NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION

INTERSTATE ENVIRONMENTAL COMMISSION DISTRICT

HYPOXIA IN WESTERN LONG ISLAND SOUND AND UPPER EAST RIVER

2013

NEIWPCC-IEC District: Who We Are

The New England Interstate Water Pollution Control Commission (NEIWPCC) is a not-for-profit interstate agency established by an Act of Congress in 1947 (www.neiwpcc.org). NEIWPCC serves and assists its member states—New York, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont—by coordinating efforts that encourage cooperation among the states, developing resources that foster progress on water issues, representing the region in matters of federal policy, initiating and overseeing scientific research projects, training environmental professionals, educating the public, and providing overall leadership in water management and protection. For well over six decades, the Commission has managed interstate water conflicts by means of sound science, coordination, and adaptation. Since May 15, 2012, NEIWPCC has served as financial and program adviser to the Interstate Environmental Commission (IEC) to coordinate and fund efforts that benefit IEC jurisdiction's water quality, fisheries, wetlands, wildlife, and recreation.

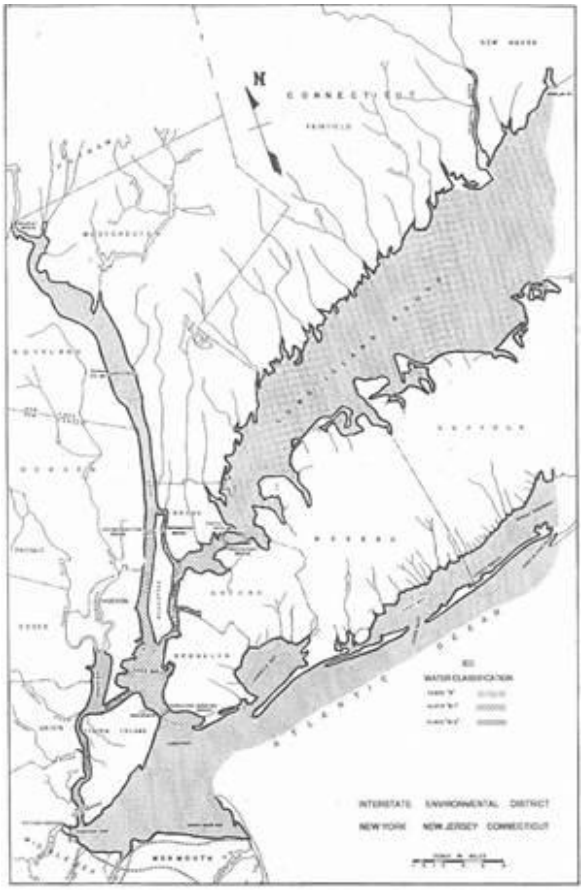


Figure 1: The waters within Interstate Environmental Commission District's area of jurisdiction (shaded area).

The Interstate Environmental Commission is a tri-state water and air pollution control agency serving the States of New York, New Jersey, and Connecticut (www.iec-nynjct.org). Established in 1936, the IEC is the oldest regulatory and enforcement agency in the region. The Commission's programs and activities reach far beyond its environmental mandates and date back to a time before state and national environmental entities were established. The Interstate Environmental Commission's area of jurisdiction— the Interstate Environmental District— runs west from New Haven, CT and Port Jefferson, NY on Long Island Sound; west from Fire Island Inlet on the southern shore of Long Island incorporating a portion of the Atlantic Ocean; and south from the borders of Rockland and Westchester Counties on the Hudson River to Sandy Hook, NJ (Figure 1). With a commitment to environmental management from a regional perspective and supported by its nationally accredited environmental laboratory, the Commission, in cooperation with the environmental departments of its member states and numerous other environmental agencies, engages in a variety of programs that include, but are not limited to: research, regulation and enforcement, ambient water quality monitoring, compliance monitoring, CSO elimination, outfall reconnaissance inspections to detect and eliminate illicit discharges, and public education and outreach.

State of Western Long Island Sound and Upper East River

Long Island Sound, located within one of the most densely populated areas in the nation, is a recognized Estuary of National Significance within the US Environmental Protection Agency (US EPA) National Estuary Program. Known for its valuable natural resources and beauty, the Long Island Sound and upper East River provide a diverse array of recreational and commercial opportunities. As an estuary, the Sound is home to numerous species of

flora and fauna and provides feeding and breeding habitat for many species of fish, shellfish, waterfowl, and other birds.

Urbanization and changes in land use have resulted in an increase in the amount of pollution entering Long Island Sound. Nutrient pollution from nearby wastewater facilities and runoff; toxic pollution from pesticides, herbicides, and industrial facilities; pathogens from inadequately treated sewage and wastewater effluent; and floatable debris from improper disposal of trash all pose significant threats to the Sound's fragile ecosystem (Figure 2).

