning of development. New Hampshire communities, especially those with urbanized areas near surface waters, need technologies that effectively treat runoff.



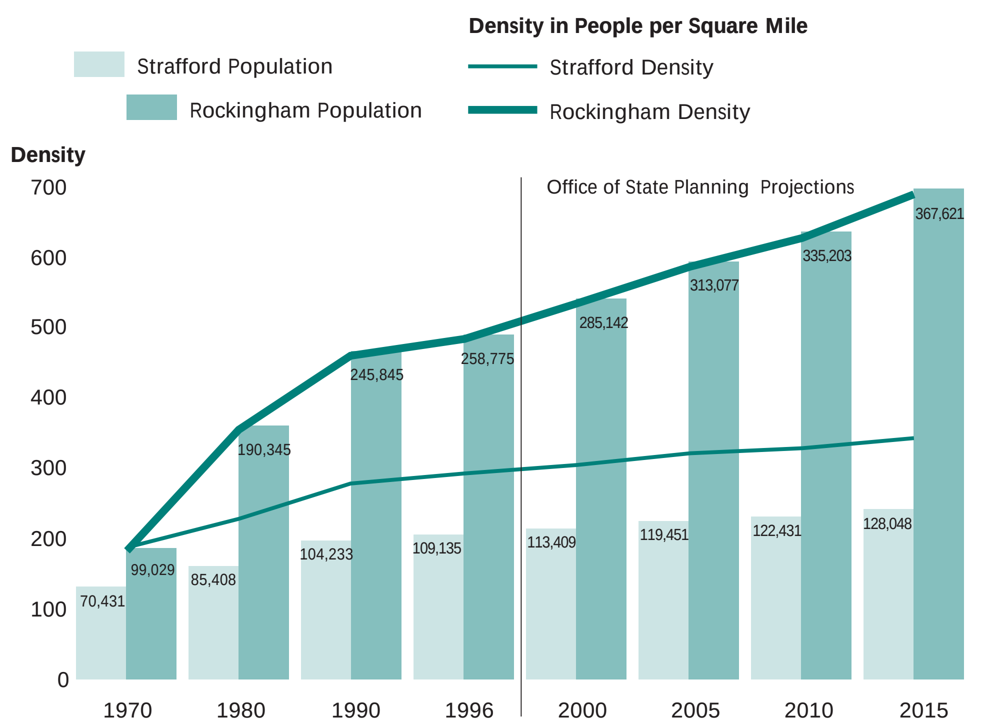
Impervious surfaces created in the built environment add to the volume and velocity of stormwater, sending more pollutants and sediments through drains and tributaries or directly into the estuaries. Shoreland development can eliminate the natural buffering of vegetated and wooded soils against erosion and runoff, destroy wildlife habitat and travel corridors, and alter scenic vistas from both shore and water. Development can fragment wildlife habitat and movement corridors**.**

Approximately 32% of the land in the 19 coastal-area towns is currently developed. Studies indicate an additional 13% is undevelopable due to permanent conservation and wetlands restrictions. Up to 55% of the total land area within these towns could potentially be developed. Future development will magnify runoff-associated problems and create new natural resource management issues by increasing impervious surfaces and destroying or degrading riparian and wetland habitats.

Shorelands are under particularly intense residential development pressures because many people desire to live by water in a coastal area. Shoreland development can impair a riparian area's ability to protect water quality and provide habitat to several important wildlife species. Recent analyses indicate 35% of New Hampshire's tidal shoreland (defined as a strip of land extending 300 feet from the water's edge) is already developed. Just 16% of tidal shoreland is permanently protected, with an additional 21% likely to remain undeveloped because of natural resource constraints. But approximately 28% of the state's tidal shorelands remain open and developable. Both shoreland preservation and conscientious development of shorelands require careful planning and attention.



Land development and potential for tidal shorelands (within 300 feet of the water's edge)



Population growth and density in Rockingham and Strafford counties, New Hampshire: 1970-2015

S. MIRICK

Adams Point

NATURAL RESOURCES

The rich diversity of habitats found in New Hampshire's estuaries support a great variety of plants, animals, and fish, including rare and endangered species. These estuarine habitats include salt marshes, eelgrass beds, algal beds, rocky intertidal areas, barrier beaches, dunes, mud and sandflats, clam flats, oyster beds, and subtidal bottom habitats with substrate ranging from mud to cobble and boulders. Botanists have identified 67 rare plant species within the Great Bay and coastal watersheds, a dozen associated with estuarine environments.

S. MIRICK

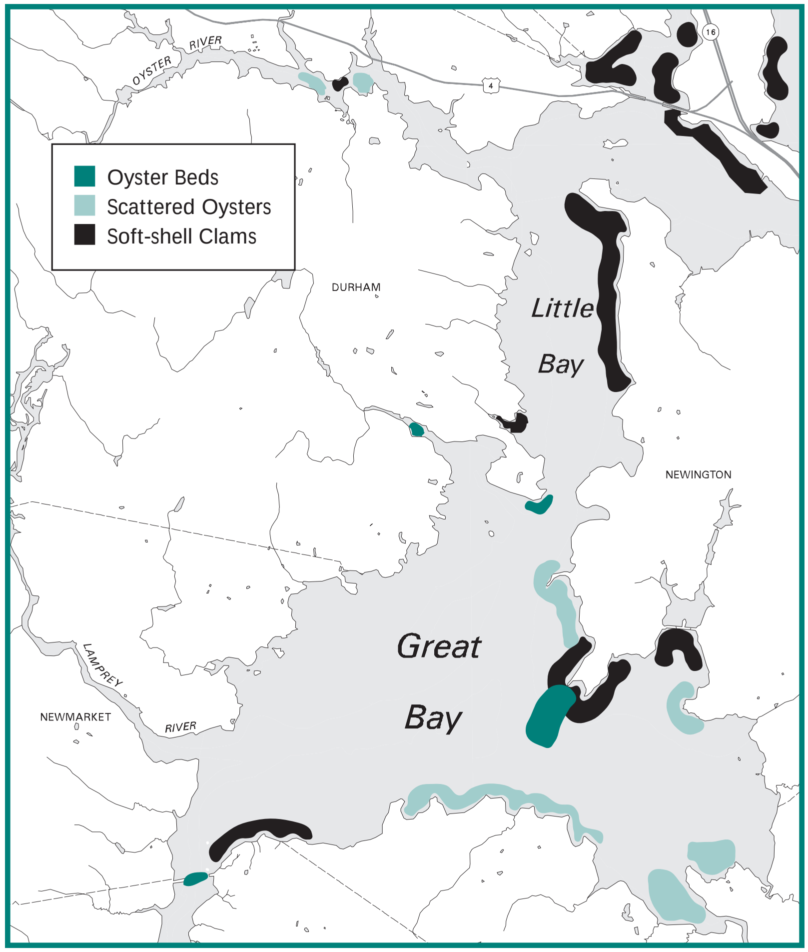
Piping plover

Protecting and buffering the variety of habitats found throughout the Great Bay and coastal watersheds safeguards the area's unique natural character, and supports the survival of the species that make it their home. Preserving and protecting these important habitats demands careful planning as development pressures grow and human uses within the watershed increase.

