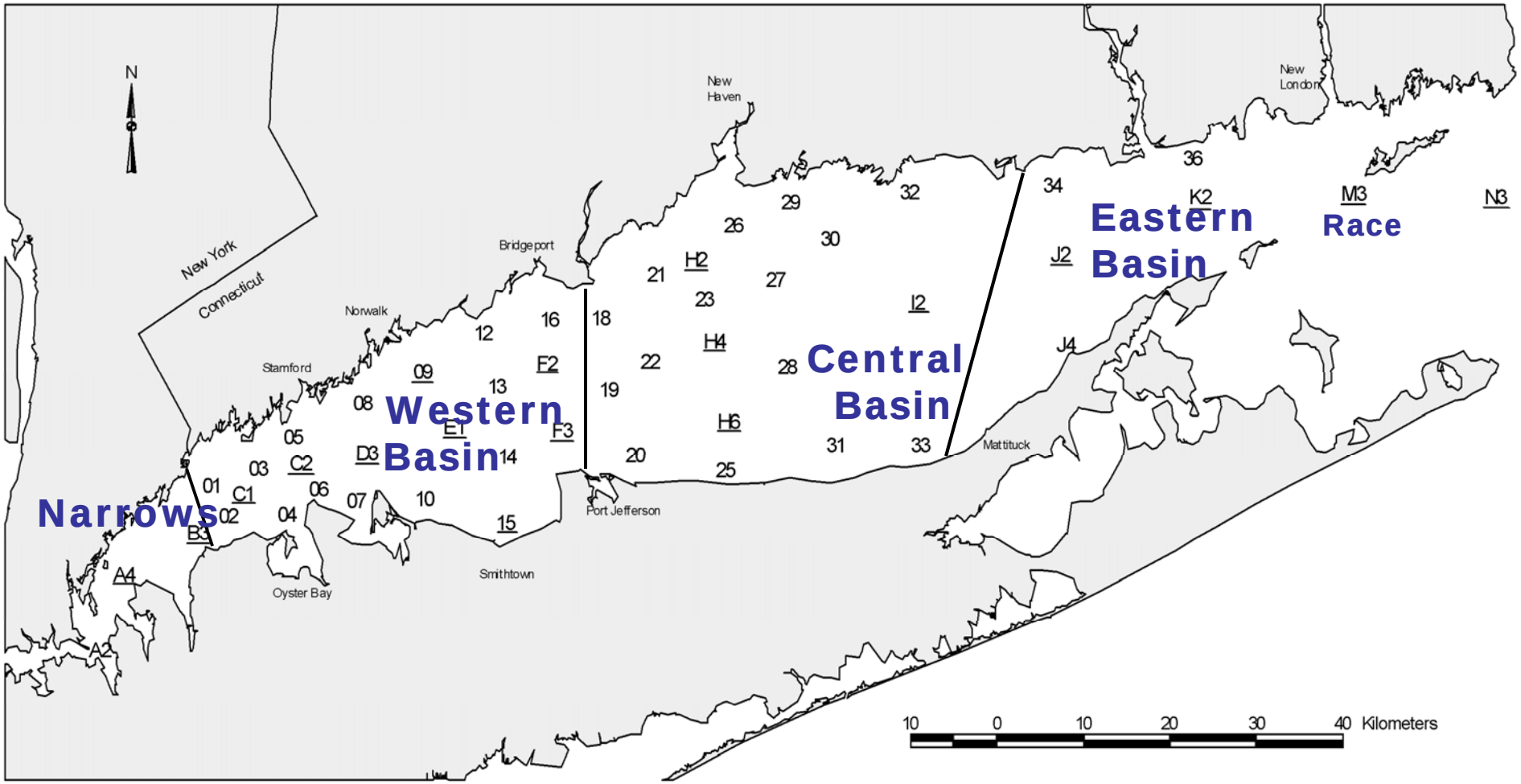
Water Quality Monitoring Stations

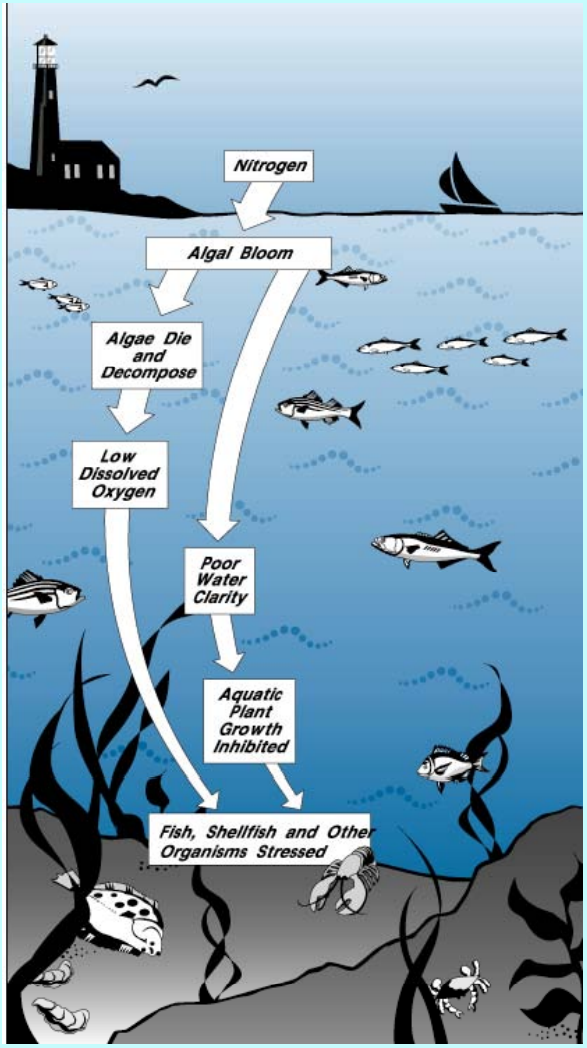


The CT Department of Environmental Protection (CT DEP) conducts a water quality monitoring program for the Long Island Sound Study. Surface and bottom waters are monitored by a crew aboard the research vessel *John Dempsey* at stations in the eastern, central, and western basins, and in the "Narrows." Testing parameters include water temperature, salinity, dissolved nitrogen, particulate nitrogen, and dissolved oxygen.

CT DEP

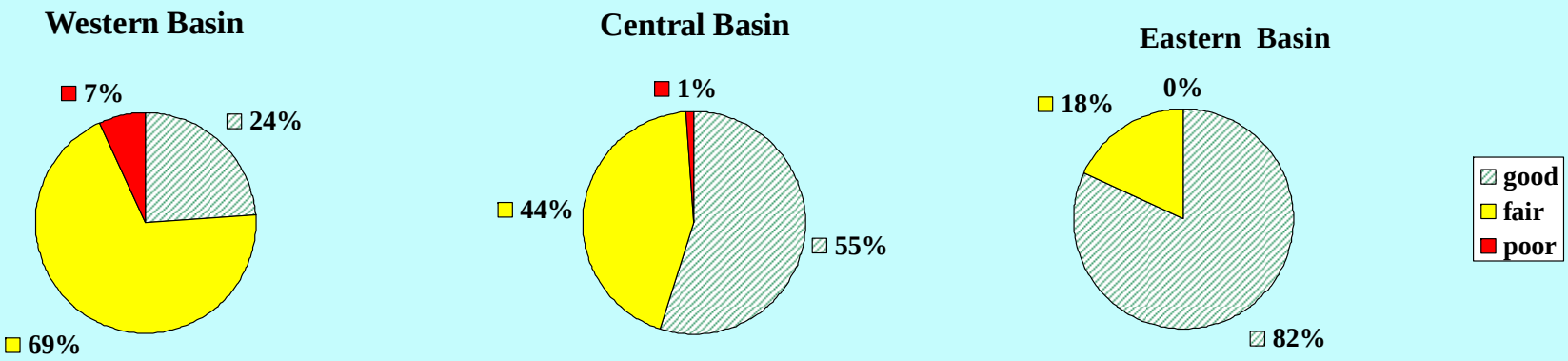
LISS Indicators: Water Quality (2.1)

Dissolved Oxygen & Hypoxia



- Dissolved oxygen (DO) levels gauge the overall health of the aquatic environment.
- Low DO levels in the bottom waters, a condition called hypoxia, impairs the survival, reproduction, or use of an area by aquatic life.
- Food sources for commercially-valuable marine species are depleted.
- Nitrogen is a nutrient. When in excess, nitrogen is a pollutant that leads to over-fertilization of the Sound.
- Nitrogen fuels excessive algae growth. The organic matter (algae and waste from animals feeding on them) that sinks to the bottom is consumed by bacteria in a process that uses up oxygen.
- In 1998, LISS adopted a 58.5 percent reduction target for nitrogen loads from human sources to the Sound over 15 years, with five and ten-year interim targets to assure steady progress.
- In 2001, the EPA approved CT and NY's Total Maximum Daily Load (TMDL) strategy for achieving the reductions and allocating responsibility among nitrogen sources.