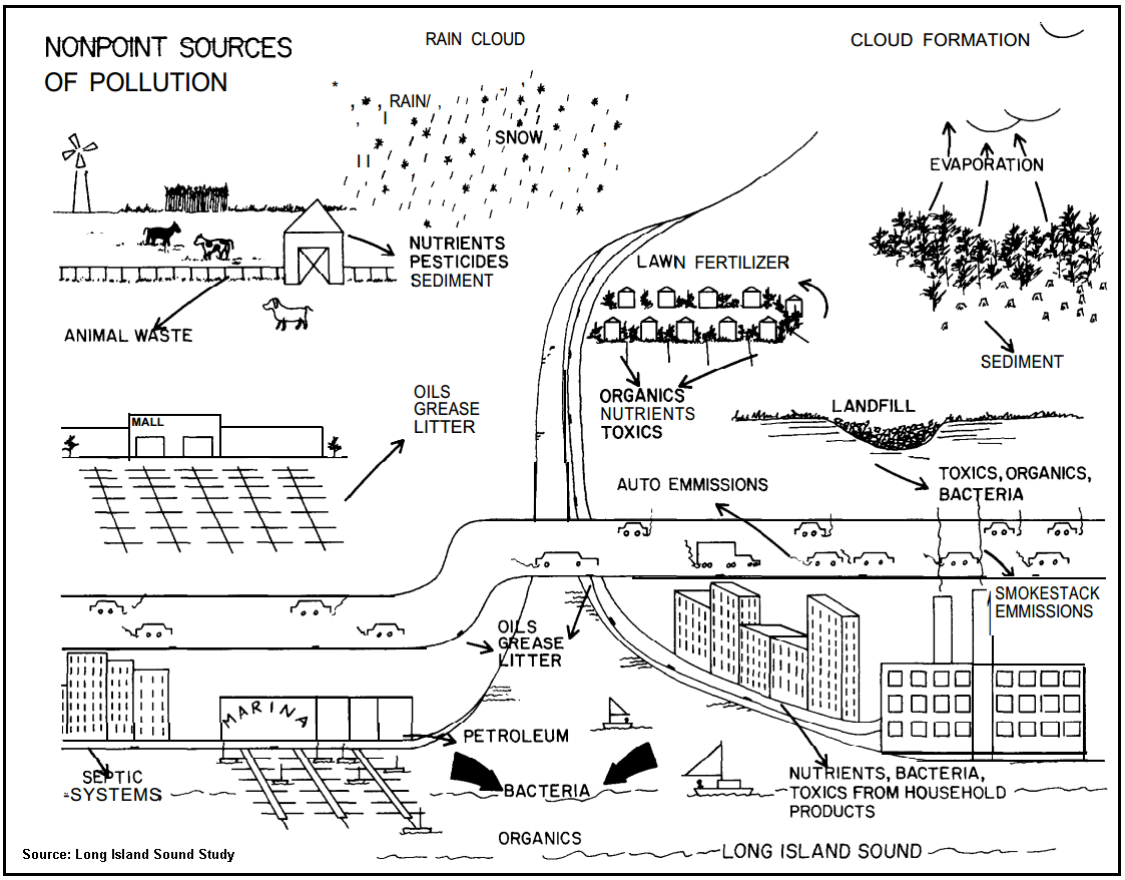


Figure 2: Examples of non-point sources of pollution which may impact the water quality and overall health of the East River and Long Island Sound.

The excessive discharges of nitrogen and the resulting hypoxic conditions in the Long Island Sound have been identified as the estuary's most pressing problems. Hypoxia occurs when levels of dissolved oxygen fall below 3 parts per million (expressed in mg/L), which can be caused by an increase in nutrient-enhanced primary production and the resulting decomposition of biomass in the water.

Dissolved oxygen concentrations that drop below an organism's threshold to survive could be fatal and persistently low levels of dissolved oxygen may alter seasonal migration routes and render habitat unsuitable. In their early life stages, aquatic organisms are more at risk than free swimming adults due to increased sensitivity and an inability to relocate. While the criterion for the onset of hypoxia has been set to 3 mg/L, in circumstances where DO is below 5 mg/L, biological stresses on aquatic organisms have been observed. Dissolved oxygen concentrations at or above 5 mg/L are believed to be protective of marine life.

Monitoring of Hypoxia

To document hypoxic conditions, the Interstate Environmental Commission District (IEC District) has conducted monitoring surveys in far western Long Island Sound and upper East River since 1991. These surveys are performed in support of the National Estuary Program's Long Island Sound Study (LISS – http://longislandsoundstudy.net/). Working cooperatively with US EPA's Long Island Sound office, the IEC District continues to participate in this multi-agency collaborative effort along with local and state entities such as the Connecticut Department of Energy and Environmental Protection (CT DEEP – http://www.ct.gov/dep), New York City Department of Environmental Protection (NYC DEP – http://nyc.gov/dep), municipal health departments, and citizen groups.

To capture the transition of waters into and out of a state of hypoxia, the IEC District's monitoring surveys are conducted during the summer. Dissolved oxygen concentrations reach minimum levels in summer when warm temperatures stratify the waters of the Sound, preventing vertical mixing. This prevents atmospheric oxygen from reaching bottom waters, significantly limiting the available oxygen at such depths. In addition to documenting hypoxia when it is most prevalent, data collected by the IEC District is also used by LISS partners to measure the effectiveness of management activities and programs implemented under the Comprehensive Conservation and Management Plan (CCMP) for Long Island Sound.

2013 Monitoring Logistics

This year marks the 23rd consecutive summer that the Interstate Environmental Commission District, in cooperation with other environmental agencies, conducted ambient water quality monitoring in the western Long Island Sound and upper East River.

NEIWPCC-IEC District's 2013 monitoring consisted of 11 weekly surveys, with the first survey conducted on June 27th and the last on September 12th, 2013. During each trip, a network of 22 stations was visited and *in situ* measurements were made for pH, temperature, salinity, water clarity (Secchi disk depth) and dissolved oxygen (Figure 3, Table 1, Figure 4).

IEC District environmental analysts utilized multi-parameter YSI meters for data collection to enhance the accuracy of *in situ* water quality measurements (Photo 1). At each station, measurements were taken from three depths: one meter below the surface, at mid-depth, and one meter above the sediment substrate. For stations with a depth of less than 10 meters, only a surface and bottom reading was recorded. In addition, samples for chlorophyll *a*, a pigment in aquatic plants used as an indicator of algal production, were collected at all stations on alternate survey runs for further analysis in the NEIWPCC-IEC District Laboratory.

Photo 1: NEIWPCC-IEC District Analyst utilizes a multi-parameter meter at station A2M during a summer monitoring survey.

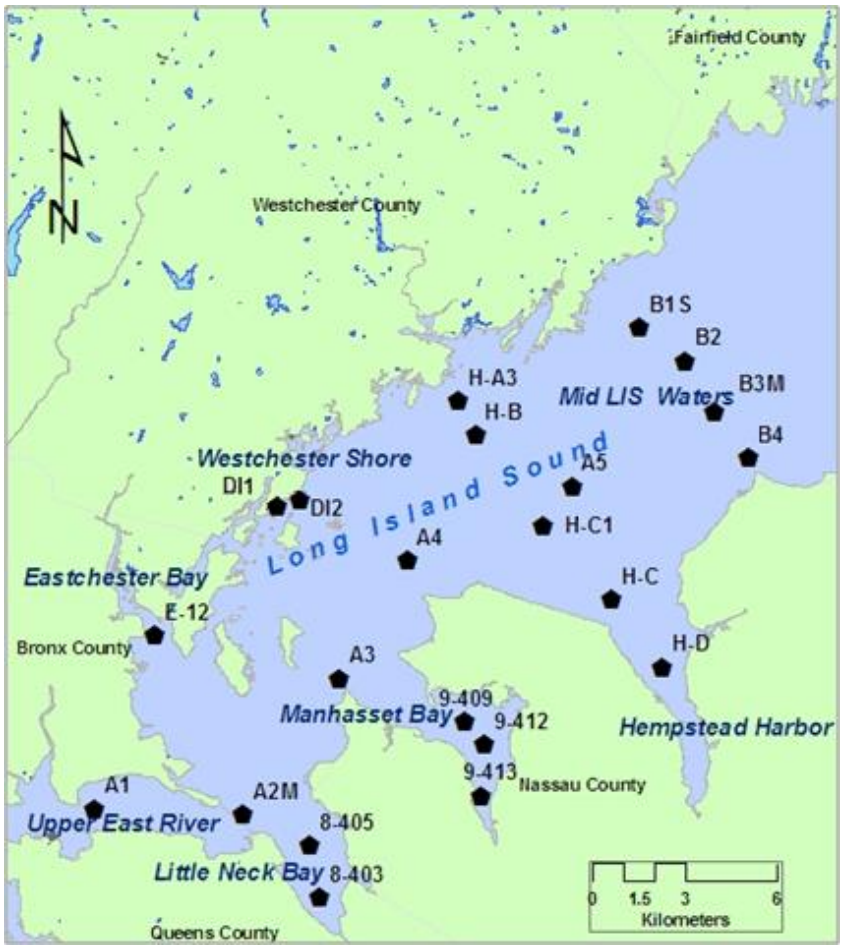


Figure 3: NEIWPCC-IEC District's 22 sampling stations located in Western Long Island Sound. *In situ* measurements of pH, temperature, salinity, water clarity (Secchi disk depth) and dissolved oxygen were collected weekly at each station during the 2013 summer survey season.