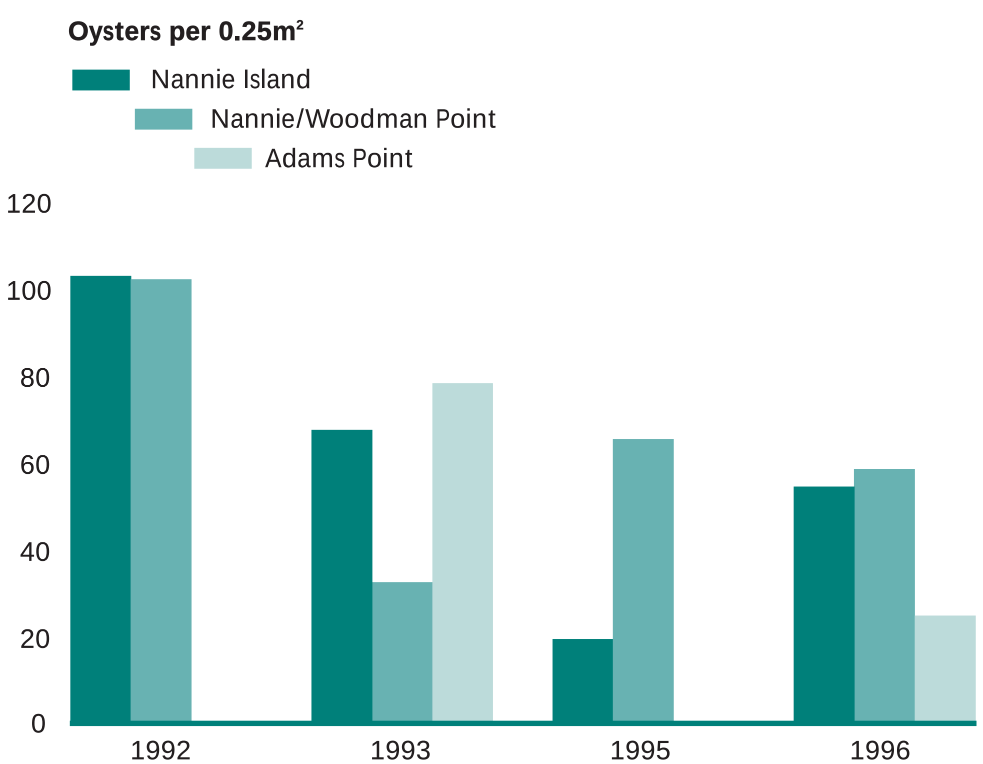
Shellfish Resources

Oyster resources in the Great Bay Estuary have declined in recent years. From 1991 to 1996 oyster density decreases ranged from 42% to 69% in three beds of recreational importance. Other oyster beds, especially in the Oyster and Bellamy rivers, have lost significant bed acreage. Oyster harvests reflect these declines: a 1991 study estimated a total harvest of 5,000 bushels of oysters by 1,000 license holders, but by 1997 the estimated harvest had declined to 2,700 bushels by 661 harvesters. Predation, limited availability of suitable substrate for larval attachment, disease, and a variety of management issues are likely factors in these declines.

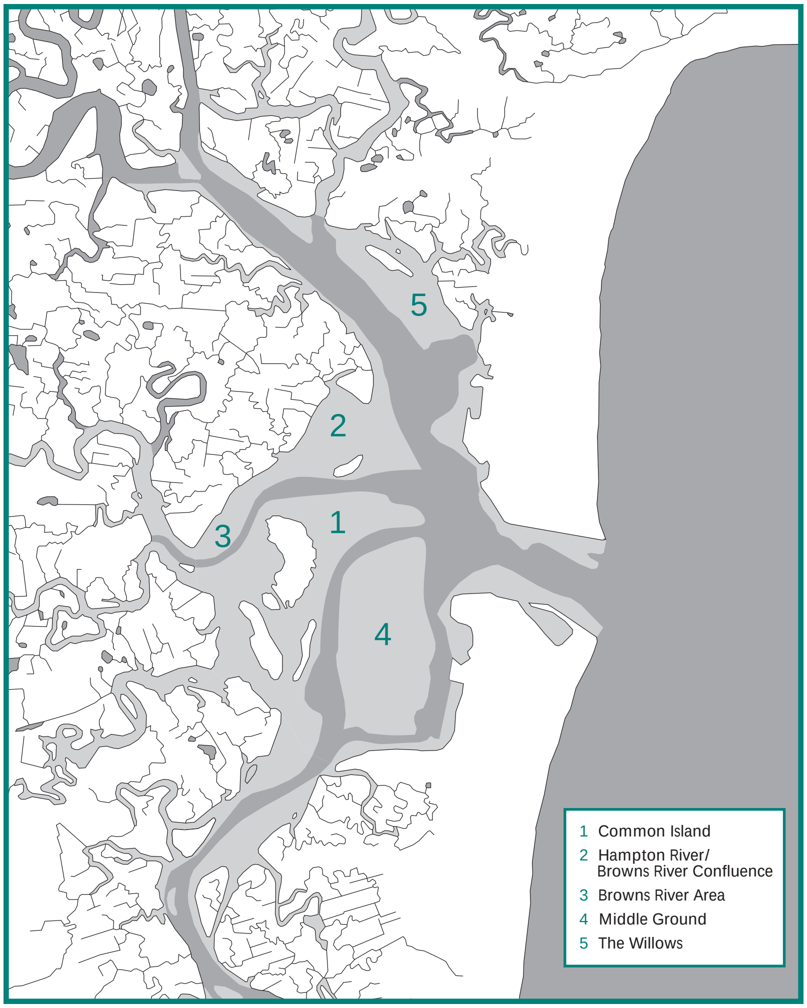
Softshell clam resources in the Hampton-Seabrook Estuary are well documented. Adult populations on three particular flats of the estuary



Above: Great Bay shellfish resources



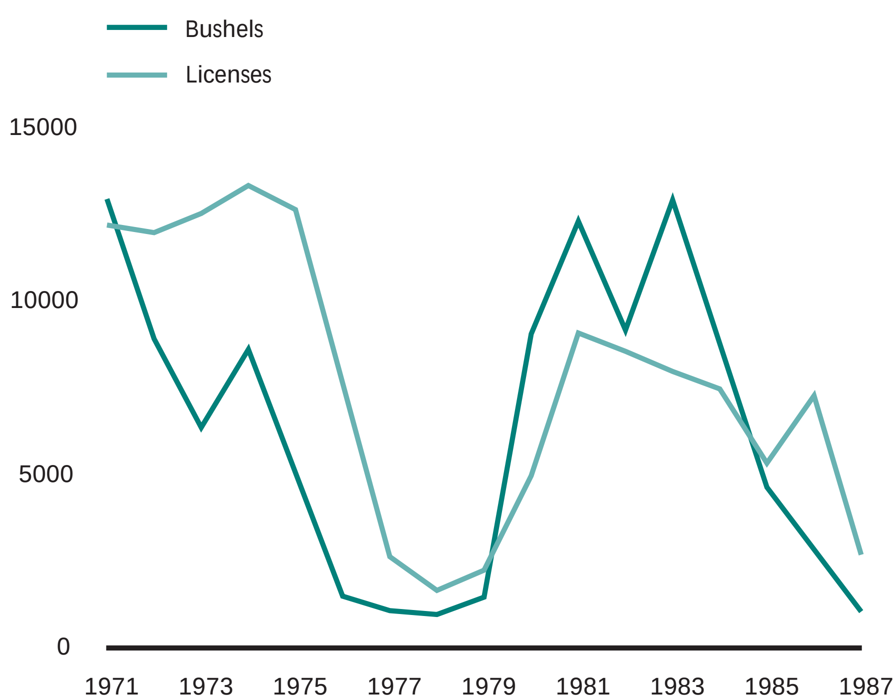
Left: Density of oyster beds in Great Bay, 1991-1996

