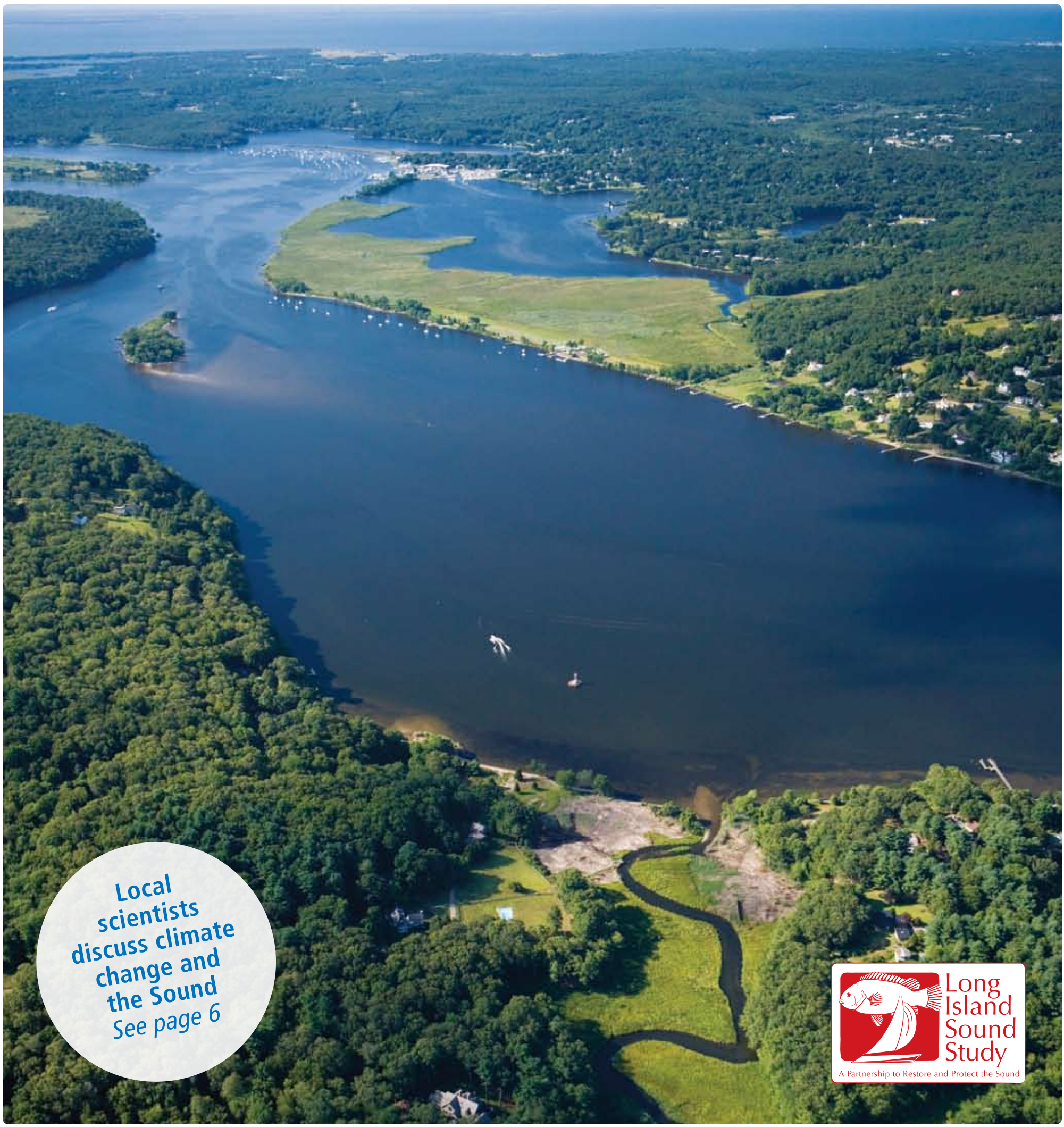
SOUND HEALTH

STATUS AND TRENDS IN THE HEALTH OF LONG ISLAND SOUND {2008}



Local scientists discuss climate change and the Sound
See page 6

Long Island Sound Study
A Partnership to Restore and Protect the Sound

{Introduction}

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Abbreviation Key:

LISS: Long Island Sound Study

EPA: U.S. Environmental Protection Agency

NYSDEC: New York State Department of Environmental Conservation

CT DEP: Connecticut Department of Environmental Protection

UCONN: University of Connecticut

Unsure about a term used in this report? See *www.LIShealth.net* for a definition.

ON THE COVER:
Tidal wetlands and forest cover provide a healthy buffer to the Connecticut River in Old Lyme, CT. Aerial photo by Jerry and Marcy Monkman.

Long Island Sound

I see it as it looked one afternoon
In August,-by a fresh soft breeze o'erblown.
The swiftness of the tide, the light thereon,
A far-off sail, white as a crescent moon.
The shining waters with pale currents strewn,
The quiet fishing-smacks, the Eastern cove,
The semi-circle of its dark, green grove.
The luminous grasses, and the merry sun
In the grave sky; the sparkle far and wide,
Laughter of unseen children, cheerful chirp
Of crickets, and low lisp of rippling tide,
Light summer clouds fantastical as sleep
Changing unnoted while I gazed thereon.
All these fair sounds and sights I made my own.

–Emma Lazarus (1849–1887)

▲ Indicators include trends in the populations of finfish (*p.11*) and coastal birds (*p.12*). A scup (porgy), swims in waters near Mason Island in CT; a piping plover walks on a beach at the David Weld Sanctuary on Long Island (*top right*).

In *"Long Island Sound,"* Emma Lazarus, famous for her poem about freedom and exile that's inscribed on the Statue of Liberty, describes the pleasures of Long Island Sound on a summer afternoon—"shining waters," "luminous grasses," "the laughter of unseen children." More than a century later, Lazarus's Sound is still a place for summer recreation, and can still inspire poetry, in spite of generations of intense human activity on its shores and in its watershed.

Long Island Sound remains true today to Lazarus's experience because the callous indifference to pollution during the early industrial development of the region has been replaced by a commitment to stewardship and protection. The environmental movement resulted in national and state legislation establishing programs to improve water quality, preserve critical habitats, and restore living resources. Today, the Long Island Sound Study brings these efforts together with a focus on improving the health of the ecosystem, while recognizing human habitation as integral to the Sound's character.

The purpose of *Sound Health 2008* is to report on the health of the Sound and its watershed (a separate report, *Protection and Progress*, details the management actions taken to improve the Sound). Environmental indicators are used to characterize the status and trends in the Sound, using data from academic research, agency programs, and other sources. This report highlights trends in pollutant levels, land use and development, water quality, living resources, and sensitive habitat. From this snapshot, *Sound Health 2008* addresses such questions as: Is the water cleaner? Are the fish safe to eat? Is the water safe to swim in? Are fish still abundant?

To answer these questions, *Sound Health 2008* assesses the threats from nutrient enrichment, toxic contaminants, polluted stormwater, and habitat loss using a sample of more than 50 environmental indicators developed by the Long Island Sound Study. *Sound Health 2008* also reports on new challenges, such as climate change and pharmaceutical contaminants, and includes an expanded section illustrating how conditions in the Sound vary by geography.

Emma Lazarus found inspiration in the sounds and sights of Long Island Sound. *Sound Health* is intended to inspire in you a commitment to its continued protection and restoration. •

Listen to the Sound
Look for the headphone icon for links to Long Island Sound reports by naturalist Laurie Sanders, which aired on WFCR-FM/Amherst and Connecticut public radio stations in summer 2007.

What Is LISS?

Authorized by Congress in 1985, the Long Island Sound Study (LISS) is a collaborative effort to restore and protect the Sound. Sponsored by the U.S. Environmental Protection Agency (EPA) and the states of Connecticut and New York, partners include federal, state, interstate, and local government agencies, industries, universities, and community groups. LISS partners work together to implement a Comprehensive Conservation and Management Plan to maintain the health of the ecosystem, restore coastal habitats, and increase public awareness of the Sound. The environmental concerns affecting the Sound cross political boundaries; by working together LISS partners can share ideas, coordinate actions, and leverage scarce financial resources to protect an entire ecosystem.

For more information about the Long Island Sound Study visit: *www.longislandsoundstudy.net/about_liss.htm.*

CREDITS: *Scup,* photo by Robert DeGoursey, UConn; *Piping Plover,* photo by George DeCamp

{Hypoxia}

◄ CT DEP staff deploy a rosette, a water sampling device, aboard the research vessel *John Dempsey.*

In 2007, the area of depleted oxygen was about four times the size of Manhattan

Imagine if the air around you had only a scarce amount of oxygen. Now, consider what fish and other wildlife in the Sound face every summer when dissolved oxygen levels drop to low levels.

The condition, known as hypoxia, occurs in the Sound every summer when dissolved oxygen levels in bottom waters fall below 3 mg/L. Hypoxia forces some fish and invertebrates to scatter, while making others more susceptible to disease. When concentrations fall below 2 mg/L conditions become suffocating; marine life unable to flee may die.

Since 1987, LISS has tracked the area and duration of hypoxia. In 2007, hypoxia lasted 58 days, and at its peak affected 162 square miles—about four times the size of Manhattan. While the area has been below the 20-year average for the last eight out of 10 years, it still remains a concern. Meanwhile, the duration of hypoxia has been above average for six out of the past 10 years.

www.LIShealth.net/pods to hear an interview with the CT DEP's Water Quality monitoring crew.

Natural factors help trigger hypoxia. As temperatures rise in the summer, the surface water heats ups and forms a distinct layer over the bottom water, which is denser due to higher salinity and cooler temperatures. This "density gradient" can restrict oxygen-rich surface waters from mixing with bottom waters, and the waters can remain hypoxic until wave and wind action, sometimes from a storm, mix the layers.

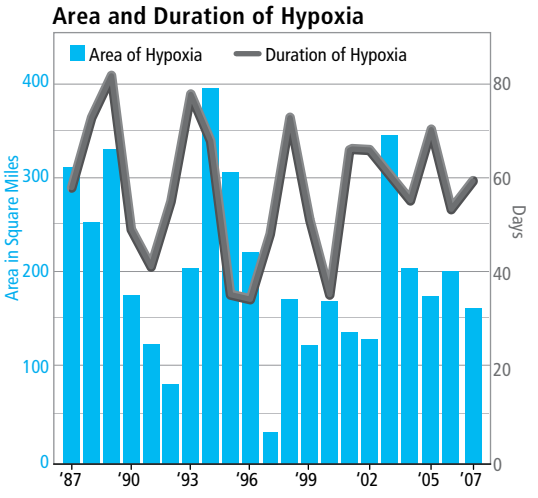
Humans also have contributed to hypoxia by adding excessive levels of nitrogen into the Sound. In a process called eutrophication, nitrogen acts as a fertilizer, fueling the growth of phytoplankton (microscopic plants sometimes called planktonic algae) in surface waters. The organic matter from the algae, and the waste from animals feeding on it, sinks to the bottom and is consumed by bacteria in a process that uses up oxygen. While nitrogen occurs naturally, human activities have increased the amount discharged into the Sound by 400 percent. Population increases in the watershed, for example, have resulted in more than 150,000 pounds of nitrogen being discharged daily from wastewater treatment plants, which is about 40 percent of the total nitrogen that makes its way into the Sound. Other sources include septic systems, deposition from air emissions from power plants and motor vehicle exhausts, and fertilizer and animal waste. •

Coastal Waters Face Hypoxic "Dead Zones"

Hypoxia is not just a Long Island Sound problem. Waterbodies on both coasts and the Gulf of Mexico also suffer from low-oxygenated waters. For example, the Gulf of Mexico's "dead zone" off the coast of Texas and Louisiana has covered more than 8,000 square miles, about the size of Connecticut and Delaware combined. Chesapeake Bay has hypoxic waters that can extend hundreds of square miles each summer. In both of these cases, agricultural runoff of fertilizer and animal waste is the largest source of the nitrogen that helps trigger hypoxia.

