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Hypoxia

The Problem

During the summers of 1987-93, from half to two-thirds of the Sound's bottom waters experienced dissolved oxygen levels below 5 milligrams of oxygen per liter of water (mg/l) (Figure 2). Levels of dissolved oxygen of 5 mg/l and higher are generally accepted as being protective of the Sound's estuarine life. In 1989, a particularly bad summer, more than 500 square miles (40 percent) of the Sound's bottom waters had dissolved oxygen levels less than 3 mg/l. During most of these years, dissolved oxygen in a portion of the Sound (up to 50 square miles) fell below 1 mg/l and in 1987 anoxia, the absence of any oxygen, was recorded in a portion of the Western Narrows.

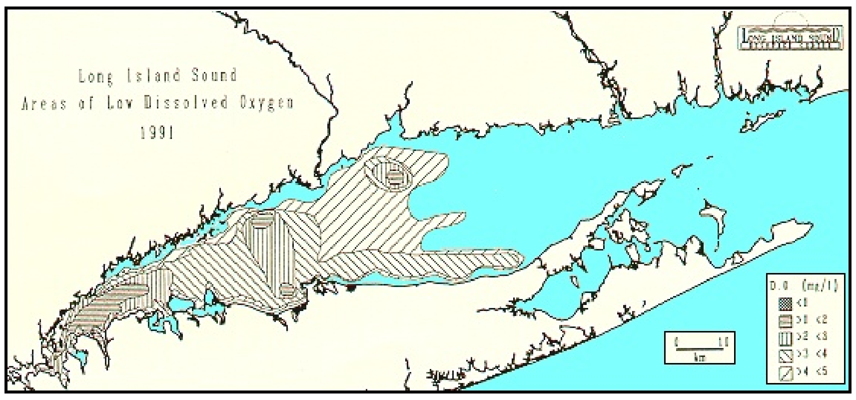
A fish kill in the Mianus River, CT, summer 1988 (Photo: R. D'Amico)

These low levels of dissolved oxygen cause significant, adverse ecological effects in the bottom water habitats of the Sound. To date, research shows that the most severe effects (such as mortality) occur when dissolved oxygen levels fall below 1.5 mg/l at any time and below 3.5 mg/l in the short-term (i.e., 4 days), but that there are probably mild effects of hypoxia when dissolved oxygen levels fall below 5 mg/l. The levels regularly observed in the Sound during late summer:

- Reduce the abundance and diversity of adult finfish;
- Reduce the growth rate of newly-settled lobsters and perhaps juvenile winter flounder;
- Can kill species that cannot move or move slowly, such as lobsters caught in pots and starfish, and early life stages of species such as bay anchovy, menhaden, cunner, tautog, and sea robin;

EXHIBIT M

- May reduce the resistance to disease of lobsters and other species; and
- Diminish the habitat value of Long Island Sound.



Low Dissolved Oxygen in the Sound

The Cause of the Problem

Excessive discharges of nitrogen, a nutrient, are the primary cause of hypoxia. Nitrogen fuels the growth of planktonic algae. The algae die, settle to the bottom of the Sound and decay, using up oxygen in the process.

Natural stratification of the Sound's waters occurs during the summer when warmer, fresher water "floats" on the top of cooler, saltier water that is more dense. This natural stratification forms a density difference between the two layers called a pycnocline. This prevents mixing of surface and bottom waters.

Oxygen from the atmosphere and photosynthesis keep the surface layer well oxygenated, but the oxygen cannot pass through the pycnocline into the bottom layer very easily. Decaying algae and other organic material in the sediment and animal respiration in the bottom layer use up oxygen faster than it is replenished. Hypoxia develops and usually persists as long as the stratification lasts (usually one to two months in late summer).

But hypoxia in Long Island Sound is too complex to fully understand using direct observations alone. Natural variations in weather and other physical factors affect the extent and severity of hypoxia. The Management Conference has constructed mathematical models in order to understand the relationship among natural variations, human-caused pollutant loadings to the Sound, and dissolved oxygen levels in the Sound. Work has been completed on LIS 2.0, a two-dimensional water quality model that provides the technical basis for the hypoxia management actions described in the plan. In June 1994, the Management Conference will complete work on LIS 3.0, a three-dimensional water quality model that will better define the area impacted by hypoxia. LIS 3.0 will be used as a tool to implement the plan and establish a detailed, cost-effective management program to reduce hypoxia.

LIS 2.0 provides a level of detail that allows the Management Conference to draw some clear conclusions about hypoxia in the Sound, its causes, and its solutions. Using LIS 2.0, the Management Conference has simulated water quality conditions as they were in the past, as they are today, and as they would be in the future under alternative nitrogen control scenarios. The model provided a cost-effective way of understanding the Sound and hypoxia.

- The most oxygen that can be dissolved in Long Island Sound at summer water temperatures is about 7.5 mg/l. This is known as the saturation level.
- In pre-Colonial days, natural, healthy biological activity brought dissolved oxygen levels below saturation due to the natural loadings of organic material and nitrogen, but oxygen levels probably were not below 5 mg/l.

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- Under today's nutrient and organic material loading conditions, minimum dissolved oxygen levels average approximately 1.5 mg/l. These levels are associated with severe hypoxia and have been documented in the field.
- By substantially reducing nitrogen loadings to the Sound from sources within its drainage basin, the minimum dissolved oxygen levels in the bottom waters during late summer can be increased to an average of about 3.5 mg/l, thereby significantly reducing the probability and frequency of severe hypoxia and reducing the area affected by hypoxia.

Understanding the components of the load of nitrogen entering the Sound is fundamental to understanding the plan (Figure 3):

- In 1990, defined as a baseline year by the Management Conference, the total nitrogen load was 90,800 tons per year.
- By 1992, the total nitrogen load had increased to 93,600 tons per year; this increase was anticipated and was a consequence of terminating ocean disposal of sewage sludge from New York City and the need to treat some of the sludge at facilities within the basin, reintroducing nitrogen to the wastestream.
- Of the 93,600 tons per year, approximately 39,900 tons are from natural sources and not subject to reductions by management activity.
- The remaining 53,700 tons of nitrogen per year are associated with human activities and have the potential to be reduced through management actions.
- 10,700 tons of nitrogen per year enter the Sound through its boundaries — the East River in the west and The Race in the east; efforts to reduce this substantial western load will come under the auspices of the New York-New Jersey Harbor Estuary Program.
- 2,200 tons of nitrogen per year enter the Sound from direct atmospheric deposition; the Management Conference estimates that this load will be reduced to 1,540 tons of nitrogen per year through implementation of the 1990 Clean Air Act amendments.
- The remaining 40,800 tons of nitrogen per year are a result of human activity coming from point and nonpoint source discharges in the Sound's drainage basin and are the subject of the plan. Point source discharges, primarily sewage treatment plants, result in 32,400 tons of nitrogen each year and nonpoint source discharges, such as agricultural and stormwater runoff, result in 8,400 tons of nitrogen each year.

