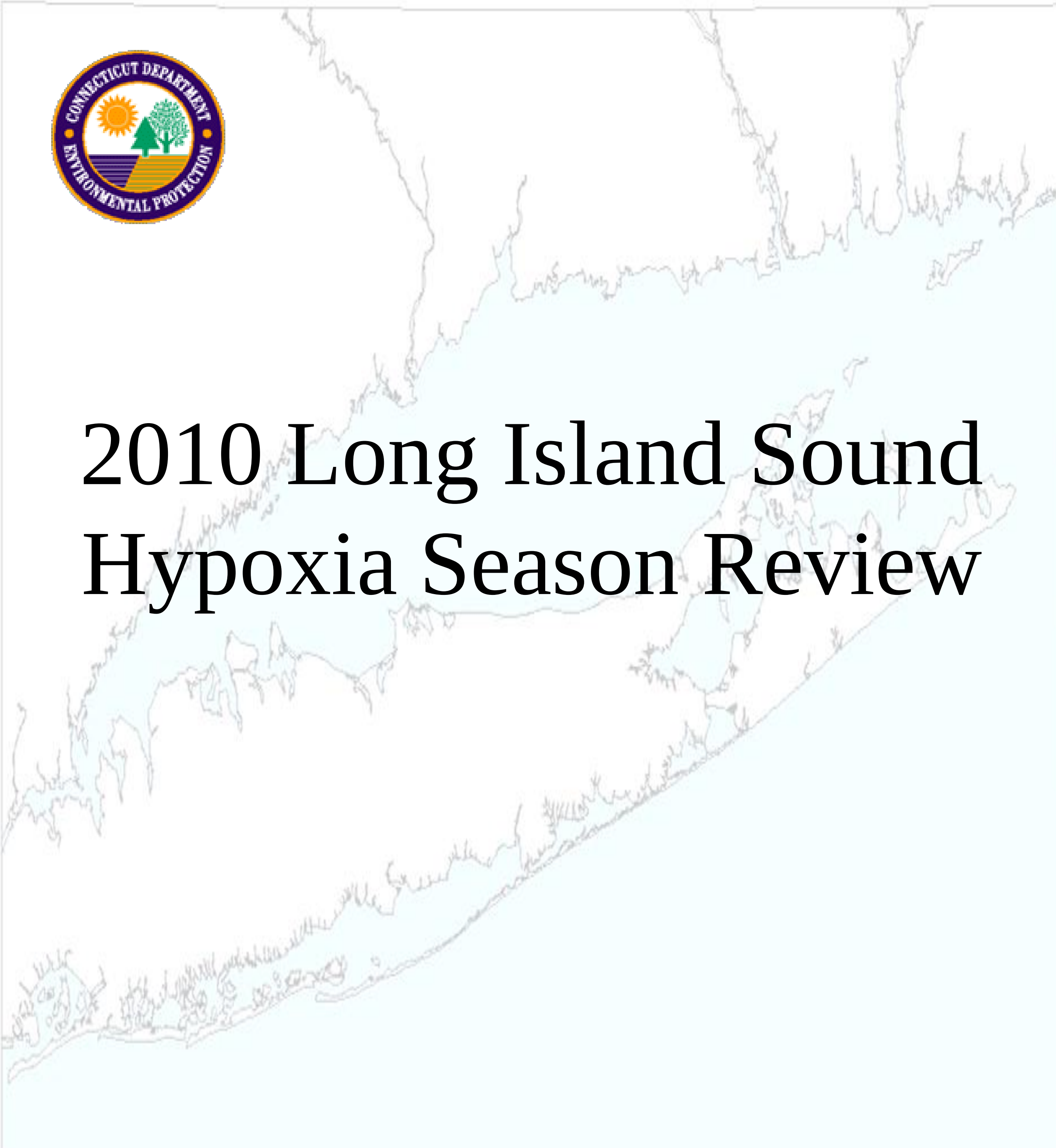


2010 Long Island Sound Hypoxia Season Review

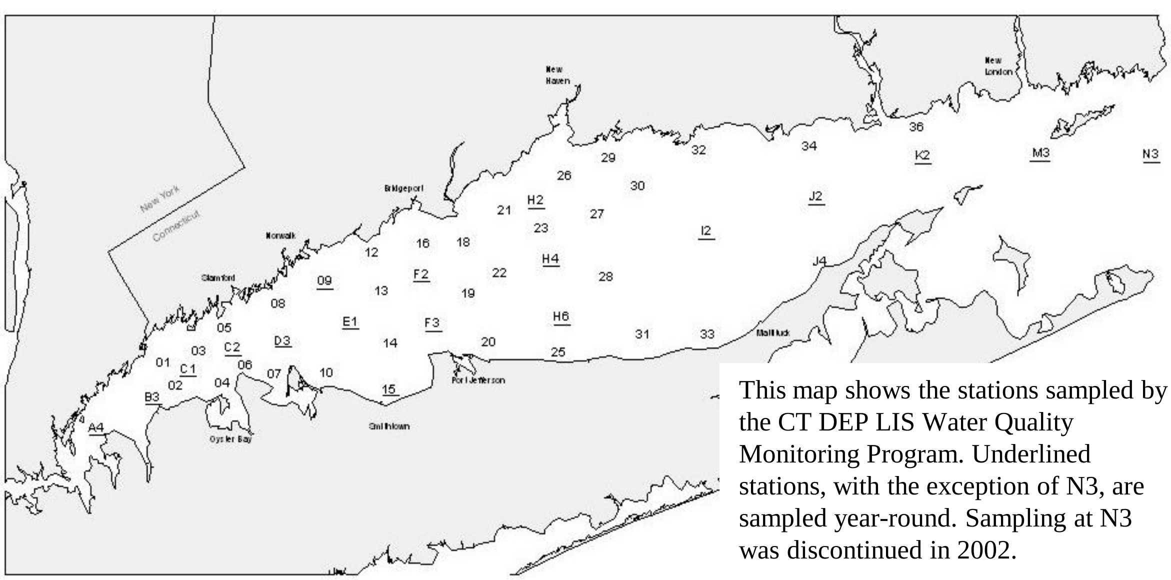
CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION
79 ELM STREET, HARTFORD, CT 06106
AMEY MARRELLA, COMMISSIONER

MONITORING LONG ISLAND SOUND 2010

Program Overview

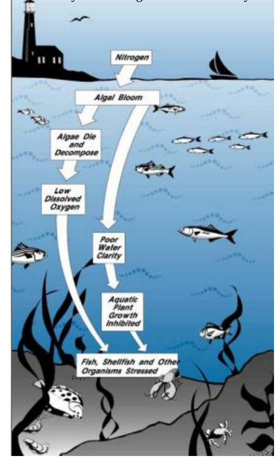
R/V John Dempsey

Since 1991, the Connecticut Department of Environmental Protection (CTDEP) has conducted an intensive year-round water quality monitoring program on Long Island Sound. Water quality is monitored at up to forty-eight (48) sites by staff aboard the Department's Research Vessel *John Dempsey*. These data are used to quantify and identify annual trends and differences in water quality parameters relevant to hypoxia, especially nutrients, temperature, and chlorophyll. These data are also used to evaluate the effectiveness of the management program to reduce nitrogen concentrations. During the summer (June - September) CT DEP conducts additional summer hypoxia surveys at bi-weekly intervals to better define the areal extent and duration of hypoxia.



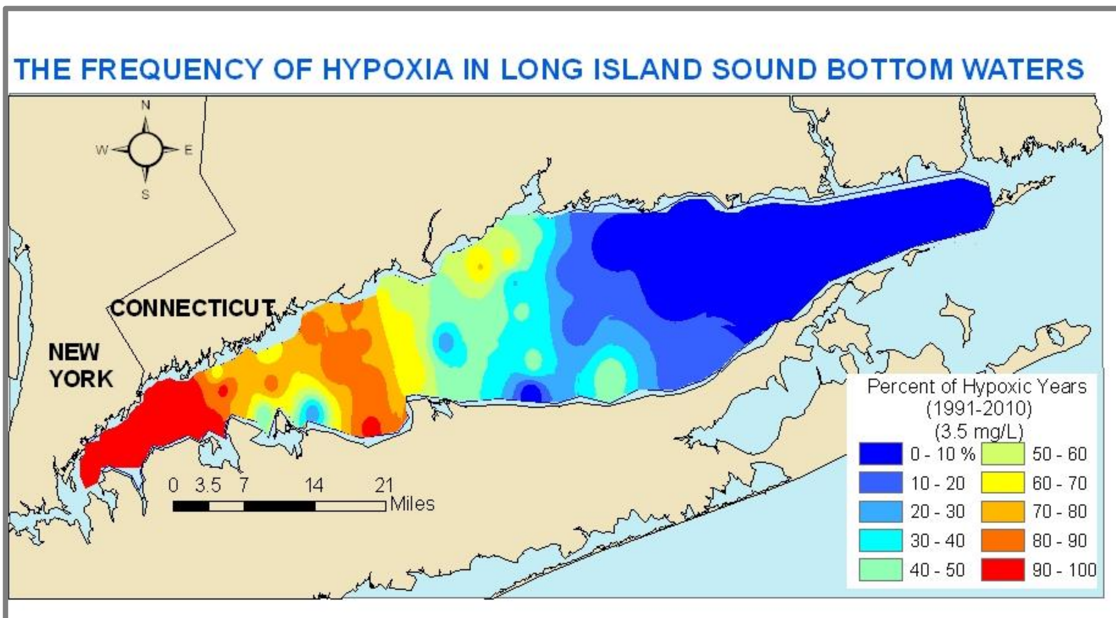
This map shows the stations sampled by the CT DEP LIS Water Quality Monitoring Program. Underlined stations, with the exception of N3, are sampled year-round. Sampling at N3 was discontinued in 2002.

What is Hypoxia?



Courtesy of the Long Island Sound Study

The term "hypoxia" means low dissolved oxygen ("DO") concentrations in the water. Marine organisms need oxygen to live, and low concentrations, depending on the duration and the size of the area affected, can have serious consequences for a marine ecosystem. As defined by the Long Island Sound Study, hypoxia exists when DO drops below a concentration of 3 milligrams per liter (mg/L), although ongoing national research suggests that there may be adverse affects to organisms even above this level, depending upon the length of exposure. In 2002, Connecticut adopted revised water quality criteria for dissolved oxygen. These criteria, designed to protect the state's waters from degradation, define hypoxia as DO concentrations below 3.5 mg/L. Low oxygen levels can occur naturally in estuaries during the summer, when calm weather conditions prevent the mixing of the water column that replenishes bottom water oxygen during the rest of the year. However, studies of the limited historical data base for the Sound suggest that summer oxygen depletion in Western Long Island Sound has grown worse since the 1950s.



How Seriously Does Low Oxygen Impact the Sound?

Each summer low oxygen levels render hundreds of square kilometers of bottom water unhealthy for aquatic life. DO levels follow seasonal patterns with a decrease in bottom water DO over the course of the summer. Hypoxic conditions during the summer are mainly confined to the Narrows and Western Basin of Long Island Sound. Those areas comprise the section of the Sound west of a line from Stratford, CT to Port Jefferson, NY. The maximum extent of the hypoxic condition typically occurs in early August.


Photo By Lloyd Langevin, June 2007

2010 Important Facts

CT DEP conducted seven cruises during the summer of 2010 between 27 May and 2 August. Over the course of the season, 15 different stations were documented to have been hypoxic and of the 191 site visits completed in 2010, hypoxic conditions were found 29 times.

Cruise	Start Date	End Date	Number of stations sampled	Number of hypoxic stations
WQJUN10	5/27/2010	6/3/2010	14	0
HYJUN10	6/18/2010	6/18/2010	21	0
WQJUL10	7/8/2010	7/9/2010	29	4
HYJUL10	7/21/2010	7/23/2010	32	6
WQAUG10	8/3/2010	8/4/2010	34	14
HYAUG10	8/17/2010	8/19/2010	35	3
WQSEP10	8/31/2010	9/2/2010	28	0

The peak event occurred during the WQAUG10 cruise between 3 and 4 August. The lowest dissolved oxygen concentration (1.17 mg/L) was also documented during this cruise at Station 02.

The hypoxia area maps for 2010 appear on pages 7, 8, and 9.

	CT Water Quality Standards 3.5 mg/L	LISS 3.0 mg/L
Estimated Start Date	7/3/2010	7/5/2010
Estimated End Date	8/15/2010	8/13/2010
Duration (days)	44	40
Maximum Area (mi^2)	154.7*	101.1*

The Long Island Sound Study has defined hypoxia as dissolved oxygen concentrations below 3.0 mg/L. In December of 2002, the State of Connecticut adopted water quality standards which state that the concentration of dissolved oxygen in offshore waters below the seasonal pycnocline shall not be less than 3.5 mg/L at anytime. As a result CT DEP began reporting on the area of Long Island Sound bottom water affected by DO concentrations less than 3.5 mg/L. Prior to that, CT DEP used the 3.0 mg/L standard. To maintain the long-term dataset and to compare to previous years, the maximum area, start date, end date, and duration based on the 3.0 mg/L standard are also presented.