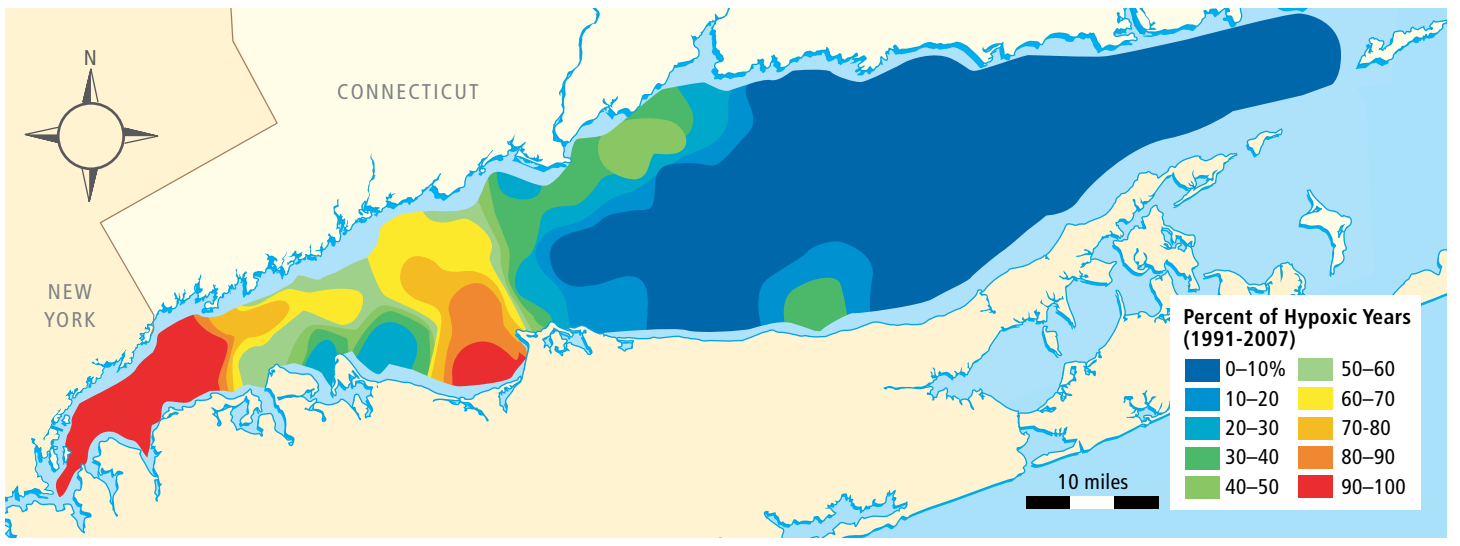
In recent years, several national and international environmental commissions, including the U.S. Commission on Ocean Policy and the United Nations Environmental Programme, have affirmed that eutrophication and hypoxia are among the most significant problems facing coastal waters.

THE DATA



▲ The maximum area of hypoxia has been below the average of 201 square miles for 8 out of the last 10 years, but the duration has been above the average of 57 days for 6 out of the last 10 years.

THE FREQUENCY OF HYPOXIA IN LONG ISLAND SOUND BOTTOM WATERS



◄ Hypoxic conditions occurred most frequently in the western Sound (areas in red and orange). In extreme hypoxic conditions, some organisms may suffocate and die, while others flee.

CREDITS: *Water Quality Monitoring,* photo by Lloyd Langevin; *Hypoxia* map, by Lucy Reading-Ikkanda/ CT DEP
SOURCES: *Area and Duration of Hypoxia* chart, CT DEP

WATER QUALITY

{Toxic Contaminants}

◄ Workers finishing hats in the early 20th century at a factory in Danbury, CT, once the hatmaking capital of the world. Many workers were poisoned by long-time exposure to mercury used in the felting process.

The discharge of chemicals into the Sound and its tributaries has often been associated with manufacturing processes. During the industrial revolution heavy metals started to accumulate in the sediments of the Sound. Concentrations of mercury off Norwalk Harbor, for example, increased by more than 1,300 percent from 1820 to 1955.

But with the advent of environmental regulation, product bans, and a decline in manufacturing, concentrations of many contaminants in sediments began to decline in the mid-20th century. Sediment concentrations of mercury, for example, have dropped by more than a third, and copper and zinc have declined as well. Since 1988, toxic chemical discharges directly into the Sound and its tributaries have decreased by 93 percent and airborne discharges throughout the entire watershed have decreased by 88 percent, according to the EPA's Toxics Release Inventory (TRI) database.

Concentrations of contaminants have also decreased in some fish and wildlife in the Sound. According to a preliminary finding from a LISS-funded study, PCBs have been declining in striped bass and bluefish since the 1980s. PCBs and DDT also have been declining in blue mussels at several sites monitored by the National Oceanic and Atmospheric Administration. And osprey, a bird of prey once threatened to extinction, is making a recovery thanks to reduced levels of DDT (see p. 12).

Toxic contaminants continue to decline, but what remains poses a threat to wildlife and humans

But manufacturing is not the only source of toxic chemicals; other sources include household cleaning products, automobile exhausts, and emissions from fossil fuel power plants. Many pesticide products continue to be applied at farms, homes, and gardens. Even reduced levels of contaminants can impair aquatic life and pose a risk to human health.

For example, airborne deposits from power plant and incinerator emissions, often from different sources, are a continuing source of mercury to the Sound. The mercury can become attached to fine particles of sediment in the water. The contaminated sediments eventually settle to the sea floor, mostly in areas of weak currents in the western Sound, where they are less likely to be flushed out. Under certain environmental conditions, mercury can be resuspended into the water column and turn into a highly toxic form of mercury that can be ingested by small aquatic life. As contaminants cycle up the food chain, shellfish and fish, and eventually humans, can accumulate the mercury at higher concentrations. To inform the public of the potential risks of eating fish, state health departments issue fish consumption advisories (see p. 10).

Scientists also are concerned about the possible effects of chemicals used in pharmaceuticals, perfumes, and other products that are entering the aquatic environment. The effect these chemicals are having on aquatic life remains unknown, and more research is needed. •

Emerging Contaminants

Are male fish developing female characteristics in Long Island Sound?

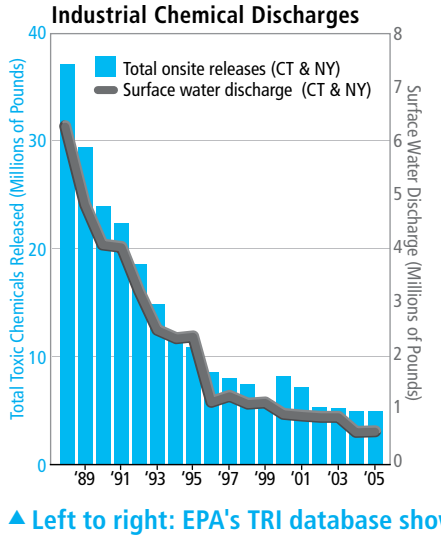
The answer may be yes, according to research done by Professor Anne McElroy of Stony Brook University. McElroy and a graduate assistant are finding evidence of high levels of endocrine disrupting chemicals in male silversides (a small baitfish) in Long Island Sound and winter flounder in Jamaica Bay. The chemicals, the female hormone estrogen, a synthetic form of estrogen found in birth control pills, and nonylphenol ethoxylates (NPEs), which mimic estrogen, are causing eggs to form in testicular tissue, decreasing sperm counts, and disrupting development and growth.

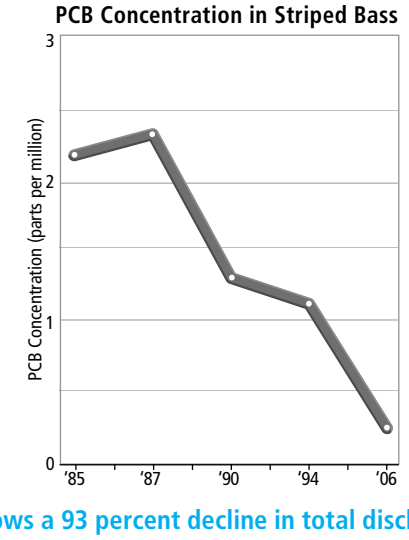
NPEs have many uses, including as a cleaning agent for laundry detergent. Products with NPEs are used in homes and industries. Since NPEs and natural and synthetic estrogen cannot be removed or broken down at wastewater treatment plants, these compounds are discharged into the environment.

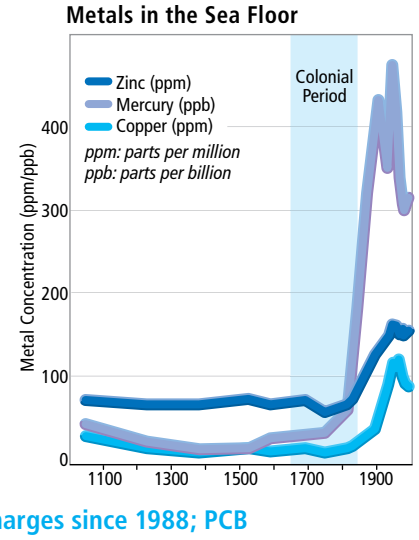
◄ Winter flounder

McElroy's study on the effects of estrogen and NPEs in the Sound and Jamaica Bay is part of a growing body of research by scientists that is looking at how natural hormones, pharmaceutical drugs, and chemicals used in industrial products can disrupt endocrine function in aquatic life. There is not enough information yet to conclude that estrogen and NPEs contribute to declining fish stocks in the Sound and Jamaica Bay.

THE DATA







▲ Left to right: EPA's TRI database shows a 93 percent decline in total discharges since 1988; PCB concentrations in striped bass from the Sound declined from about 2.5 parts per million to less than 0.5 parts per million; levels of heavy metals from sediments in Norwalk Harbor have declined in recent decades.

CREDITS: *Danbury Hat Factory* photo, courtesy of MemoryLane.com **SOURCES:** *Industrial Chemical Discharges* chart, EPA 2005 Toxics Release Inventory; *PCB Concentration* chart, NYSDEC; *Metal in the Sea Floor (concentrations taken off Norwalk Harbor)* chart, Johan C. Varekamp and Ellen Thomas—Dept. of Earth & Environmental Sciences, Wesleyan University, Middletown CT—and Marilyn R. Buchholtz ten Brink and Ellen L.Mecray, U.S. Geological Survey, Coastal and Marine Geology Program, Woods Hole Field Center, Woods Hole, MA)

Stormwater runoff can lead to contaminated shellfish beds and beaches

{Pathogens}

▲ A closed shellfish area in Jordan Cove in Waterford, CT.

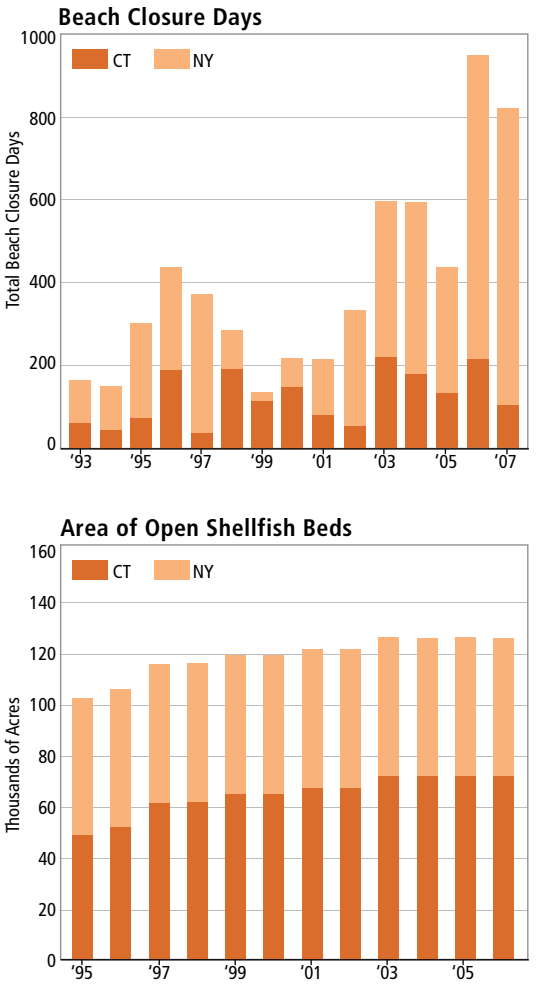
For many, the most obvious sign of poor water quality occurs when a "no swimming" or "no shellfishing" sign gets posted because of potential pathogen contamination.