Table 1: NEIWPCC-IEC DISTRICT'S 2013 LONG ISLAND SOUND SAMPLING STATIONS BY STUDY AREA

Station	Depth (m)	Description	Study Area
A1	26	East of Whitestone Bridge	Upper East River
A2M	35	East of Throgs Neck Bridge	
E-12	4	Eastchester Bay mid-channel at N 6	Eastchester Bay
DI1	10	Davids Island north of Nun "10A"	Westchester County Shoreline
DI2	6	Davids Island east of Nun "4"	
H-A3	3	Delancy Point south of Can "1"	
H-B	12	0.7 nm southeast of Daymarker Fl R 4 Sec	
A3	12	Hewlett Point south of Fl G 4 Sec "29"	Mid-Long Island Sound Waters
A4	35	East of Sands Point, mid-channel	
A5	13	~2.6 nm east of Execution Lighthouse	
H-C1	11	Hempstead Harbor ~2.0 nm east of Sands Point	
B1S	15	Porgy Shoal south of Fl G 4 Sec R "40"	
B2	20	Matinecock Point 1.6 nm north of Gong "21"	
B3M	19	Matinecock Point 0.7 nm north of Gong "21"	
B4	15	Matinecock Point south of Gong "21"	
8-403	3	Little Neck Bay ~0.2 nm west of yellow Nun "B"	Little Neck Bay
8-405	3	Little Neck Bay ~0.15 nm north of mid-channel buoy	
9-409	4	Manhasset Bay	Manhasset Bay
9-412	4	Manhasset Bay	
9-413	3	Manhasset Bay	
H-D	7	Hempstead Harbor east of Can "9"	Hempstead Harbor
H-C	8	Hempstead Harbor east of R Bell "6"	

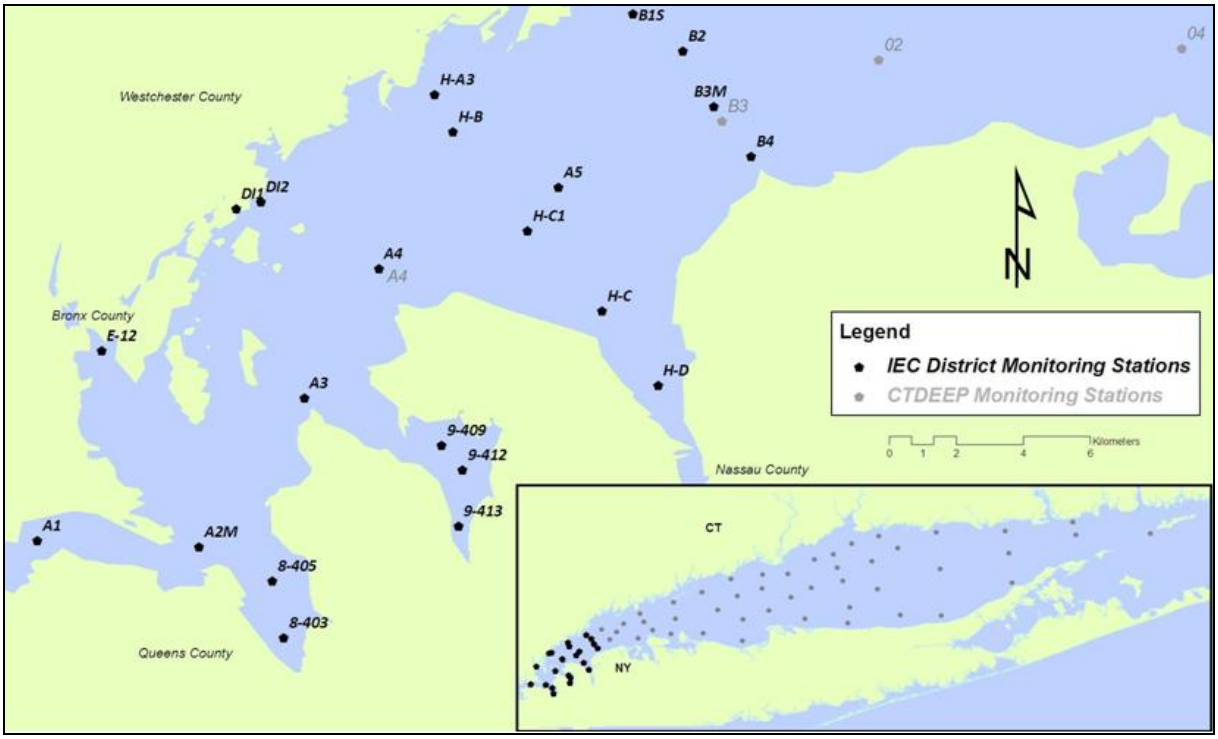


Figure 4: NEIWPCC-IEC District's 22 western Long Island Sound sampling stations in relation to CT DEEP's network of sampling stations.

Quality Control

All field work was conducted in accordance to NEIWPCC-IEC District's Quality Assurance Project Plan (QAPP) entitled *Ambient Water Quality Monitoring in the Western Long Island Sound*, which was approved by the US EPA on June 6, 2013. All analyses were performed by NEIWPCC-IEC District staff in accordance with IEC's *Laboratory Quality Control Manual*, the QAPP, and NEIWPCC's *Quality Management Plan*. A field audit was conducted on August 22, 2013 by NEIWPCC's Quality Assurance Manager and no non-conformances were found.

To further ensure the quality of collected field data, duplicate measurements were taken at one station per sampling trip. As per the QAPP, a target acceptance criterion of replicate measurements being within 15% of their average was adopted. For this sampling season, replicate measurements of dissolved oxygen were found to be within this limit, with all measurements within 13% of their average.