In December 2009, CT DEP public noticed revisions to the water quality standards that specified dissolved oxygen in Class SA and SB waters shall not be less than 3.0 mg/L at anytime. These revisions have not yet been finalized/approved.

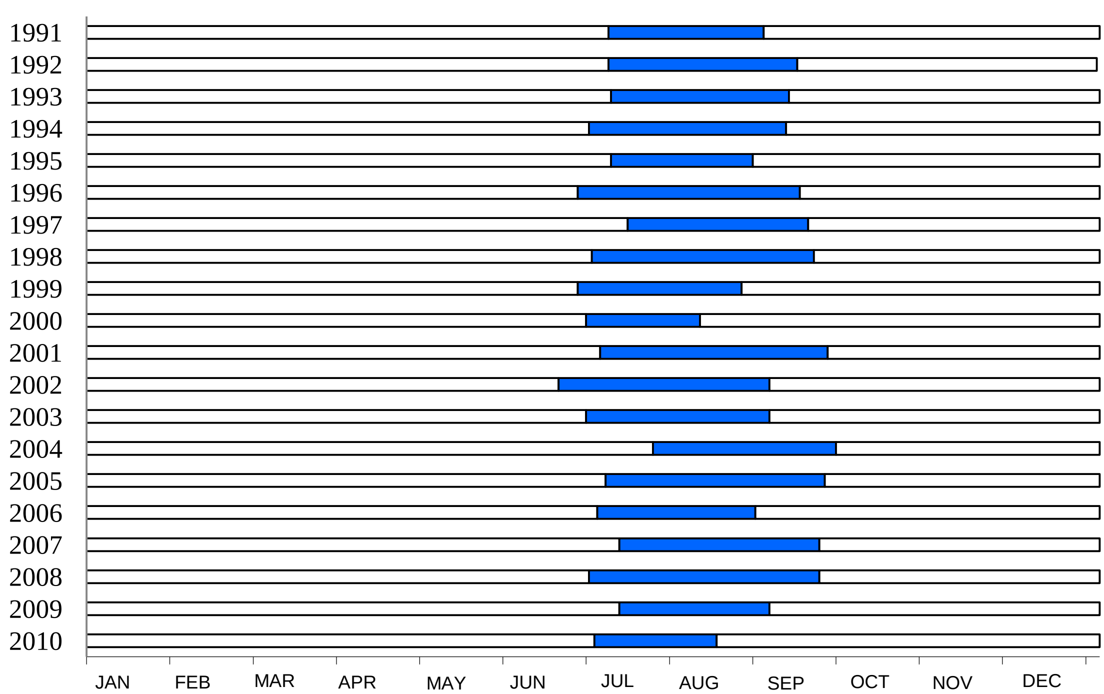
* This number is different than that reported in the WQAUG10 email summary as an error occurred while converting from km^2 to mi^2. The km^2 area was correct as reported in the summary.

Timing and Duration of Hypoxia, 1991 - 2010

The figures and tables below displays the onset, duration, and end of the hypoxia events from 1991 through 2010 based on both the CT 3.5 mg/L standard and the LISS 3.0 mg/L standard.

CT Water Quality Standards 3.5 mg/L				
Year	Estimated Start Date	Estimated End Date	Maximum Area (mi²)	Duration (days)
1991	July 8	Sept 1	263.2	56
1992	July 7	Sept 12	194.5	68
1993	July 5	Sept 12	335.9	70
1994	July1	Sept 16	513.7	71
1995	July 9	Aug 28	415.6	51
1996	June 26	Sept 13	340.4	80
1997	July 15	Sept 17	51	65
1998	July 2	Sept19	286.1	80
1999	June 27	Aug 24	229.4	59
2000	June 29	Aug 8	260.2	41
2001	July 5	Sept 24	215.7	82
2002	June 20	Sept 4	193.9	76
2003	June 30	Sept 3	430.6	66
2004	July 23	Sept26	257.5	66
2005	July 7	Sept 23	300.2	79
2006	July 4	Aug 29	346.1	57
2007	July 12	Sept 21	354	72
2008	June 30	Sept 20	359.9	83
2009	July 12	Sept 3	369.6	54
2010	July 3	August 15	154.7	44
Average	July 4	Sept10	294	66
Deviation	± 7 days	± 14 days	± 106 mi²	± 13 days

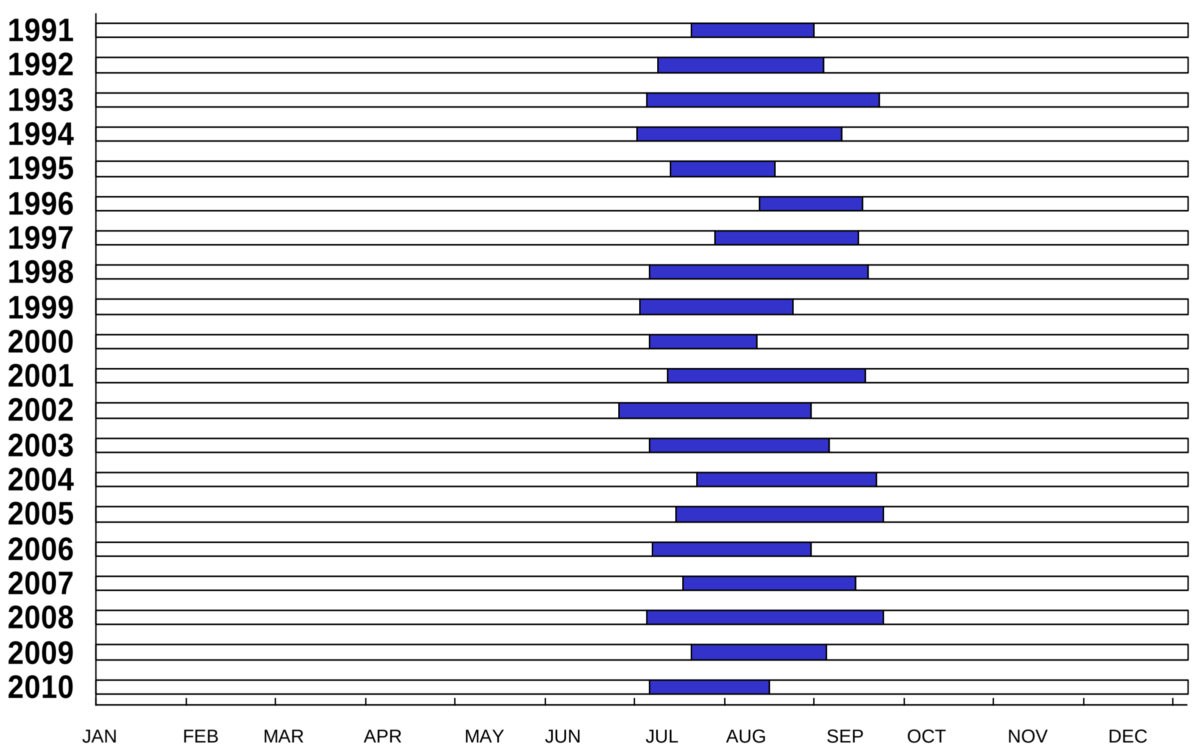
Based on the CT standard of 3.5 mg/L, the average date of onset was July 4 (± 7 days), the average end date was September 10 (± 14 days), and the average duration was 66 days (± 13 days). The earliest onset of hypoxia occurred on 20 June 2002 and the latest end date occurred on 26 September 2004. The maximum area of hypoxia was 513.7 square miles and occurred in 1994. The longest hypoxic event occurred in 2008 and lasted 83 days.



Timing and Duration of Hypoxia based on 3.5 mg/L

LISS 3.0 mg/L				
Year	Estimated Start Date	Estimated End Date	Maximum Area (mi²)	Duration (days)
1991	July 19	Aug 28	122	41
1992	July 7	Aug 30	80	55
1993	July 9	Sept 10	202	64
1994	July 1	Sept 6	393	68
1995	July 12	Aug 15	305	35
1996	Aug 10	Sept 12	220	34
1997	July 27	Sept 12	30	48
1998	July 5	Sept 15	168	73
1999	July 2	Aug 21	121	51
2000	July 2	Aug 6	173	35
2001	July 10	Sept 14	133	66
2002	June 25	Aug 28	130	65
2003	July 5	Sept 3	345	61
2004	July 20	Sept 12	202	55
2005	July 14	Sept 20	177	69
2006	July 6	Aug 27	199	53
2007	July 16	Sept 11	162	58
2008	July 3	Sept 19	180.1	79
2009	July 19	Sept 1	169.1	45
2010	July 5	August 13	101.1	40
Average	July 10	Sept 3	181	55
Deviation	±11 days	±13 days	± 86 mi²	± 14 days

Based on the LISS standard of 3.0 mg/L, the average date of onset was July 10 (± 11 days), the average end date was September 3 (± 14 days), and the average duration was 66 days (± 13 days). The earliest onset of hypoxia (red text) occurred on 25 June 2002 and the latest end date (green text) occurred on 20 September 2005. The maximum area of hypoxia was 393 square miles (blue text) and occurred in 1994. The longest hypoxic event occurred in 2008 (magenta text) and lasted 79 days.

