



SOUND HEALTH 2012

STATUS AND TRENDS IN THE HEALTH OF LONG ISLAND SOUND

WELCOME

A BAY SCALLOP shows its blue eyes used for sensing light and dark. See p. 10 for more about shellfish.

The *Sound Health* report tracks key measures of the health of Long Island Sound

Sound Health 2012 provides a snapshot of the environmental health of Long Island Sound. It uses environmental indicators—developed from data collected by research and monitoring programs—to provide insight into whether waters are becoming cleaner, habitats such as wetlands healthier, and natural resources such as fish more abundant. *Sound Health 2012* considers both the science of how Long Island Sound functions and the uses of the ecosystem valued by citizens, communities, and businesses.

But for many, the events of Oct. 29, 2012 will dominate thoughts about the health of Long Island Sound and the communities around it. That day Hurricane Sandy made landfall in southern New Jersey with catastrophic impacts on our region's coasts. The storm surge in parts of western Long Island Sound and the New York-New Jersey Harbor rose as much as 13 feet above mean sea level, resulting in billions of dollars in damages to the region's infrastructure. The surging waters overwhelmed many wastewater treatment facilities, mixed with oil and gasoline spilled from flooded cars and homes, and altered coastal habitats.

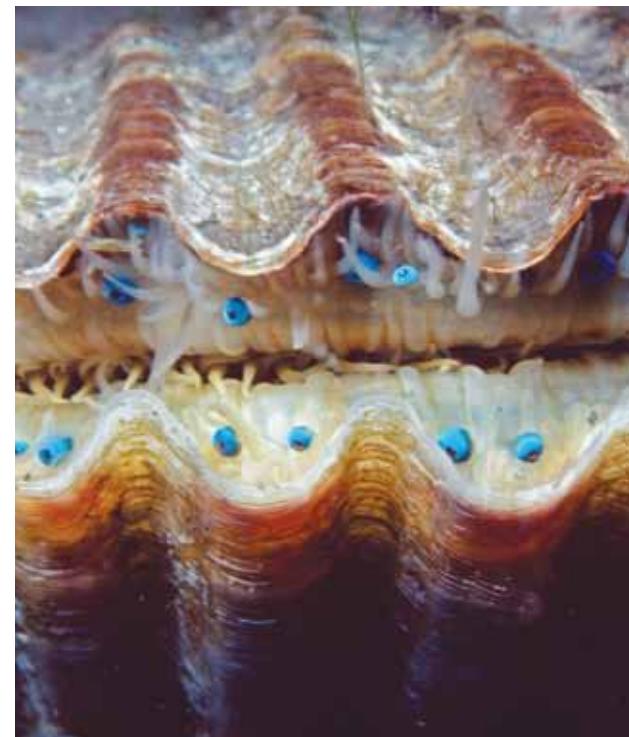
No one can say whether Hurricane Sandy was caused by climate change. But the storm dramatized some of the consequences that can be caused or exacerbated by it. To date, the changes to climate affecting the Sound have been subtle relative to the natural year-to-year variability in weather and to the significant consequences of human activity—port and industrial development, dredging, hardening of the shoreline, destruction of wetlands, diversion of water courses, industrial and sewage pollution, and fishing pressure. But the impact of the storm surge, exacerbated by sea level rise, was anything but subtle.

The need to understand how climate change can affect the future state of Long Island Sound was one of the main objectives of a new book, expected to be published in early 2013, that will synthesize and summarize the latest science regarding the Sound. Sponsored by the Science and Technical Advisory Committee of the Long

Island Sound Study (LISS), the book, *Long Island Sound: Prospects for the Urban Sea*, will provide a firmer foundation for improving management of the ecosystem, including responding and adapting to climate change, and will help to further develop and refine environmental indicators for future assessments of the health of the Sound.

The LISS, part of the EPA's National Estuary Program, developed a Comprehensive Conservation and Management Plan for the Sound in 1994. Since that time, much new research has been conducted, and the National Estuary Program's approach in applying the best science in collaborative efforts that incorporate society and the economy have been embraced by scientists and adopted by policymakers. The synthesis, combined with the community vision for the Sound developed in 2011 by the Long Island Sound Study Citizens Advisory Committee, is particularly timely, with planning underway to update and revise the Comprehensive Conservation and Management Plan by 2014.

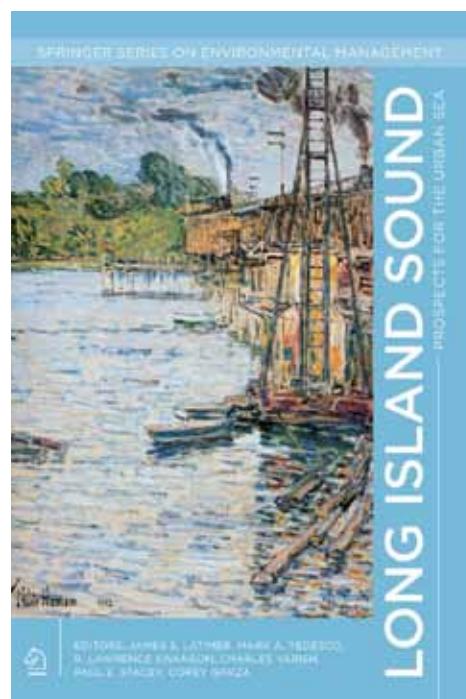
LONG ISLAND SOUND: PROSPECTS FOR THE URBAN SEA will be available in early 2013. *The Mill Pond*, the painting on the book's cover, is an early example of American Impressionist painter Childe Hassam's use of industrial imagery, showing approaching trains on the Mianus River railroad bridge in Cos Cob, CT.



WHAT IS THE 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 US 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 implement a Comprehensive Conservation and Management Plan (CCMP) to maintain the health of the ecosystem, improve water quality, restore coastal habitats, and increase public awareness of the Sound. Since the concerns affecting the Sound cross political boundaries, LISS partners work together to share ideas, coordinate actions, and leverage scarce financial resources to protect an entire ecosystem. For more information about LISS visit the *About Us* section of www.longislandsoundstudy.net.

VISIT LIShealth.net for additional *Sound Health* features.



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ON THE COVER

A snowy egret eats an eel at Dosoris Pond, a saltwater pond in Glen Cove, NY. See LIShealth.net for an illustrated view of the feeding relationships that help maintain a healthy Long Island Sound ecosystem.

ACRONYM KEY

CTDEEP Connecticut Department of Energy and Environmental Protection
 EPA US Environmental Protection Agency
 FWS US Fish and Wildlife Service
 LIS Long Island Sound
 LISS Long Island Sound Study
 NOAA National Oceanic and Atmospheric Administration
 NYSDEC New York State Department of Environmental Conservation
 UCONN University of Connecticut
 Unsure about a term used in this report? See www.LIShealth.net for a definition.

HYPOXIA & NUTRIENTS

JAMIE VAUDREY conducting research on board a southern skimmer in Cold Spring Harbor, NY.

Many factors contribute to hypoxia. While nutrient load reductions should cause a long-term decline in hypoxia, its severity varies year to year depending on nutrients and weather conditions.

DID YOU KNOW?

In lay terms, severely hypoxic waters are often referred to as "dead zones." In 2012, the most severe conditions occurred the week of Aug. 13, with nearly 18 square miles of water containing only 1 mg/L or less of oxygen.

HAB EVENTS

Harmful algal blooms (HABs) are phytoplankton that produce chemicals toxic to shellfish and to humans who eat shellfish. HAB events are relatively rare in the Sound, but are beginning to appear regularly in the Northport-Huntington Harbor area in Long Island (see HAB chart, right). Visit LIShealth.net to find out more about harmful algal blooms.

One of the world's most vexing environmental problems in coastal waters is hypoxia, the lack of sufficient oxygen. More than 500 hypoxic zones threaten coastal waters around the world, with the number doubling every decade for the past 50 years, according to the United Nations Environment Programme.

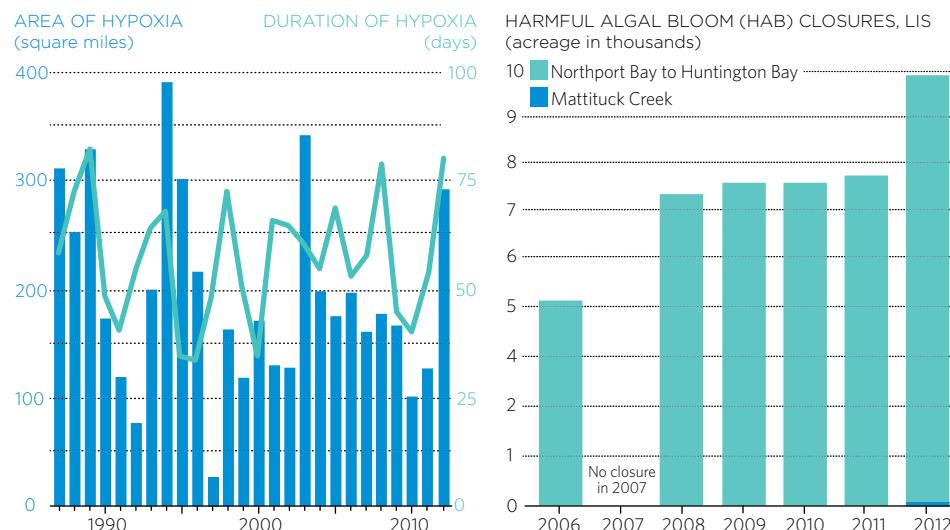
Estuarine coastal waters such as Long Island Sound are some of the most productive ecosystems in the world. When estuaries become hypoxic, non-mobile animals, such as clams or worms can die, and mobile animals, such as fish, can be forced to seek better conditions elsewhere.

Hypoxia in the Sound occurs in the summer months, usually in the Western Sound and Narrows (see conditions by basin, p. 5). It varies in area and duration from year to year. After seven years of below average severity, hypoxia increased slightly in 2011 and more significantly in 2012. The area affected by hypoxia in the summer of 2012 was the fifth largest since 1987—289 square miles, an area about 13 times the size of Manhattan. The duration of hypoxia in 2012 was 80 days, 23 days more than the average between the years 1987 and 2012.

Low-oxygen waters are linked to an increase in nutrients such as nitrogen in a process called eutrophication, in which high nutrient concentrations stimulate blooms of algae (see LIShealth.net for a graphic describing the eutrophication-nitrogen cycle). In New York and Connecticut, major sources of nitrogen include sewage from wastewater treatment plants and septic systems, atmospheric deposition from power plants and vehicles, and fertilizer runoff. In an effort to reduce nitrogen levels, the states, with the cooperation of EPA, have embarked on a plan to reduce nitrogen levels by 58.5 percent by 2017.

In addition to nutrients, physical, chemical, biological, and geographical factors also affect hypoxia. Warmer water in the summer holds less oxygen than colder winter waters. Also, during the summer the surface water of the Sound warms and forms a distinct layer floating over the bottom water, which is denser due to greater salinity and cooler temperatures. This layering (or stratification) of the water column leads to a pycnocline, a sharp density gradient that restricts oxygen-rich surface waters from mixing with the less oxygenated bottom. Wind intensity and direction can also affect the degree of mixing between surface and bottom waters. Coves and protected harbors also can restrict the circulation of oxygen-rich tidal waters.

THE NUMBER OF DAYS AND AREA OF HYPOXIA have varied from year to year since monitoring began in 1987 (left). Shellfish areas closed due to HAB events have occurred since 2006. Closures have occurred in Northport-Huntington Harbor every year (except 2007) and in Mattituck Creek in 2012.



MONITORING EMBAYMENTS

EMBAYMENTS ARE RECESSES in the shoreline that form the bays and harbors of coastal waters. When healthy, they support valuable habitats such as eelgrass meadows and shellfish beds. But very little is known about the eutrophic condition of most of the more than 60 embayments in the Sound, even though they are the receiving waters, for many of the man-made sources of nitrogen delivered into the Sound. The lack of knowledge is beginning to change thanks to a University of Connecticut research project funded by the Long Island Sound Study research grant program.