Priority Nitrogen Management Areas

The Plan to Solve the Problem

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The goal of the hypoxia management plan is to eliminate adverse impacts of hypoxia resulting from human activities.

Achievement of this goal will require very large investments of capital, a long-term commitment, and the assistance of the New York-New Jersey Harbor Estuary Program. Therefore, the Management Conference has established interim targets for dissolved oxygen and has outlined a phased approach to achieving them, using what is known now to support early phases and committing to take additional steps as increased understanding of the environment will dictate in the future.

Geographic Zones for Total Nitrogen Management Loads

Interim Dissolved Oxygen Targets

Using scientific information on the relationship between oxygen levels and ecological effects, the Management Conference has established interim target levels for oxygen that, if achieved, would minimize the adverse impacts of hypoxia. In summary, the interim dissolved oxygen targets for the bottom waters of the Sound are to:

- Maintain existing dissolved oxygen levels in waters that currently meet state standards;
- Increase dissolved oxygen levels to meet standards in those areas below the state standards but above 3.5 mg/l; and,
- Increase short-term average dissolved oxygen levels to 3.5 mg/l in those areas currently below 3.5 mg/l, ensuring that dissolved oxygen never goes below 1.5 mg/l at any time.
- There are also interim targets for the surface waters of the Sound.

Phased Approach

The Management Conference is implementing a phased approach to reducing nitrogen loadings to the Sound from point and nonpoint source discharges within the Sound's drainage basin.

- Phase I, as announced in December of 1990, froze nitrogen loadings to the Sound in critical areas at 1990 levels to prevent hypoxia from worsening.
- Phase II, as detailed in the plan, includes significant, low-cost nitrogen reductions that begin the process of reducing the severity and extent of hypoxia in the Sound.
- Phase III will present nitrogen reduction targets to meet the interim targets for dissolved oxygen, which will prevent most known lethal and sublethal

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effects of hypoxia on the Sound's estuarine life. Phase III also will lay out the approach for meeting the nitrogen load reduction targets.

PHASE I – THE NITROGEN LOADING FREEZE

Phase I was announced in December 1990. It called for a freeze on point and nonpoint nitrogen loadings to the Sound in critical areas at 1990 levels. It committed the states and local governments to specific actions to stop a 300-year trend of ever- increasing amounts of nitrogen entering the Sound.

The states have moved aggressively to implement the freeze, seeking the full cooperation of local governments.

- Connecticut reacted quickly to obtain $15 million in state funds to ensure that the nitrogen freeze was implemented. Consent orders are in place to cap the nitrogen loads at the 15 affected facilities.
- In New York City, the New York State Department of Environmental Conservation (NYSDEC) and the city have reached full agreement on sewage treatment permit limits, freezing total nitrogen loadings at 1990 levels. The permits will be finalized shortly.
- In Westchester County, the NYSDEC has issued final permits to the four existing sewage treatment plants, freezing their aggregate load at the 1990 level. This was done with the full agreement of the county.
- On Long Island, the NYSDEC has proposed individual permits that freeze the loads from individual discharges at 1990 levels; in response, the dischargers have proposed establishment of an aggregate limit. This proposal is currently under review by the NYSDEC.

Phase I agreements to control nonpoint sources centered around three categories:

- Use of existing nonpoint source and stormwater management programs to focus on nitrogen control with the objective of freezing the loads.
- Assessing tributary loads to Long Island Sound to begin planning for their control.
- Assigning priorities for management to coastal subbasins where nitrogen loads were estimated to be the highest (Figure 4).

PHASE II – LOW COST NITROGEN REDUCTIONS

Phase II includes firm commitments to reduce the annual, human-caused nitrogen load of 40,800 tons from in-basin sources by approximately 7,600 tons (or 18.6 percent). This includes complete compensation for the 2,800 tons per year increase associated with the end of ocean dumping and a 4,800 tons per year reduction from the 1990 freeze baseline.

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- New York state will reduce its aggregate annual nitrogen load from 11 sewage treatment plants in New York by 25% percent (approximately 6,700 tons) at a total capital cost of $103.1 million. Five of the actions will be achieved by the end of 1995; four will be achieved by the end of 1996. The load reduction associated with centrate treatment is to be achieved by the year 2000. The target date for achieving the load reductions associated with the upgrade of the Newtown Creek water pollution control plant in the East River is currently being negotiated by the New York City Department of Environmental Protection (NYCDEP), the NYSDEC, and the EPA. Funding for these actions is available through the State Revolving Fund.
- Connecticut will reduce its aggregate annual nitrogen load from the 15 affected treatment plants by 25 percent (approximately 900 tons) by 1995. Funding is in place for the $18.1 million expenditure with $14 million available as 100 percent grants and the balance as State Revolving Fund loans.
- Phase II activities for nonpoint nitrogen control will continue to take advantage of existing programs by focusing additional attention on nitrogen in priority coastal subbasins. The states of Connecticut and New York are formulating their Coastal Nonpoint Pollution Control programs to address coastal nitrogen sources.

The benefits of Phase II nitrogen reductions, as forecast by the LIS 2.0 model, will be substantial. Summertime minimum dissolved oxygen concentrations in the bottom waters of the western Sound will be raised on average from 1.5 mg/l to about 2.4 mg/l. The amount of estuarine habitat presently degraded will be reduced by about 10 percent. The area most severely affected by hypoxia will shrink by more than 30 percent.

However, these reductions alone will clearly not meet the interim dissolved oxygen targets nor achieve the goal for dissolved oxygen. Therefore, an additional level of nitrogen reduction will be necessary.

PHASE III – NITROGEN REDUCTION TARGETS TO ELIMINATE SEVERE HYPOXIA

LIS 2.0 was used to begin to estimate nitrogen reductions required to meet the interim dissolved oxygen targets. Of the 40,800 tons per year total, in-basin, human-caused nitrogen load, required reductions are expected to range from 17,000 to 24,000 tons per year (or 42 percent to 59 percent). Achievement of these reductions would require the implementation of the mid- to high-level management scenarios as described in the Management Conference's 1990 Status Report and Interim Actions for Hypoxia Management. Preliminary cost estimates of these two levels of control for point sources are from $5.1 to $6.4 billion for New York state and from $900 million to $1.7 billion for Connecticut.

Cost estimates for the necessary level of control of nonpoint sources have not been developed but are expected to be substantial.

The benefit of achieving the interim targets would be the elimination of severe hypoxia. Most lethal and sublethal effects of hypoxia would be prevented and most of the severely impacted habitat area would be restored.