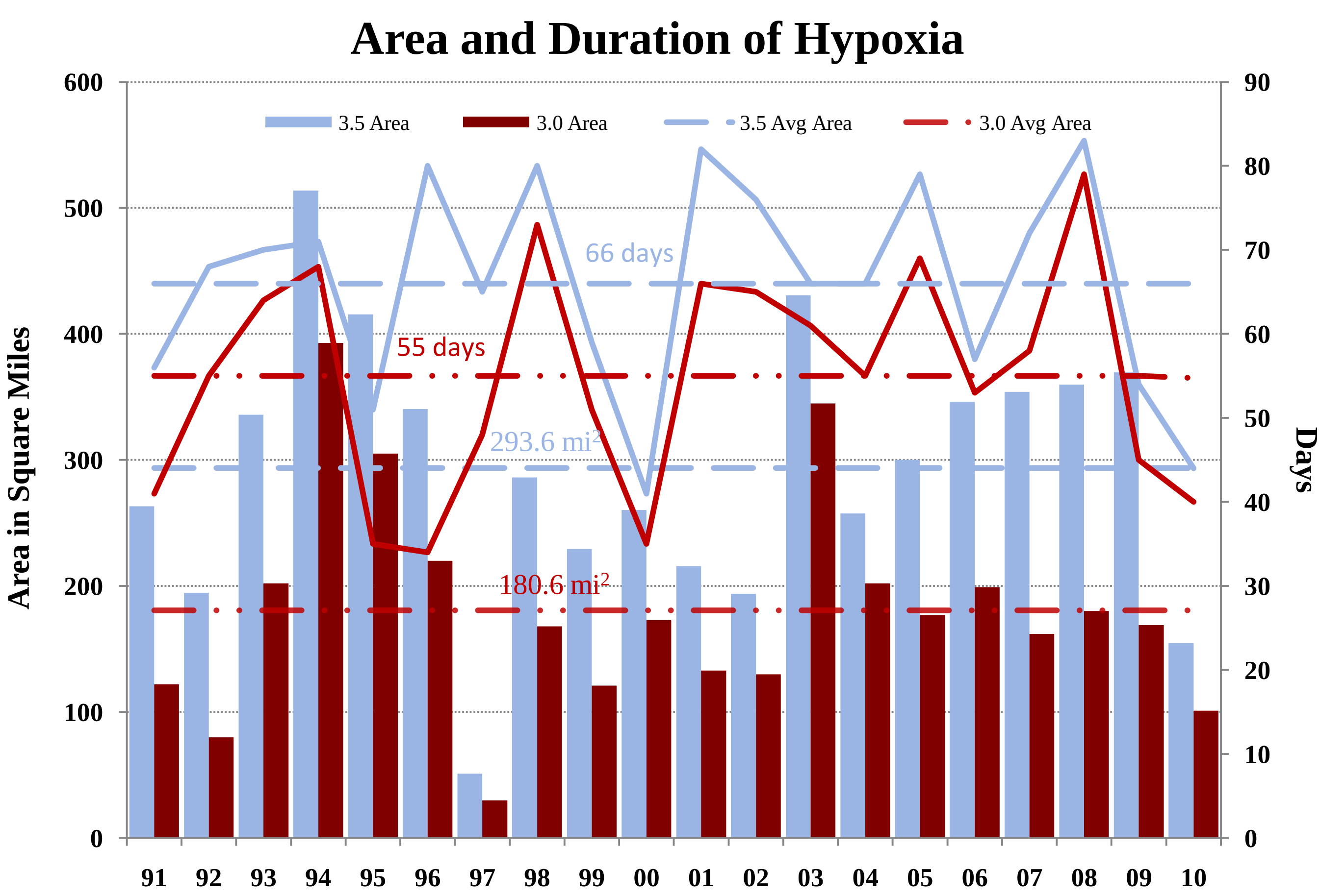


Timing and Duration of Hypoxia based on 3.0 mg/L

Yearly Comparison of Maximum Areal Extent and Duration of Hypoxia

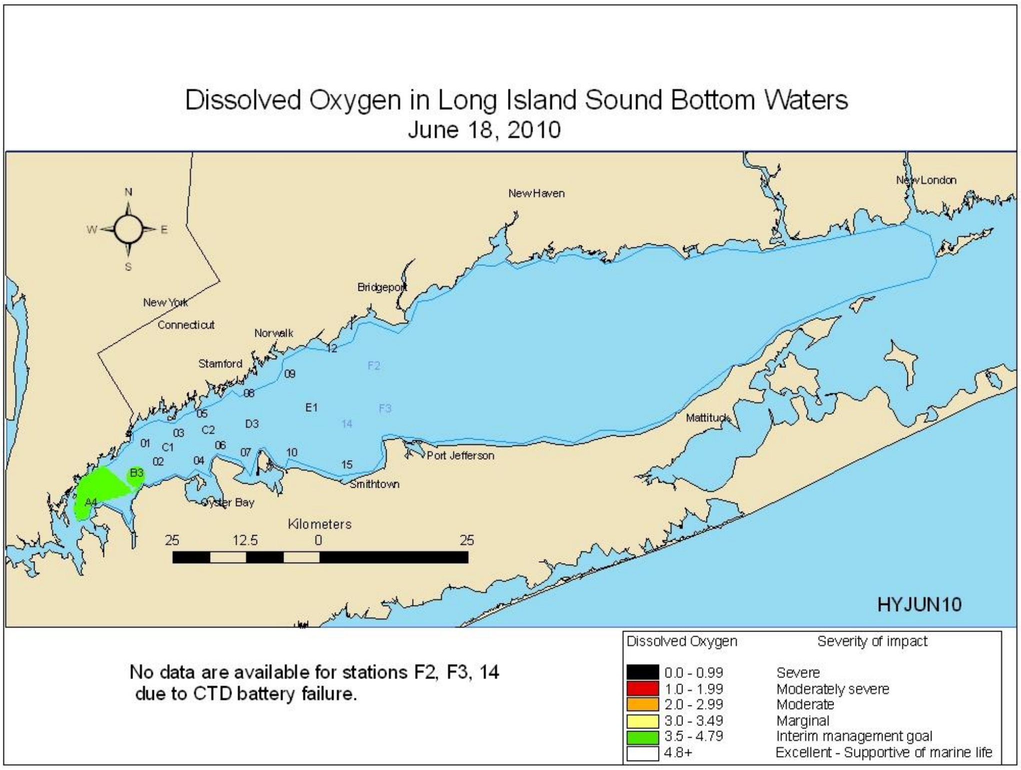
This graph utilizes the data presented on the previous page to illustrate the year-to-year differences in the maximum areal extent of hypoxic conditions. The blue color corresponds to the CT 3.5 mg/L standard while the red color corresponds to the LISS 3.0 mg/L standard.

Based on the 3.5 mg/L standard the average areal extent from 1991-2010 was 293.6 mi^2 and the average duration was 66 days . Based on the 3.0 mg/L standard the average areal extent was 180.6 mi^2 and the average duration was 55 days.

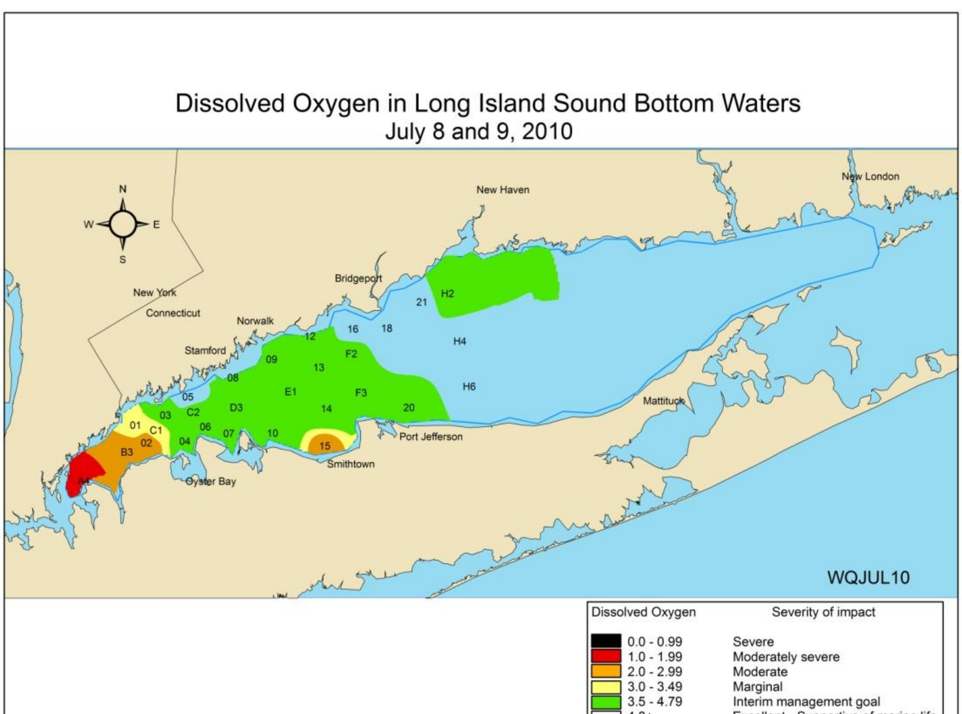


Hypoxia Maps

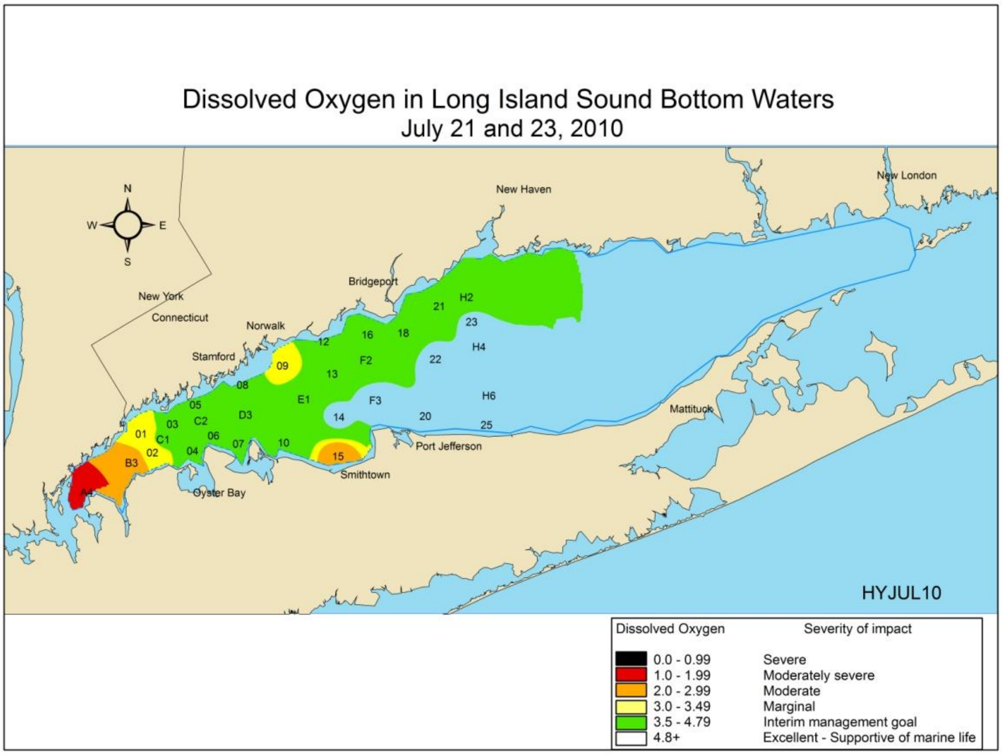
The following maps depict the development of hypoxia through the 2010 season, beginning with the HYJUN10 survey. During this survey DO concentrations were less than 4.8 mg/L at three stations. Data for all surveys are available upon request.



During the WQJUL10 survey, DO concentrations continued to decrease below 4.8 mg/L in the Narrows and Western Basin with Stations 01 and C1 measuring between 3.0 and 3.49 mg/L, Stations B3 and 02 measuring between 2 and 2.99 mg/L and Station A4 dropping below 1.99 mg/L.

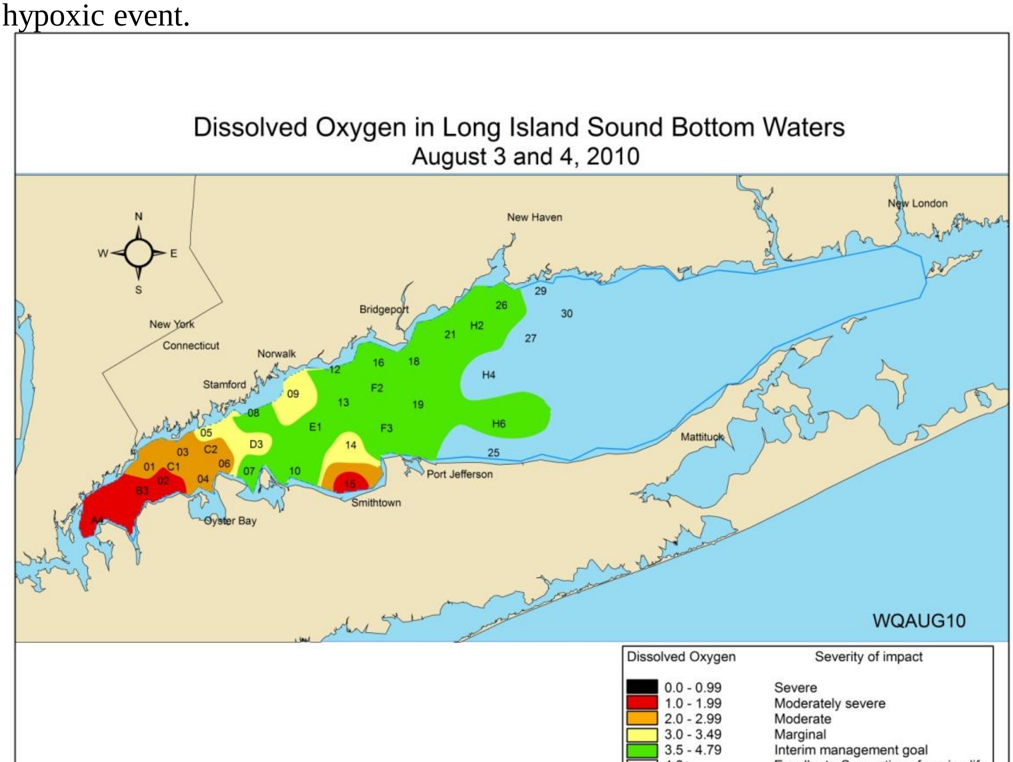


During the HYJUL10 survey, DO concentrations dropped below 3.5 mg/L at 6 stations; two of those stations fell below 3 mg/L, and one station was below 2 mg/L.