Pathogens are disease-causing bacteria and viruses that enter the Sound from inadequately treated human sewage and domestic and wild animal wastes. Sources of pathogens include stormwater runoff carrying animal waste from paved surfaces and lawns, and human waste from improperly maintained septic systems. Some older communities also still use an early generation of sewer system that collects stormwater runoff and sanitary sewage into the same pipe. During dry weather, these combined sewer systems transport wastewater to the sewage treatment plant. During rainfall, if the combined wastewater volume exceeds the capacity of the plant, the system overflows and excess wastewater is discharged directly without adequate treatment. Other sources of pathogens can be leaking sewage pipes, illegal connections that bring sanitary waste to storm sewers, sewage treatment equipment failure, and discharge of sewage from boats.

Generally, the Sound's 203 beaches are safe for swimming. To avoid illnesses caused by pathogens, health departments will close beaches when monitoring data indicate contamination or "preemptively" after a rainstorm at sites known to be susceptible to contamination. Most of the closings happen in the western Sound, where many beaches are downstream from densely populated areas that have more potential sources of pollution. Many of these beaches also are located in narrow, protected harbors, where there is less mixing action with cleaner waters from the open Sound.

Shellfish beds are also regularly monitored to assure that shellfish harvested in commercial and recreationally approved areas are safe to eat. From 1995 to 2006, the area certified for shellfishing increased by 22 percent to 127,200 acres. But resource managers are concerned that pathogen contamination may impede the progress in opening new shellfish areas, prompting temporary closures of existing areas. •

THE DATA



▲ Closures increase in years with frequent rainstorms during the beach season (*top*). Shellfish acreage increased by thousands of acres, but has leveled off in the last few years (*bottom*).

Tale of Two Beaches

Hudson Park Beach and Glen Island Beach lie only two miles apart from each other in the shoreline city of New Rochelle, New York. While Hudson Park Beach has been closed 166 days from 2003 to 2007 to protect the public from potential pathogen contamination, Glen Island Beach never was closed.

A closer look at their locations reveals the reason why. Hudson Park Beach receives water from inland fresh water sources, including the Pine Brook River, Premium River, Stevenson Creek, and the Pelham Road storm drain. Like a lot of communities in densely populated areas, polluted stormwater runs off from paved surfaces, such as roads and parking lots, into tributaries, including those flowing to Hudson Park Beach. Glen Island Beach, however, has no inland freshwater source, only the cleaner waters from the Sound.

Westchester County and New Rochelle are currently tracing the sources of the pollution so that they can work with the polluters to correct the problems. The Health Department's tools include traceback methods such as dye testing to locate the original source of pollution in drainage pipes. The goal is to correct the problem to reduce the number of beach closure days.

"That's the whole idea," said Gabe Sganga, beach program director at the Westchester County Health Department. "We try to find a smoking gun. Instead, we find a little problem here and a little problem there and it adds up. The more we look the more we will find."

▼ Hudson Park Beach receives water from freshwater inland sources as well as the Sound.

CREDITS: *Jordan Cove*, photo by Kara Bonsack/UConn; *Hudson Park Beach*, photo by Ixtayul
SOURCES: *Beach Closures* chart, CT DEP and NYSDEC; *Open Shellfish Beds* chart, CT Dept. of Agriculture's Aquaculture Division and NYSDEC

{Climate Change}

Climate change is often seen as a national and international concern, but it is very much a local issue as well. Temperatures are rising in Long Island Sound, and those increases already have resulted in changes to the Sound. What are these changes? LISS asked area scientists to assess the impact of climate change in the Sound, and what the Sound might experience in the future.

Overview

Cynthia Rosenzweig, PhD

Cynthia Rosenzweig is a research scientist at the NASA Goddard Institute for Space Studies (GISS) and Columbia University. She currently leads the Climate Impacts Research Group at GISS, with which she has been affiliated since 1984.

What have been the water temperature and sea level rise trends over the past 100 years, and what is projected in the next 25, 50, and 100 years?

Between 1979 and 2002, sea surface temperature at two locations in the eastern Long Island Sound has been observed to increase by approximately 1°C (1.8° F). This warming affects marine ecosystems, from plankton up to lobsters. Over the past century, sea levels have been rising in the New York Metropolitan region by about an inch per decade. Recent research based on global climate models suggests a possible range of regional sea level rise of 2.5 to 7 inches in the next 25 years, 6 to 15 inches in the next 50 years, and 1 to 3 feet in the next 100 years. These projections are uncertain, however, in part because climate models cannot currently tell us how ice sheets may respond to increasing temperatures. If melting of ice sheets accelerates, sea level rise will likely be higher.

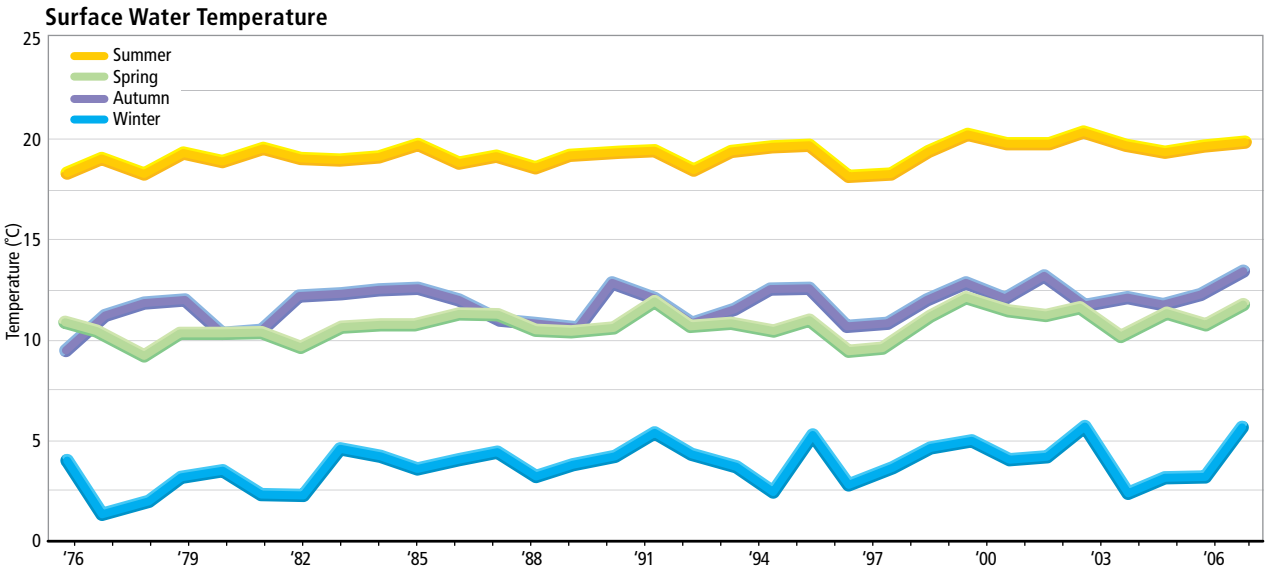
How does an increase in temperature affect sea level rise?

Increasing ocean temperatures cause ocean water to expand, leading to higher sea levels. Increasing air temperatures can cause sea level to rise, either indirectly by causing ocean warming or directly by melting land ice that then flows to the sea. The situation is made even more complex by the role of atmospheric temperature change in modifying the balance of precipitation and evaporation over land and ocean.

What are the implications of continued sea level rise in Long Island Sound, and what do we need to do to adapt if this trend continues?

Rising seas in Long Island Sound may increase the intensity, duration, and frequency of high water levels associated with coastal storm flooding. Coastal flooding threatens natural ecosystems as well as commercial, civil, and residential infrastructure and assets. Flooding can also cause groundwater pollution. A range of possible adaptation measures should be considered, including building seawalls, restoring wetlands to act as natural buffers, and modifying coastal development policies.

Over the past century, sea levels have been rising by about an inch per decade



▲ Yearly seasonal temperatures as measured at Millstone Power Station in New London, CT. On average, temperatures have increased over the past 30 years.

▲ From top to bottom: Lobsters are facing difficulties tolerating warmer temperatures; beach erosion, such as shown at Hammonasset Beach in Madison, CT, is already a problem, but can worsen if sea levels continue to rise; coastal storm flooding, as experienced in Guilford, CT as a consequence of a 2007 nor'easter, may increase in intensity as a result of rising seas.

CREDITS: *Lobster off Noank*, photo by Robert deGoursey/UConn; *Beach Erosion at Hammonasset Beach,* photo by Matthew Bristol; *Nor'easter at Guilford Harbor,* photo by Sidney Gale.

SOURCES: *Overview*: NASA GISS and Columbia University, Center for Climate Systems Research; "Effects of Thermal Input and Climate Change on Growth of *Ascophyllum nodosum* (Fucales, Phaeophyceae) in Eastern Long Island Sound. Milan Keser, John T. Swenarton and James F. Foertch, Millstone Environmental Laboratory, Dominion Nuclear Connecticut, Inc., Waterford, CT (2005); *Surface Water Temperature* chart, Millstone Environmental Laboratory

Fisheries

David Conover, PhD
David Conover is Dean of the School of Marine and Atmospheric Sciences, Stony Brook University.

Increased carbon dioxide in the atmosphere leads to an increase in carbonic acid in the ocean, making oceans more acidic. Why is this a concern?

Most of our knowledge of the direct effects of ocean acidification on marine organisms focuses on species known as "marine calcifiers" (e.g., corals, mollusks) that build skeletons or shells made of calcium carbonate. Many of these species will suffer from an impaired ability to build skeletons as too much carbon dioxide produces carbonic acid, which corrodes shells. We know less about the direct impacts of acidification on harvested species like fishes and squids. In these species, the response to acidification is likely to involve physiological diseases including acidosis of tissue and body fluids leading to impaired metabolic function. Egg and larval stages are likely to be much more susceptible than adults, suggesting that reduced reproductive success will be among the first symptoms to appear.

Some fish species will not be able to adapt to lower oxygen levels caused by warmer temperatures

Why is "ocean warming" a concern?

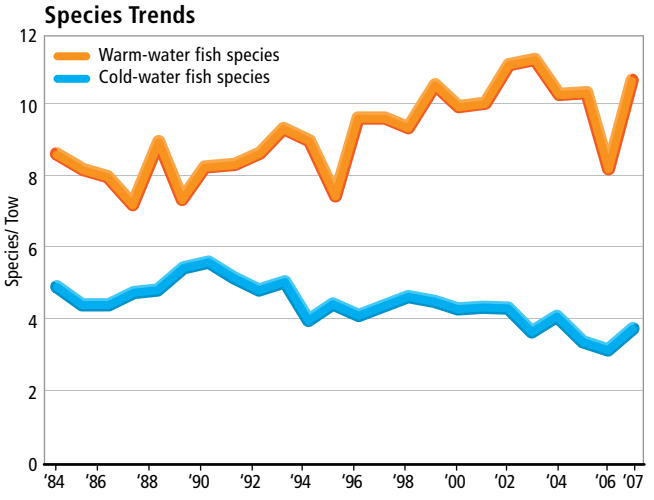
All species are adapted for life over a relatively moderate range of temperatures compared with the extremes experienced from the poles to the tropics. Temperatures below the optimal range slow the rate of metabolism and can become lethal if too low. Temperatures above the optimal range increase metabolism and, because warmer water contains less dissolved oxygen, a thermal threshold is reached where respiratory demand exceeds the capacity for oxygen uptake. This is sometimes referred to as the "temperature oxygen squeeze." Hence, temperature is one of the primary environmental factors that determine the geographic range of a species.