However, in order to proceed with such a costly enterprise in a way that obtains the greatest environmental benefits for each dollar spent, approximate Soundwide reductions must be translated into discharge- or zone-specific load reduction targets.

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- Using the LIS 3.0 model, the Management Conference will identify the most beneficial and cost-effective nitrogen load reduction targets for geographic management zones established around the Sound (Figure 5).
- The states and local governments will then be given the opportunity to propose the most cost-effective mix of point and nonpoint source reduction actions to achieve these nitrogen load reduction targets within each zone.

The third phase of the plan, therefore, is to:

- Complete work on LIS 3.0 by June 1994.
- Establish LIS 3.0-based dissolved oxygen targets, and nitrogen load reduction targets by zone, by December 1994.
- Encourage and support the development of innovative, cost- effective technologies to reduce point and nonpoint sources of nitrogen.
- Complete in 1995-1997 the zone-by-zone plans to achieve the load reduction targets.
- Establish a firm timetable for achieving the load reduction targets by zone within 20 years with progress measured in five year increments; this timetable can only be met if the State Revolving Funds are adequately capitalized.
- Continue long-term implementation to ensure steady increases in dissolved oxygen and reductions in the area impacted by hypoxia.

The Management Conference has already allocated funds to complete work on LIS 3.0. Resources and staff from existing programs will be used to establish LIS 3.0-based dissolved oxygen targets and nitrogen load reduction targets. The development of zone-by-zone plans to achieve the nitrogen reduction targets has already been initiated, with over $1 million committed. To complete all the zone-by-zone plans by 1997, the Management Conference estimates that $700,000 per year for three years will be needed.

The phased plan to reduce the annual load from point and nonpoint source discharges of nitrogen is depicted in Figure 6.

Going Beyond the Interim Dissolved Oxygen Targets

Full attainment of the goal of eliminating the adverse impacts of hypoxia from human activities (not just eliminating severe hypoxia) will require additional actions beyond the scope of the Long Island Sound Study. The New York-New Jersey Harbor Estuary Program is currently considering the need for nitrogen control on a systemwide basis; nitrogen control in the Harbor could reduce the export of nitrogen and increase the export of oxygen from the Harbor to the Sound. Additionally, New York City has initiated studies to evaluate the efficacy of relocating discharges from the upper and lower East River, thereby reducing these inputs of nitrogen to Long Island Sound.

The Management Conference recommends a long-term program of monitoring and modeling to assess progress in meeting the nitrogen reduction and dissolved oxygen targets, and to assess the ecosystem's response. This program is essential to ensuring that the management actions that are implemented are benefiting the Sound as expected.

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A key element of the program is the use of the LIS 3.0 model. The Management Conference recommends that LIS 3.0 be periodically recalibrated to reflect the changing conditions of the Sound, and be used to explain these changing conditions. Furthermore, the Management Conference recommends that LIS 3.0 be used to evaluate proposals to modify the management plan, as necessary.

A comprehensive hypoxia monitoring and modeling program has been proposed, building upon elements of existing programs, primarily those of the Connecticut Department of Energy and Environmental Protection (CTDEP), the NYCDEP, and the Interstate Sanitation Commission. Full implementation of the monitoring program would require additional funding of $300,000 per year. Recalibration of LIS 3.0 would cost approximately $300,000.

Costs and Funding

The Management Conference recommends increased funding of the Connecticut and New York State Revolving Fund programs. Based on the preliminary estimates, if the high-level of nitrogen control were selected, the Connecticut State Revolving Fund would need an infusion of $70 million per year in federal Clean Water Act funds and $47 million per year in state funds over 20 years to meet all statewide wastewater control needs, including Long Island Sound nitrogen control needs. The New York State Revolving Fund would need an infusion of $623 million per year in federal Clean Water Act funds and $128 million per year in state funds over 20 years to meet statewide needs, including Long Island Sound nitrogen control needs.

The Management Conference also recommends that the Congress authorize a total of $50 million under Section 119(d) of the Clean Water Act. This section of the Clean Water Act, created by the Long Island Sound Improvement Act of 1990, authorizes grants for projects that will help implement the plan. Appropriations could be spread over a period of five years. The Management Conference would use the $50 million to fund a Long Island Sound Challenge Grant program. A significant portion of appropriated funds would be used to ensure that the Phase III nitrogen control efforts get off to a fast start with full local government cooperation. The portion of these funds allocated for nitrogen control would be used to fund cost-effective point and nonpoint source control actions not involving major capital improvements. Innovative projects would be encouraged.

And finally, the Management Conference recommends that Congress fully fund the nonpoint source control programs under Section 319 of the Clean Water Act and Section 6217 of the Coastal Zone Act Reauthorization Amendments to support additional nonpoint source management activities.

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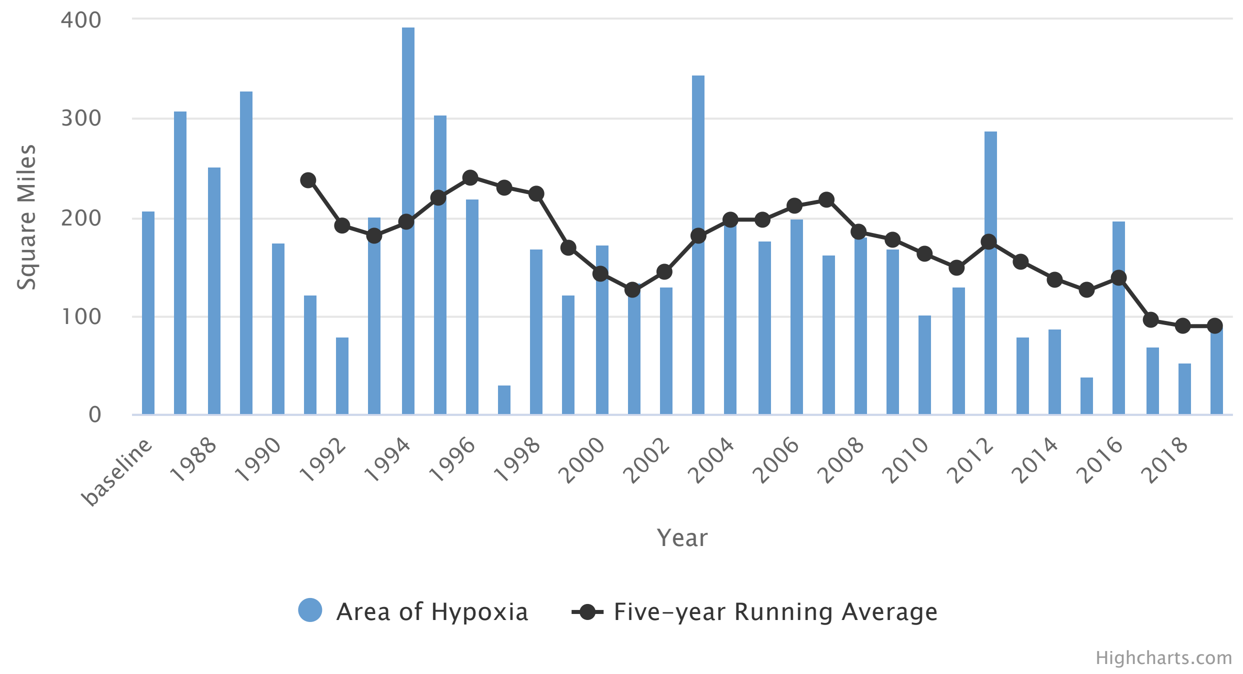
ECOSYSTEM TARGETS AND SUPPORTING INDICATORS

Extent of Hypoxia

Target: Measurably reduce the area of hypoxia in Long Island Sound from pre-2000 Dissolved Oxygen TMDL averages to increase attainment of water quality standards for dissolved oxygen by 2035, as measured by the five-year running average size of the zone.