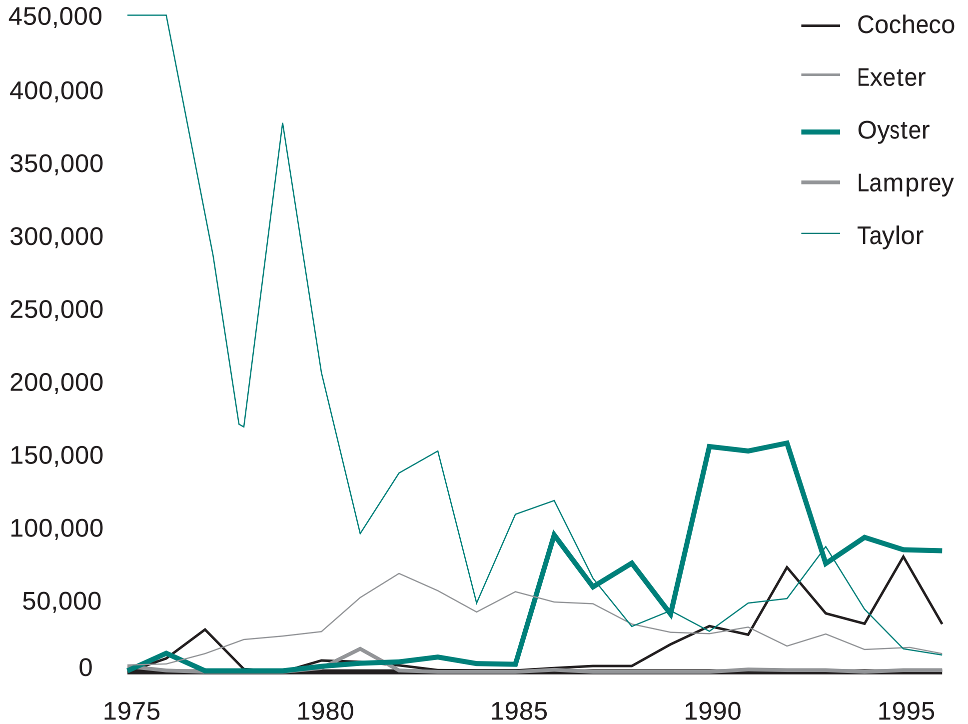


peaked in abundance in the early to mid-1980s, then declined sharply in the late 1980s – most likely due to intense harvest pressure. After the flats were closed to harvesting in the late 1980s, adult clam densities began to recover. From 1990 to 1995 adult clam densities quadrupled on the Middle Ground flat, but Common Island densities remained essentially unchanged. While the Middle Ground flat remained closed until November of 1998, the conditional reopening of the Common Island area to harvest in 1994 appears not to have significantly affected the resource. Clam densities in the Hampton River decreased by 50% from 1990 to 1995. A suspected cause is a lethal form of leukemia in clams, *Sarcomatous neoplasia*. Little information is available on the soft-shell clam resources of the Great Bay Estuary and the Little Harbor-Back Channel area.

Above:
Hampton-Seabrook Harbor clam flats

Left:
Number of clam licenses and the adult clam standing crop (bushels) in Hampton-Seabrook Harbor: 1971-1987.





River herring returns in Seacoast rivers: 1975-1996.

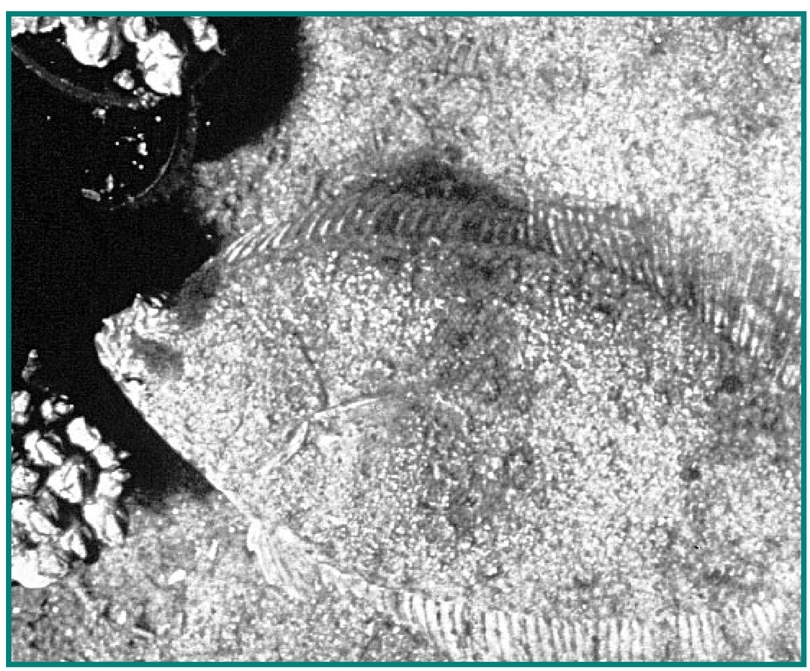
Finfish

A region-wide moratorium and subsequent harvest restrictions on striped bass in the 1980s and 1990s yielded a dramatic comeback in the seasonal occurrence of stripers in New Hampshire waters. Catches of both legal and undersized fish tagged by the U.S. Fish and Wildlife Service have increased steadily since 1988. Biologists and anglers generally confirm that fish of all sizes have increased in abundance.

Recreational anglers have not enjoyed this same abundance with winter flounder. Catch per unit effort declined steadily from 1988 to 1993, rose briefly in 1994 and 1995, then decreased again in 1996. Although juvenile fish appear abundant in the estuaries, adult populations have declined due to commercial harvest pressure in the Gulf of Maine. Commercial landings of winter flounder show a similar, steady decline.

Rainbow smelt catches have varied greatly at several locations in the Great Bay Estuary: peaking in the late 1980s, declining sharply in the

Winter flounder



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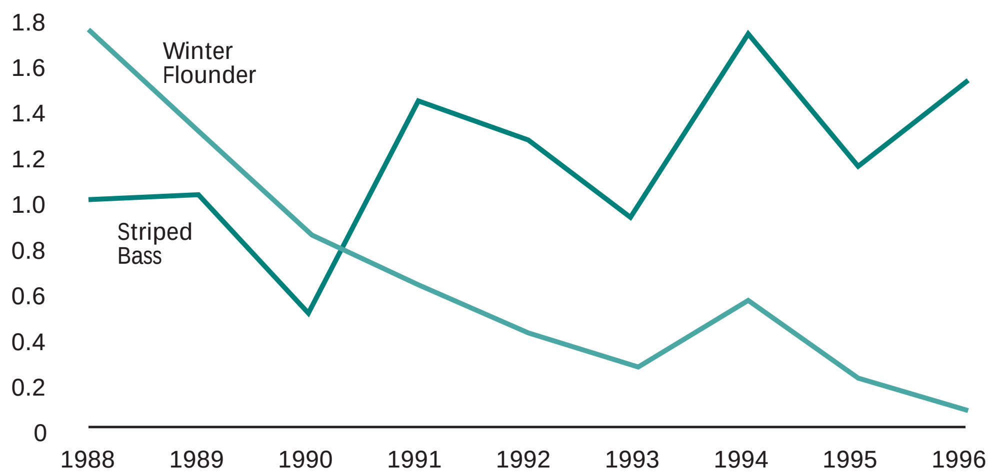
Catch per trip of striped bass and winter flounder.



early 1990s, and increasing in the mid 1990s. From 1975 to 1996 spring returns of river herring (alewife and blueback) declined in the Exeter, Lamprey, and Taylor rivers, but increased in the Oyster and Cocheco rivers.