Water Quality Index



Percent of time water quality was good, fair, or poor, from 1991-2007

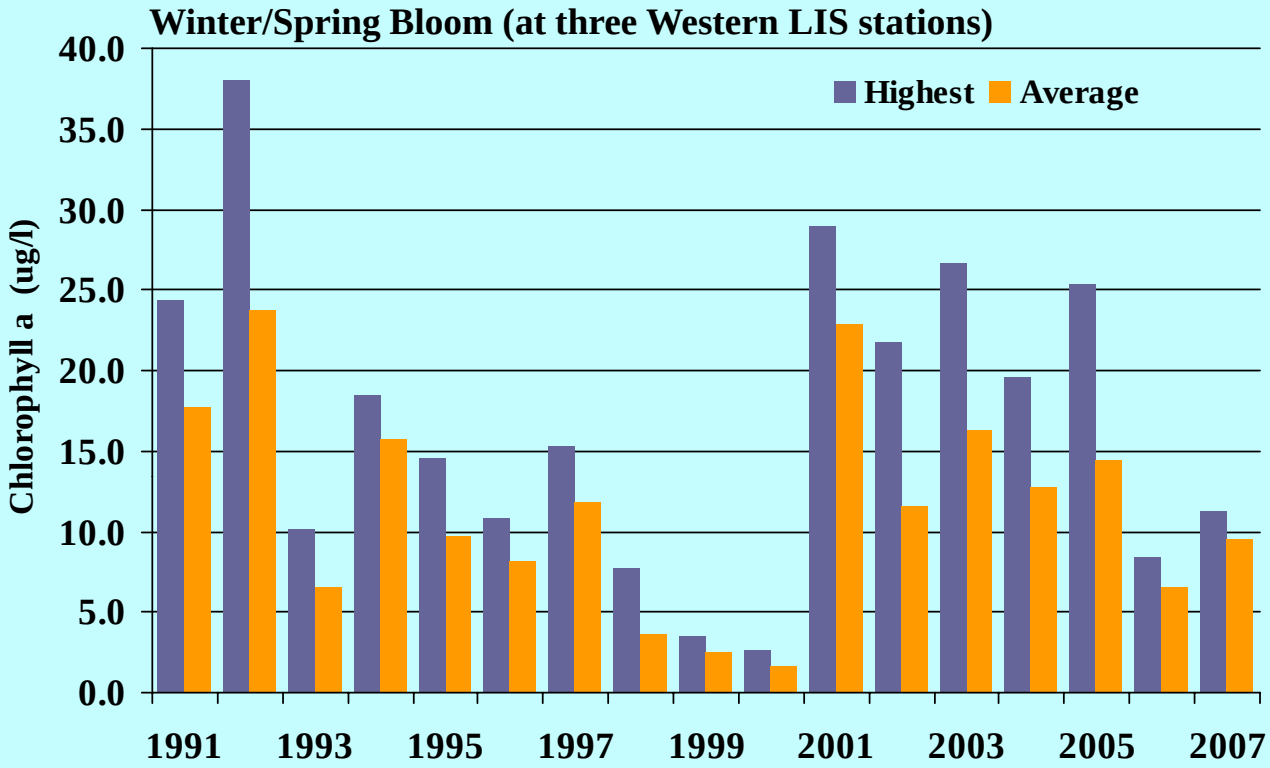
EPA National Coastal Assessment

The EPA's National Coastal Assessment (NCA) index for Long Island Sound is based on five chemical and biological measures (dissolved oxygen, chlorophyll a, water clarity, nitrogen, and phosphorus). Monthly data from May to October, when pollution has the greatest effect on water quality, were summarized from 1991 to 2007. Using this approach, EPA's Office of Research and Development characterized conditions in the Sound as good, fair, or poor for each of the three major basins. As expected, the western basin is the most stressed, with fair water quality the majority of the time. Water quality improves in the central basin, and in the eastern basin water quality is good most of the time. The gradient in improving water quality from west to east reflects both the decrease in population density and conditions within the basins themselves.

Indicator Type: State

r24

Chlorophyll a in Western Long Island Sound



The concentration of chlorophyll a, the green pigment in plants, indicates the amount of microscopic plants (called phytoplankton) in surface water. High levels of chlorophyll a indicates excessive plant growth, which can lead to a decline in oxygen.

CT DEP water quality monitoring program

Nutrients such as nitrogen promote phytoplankton growth. From 1992 to 2000, the decline in chlorophyll a levels coincided with decreased nitrogen loads from sewage treatment plants. But chlorophyll a levels increased again in 2001 even though nitrogen discharge levels have remained about the same as late–1990s levels.

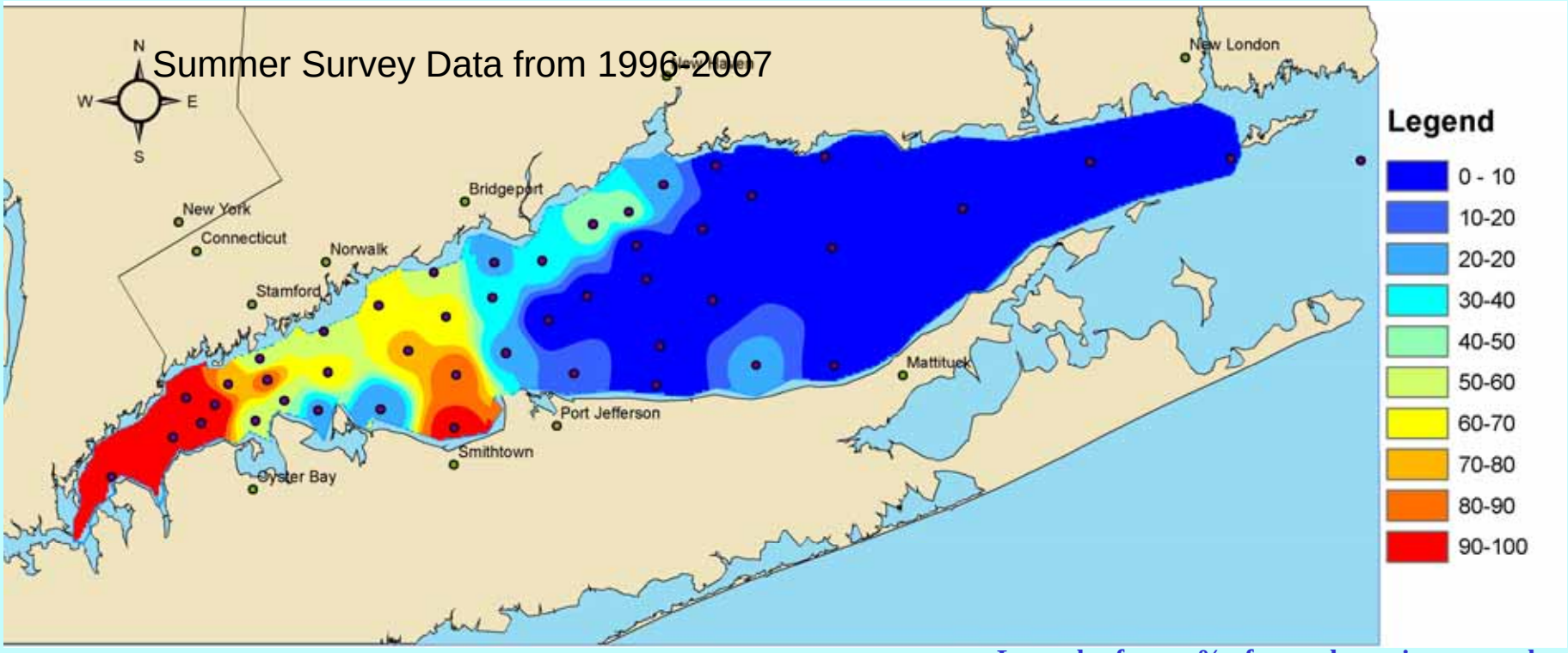
Indicator Type: State

LISS Indicators: Water Quality (2.1)

r24 future--add functional groups

rburg, 12/27/2007

Frequency of Hypoxia in Long Island Sound Bottom Waters



CT DEP LIS Water Quality Monitoring Program

Legend refers to % of years hypoxia occurred at least once in a year per water quality monitoring station. Each station represented by a dot.