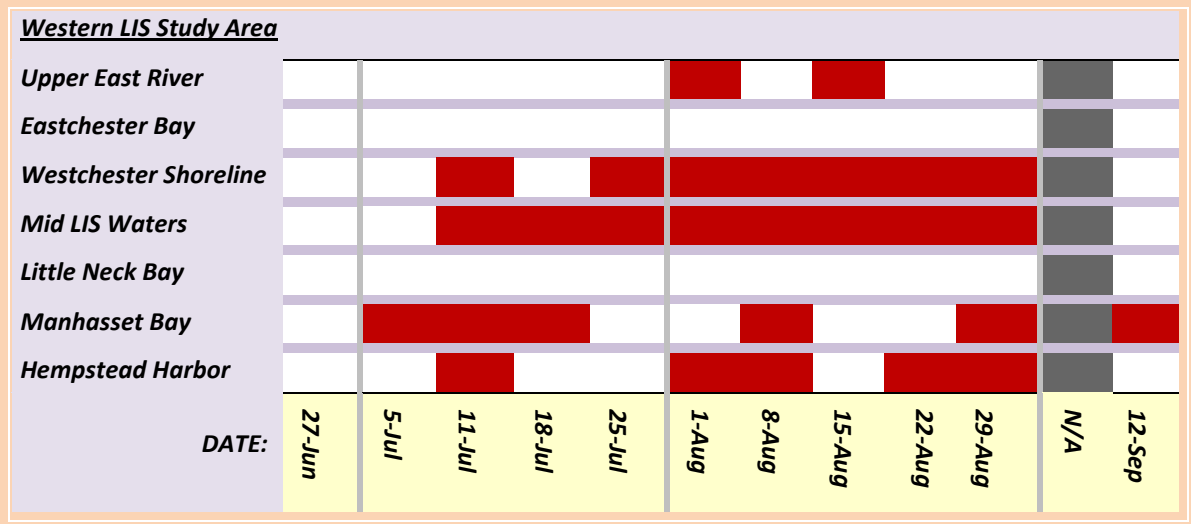
Photo 2: Westchester County shoreline as seen from NEIWPCC-IEC District's sampling vessel.

Temporal and Spatial Dissolved Oxygen Variations

As in previous years, IEC District's 2013 monitoring survey focused on documenting hypoxia and estimating its duration in the upper East River and western Long Island Sound. Waters enter a hypoxic state when dissolved oxygen concentrations fall below 3 mg/L. The severity of hypoxia varies according to the time of day, tidal cycle, depth, and the water's temperature and salinity.

The chart below illustrates hypoxia (shaded red) in segments of the study area during the survey season (Table 2). Data from each study area - western Long Island Sound embayments, the upper East River, Westchester County shoreline, and along the center of the Sound - was analyzed separately. Dissolved oxygen measurements were obtained from two or more stations within each study area, with the exception of Eastchester Bay, which was represented by only one station. No sampling was conducted the week of September 5th due to mechanical issues with the sampling vessel (Table 2).

Table 2: OBSERVED INCIDENTS OF HYPOXIA BY STUDY AREA AND SURVEY DATE



Continued observances of hypoxia (DO below 3 mg/L) from mid-July through early September were limited to stations along the Westchester Shore and mid-Sound waters. Hypoxia occurred intermittently in all other areas (Table 2). To assess which of the study areas was most impacted by hypoxia, the amount of study sites within each of the study areas and the percentage of the survey period where hypoxia was observed was considered. When taking these factors into account, hypoxia appeared more frequently within Manhasset Bay, Hempstead Harbor, and sites along the Westchester County shoreline.

The majority of hypoxic incidents were observed in bottom waters (one meter above the sediment) with only one hypoxic incident observed in surface waters (one meter below the water's surface). This occurred at station 9-413 (Manhasset Bay) on September 12, 2013.

No hypoxia was observed in Eastchester Bay or Little Neck Bay this study season. Only one severe instance of hypoxia (DO below 1.00 mg/L) was observed this sampling season. A dissolved oxygen concentration of 0.16 mg/L (~2% DO saturation at 22.1 °C) was recorded at mid-Sound station A3 (at a bottom depth of 18.3 meters) during Survey Run #5 on July 25, 2013.

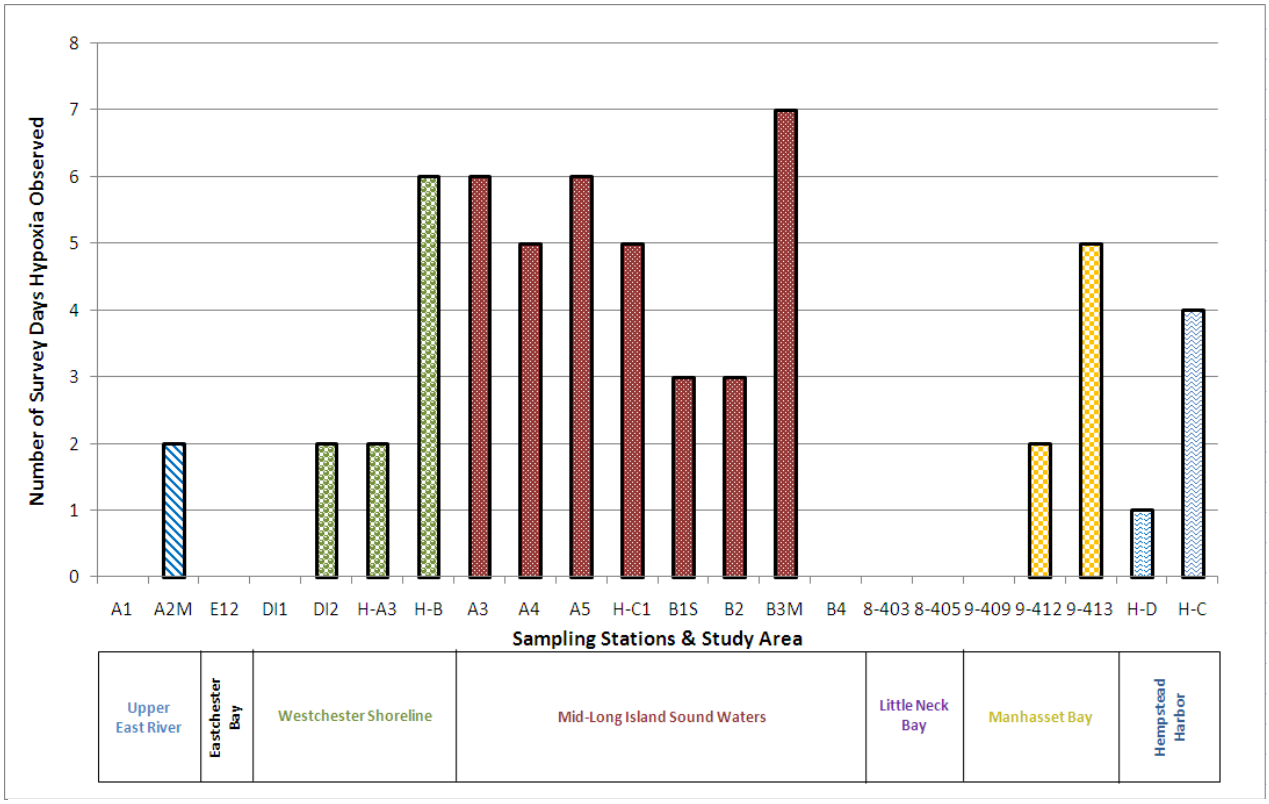


Figure 5: Number of survey days hypoxia was observed at each sampling location during NEIWPCC-IEC District's 2013 monitoring season (11 total surveys).