Waterfowl and Shorebirds

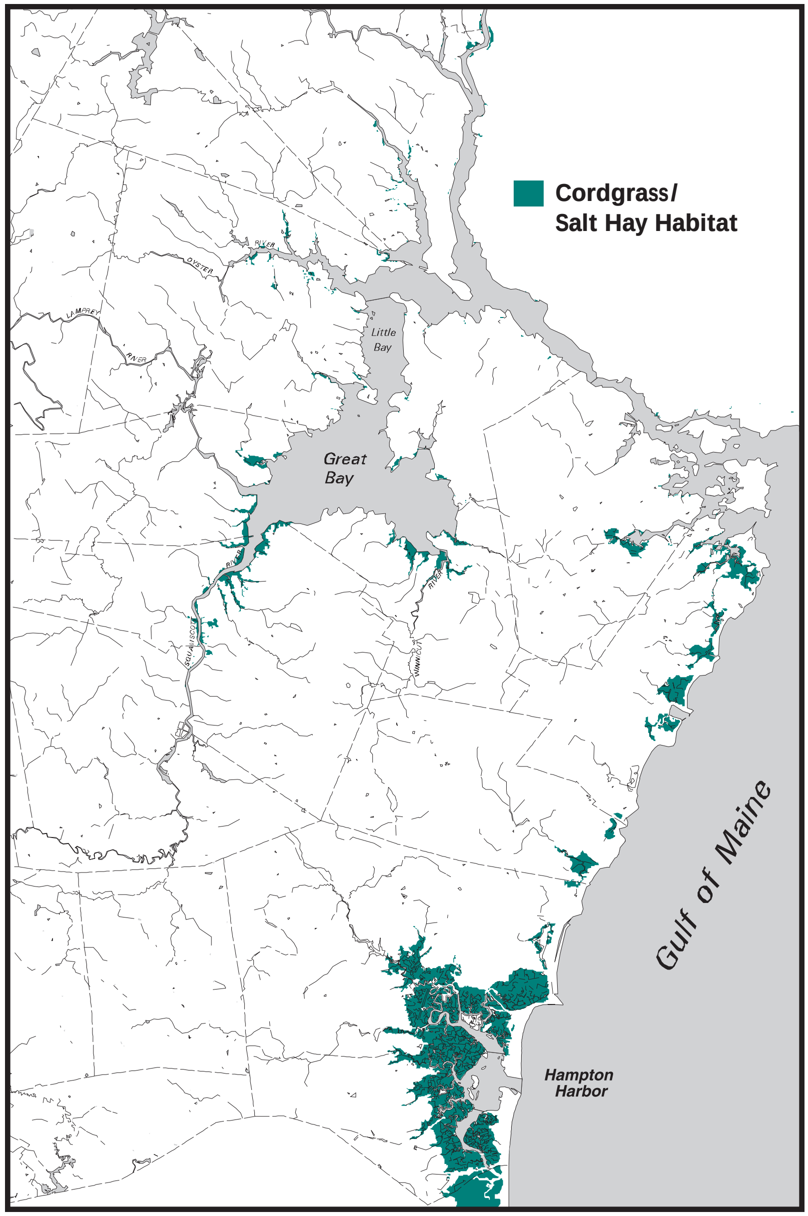
The Seacoast area is the principal waterfowl wintering location in New Hampshire, with 75% of wintering waterfowl in Great Bay. A recent mid-winter survey recorded mallards, black ducks, greater and lesser scaup, goldeneye, bufflehead, red-breasted mergansers, and Canada geese as the predominant waterfowl. Great Bay is a focus area for the North American Waterfowl Management Plan. State, federal and locally controlled reserves and sanctuaries in the Great Bay area provide over 6,300 acres of protected wetlands, salt marshes and upland habitat. This makes Great Bay an important destination for birders interested in a wide range of waterfowl and shorebirds. The Great Bay National Estuarine Research Reserve lists over 170 species by season and abundance on its checklist of the birds of Great Bay.

Whimbrel

S. MIRICK

Salt Marsh

The 5,000-acre salt marsh of the Hampton-Seabrook Estuary is the largest contiguous salt marsh in the state. Tidal marshes of the Great Bay Estuary total 2,230 acres, with the most extensive salt marshes found along the lower Piscataqua River, the Squamscott River, and Great Bay itself. The fringing marshes of the Great Bay Estuary wind along tidal shorelines between the low tide line and adjacent upland areas, wherever the soils, elevation, and tidal action are favorable.



Cordgrass/ salt hay habitat

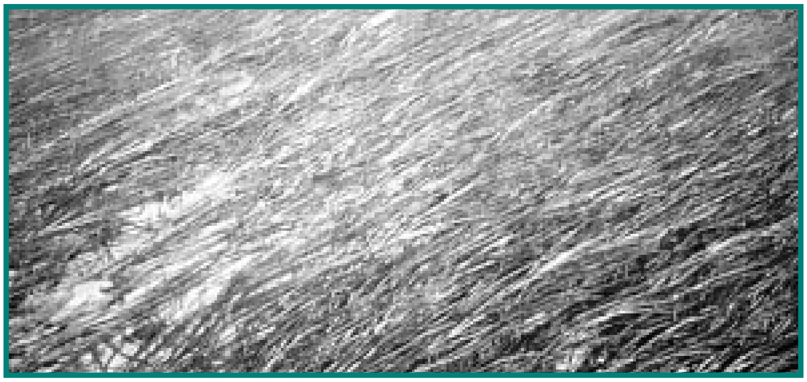
Nearly all salt marshes in New Hampshire were subject to ditching in the first half of this century, in attempts to control mosquitoes. Present salt marsh acreage is half what it once was, with most of the lost acreage filled for residential and industrial development, and road or rail construction. Total salt marsh acreage has remained stable over the past decade. But past development in or near salt marshes, as well as road and rail crossings, have restricted water circulation and tidal flow within many remaining marshes, and increased freshwater runoff into the marshes. These changes in the natural tidal flow and salinity have degraded salt marsh function, with resulting impacts including growth of invasive species such as purple loosestrife and common reed.

A number of salt marshes have recently been successfully restored. Most projects have focused on re-establishing tidal flow and exchange to marsh areas where tides were restricted by undersized or damaged culverts, water control structures, and/or berms of debris or dredge spoil. Recovery of marsh functions and habitat has been rapid and successful. By 1999 the collaborative efforts of many different agencies and landowners had restored or enhanced over 430 acres of salt marsh in New Hampshire.

NHCP

Salt marsh restoration at Awcomin Marsh, Rye

Eelgrass



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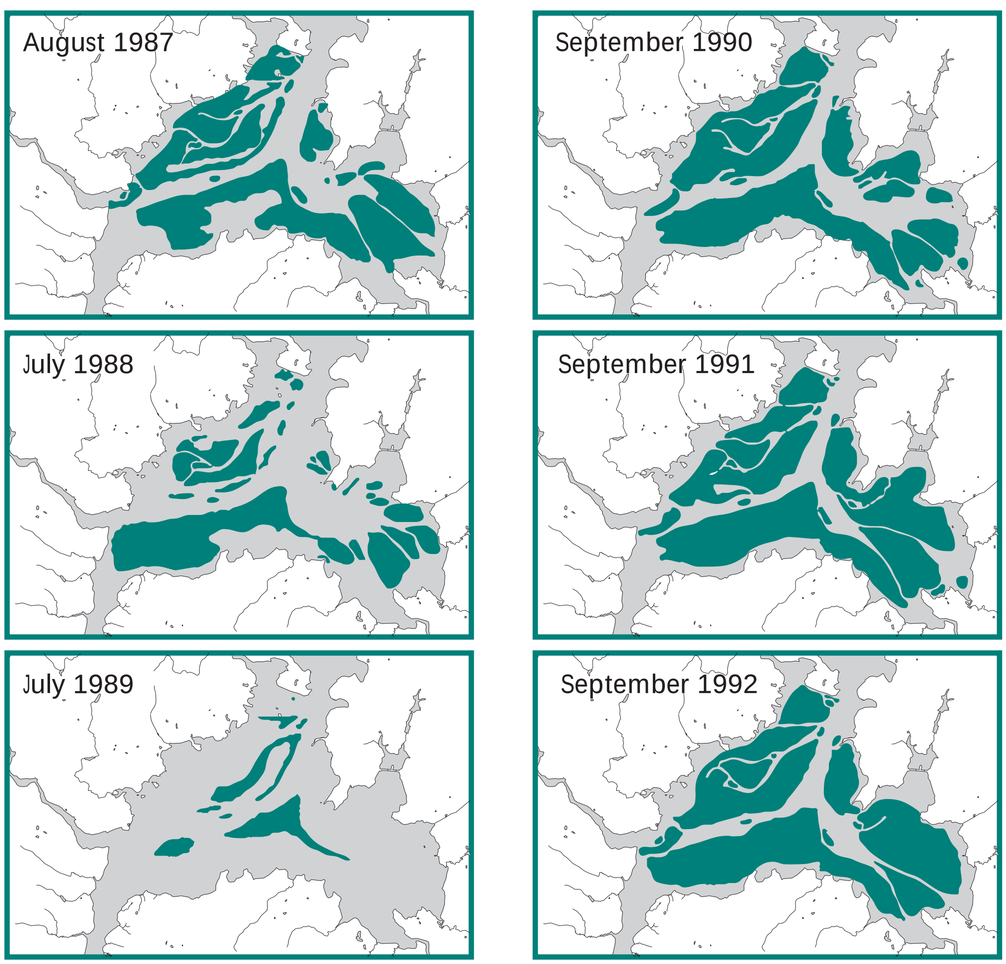
Eelgrass

Eelgrass beds and meadows form subtidal and intertidal seagrass habitats that cover the greatest area of all habitat types in the Great Bay Estuary. Eelgrass habitats are important as breeding and nursery grounds for finfish, shellfish, and other invertebrates, and as feeding grounds for many fish, invertebrates, and birds. Eelgrass may also filter nutrients, suspended sediments, and contaminants from estuarine waters.