Area of Hypoxia



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Progress

Data | Behind | On Track | Ahead of | Meeting

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All Ecosystem Targets and Indicators
Only Ecosystem Targets
Waters and Watersheds Ecosystem Targets and Indicators
Extent of Hypoxia
Nitrogen Loading
Water Clarity
Impervious Cover
Riparian Buffer Extent
Approved Shellfish Areas
Sediment Quality Improvement
Industrial Chemical Discharges (TRI data – Total LIS watershed and CT and NY portion of watershed)
Duration of Hypoxia
Severely Hypoxic and Anoxic Areas
Water Quality Index
Habitats and Wildlife Ecosytem Targets and Indicators
Sustainable Communities Ecosystem Targets and Indicators
Climate Change Indicators
Water Quality Modeling
Sea Level Affecting Marshes Modeling

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Unavailable	Schedule	Schedule	Goal

STATUS AND TRENDS

Meeting the ecosystem target (measured as the maximum area of bottom waters with dissolved oxygen ≤ 3 mg/L) based on a five-year rolling average of hypoxia is ahead of schedule. The five-year rolling average (2015-2019) is 89 square miles compared to an average of 208 square miles from 1987-2000, a 57 percent reduction. The hypoxic area also has declined by 63 percent from the peak five-year period (1992-1996), which was 240 square miles. Based on the last 20 years of interannual variability, a 28 percent reduction is necessary to achieve a measurable reduction (see data note). While achieving a measurable reduction in hypoxia from 2015-2019 is a major achievement, further reductions in the area of hypoxia are needed through 2035 in order to fully attain water quality standards and achieve the ecosystem target goal.

The years 1987-2000 are used as a benchmark (or the baseline) because they represent the beginning of Long Island Sound Study's water quality monitoring program up to the December 2000 Total Maximum Daily Load (TMDL) agreement to reduce nitrogen loads into the Sound.

Compared to 2018, the area of hypoxia increased from 52 square miles to 89 square miles. However, the 2019 five-year rolling average of the maximum area (2015-2019) of hypoxic waters remained the same as the 2018 five-year rolling average (2014-2018), which also happens to be 89 square miles.

In assessing trends, LISS uses the five-year rolling average because conditions in any given year could be impacted by variable factors, such as extreme changes in heat or precipitation, which would be hard to compare to the normal conditions over a long period of time. Hypoxia in the western Sound also appeared more intense (lower oxygen concentrations) in 2019, perhaps due to the hot and wet summer weather.

As shown in the chart above, there is considerable annual variability in the maximum area of hypoxic waters, in part due to annual variations in weather (temperature, wind, rainfall, etc.).

While the area of hypoxia has been reduced compared to the pre-TMDL baseline, the duration of hypoxia has remained unchanged at 56 days compared to the pre-TMDL baseline (see the duration of hypoxia, supporting indicator, 1987-2017).

CHALLENGES

Warming water temperatures will reduce the amount of oxygen that the water can contain, making it more difficult to meet the target long term. In addition to weather variables affecting the area of hypoxia year to year, longer-term climate influences will affect the vulnerability of the Sound to hypoxia. Improvements in monitoring, including increased monitoring in embayments, will better define areas affected by hypoxia, and the factors contributing to it.

HOW IS THIS TARGET MEASURED?

Routine monitoring of bottom-water hypoxia is done monthly throughout the year and biweekly in the summer by the Connecticut Department of Energy and Environmental Protection (CTDEEP).

Climate Change and Sentinel Monitoring

Water Quality Monitoring in the Sound and Embayments

Habitat and Wildlife Monitoring

Seafloor Mapping

LISS Research Grant Program

Supporting Indicators

- Area of Anoxia/Severe Hypoxia
- Duration of Hypoxia
- Water Quality Index
- increases in population and sewage (archived/historical)

Hypoxia Data

Here are links to find data on dissolved oxygen levels and the extent of hypoxia in Long Island Sound:

- CTDEEP Long Island Sound Water Quality Monitoring Program (open waters of LIS)
- Interstate Environmental Commission (western Narrows)
- Long Island Sound Integrated Coastal Observing System (real-time monitoring)
- LIS water quality monitoring program survey data on the LISICOS website
- Save the Sound Unified Water Study (embayments)

Did You Know?

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Additional year-round monitoring is conducted by the Interstate Environmental Commission in Western Long Island Sound and the Narrows. The Long Island Sound Integrated Coastal Observing System (LISICOS) also deploys real-time monitoring instruments on buoys across the Sound, including three with bottom water oxygen sensors in the Western Sound. The three monitoring programs help provide a comprehensive long-term data set on both the area and duration of hypoxia, with the monitoring data going back to 1987 (initially conducted by the University of Connecticut from 1987-1990, and beginning with CTDEEP since 1991).

Bottom hypoxia is measured by lowering instruments with multiple sensors (including dissolved oxygen) through the water column from a research vessel or smaller boat.

IMPORTANCE

Hypoxia, a deficiency in the amount of oxygen in the water, can be harmful or lethal to fish, invertebrates, and other animals and therefore decrease or eliminate them from Long Island Sound.

Hypoxia may also limit the growth of animals that are exposed but not killed.

CONTACT

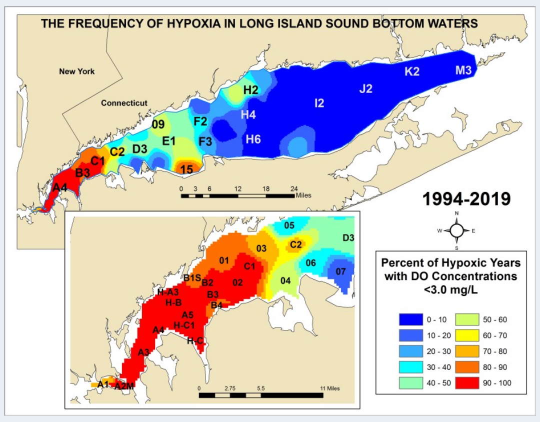
Dr. James Ammerman, Long Island Sound Study
james.ammerman@longislandsoundstudy.net

SOURCE OF DATA

CTDEEP (primary data source), also the Interstate Environmental Commission for Western Long Island Sound, and LISICOS.