What is the impact to Long Island Sound?

Most of the cold-water species of Long Island Sound have been declining over the past 15 years (e.g., lobster, winter flounder, Atlantic herring, cunner, longhorn sculpin, sea raven, ocean pout, winter skate, and little skate), while most of the warm-water fishes have been increasing (e.g., striped bass, weakfish, summer flounder, menhaden, scup, striped sea robin, butterfish, Atlantic moonfish, hickory shad). Finally, there is also evidence from Long Island Sound that the recent trend of warmer winters favors the growth and recruitment of invasive species over those of native species. Researchers from the University of Connecticut showed that exotic ascidian species (sea squirts) benefit more from mild winters, while native species benefit more from cold winters.

What preventive measures should be taken?

Resource managers need to recognize that local populations of species near the limits of their distributional ranges will need additional precautionary measures to protect them from extinction. Warming and acidification represent additional stresses that make populations less resilient to the effects of harvest. We may need to reduce harvest of some species in certain areas to enable them to withstand the additional stress. The ultimate and best solution is the reduction of greenhouse gases that cause acidification and warming.



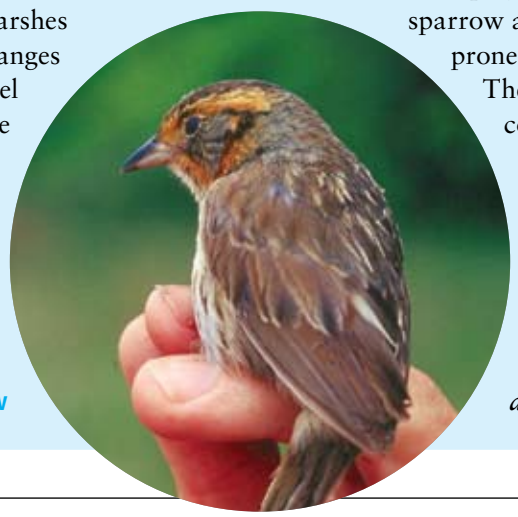
▲ Fish are dependent on suitable water temperatures for their metabolism to survive. In recent years, warm–water species have increased in Long Island Sound, while cold–water species have declined.

Wildlife & Habitats

Chris Elphick, PhD
Chris Elphick is a conservation biologist at the Department of Ecology & Evolutionary Biology, University of Connecticut.

How can sea level rise affect the population of the saltmarsh sharp-tailed sparrow and the seaside sparrow?

The main cause of nest failure in saltmarsh sharp-tailed sparrow is nest flooding, so rises in sea-level are expected to increase the rate at which nests are lost unless marsh elevations increase or marshes are able to move inland. Neither of these marsh changes seems likely to happen fast enough to match sea-level rise, although our research on the likely speed of the population changes is not complete. Both species are also specialists in salt marsh habitats, and the loss of these habitats due to sea-level rise will reduce the area of habitat available. This change is likely to affect both species, but especially seaside sparrows, which only occur in a few large marshes in Connecticut.



▶ Saltmarsh sharp-tailed sparrow

What will be the effect of continued warming on the diversity of wildlife that live along the Sound's shoreline?

This question is difficult to answer. Some southern species might become more common. For example, boat-tailed grackle and black skimmers have both colonized the state in recent years and seem to be increasing. But, several species for which the state plays an important conservation role—such as saltmarsh sharp-tailed sparrow and piping plover—are likely to suffer as their habitats become prone to increased flooding and birds are confined to smaller areas. The biggest problem is that climate change and sea-level rise will come on top of the existing effects of habitat loss along the shore. Consequently, species that are already in a precarious state will have to deal with an additional set of problems. Ultimately, large-scale land use planning and better long-term monitoring of the state's biological diversity are the best ways to address all of these issues.

More on Climate Change: Biologists Ron Rozsa and Juliana Barrett discuss the impact of climate change on tidal wetlands at: www.LISHealth.net.

www.LIShealth.net/pods to hear an interview with Elphick about climate change's impact on the sharp-tailed and seaside sparrows.

SOURCES: *Fisheries*: Edited and condensed from Conover's testimony, May 10, 2007, at a U.S. Senate subcommittee hearing on "Effects of Climate Change and Ocean Acidification on Living Marine Resources; Pörtner, H.O., Knust R. (2007), Science 315, 95 – 97; Stachowicz, J.J., J. R. Terwin, R.B. Whitlatch, and R.W. Osman (2002), Proc. Natl. Acad. Sci. 99:15497-15500; *Species Trends* chart, CT DEP

{Conditions by Basin}

Describing the condition of a water body 110 miles long poses a challenge. Hydrology (the movement of water) and sediment characteristics vary within each of the Sound's subbasins, as does the degree of shoreline development. Water quality in any location varies by season. And in some locations, historical contaminant discharges still affect present-day conditions. In other words, the Sound can be described as healthy and vibrant, or distressed and impaired, depending on location, season, and issue.

But recent work by the EPA's Office of Research and Development to characterize water quality, the toxicity of sediments on the sea floor, and the variety of species living in or on the seafloor (benthic community) offers an approach to quantitatively characterizing conditions geographically in Long Island Sound. Using an index of different indicators for each of these measures, the Sound's western, central, and eastern basins can be rated as good, fair, or poor.

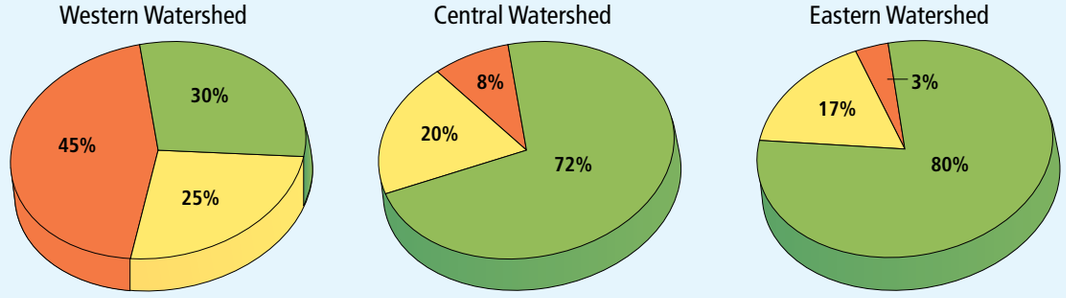
The Western Basin is the Most Stressed

As expected, the densely populated and developed western basin, which includes "the Narrows," a narrow section leading to the East River, is the most stressed, with fair water quality the majority of the time, sediment conditions rated as poor almost half the time, and a benthic community rated as poor 41 percent of the time. Water quality improves in the central basin, and improves to good most of the time in the eastern basin. Sediment and benthic conditions also improve in the central and eastern basins, although sediment conditions are not quite as good in the eastern basin compared to the central basin.

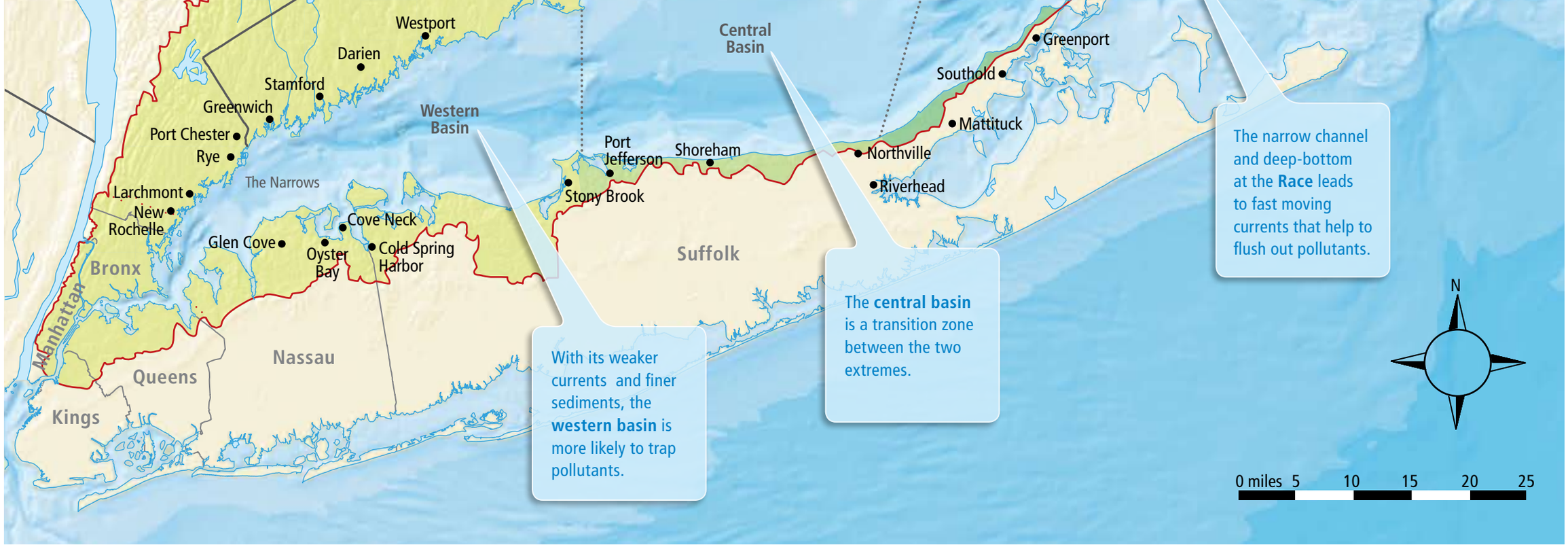
The gradient in improving conditions from west to east reflects the decrease in human population density among basins. In the watershed drainage to the western basin, 45 percent of the subwatersheds are developed at levels that correlate to poor local water quality. This decreases to eight percent of the subwatersheds draining to the central basin, and three percent in the eastern basin.

The gradient in improving conditions also reflects geological differences. For example, the eastern basin, carved out from a melted glacier, is deep, dipping to 350 feet at the Race. The narrow channel opening to Block Island Sound acts as a funnel, leading to fast moving currents that scour the bottom and actively mix the water. The western basin is shallower, generally less than 60 feet deep, with a sea bottom of fine sand and mud. Currents are weaker, and in the summer months there is little mixing between the lighter, oxygenated surface waters and the denser bottom layer. In combination with high nitrogen loads and phytoplankton production, reduced mixing leads to hypoxia in the western basin. The weak currents in the western Sound also make for conditions that are less likely to flush out toxic contaminants that settle in the fine sand. •

Watershed Indicator ▶ Research from around the country shows that stream health tends to be good when the impervious coverage of the contributing watershed is below 10%. Impacts start to become evident once imperviousness exceeds 10%, and can become severe at watershed levels greater than 25%. These charts show the percentage of subregional watersheds in each of the three major LIS basins that fall into these three categories. As can be seen, the number of subregional watersheds with less than 10% imperviousness (indicating good water quality) increases from west to east.