In the late 1980s eelgrass wasting disease caused dramatic eelgrass declines in the Great Bay Estuary, arousing great concern into the early 1990s. However, historical eelgrass beds have made an impressive recovery of acreage and densities, and new beds have been observed in areas previously devoid of eelgrass. While overall the resource is improving, lost eelgrass beds in Little Bay have been significantly slower to recover.

Efforts have been made to restore eelgrass at several sites in the Great Bay Estuary, including Little Bay where beds killed by the wasting disease have not recovered in over 10 years. Efforts to restore eelgrass have also been made in Rye Harbor, the Bellamy River, and the Piscataqua River adjacent to the State Port Facility expansion.



Time series of eelgrass distribution in Great Bay.

Introduced and Nuisance Species

Many people familiar with New Hampshire's estuarine creatures are unaware that the green crab and common periwinkle are introduced species. Introduced to North America in the early 1900s, green crabs are a major predator of juvenile shellfish. While green crabs are present throughout the estuary, they are more prevalent in the lower portions of the system. Crab densities in any year appear to be related to winter temperatures, with fewer crabs surviving colder winters. In addition to preying on juvenile clams, green crab burrowing activities can uproot and kill eelgrass plants.

S. MILLER

Green crab

The common periwinkle is highly abundant in estuarine and coastal waters and may control ecological community patterns along rocky shores. The widespread distribution of this species and the lack of habitat information prior to periwinkle colonization in the 19th Century make it difficult to determine whether the periwinkle has caused adverse ecological impacts in coastal New Hampshire and the Gulf of Maine.

The common reed (*Phragmites australis*) and purple loosestrife *(Lythrum salicaria)* are two emergent plants considered nuisances in tidal marshes and other areas. These plants drastically reduce plant diversity in marshes, restrict bird and fish access to marsh habitats, and have been cited as fire hazards to nearby homes. Restricted tidal exchange and increased freshwater entering a marsh (often the result of stormwater runoff) can reduce salt marsh soil salinity and provide opportunities for these aggressive plants to colonize suitable areas. The presence and spread of these species indicate adverse changes in the marshes, and may reflect the loss of marsh functions and habitat values. *Phragmites* invasion of Seacoast salt marsh habitat has been the focus of much recent restoration work by several federal, state and local agencies. Natural tidal flow has been re-established and high marsh habitats have been reclaimed in efforts to halt advancing *Phragmites* stands and restore salt marsh functions.

NHCP

Common reed

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Sailing on Great Bay

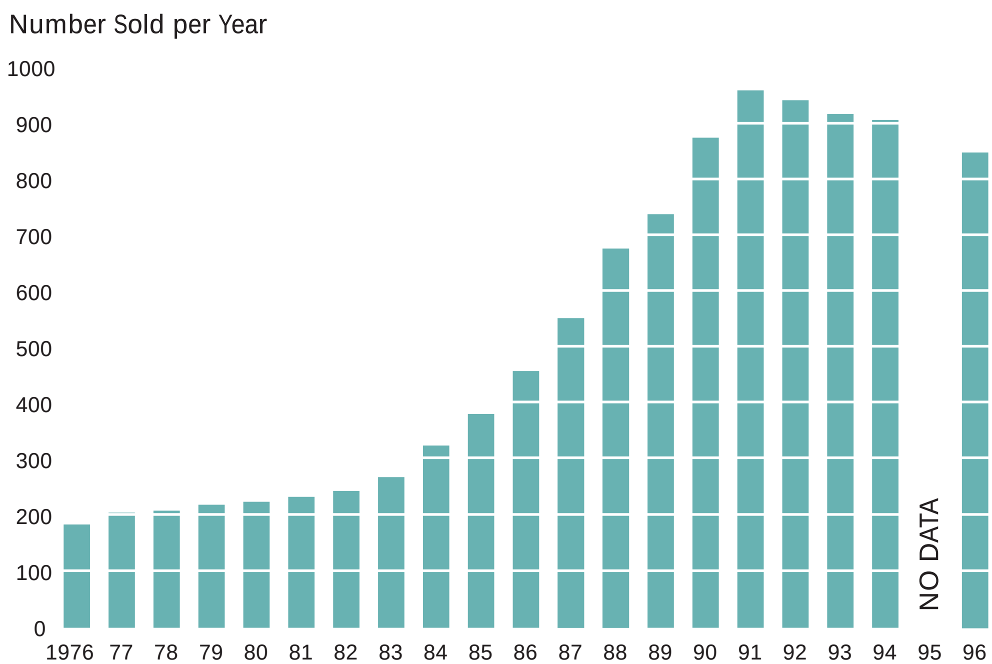
RECREATIONAL AND COMMERCIAL USES

Recreation and Tourism

Tourism and recreation are important to the Seacoast economy, with over 15% of the region's jobs related to the tourism industry. Important recreational activities include boating, fishing, sailing, day cruises, and tours.

Boating has grown in popularity since the 1980s, with over 8,500 boats registered for tidal waters in 1992. Annual mooring permit sales grew dramatically in the 1980s and into the early 1990s, but have leveled off since the NH Port Authority implemented a harbor management plan. Canoeing, rowing, kayaking, and windsurfing are also popular activities in the estuaries.

Annual mooring permit sales by the New Hampshire Port Authority: 1976-1996



Recreational Fishing

New Hampshire's estuaries support a diverse community of resident, migrant, and anadromous fishes, many of which are pursued by recreational fishermen. Striped bass, bluefish, Atlantic mackerel, codfish, haddock, pollock, rainbow smelt, and winter flounder are the most popular recreational fisheries. In addition to the many boat access locations, numerous shore and bridge locations are used for fishing. Several charter boat companies in the

Striped bass fisherman

NHEP

Great Bay and Hampton-Seabrook estuaries take fishermen to inshore and offshore locations. Another important recreational fishing activity is trapping lobsters. Almost 150 recreational lobstermen set traps throughout the Great Bay and Hampton Harbor estuaries and Portsmouth Harbor. A 1990 NH Fish & Game study estimated 88,000 saltwater anglers spent over $52 million dollars in fishing-related expenses. The largest expenditures were for food and beverages, automobile fuels, charter and party boat fees, bait, tackle, and boat fuel.

Recreational Shellfishing

Recreational shellfishing is an important part of the history and tradition of coastal New Hampshire. Softshell (steamer) clams and oysters are the principal quarries of recreational diggers, but other shellfish species are also sought. Oysters are primarily harvested from the Great Bay Estuary, while softshell clams are primarily dug from the Hampton-Seabrook Estuary. In 1994 almost 3,000 clamming licenses were sold to New Hampshire residents, while

Clammers at the Common Ground, Hampton

NHEP

Oysterman

GBNERR

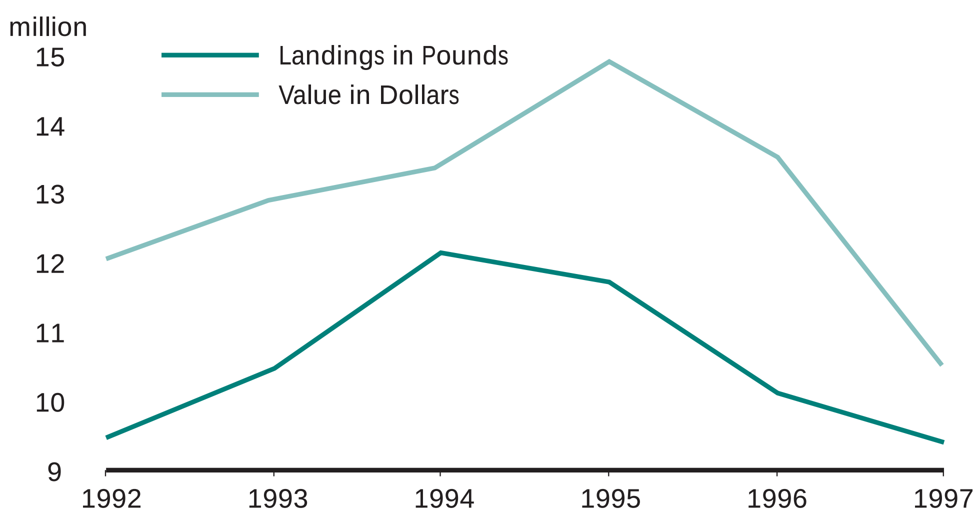
oyster harvesters numbered nearly 1,000. A UNH study in 1992 estimated that recreational clamming in the Hampton-Seabrook Estuary contributed nearly $3 million to the state and local economy.