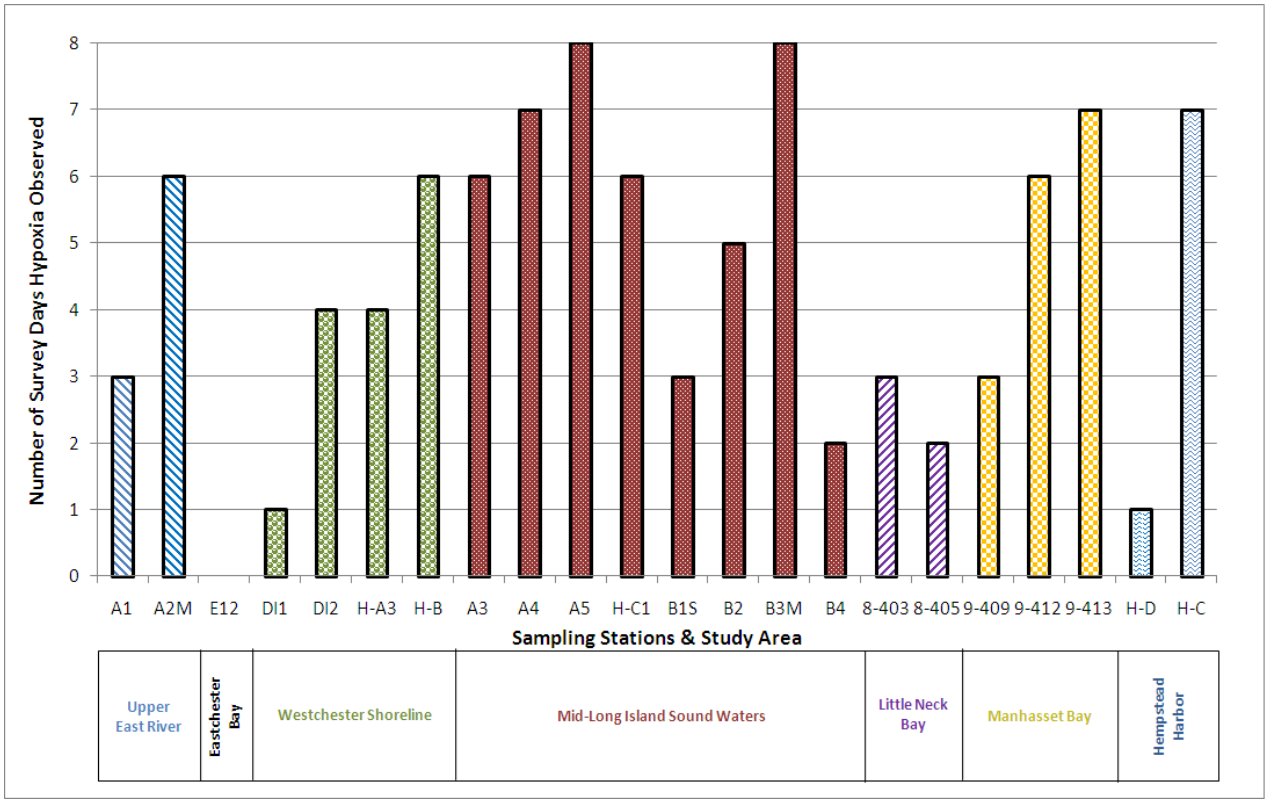


Figure 6: Number of survey days hypoxia was observed at each sampling location during NEIWPCC-IEC District's 2012 monitoring season (12 total surveys).

Although hypoxia was observed on 7 out of the 11 surveys at station B3M this sampling season (Figure 5), there was only one instance of DO below 2.00 mg/L. Dissolved oxygen concentrations below 2.00 mg/L were observed most often at mid-Sound station A3, Westchester County shoreline station H-B, and Manhasset Bay station 9-413.

Dissolved Oxygen in June

IEC District's monitoring of hypoxia began with one survey trip conducted during the last week of June. The minimum dissolved oxygen (DO) readings obtained in June were plotted on the map below (Figure 7). All dissolved oxygen measurements were above 3.00 mg/L, throughout in the study area in June.