In late July and early August 2011 and 2012, professors Jamie Vaudrey and Charles Yarish set out to investigate the susceptibility to hypoxia of eight embayments across the Sound. Their research team started sampling as the sun was rising. After a night of respiration, without the replenishing effects of photosynthesis, the oxygen levels in the embayments are generally at their lowest. Habitat characteristics that may indicate the susceptibility to nitrogen were also investigated, including: sediment characteristics, dominant benthic community (organisms living on the seafloor), and water column phytoplankton concentrations.

In the first year of monitoring, the lowest oxygen concentrations were found in the western embayments, with Cold Spring Harbor exhibiting hypoxia in bottom water throughout the embayment. Embayments in the Eastern Sound exhibited high oxygen levels although freshwater inputs discharging into the embayments did exhibit hypoxia. Further analysis of these results should elucidate the extent, severity, and future susceptibility of these embayments to eutrophication and provide a baseline for future monitoring efforts.

TOXIC CONTAMINANTS

BLUE MUSSELS surround a sea star at a beach near Hempstead Harbor in Long Island.

Toxic discharges into the Sound have decreased dramatically over the past few decades, but persistent legacy contaminants and new emerging toxins remain a concern.



DID YOU KNOW?

The osprey, a bird of prey once threatened with extinction, is on the rebound in coastal areas such as the Sound thanks to reduced levels of DDT, a pesticide banned in the US in 1972.

The discharge of toxic contaminants from factories, power plants, automobile exhaust and other activities associated with high population densities is a threat to marine and coastal life. Fortunately, the amount of pollutants discharging into the Sound has declined significantly over the past three decades.

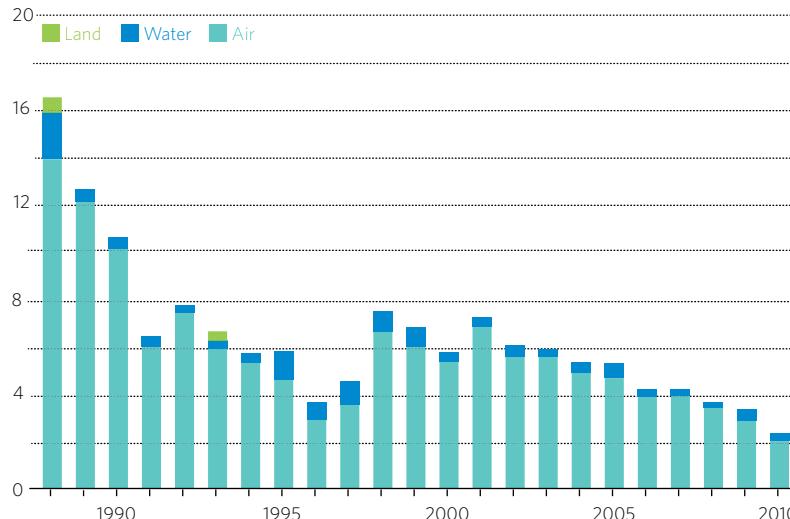
According to EPA's Toxic Release Inventory—a database which tracks more than 650 pollutant discharges from industrial facilities across the US—air, water, and land discharges in the watershed declined by 86 percent from 1988 to 2010 (from 16.5 million pounds to 2.3 million pounds). In 2010, 81.5 percent of the pollutant discharges (1.85 million pounds) in the Sound's six-state watershed originated from 340 facilities in Connecticut and New York. Of that amount, the total releases discharged directly into the water (as opposed to air or land discharges) were about 300,000 pounds.

Product bans of toxic chemicals, tighter regulation of industrial facilities, and a decline in manufacturing contributed to this reduction, leading to direct benefits to animal and human health. Using sediment core samples taken from the bottom of the Sound, Wesleyan University scientist Johann Varekamp has shown that amounts of heavy metals such as lead and mercury began to spike during the beginning of the industrial age in the 19th century. Concentrations peaked and started to fall in the mid-20th century.

Despite the declines, contaminants still pose a risk to animals and to humans who eat contaminated fish. For example, airborne deposits from power plant and incinerator emissions are a continuing source of mercury to the Sound. The deposits can become attached to fine particles of sediment and eventually settle to the seafloor, mostly in areas of weak currents in the Western Sound, where they are less likely to be flushed out. If they get stirred up in the sediment and recirculate, these new sources (as well as mercury deposited into the Sound from previous decades) can be consumed by microscopic plant and animal life and then move up the food chain to larger species. A 2011 report from the Biodiversity Research Institute on mercury in terrestrial ecosystems of the Northeast noted that mercury levels in Connecticut and New York populations of the saltmarsh sparrow, an endangered species that inhabits tidal marshes, pose a moderate risk for reducing nesting success.

CHEMICAL DISCHARGES into the Sound's watershed decreased by 86 percent from 1988 to 2010.

INDUSTRIAL CHEMICAL DISCHARGES (TRI DATA)
(releases, millions of pounds)



MUSSEL WATCH PROGRAM MONITORS FLAME RETARDANT CHEMICAL

EXAMINING THE TISSUES of shellfish, such as mussels and oysters, can provide scientists with a long-term record of contaminants in coastal waters. For that reason, the Mussel Watch program of NOAA's National Centers for Coastal Ocean Science, has been monitoring bivalves in coastal waters across the US since 1986, including nine sites in Long Island Sound, to measure concentrations of more than 130 chemical contaminants. NOAA is also concerned about the presence of contaminants of emerging concern, or CECs, which are previously unknown or unidentified classes of contaminants that may be negatively impacting the environment. Some of these chemicals pose a threat to human health and reproduction by disrupting the body's endocrine system. They are often found in everyday products—including pharmaceuticals, personal care products, furniture, and plastics—and a number of them can enter coastal waters through the wastewater stream.

NOAA has analyzed samples of bivalve tissues from 1996, and 2004 to 2007 for polybrominated diphenyl ethers, or PBDEs, and found that concentrations are still widely distributed in coastal waters even though production peaked in the late 1990s. PBDEs have been added as a flame retardant in products, including high impact polystyrene (plastics), foams, carpets and upholstery, textiles, office furniture, and electronic equipment. A growing body of research, however, indicates that PBDEs may impair liver and thyroid function and neurobehavioral development. There are 209 unique PBDEs, referred to as congeners. In the Sound, an area off of Throgs Neck in the Bronx had elevated concentrations of three of the major PBDE congeners in comparison to samples taken from across the country, but still well below the highest levels detected in Anaheim Bay, California.

At this time no guidelines exist on concentrations of PBDEs in mussels that are a threat to animal or human health. A number of PBDE congeners have been banned in Europe and are also being phased out in the US. But the continued detection of PBDEs in the Sound points to the need for additional monitoring of these and other CECs.

CONDITIONS BY BASIN

While conditions affecting water quality and life on the seafloor are worse in the Western Sound, the area has the greatest potential for improvement because of sewage plant upgrades.

DID YOU KNOW?

Twice a day, 25 billion gallons of water rush into the Sound with the incoming tide at the Race in strong currents that move faster than 5 knots (nautical miles per hour).

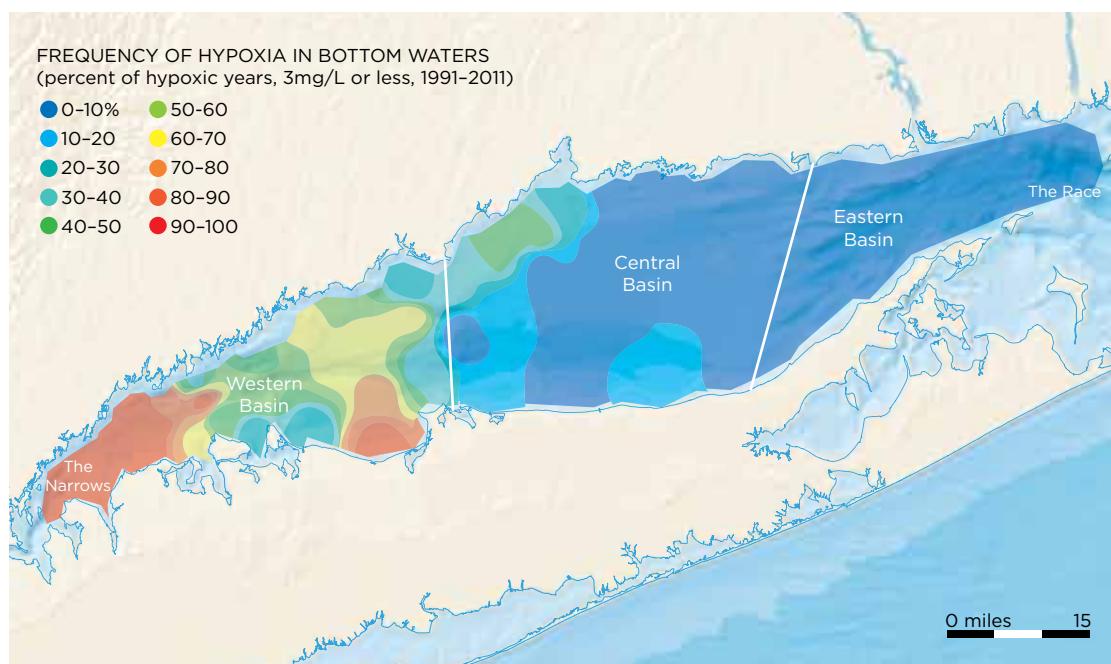
The EPA's Office of Research and Development has developed an approach to characterize water quality, the toxicity of sediments on the sea floor, and the variety of species living on the sea floor (the benthic community). Using an index of different indicators for each of these measures, the Sound's western, central, and eastern basins can be rated as good, fair, or poor.

The Western Sound is the most stressed

The densely populated and developed Western Sound is the most stressed, with fair water quality the majority of the time, and with sediment conditions rated as poor for half of the basin area. Improving water conditions from west to east partly reflect the decrease in development and population density from west to east. (see p. 14). Developed land results in more pollutants flushed from hard surfaces, such as roads and parking lots, into storm drains that connect to the Sound. The higher population also contributes more sewage to wastewater treatment plants and septic systems and cesspools, and more vehicle emissions that deposit air pollution into the Sound. Recent plant upgrades in Connecticut and New York have the potential to dramatically improve water quality in the Western Sound over the next few years.

Improving conditions toward the east reflects geological differences. For example, the Eastern Sound, carved out from a melted glacier, is deep, dipping to 350 feet at the Race (see map). The narrow channel opening to Block Island Sound funnels fast moving currents that scour the bottom and actively mix the water. The Western Sound 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. The weak currents in the Western Sound also make for conditions that are less likely to flush out toxic contaminants that settle in the sediment.

AREAS IN THE WESTERN and central parts of the Sound are most frequently affected by hypoxia. The colors on the map represent the percentage of years between 1991 and 2011 in which hypoxic conditions have occurred in bottom waters for at least one day.

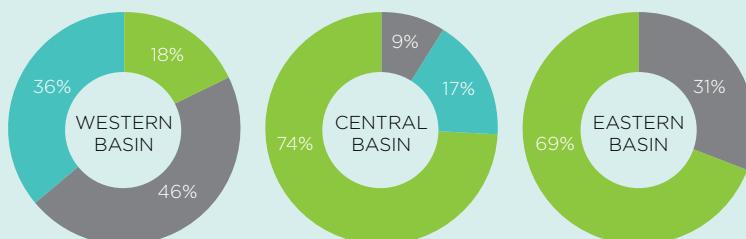


SUMMARY OF RATING CRITERIA

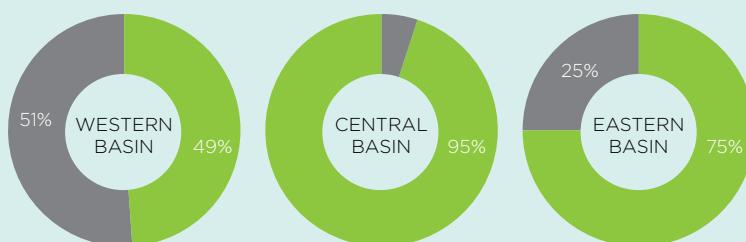
WATER QUALITY INDEX: When nutrients, such as nitrogen, are in excess they can stimulate the overgrowth of plants (indicated by an abundance of chlorophyll *a*, a plant pigment), which can decrease water clarity and lower concentrations of dissolved oxygen in bottom waters. The index includes five water 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) are summarized Soundwide from 1991 to 2011.