However, over 50% of shellfish-growing waters in New Hampshire's estuaries remain closed to harvesting. Shellfish beds are most often closed for two reasons: bacterial contamination, or insufficient monitoring to declare areas open and their shellfish safe for human consumption. Pollutants from wastewater treatment plant overflows, stormwater/sewer cross-connections, and stormwater run-off require closure of beds after even small amounts of rain, demonstrating the direct links between human activity in the watershed, water quality, and shellfish sanitation.

Commercial Fishing

The American lobster is one of the most important commercially harvested species in New Hampshire. Lobsters migrate into the estuaries during late spring, with some moving well into Great Bay during the summer. Despite fishing pressure in estuarine and ocean areas from 300 lobster fishers, landings remained relatively stable during the 1990s, averaging almost 1.6 million

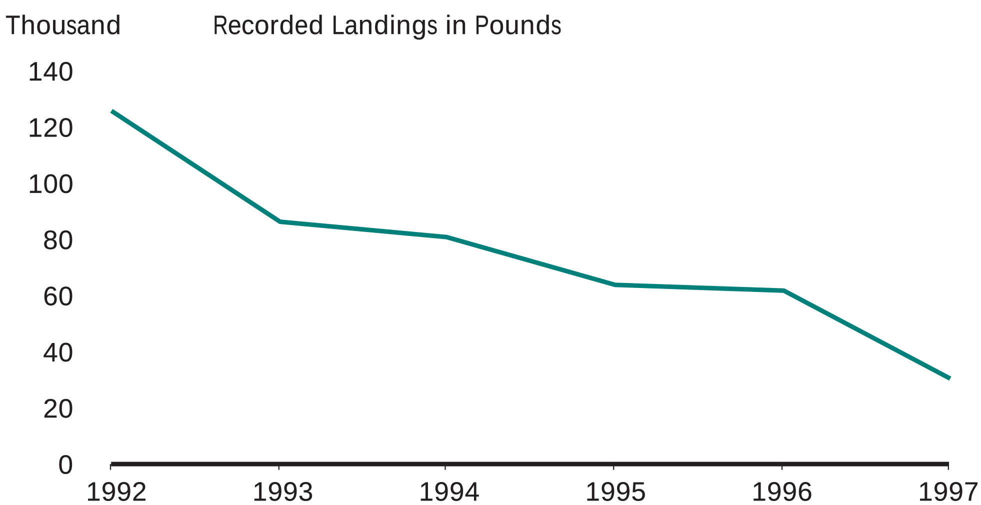
Total recorded fish landings and value in New Hampshire: 1992-1997 (NMFS).



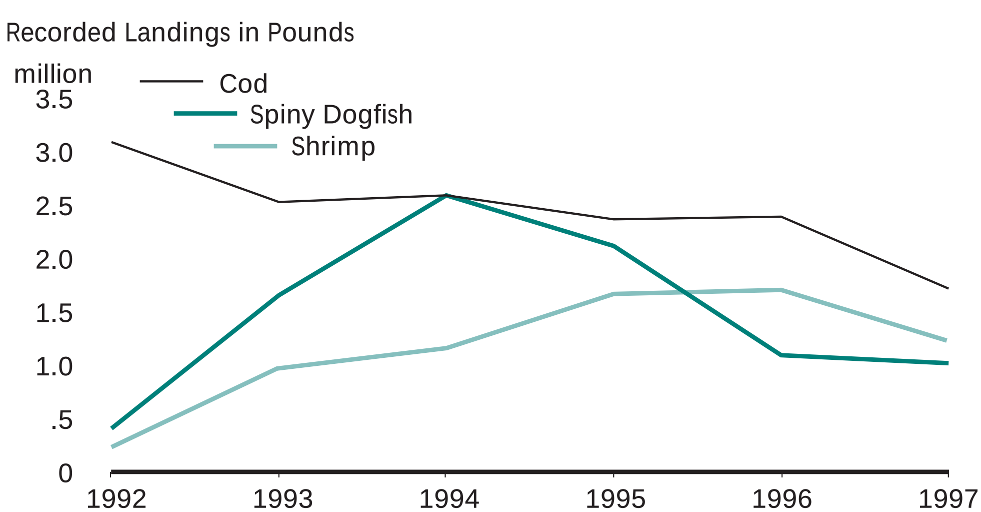
pounds annually from 1992 to 1997. In 1996 a summer oil spill and an October drop in salinity caused by a particularly heavy rainfall event (more than 12 inches of rain in two days in some areas) had negative impacts on lobsters, particularly those in traps at the time of the events. Mortality estimates are not available, but slightly lower lobster catches in 1997 may be partly due to these events.

American lobster

Landings of cod and winter flounder – also important to New Hampshire's commercial fishing fleet – consistently declined from 1992 to 1997. Spiny dogfish, shrimp, sea urchin, and other species have gained importance to the state's fishing industry. Recent catch records may indicate that these species are also succumbing to increased fishing pressure.

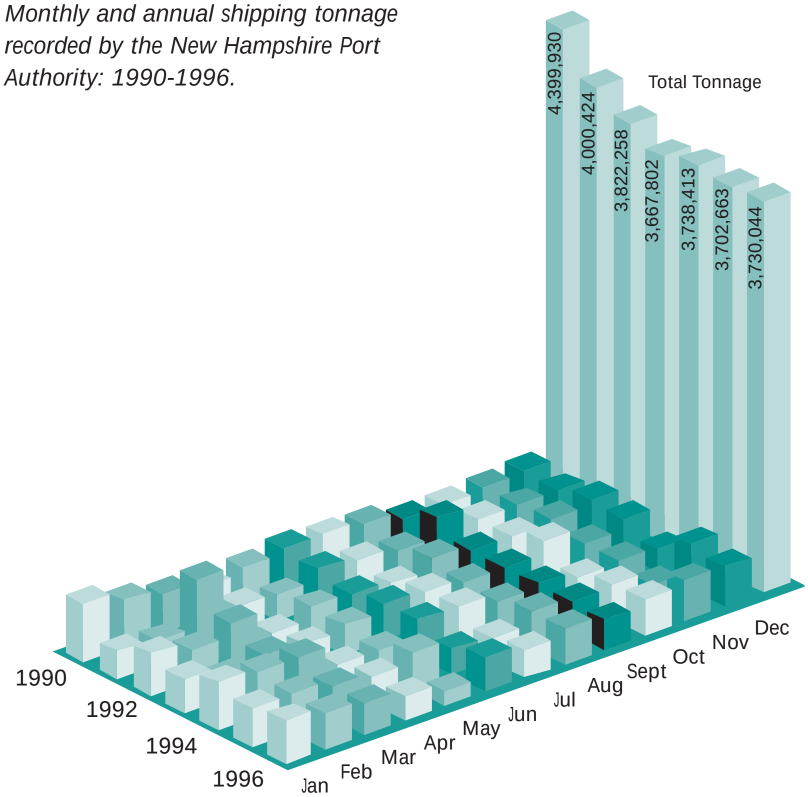


Recorded landings of winter flounder in New Hampshire: 1992-1997 (NMFS).



Recorded landings of cod, spiny dogfish and shrimp in New Hampshire: 1992-1997 (NMFS).

Monthly and annual shipping tonnage recorded by the New Hampshire Port Authority: 1990-1996.