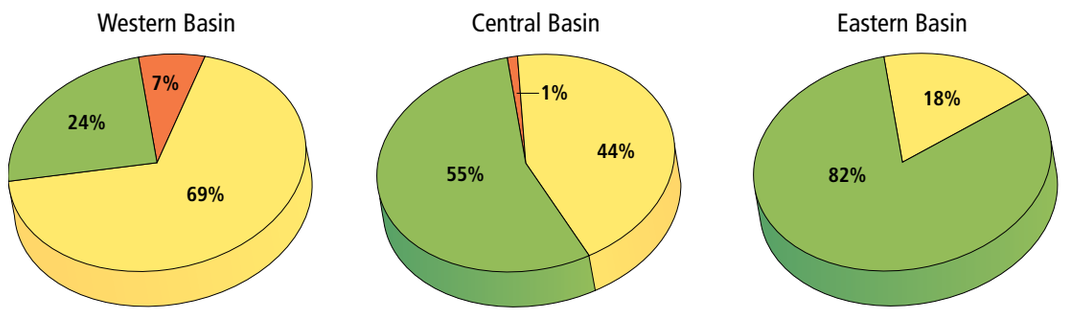


CREDITS: *Map*, by Mapping Specialists and Lucy Reading-Ikkanda

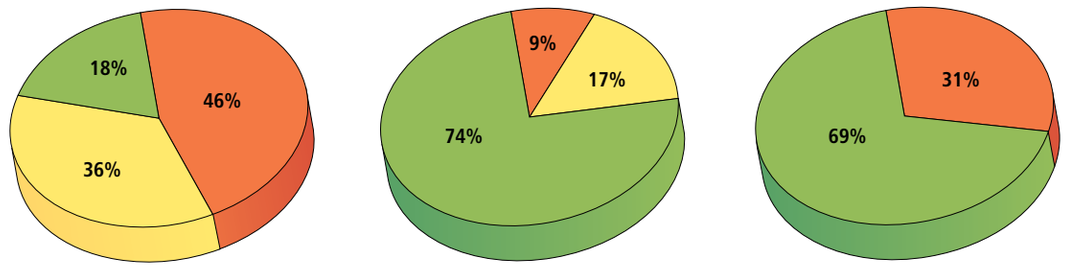


Summary of Rating Criteria:

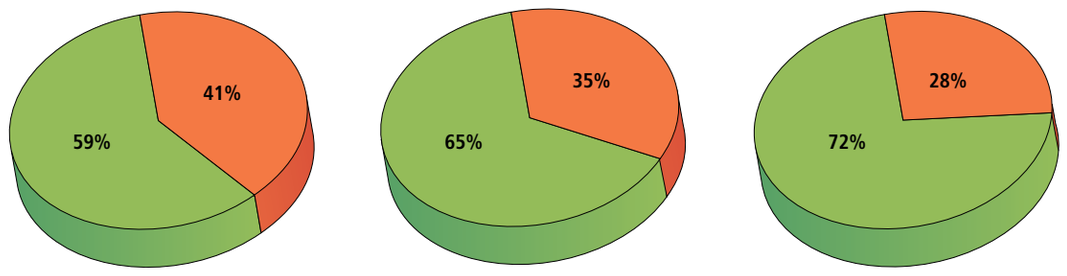
Water Quality Index ▶ Excess nutrients, such as nitrogen, can lead to too much plant production (indicated by abundance of chlorophyll a, a plant pigment), which can decrease water clarity and lower concentrations of dissolved oxygen. The index includes five water quality component indicators—dissolved inorganic nitrogen, dissolved inorganic phosphorus, chlorophyll a, water clarity, and dissolved oxygen. Monthly data (from May to October, when pollution has the greatest effect on water quality) were summarized Sound-wide from 1991 to 2007.



Sediment Quality Index ▶ A wide variety of metals and organic substances, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides are discharged into estuaries from urban, agricultural, and industrial sources from the Sound's watershed. These contaminants adsorb onto suspended particles and eventually accumulate in the sediments where they can disrupt the benthic community. The index is based on three sediment quality component indicators—sediment toxicity by measuring the survival of a marine amphipod, the concentration of sediment contaminants, and the total organic carbon in the sediment. Data were collected from 2000-2004 (excluding 2002).



Benthic Quality Index ▶ The worms , clams, and crustaceans that inhabit the sea floor of estuaries are collectively called benthic macroinvertebrates, or benthos. Benthos are often used as indicators of disturbances in estuarine environments because they are not very mobile; as a result, they cannot avoid environmental problems. The index indicates the condition of the benthic community by a measure of benthic community diversity and the presence and abundance of pollution-tolerant species. Data were collected from 2000-2004 (excluding 2002).



Coastal Condition Report

The information used for Conditions by Basin was originally collected by CT DEP and Stony Brook University for the EPA's National Estuary Program Coastal Condition Report. The EPA uses monitoring data from 28 National Estuary Programs such as the Long Island Sound Study to track conditions across coastal regions around the country.

Estuaries are transition zones between the fresh water from rivers and the saline conditions of the oceans. The nation's estuaries are a subset of U.S. coastal waters and encompass a wide variety of coastal habitats, including wetlands, salt marshes, coral reefs, mangroves and kelp forests, seagrass meadows, tidal mudflats, and upwelling areas. These habitats produce unique environments that support wildlife and fisheries and contribute substantially to the U.S. economy.

SOURCES: *Watershed Indicator*, UCONN Center for Land Use Education and Research; *Conditions by Basins Indices*, EPA's Office of Research and Development/Office of Water

LIVING RESOURCES

{Shellfish}

◄ A crew transfers bushels of oysters harvested from spawning areas in the Housatonic River to a boat that will take them to their open water growing beds in Long Island Sound.

The oyster harvest shows signs of recovery, but lobster stocks are still low

Oysters, lobsters, and clams are a culinary delight for many, and important resources for the Sound's fishermen. One species is on the verge of recovery, one is in decline, and one is doing well. Together, they provide a snapshot of the diverging fortunes of the Sound's fishery.

Oysters are making the comeback. In the 1990s, two parasitic diseases, MSX and Dermo, decimated the Sound's oyster population. In 1992, the oyster harvest reached a peak value of $48 million. In 2007, it was $7.4 million. But aggressive efforts to raise disease-resistant oysters in New York and Connecticut have helped to reverse the collapse, first in Oyster Bay, where up to 90 percent of New York's oyster harvest is produced, and more recently along oyster beds in Connecticut. In 2006, the oyster harvest Soundwide increased by 70 percent, and a year later increased by another 93 percent from 2006. The value of the harvest increased from $4.4 million in 2006 to $7.4 million in 2007, but is still well below the peak harvest year of $48 million in 1992. Resource managers expect the increase to continue as disease resistant seed oysters grow to harvestable size.

Lobsters also faced a severe setback in the 1990s, but, unlike oysters, have not shown signs of recovery. Scientists found evidence that lobsters, at an all-time high abundance in the 1990s, with a peak harvest value of almost $40 million in 1997, were suddenly subjected to sustained, stressful environmental conditions, including above average water temperatures. Weakened by these conditions, lobsters became susceptible to disease—including infection by parasitic amoebae—and experienced a massive die-off. In an effort to restore the population, Connecticut and New York have toughened limits on harvesting of lobsters.

Clam harvests have steadily increased in Connecticut, reflecting both an increase in clams and in clammers harvesting them, while in New York harvests have increased slightly. In 2007, more than 600,000 bushels of clams were harvested Soundwide, a 282 percent increase from 1995, with an all-time high value of $31 million.

While important to humans, shellfish are also important to the ecosystem. As filter-feeders, each oyster and clam can filter up to 50 gallons of water a day, while straining food particles such as phytoplankton from the water column. In the process, they help to improve water quality by removing pollutants, such as excess nitrogen. Lobsters provide food for many fish, and in turn prey on crabs, snails, bivalves, polychaetes, small fish, kelp, and algae. They're also well-known scavengers, seeking out and eating dead organisms on the sea floor. •

LIS Fish Consumption Advisories

These advisories refer to fish, crabs, and lobsters that people catch, not to fish bought in stores. Due to the possibility that ingested fish will have elevated concentrations of contaminants, the New York and Connecticut health departments have issued consumption advisories for the following marine organisms:

► Marine Bluefish and Eels

NY: Eat no more than one meal per week of bluefish or eels. (PCB contamination).
CT: Bluefish 13-25"—Eat no more than one meal per month. Bluefish over 25"—Eat no more than one meal per two months; high risk group (women of childbearing age, pregnant women, and children under six) should not eat bluefish over 25".

► Marine Striped Bass

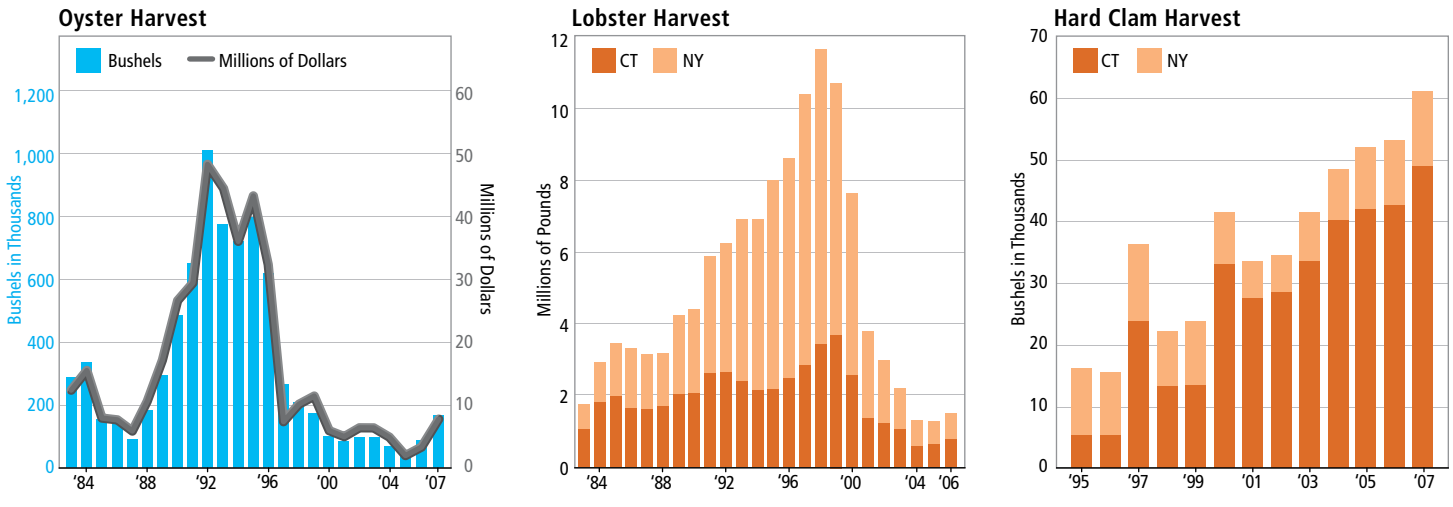
NY: Women of childbearing age and children under 15 should not eat striped bass taken from Long Island Sound west of Wading River. Others should eat no more than one meal per month from the above-mentioned area. Everyone should eat no more than one meal per week of striped bass taken from the Sound east of Wading River (PCB contamination).
CT: High risk group should not eat striped bass. Others should not eat more than one meal per month.

► Crabs and Lobsters

NY: Hepatopancreas (green meat or mustard) should not be eaten (PCB, cadmium, and dioxin contamination). Discard crab or lobster cooking liquid.
CT: High risk group should avoid eating hepatopancreas; others should not eat more than one meal per month.

For more information, visit: *www.health.state.ny.us/nysdoh/fish/fish.htm;* and *www.ct.gov/dph/* (search fish consumption advisory)

THE DATA



▲ Left to right: The oyster harvest is beginning to increase after collapsing in the 1990s; the lobster harvest still has not shown signs of recovery; clam harvests have more than tripled since 1995.

CREDITS: *Oyster Harvest,* photo by Brian A. Pounds/Connecticut Post
SOURCES: *Oyster Harvest, Lobster Harvest and Hard Clam Harvest* charts, CT Dept. of Agriculture's Aquaculture Division and NYSDEC

{Finfish}

Species composition varies year to year, but the amount of finfish remains stable

◄ A juvenile bluefish in a sandy underwater habitat of Long Island Sound. Bluefish were the third most popular fish caught in the Sound in 2006 (2.18 million caught; 918,000 harvested).

Pound for pound, the amount of fish in Long Island Sound has been about the same since 1992, according to a study that is part of the CT DEP's Long Island Sound fish trawl survey. The total weight (biomass) of 38 finfish and 15 invertebrates collected in trawl nets shows no significant trend up or down.

The abundance of different species of fish, however, has varied from year to year, and some species appear to be declining in number while others are increasing. Insight into the possible causes of these trends can be found by comparing the populations of warm water versus cold water species.