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 adhere 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 as measured by the survival of a marine amphipod, the concentration of sediment contaminants, and the total organic carbon in the sediment. Data were collected from 2002 to 2006.



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 2002 to 2006.



LIShealth.net has more information on how the indices are created as well as links to EPA's National Coastal Condition Report.

PATHOGENS

AFTER BEING CLOSED for 40 years, the reopened Hempstead Harbor shellfishery has yielded bountiful clam harvests.

CT and NY have shown that better stormwater management can result in improved water quality and opening of shellfish beds.



DID YOU KNOW?

Most beach closures occur in enclosed embayments, such as harbors and coves, rather than at beaches located directly on the Sound where there is more tidal action to flush pathogens.

ABOVE: A lifeguard at Calf Pasture Beach in Norwalk prepares a "no swimming" sign on June 4, 2012, following a heavy rainfall.

Typically, Long Island Sound's 210 monitored beaches are open for swimming in the summer. But closures do occur, caused by potential or actual cases of pathogens in the water. 2011 was a particularly bad year for beach closures as well as advisories warning of potential risks.

Pathogens are disease-causing organisms, including bacteria and viruses. Health departments sample coastal bathing waters to determine whether the water exceeds an acceptable level of an indicator bacteria, *Enterococcus*. These bacteria may indicate the presence of pathogens that can lead to gastrointestinal illnesses among swimmers.

Beach managers in Connecticut and New York close beaches preemptively when high rainfall generates stormwater runoff that may contain animal waste, untreated sewage discharge, or other contaminants. High incidents of closures in Connecticut and New York in 2011, for example, were attributed to the impact of Tropical Storm Irene and other storms. In 2010 and 2011, Connecticut also saw an increase in beaches that exceeded the *Enterococcus* standard during routine testing.

Many of the beaches that are closed preemptively are located near densely developed communities with high levels of polluted stormwater runoff. In seven municipalities—including New York City and six in Connecticut—where stormwater and sanitary sewers are combined, sewage is discharged directly into the Sound during heavy periods of rain when the combined flow of sewage and water exceeds the capacity of the wastewater treatment plant. Sewage discharges can also occur as a result of wastewater treatment plant disruptions, illegal connections that discharge sewage directly into the Sound and its tributaries, and illegal dumping from boats.

The same sources of pollution that close beaches also can result in the closure of shellfish beds. In Connecticut, more than 6,000 acres of approved growing areas were downgraded from 2010 to 2011, adding to the decline of more than 16,000 acres that occurred from 2005 to 2006. These shellfish beds are now classified as "conditionally approved," which means they remain open unless rainfall exceeds one inch. Resource managers cited increased stormwater runoff that resulted from coastal development as a reason for the downgrade. In recent years, New York has issued temporary closures in a few embayments that have experienced toxic algal blooms that can concentrate in the tissues of shellfish. Most algal blooms, the result of waters with high amounts of nitrogen, are not toxic (see water quality, page 3). While both states have experienced closures they have also seen successful efforts to reopen shellfish beds (see sidebar).



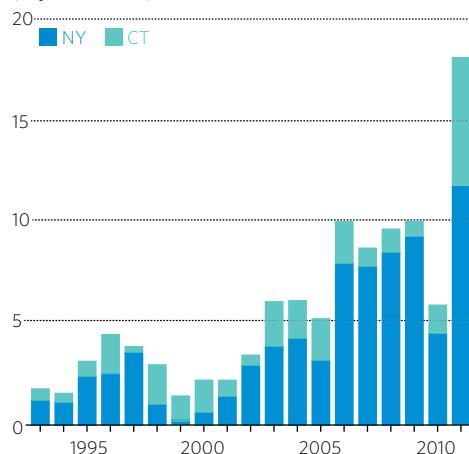
SHELLFISH BEDS REOPEN IN HEMPSTEAD HARBOR AND WATERS OFFSHORE NEAR WESTPORT

CITING THE POSITIVE RESULTS of sanitary surveys, water quality monitoring, and shellfish tissue testing, NYSDEC reopened 2,500 acres in Hempstead Harbor for shellfish harvesting in June 2011. The area had been closed for shellfishing for more than 40 years.

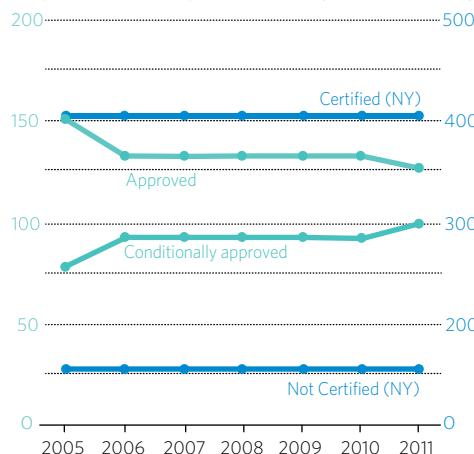
NYSDEC attributes the success to improved wastewater treatment plants, a new Stormwater Management Plan to reduce polluted runoff, and a 2008 decision to create a zone prohibiting the discharge of sewage from vessels in Hempstead Harbor. In 2011, the New York side of the Sound was designated as a No Discharge Zone, giving the entire Sound protection. Connecticut received this designation in 2007. At the time of the reopening, the Hempstead Harbor Protection Committee, an intermunicipal watershed group that monitors water quality in the Harbor, and the state hailed the effort as an example of federal, state, and local partners working together to accomplish a significant water quality improvement.

In 2010, Connecticut also added an additional 950 acres of approved shellfish acreage in offshore waters near Westport. The improvements in water quality are attributed to new sewers in Westport, upgrades to Norwalk's wastewater treatment plant, and identification and correction of sewage infiltration and cross-connections between the sewage collection system and the stormwater system.

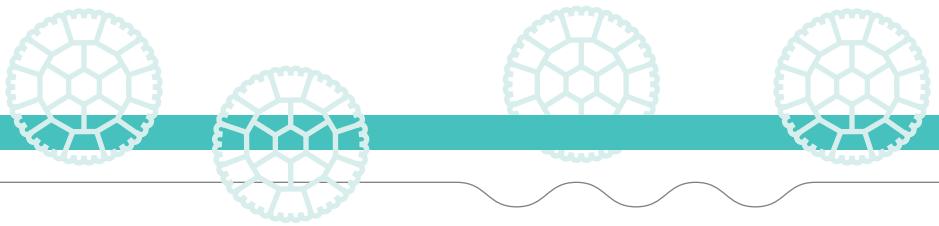
BEACH CLOSURES AND ADVISORIES (days, hundreds)



APPROVED SHELLFISH ACREAGE
CT (acres, thousands) NY (acres, thousands)



BEACH CLOSURES increase in years with frequent rainstorms. Approved shellfish beds were downgraded in Connecticut to conditionally approved in part because of high bacteria counts after rain events. Approved shellfish acreage increased in New York because of long-term efforts to improve water quality in Hempstead Harbor and other areas.



MARINE DEBRIS

Most marine debris comes from littering, including easily recyclable plastic items such as cups, beverage containers, and bags.

DID YOU KNOW?

Nearly 8 million plastic bags were collected in coastal cleanups the International Coastal Cleanup from 1987 to 2011, according to the Ocean Conservancy. Locally, Westport, Rye, and Mamaroneck have responded to the threat by banning plastic bags from retail stores.

VOLUNTEERS, such as the Coalition to Save Hempstead Harbor, helped to collect plastic biodisks accidentally released from the Mamaroneck wastewater treatment plant (below).

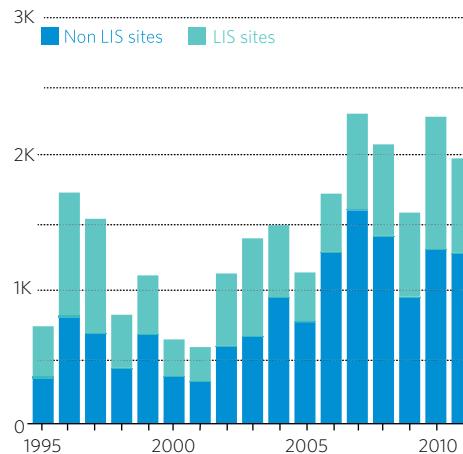
Trash found floating in coastal waters or washed up on the beach is called floatable debris. Floatable debris is a unique form of water pollution because it is readily visible to even the untrained eye.

Most floatable debris consists of waste material and litter from the products we use on a daily basis—such as plastic bags, plastic beverage containers, and cups. Whether careless disposal occurs at the beach or waterfront area or far inland, the litter can be transported by stormwater runoff or wind to the Sound. In urban cities in which sewage and stormwater runoff are discharged to a common wastewater treatment plant, floatable debris (and untreated sewage) could be discharged directly into the Sound during periods of rain when the combined sewage and stormwater exceeds the capacity of the plant.

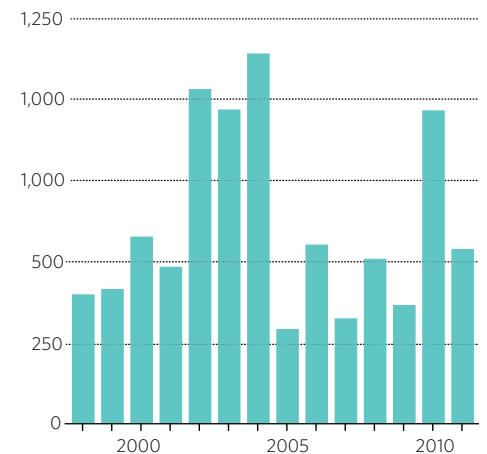
The unsightly appearance of garbage on the beach and shoreline can lead to a significant economic impact. When a small amount of medically related waste, including syringes, washed up on ocean beaches in Long Island and New Jersey in the late 1980s, beach attendance in the region plummeted as did seafood sales as the worries about polluted beaches spread to concerns about seafood consumption. For wildlife, exposure to trash can lead to serious problems. Birds, fish, and other animals can become entangled in ocean trash, which could lead to drowning or prevents them from feeding, swimming, and reproducing, according to the Ocean Conservancy. In addition, animals can mistake objects such as bottle caps and cigarette butts for food.

Long-term efforts to develop and implement stormwater management plans are the best ways to eliminate floatable debris. Communities and environmental organizations also operate and organize shoreline clean-up programs. New York City, for example, operates a boom and skim program—floating barriers that collect trash so that it can be removed by skimmer boats—throughout its harbors, including nine sites that drain into Long Island Sound waters. In 2010, 1,310 cubic yards of trash were collected from these sites. Each September, the American Littoral Society and Save the Sound organize citizen beach cleanups coinciding with the Ocean Conservancy’s International Coastal Cleanup program. In 2011, volunteers from both states collected 53,345 pounds of trash on 99 miles of shorelines, an equivalent of 539 pounds per mile. In New York, the types of debris collected included 15,261 plastic bags, 14,542 cigarette butts, and 3,650 balloons.

FLOATABLE DEBRIS, NYC (volume, cubic yards)



BEACH DEBRIS COLLECTED (pounds of debris collected/mile of beach)



NEW YORK CITY collects thousands of cubic yards of floatable debris using booms, or floating barriers, installed at 24 locations, including nine sites that discharge into the Sound (top left). Each year in September, volunteers across the Sound collect hundreds of pounds of debris at coastal cleanups (top right). Cleanups happen in other months too, including this one to remove trash at Milford Pt., CT (right).



GROUPS COLLECT "GHOST GEAR" & "PASTA WHEELS"

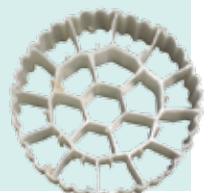
WHAT DO "GHOST GEAR" and disks that resemble pasta have in common? They are both types of marine debris that have been found in the Sound.

Ghost gear is a term used to describe recreational and commercial fishing equipment that has been lost, abandoned, or discarded in the marine environment. This marine debris can destroy habitats, unintentionally trap animals, cause hazards to navigation, and entangle and kill protected and endangered species. At the bottom of the harbors and bays of Long Island's North Shore lies an estimated 260,000 pounds of abandoned lobster traps and one ton of ropes, buoys, and other marine debris, according to New York Cornell Cooperative Extension,

which is working on a project with former lobstermen to retrieve the gear.