Shipping

The lower Piscataqua River hosts active commercial port facilities in Portsmouth and Newington. From 1949 to 1992 the total annual shipping tonnage moved through Portsmouth and Newington increased from 505,000 to 4,200,000 tons. Oil comprises the largest single portion of the shipping tonnage for any given year, but salt, gasoline, scrap metal, propane, asphalt, cable, and gypsum have also been routinely handled. A slight decrease in total tonnage has moved through the 'Port of New Hampshire' in the 1990s, but recent NH Port Authority expansion projects increase the area's potential to sustain commercial shipping traffic into the future.

The economic value and jobs generated by coastal New Hampshire industries.

Industry	**Value in $**	**Jobs**
commercial fishing	160 million	1065
recreational boating	18 million	55
cargo shipping	12 million	91
boatbuilding and repair	2.1 million	56
water transportation/tourism	1.7 million	14
Total	193 million	1281

Harbor-related activities in New Hampshire.

	Cargo terminal	**Tourism**	**Commercial fishing**	**Boat yards**	**Ferry**	**Recreational boating**	**Other**
River							
Squamscott R.	-	-	x	-	-	x	
Lamprey R.	-	-	x	-	-	x	
Oyster R.	-	-	-	-	-	x	
Cocheco R.	-	x	x	x	-	x	
Harbor/Bay							
Great Bay	-	-	-	-	-	x	
Little Bay	-	-	x	x	-	x	
Portsmouth Harbor	x	x	x	x	x	x	(tugs, barges)
Portsmouth back channels	-	-	x	-	-	x	
Little Harbor	-	x	x	-	-	x	
Hampton Harbor	-	x	x	x	-	x	
Isles of Shoals	-	x	x	-	x	x	

Portsmouth Tugboats

Dredging

Dredging is sometimes required to maintain safe passage and provide adequate anchorages for the volume of recreational and commercial vessel traffic in New Hampshire's estuaries. Since 1950, over 2.9 million cubic yards of dredge materials have been removed from the estuaries. Portsmouth Harbor/Piscataqua River and Hampton-Seabrook Harbor are the most frequently dredged, with over 27 dredge operations each since 1950. Dredge materials have been disposed of in intertidal, near-shore, open water, and upland locations. Some dredged materials from Hampton/Seabrook harbor have been disposed near-shore for beach replenishment.

Over the years, some dredge materials have been chemically analyzed. While most samples showed low to moderate concentrations of metals, DDT, and PCBs, some samples showed elevated concentrations of PCB, vanadium, copper, lead, mercury, and zinc. Most of the sediments with elevated concentrations were associated with the area surrounding the Portsmouth Naval Shipyard.

Aquaculture

In the early 1980s four commercial shellfish aquaculture operations were engaged in the culture of eastern oysters, European flat oysters and hard clams (quahogs) in the Great Bay Estuary. Today only one operation remains on the Maine side of the Piscataqua River. New Hampshire operations were not viable because of the state's noncompliance with federal shellfish resale and commerce regulations, preventing shellfish growers from selling their product.

Estuarine managers across the country are addressing new issues related to the development of the aquaculture industry in coastal waters. With the uncertainties facing the wild fisheries in New Hampshire and the Gulf of Maine, the commercial fishing community and Seacoast economy might benefit from identifying and realizing opportunities for aquaculture.

GBNERR

WHAT DOES THE FUTURE HOLD FOR NEW HAMPSHIRE'S ESTUARIES?

Continued growth and development is projected for New Hampshire's Seacoast region. A strong economy and the attractiveness of Seacoast communities lead to growth pressures that can degrade estuarine water quality, habitat values, and the unique character of the region. Population growth and development will continue to be the greatest threats to the health of the estuaries. The health of the estuaries in turn affects human health and well-being – and the economic, recreational, and cultural opportunities for people in the region and the state.

New Hampshire's Great Bay and coastal estuaries are dynamic, complex systems. Their location and wealth of resources have drawn human activity since pre-Colonial times. The people who live, work, and visit within the watersheds of the estuaries are part of this sensitive ecosystem, and the health and future of these unique resources are in our hands. The beauty, diversity, and productivity of New Hampshire's estuaries make them treasure troves of natural and cultural heritage worth protecting.

Most of the significant threats to New Hampshire's estuarine environment are linked to water quality. Water quality is a critical element for healthy estuaries. Protecting and improving water quality requires both correcting existing problems and preventing future problems. Environmental quality is influenced by a broad and interrelated range of issues and problems. All healthy organisms – including people – and their habitats require clean water. Clean water is fundamental to enjoying the estuary and its abundant living resources, whether as a source of food, of earning a living, or for quality of life and recreation.

S. MIRICK

The mission of the New Hampshire Estuaries Project is to promote, protect, and enhance the environmental quality of the state's estuaries. Continuing growth and development in the region makes realizing this mission more challenging.

Through a careful planning process, NHEP participants have mapped a vision for the estuaries in 2005 and beyond – a future of cleaner water; regional development patterns that protect water quality, maintain open space and important habitat areas, and preserve the beauty and views of the estuaries; more healthy shellfish beds open to recreational harvest; and restoration and enhancement of important habitat areas that have been altered or degraded.

The New Hampshire Estuaries Project Management Plan presents a detailed perspective on this vision, and a plan to make it a reality. Teams of citizens, resource professionals, and state and local officials worked together over three years to develop this new tool for the New Hampshire Seacoast. The *Plan* addresses the dilemmas brought by growth, development, and prosperity in a sensitive estuarine area rich with natural resources.

S. MIRICK

Above and left: Great Bay

Issue	Problem	Isolated Locations within NH estuaries	Throughout NH Estuaries	Impacts
Water/ Sediment Quality Microbial Pathogens/ Fecal Bacteria	Elevated concentrations	Dry weather	Wet weather	Public health risk and shellfish closures
Nutrients	Loading to some rivers	Salmon Falls & Cocheco Rivers	No	Intense blooms (Freshwater), isolated low dissolved oxygen (Salmon Falls River)
Trace metals: Chromium (Cr), Lead (Pb), Mercury (Hg)	Elevated concentrations in sediments	Cr (Great Bay), Hg	Pb	Unknown
Polyaromatic Hydrocarbons (PAHs)	Unknown	Yes	Unknown	Unknown
Polychlorinated Biphenyls (PCB)	PCB residues elevated in lobster tomally	Unknown	Yes	Lobster tomally consumption warning
Suspended Sediments	Unknown	Seasonal occurences	Unknown	
Toxic Algal Blooms	Coastal		Throughout the Gulf of Maine	Shellfish closure (mussels), potential public health risk
Living Resources: Shellfish Oysters	Low oyster population densities, reduced bed area	Great Bay and Tributary Rivers		Loss of critical habitat, ecosystem functions, and economic activity
Soft Shell Clams	Decreasing density		Unknown	Loss of ecosystem function, and economic activity
Blue Mussels	Unknown		Unknown	Unknown
Scallops	Unknown		Unknown	Unknown
Lobsters	Catch stable, some die off			Some dead from oil, more from freshwater
Finfish Striped bass	No			
Winter flounder	Declining population, commercial and recreational catch		Throughout the Gulf of Maine	Loss of important commercial and recreational resource
Smelt	Unknown		Unknown	Unknown
River herring	Unknown		Unknown	Unknown
Shad	Decreasing returns		Unknown	Unknown
Silversides	Unknown		Unknown	Unknown
Infaunal Benthos	No			
Eelgrass		Little Bay, Rye Harbor		
Saltmarshes	Restricted tidal flow and changes in vegetation		Great Bay, Hampton-Seabrook and seacoast areas.	Loss of salt marsh function
Macroalgae	Unknown	Anecdotal reports of increased algae		Unknown