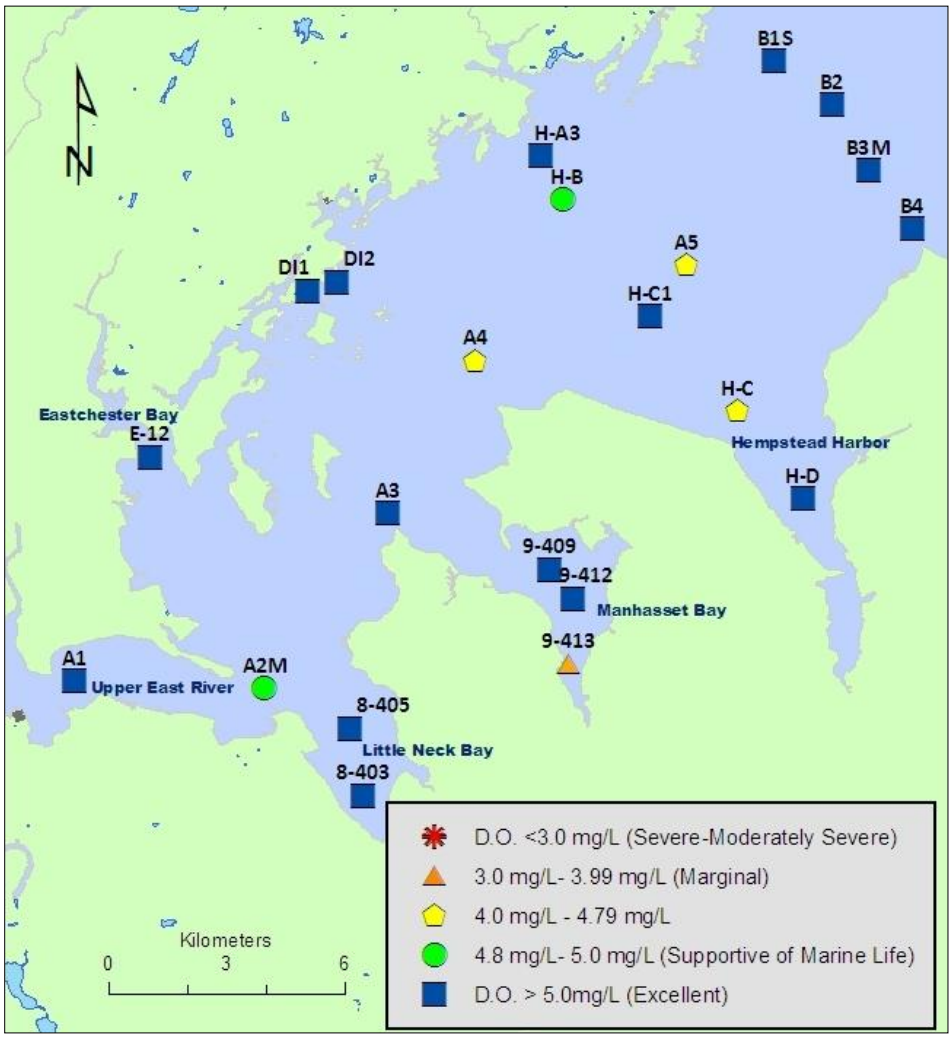


Figure 7: IEC District's observed minimum dissolved oxygen concentrations in June 2013. The locations of monitoring stations are identified with specific markers, each representing the observed dissolved oxygen minimums of the month. Red asterisks indicate hypoxic conditions (DO < 3.00 mg/L). Only one survey was conducted in June 2013.

For this first survey, the average surface dissolved oxygen concentration was 7.37 mg/L and average bottom dissolved oxygen concentration was 5.53 mg/L. The lowest dissolved oxygen measurement observed in June was found in the bottom waters of Manhasset Bay (station 9-413 (3.59 mg/L at 20.9 °C). Dissolved oxygen was greater than 4.00 mg/L at all other stations.

The highest DO (9.21 mg/L at 20.6 °C; ~119% DO saturation) was found in surface waters of mid-Sound station A5. Surface DO was at or close to saturation at all stations except for seven embayment stations (9-413, 8-403, A2M, A1, E12, DI1, DI2) and two open water stations (A3 and HA-3).

Overall, fair weather conditions were prevalent during the June survey with no hypoxia observed; however, 5 of the 22 DO readings in bottom-waters were below IEC District's DO standard of 5.00 mg/L.

Dissolved Oxygen in July (Overview)

In July, NEIWPCC-IEC District conducted four monitoring surveys in the Long Island Sound and upper East River. Surface waters appeared to be fairly oxygenated with no instances of hypoxia and the majority of DO measurements (87.5%; 77 of 88 readings) above 5 mg/L (Figure 8). Dissolved oxygen concentrations of less than 3 mg/L increased towards the end of the month, with the most severe incidents of hypoxia observed during Survey Run #5 (July 25th).

Altogether, nine different stations demonstrated hypoxic conditions in July: 9-413, 9-412, A3, H-B, B3M, H-C, HC-1, A5, and A4 (Figure 9). Hypoxia was observed at least once within the Westchester Shoreline, Mid-Long Island Sound, Manhasset Bay, and Hempstead Harbor study sites. No incidents of hypoxia were observed at the upper East River, Little Neck Bay, and Eastchester Bay sites during the month of July. Dissolved oxygen measurements of less than 2 mg/L were recorded in Manhasset Bay (1.34 mg/L on July 5th at station 9-412; 1.03 mg/L on July 18th at station 9-413) and in mid-Long Island Sound (0.16 mg/L on July 25th at station A3).

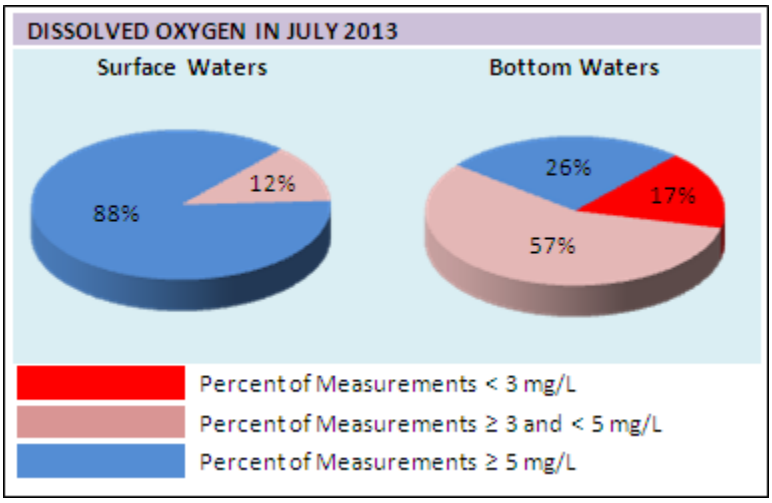


Figure 8: Dissolved oxygen concentrations in surface and bottom waters during four survey runs in July 2013. The data above represents a total of 88 surface water and 88 bottom water measurements taken at the 22 stations.

Summary of July Surveys

Photo 3: NEIWPCC-IEC District Analyst uses a Secchi disk to assess the water clarity of the Long Island Sound during a summer monitoring survey.

Looking at the first survey run in July (Run #2 on July 5th), average bottom DO was 4.79 mg/L, and average surface DO was 7.73 mg/L. Atmospheric temperatures ranged from 20-23 °C. There was only one instance of hypoxia which was observed in bottom waters of Manhasset Bay station 9-413 (2.46 mg/L at 20.3 °C; depth of 3 meters). The highest DO for this survey was found in surface waters of H-C with a concentration of 10.83 mg/L and percent saturation of ~127%. Dissolved oxygen was at or above saturation at all depths throughout the water column at stations B4 and H-D. Surface DO was at or close to saturation at all sites except for embayment stations 8-405, 8-403, A2M, A1, DI1, and DI2, and open water stations HA-3, B1S, and A3.

On the following run conducted on July 11th, atmospheric temperatures were slightly warmer (25-27 °C). Average bottom DO was 3.73 mg/L and average surface DO was 6.61 mg/L – both exhibiting a slight decrease from the previous week. Hypoxia was observed in bottom waters at seven stations: 9-413, 9-412, H-B, H-C, H-C1, A5 and A4. The lowest observed DO of 1.03 mg/L was found at Manhasset Bay station 9-413 at a bottom depth of 2.1 meters at 19.9 °C. The highest DO for this survey was found in surface waters of H-C1 with a concentration of 9.15 mg/L and percent saturation of ~102%. Bottom DO at this station was hypoxic: 2.75 mg/L at 17.5 °C; depth of 11.3 meters. Conditions were similar at stations A5 and A4 where surface water DO was

saturated and hypoxia was observed in bottom waters. At station A5, surface DO was 9.09 mg/L at 20.8 °C and bottom water DO was 2.16 mg/L at 16.8 °C (depth of 11.6 meters). At station A4, surface DO was 8.25 mg/L at 20.9 °C and bottom water DO was 2.67 mg/L at 17.0 °C (depth of 30.5 meters). DO was also saturated in surface waters of B3M and at or close to saturation throughout the entire water column at station B4.