The plastic biodisks, which look like wagon-wheel shaped pasta, are installed in wastewater treatment plants to help break down nitrogen and other pollutants in the wastewater. In March 2011, millions of these disks were accidentally released at the Mamaroneck wastewater treatment plant during a start up test after the initial installations. In total, about 33 million disks were released into Long Island Sound. An estimated 1.6 million were subsequently collected through cleanups.

ACTUAL SIZE



CLIMATE CHANGE

Weather varies from year to year, but long-term climate trends show an increase in temperature and sea level.

DID YOU KNOW?

According to the NOAA Hurricane Center, storm surge is often the greatest threat to life and property from a hurricane. Storm surge is an abnormal rise of water generated by a storm over and above the predicted astronomical tides. During Hurricane Sandy, the largest storm surge in the Sound—12.5 feet above mean sea level—happened at Kings Point, New York.

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time (from minutes to months); climate is how the atmosphere "behaves" over relatively long periods of time. Some scientists, according to NASA, define climate as the average weather for a particular region and time period, usually taken over 30 years.

In recent years, Long Island Sound has experienced extreme weather events, including a hurricane, tropical storms, nor'easters, and a freak October blizzard. The storms have led to power outages, flooded streets, uprooted trees, and eroded shorelines. Scientists cannot say that any single weather event is the result of climate change. But climate change may increase the frequency and severity of storms. Scientists and managers are also assessing impacts to habitat quality due to long-term trends in water temperature, sea level, river flow, and other parameters that are related to climate. Going back as far as possible helps to separate long-term trends from naturally-occurring changes on decadal scales, such as in El Niño or the Atlantic Multidecadal Oscillation (naturally occurring cooling and warming trends in the Atlantic Ocean in 20- to 40-year periods).

Rising water temperatures may alter the fishery

In winter, temperatures of coastal waters throughout Long Island Sound and the Southern New England region should not vary by much. As a result, the long-term temperature datasets that exist for some locations can be used to indicate long-term temperature patterns for the entire Sound. When plotted on the same chart (see below), the datasets do behave similarly, providing evidence that, while temperatures varied year to year and were oscillating, temperatures were also rising slowly over decades of time – the equivalent of about 1 degree Celsius per century. This is consistent with the global average.

A consequence of warming temperatures might be recent changes in the abundance of fish species that have been observed in Long Island Sound. While there are many factors that influence fish populations, resource managers believe warming temperatures in the Sound and the Atlantic Ocean might be favoring the growth and recruitment of southern species over those of more cold-adapted species. Many cold-water species common in Long Island Sound have been declining in abundance over the last two decades (e.g., lobster, winter flounder, Atlantic herring, cunner, longhorn sculpin, sea raven, ocean pout, winter skate, and little skate), while many warm-water fishes have been increasing (e.g., striped bass, weakfish, summer flounder, menhaden, scup, striped sea robin, butterfish, Atlantic moonfish, and hickory shad).

Invasive species that favor warmer temperatures might also outcompete native species. Scientists are concerned, for example, that an invasive type of tunicate, which has been seen on the sea bottom in the Sound since 2000, will outcompete native organisms for food and space.

A NASA SATELLITE image captured the sediment flowing down the CT River into the Sound on Sept. 2, 2011, six days after Irene.



STORM BLOWS IN AND WREAKS HAVOC ON CT RIVER AND SOUND

NEARLY A WEEK after Tropical Storm Irene drenched New England with rainfall in late August 2011, the Connecticut River was spewing still muddy sediment into the Sound. It is a graphic reminder that what goes on the ground might eventually go into the Sound.

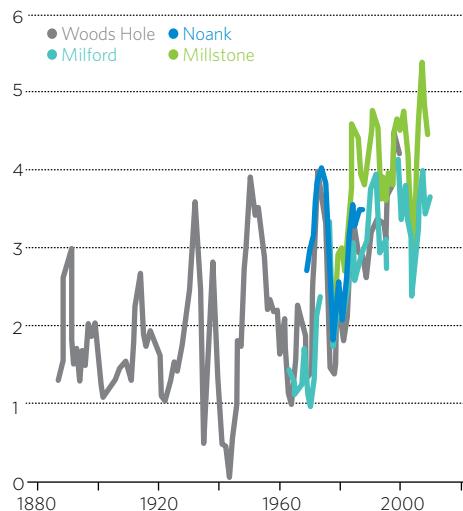
With its headwaters near the Canadian border, the Connecticut River drains nearly 11,000 square miles (28,500 square kilometers) and receives water from at least 33 tributaries in Vermont, New Hampshire, Massachusetts, and Connecticut. The 410-mile river—New England's longest—enters Long Island Sound near Old Lyme, Connecticut, and is estimated to provide 70 percent of the fresh water entering the Sound.

When Irene blew through the region on Aug. 27-28, substantial portions of the Connecticut River watershed received more than six to eight inches of rainfall and several locations received more than 10 inches. Whole towns were cut off from overland transportation—particularly upstream in Vermont, which suffered its worst flooding in 80 years. Thousands of people saw their homes flooded, if not washed off their foundations, at a time of year when rivers are usually at their lowest.

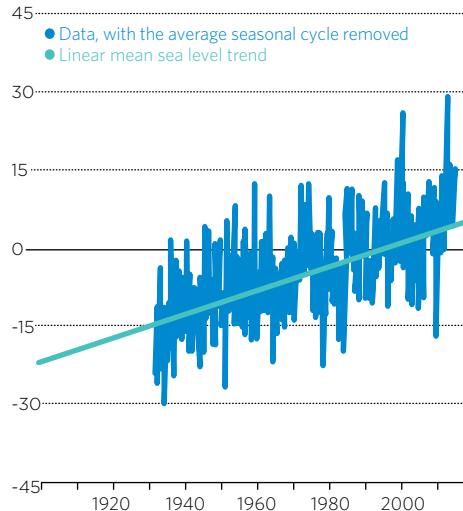
CHANGES IN SPRING FRESHET CT River (volume flow)



MEAN WINTER WATER TEMPERATURES (degrees celsius)



INCREASE IN SEA LEVEL Willets Point/Kings Point, NY (centimeters per year)



THE SPRING FRESHET, an indicator of when winter weather turns to spring, is arriving about 10 days earlier in the Connecticut River (left). The long-term trend of an overall increase in winter temperatures is similar at different stations in southern New England (middle). Kings Point has experienced gradual sea level rise, an average of about an inch per decade (right).

OYSTERMAN Brendan Smith's business was impacted by the effects of Tropical Storm Irene.

Local sea level is gradually rising

Higher temperatures cause melting of polar ice caps and glaciers, and create an expansion of seawater molecules that increase ocean volume—factors that lead to global sea level rise, according to the Intergovernmental Panel on Climate Change. IPCC estimates that the global average sea level will rise between 0.6 and 2 feet in the next century.

Gradual sea level rise is already occurring along the Long Island Sound coast. NOAA monitoring stations in the Sound have been documenting local sea level rise for decades, although it is important to note that other factors besides temperature, such as changes in the relative height of the land as a result of subsidence (gradual caving in or sinking of land) and short-term climatic fluctuations, can also play a role in local conditions. The longest documented tidal height monitoring station in the region has been operating since 1931 in Kings Point, Long Island. Over that time, there has been a mean sea level rise of 2.35 mm/year (see chart, p. 8), the equivalent of almost one inch every 10 years. Other stations in Long Island Sound and the rest of southern New England show similar trends. Tidal wetlands typically manage to accumulate enough sediment and organic matter to keep up with this naturally-occurring, gradual sea level rise. But resource managers are concerned that the marshes might not be able to keep up with rise in sea level projected for the coming decades, which will result in beach erosion and land converting to open water. They are also concerned that sea level rise, combined with high tides and heavy rains, could lead to dangerous storm surges similar to those of Tropical Storm Irene in 2011 and Hurricane Sandy in 2012 that would cause widespread flooding and damage to buildings and other infrastructure. An increased volume of salty and brackish waters flowing upstream into freshwater rivers also might alter the types of plants in upland communities, which in turn would affect the animal communities that depend on existing habitats.

The snow melt is occurring earlier

Winter snow collects in the hills and mountains of the New England countryside instead of flowing directly into the Connecticut River. As a result, the river, which provides 70 percent of the Sound's fresh water, usually experiences its lowest flows from January to March. As temperatures rise in the spring, the snow and ice melts. This leads to higher runoff and is referred to as the spring 'freshet'. By looking at 80 years of river data, scientists at the US Geological Survey and the UConn have determined that the spring freshet is occurring earlier in the spring. Using measurements of river flow from a gauge at Thompsonville, CT, (near the Massachusetts border) the investigators identified the date that the total volume of water that has passed by the gauge exceeds half of the total for the year. The critical date is called the "winter-spring center of volume" or WSCV. While spring weather in New England is quite variable, the WSCV usually occurs in late March or early April. The green line in the graph (see p. 8) shows the five year running average of the WSCV for the last 80 years. Despite large oscillations, the freshet is getting to Long Island Sound on average about 10 days earlier than it did a hundred years ago.

Changes in the timing of the freshet may have implications for some aquatic species and human activities along the coast. Flooded fields and marshes along the river during the freshet provide critical feeding areas for migratory waterfowl. So if the freshet comes earlier, waterfowl could be impacted if they do not adjust the timing of their migration. Changes in the timing of flooding may also provide a competitive advantage to invasive plants (such as purple loosestrife and *Phragmites*) in the marshes since some of these species emerge earlier than the natives. In the past, these invasives were flooded in early spring and often rotted due to submergence for prolonged periods. So, if the flooding occurs earlier, the invasives (still emerging before the natives) will no longer rot in early spring and may gain a competitive advantage over natives.



Q and A with an Oysterman

OYSTERMAN BRENDAN SMITH is the owner/operator of the Thimble Island Oyster Co., located in the Thimble Islands off Branford, CT. Brendan works to incorporate sustainable practices into each phase of oyster farming, including designing and building a solar refrigeration unit, and using recycled cages and gear. Like many shellfisherman working in the Sound, Smith faced difficult environmental conditions as a result of Tropical Storm Irene. After this interview, Smith's oyster crop was wiped out again as a result of Hurricane Sandy.

HOW DID TROPICAL STORM IRENE HURT THE HARVESTING OF OYSTERS IN LONG ISLAND SOUND?

Irene brought with it the largest storm surge since 1938. Over three feet of mud and silt came and buried my oyster cages, resulting in a loss of 80 percent of my harvestable crop. I also lost about 40 percent of my gear and have spent months with divers recovering my cages. Finally, the heavy rains shut down shellfish beds so there was nothing that could go to market for several weeks.

HAVE CONDITIONS IMPROVED?

For the first few month there was still a lot of movement of the sediment, but since November 2011 my grounds seem to be back to normal. It'll take two years to recover back to where I was, but we're back on the right track.

WHAT CAN PEOPLE ON LAND DO TO HELP ENSURE GOOD WATER QUALITY FOR OYSTER HARVESTING?

Nitrogen runoff from fertilizer is one of the prime pollutants in the Sound. Residents should use environmentally friendly products on their lawns. As a region we must also ensure that our waste water treatment plants are using the latest technologies to ensure we maintain high-quality wastewater standards in our region.

WHY IS OYSTERING GOOD FOR LONG ISLAND SOUND?

Shellfish farms significantly improve water quality and have a positive impact on our shoreline. They extract nitrogen and carbon out of waterways as well as help restore marshland. Oysters are considered a "keystone" species by conservation biologists because of the critical role they play in maintaining the structure of an ecological community. With over 80 percent of the world's oyster reefs destroyed, oyster farming is now considered vital to saving our coastal waters and our food systems. According to Mike Beck, lead marine scientist with The Nature Conservancy: "Shellfish farms represent one of the most—if not the most—sustainable forms of aquaculture and fish production." That's why oysters are now ranked as one of the top five "Super Green Seafoods" by the Environmental Defense Fund, and Food & Water Watch Smart Seafood Guide and Seafood Watch have both heralded locally-farmed oysters as central to any sustainable seafood menu. At the same time, cage culture of oysters create artificial reefs for striped bass, blackfish, and other species native to Long Island Sound.