DATA NOTES

- The technical explanation on how the target was selected is found in Appendix B of the Comprehensive Conservation and Management Plan.



Frequency of Hypoxia, 1994-2019

Hypoxia is more frequent in the western Sound.

Learn More

2019 Long Island Sound CTDEEP and IEC Hypoxia Review Report

Hypoxia diagram

- Total Maximum Daily Load plan
- TMDL 2009 fact sheet (short version)
- TMDL 2009 fact sheet (long version)

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Long Island Sound Study

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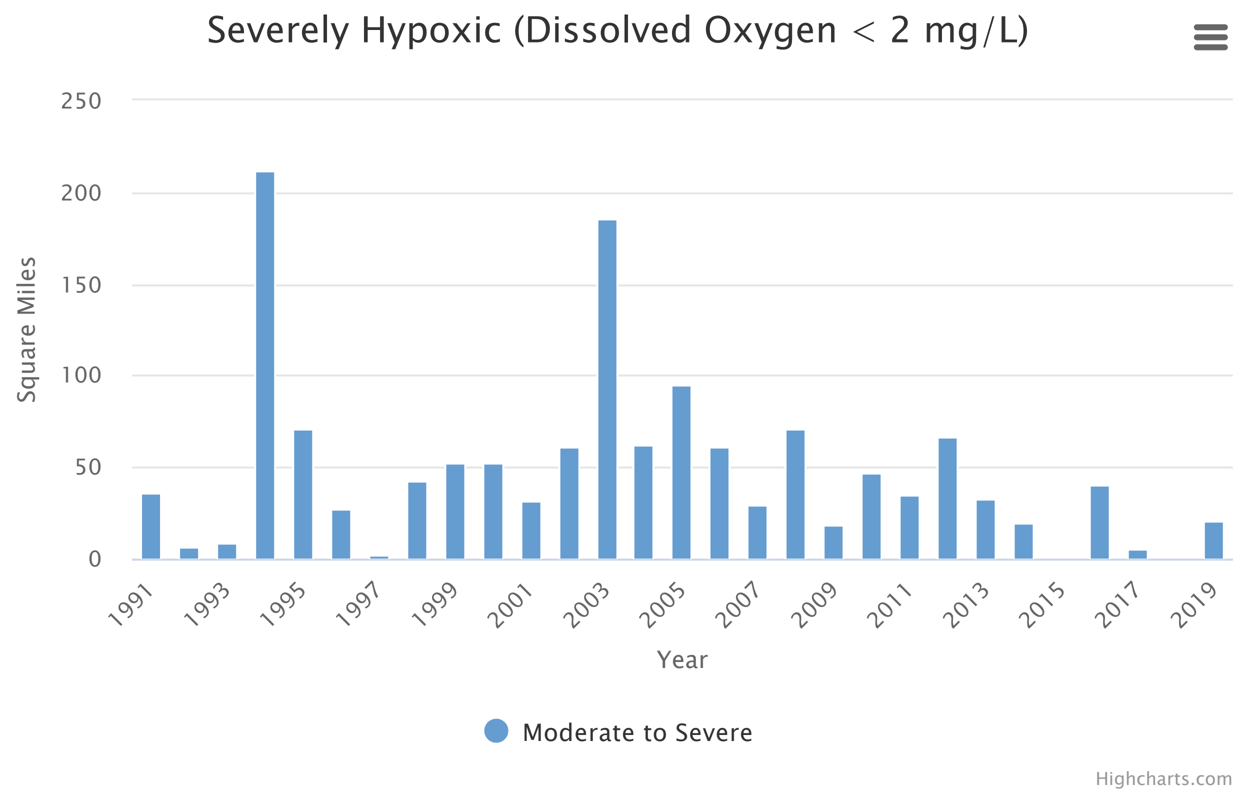
Severely Hypoxic and Anoxic Areas

Hypoxia is a condition that occurs in bodies of water as dissolved oxygen concentrations decrease to levels where organisms become physically stressed and ultimately cannot survive. The area of hypoxia in Long Island Sound refers to the number of square miles in which dissolved oxygen concentrations were less than 3 mg/L over the course of a single year. Severely hypoxic areas are less than 2 mg/L and anoxic areas are less than 1 mg/L.

Severely Hypoxic | Anoxia | Area of Hypoxia



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Sea Level Affecting Marshes Modeling

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WHAT IS HYPOXIA?

Hypoxia is a condition that occurs in bodies of water as dissolved oxygen concentrations decrease to levels where organisms become physically stressed and ultimately cannot survive. Prolonged hypoxic conditions result in severe die-offs of animals that are unable to move out of hypoxic waters, mass migrations of mobile animals, changes in water chemistry and other adverse ecological effects. The Long Island Sound Study defines hypoxia as waters with dissolved oxygen concentrations less than 3 mg/L.

For more information on hypoxia and efforts to reduce its occurrence in Long Island Sound visit: http://longislandsoundstudy.net/about/our-mission/management-plan/hypoxia/

WHAT IS SEVERE HYPOXIA?

The Long Island Sound Study defines dissolved oxygen concentrations of less than 2 mg/L as severely hypoxic. In most other ecosystems with similar oxygen depletion problems, like the Chesapeake Bay and the northern Gulf of Mexico, 2 mg/L of dissolved oxygen is the upper limit for hypoxia.

WHAT IS ANOXIA?

Anoxia is typically defined as the complete lack of oxygen or often less than 0.2 mg/L. The Long Island Sound Study, however, defines anoxia as oxygen concentrations below 1 mg/L because this is the threshold below which most marine animals cannot survive even for a short period of time.

WHAT DOES THIS INDICATE?

The area of hypoxia in Long Island Sound refers to the number of square miles in which dissolved oxygen concentrations were less than 3 mg/L over the course of a single year. Hypoxia is most common during summer months when waters are stratified (preventing mixing of oxygen from the surface to the bottom) and temperatures are higher (so less oxygen can be dissolved in the water). The area of hypoxia is calculated from measurements taken every other week during summer months as part of the Long Island Sound Study Water Quality monitoring program by the Connecticut Department of Energy and Environmental Protection.

STATUS

The five-year rolling average (2015-2019) of **hypoxia** is 89 square miles compared to an average of 208 square miles from 1987-2000, a 57 percent reduction (see extent of Hypoxia ecosystem target). The hypoxic area also has declined by 63 percent from the peak five-year period (1992-1996), which was 240 square miles. Based on the last 20 years of interannual variability, a 28 percent reduction is necessary to achieve a measurable reduction (see data note). Further reductions in the area of hypoxia are needed in order to fully attain water quality standards for dissolved oxygen.