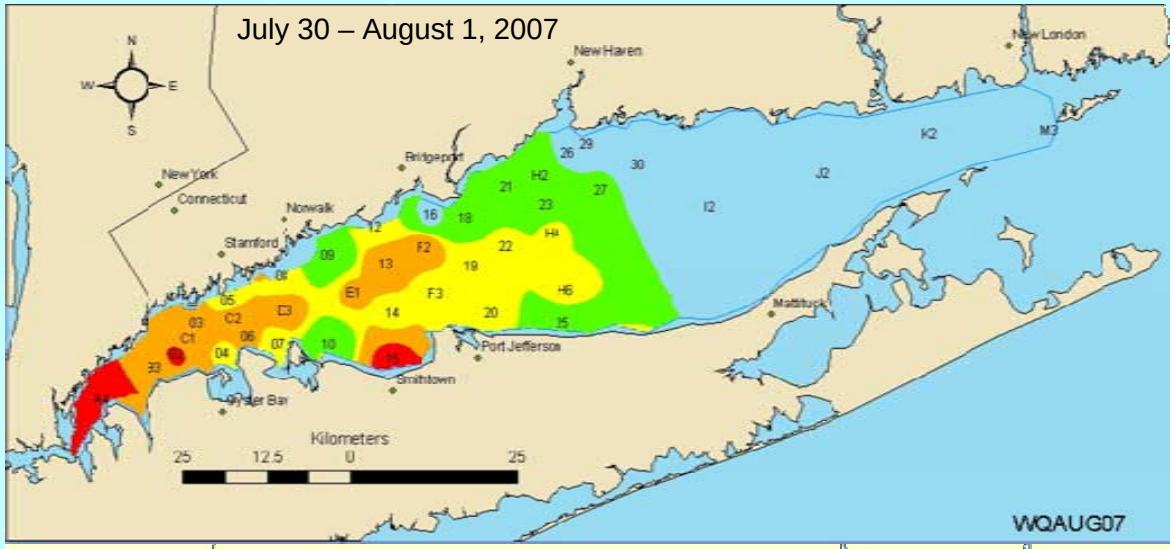
From mid-July through September, portions of the Sound experience hypoxic conditions (oxygen levels <3 mg/l) that impairs the feeding, growth, and reproduction of aquatic life. In the red areas of the map (primarily in the western basin) hypoxic events occurred at least once a year in more than nine years during the 11-year period. In extreme hypoxic conditions, some organisms may suffocate and die, while others flee.

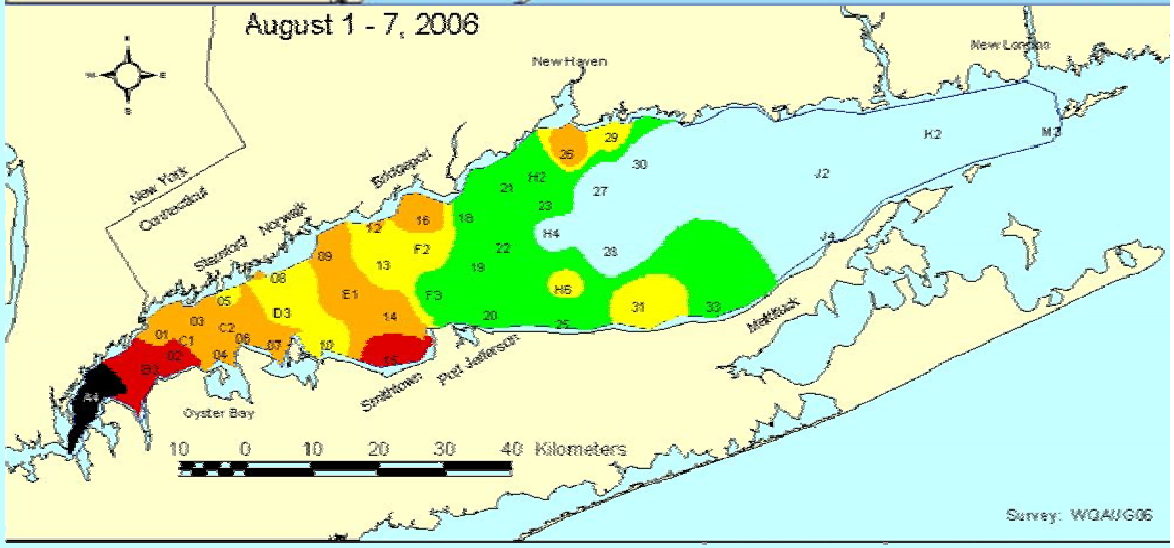
Indicator Type: State

LISS Indicators: Water Quality (2.1)

Dissolved Oxygen in LIS Bottom Waters

Hypoxia is typically at its worst in early August. These contour maps depict the areas of bottom waters within 1 mg/liter increments during the peak hypoxic period in 2006 and 2007. In 2006, some areas of the western Sound were anoxic (severely hypoxic) with oxygen levels dropping below 1 mg/l. In 2007, conditions in the western basin were moderately severe.





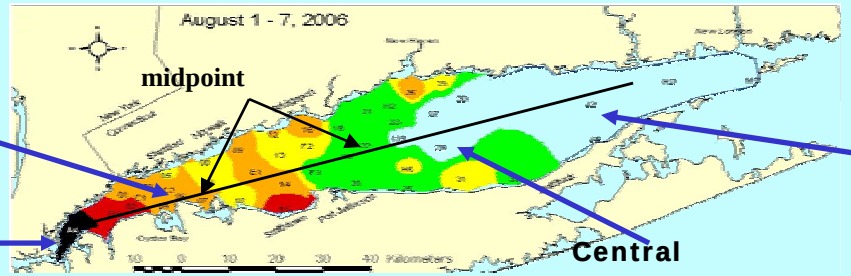
CT DEP LIS Water Quality Monitoring Program

Dissolved Oxygen mg/L	Severity of impact
0.0-0.99	Severe
1.0-1.99	Moderately severe
2.0- 2.99	Moderate
3.0-3.99	Marginal
4.0-4.99	Interim management goal
4.8+	Excellent- Supportive of marine life