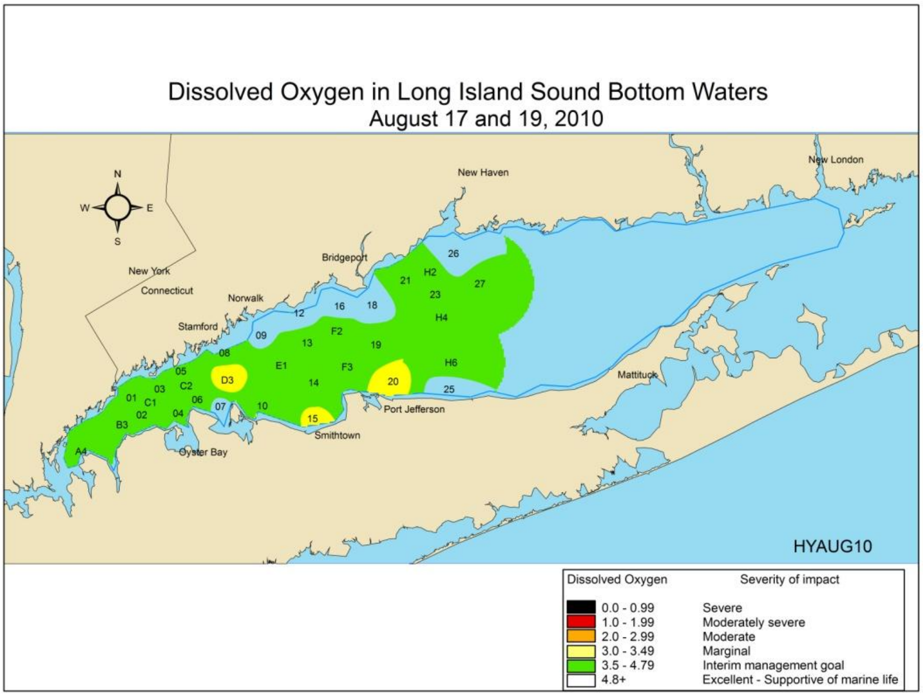


Maximum Areal Extent (248.9 mi^2) of Hypoxia

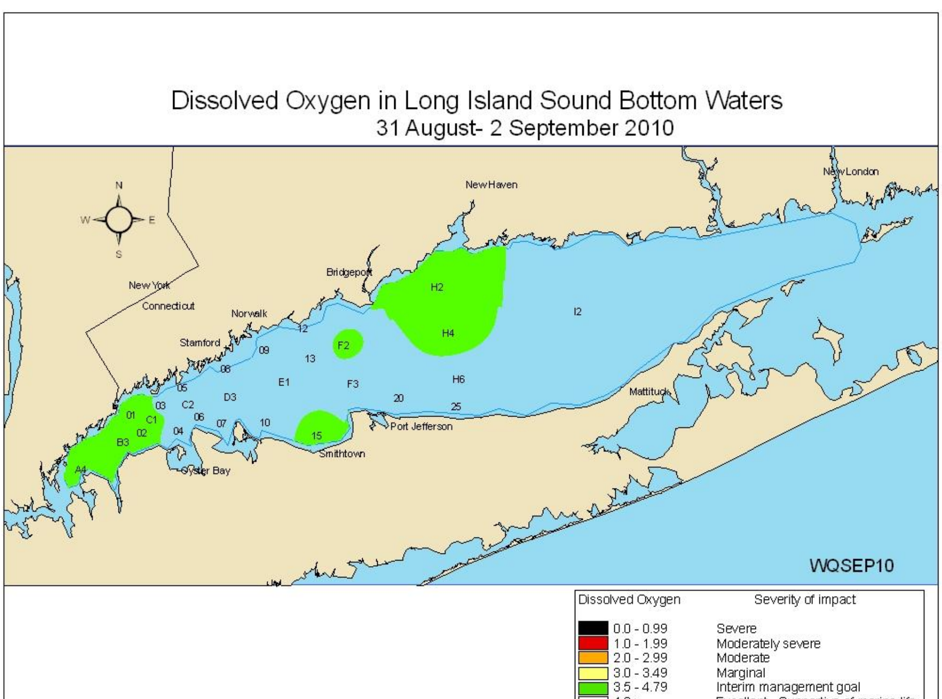
During the WQAUG10 survey, DO concentrations dropped below 3.5 mg/L at 14 stations; 10 of those stations fell below 3 mg/L, and three stations were below 2 mg/L. The map illustrates the dissolved oxygen concentrations in the bottom waters of Long Island Sound during the height of the hypoxic event.



Concentrations began to improve during the HYAUG10 survey with only three stations exhibiting DO concentrations below 3.5 mg/L. Cooler than average temperatures and an east wind the week prior to the survey helped DO levels rebound, preventing the severe hypoxia normally observed this time of year.



By the WQSEP10 survey only nine stations had concentrations below 4.8 mg/L. Conditions continued to improve and the HYSEP10 survey was cancelled.

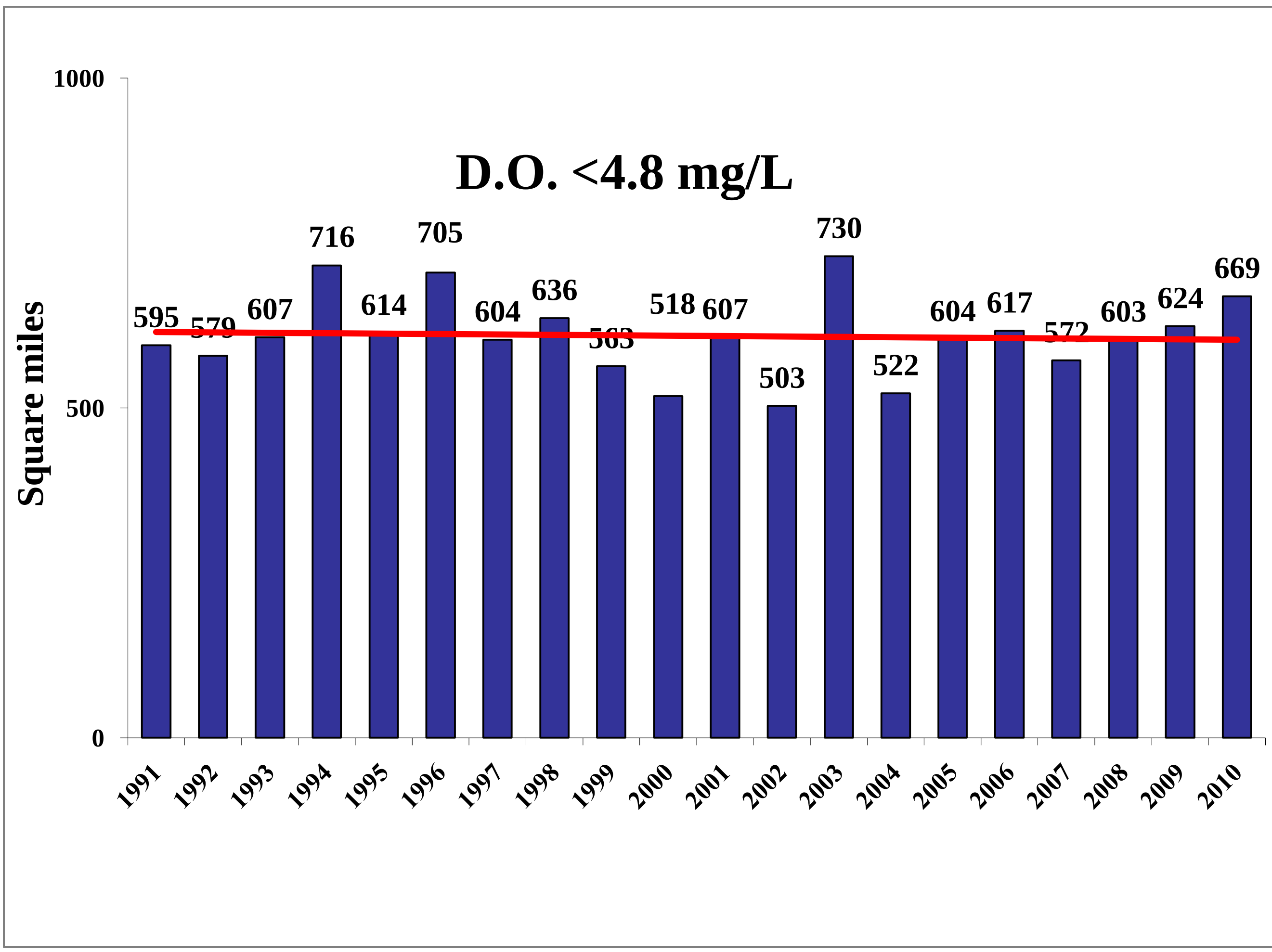


Area of Dissolved Oxygen Below the Chronic Criterion for Growth and Protection of Aquatic Life for LIS

Aquatic organisms are harmed based on a combination of minimum oxygen concentration and duration of the low DO excursion. A DO concentration of 4.8 mg/L meets the chronic criterion for growth and protection of aquatic life regardless of the duration.

This chart illustrates the maximum area of bottom waters within Long Island Sound with DO concentrations less than 4.8 mg/L. In 2010, the maximum area occurred during the HYJUL10 survey. This area was the highest since 2003. The area affected by concentrations less than 4.8 mg/L averages 609.4 square miles and varies slightly from 503 to 730 square miles.

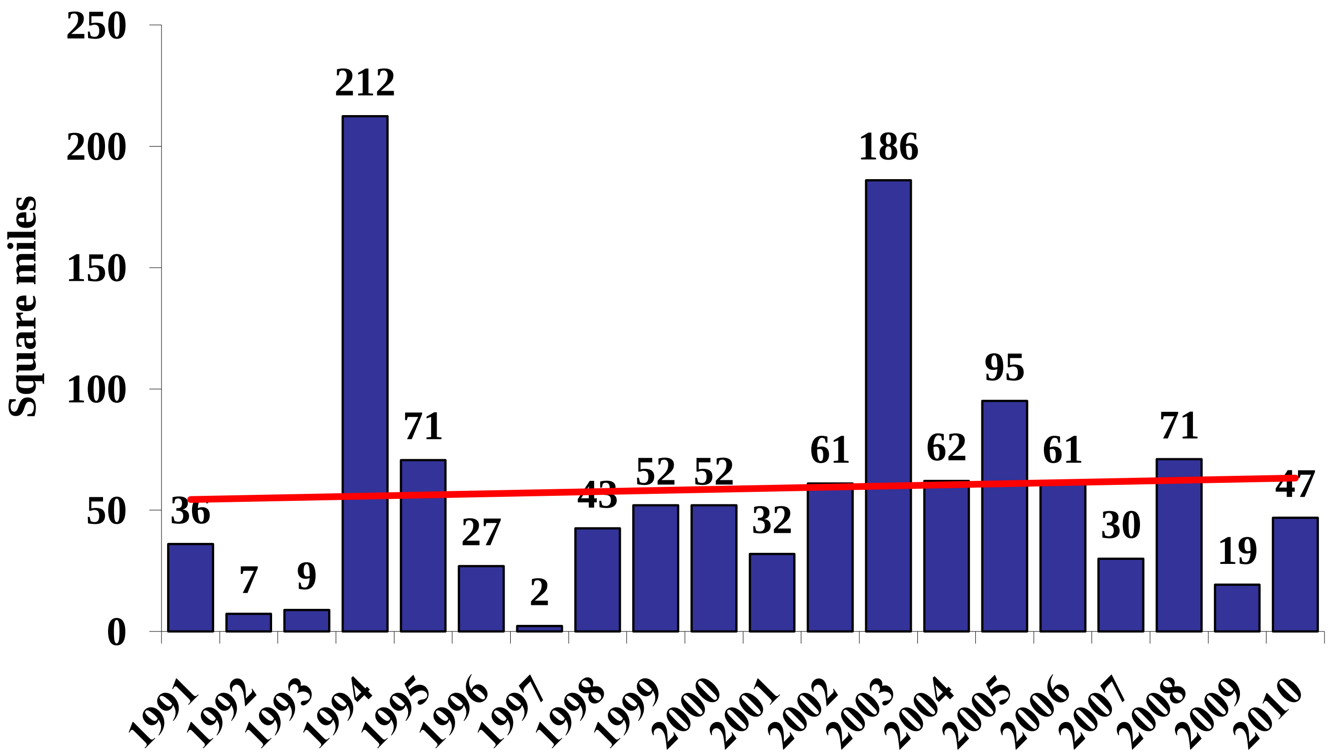
The trend in area affected seems to be decreasing.



Severe Hypoxia

D.O. <2 mg/L

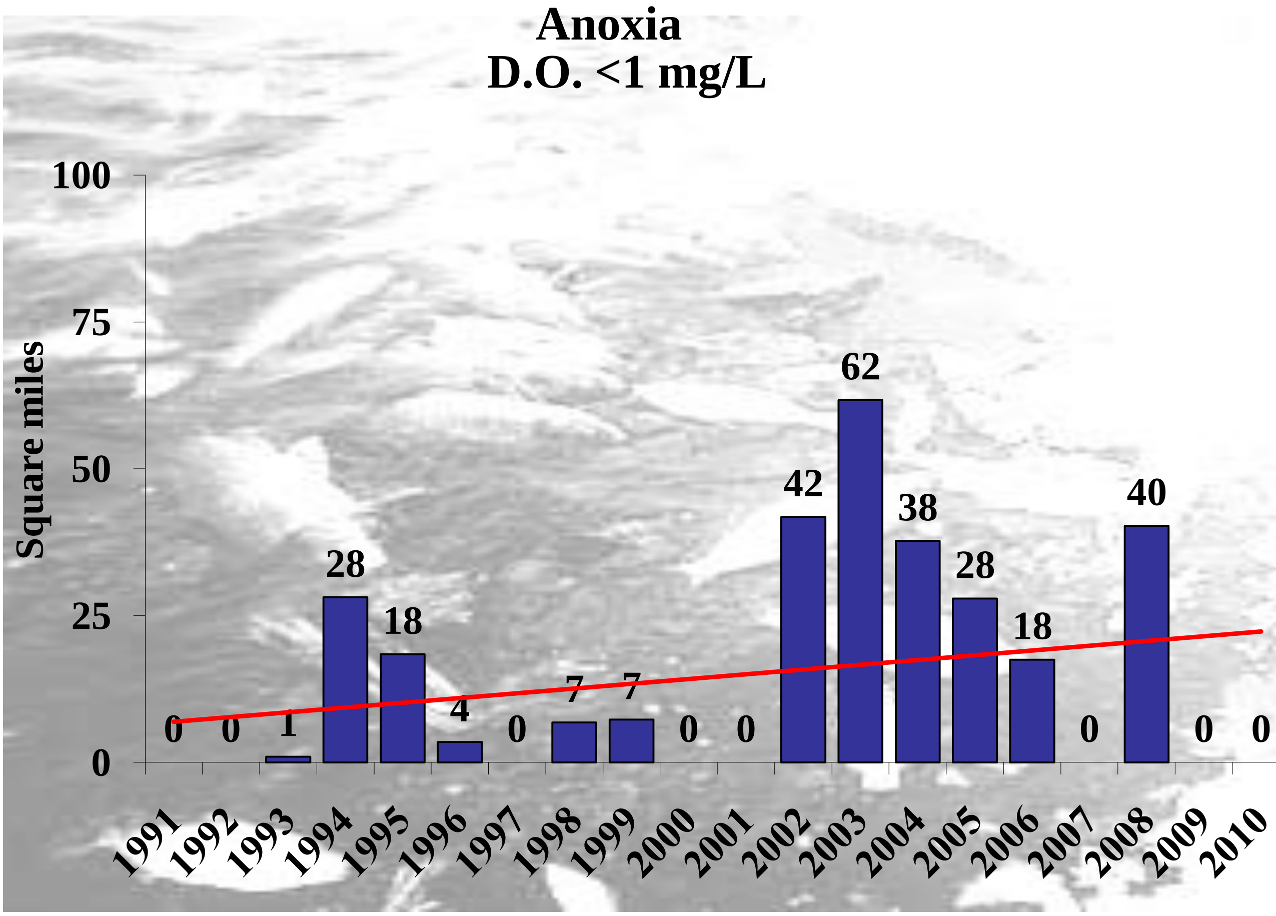
This chart illustrates the area of bottom waters of Long Island Sound with concentrations less than 2 mg/L.