SHELLFISH

Lobster populations continue to decline, probably due to warmer water. Oyster and clam fisheries remain viable.



DID YOU KNOW?

A single oyster or 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 remove organic material that would otherwise contribute to hypoxia.

Oysters and clams are part of a rich culinary and seafaring history. By 1898, oystermen were harvesting 15 million bushels of oysters in the Sound. But by the early 20th century, oyster beds were closing as a result of pollution, especially raw sewage in the era before modern wastewater treatment. Other damage came from poor land-use practices and sedimentation following storms.

However, the industry has managed to survive through the years as water quality and aquaculture techniques have improved. Harvests peaked in Connecticut in the early 1990s, but were decimated in the late 1990s from high mortality rates caused by MSX, a parasitic disease, that is not known to be harmful to humans. From 2005 to 2008, the industry rebounded and harvests increased by 600 percent. Since 2008, Connecticut shell fishermen have not been reporting their oysters and clam harvest data, but state managers report that efforts to rebuild stocks through proven historical cultivation and farming practices have resulted in dramatic increases in oyster harvests. These efforts include lining shellfish beds in tributaries and coastal water areas known for high levels of breeding success with clean shell for oyster larvae to attach to during their spawning period, and transplanting young seed oysters to deeper waters. Oyster production in 2011, however, was hurt by the flow of sediment discharged into oyster beds during Tropical Storm Irene. In 2009, New York's oyster production dropped by more than half, possibly due to consumers buying fewer oysters during the recession and oystermen seeking other areas on Long Island to harvest, according to New York resource managers. Harvests started to increase again in 2010.

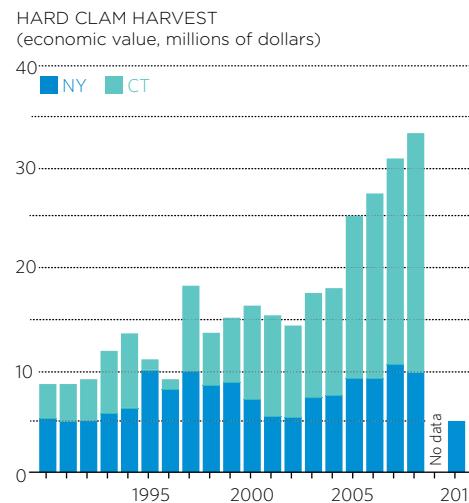
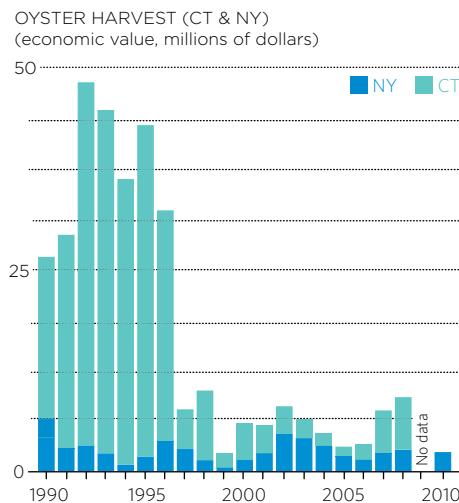
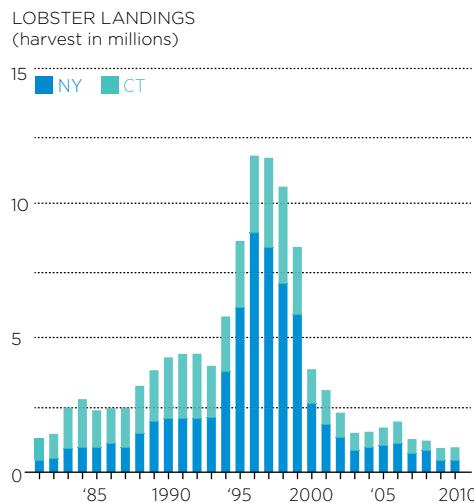
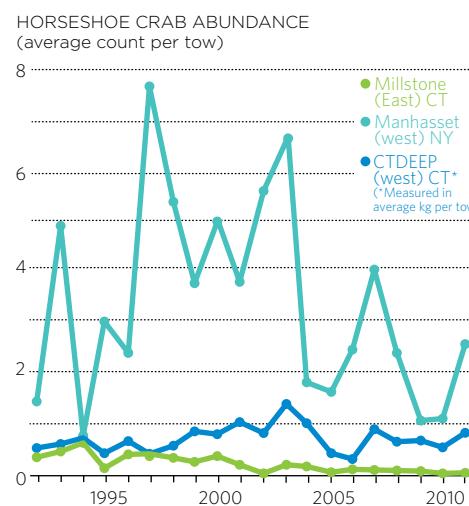
Lobster harvest from the Sound has also declined dramatically since 1999 when the population suffered a die-off due to sustained stressful environmental conditions. Scientists found evidence that lobsters, at an all-time high abundance in the late 1990s and a peak harvest value of almost \$40 million, are now experiencing a recruitment failure with little sign of recovery. Known stressors include water temperatures exceeding 20°C, which are now common in summer and cause lobsters to hyperventilate. Weakened by these conditions, lobsters become susceptible to several diseases and cannot efficiently feed or reproduce. In an effort to sustain a viable lobster stock, all states from Massachusetts to Virginia, in coordination with the Atlantic States Marine Fisheries Commission, have tightened harvest limits. New York and Connecticut will reduce the harvest season by 11 weeks beginning in 2013. Other invertebrates commercially harvested from the Sound include horseshoe crab (see sidebar), squid, and conch (whelk).

A HORSEHOE CRAB on Long Wharf Beach in New Haven.



HORSESHOE CRABS

WITH THEIR SPIKY TAILS (or telson) and helmet-like shells, American horseshoe crabs strike a unique figure when they come ashore on Long Island Sound beaches every spring to mate and lay eggs. The horseshoe crab (*Limulus polyphemus*) is actually an arthropod more closely related to spiders than other crabs and has a body form that evolved more than 300 million years ago. These ancient creatures are a valuable part of the ecosystem. Their eggs are an essential food source for migrating shorebirds. They also are valuable to humans for their blood proteins, which are extremely sensitive to bacteria. The extracted compound, known as LAL, is used to screen injected drugs and implanted biomedical devices for contamination. The crabs also harvested as preferred bait for the increasingly popular whelk fishery, among others. This species ranges from Nova Scotia to Mexico and lives year round in the Sound. Surveys conducted by Connecticut and New York show stable or increasing abundance of horseshoe crabs in the central and western Sound since the 1990s. Although abundance was equally strong in the eastern Sound and Peconic Bay in the early 1990s, it has steadily declined since 1995, currently reaching very low levels. Resource managers are unsure why the trends are diverging. Since horseshoes rely on beaches and shallow embayments to produce their young, their abundance is an indicator of the health and productivity of these transitional environments.



HORSEHOE CRAB POPULATIONS are increasing or remaining stable in the Western Sound, but are declining in the east (top, right). Lobster harvests continue to decline (left). Clam harvests have been steadily increasing, while oyster harvests are beginning to increase following a parasitic outbreak in the 1990s (middle and right).



FINFISH

SCUP, OR PORGIES, are increasing in abundance in Long Island Sound.

Populations of some fish species have increased over time, while others have decreased. The overall biomass of finfish, however, has held relatively constant.



DID YOU KNOW?

Diadromous fish are fish that migrate between the ocean and freshwater streams and rivers. Anadromous fish migrate upriver from the sea to breed in fresh water, while catadromous fish migrate down river to breed in ocean waters. The American eel is an example of a catadromous fish. It lays its eggs in the Sargasso Sea between the West Indies and the Azores, which drift into the Gulf Stream as larvae and eventually make their way as juvenile fish to the Sound and to freshwater streams where they feed and mature.

The waters of Long Island Sound provide nursery and feeding grounds for over 100 species of finfish. The Sound's wide variety of bottom types, water depths, currents, and tidal ranges create different types of habitat that attract this large array of species.

CTDEEP's Long Island Sound Trawl Survey (LISTS) has tracked the abundance of all these finfish since 1984. LISTS biologists began generating an annual Biomass Index (average weight of all finfish collected in each sample) in 1992 to measure overall fish abundance in the Sound. This index shows no trend up or down, a sign of a stable ecosystem even as some species have increased and others declined. Another signal of the Sound's health is the Forage Fish Index, a composite accounting of 14 common species that are important components of the food web. This equally stable index indicates that the Sound has a sufficient food base to support a wide diversity of resident marine and migratory species.

Charts of two game fish on this page show the abundance and variability of individual species targeted by anglers. For example, increasing abundance of scup (porgy) in recent years has made this species one of the largest contributors to the Biomass Index. At the other end of the spectrum is winter flounder, which once supported important commercial and recreational fisheries, but now is in such low abundance that harvest is severely restricted. There are several competing reasons why some species are enjoying record high numbers while the abundance of others has plummeted. Coast-wide management plans designed to protect stocks from depletion are in place for all species subject to substantial harvest. Managed species such as scup, summer flounder, and striped bass have flourished coast-wide while supporting strong commercial and sport fisheries. These mid-Atlantic species also may be increasing in abundance in the Sound because they have taken advantage of increasing water temperature. The abundance of winter flounder, a species more common in northern waters, may be declining because they are now exposed to increased mid-Atlantic predators, as well as cormorants and seals. However, not all warm-tolerant species are flourishing; tautog and weakfish have also dropped in abundance, indicating that there are many other variables playing a role in fashioning the mix of species swimming in the Sound.

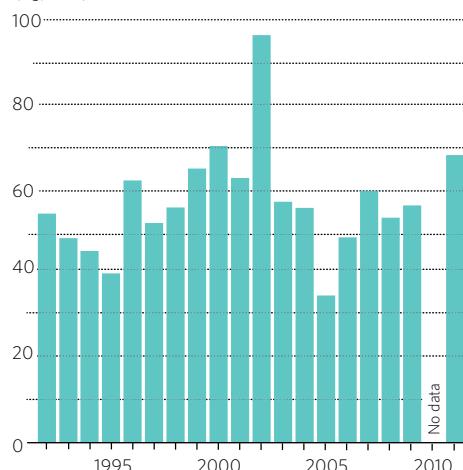
Although one or two species can be large contributors to a year's biomass index, on average more than 11 species are caught each time the LISTS trawl net comes up. This relatively high diversity is another measure of the health and vitality of the Sound's aquatic community.



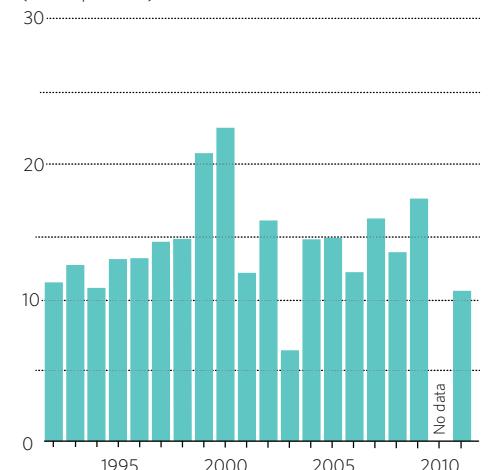
LIS FISH CONSUMPTION ADVISORIES

FISH CAUGHT FROM THE SOUND are a nutritious and flavorful food source, but Connecticut and New York Health Department consumption advisories should be followed, particularly by groups with the greatest risk from contaminants—women of child-bearing age and young children. Check www.LIShealth.net for links to the full advisories.