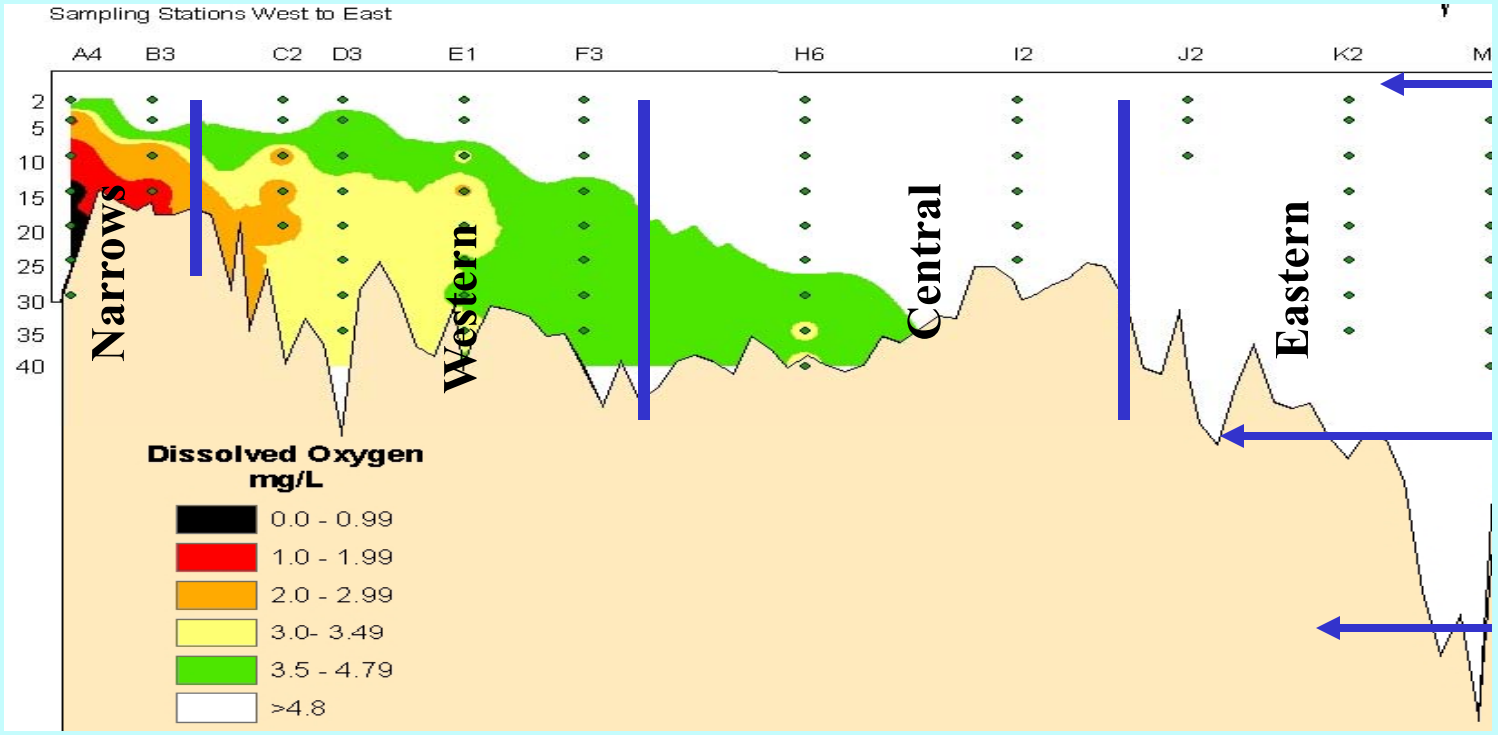
Indicator Type: State

LISS Indicators: Water Quality (2.1)

DO Profiles from Surface to Bottom–Aug. 1-7, 2006



DO levels in bottom waters only



Surface

DO Levels—surface to bottom

troughs represent bottom waters

Sea floor of LIS

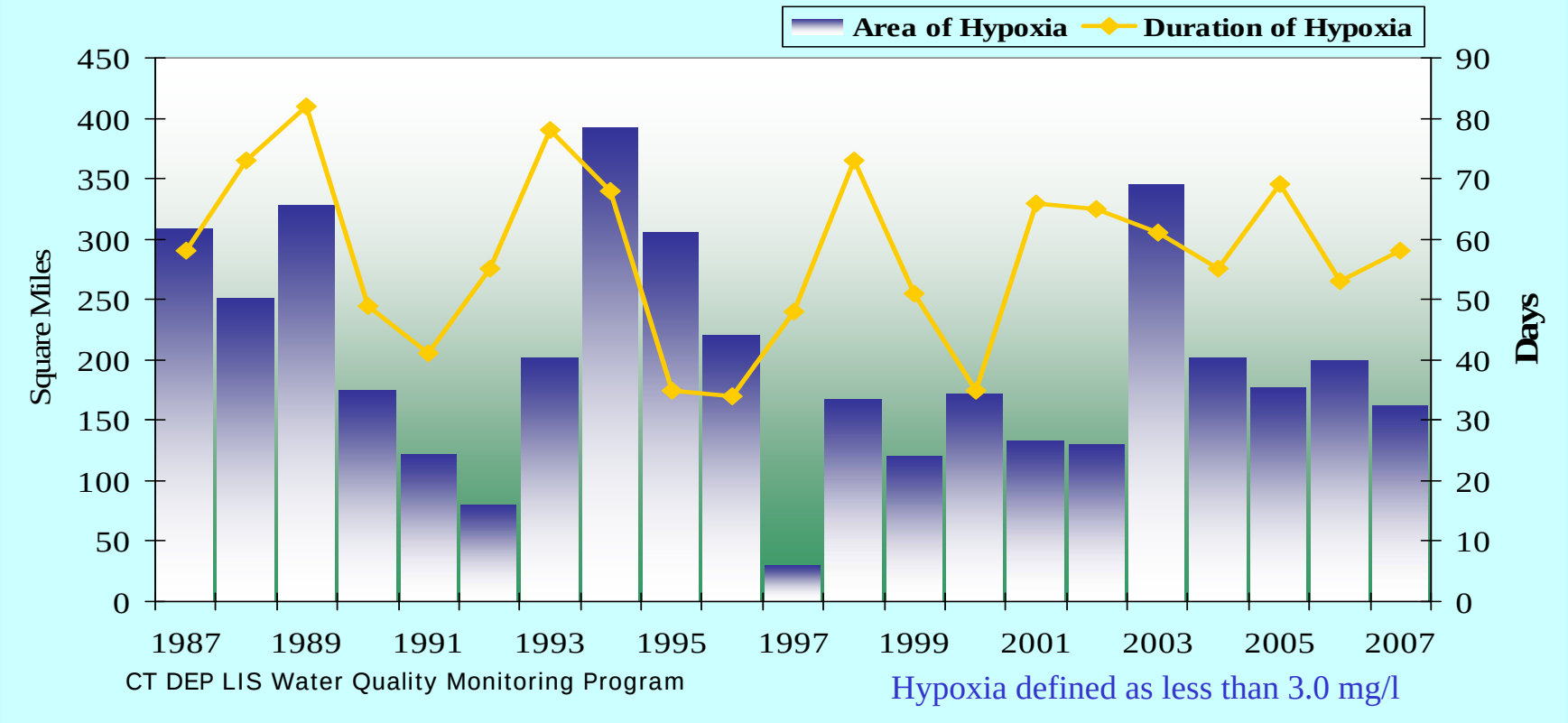
CT DEP

The gradients in dissolved oxygen levels from surface to bottom reflect the pycnocline, or density differences, in the water column. In the western Sound, the density differences are greater with the bottom waters experiencing more hypoxic conditions. The above data tracks measurements collected from monitoring stations along the midpoint of the Sound between CT and NY by the research vessel *John Dempsey.*

Indicator Type: State

LISS Indicators: Water Quality (2.1)