Atmospheric temperatures continued to rise, ranging between 29-34 °C during Survey Run #4 which was completed on July 18th. However, dissolved oxygen concentrations during the survey appeared to improve from the previous week. Average surface DO for Survey Run #4 was 9.38 mg/L – the highest average surface DO for the 2013 sampling season. Dissolved oxygen in surface waters were at or above saturation at 18 of the 22 stations. At station B4, DO was above saturation at all depths. The highest observed DO concentration was 16.16 mg/L in the surface water of station A4 (~194% saturation). Instances of hypoxia were down for the previous week, with only 4 stations where DO was less than 3.00 mg/L in bottom waters. The lowest observed DO concentration was 1.34 mg/L at Manhasset Bay station 9-412 (21.9 °C at a bottom depth of 4.9 meters). At station B3M, DO was 2.82 mg/L at 18.6 °C (bottom depth of 17.7 meters). At station H-C1, DO was 2.22 mg/L at 19.9 °C (bottom depth of 10.4 meters). At station A5, DO was 2.50 mg/L at 20.1 °C (bottom depth of 10.4 meters). The average bottom dissolved oxygen concentration for the survey was 4.62 mg/L.

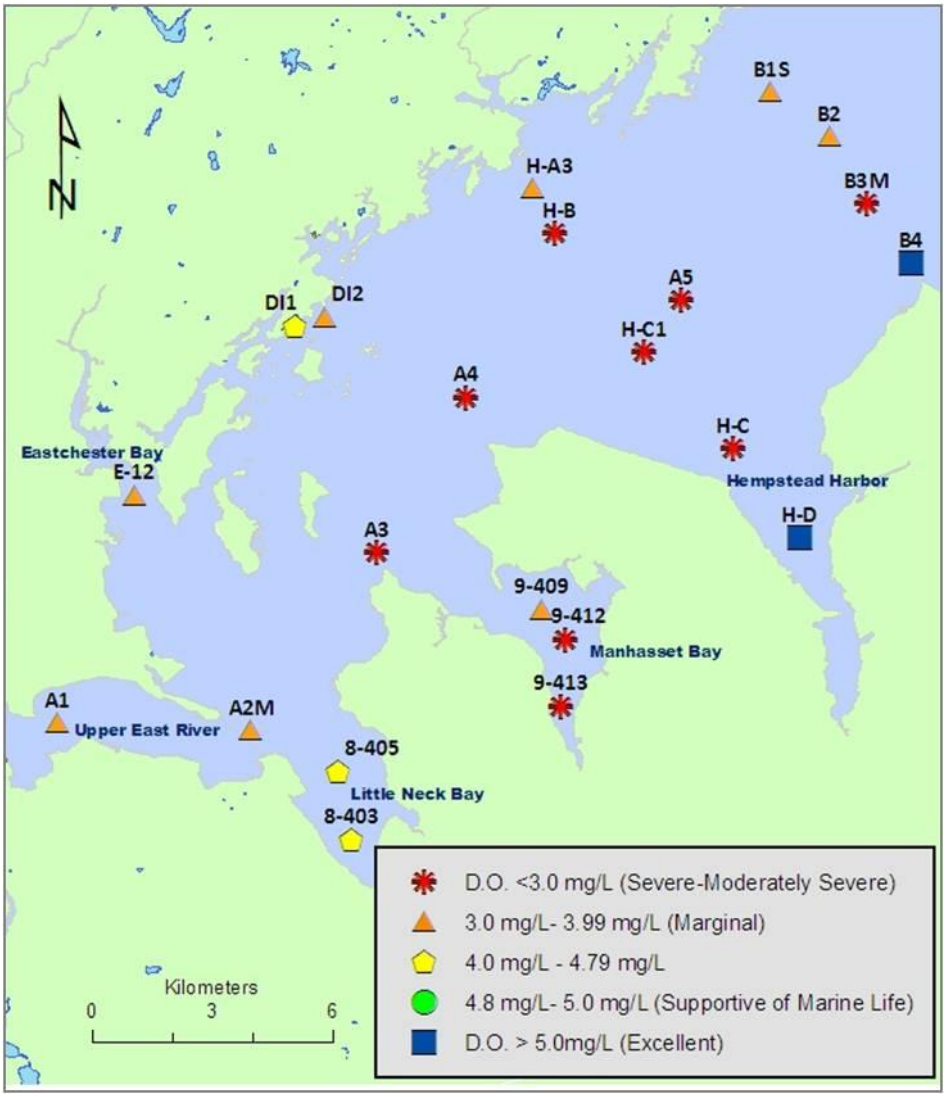


Figure 9: Observed minimum dissolved oxygen concentrations at IEC District's 22 sampling stations in July 2013. Four weekly survey runs were completed in the month of July.

Conditions appeared to improve during the final survey in July, although hypoxia was still observed in bottom waters at 3 locations: mid-Long Island Sound stations A3 and B3M, and station H-B adjacent to the Westchester shoreline. Average bottom DO was 4.53 mg/L. The lowest observed dissolved oxygen concentration for the sampling season was observed at station A3: 0.16 mg/L at a bottom depth of 18.3 meters at 22.1 °C. Average surface DO was 5.62 mg/L. The highest dissolved oxygen concentration was 6.94 mg/L (~82% saturation at 23.8 °C) and was observed in surface waters of Manhasset Bay station 9-412.

Dissolved Oxygen in August (Overview)

Hypoxia was well-documented throughout the month of August, especially in bottom waters, where it appeared to be at its peak both in terms of severity, as well as duration (Figure 10). Hypoxic conditions were observed in 13 of the 22 stations (~59% of stations tested). Hypoxia was not observed at open water station B4 and embayment stations 9-412, 9-409, 8-405, 8-403, A1, E-12, DI1, and H-D in August (Figure 11). Extremely low dissolved oxygen concentrations, where DO was less than 2.00 mg/L, was observed in 9 of the 22 stations (9-413, A3, H-B, B2, B3M, H-C, H-C1, A5, and A4). Open water station A3 reflected continuous hypoxia in bottom waters (observed during Survey Runs #6-10). Open water stations A5 and A4 also reflected continuous hypoxic conditions throughout Survey Runs #6-9, but were not sampled on Survey Run #10.