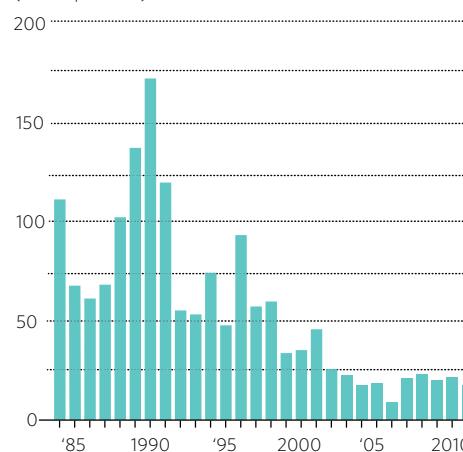
FINFISH BIOMASS INDEX (kg/tow)



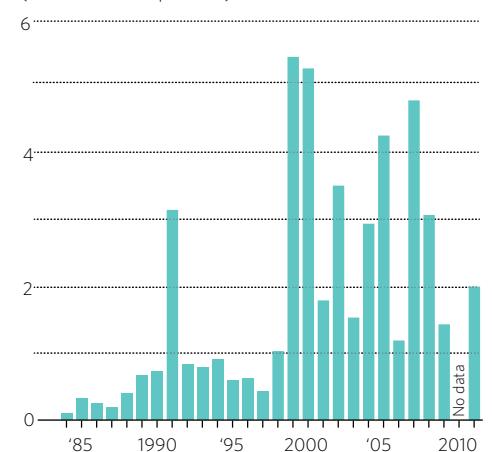
FORAGE FISH INDEX (count per tow)



GAME FISH ABUNDANCE/WINTER FLOUNDER (count per tow)



GAME FISH ABUNDANCE/SCUP (hundred count per tow)



THE BIOMASS AND FORAGE FISH INDEXES reflect ecosystem stability (top). The decline in winter flounder and increase in scup show that abundance of individual species can vary, even while overall abundance is stable.

COASTAL BIRDS

ROSEATE TERNS on Great Gull Island

Concerted efforts to protect beach nesting birds have resulted in mostly stable populations, despite increasing threats from habitat loss and human activity.



DID YOU KNOW?

Small islands in New York City provide critical nesting grounds for several waterbirds. For example, the seven-acre South Brother Island in the East River off Manhattan was home to 387 nests of five waterbird species in 2011, according to the New York City Audubon Harbor Heron project.

ABOVE: Snowy egret on South Brother Island.

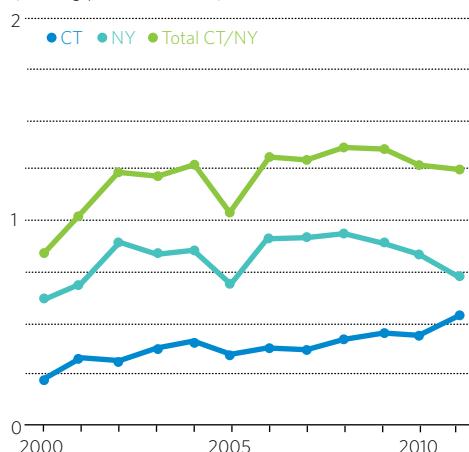
More than 400 bird species live in coastal habitats in Long Island Sound, feeding on fish, shellfish, worms, and other wildlife in the estuary. Because of their diverse nesting and feeding habits, birds are important indicators of the overall health of the Sound's ecosystem.

The abundance of piping plovers, for example, indicates if there is sufficient food as well as beach habitat on the Sound's coast. Piping plovers are small shorebirds that nest on beaches and eat crustaceans, spiders, and insects. They are listed as an endangered species by the US Fish and Wildlife Service. Their nesting and reproduction are threatened by human intrusion, storm tides, and predators. Since protection and monitoring efforts began in 1984, nesting success has improved, resulting in more returning adults. Connecticut has met its restoration target of 30 or more pairs of plovers for the past 11 years. New York's counts, after improving for several years, dropped in 2009, possibly due to severe storms that may have destroyed eggs. Overall, state wildlife officials credit intensive on-site management, including construction of predator-proof fences around nests to protect eggs, for the improvement. Regulation of activities that impact beach habitats, as well as the public's cooperation in response to public education campaigns, have also helped to protect plover populations.

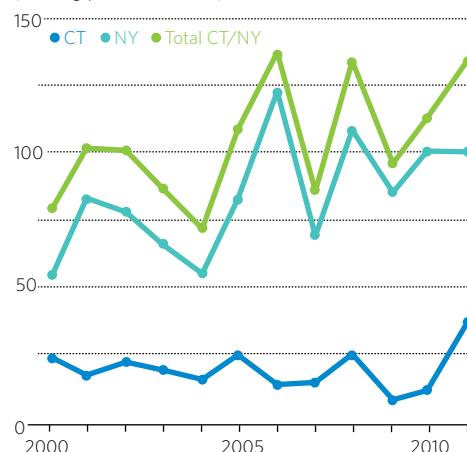
Least terns live on beaches in large colonies and plunge into nearby waters to catch small fish. They are a threatened species in New York and Connecticut. Predators, human disturbances, and tidal flooding can disrupt tern nesting sites, but the terns have been found to recolonize on other beaches within a four-state region that also includes Rhode Island and Massachusetts. In 2011, there were 7,078 least tern pairs in the region, 735 pairs above the 20-year average. In 2011, approximately 361 pairs of least terns nested along the shoreline in Connecticut, an increase of 401 percent from 2009 when there were 90 pairs.

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 shrub and woodland habitats, and often feed on estuarine fish and invertebrates in nearby salt marshes. Although the populations have been relatively steady since 1998, there has been a 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. Additionally, a loss of nesting habitat, including from human disturbance, a loss of wetlands important for feeding, and exposure to contaminants may have contributed to the declines.

PIPING PLOVERS
(nesting pairs, hundreds)



LEAST TERNS
(nesting pairs, hundreds)



PIPING PLOVERS HAVE INCREASED despite a decline in New York since 2009. Least tern populations vary year to year because the birds colonize back and forth between a four-state region. Colonial waterbird populations are stable (see LIShealth.net for chart).



ROSEATE TERNS

A TINY ISLAND AT THE FAR eastern end of Long Island's North Shore is home to almost half of the northeast North American population of roseate terns, a migratory bird listed as endangered by the US Fish and Wildlife Service.

Although only 17 acres in size, Great Gull Island was home to 1,500 pairs of summer nesting roseate terns in 2011 compared to a total of 3,139 pairs of the birds counted in all of the northeast US and Canada. While roseate terns live on all continents, they nest only in North America along the Atlantic Coast.

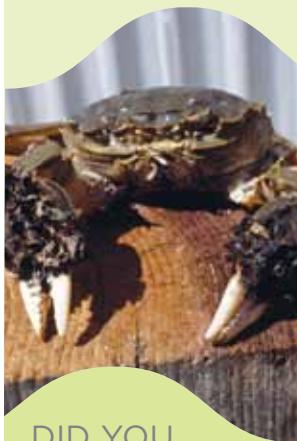
The roseate tern is a slender bird with a body that is approximately 35 to 40 cm in length. Its tail is deeply forked with white streamers. On Great Gull Island, the birds nest under boulders that were dropped by the US government around the edge of the island to help stabilize the shoreline.

The island once housed a fort in the 19th century to protect New York from British invasion. Since 1949 the island has been owned by the American Museum of Natural History for a bird research station and sanctuary. Helen Hays, who has been managing the island since 1969, said that the roseate tern population on the island has been stable for several years. She also said that the common tern, which is listed as endangered in New York, has seen its population rise from 2000 pairs in 1966 to 10,000 pairs in 2011. Unlike roseate terns, common terns nest in open areas. Hays credits the introduction of the meadow vole, which clears ground areas by eating the grass, for the increase.

HABITATS

MOWING PHRAGMITES at a wetlands habitat in New London.

Despite laws to protect wetlands, coastal habitat loss continues to occur for a variety of reasons.



DID YOU KNOW?

The first sighting of the Chinese mitten crab near Long Island Sound was found in the Mianus River in Greenwich in June 2012. Read more about the crab and why it is potentially harmful to the Sound's ecosystem in LIShealth.net

Estuaries, semi-enclosed bodies of water that mix salt water from the open sea with fresh water from streams and rivers, are among the most productive environments on earth. Estuaries such as Long Island Sound create more organic matter each year than comparably-sized areas of forest, grassland, or agricultural land. The tidal, sheltered waters of estuaries also support unique communities of plants and animals especially adapted for life at the margin of the sea. The Sound, for example, is home to more than 1,300 species of invertebrates and finfish.

Thriving estuaries contain a variety of healthy coastal habitats. The LISS Habitat Restoration Initiative has identified 12 habitats as priorities for restoration and protection, ranging from submerged aquatic vegetation to rivers free of restrictions for fish passage to coastal grasslands.

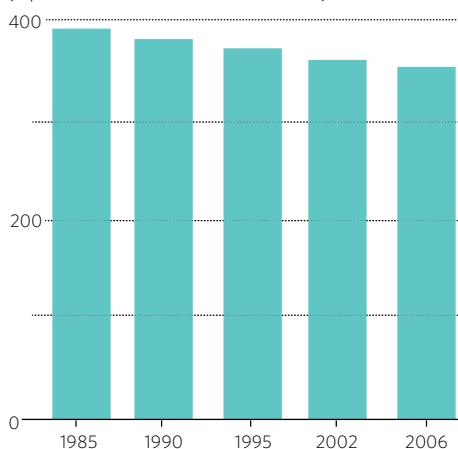
Among the most critical habitats are tidal wetlands. The vegetation in this habitat provides food, shelter, and breeding or nursery grounds for many species of wildlife. The marsh vegetation also protects the land from flooding and erosion, and filters pollutants contained in stormwater runoff. Today, there are about 21,000 acres of tidal wetlands along the Sound's shoreline. Federal and state agencies regulate new development on wetlands, but in the past wetlands were filled and dredged for development. About 25 to 35 percent of the Sound's tidal wetlands were lost before laws protecting them were enacted in the early 1970s. But despite protection and restoration efforts, marsh grasses are still disappearing, with hundreds of acres converting to mudflats in the past 35 years. For example, mudflats at Scott Cove in Darien, Connecticut increased by 17 acres from 1974 to 2004, while marsh grasses declined by 17 acres. It was one of six wetland complexes in southwestern Connecticut that showed a total decline of 53 acres of marsh grass. A similar survey in Long Island at four wetland complexes from 1974 to 2005 revealed a loss of 88 acres of marsh grasses.

The reasons for this marsh loss are 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. New research also suggests that nutrient runoff from sources such as lawn fertilizer and septic tanks might play a role in the deterioration of marshes.

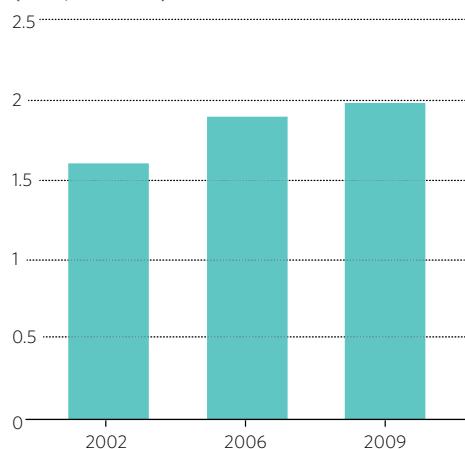
Coastal forests are another important habitat. Northeastern coastal forests are home to a rich diversity of animal species, but according to the World Wildlife Fund more than 98 percent of the region's natural habitat have been lost due to suburban sprawl. Much of what remains are fragmented or degraded forests. According to research done at UCONN's Center for Land Use Education and Research, the Sound has lost about 36 square miles of coastal forested land from 1985 to 2006.

In the water, there are also distinct habitats, including submerged aquatic vegetation such as eelgrass meadows. Eelgrass, a rooted underwater grass, grows along our coasts, providing food and nursery grounds for fish and protecting shorelines from erosion. It is now found predominantly in the eastern portion of the Sound. Its abundance plummeted in the 1930s

CHANGES IN FOREST COVER (square miles of forested coastal area)



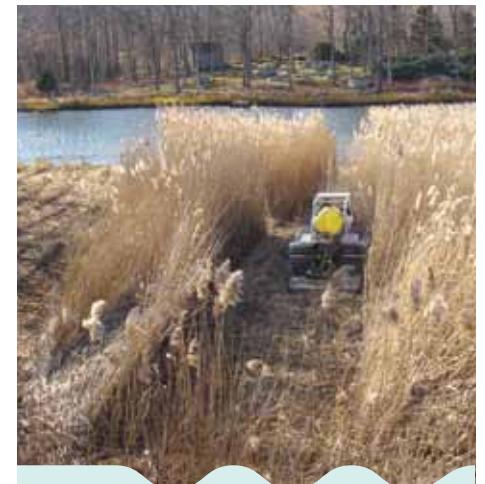
EELGRASS ABUNDANCE (acres, thousands)



FOREST COVER ALONG the Long Island Sound coast has declined by about 36 square miles from 1985 to 2006. Recent surveys have observed more eelgrass, but improved monitoring techniques may have contributed to the increase. Further surveys will help to determine the trend.

due to a fungal disease and continued to decline for decades as a result of poor water quality, which has been attributed in part to nitrogen pollution from sewage discharges and stormwater runoff.