Maximum Area and Duration of Hypoxia

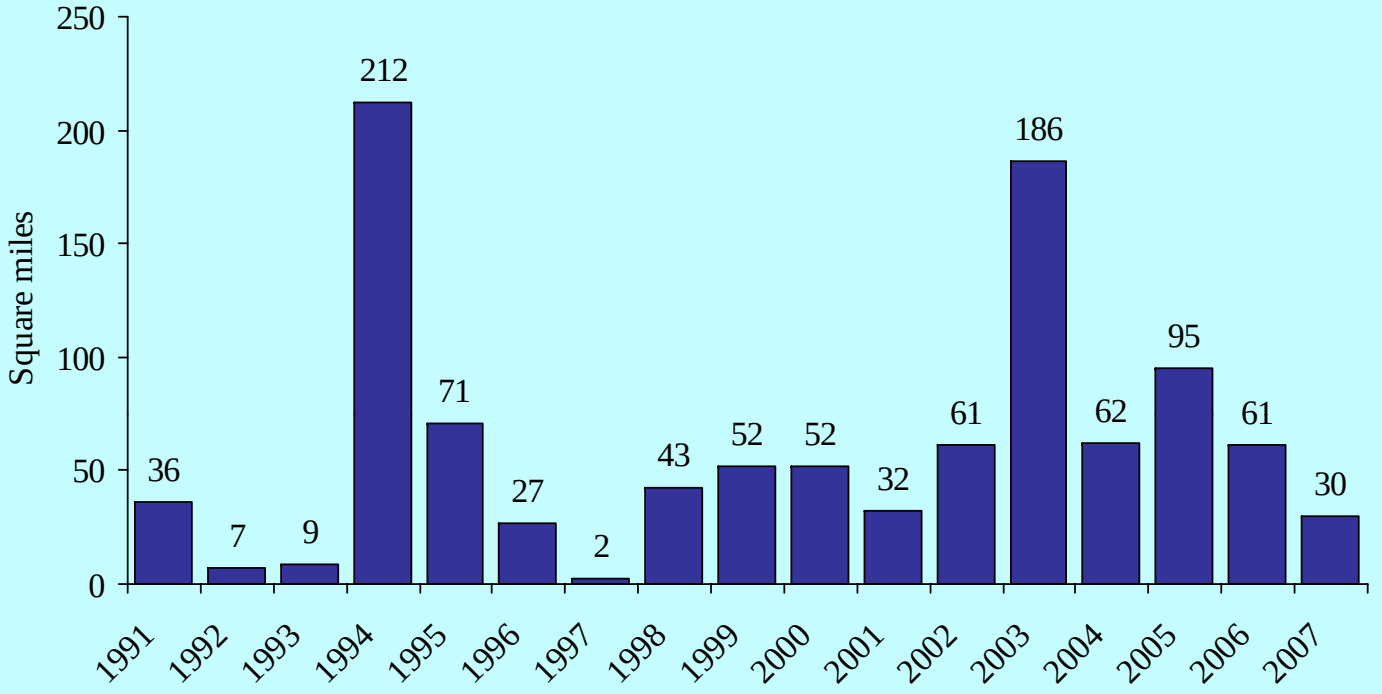


The maximum area of hypoxia averaged 201 square miles from 1987 through 2007. Hypoxia has been below the average for eight out of the last 10 years. The summer of 2007 was the seventh least severe year since 1991 with hypoxic conditions at 162 square miles. In 2007, the duration of hypoxia in the bottom waters lasted 58 days, one day above the average from 1987 through 2007.

Indicator Type: State

LISS Indicators: Water Quality (2.1)

Maximum Extent of Moderately Severe Hypoxia



CT DEP LIS Water Quality Monitoring Program

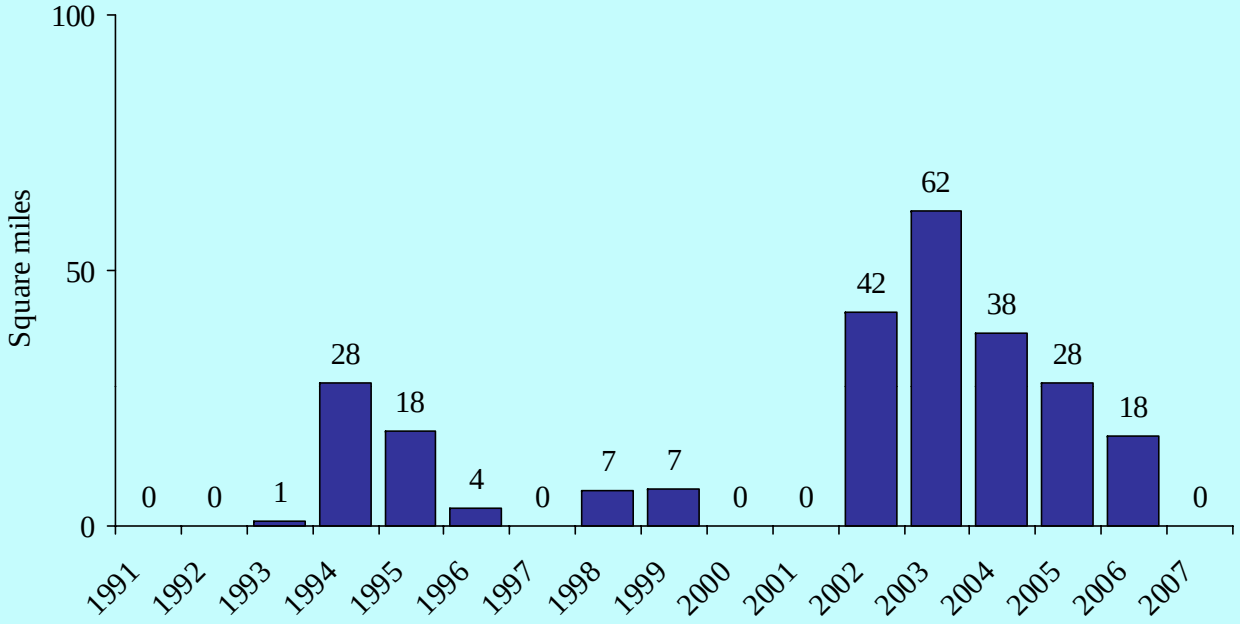
Moderately Severe Hypoxia defined as D0 <2 mg/L

This chart illustrates the area of bottom waters of Long Island Sound with oxygen concentrations less than 2 mg/L. The average area, calculated from 1991-2007, is 70 square miles. The years 1994 and 2003 were especially bad years for concentrations less than 2 mg/L. In 1994. cold winter bottom water temperatures and an unusually warm June led to the establishment of strong stratification. The highest average Delta T in July 1994 was 8.54 ºC. The year 2003 was the second hottest summer since 1895 and the 28th wettest which also led to the Sound being very strongly stratified. Strong stratification (Delta T greater than 4) lasted for four months in 1994 (May-August) and only one month (July) in 2003.

Indicator Type: State

LISS Indicators: Water Quality (2.1)

Maximum Extent of Anoxia (Severe Hypoxia)



CT DEP LIS Water Quality Monitoring Program

Anoxia defined as DO concentrations <1 mg/L

Anoxia, DO concentrations <1mg/L, has been declining since it spiked in 2003. The overall average area affected from 1991-2007 is 14.8 square miles.

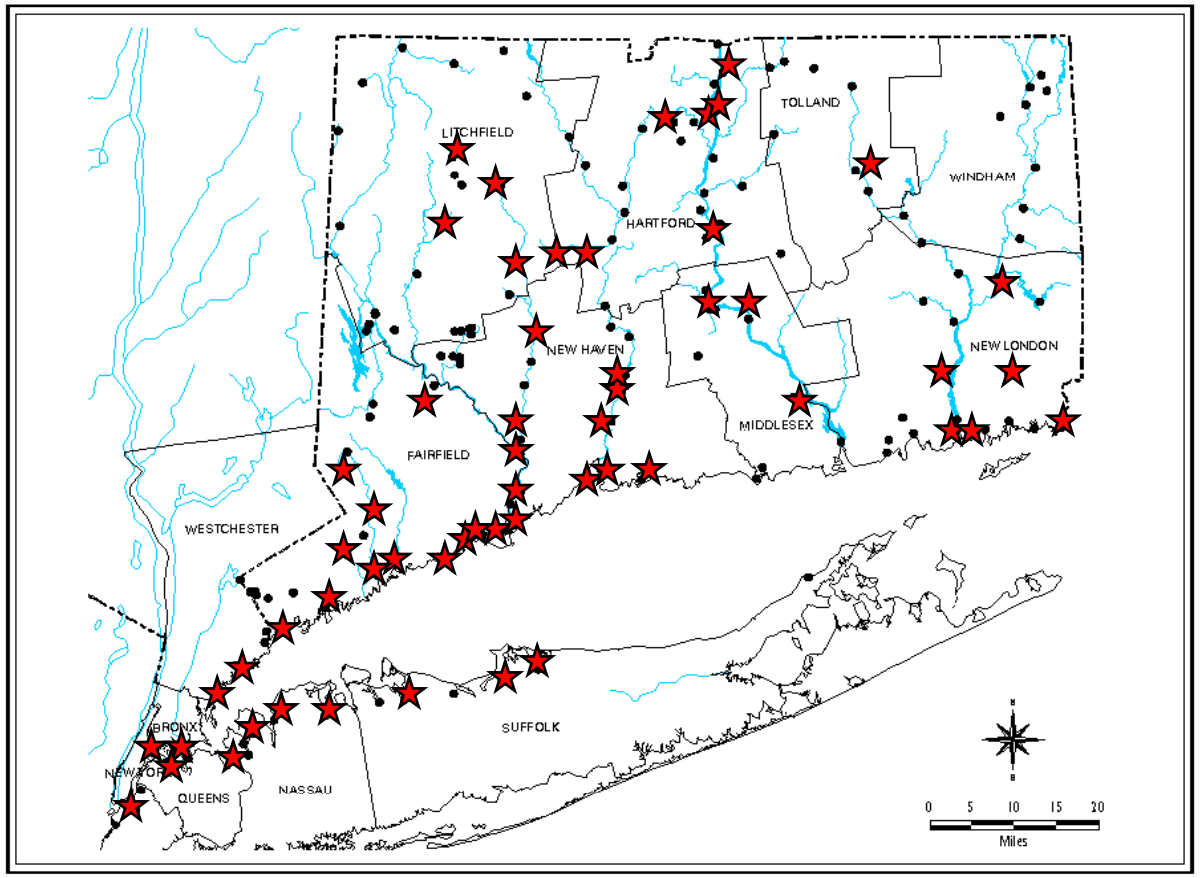
Indicator Type: State

LISS Indicators: Water Quality (2.1)

Advanced Nutrient Removal (ANR)

There are 105 sewage treatment plants (STPs) in CT and NY that discharge into the Sound or its tributaries. ANR systems to remove nitrogen are being phased in at selected STPs.