Documented	Trend	Suspected/Documented Causes	Potential Solutions
Yes	Decreasing	Stormwater, Waste water treatment facilities bypasses and malfunctions, possible failing septic systems, and possibly illegal direct discharges of septage	Point source identification, stormwater management, monitoring, local code enforcement and innovative treatment technologies
Yes	SW-Unchanged	Waste water treatment facilities effluent, stormwater runoff	Reduce point source loading, stormwater management
Yes	Decreasing	Historical sources, stormwater, municipal and industrial discharges, and atmospheric deposition	Continued sediment and water quality monitoring
Yes	Down/episodic inc.	Stormwater, vessels, oil spills	Continued sediment and water quality monitoring and spill prevention
Yes	Decreasing	Historical discharges	Unknown
Yes	Decreasing 93-96	Resuspension by wind, waves, tides and ice	Continued sediment and water quality monitoring
—	Unknown	Circulation patterns and toxic algae distribution in the Gulf of Maine	Continued phytoplankton and water quality monitoring
Yes	Decreasing	Sediment accumulation, cultch removal, disease, and poor spatfal	Habitat restoration, disease monitoring, and resource management
No	Decreasing	Sedimentation, predation,disease and possibly harvest pressure	Habitat restoration, resource assessment and management
	Population increasing		None needed
	Unknown		Further research
Yes(oil), No (Freshwater)	Stable	Current management and existing capture methods	Continued management
Yes	Increasing	Good regional and local management	Continued management
Yes	Decreasing	Overharvesting in Gulf of Maine	Improve management and possible stocks enhancement
Yes	No trend, highly variable	Unknown	Continue stocks assessment
Yes	Some rivers up, other down	Unknown	Continue stocks assessment
Yes	Decreasing returns	Possibly overharvest or predation	Continue stocks assessment, and examine stocking program
Yes /No	Insufficient data	Unknown	Consistent stocks assessment
Yes	Stable		Periodic monitoring
Yes	Increasing since 1989	Increased resource protection, recent lack of disease outbreaks, restoration efforts	Continued protection, monitoring, restoration and mitigation
Yes	Increase in restored march acreage	Restoration of tidal flow and reduction in freshwater volume through stormwater management	Continued restoration and stormwater management
No	Possibly increasing	Possible local excess nutrients	Research and monitoring

Issue	Problem	Isolated Locations within NH estuaries	Throughout NH Estuaries	Impacts
Phytoplankton	Late summer blooms during low flow periods	Salmon Falls River		Low dissolved oxygen-Salmon Falls River
Freshwater Wetlands	Loss of wetland acreage (some local gains)		Yes	Loss of wetland habitat and function
Swans	Too many swans		Yes	Displace other species
Other Waterfowl	No			
Shore birds	Unknown			
Eagles	No			
Terns	Limited breeding in NH	Nearshore islands, coastal salt marshes		Lower seabird diversity
Ospreys	No			
Other Issues Shoreline Habitat	Loss of shoreline habitat acreage		In all watersheds	Potential for decreased water quality, loss of habitat function
Upland Habitat	Loss of upland habitat acreage		In all watersheds	Potential for decreased water quality, loss of habitat function
Conservation Lands	Acquisition of land and conservation easements for open space and habitat preservation		In all watersheds	Protection/loss of habitat
Impervious Surfaces	Increased area of impervious surfaces		In all watersheds	Water quality degradation, increased stormwater runoff volume and velocity, loss of habitat
Shipping	Potential for spills and discharges		Yes	Oil spills and ballast water contaminants
Boating	Potential for spills, discharges and habitat disruption		Yes	Illegal waste discharge, habitat destruction, other contaminants (debris, oil&gas)
Commercial fishing Finfish	Declining stocks		Throughout the Gulf of Maine	Tremendous economic impact and ecosystem alterations
Lobsters	Potential gear conflicts			
Anadromous fish	Unknown		In all estuarine rivers	Restoration of spawning habitat and improved access to habitat
Dredging	Resuspention of potentially contaminated sediments	Cocheco River		Re-introduction of historical contaminants to the estuarine environment

Documented	Trend	Suspected/Documented Causes	Potential Solutions
Yes	Unchanged	Phosphorus in waste water treatment plant effluent (low flow periods) and stormwater runoff	Phosphorus removal and stormwater management
Yes/No	Decreasing acreage overall	Acreage decreasing due to road construction and residential and commercial development. Increased beaver population may create new wetland areas, often at expense of surrounding upland properties	Protection, mitigation
Yes	Increasing	Feeding, protection and growing regional population	Stop feeding, possible relocation
Yes	Increasing	Habitat protection, restoration and resource management	Continued protection, monitoring, resource management and habitat restoration
No	Unknown		Research and monitoring
Yes	Variable, possibly increasing seasonal population	Species preservation and habitat protection	Continued preservation, protection and monitoring for environmental risk factors
Yes	Increasing	Breeding colony being re-established	Continued preservation, protection and re-colonization efforts
Yes	New nesting sites	Establishment of nesting platforms	Continued preservation, protection and monitoring for environmental risk factors
Yes/No	Acreage lost is Increasing (rate unclear)	Residential and commercial development, increase in impervious surfaces generating contaminated runoff	Establishment of riparian buffers, local zoning, various land protection and habitat restoration strategies, property owner education
Yes	Increasing	Residential and commercial development, increase in impervious surfaces generating contaminated runoff	Local zoning, various land protection and habitat restoration strategies, property owner education
Yes	Increasing	Growth, development and land use practices reducing habitat values and functions	Continued land purchases and conservation easements on local and regional levels
Yes	Increasing	Residential and commercial development, road construction	Local zoning, various land protection and habitat restoration strategies, property owner education
Yes	No trend	Result from accidents and operator error. Ballast water discharge is a routine function.	Improved accident prevention, oils spill response and potential treatment of ballast discharge
Unknown	Increasing/stable	Lack of facilities, boater ignorance of consequences of their actions	Education, pumpouts
Yes	Decreasing fish stocks	Overharvesting and habitat destruction	Comprehensive management strategies, stocks enhancement, potential for aquaculture
Yes	Stable	Current management and existing capture methods	Continued management
Yes	Increasing	Fish ladders, destruction of spawning habitat, and predation	Continued management, research and restoration activities
Yes/No	Unknown	Contaminant from historical and current sources buried in sediments	Research, continued dredge management

WHAT'S YOUR POLLUTION PREVENTION QUOTIENT?

Many pollutants get into the water from the land. What you do around the home or yard can help make the difference between a clean environment and a dirty one. Check your Pollution Prevention Action Quotient (PPQ) |by answering the following questions.

1 If you have a septic system, have you had the tank pumped within the last three years? (Failed septic systems pose public health and environmental risks.)

2 Is your septic system less than 20 years old? (Older systems are prone to failure and may need replacement.)

3 Do you mulch and reseed exposed areas in your yard as quickly as possible to prevent soil erosion? (Disturbed sites may lose from 30-40 tons or more of soil per acre per year.)

4 Do you test your soil every couple of years to determine how much fertilizer is appropriate for your lawn or garden? (Excess nutrient and chemical additives can get into groundwater or run off into surface waters.)

5 Do you leave lawn clippings on your lawn to recycle the nutrients in them?

6 Does runoff from your roof or driveway drain into places where it can soak into the soil? (Runoff from paved surfaces picks up pollutants and carries them to nearby water bodies. It also increases the likelihood of flooding and degrades stream channels.)

7 Do you use low-flow shower heads, faucets, and low-volume toilets to conserve water and extend the life of leachfields and treatment plants?

8 Do you take leftover hazardous household products like antifreeze, motor oil, and solvents to recycling centers and hazardous waste collection days? (When hazardous household materials go to landfills or incinerators they can cause groundwater contamination and air pollution.)

9 Do you walk, ride a bike, carpool, or take public transportation (when available) as an alternative to driving a vehicle whenever possible? (Cars and trucks contribute significantly to smog, acid rain, and other health and environmental problems.)

10 Do you maintain your vehicle in proper running order to minimize pollution?

11 Does your home's landscape provide wildlife habitat opportunities, and use natural vegetated cover while minimizing impervious surfaces to prevent stormwater run-off and allow for groundwater recharge?

If you answered "yes" to all these questions, you have the PPQ of a genius. Let your friends and neighbors be guided by your great example. If you didn't score so well and would like additional information on pollution prevention, contact the New Hampshire Department of Environmental Services at 271-2975.

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