The Gulf of Mexico is another water body that exhibits severe hypoxia, although the standard is determined at the 2.0 mg/L level. The average size of the hypoxic zone in the northern Gulf of Mexico from 2004-2008 is roughly 6563.7 mi^2 (http://www.gulfhypoxia.net/Overview/). For comparison, the average area of LIS with DO concentration less than 2.0 mg/L between 2004 and 2008 is 63.8 mi^2.

In 2010 the maximum area of LIS affected by severe hypoxia was 47 mi^2, an increase over 2009. The average area, calculated from 1991-2010, is 58.8 mi^2. It seems that there is an increasing trend towards severe hypoxia in LIS (i.e., hypoxia area at 2.0 mg/L seems to be getting worse).

1994 and 2003 appear to be especially bad years for concentrations less than 2 mg/L. 1994 had cold winter bottom water temperatures and an unusually warm June which led to the establishment of strong stratification. The highest average Delta T in July 1994 was 8.54 ºC. 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.

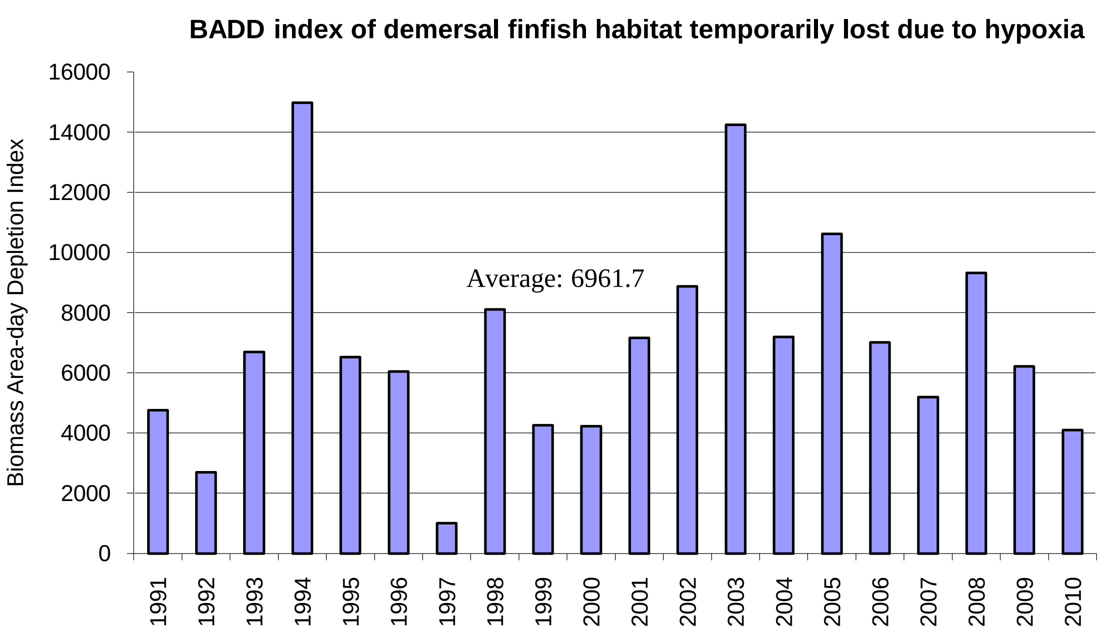


For management purposes the Long Island Sound Study defines anoxia as DO concentrations less than 1 mg/L. Since 1991, the long term trend has been an increase in the area of Long Island Sound bottom waters affected by anoxia. However, in eight of the twenty years there was no anoxia reported by CT DEP. The greatest area with D.O. below 1 mg/L observed in LIS, based on ~biweekly sampling by CT DEP, was during the summer of 2003. Prior to 2002, the average area of bottom waters affected by anoxia was 5.92 mi^2. From 2002-2010 the average area affected was 25.2 mi^2. The overall average area affected from 1991-2009 is 14.6 mi^2. A consistent decline was observed from 2003-2007. During the summer of 2008 three stations (A4, B3, and 02) were observed to have gone anoxic. In 2009 and 2010, CT DEP did not document any stations with DO < 1 mg/L. However, on 31 August2009 the Interstate Environmental Commission documented two stations that were anoxic, Stations B3 (same as CT DEP) and B2 (northwest of B3). In 2010 IEC also documented two stations that were anoxic- Station B3 on 2 August and Station H-D (Hempstead Harbor) on 9 September.

HABITAT IMPAIRMENT ASSOCIATED WITH HYPOXIA

Simpson *et al*, (1995) identified low oxygen tolerance thresholds for 16 individual species of finfish and lobster, and six aggregate species indices. For the most sensitive species (scup, striped sea robin) dissolved oxygen becomes limiting at over 4.0 mg/l, whereas more highly tolerant species (Atlantic herring and butterfish) did not decline in abundance until oxygen levels were below 2.0 mg/l. Both demersal species biomass and demersal species richness begin to decline when dissolved oxygen levels fall below about 3.5 mg/l. No finfish or macroinvertebrates were observed when dissolved oxygen fell below 1.0 mg/l.

An index of habitat impairment (Biomass Area-Day Depletion, BADD) was developed based on the percent reduction in demersal finfish biomass associated with each 1 mg/L interval below 3.5 mg/L. Based on Simpson *et al* (1996), demersal finfish biomass is reduced 100% (total avoidance) in waters with DO<1.0 mg/L. From 1.0-1.9 mg/L biomass is reduced 82%, while a 41% reduction occurs at 2.0-2.9 mg/L, and a 4% reduction occurs at 3.0-3.9 mg/L dissolved oxygen. These rates are applied to the area-days within each DO interval calculated during each survey and summed over the hypoxia season defined here as July 3- August 15 (44 d). The index is then expressed as a percentage of the available area-days (sample area 2,723 km^2 x 44 d, or 119,812 area-days).

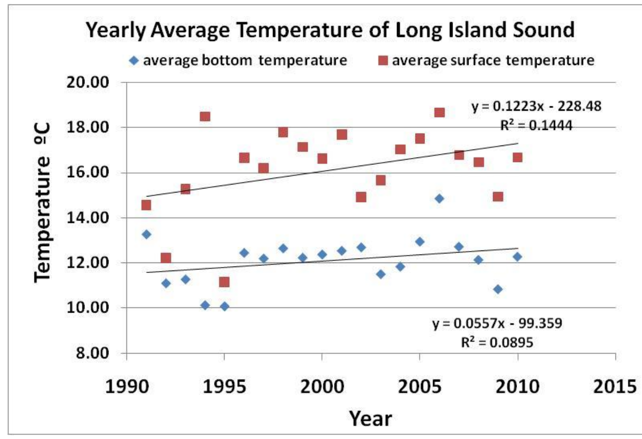


Simpson, David G., Kurt Gottschall, and Mark Johnson. 1995. Cooperative interagency resource assessment (Job 5). In : A study of marine recreational fisheries in Connecticut, CT DEP Marine Fisheries Office, PO Box 719, Old Lyme, CT 06371, p 87-135.

Simpson, David G., Kurt Gottschall, and Mark Johnson. 1996. Cooperative interagency resource assessment (Job 5). In : A study of marine recreational fisheries in Connecticut, CT DEP Marine Fisheries Office, PO Box 719, Old Lyme, CT 06371, p 99-122.

WATER TEMPERATURE

In LIS, water temperature plays a major role in the ecology of the Sound especially in the timing and severity of the Summer hypoxia event. CT DEP's monitoring program records water temperatures and salinity year round, but data collected during the hypoxia monitoring cruises are used to help estimate the extent of favorable conditions for the onset, extent, and end of the hypoxic event. In LIS, there are two key contributors to hypoxia: nutrient enrichment and stratification. Nutrients, especially nitrogen, flow into the Sound from numerous sources including point sources like wastewater treatment plants and nonpoint sources such as stormwater runoff. This enrichment leads to excessive growth of phytoplankton, particularly in the spring. As the plankton die, they begin to decay and settle to the bottom. Bacterial decomposition breaks down the organic material from the algae, using up oxygen in the process.



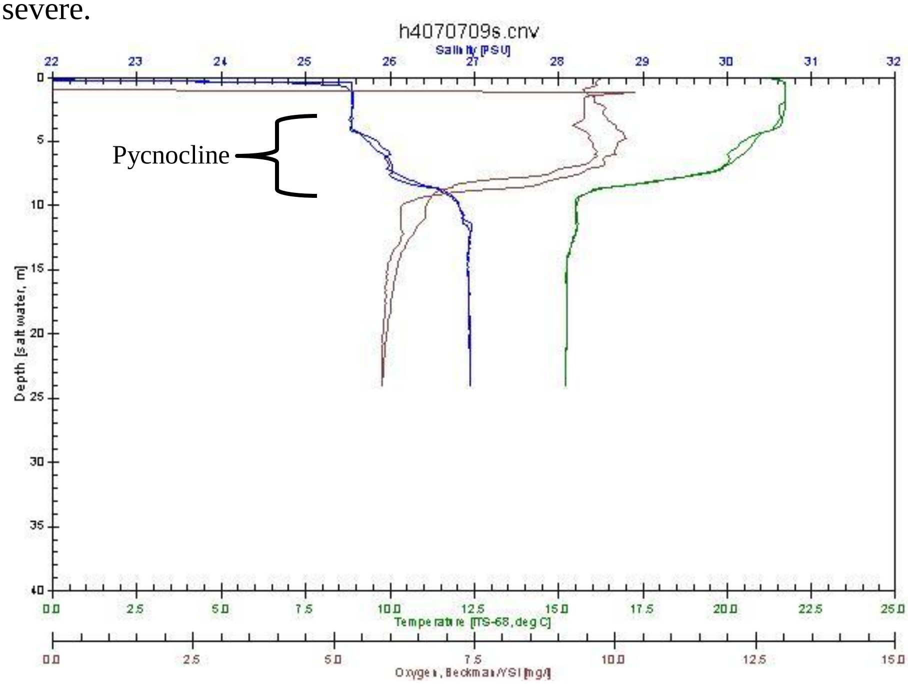
The Sound is coldest during February and March and warmest during August and September. The yearly average surface and bottom temperature of the Sound appear to be increasing.