A LISS-funded 2009 survey conducted by FWS identified 1,980 acres of eelgrass, all in the Eastern Sound, compared to 1,559 acres surveyed in 2002. Improved monitoring techniques that may have identified acreage unaccounted for in the earlier survey may be partially responsible for the increase in acres observed. A new survey was conducted in 2012 and will be assessed by early 2013. Continued monitoring will be required to determine long-term trends.



HABITAT INVADERS

PLANT AND ANIMAL SPECIES that are not native to Long Island Sound can cause environmental and economic harm according to the Long Island Sound Interstate Aquatic Invasive Species Task Force.

Invasive species can range in size from tiny parasites posing threats to fish and shellfish to mute swans that destroy eelgrass. If they outcompete natives, they can harm the environment because they often provide less value as food or shelter.

According to a draft Task Force report, there are at least 90 species in the Sound that could possibly meet the definition of invasive species that cause environmental and economic harm. An example is *Phragmites australis* or the common reed, considered by the Task Force to be "one of the preeminent threats to salt marsh habitat." *Phragmites* competes with native salt marsh grasses when salinity declines. It can form dense colonies, creating a nearly impenetrable barrier to the movement of animals and large birds, such as ducks, shorebirds, and wading birds. According to CTDEEP, as much as 10 percent of Connecticut's tidal wetlands are dominated by *Phragmites*. There are several strategies to eradicate *Phragmites* including using herbicides and restoring saltwater tidal flow to wetland complexes that have been compromised by railroads, roads, causeways, or dikes. Both Connecticut and New York have restored wetlands by upgrading tidal gates to allow tidal flow to support salt marsh plants.



LAND & PEOPLE

People love the coast and the Long Island Sound region, but increasing population and development can impair water quality.



DID YOU KNOW?

Long Island Sound has 600 miles of coastline. All around the Sound community groups are doing their share to protect habitats and wildlife, and improve water quality. Visit LISvolunteer.net to learn more.

ABOVE: Volunteers in Clinton, CT, weave eelgrass shoots into burlap disks to be planted by SCUBA divers to create eelgrass meadows.

Long Island Sound faces environmental pressures from the impact of millions of people living within a short drive of its shoreline. For example, each day millions of gallons of treated sewage from coastal municipal wastewater treatment plants are discharged into the Sound—free of pathogens thanks to modern plant upgrades, but not totally free of nutrients that lead to algal blooms and oxygen-depleted waters. But even while coastal communities have the most impact on the Sound, watershed residents who live hundreds of miles from the Sound can also have an impact. Everyone in the watershed shares some responsibility for the Sound's water quality because pollution in the watershed that originates from industrial plants, cars, streets, parking lots, lawns, and farms can deposit or flow into the Sound from storm drains, streams, rivers, and groundwater.

What is the Long Island Sound watershed?

The Long Island Sound watershed is all of the land area that drains directly into the Sound or to the bodies of water that connect to the Sound. The watershed of Long Island Sound covers more than 16,000 square miles in Connecticut, New York, and four other states—Massachusetts, Rhode Island, New Hampshire, and Vermont. Connecticut has 5,375 square miles in the watershed and New York has 428 square miles, covering mostly shoreline communities in Long Island, Queens, the Bronx, and Westchester. Another way to look at the watershed is that it consists of major drainage basins, areas that drain into the Sound's largest river systems, and then into Long Island Sound. The Connecticut River basin is the largest, delivering about 70 percent of all of the Sound's fresh water. It begins 407 miles north of the coast near the Canadian border.

THE DRAINAGE BASINS with the highest impervious cover (in red, right) indicate severe degradation of water quality. Areas with high amounts of impervious cover are more likely to have streams with poor water quality.

The watershed population is increasing

Nearly 9 million people live in the watershed, according to the 2010 US Census, an increase of about 3.5 percent from 2000. This increase tracks closely with the 3.2 percent population growth for the Northeast during the same period. About 80 percent of the population lives in Connecticut and New York, including an estimated 3 million people who live within a few miles of the shoreline (the Long Island Sound Study coastal study area). The counties experiencing the greatest population growth lie in eastern Long Island and eastern Connecticut. The county with the highest growth rate, 12 percent from 2000-2010, is Tolland County in northeastern Connecticut.

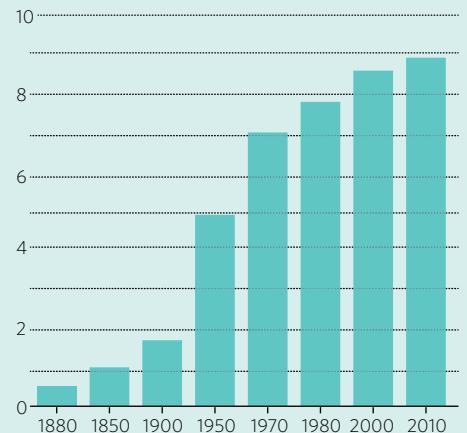
Connecticut is adding more impervious cover

Impervious cover is any surface in the landscape (such as streets and parking lots) that cannot effectively absorb or infiltrate rainfall. In the watershed, New York's impervious cover is 17 percent of its total land cover compared to seven percent in Connecticut, a reflection of a greater percentage of its population living in urbanized areas. From 1985 to 2006, Connecticut added about 40 square miles of impervious cover compared to 1.6 square miles in New York. Population growth for both states, is about the same, an indication that New York is adding population mainly in its existing built environment, while Connecticut is adding population into previously undeveloped areas.

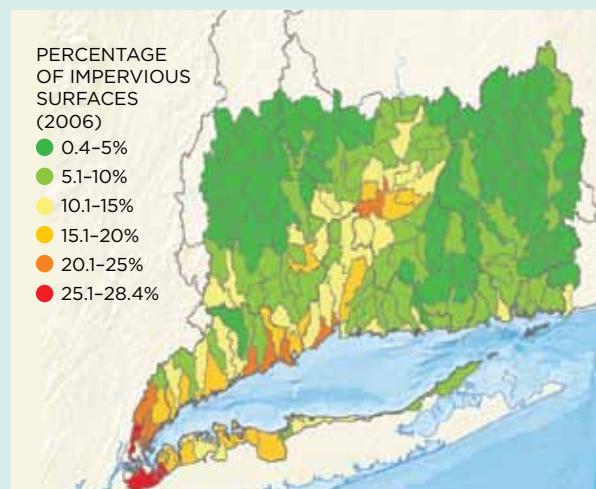
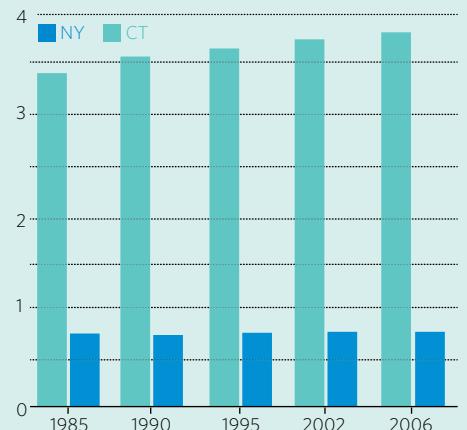
Impervious cover affects water quality

Each of the major drainage basins can be broken down into smaller basins with tributaries that flow into the larger rivers and the Sound. The basins that have high amounts of impervious cover threaten these tributaries because stormwater can carry pollutants from hard surfaces directly into streams or into storm drains that discharge into streams. An Impervious Cover Model based on hundreds of studies around the country predicts that water quality starts to degrade when a basin has 10 percent impervious cover, and severe degradation begins when there is 25 percent impervious cover. Based on the model, 73 percent of the Sound's 194 drainage basins in New York and Connecticut, covering 4,254 square miles, have impervious cover of less than 10 percent, indicating good stream quality, 25 percent of the basins, covering 1,468 square miles, have impervious cover between 10 and 25 percent, indicating signs of degradation, and 2 percent of the basins, covering 81 square miles, have large amounts of impervious cover, indicating severe degradation and poor stream health.

WATERSHED POPULATION
(number of people, millions)

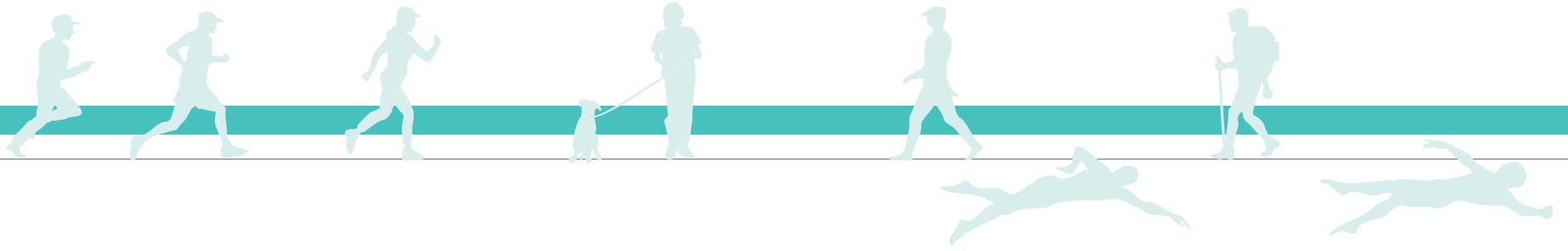


IMPERVIOUS COVER (IC) IN LIS WATERSHED
(square miles of IC, hundreds)



Analysis of land cover data from 1985 to 2006 by UConn's Center for Land Use and Education Research showed that four basins totaling 119 square miles that previously were less than 10 percent impervious cover now fall into the 10-25 percent class—two are along the coast in Fairfield County and New London County and two are upland in the Connecticut River basin.

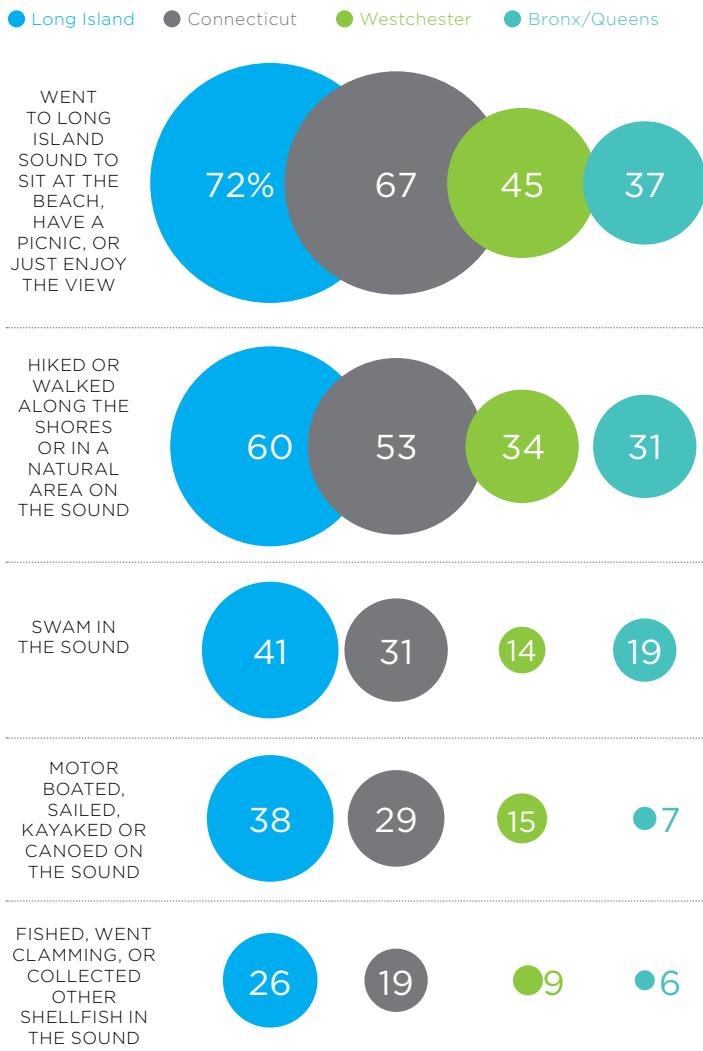
Most of the basins with high impervious cover are in the densely populated area around the Western Sound. Conditions by Basin (see p. 5) describes how water quality is affected by development and population patterns.