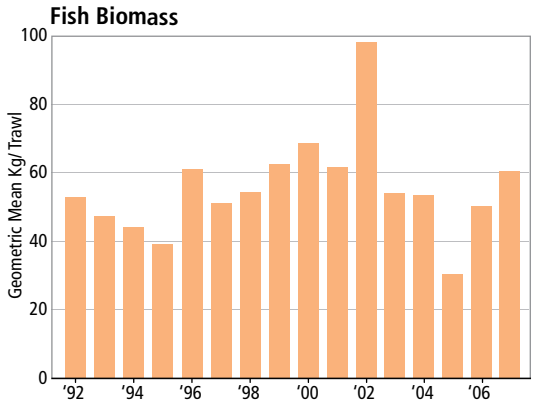
The average number of warm-water species caught in the CT DEP's trawl nets has increased over the past 23 years from about eight species per trawl to about 11. Some of this increase can be attributed to management efforts to expand the population of recreational fish. Striped bass, for example, have increased in number to historic highs in response to stringent fishery conservation measures to restrict catch. But the increase in species such as moonfish and northern sea robin cannot be explained readily by changes in fishery management. Regional warming of water temperatures could be contributing to the increase in these non-game fish species. As temperatures warm, these species may be migrating into the Sound earlier and leaving the Sound later. In all, 19 "warm temperate" species have exhibited a significant increase in occurrence in the fall trawl survey.

In contrast, the average number of cold-water species decreased over the past 23 years from about five species per tow to about four (a statistically significant decrease). Of the eight "cold temperates" exhibiting significant declines in abundance, winter flounder is the most widely known and conspicuous example. In the early 1980s, this species supported a robust recreational fishery in the spring with landings of more than one million fish. Fewer than 5,000 fish were caught and kept by fishermen in 2007. Other cold temperates in decline include the longhorn sculpin, sea raven, and cunner—species with no recreational or commercial value.

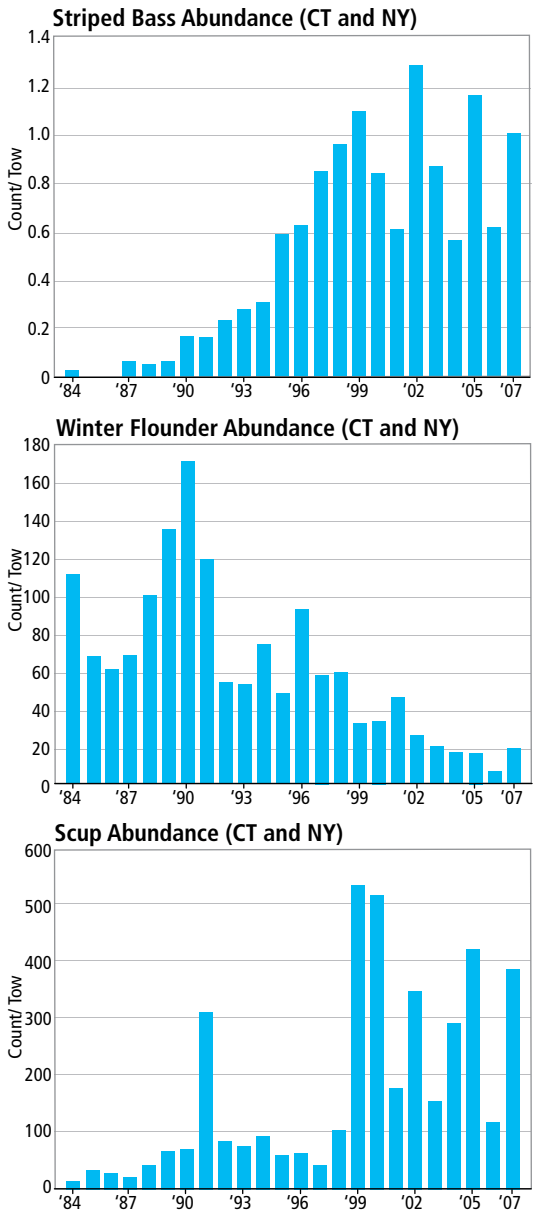
The change in fish populations has not deterred recreational fishing, one of the most popular pastimes in the Sound. In recent years, scup, bluefish, and striped bass have been the most popular fish caught by anglers in the Sound. In 2006, for example, nearly 12 million fish were caught by recreational anglers (of which about 75 percent were returned to sea in order to comply with fishing regulations intended to protect species from being overfished). •

www.LIShealth.net/pods to listen to an interview about the trawl survey aboard the research vessel *John Dempsey*.

THE DATA



▲ The biomass of fish counted in the Long Island Sound Trawl Survey shows no significant trend up or down.



▲ Top to bottom: Striped bass abundance has seen dramatic growth since the 1980s, while winter flounder shows a steady decline. Scup (porgies) vary annually, but the average abundance from 1997 to 2007 was significantly higher than the previous 10 years. This may be the result of fishery management decisions to limit catch.

Blueback Herring Faces the Blues

The success of the striped bass may not be good news for small, anadromous fish, such as the blueback herring.

The sleek silvery fish, which, like shad, spends most of its time in the ocean and then migrates to freshwater rivers as an adult to reproduce, has seen its numbers drop dramatically. In 2006, only 69 herring were counted at the Holyoke Dam on the Connecticut River in Massachusetts near the Connecticut border. In contrast, in 1985, the herring population peaked at 630,000, nine years after the U.S. Fish and Wildlife Service installed a modern fish lift at the dam. Similar declines have also been tracked in the Sound by the CT DEP's Fish Trawl Survey.

While a definitive answer for the decline is not known, some resource managers believe that stripers, which are also anadromous and migrate up the Connecticut River, are eating the blueback herring, along with alewives, a similar species.

While not a popular fish for human consumption, the blueback herring is an important prey of fish higher in the food chain. As a result, the CT DEP has prohibited fishermen from catching blueback herring until the fish recovers.

◄ Blueback herring populations are in decline, possibly because of predation by striped bass.

CREDITS: *Juvenile Bluefish,* photo by Bob Bachand; *Blueback Herring,* photo courtesy of CT DEP
SOURCES: *Fish Biomass, Striped Bass Abundance, Winter Flounder Abundance and Scup Abundance* charts, CT DEP Marine Fisheries Division

LIVING RESOURCES

{Coastal Birds}

Conservation efforts are helping the piping plover population

▲ A snowy egret flying over Sunken Meadow State Park on Long Island.

More than 125 species of birds inhabit the Sound's shoreline, with the numbers and types varying with the seasons. Spring, for example, brings the annual migration of a wide variety of plovers, terns, sandpipers, waterfowl, herons, egrets, and songbirds. But loss of coastal lands to development (see p. 14) has affected the ability of several species to find habitat away from human disturbance and predators. Monitoring bird populations can indicate how society is faring in maintaining suitable coastal habitat for all wildlife, and in the success of specific bird conservation efforts.

Piping plovers are small shorebirds that nest on beaches and dune grasses. Their nesting and reproduction are threatened by human intrusion, storm tides, and predators, and they are listed as an endangered species in New York and Connecticut. Since protection and monitoring efforts began in 1984, nesting success has improved, resulting in more returning adults. State wildlife officials credit intensive on-site management, including construction of predator proof fences around nests to protect eggs. Carefully designed beach renourishment projects, regulation of development and maintenance projects that impact beach habitats, and public education campaigns have also helped protect plover populations.

Least terns live in large colonies on the beach and plunge into nearby waters for food. Wildlife, human disturbances, and strong tides can disrupt tern nesting sites, but they can quickly recolonize other beaches within the Sound's shoreline or neighboring beaches in the region. In Connecticut, the least tern population has generally declined since the 1980s; New York's population has started to increase again in the last few years due to increased management efforts, including adding fencing to reduce human disturbance.

Colonial waterbirds, particularly long-legged wading birds, such as snowy egrets, great egrets, and black-crowned night herons, nest primarily in groups on islands along the Atlantic coast. They typically nest within scrub-shrub and woodland habitats, and often feed on estuarine fish and invertebrates in nearby salt marshes. While populations of these three species have been stable in the Sound area in recent years, there has been a 20-40 percent decline in snowy egrets and night herons since the 1970s. This may be due to predation by animals associated with humans, including rats and feral cats, a loss of nesting habitat from human disturbance, a loss of wetlands, and exposure to contaminants. •

Success Story

The osprey, once endangered in the Sound and throughout the nation, is now soaring again in population. As a result, this bird of prey has been lifted from New York and Connecticut's endangered bird lists.

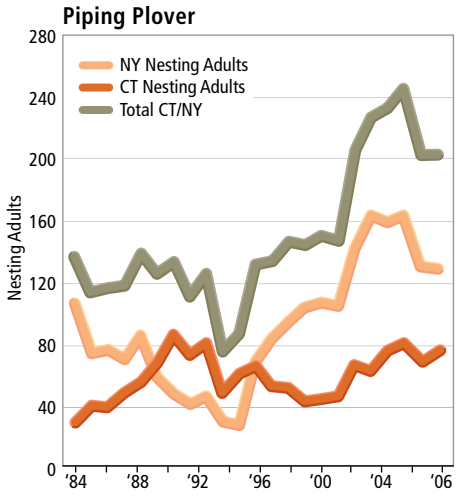
In the 1960s, scientists learned that the ospeys' ability to produce healthy eggs was affected by exposure to the pesticide DDT. After Rachel Carson's groundbreaking book, *Silent Spring*, publicized the plight of the osprey and other birds of prey, a successful campaign led to the ban of DDT in the United States in 1972, and the osprey population began to recover. Locally, recovery of the osprey was assisted by volunteer groups that helped build and maintain hundreds of nesting platforms. Ospreys prefer nests near water, especially in large trees, but will also nest on artificial platforms.

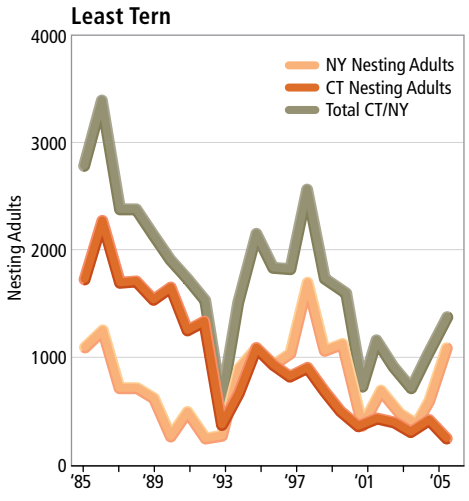
An osprey is a large bird that can grow up to 25 inches, with a wingspan of 4.5-6 feet and a weight of approximately 4 pounds. The osprey, also known as a fish hawk, dines almost exclusively on live fish, often catching its meals by hovering over the water at an altitude of 50 to 200 feet, then diving feet first into the water to catch its prey.

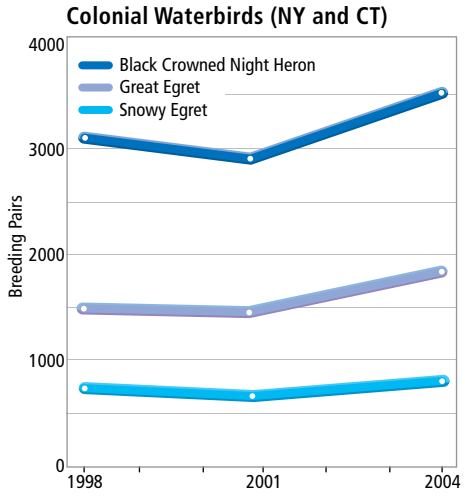
In 2001, a total of 910 osprey adults were counted by New York and Connecticut state environmental agencies, 612 more than were tracked when monitoring began in 1984. Because the population has rebounded, a Soundwide count is no longer maintained.

▼ An osprey with fish going to its nest at Kings Park on Long Island.