Both states have actively implemented actions and incentives to upgrade plants. Since 1990, 46 (43%) of the STPs have been upgraded to include ANR.



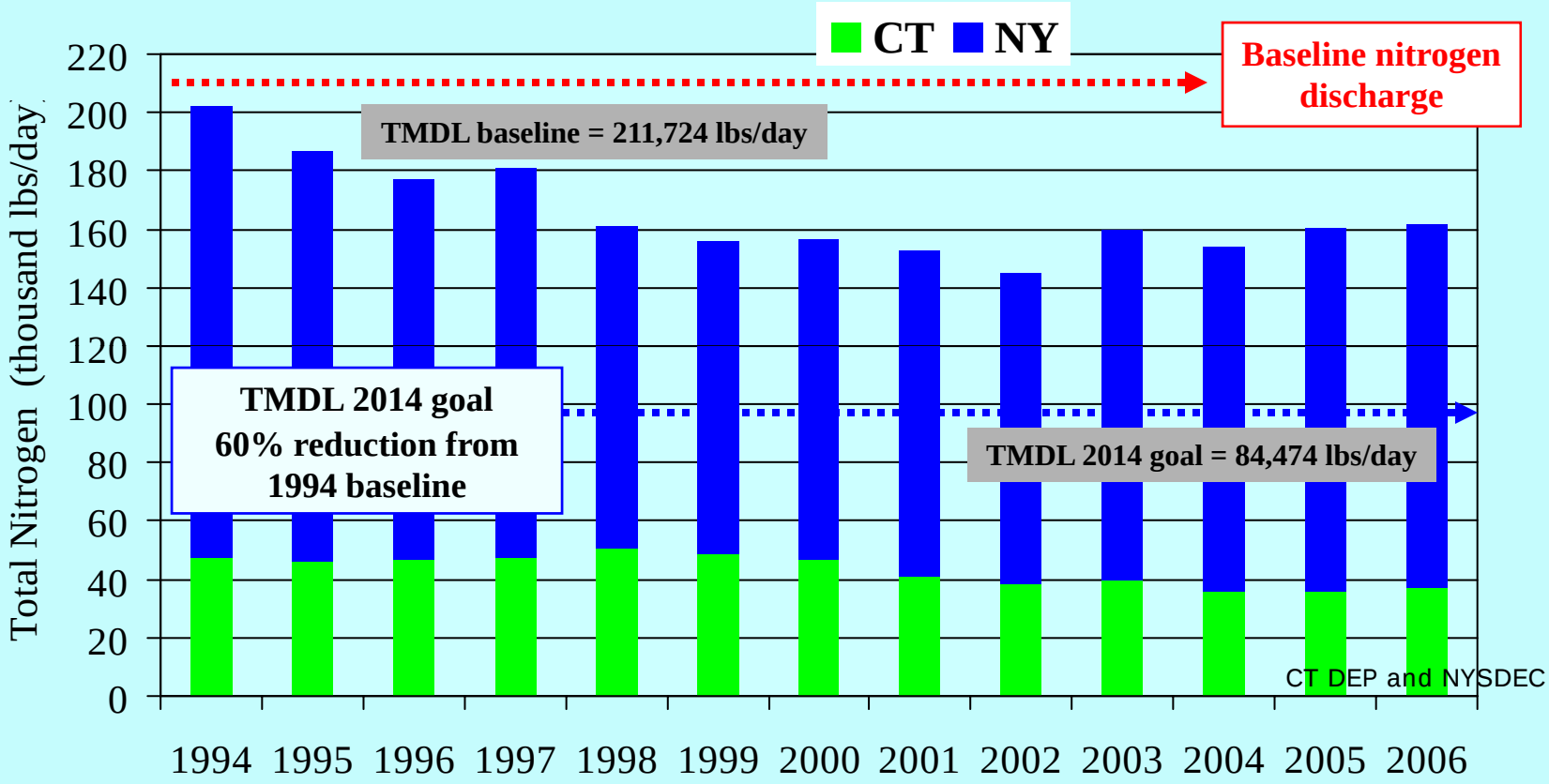
CT DEP/ NYSDEC (2006)

Sewage Treatment Plants
STPs with ANR
STPs without ANR

Indicator Type: Response

LISS Indicators: Water Quality (2.1)

Point Source Nitrogen
End-of-Pipe Discharge (from STPs)

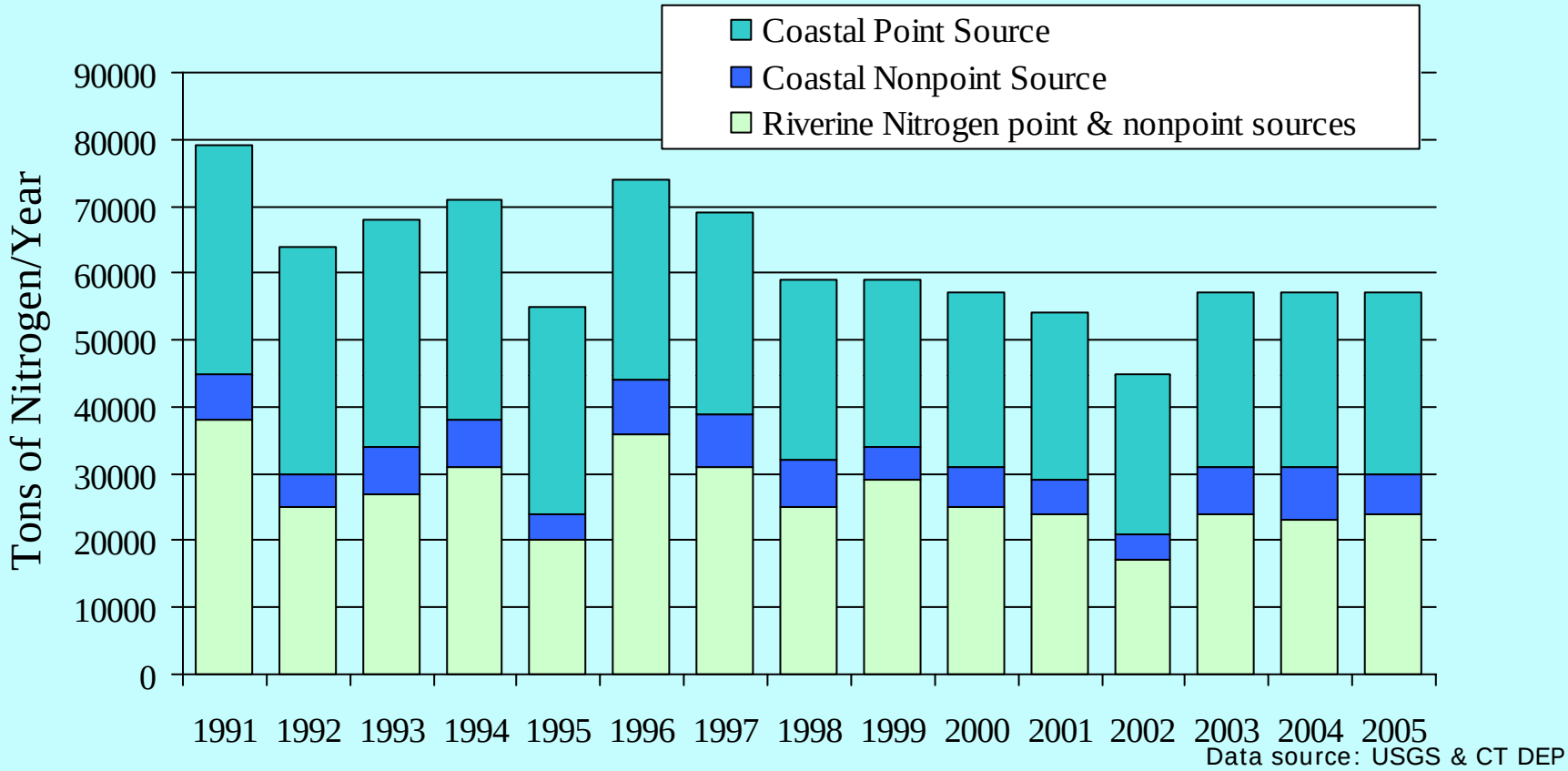


As a result of upgrades to sewage treatment plants (STPs), there has been a reduction of 20% in nitrogen End-of-Pipe discharges from STPs over the past 15 years. Factors such as wet years and STP process problems contribute to years of higher nitrogen discharge.