In 2019 **severe hypoxia** covered 21 square miles of the Sound, relative to the 1991-2019 average of 48 square miles.

Anoxia covering 1 square mile was detected in the Long Island Sound water quality monitoring program in the western Sound for the first time since 2012 when it affected 18 square miles. While the overall average area of anoxia is 11 square miles from 1991-2019, the variability in area of anoxia from year to year can be quite high. No anoxia was detected in the Sound during 14 of the last 27

Climate Change and Sentinel Monitoring

Water Quality Monitoring in the Sound and Embayments

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Hypoxia Data

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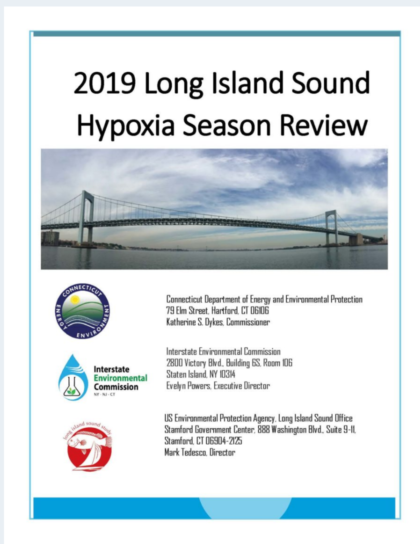
Learn More



2019 Long Island Sound CTDEEP and IEC Hypoxia Review Report

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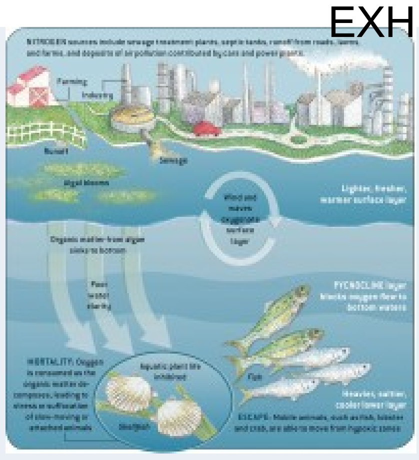
years, but the area affected by anoxia has been as high as 61.7 square miles (in 2003). Other monitoring programs by the Interstate Environmental Commission and the Long Island Sound Integrated Coastal Observing System that monitor western Long Island Sound more intensively have found more frequent anoxia in this area.

For reference, the entire area of Long Island Sound is about 1,300 square miles.



Hypoxia diagram

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Ecosystem Targets and Supporting Indicators

All Ecosystem Targets and Indicators

Only Ecosystem Targets

Waters and Watersheds Ecosystem Targets and Indicators

Extent of Hypoxia

Nitrogen Loading

Water Clarity

Impervious Cover

Riparian Buffer Extent

Approved Shellfish Areas

Sediment Quality Improvement

Industrial Chemical Discharges (TRI data – Total LIS watershed and CT and NY portion of watershed)

Duration of Hypoxia

Severely Hypoxic and Anoxic Areas

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Climate Change Indicators

Water Quality Modeling

Sea Level Affecting Marshes Modeling

Home > Targets/Indicators > Waters and Watersheds Ecosystem Targets and Indicators > Nitrogen Loading

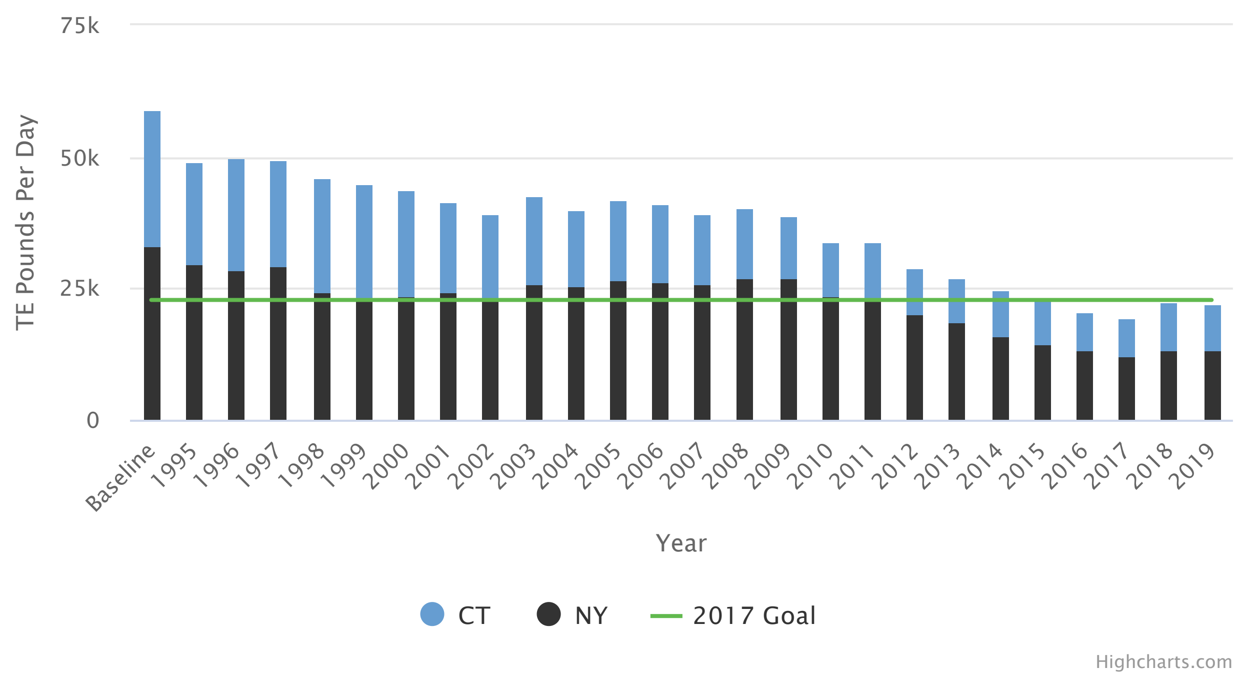
ECOSYSTEM TARGETS AND SUPPORTING INDICATORS

Nitrogen Loading

Attain wastewater treatment facility nitrogen loading at the recommended 2000 Dissolved Oxygen Total Maximum Daily Load allocation level by 2017 and maintain the loading cap. Have all practices and measures installed to attain the allocations for stormwater and nonpoint source inputs from the entire watershed by 2025.

Nitrogen Loads from Point Sources

Wastewater Treatment Plant Point Sources–Nitrogen Trade Equalized (TE) Loads, 1995–2019



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Progress (to 2017 goal)

The 2017 goal to reduce nitrogen loads discharged into Long Island Sound from wastewater treatment plants has been met.