THE DATA



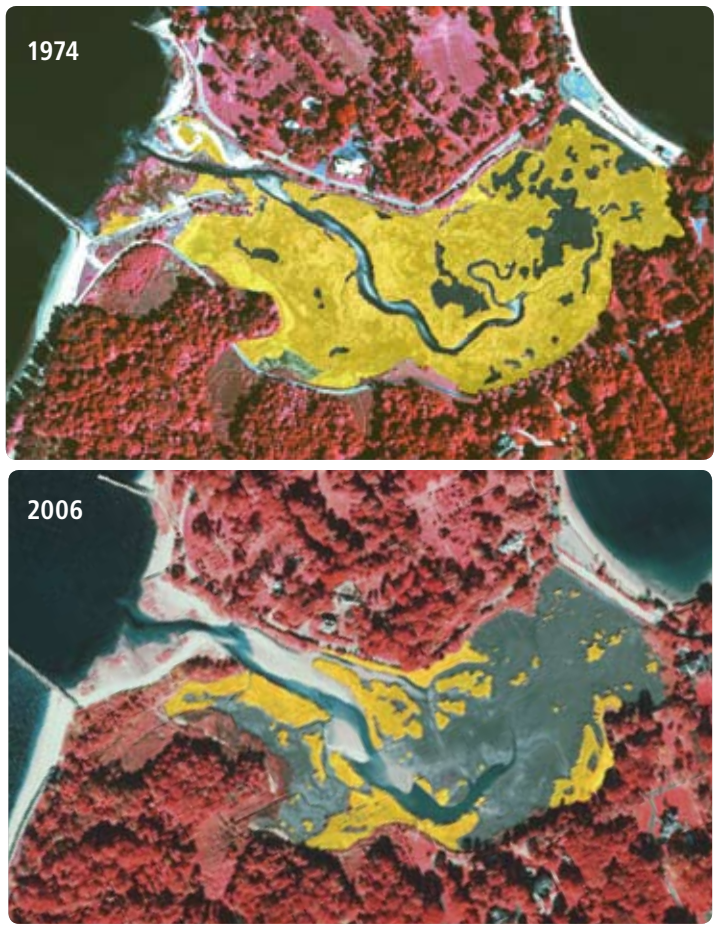




▲ Left to right: Shorebird management programs have helped trigger an increase in piping plovers and least terns; the colonial waterbird population has been stable in recent years, but is down compared with the population in the 1970s.

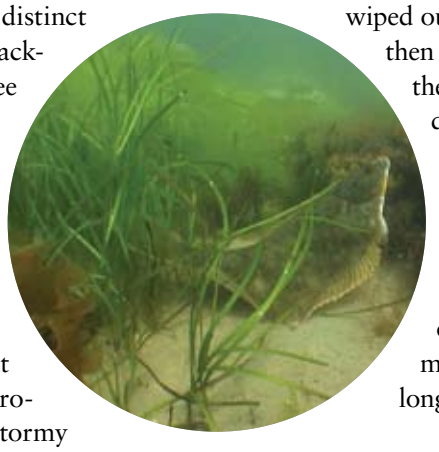
CREDITS: *Snowy Egret and Osprey,* photos by George DeCamp
SOURCES: *Piping Plover and Least Tern* charts, NYSDEC and CT DEP; *Colonial Water Birds* chart, U.S. Fish and Wildlife Service SNE/NYB Coastal Ecosystems Program, NYSDEC, and CT DEP

Regulations protect wetlands from development, but losses still occur for unknown reasons



▲ Infrared imagery of West Pond in Glen Cove, Long Island in 1974 shows 23.4 acres of salt marsh, depicted by yellow shading. In 2006, the area was mostly mudflats, with only 8.6 acres of marsh remaining.

Long Island Sound is an estuary where the ebb and flow of oceanic tides meet and mix with freshwater coming from rivers and streams. About a dozen distinct habitats help this unique environment of brackish waters and tidal extremes to function (see sidebar). Two habitats, tidal wetlands and eelgrass habitats, are particularly important because of the ecosystem benefits they provide.



Tidal wetlands are among the most productive ecosystems in the world, providing food, shelter, and breeding or nursery grounds for many species of wildlife. The salt marsh vegetation in these wetlands also protects the land from flooding and erosion in stormy weather, and filters pollutants from the water.

In the past, the value of wetlands was not recognized. They were thought of as places to fill, dredge, and build. About 25 to 35 percent of the Sound's tidal wetlands were destroyed before federal and state legislation halted the practice in the early 1970s.

There are now an estimated 12,000 acres of salt marsh around the Sound, according to an analysis of satellite imagery by the UCONN's Center for Land Use Education and Research. Despite protection and restoration efforts, state resource managers are finding that marsh grasses are still disappearing, with hundreds of acres converting to mudflats in the past 30 years. In New York, for example, a survey of four wetland sites in Long Island revealed that the total area of salt marsh declined from 434 to 346 acres from 1974 to 2005. In Connecticut, a survey of six wetland complexes in southwestern Connecticut revealed that the total area of salt marsh declined from 230 acres to 177 acres from 1974 to 2004.

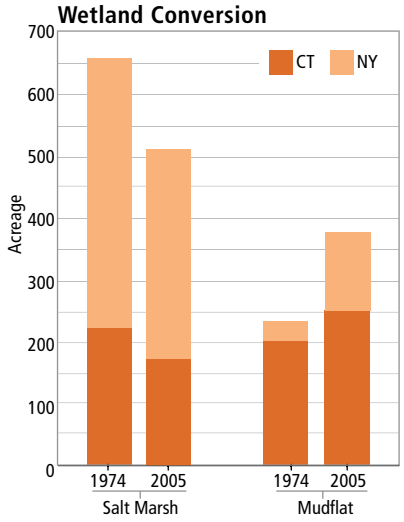
The reason for this marsh loss is not yet understood. Possible contributing factors include sea level rise flooding the marsh, insufficient sediment supplies to the marsh from upstream sources to balance moderate sea level rise, erosion of sediments caused by the force of wave action from boat wakes, and the indirect effect of local dredging. Continued sea level rise may result in marsh migration upland in undeveloped areas.

Another priority habitat consists of meadows of eelgrass, a rooted underwater grass that grows along the coast. The eelgrass habitat provides food and nesting grounds for fish, and food for many migratory birds. Eelgrass is still found in the eastern Sound, but was once common throughout. It was nearly wiped out, first by a fungal disease in the 1930s, and then gradually by poor water quality attributed to the effects of nitrogen pollution from sewage discharges and stormwater runoff.

Eelgrass acreage in the eastern Sound was 1,905 acres in 2006, according to a LISS-funded aerial survey mapped by the U.S. Fish and Wildlife Service. A 2002 survey showed 1,559 acres. While the additional observed acreage is encouraging, continued monitoring will be required to determine long-term trends. •

THE DATA

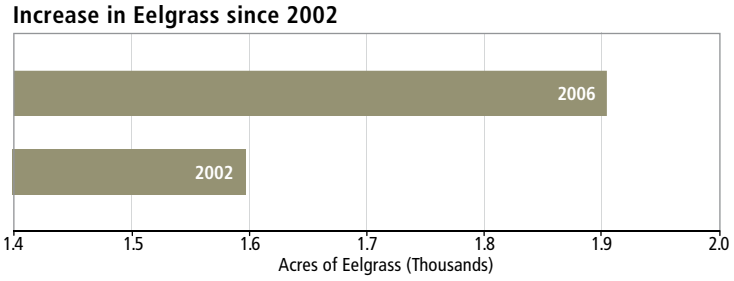
Wetland Conversion



◄ Marshes in 10 wetland areas in Connecticut and New York are converting into mudflats.

THE DATA

Increase in Eelgrass since 2002



▲ A flounder in an eelgrass habitat at Mulford Point in Orient, Long Island (*photo*). Eelgrass coverage has increased in the eastern Sound since 2002 (*chart*).

Habitats

In addition to tidal wetlands, Long Island Sound's coastline contains 11 other habitats vital to the animals and plants that live in the estuarine environment.

Beaches and dunes: Transitional sandy or cobble shoreline area between the land and the Sound.

Cliffs and bluffs: Steep coastal slopes of glacial sands and till that are created through long-term wave erosion and sea-level rise.

Estuarine embayments: Confined areas of the Sound that have narrow inlets and significant freshwater inflow.

Coastal and island forests: Forest stands on islands that are of particular importance to nesting colonial water birds.

Freshwater wetlands: Transitional zone between the land and fresh water.

Coastal grasslands; Open glacial outwash plains dominated by tall grasses.

Intertidal flats: Shallow areas of bays and harbors that lie between the spring high- and low-tide marks.

Rocky intertidal zone: Areas of exposed bedrock characterized by attached species such as barnacles, algae, and mussels.

Riverine migratory corridors: River systems that drain to the Sound (see riparian buffers, p. 14).

Submerged aquatic vegetation: Rooted plants, such as eelgrass and widgeon grass, which grow on shallow bay bottoms below the spring low-tide mark.

Shellfish reefs: Clusters of oysters and blue mussels on the seafloor near the shore.

For full descriptions and photos of the habitats see: *www.longislandsoundstudy.net/habitatrestoration*

CREDITS: *West Pond Infrared* images, courtesy of NYSDEC; *Eelgrass*, photo courtesy of Chris Pickerell, Cornell University Cooperative Extension of Suffolk County
SOURCES: *Wetland Conversion* chart, U.S. Fish and Wildlife Service National Wetlands Inventory Program and NYSDEC;
Eelgrass Acreage chart, U.S. Fish and Wildlife Service SNE/NYB Coastal Ecosystems Program

{Altered Landscapes}

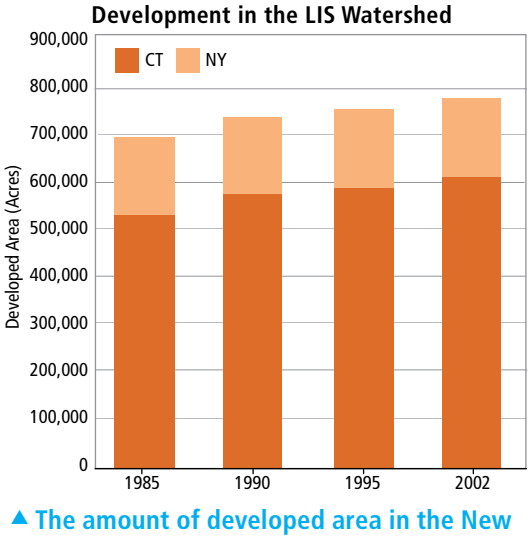
Protecting Rivers

Riparian buffers—vegetated areas next to rivers, streams, and lakes—filter pollutants before they can reach the water. They also help to stabilize banks, keep streams cool in summer, and provide habitat for wildlife. Since pollutants flow downstream, the health of riparian buffers affects the Sound's water quality.

To assess whether communities are placing a value on protecting riparian buffers, LISS funded CLEAR to analyze changes in land use between 1985 and 2002 in the areas adjacent to rivers and streams of Connecticut coastal communities. The findings showed that within 100 feet on either side—an area in which most towns review development actions to determine its impact on the water resource—there was a loss of natural vegetation of 1.6 percent. This loss was mainly due to development. The vegetation loss for the 300-foot buffer zone was 2.6 percent, and for the entire coastal study area, it was 3.7 percent. The data appear to show Connecticut municipalities see more value in protecting lands closest to waterbodies. But the study also revealed that in rapidly developing areas in southeastern Connecticut, in the stretch of shoreline from East Lyme to Stonington, and in a region draining to the Bridgeport area along its western coastline, development within the 100 foot zone was as high as 13.4 percent.

THE DATA

Development in the LIS Watershed



▲ The amount of developed area in the New York and Connecticut portion of the Sound's watershed increased by 12 percent from 1985 to 2002, an increase of 129 square miles (about four times the size of Manhattan).

Water quality declines when built surfaces exceed 10% of a watershed

◄ Fertilizers and pesticides can drain into the CT River from this rolling lawn landscape.

▼ A densely vegetated buffer, such as this landscape along the CT River, can help to reduce the impact of development.

Long Island Sound residents use the Sound to swim, fish, boat, or just to relax and enjoy the views. But the millions of people who live and work near the Sound have also exacted a price on a body of water sometimes referred to as the Urban Sea. Almost 400 years after European explorers first came to the Sound to trade with American Indians, people still are moving to the coast, enriching the bi-state area economy, but at the same time altering the natural landscape and, in turn, the Sound and its tributaries.