Indicator Type: Response

LISS Indicators: Water Quality (2.1)

Estimated Nitrogen Load from all CT Coastal and Riverine Sources



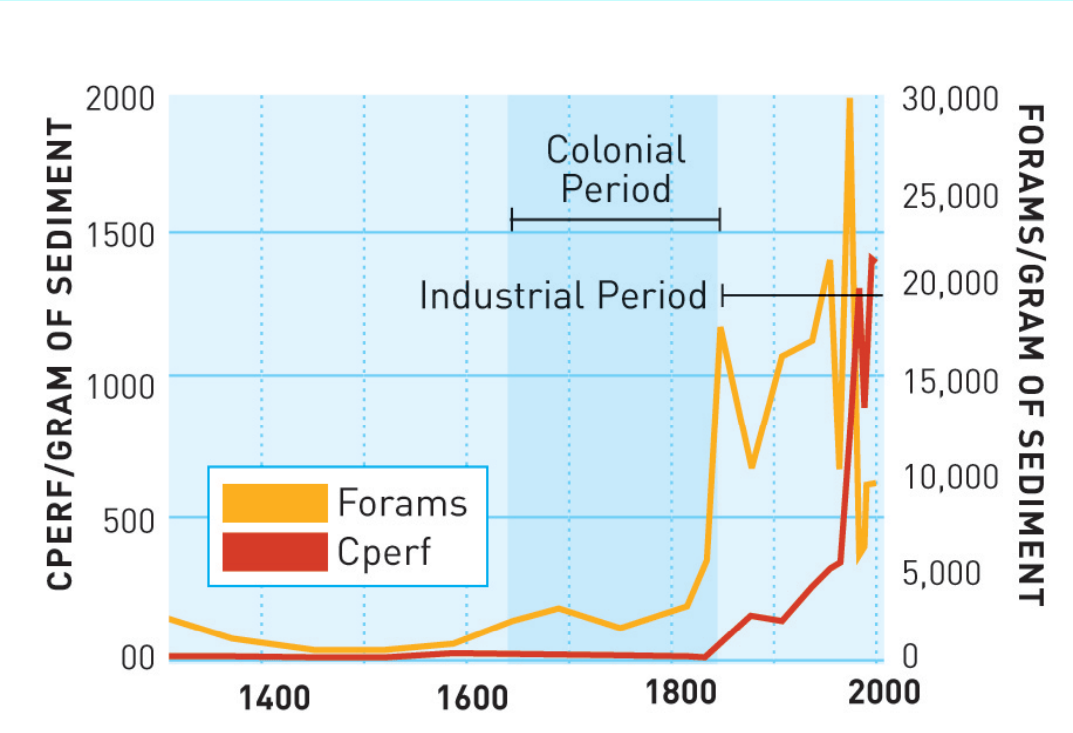
Data source: USGS & CT DEP

Nitrogen enters Long Island Sound from point sources such as sewage treatment plants within the coastal zone, nonpoint sources near the coast such as septic systems and stormwater runoff, and point and nonpoint sources from the rivers that flow into CT. Nitrogen is also found as a natural component of the Sound's physical environment. Nitrogen discharges from point sources have been decreasing since 1991, while nonpoint sources discharges have stayed about the same.

Indicator Type: Pressure

LISS Indicators: Water Quality (2.1)

Increased Population & Sewage



Samples collected off Norwalk coast

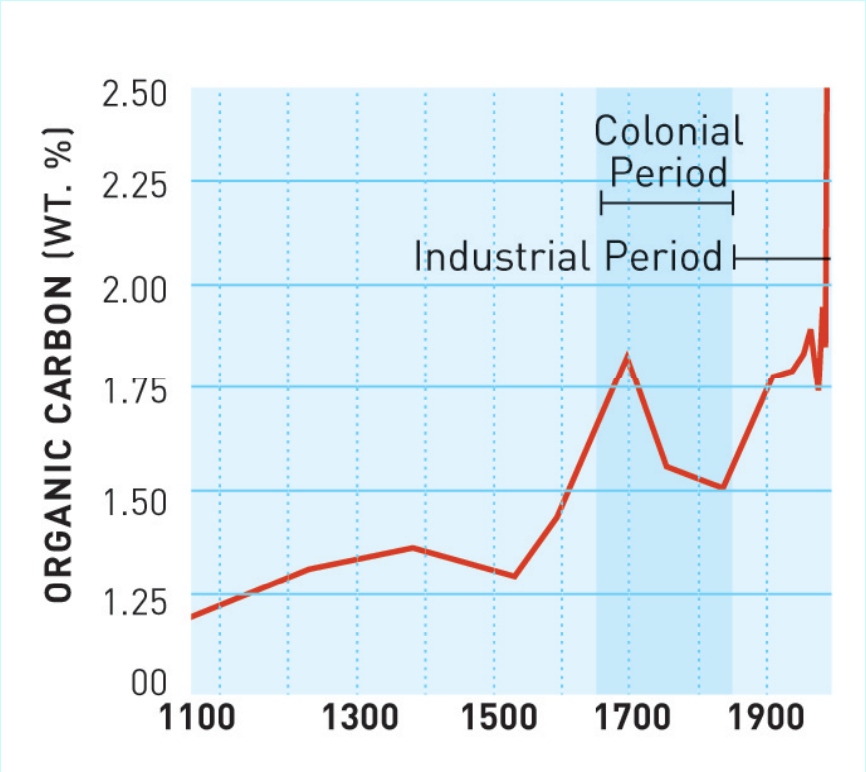
Wesleyan Univ./USGS Woods Hole Field Center

Clostridium perfringens (Cperf), a bacterial spore found in sediments, is an indicator of the amount of sewage input to the Sound. The bacteria that produce these spores live in the guts of mammals and are capable of surviving sewage treatment. The increase in Cperf reflects the increase in treated sewage entering the Sound as a result of the increase in human population. Foraminifera (forams) are microscopic organisms, and an indicator of more eutrophication—the increase of algae fueled by nitrogen-rich sewage. The forams increased because its food supply, algae, became more abundant.

Indicator Type: Driver

LISS Indicators: Water Quality (2.1)

Sediment Carbon Concentration has Increased



Samples collected off Norwalk coast

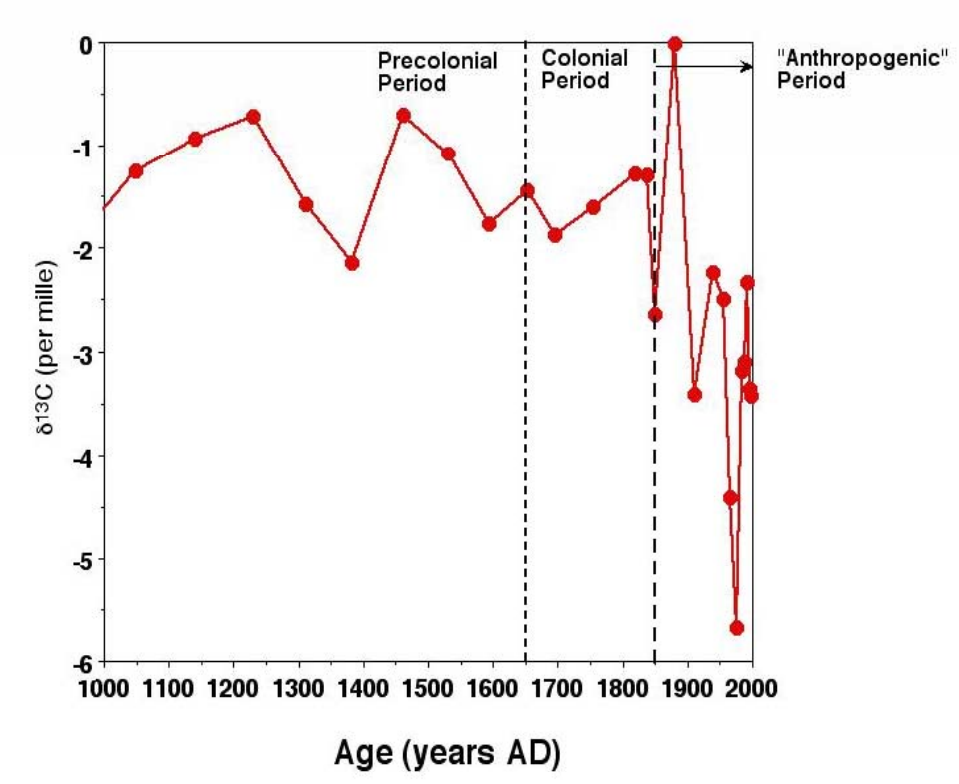
Wesleyan Univ./USGS Woods Hole Field Center