2010 maximum, minimum, and average temperatures (ºC) across Long Island Sound by cruise based upon CT DEP Conductivity, Temperature, Depth (CTD) profile data

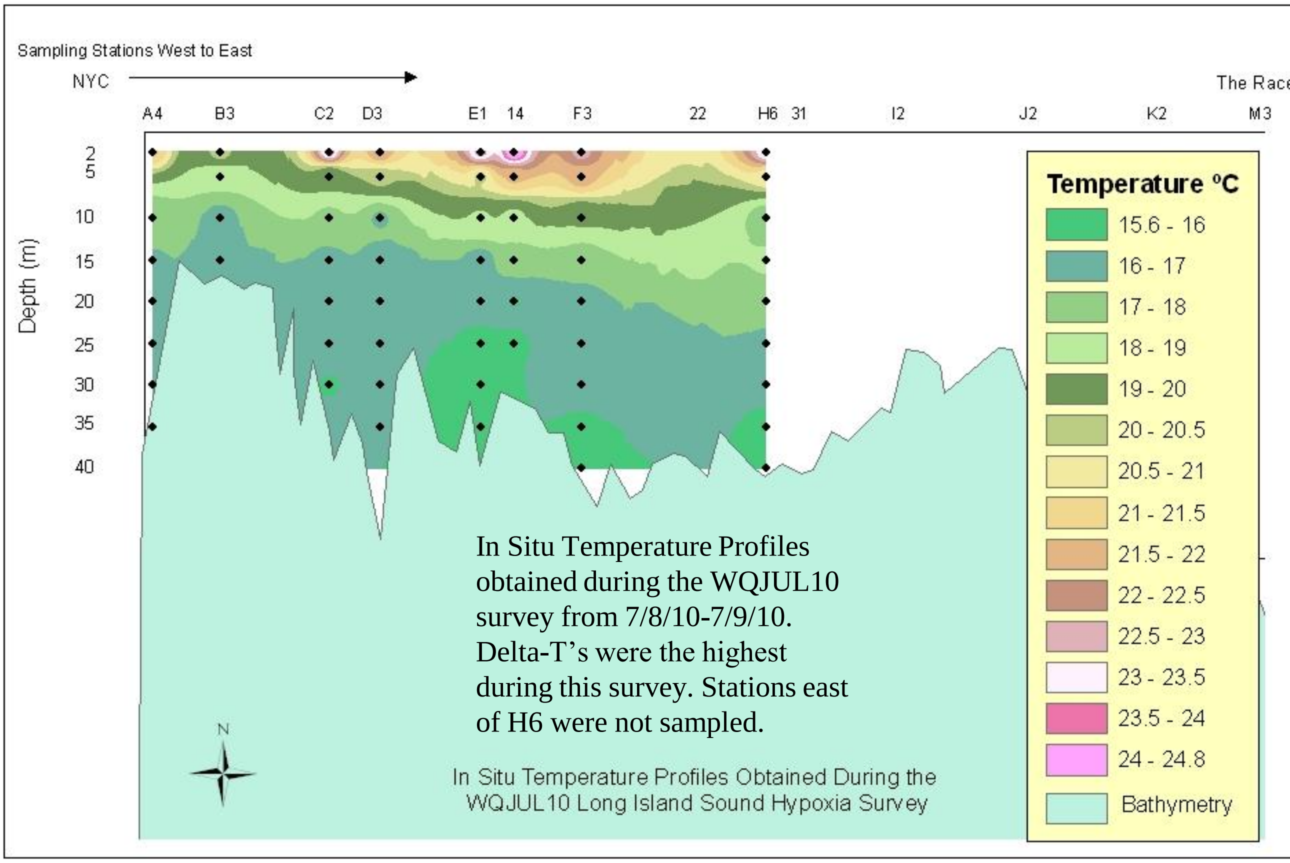
Cruise	Max	Min	Average
WQJAN10	5.393	1.325	3.315
WQFEB10	3.338	0.126	1.367
WQMAR10	3.977	1.679	2.189
WQAPR10	7.295	4.174	5.367
WQMAY10	14.145	7.933	9.265
WQJUN10	18.989	10.642	12.824
HYJUN10	18.557	13.280	15.366
WQJUL10	25.336	15.640	18.220
HYJUL10	25.363	18.399	20.338
WQAUG10	25.040	19.500	21.453
HYAUG10	24.939	21.389	22.673
WQSEP10	24.986	21.730	22.775

Delta T

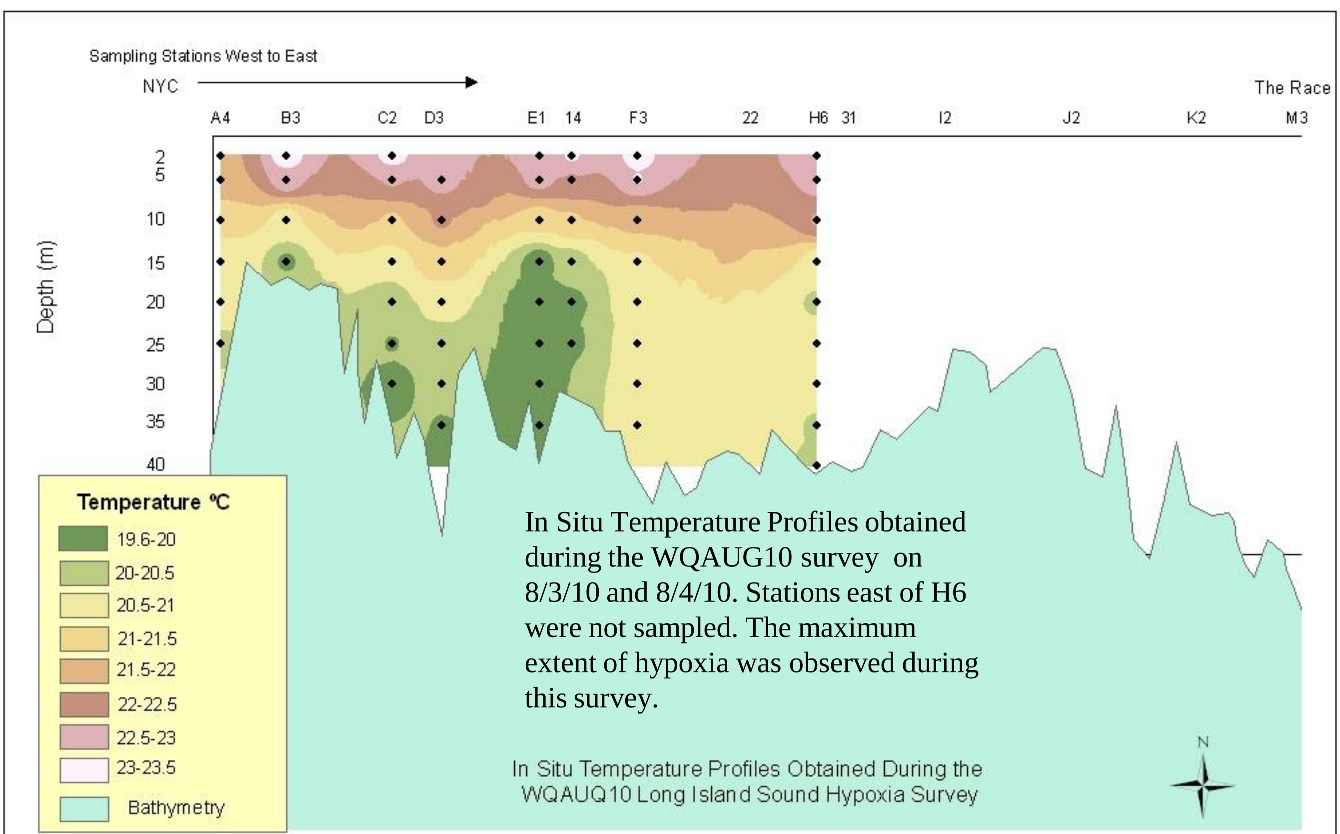
The temperature difference between the bottom waters and the surface waters is known as "delta T". This delta T, along with salinity differences, creates a density difference, or "density gradient" resulting in a separation or "stratification" of water layers that hinders the oxygenated surface waters from circulating downward and mixing with the oxygen starved bottom waters. The pycnocline, or zone where water density increases rapidly with depth due to the changes in temperatures and salinity (see image on next page), inhibits oxygenated surface waters from mixing with oxygen deplete bottom waters exacerbating the hypoxia. The pycnocline typically develops in LIS in late spring/early summer when rapid surface water warming exceeds the rate of warming in the bottom waters and persists into early fall when it is disrupted by strong winds associated with storms which lead to mixing or cooling air temperatures. With the dissolution of the pycnocline, hypoxic conditions are alleviated/eliminated. The smallest Delta-Ts occur during the winter when the water column is well mixed. The largest Delta T's occur during the early summer. The greater the delta T the greater is the potential for hypoxia to be more severe.



The temperature graphs on page 16 show computer interpolations along the west-east axis of LIS generated from profile data collected during two CT DEP surveys. During the WQJUL10 survey, surface water temperatures were rapidly warming up to 25ºC while the bottom water remained cooler around 16ºC. This set up the largest differences in temperatures between the surface and bottom waters. The second graph shows how the water column was thermally stratified during the WQAUG10 survey when hypoxic conditions were at their worst. The graphs on page 17 show how the Delta T's varied over the course of the summer sampling season. Delta T's increased from the WQMAY10 survey through the WQJUL10 survey, setting up the stratification and leading to the maximum extent of hypoxia in August. By the September survey Delta T's decreased to around 1 ºC over much of the Sound allowing the oxygenated surface waters to mix through to the bottom, leading to the end of the hypoxic event. The graphs also show how the Delta T varies spatially. The western Sound has higher Delta T's due to the limited flushing capacity, topology, and geology. In the east where cooler, oxygen rich, off- shore ocean water mixes with the Sound water, Delta T's are much lower and hypoxia rarely occurs.

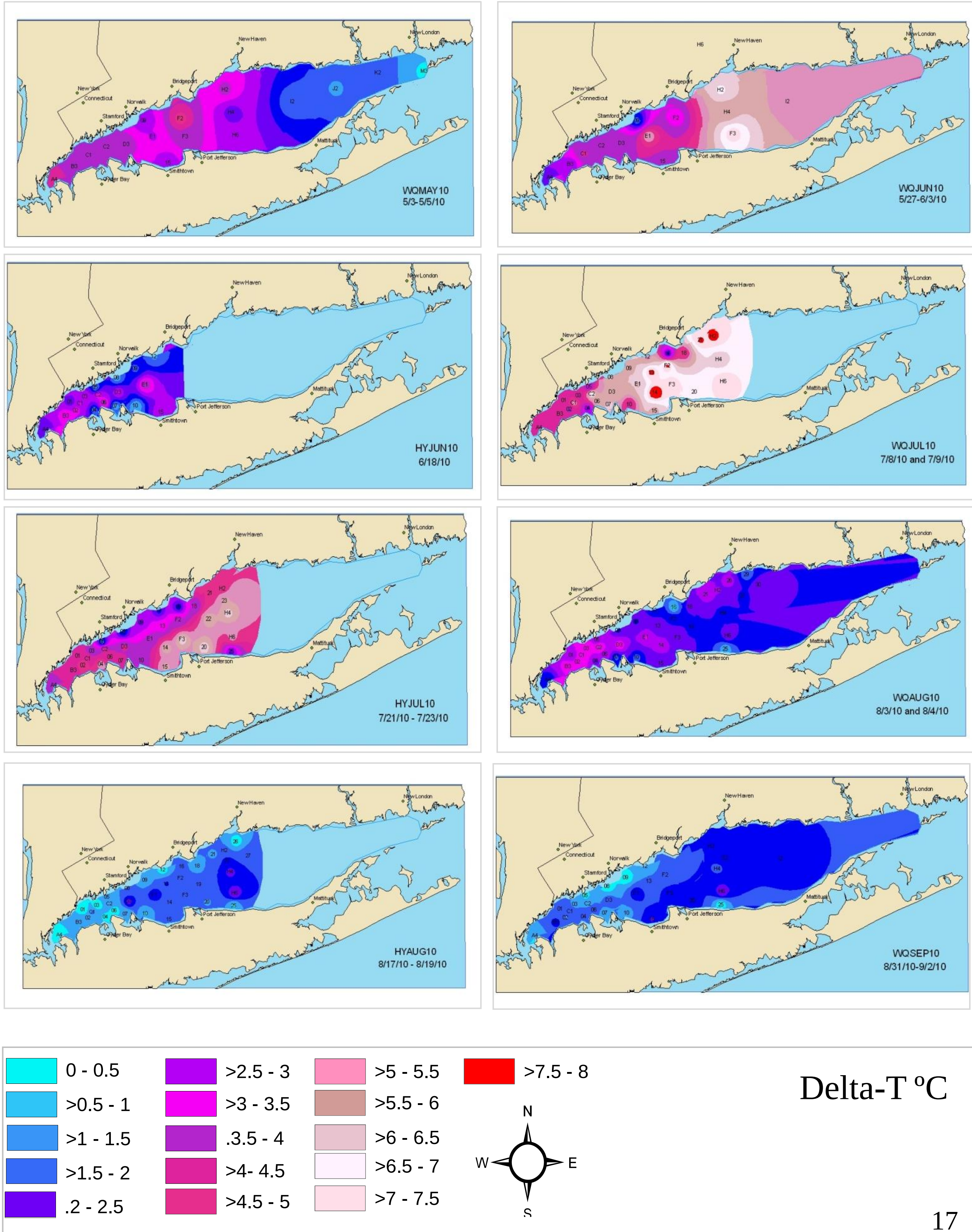


In Situ Temperature Profiles obtained during the WQJUL10 survey from 7/8/10-7/9/10. Delta-T's were the highest during this survey. Stations east of H6 were not sampled.



In Situ Temperature Profiles obtained during the WQAUG10 survey on 8/3/10 and 8/4/10. Stations east of H6 were not sampled. The maximum extent of hypoxia was observed during this survey.