Hundreds of studies around the U.S. suggest that water quality and overall stream health decline when the level of impervious surfaces, such as roads and rooftops, exceed 10 percent in a watershed (the area of land that drains into a body of water). When the developed area in a watershed exceeds 25 percent, stream conditions become poor. Of the Sound's 414 sub-regional watersheds in New York and Connecticut, those that reached the 10 percent threshold increased from 278 in 1985 to 293 in 2002. Sub-regional watersheds exceeding the 25 percent threshold increased from 40 in 1985 to 54 in 2002.

The information was collected by UCONN's Center for Land Use Education and Research (CLEAR), which found that by 2002 impervious surfaces were 9.7 percent of the watershed, a 17 percent increase from 1985. Stormwater runoff carries pollutants such as pesticides, pathogens, motor oil, debris, and excess nutrients from impervious surfaces into storm drains and streams. These pollutants eventually flow into the Sound.

The increase in development is spurred in part by the need to serve an increased population. From 1980 to 2006, the population in the New York and Connecticut portion of the watershed increased from 6.3 million to 7.2 million (the population of the entire watershed increased from 7.8 million to 8.8 million). But in Connecticut, development is also increasing at almost twice the rate of population, indicating that the state is also experiencing spread-out development patterns that some people describe as sprawl. Since the 1980s, Connecticut's forest cover has also been declining as forested land has been lost to new roads and development. This decrease is a reversal of a decades-old trend of forest recovery, a consequence of fewer farms and the use of fossil fuels for energy instead of wood.

While population and development is spreading out, about 4.6 million people still live within 15 miles of the coast, the area with the greatest impact to the Sound. Most of the largest population centers, including New York City, are in the western Sound, the region that also has the poorest water quality. •

www.LIShealth.net/pods to hear an interview with Judy Preston about protecting natural habitats along the Connecticut River.

CREDITS: *CT River Buffer* photos, courtesy of Judy Preston, Tidewater Institute
SOURCES: *Development in the LIS Watershed* chart, UConn's Center for Land Use Education and Research (CLEAR)

{What You Can Do}

▶ Appreciating the Sound and its watershed helps raise awareness. Here a woman and her children hike through a grassy field at The Nature Conservancy's Pleasant Valley Preserve, near the Eightmile River in Lyme, Connecticut.

At Home

- ✔ Conserve water to reduce the volume of waste water that must be treated by a sewage treatment plant or septic system. This will increase the efficiency of treatment and save you money. When purchasing new products, look for the EPA "WaterSense" label.
- ✔ Conserve electricity and fuel to reduce carbon and other greenhouse emissions that lead to increased temperatures and ocean acidification.
- ✔ Maintain your septic system by having it pumped out every three to five years. Nutrients that leak into the soil from septic system tanks that are not working properly may eventually run into the Sound.
- ✔ Use safe, non-toxic alternatives for cleaning and for controlling pests.
- ✔ When disposing of household chemicals, take them to a recycling center instead of pouring them down drains or putting them in the trash. REMEMBER: Substances poured down drains, storm sewers, or on the land are likely to be transported to Long Island Sound.
- ✔ Take advantage of pharmaceutical take-back programs or household hazardous waste collection programs that accept pharmaceuticals. If there are no take-back programs near you, contact your state and local waste management authorities with questions about discarding unused pharmaceuticals.
- ✔ Never pour motor oil or other auto fluids down a drain or sewer or discard them with the trash (in Connecticut and New York, it's against the law!).

- ✔ Consult your public works department about proper disposal of batteries, appliances, and fluorescent bulbs.
- ✔ Use environmentally friendly landscaping techniques that require less fertilizer, prevent erosion, and use native plants. This helps prevent sediments and nutrients, like nitrogen and phosphorus, from reaching the Sound, and provides habitat for native species.
- ✔ Leave grass clippings on the lawn to recycle nutrients. Start a compost pile to reduce the amount of waste you put into the garbage disposal or garbage can. Use a soil test kit to determine the amount of fertilizer needed. Learn how to practice environmentally sound gardening.
- ✔ Scoop up pet waste. Flush waste down the toilet, or seal it in a plastic bag and dispose of it in the trash.
- ✔ Wash your car on a grassy area, so the ground can filter the water naturally. Use soap sparingly and try to use non-phosphate biodegradable detergents. Empty the bucket of soapy water down the sink, not in the street. Best of all, go to a car wash.
- ✔ Preserve any wetlands on your property, even small areas.

In and Around the Sound

- ✔ Don't be a litterbug. Never throw litter into the street, down storm drains, or onto the beach. Rainfall carries the trash into the sewers where it eventually travels into the Sound. Cigarette butts, which contain non-biodegradable filters, make up the largest percentage of litter collected during beach clean-ups.
- ✔ Be a responsible boater. Be sure your boat is working properly and not leaking contaminants. Remember, it is illegal to discharge boat wastes in Connecticut coastal waters and some New York harbors. Contact your state environmental agency for information about pumpout facilities.
- ✔ Never feed geese and other waterbirds. This encourages them to stay through the winter and gather in flocks. Their droppings, which contain bacteria and nitrogen, can contaminate shellfish beds and may cause the closing of beaches. •

◀ Volunteering also helps the Sound. Here volunteers through a project coordinated by the Bronx River Alliance plant trees in a woodland area along the Bronx River. For more information about the site, visit: *www.bronxriver.org/plans/.*

Contacts

Key agency and organization contacts for Long Island Sound:

FEDERAL

EPA Long Island Sound Office
CT 203-977-1541
www.longislandsoundstudy.net

EPA National Estuary Program
202-566-1240
www.epa.gov/owow/estuaries

U.S. Fish and Wildlife Service
401-364-9124
www.fws.gov

CONNECTICUT

CT Dept. of Environmental Protection
860-424-3000
www.dep.state.ct.us

Oil and Chemical Spill Response
(24-hour hotline) 860-424-3338

CT Dept. of Public Health
860-509-8000
www.dph.state.ct.us

NEW YORK

NYS Dept. of Environmental Conservation, Bureau of Marine Resources
631-444-0430
www.dec.ny.gov

NYSDEC Spill Hotline
800-457-7362
www.dec.ny.gov

NYS Dept. of State, Division of Coastal Resources
518-474-6000
www.dos.state.ny.us

NYS Dept. of Health
800-458-1158
www.health.state.ny.us

SEA GRANT COLLEGE PROGRAMS

Connecticut Sea Grant
860-405-9128
www.seagrant.uconn.edu

New York Sea Grant
631-632-6905
www.nyseagrant.org

INTERSTATE AGENCIES

Interstate Environmental Commission
212-582-0380
www.iec-nynjct.org

New England Interstate Water Pollution Control Commission
978-323-7929
www.neiwpcc.org

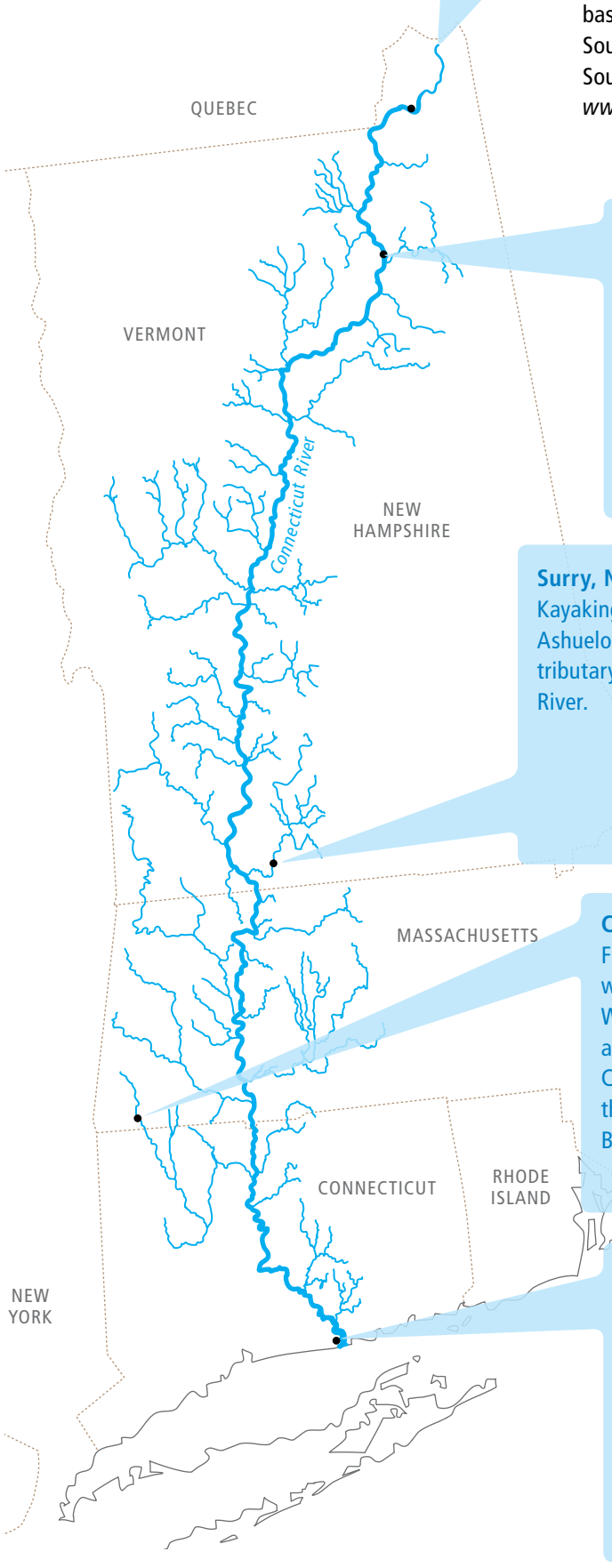
Long Island Sound Study sponsors:

Near Pittsburg, NH: This border marker between Canada and the U.S. near Pittsburg, N.H. also marks a boundary between the LIS and St. Lawrence River watersheds. Nearby, a small portion of Quebec, Canada lies in the LIS watershed.

A River Runs to LIS

The Long Island Sound (LIS) watershed starts at the source of the Connecticut River, along the Canadian border in Pittsburg, NH (population 867). Water drains into the Fourth Connecticut Lake, the river's headwaters, and winds its way down 410 miles to the Sound. The CT River basin is the source of 70 percent of the Sound's fresh water. The Sound's 16,000-square-mile watershed includes the CT River basin and nine other basins. Hundreds of local watersheds feed into these basins, and eventually to the Sound. To learn more about the Sound's watersheds, visit *www.LIShealth.net*.

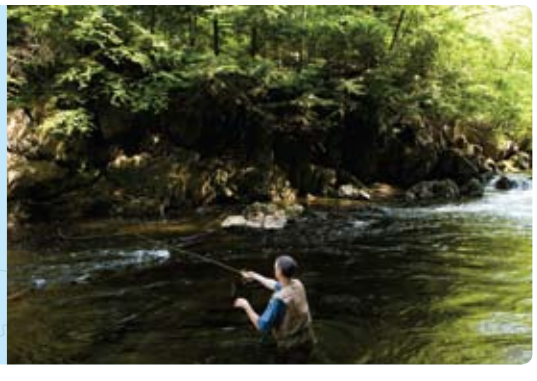
www.LIShealth.net/pods to hear an interview with Elizabeth Farnsworth about the unique tidal wetlands of the lower CT River.



Maidstone, VT: An aerial view of farms along the CT River in Maidstone (rear) and Stratford, New Hampshire.

Surry, NH: Kayaking the Ashuelot River, a tributary of the CT River.

Chester, MA: Fly-fishing on the west branch of the Westfield River, a tributary of the CT River. Part of the Keystone Arch Bridge Trail.



Old Saybrook, CT: Lynde Point Lighthouse in Old Saybrook, Connecticut, as seen from across the mouth of the CT River in Old Lyme.

The Long Island Sound Study is a cooperative effort involving researchers, regulators, user groups, and other concerned organizations and individuals. These people are working together to protect and improve the health of the Sound by implementing the Study's Comprehensive Conservation and Management Plan, completed in 1994.

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