Carbon is a basic element for all life, including algae. The first peak in organic carbon coincides with an increase in carbon supply from the land as the forests were cleared for farming. But the second peak, starting after 1800, reflects the increased production of algae caused by nutrient enrichment. This eutrophication ultimately leads to hypoxia.

Indicator Type: State

LISS Indicators: Water Quality (2.1)

The increased production has increased oxidation of carbon



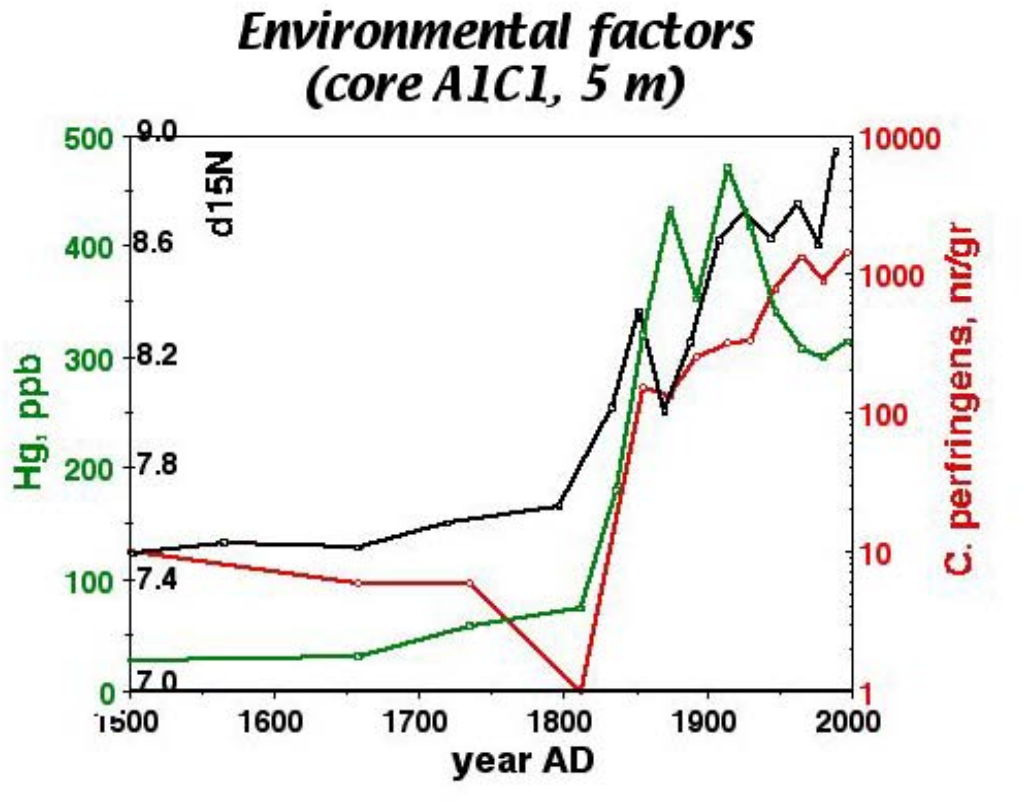
Samples collected off Norwalk coast

Varekamp et al. 2004

The $\delta^{13}C$ values reflect the oxidation of organic materials, and thus serves as an indirect proxy for bottom water oxidation. Strongly negative $\delta^{13}C$ values in surface sediment samples is a good signal for organic carbon oxidation and associated hypoxia. Data suggest that only small amounts of organic carbon were oxidized at the bottom of LIS prior to 1800. At around 1850 $\delta^{13}C$ values started to decline indicating increased oxidation of organic carbon.

Indicator Type: State

Sediment $\delta^{15}N$ has increased after 1800, reflecting increased anthropogenic nitrogen



Samples collected off Norwalk coast

Varekamp et al. 2004

Anthropogenic nitrogen loadings from wastewater have higher $\delta^{15}N$ levels relative to natural sources. The increase in sediment $\delta^{15}N$ values since 1850 reflects increased wastewater discharges.

Indicator Type: State

LISS Indicators: Water Quality (2.1)

Sediment $\delta^{15}N$ is also higher in the western Sound reflecting increased anthropogenic nitrogen

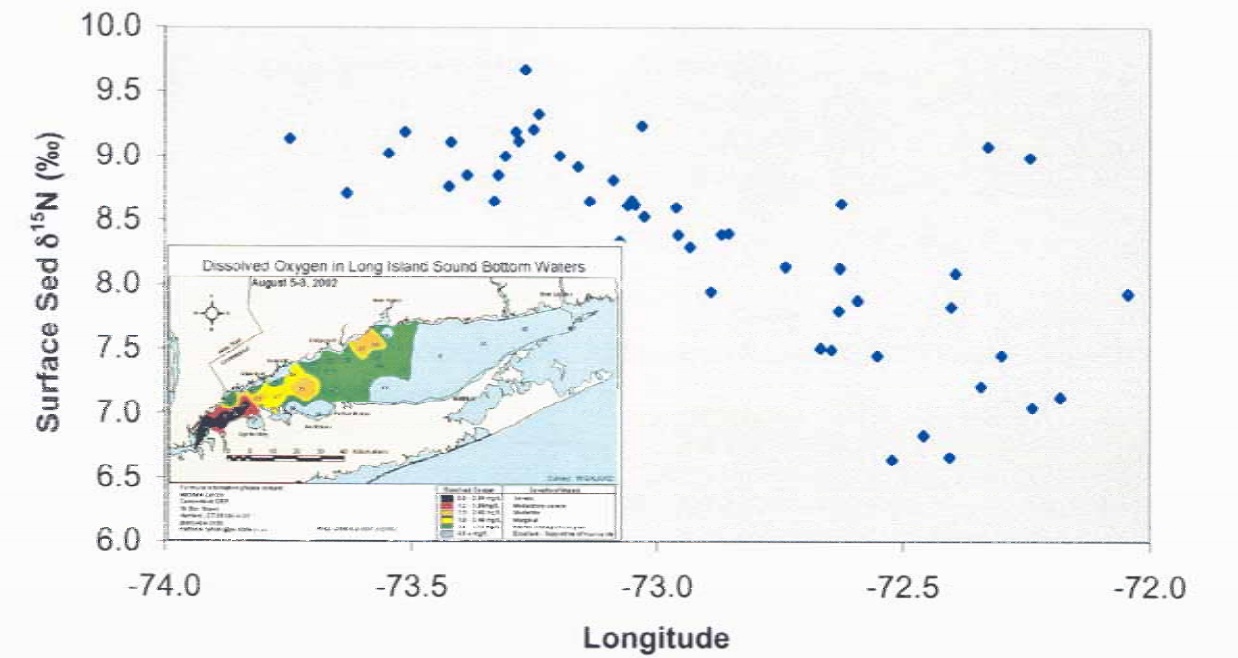


Fig. 4 Increasing $\delta^{15}N$ of surface sediments in LIS going from east to west. Inset shows the association with summertime subsurface hypoxia (black coloration).

Varekamp et al. 2004

In LIS surface sediment $\delta^{15}N$ increases from east to west. This increase is associated with higher levels of water discharge in the western LIS.

Indicator Type: State

LISS Indicators: Water Quality (2.1)