Data Unavailable | Behind Schedule | On Track | Ahead of Schedule | **Meeting Goal** (selected)

Progress (to 2025 goal)

Data is not yet available for the second half of the target – reducing nitrogen from nonpoint source and stormwater inputs.

Data Unavailable (selected) | Behind Schedule | On Track | Ahead of Schedule | Meeting Goal

STATUS AND TRENDS

The 2000 Total Maximum Daily Load (TMDL) agreement between EPA and the states of Connecticut and New York called for a 60 percent reduction from the baseline level of 59,000 trade equalized pounds per day of nitrogen. As of 2017, this goal has been met. In 2019, nitrogen loads decreased by 401 pounds per day from the prior year, but it is still higher than in 2017, the year with the lowest amount.

Through the middle of the last decade, there was a significant trend of year to year declines in the amount of nitrogen discharged from wastewater treatment plants into Long Island Sound as more advanced Biological Nutrient Removal systems came online at the plants. With most of the upgrades accomplished by 2016, nitrogen loads have since fluctuated up and down by relatively small amounts, mainly may due to other factors, such as high precipitation rates decreasing the efficiency of nitrogen removal, and more development increasing amounts of sewage requiring treatment.

Greater than normal amounts of precipitation are believed to be primary causes in Connecticut of increased nitrogen being discharged into the Sound from Connecticut and New York in 2018 and 2019. Heavy rainfall and elevated groundwater levels entering as infiltration and inflow into a wastewater treatment plant through the sewage collection system could fill a wastewater treatment plant's processing tanks to near capacity or capacity. If that happens, the effectiveness of treatment technologies to break down nitrogen into a harmless gas can be reduced.

CHALLENGES

The second half of the target addressing stormwater and nonpoint source inputs will be more challenging since such inputs are widely dispersed.

An expanded EPA nitrogen strategy for Long Island Sound focuses not only on the nitrogen inputs from wastewater treatment plants, but also on the nonpoint contributions from tributaries and embayments. It also looks at ecological

Climate Change and Sentinel Monitoring

Water Quality Monitoring in the Sound and Embayments

Habitat and Wildlife Monitoring

Seafloor Mapping

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Related Ecosystem Targets

- Extent of Hypoxia
- Water Clarity
- Eelgrass Extent

Supporting Indicators

- Area of Anoxia/Severe Hypoxia
- Duration of Hypoxia
- Water Quality Index
- Increases in population and sewage (archived/historical)

Learn More

Trade equalized nitrogen zones in CT and NY. The calculated impact of nitrogen inputs declines with increased distance from the Western Sound. see tmdl map description

- Total Maximum Daily Load plan
- Long Island Sound Nitrogen Reduction Strategy

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endpoints beyond hypoxia, such as eelgrass acreage, as increased eelgrass coverage is dependent on good water quality. An initial effort to develop nonpoint source tracking was summarized in a 2014 report (see Final Report link, data notes below) which evaluates existing nonpoint source tracking tools for their applicability to Long Island Sound. This report suggested the adoption of the Chesapeake Bay Assessment and Tracking Tool (CAST) for use in Long Island Sound. The report also outlines four tasks to be completed to allow CAST to be applied to the various sub-basins of the Long Island Sound watershed. In fiscal year 2019, NEIWPCC is receiving funding to conduct a pilot tracking tool project in Connecticut communities.

HOW IS THIS TARGET MEASURED?

Nitrogen loading from wastewater treatment facilities is reported by the states of Connecticut and New York.

The nitrogen loading reported by Connecticut and New York is called trade-equalized because the amounts are corrected for the impacts of particular wastewater treatment facilities based on their location (see trade equalized nitrogen zones, sidebar). The information needed for nonpoint nitrogen source controls will be produced by the tracking tools and models currently under development as described under Challenges.

IMPORTANCE

Nitrogen is a plant nutrient. Large amounts of nitrogen loads into Long Island Sound can stimulate excessive growth of plant plankton and macroalgae in a process called eutrophication.

When plankton or microorganisms that eat the plankton decay, oxygen is consumed by bacteria and the bottom waters can become “hypoxic,” with less than 3.0 mg/l of oxygen. This can lead to stress or suffocation for slow-moving animals, and cause other animals to scatter. Harmful algal blooms, some of which are toxic to humans, are another potential result of eutrophication.

Nitrogen typically comes from point sources, large fixed sources like wastewater treatment or industrial plants, or non-point sources, smaller diffuse sources like septic systems, stormwater, and agricultural runoff.

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SOURCE OF DATA

Connecticut Department of Energy and Environmental Protection (CTDEEP) and New York State Department of Environmental Conservation (NYSDEC).

DATA NOTES

- The technical explanation on how the target was selected is found in Appendix B of the Comprehensive Conservation and Management Plan.
- 2014 Final Report: An Evaluation of Nonpoint Source Pollution Control Measure Tracking Systems for Long Island Sound, prepared for the New England Interstate Water Pollution Control Commission by WaterVision, LLC, 30 pages.Open pdf.

- 2019 Long Island Sound CTDEEP and IEC Hypoxia Review Report
- CT Nitrogen Trading Program
- TMDL 2009 fact sheet (short version)
- TMDL 2009 fact sheet (long version)

Project Spotlight

Hunts Point wwtp: 42" sludge pipe at West Aeration Tanks
Credit: NYCDEP

New York City has spent $1 billion to upgrade four wastewater treatment plants that has resulted in a 60 percent reduction in the amount of nitrogen being discharged into the Upper East River. These significant upgrades are helping the states of New York and Connecticut to meet their goal of preventing more than 45 million pounds of nitrogen a year from being discharged into Long Island Sound. See Jan. 5, 2017 news release from New York City Department of Environmental Protection.