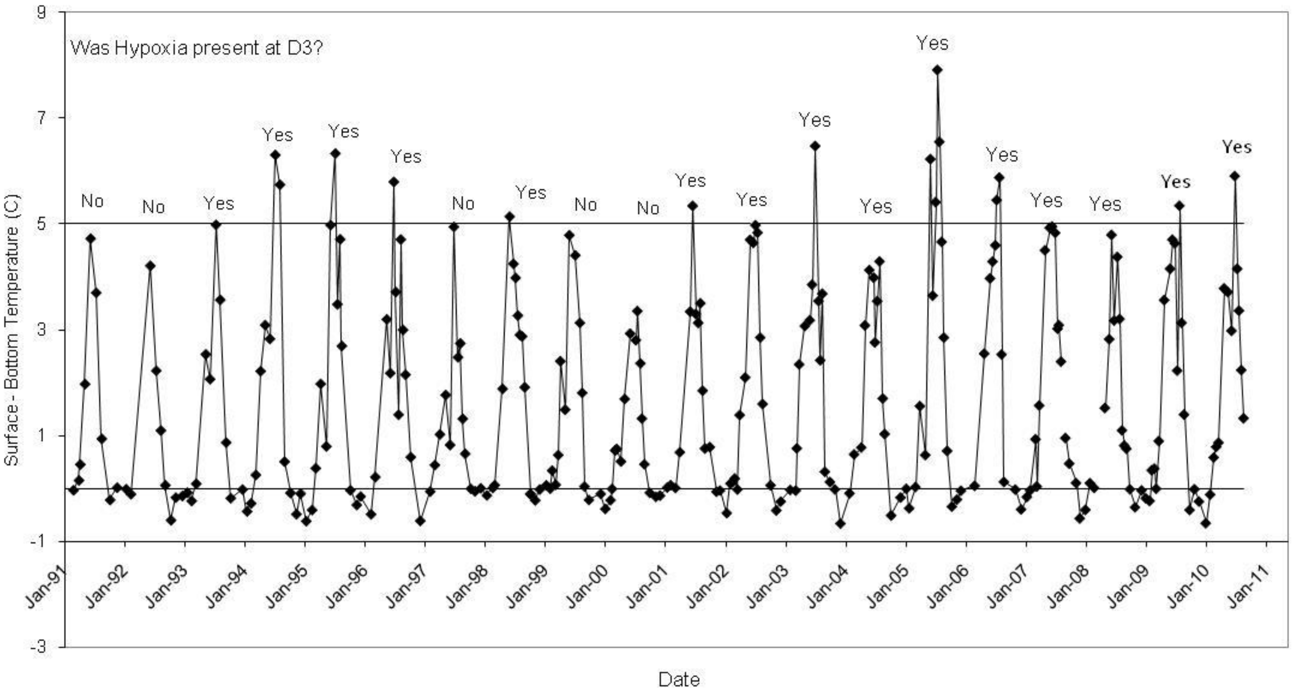
2010 Delta-T Maps



This table summarizes the minimum winter temperatures (January, February, and March), the maximum summer temperatures (June, July, August, and September), the maximum delta T, and maximum hypoxic area at Station D3. Station D3 is located in the eastern-most and deepest portion of the Narrows (see map on page 1). The CT DEP 1991-1998 Data Review report (Kaputa and Olsen, CT DEP 2000) found a positive correlation between the maximum delta T observed at D3 and the maximum area of hypoxia in the same year. Delta T was not correlated to the duration of hypoxia. 2004 had the lowest water temperature recorded, 2006 had the highest, 2005 had the highest ΔTmax, and 1994 had the largest area of hypoxia.

Year	Minimum Winter Temp (ºC)	Maximum Summer Temp (ºC)	Maximum ΔT (ºC)	Maximum Area of Hypoxia (mi^2) DO<3.0 mg/L	Maximum Area of Hypoxia (mi^2) DO<3.5 mg/L
1991	2.69	22.23	4.75	122	263.2
1992	1.86	20.89	4.83	80	194.5
1993	1.06	22.68	5.33	202	335.9
1994	-0.68	24.08	6.33	**393**	**513.7**
1995	0.95	23.78	6.33	305	415.6
1996	-0.19	23.78	5.91	220	340.4
1997	1.87	21.81	4.96	30	51
1998	3.40	23.20	5.22	168	286.1
1999	2.67	23.41	5.51	121	229.4
2000	0.57	21.99	6.02	173	260.2
2001	1.67	23.20	5.38	133	215.7
2002	4.03	23.47	5.52	130	193.9
2003	-0.52	22.88	6.74	345	430.6
2004	**-0.93**	23.09	4.33	202	257.5
2005	0.53	25.10	**8.19**	177	300.2
2006	2.17	**25.11**	6.72	199	346.1
2007	0.83	23.03	5.12	162	354
2008	2.45	22.47	4.91	180.1	359.9
2009	0.72	24.31	5.90	169.1	369.6
2010	0.72	24.91	6.36	101.1	154.7

Kaputa, Nicholas P., and Christine B. Olsen. 2000. Long Island Sound summer hypoxia monitoring survey 1991-1998 data review. CTDEP Bureau of Water Management, Planning and Standards Division, 79 Elm Street, Hartford, CT 06106-5127, 45 p.



Time series of ΔT (surface water temperature - bottom water temperature) at station D3, 1991 through 2010.

Generally, when Station D3 became hypoxic the observed maximum delta-T was greater than 5ºC and the observed values were largest. 2004, 2007, and 2008 seem to be exceptions.

Salinity

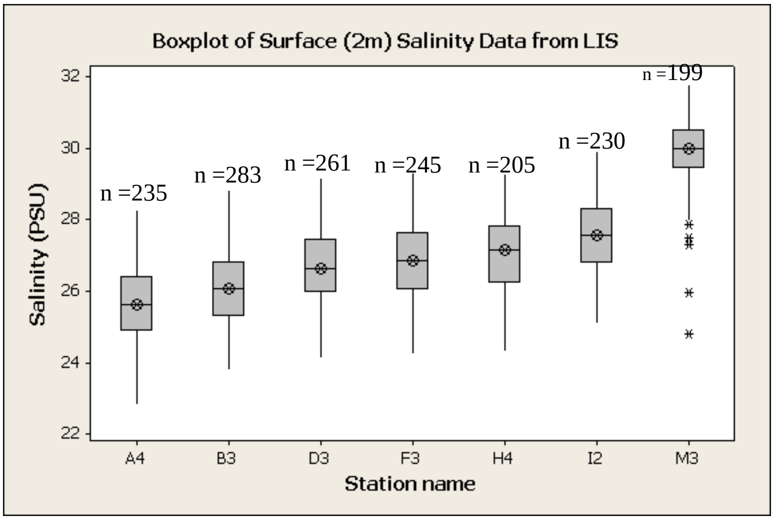
Salinity is a measure of the dissolved salts content of seawater. It is usually expressed in practical salinity units (PSU). Salinity levels across Long Island Sound vary from 23 PSU in the Western Sound at Station A4 to 33 PSU in the eastern Sound at Station M3. The Thames, Connecticut, and Housatonic rivers are the major sources of freshwater entering the Sound. Summary statistics for salinity data collected from seven stations across the Sound from1991-2010 are presented in the tables below. Data collected this year are also presented separately.

		1991-2010 Bottom Water Statistics						
Station Name	Count	Minimum	Maximum	Mean	Median	SE Mean	Standard Deviation	Variance
A4	242	23.823	28.727	26.331	26.310	0.0599	0.918	0.843
B3	294	24.259	28.926	26.604	26.557	0.0544	0.915	0.838
D3	277	24.912	29.215	27.245	27.289	0.0542	0.875	0.766
F3	268	25.153	29.432	27.597	27.628	0.0548	0.857	0.735
H4	215	25.508	29.700	27.741	27.760	0.0592	0.848	0.720
I2	246	25.762	29.985	28.071	28.178	0.0556	0.844	0.712
M3	213	28.608	32.622	30.575	30.566	0.0507	0.715	0.511

		2010 Bottom Water Statistics						
Station Name	Count	Minimum	Maximum	Mean	Median	SE Mean	Standard Deviation	Variance
A4	12	23.823	27.302	26.122	26.098	0.328	1.089	1.185
B3	12	24.318	27.547	26.329	26.259	0.303	1.049	1.100
D3	12	25.399	28.274	26.943	26.797	0.284	0.982	0.964
F3	11	26.052	28.738	27.458	27.351	0.298	0.989	0.979
H4	11	26.087	28.729	27.555	27.602	0.275	0.911	0.830
I2	7	26.162	28.919	27.418	27.421	0.362	0.958	0.918
M3	5	29.205	30.727	30.176	30.406	0.265	0.593	0.351

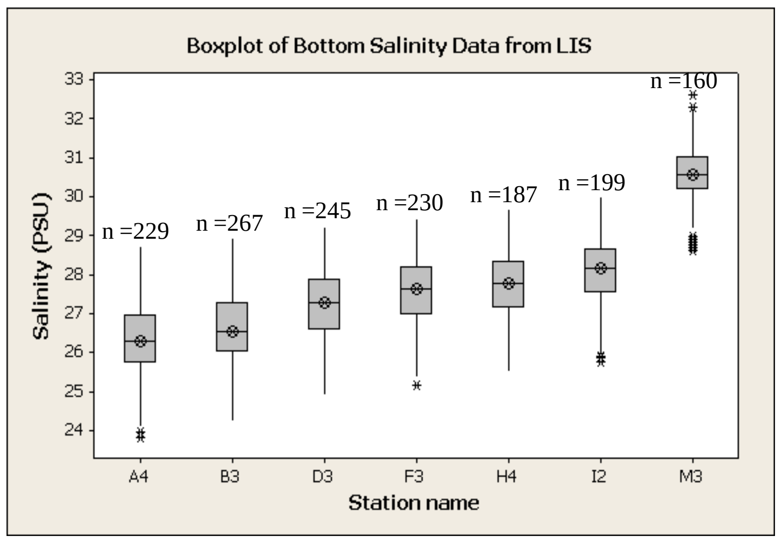
		1991-2010 Surface Statistics						
Station Name	Count	Minimum	Maximum	Mean	Median	SE Mean	Standard Deviation	Variance
A4	249	22.833	28.278	25.655	25.635	0.0661	1.000	1.001
B3	303	23.783	28.840	26.073	26.079	0.0624	1.020	1.040
D3	290	24.148	29.146	26.674	26.645	0.0657	1.028	1.057
F3	274	24.246	29.307	26.839	26.835	0.0698	1.058	1.119
H4	223	24.315	29.262	27.067	27.148	0.0777	1.062	1.128
I2	250	25.117	29.909	27.513	27.572	0.0720	1.016	1.031
M3	215	24.789	31.758	29.931	29.998	0.0804	1.017	1.035

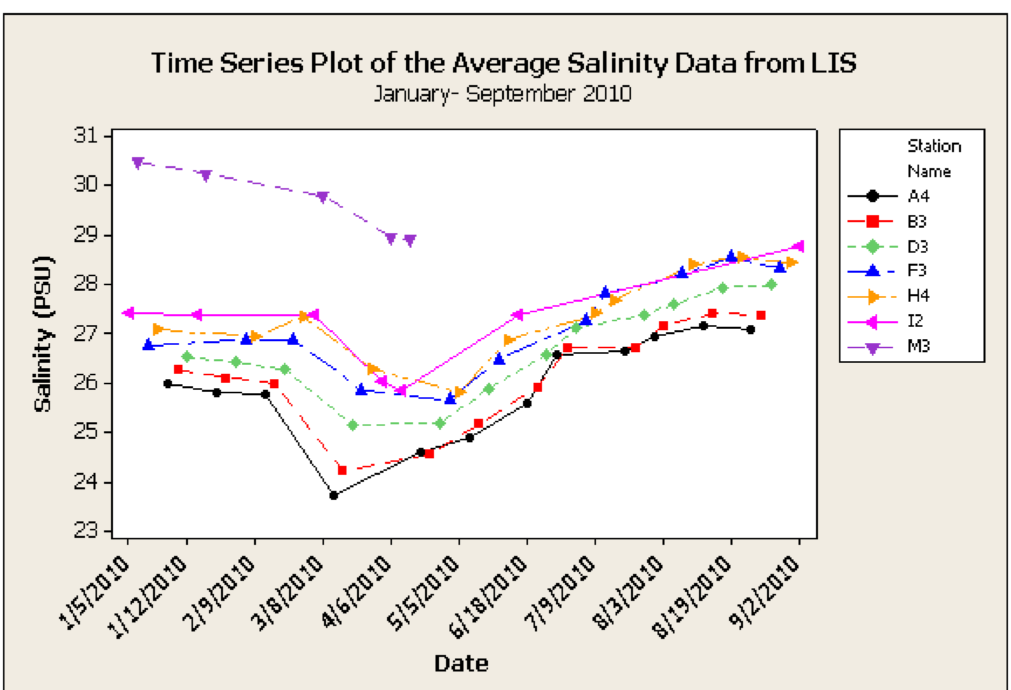
		2010 Surface Statistics						
Station Name	Count	Minimum	Maximum	Mean	Median	SE Mean	Standard Deviation	Variance
A4	12	23.178	26.957	25.574	25.855	0.357	1.185	1.405
B3	12	23.783	27.185	25.876	26.079	0.332	1.101	1.212
D3	12	24.148	27.750	26.183	26.325	0.363	1.148	1.317
F3	11	24.799	28.113	26.516	26.612	0.319	1.057	1.118
H4	11	25.010	28.134	26.912	26.908	0.380	1.076	1.158
I2	7	25.381	28.567	27.070	27.166	0.660	1.319	1.741
M3	5	24.789	29.858	28.016	27.979	0.903	2.019	4.075



This box plot, based upon data collected during CT DEP surveys from January 1991-August 2010 (n=292), shows the median surface salinity, range, interquartile range, and outliers by station. Surface in this case refers to data collected two (2) meters below the air/water interface. Salinity increases from west to east across the Sound.