Long Island Sound is a highly-valued resource

People value the Sound for its recreational resources. Visit a harbor or beach on a warm day and you will likely see scores of people boating, fishing, swimming, or simply enjoying the view. All this activity results in the Sound being a great economic resource. Adjusted to 2011 dollars, a 1990s study estimated that water quality dependant activities, such as boating, beachgoing, and fishing, are worth \$8.91 billion dollars each year to the local economy.

PERCENTAGE OF LIS WATERSHED RESIDENTS PARTICIPATING IN SOUND ACTIVITIES IN SUMMER 2006, BY REGION



Millions of people fish and swim in the Sound

In 2011, about 7.4 million fish were caught in Long Island Sound by recreational anglers, according to NOAA, which collects data on recreational boating and fishing of US waters. Some of the most popular fish caught included scup (2.3 million caught) and bluefish (2 million). These anglers took 2.15 million boat trips in 2011 to get their catch, according to NOAA. About 70 percent of the fish were released back into the Sound to comply with fishing regulations that help protect species populations.

Another popular activity is swimming at the Sound's 210 bathing beaches. Beach attendance at the six top beaches in the watershed totaled 6.4 million people in 2010. The beach with the highest attendance in Connecticut that year was Hammonasset State Beach at 2.2 million. The highest attendance in New York in 2010 was Sunken Meadow State Beach at 1.6 million.

Passive activities are popular

Fishing and swimming were identified in a 2006 Public Perception Survey, conducted by Stony Brook University's Center for Public Survey Research, as important activities for people who valued the Sound. But the survey also identified passive non-water activities as even more popular among Long Island Sound residents. For example, in Nassau and Suffolk counties, sitting at the beach, having a picnic, or enjoying the view was the most commonly reported Long Island Sound activity (at 70 percent) by the survey respondents followed by walking along the shore or in a natural area on the coast.

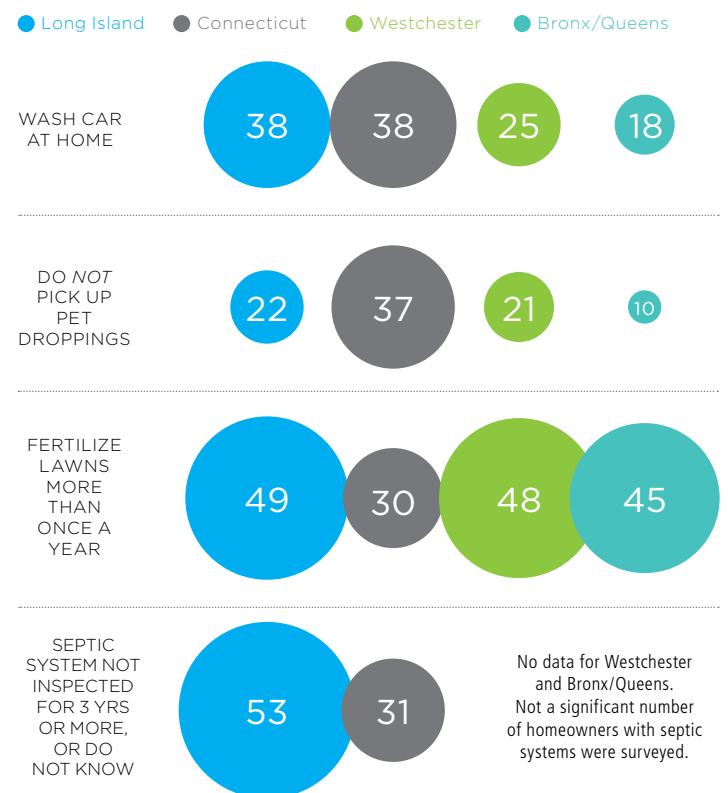
One of the most popular shoreline activities, birding, is also a four-season activity. Audubon's Christmas Bird Count, for example, recruits citizen volunteers to count birds as part of a research effort to monitor the health of bird populations. In the winter of 2010-2011, nearly 67,000 people helped to count different bird species totaling 305,000 birds in areas around the Long Island Sound shoreline.

The Christmas Bird Count provides an opportunity to engage people who enjoy the Sound to volunteer to restore and protect it. Throughout the Sound, thousands of citizens volunteer each year to monitor water quality of local harbors, to monitor the abundance of shoreline animals such as horseshoe crabs and diamondback terrapins, work with environmental organizations to restore habitats by removing invasive species or planting native plants, and participate in beach cleanups.

Most residents are unaware how behaviors affect LIS

Long Island Sound residents care about the environment, but many are uncertain about how their behaviors have an impact on the Sound. According to the 2006 Public Perception Survey, about 70 percent of residents said that protecting the environment was more important than economic growth. But many residents reported that they engaged in activities that were potentially harmful to the Sound, including over fertilizing lawns and washing cars on pavement. Furthermore, more than 70 percent of residents in the coastal communities reported that they believed they did nothing to worsen the quality of water in Long Island Sound even though they were just as likely to partake in activities that were potentially harmful to the Sound as those who said their activities could contribute to water quality degradation.

PERCENTAGE OF LIS WATERSHED RESIDENTS WHO ENGAGE IN POTENTIALLY HARMFUL BEHAVIORS, BY REGION, 2006



WHAT YOU CAN DO

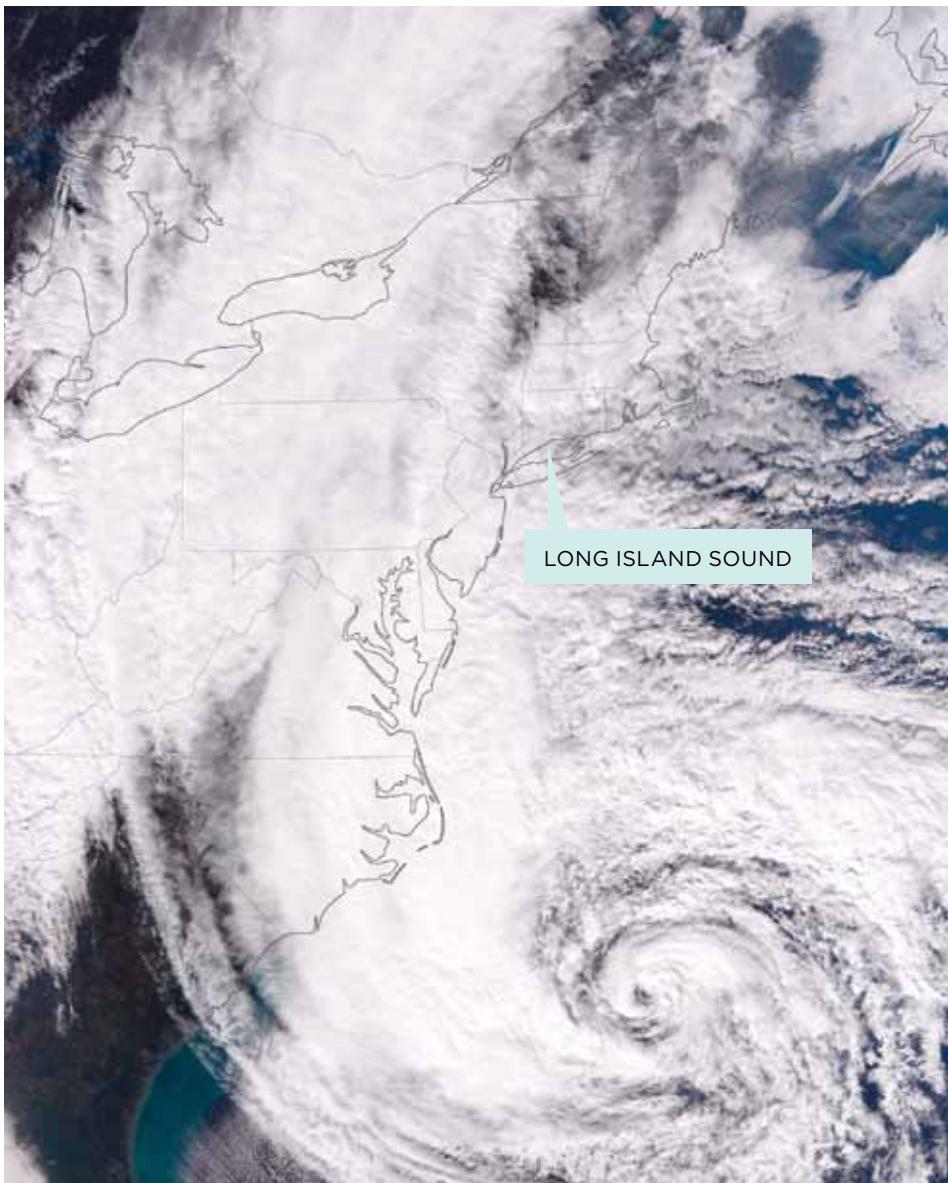
THERE ARE MANY WAYS that you can help, by changing some simple things you do around your home, community, and on the shore. Remember, we all affect the Sound. Trash we leave on the ground or liquids we pour down the drain can eventually lead to Long Island Sound and pollute it.

AT HOME: When it comes to fertilizer, more is not better. Healthy lawns help prevent erosion, but excess fertilizer that is not absorbed by your lawn or garden can be carried away with the rain and end up in Long Island Sound. Use organic, slow-release fertilizers, test your soil before applying and never fertilize before a rainstorm! Strive for zero runoff on your property.

ON THE SHORE: 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.

For more tips, go to LIShealth.net

HURRICANE SANDY



Hurricane Sandy blew into the region on Oct. 29, 2012. The storm surges and heavy winds from the storm led to loss of life and billions of dollars of property damage. It also wiped away dunes, altered other shoreline habitats, and led to the discharge of toxic contaminants and pathogens into the Sound. Hurricane Sandy and Tropical Storm Irene, which struck in 2011, are vivid examples of the kinds of extreme weather events that scientists forecast will increase as a consequence of climate change. For more information about the impacts of climate and weather to the Sound, see pages 8 and 9.

A NASA SATELLITE IMAGE shows the eye of Hurricane Sandy on Oct. 28, 2012 approaching the coast about 575 miles from the Sound (top left). Water pollution and shoreline destruction along the CT coast in the wake of the storm (top right). Floods and heavy winds destroyed parts of the boardwalk and caused other damage at Rye Playland and the Edith Read Wildlife Sanctuary in Rye, NY (bottom left).

SOUND HEALTH 2012

MARK TEDESCO (Director)
EPA Long Island Sound Office

ROBERT BURG (Editor)
New England Interstate Water Pollution
Control Commission (NEIWPC)

SARAH DEONARINE (Technical editor)
New York State Department of
Environmental Conservation

MARK PARKER (Technical editor)
Connecticut Department of Energy
and Environmental Protection

LUCY READING-IKKANDA (Designer)

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.

The Long Island Sound Study (LISS) appreciates the many people in the EPA, CTDEEP, NYSDEC, Interstate Environmental Commission, NEIWPC, NYC Department of Environmental Protection, New York and Connecticut Sea Grant programs, and US Fish and Wildlife Service, who assisted in preparing Sound Health 2012. If you are interested in receiving our newsletter, Sound Update, or have comments or questions about LISS and Long Island Sound, contact us by:

E-MAIL

info@longislandsoundstudy.net

MAIL

EPA Long Island Sound Office
Stamford Government Center
888 Washington Blvd.,
Stamford, CT 06904-2152

TELEPHONE

EPA Long Island Sound Office
203.977.1541

LISS Public Outreach Coordinator/NY
631.632.9216 (NY Sea Grant)

LISS Public Outreach Coordinator/CT
860.405.9303 (CT Sea Grant)

STATE CONTACTS

NYSDEC Bureau of Marine Resources:
631.444.0430

CTDEEP: 860.424.3000

WEB

www.longislandsoundstudy.net
www.LIShealth.net



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