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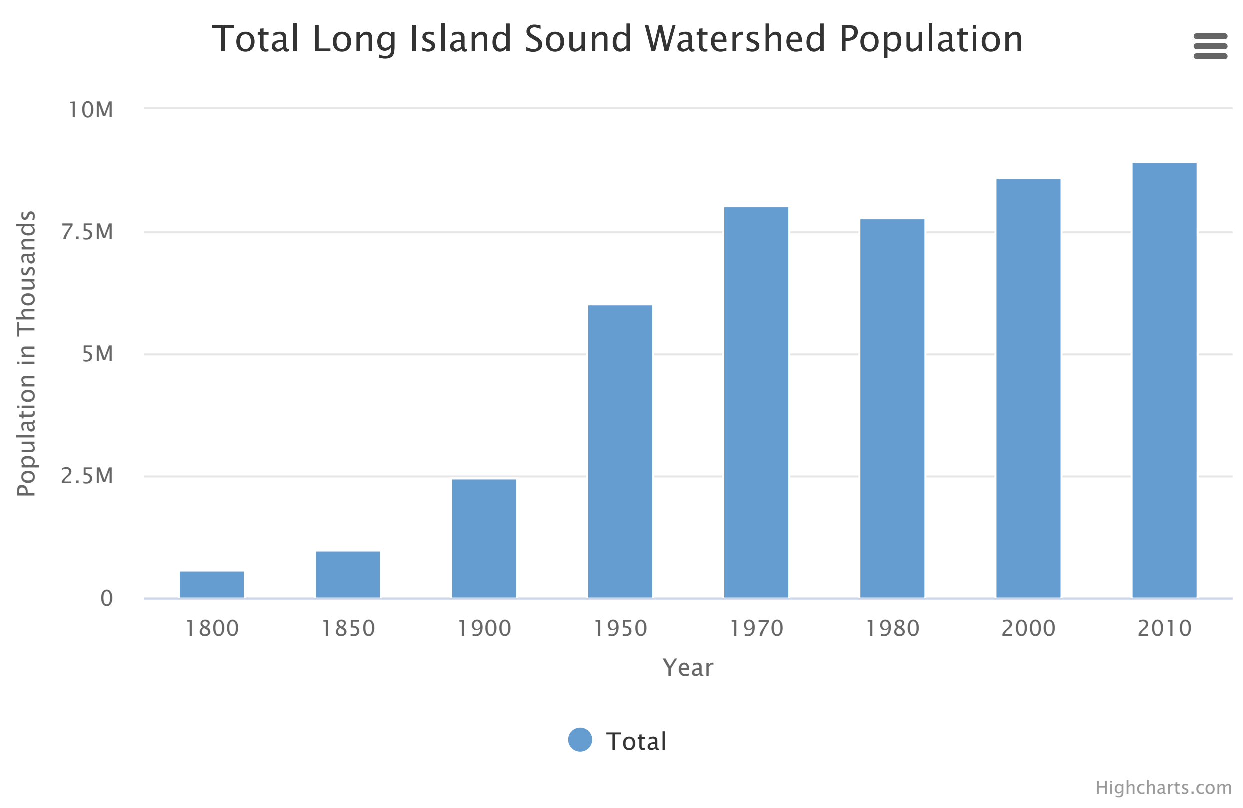
Home > Targets/Indicators > Sustainable Communities Ecosystem Targets and Indicators > Watershed Population

← ECOSYSTEM TARGETS AND SUPPORTING INDICATORS

Watershed Population

This indicator uses US Census data to track the population living within the Long Island Sound watershed.

Total | By State



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WHAT IS A WATERSHED?

The watershed is all of the land that drains into Long Island Sound itself or bodies of water that connect to the Sound. The watershed of Long Island Sound includes land from six states and extends north up to the border with Canada. The total area of the LIS watershed in Connecticut is 3,296,015 acres, which

RESEARCH

- Ecosystem Targets and Supporting Indicators
  - All Ecosystem Targets and Indicators
  - Only Ecosystem Targets
  - Waters and Watersheds Ecosystem Targets and Indicators
  - Habitats and Wildlife Ecosytem Targets and Indicators
  - Sustainable Communities Ecosystem Targets and Indicators
    - Waterfront Community Resiliency and Sustainability
    - Harbor and Bay Navigability
    - Public Engagement and Knowledge
    - Public Beach Closures
    - Marine Debris
    - Public Access to Beaches and Waterways
    - Watershed Population
    - Population Within 50-mile Buffer of Long Island Sound
    - Volunteers at Coastal Cleanups
  - Climate Change Indicators
- Water Quality Modeling
- Sea Level Affecting Marshes Modeling
- Climate Change and Sentinel Monitoring

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includes nearly the entire state. The total area of the LIS watershed in New York is 306,052 acres and is situated primarily along the coast in Long Island, Queens, the Bronx, and Westchester.

WHAT DOES THIS INDICATE?

This indicator provides population information for the total watershed plus state-level data for the parts of each state within the watershed.

STATUS

About 8.93 million people live in the watershed, according to the 2010 US Census, an increase of 3.5 percent from 2000. The increase is slightly higher than the 3.2 percent growth for the entire Northeast. From 2000 to 2010, regional growth was much faster for the South and West (14.3 and 13.8 percent, respectively) than for the Midwest (3.9 percent) and Northeast (3.2 percent). About half of the watershed population lives near the coast in New York and Connecticut, according to an analysis done for a public perception survey of Long Island Sound in 2006.

DATA NOTES

Compiled by M.A. Parker, CTDEEP, from population data estimates maintained by the US Census Bureau, the University of Virginia Library with the cooperation and consent of the Inter-University Consortium for Political and Social Research, and New York census 2000 town/city data from the Empire State Development – DataCenter.

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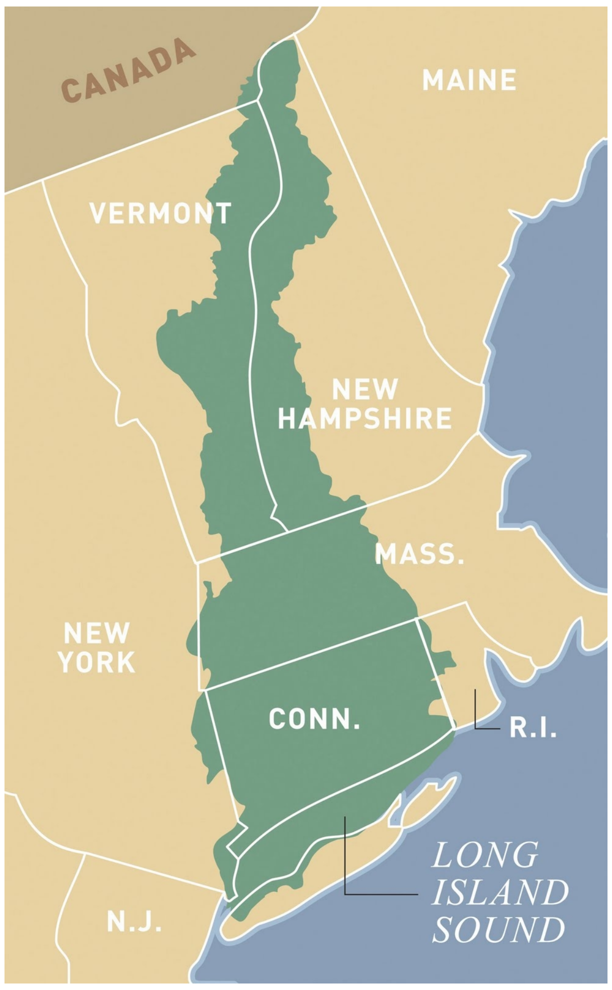

Long Island Sound Watershed

Population density of coastal NY and CT in the Sound's watershed

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