This box plot, based upon data collected during CT DEP surveys from January 1991-August 2010 (n=292), shows the median bottom salinity, range, interquartile range, and outliers by station. Bottom in this case refers to data collected five (5) meters above the sediment/water interface. The bottom waters are generally saltier than the surface waters.

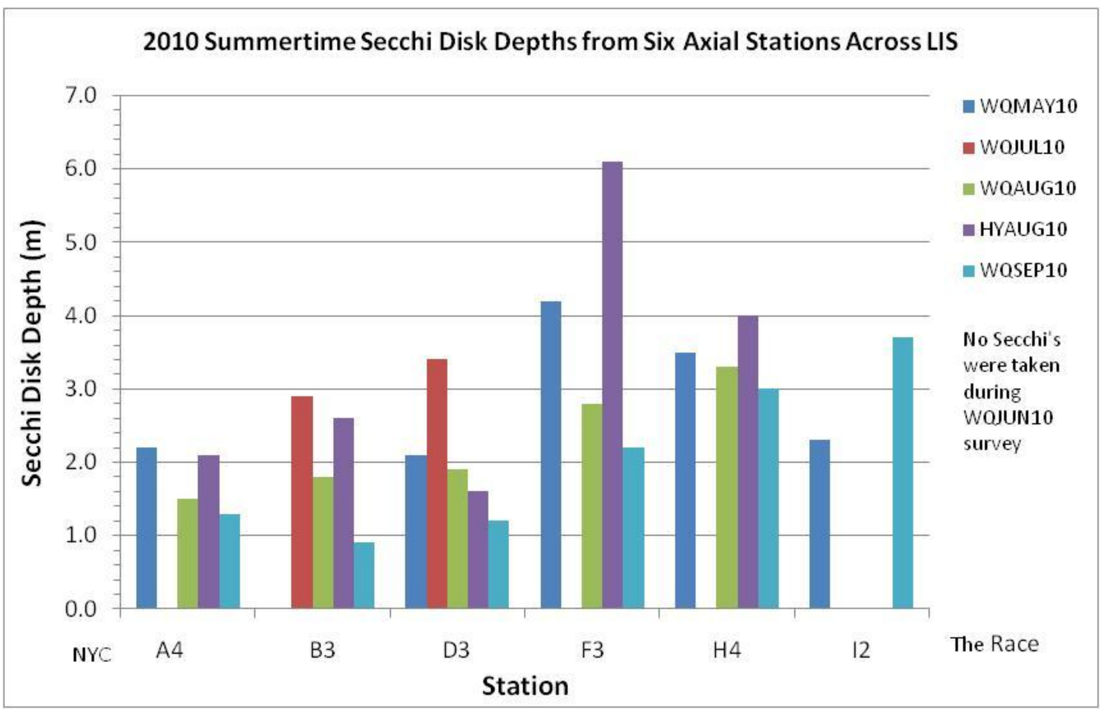




This time series plot illustrates the temporal variability of the mean salinity values by station from January-September 2010.

Water Clarity

Water clarity is measured by lowering a Secchi disk into LIS by a measured line until it disappears. It is then raised until it reappears. The depth where the disk vanishes and reappears is the Secchi disk depth. The depth to disappearance is related to the transparency of the water. Transparency may be reduced by both absorption and scattering of light. Water absorbs light, but absorption is greatly increased by the presence of organic acids that stain the water a brown "tea" color and by particles. Scattering is largely due to turbidity, which can be attributable to both inorganic silt or clay particles, or due to organic particles such as detritus or planktonic algae suspended in the water. CT DEP began taking Secchi Disk measurements in June 2000. Since then, 1,995 measurements have been entered into our database; of those 1167 are from the 17 stations sampled annually. The 2000-2010 average Secchi depth is 2.30 m with a minimum depth of 0.4 m (WQSEP05, station A4) and a maximum depth of 6.2 m (WQNOV00 Station K2). Below is a graph depicting Secchi disk depths from six of the axial stations sampled by CT DEP LISS Water Quality Monitoring Program between May and September 2010.



2009 data

- **Average Secchi Disk Depth: 2.94 m (n=166)**
- **Minimum Secchi Disk Depth: 1.4 m at Station B3 during the WQJUN09 cruise**
- **Maximum Secchi Disk Depth: 4.2 m at Station H4 during the WQJUL09 cruise**

2010 data

- **Average Secchi Disk Depth: 2.68 m (n=174)**
- **Minimum Secchi Disk Depth: 0.9 m at Station B3 during the WQSEP10 cruise**
- **Maximum Secchi Disk Depth: 6.1 m at Station F3 during the HYAUG10 cruise**

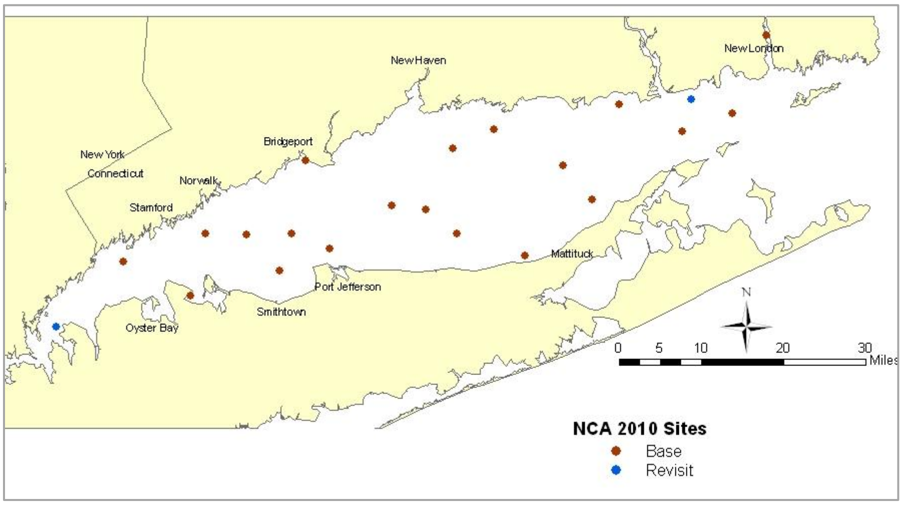
pH and Ocean Acidification

Human activities have resulted in increases in atmospheric carbon dioxide (CO_2). The ocean absorbs CO_2, greatly reducing greenhouse gas levels in the atmosphere and minimizing the impact on climate. When CO_2 dissolves in seawater carbonic acid is formed. This acid formation reduces the pH of seawater and reduces the availability of carbonate ions. Carbonate ions are utilized by marine organisms in shell and skeletal formation. According to the NOAA Pacific Marine Environmental Laboratory Ocean Acidification Home Page, the pH of the ocean surface waters has already decreased from an average of 8.21 SU to 8.10 SU since the beginning of the industrial revolution and the Intergovernmental Panel on Climate Change predicts a decrease of an additional 0.3 SU by 2100. (See http://www.pmel.noaa.gov/co2/OA/background.html.)

With this issue in mind, CT DEP upgraded its SeaCat Profilers and began collecting and reporting pH data in August 2010. Data from the two surveys conducted to date are summarized below.

	Surface pH (SU)			Bottom pH (SU)		
Survey	Max	Min	Avg.	Max	Min	Avg.
HYAUG10 (n=34)	8.19	7.49	7.94	7.96	7.51	7.74
WQSEP10 (n=27)	8.31	7.57	8.09	8.17	7.52	7.79

National Coastal Condition Assessment 2010 Sampling



CT DEP participated in the 2010 National Coastal Condition Assessment. Beginning in July and ending in September, CT DEP sampled 22 sites, including one revisit site, to assist the EPA with providing a "comprehensive assessment of coastal waters across the United States." Sites were pre-selected by EPA using a probability based design. See http://water.epa.gov/type/watersheds/monitoring/upload/2009_03_19_monitoring_pdf_narsprogress.pdf for more details.

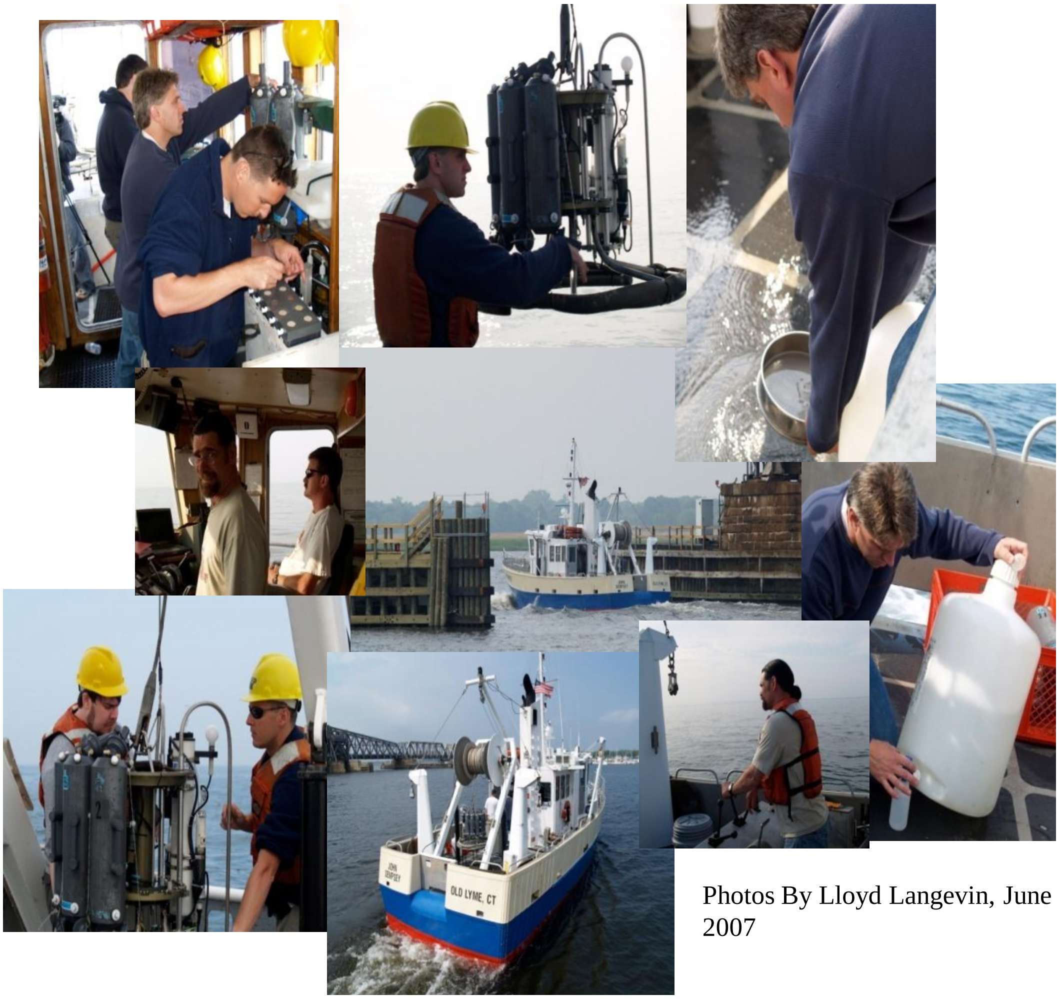
In situ measurements (pH, temperature, dissolved oxygen, salinity/conductivity, and light attenuation (PAR)) were collected using either a YSI 6600 Series multisonde or a SeaCat profiler (CTD). Secchi disk depths were recorded. Surface water grab samples were collected and sent to the University of Connecticut Center for Environmental Science and Engineering to be analyzed for nutrients (chlorophyll a, total and dissolved nitrogen and phosphorus).

Sediments were collected and analyzed for benthic macroinvertebrate species composition and abundance, organics, metals, TOC (total organic carbon), grain size determination, and acute toxicity. Sediment grain size and TOC samples will be analyzed by CESE. Sediment toxicity and organics/metals were shipped to Tetra Tech (EPA contractor) for analysis. Benthos samples were shipped to EcoAnalyst Inc (EPA Contractor) for analysis.

Surface water samples were also collected for *Enterococci* bacteria analysis. Samples were sent to the EPA Region 1 Lab.

Fish (5 individuals totaling at least 500 g) were collected by rod and reel and analyzed for whole body organic and inorganic contaminants. Target fish species collected included summer flounder and scup. Additionally bluefish, blue crab, sea bass, and sea robin were collected and submitted for analysis. Fish were sent to California State University at Long Beach (EPA specified contract lab) for analysis.

Results are expected to be reported in 2012 by EPA in a National Coastal Condition Report.



Photos By Lloyd Langevin, June 2007

Acknowledgements

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