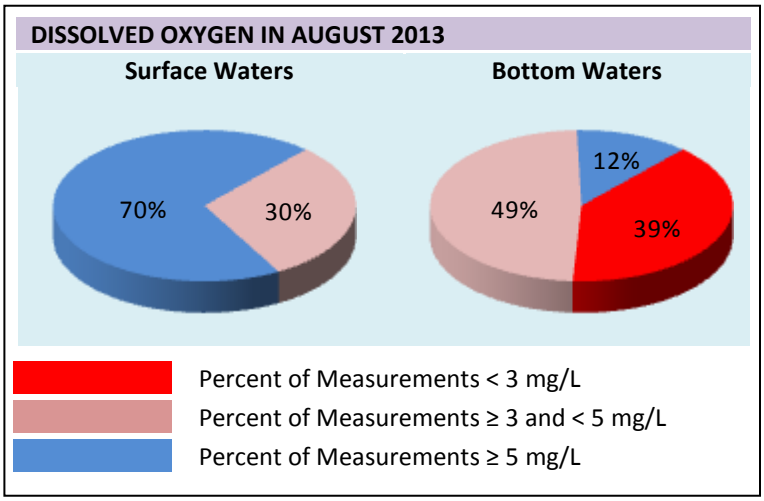


Figure 10: Dissolved oxygen concentrations in surface and bottom waters during four survey runs in August 2013. The data above represents a total of 106 surface water and 107 bottom water measurements taken at the 22 stations.

Overall, in bottom waters of all stations, a substantial percentage (39%) of dissolved oxygen measurements taken in August (42 out of 107) were below 3.00 mg/L (Figure 10). Just 12% (13 out of 107) of bottom water DO concentrations were above or equal to 5 mg/L, IEC's applicable DO standard. Conditions in surface waters were fair, with no incidents of hypoxia observed. However, 30% (32 out of 106) of dissolved oxygen measurements in surface waters fell below IEC's applicable DO standard.

Summary of August Surveys

The first August survey marked the mid-way point of IEC's summer monitoring and assessment of hypoxic conditions in western Long Island Sound and upper East River. Survey Run #6 was conducted on August 1st, with scattered showers and atmospheric temperatures holding steadily around 24 °C. The average surface dissolved oxygen concentration for the survey was 6.74 mg/L. The highest observed DO concentration was 9.58 mg/L (~113% saturation at 23.7 °C) in the surface water of B4. DO was also saturated at mid and bottom depths at this station. The average bottom DO was 3.56 mg/L – the lowest average bottom DO observed since the start of the sampling season. The lowest observed DO reading of 1.14 mg/L at 22.2 °C was found at H-C (Hempstead Harbor east of R Bell "6") at a depth of 8.5 meters. Hypoxia was observed in nine locations including both embayment and open water stations: embayment stations A2M, DI2, H-C; open water stations A3, HA-3, B3M, H-C1, A5, A4. DO was saturated in surface waters of stations E-12 and B4, in addition to stations B3M, H-C, H-C1, and A5 which exhibited hypoxia at bottom depths.

Photo 4: Throgs Neck Bridge and sampling station A2M as viewed from NEIWPCC-IEC District's sampling vessel.

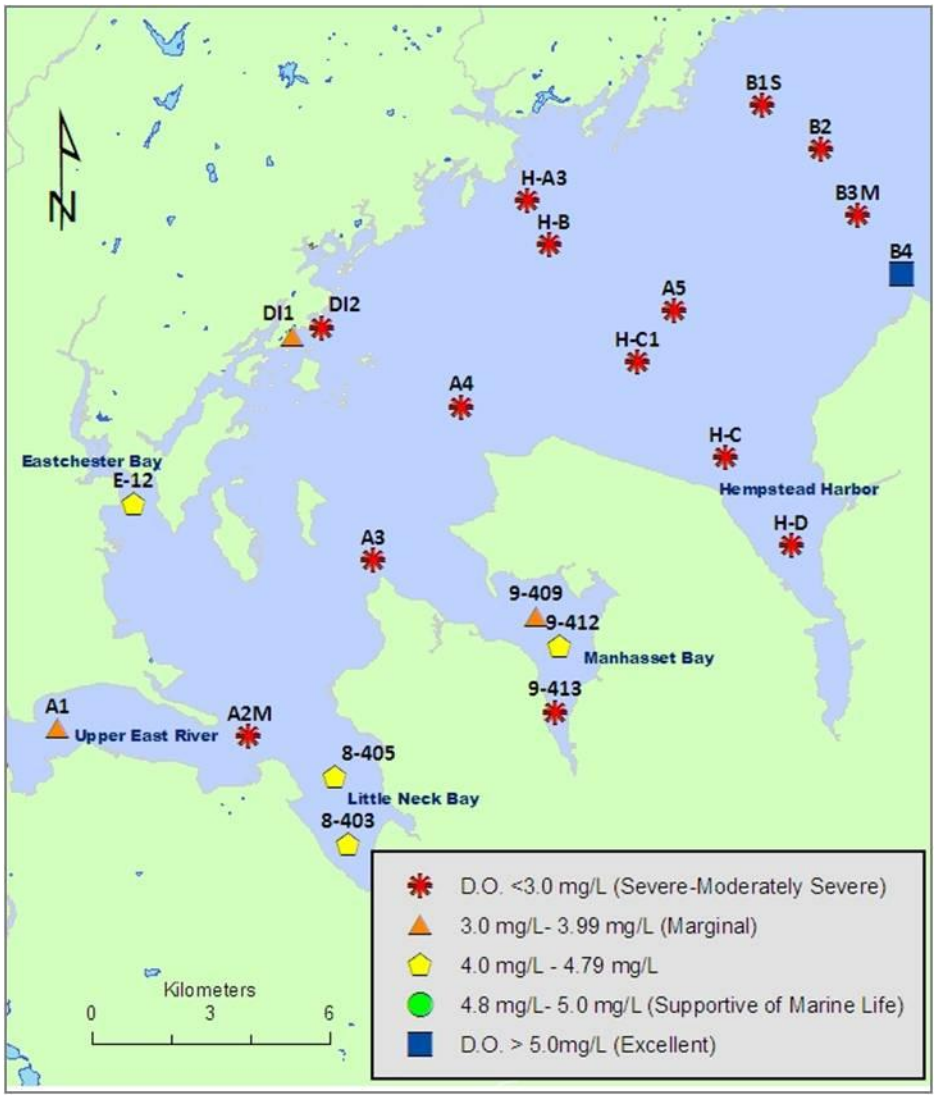


Figure 11: Observed minimum dissolved oxygen concentrations at IEC District's 22 sampling stations in August 2013. Five surveys were completed in the month of August.

The lowest average bottom dissolved oxygen concentration for the 2013 sampling season was observed during Survey Run #7 on August 8th. Average bottom DO was 3.39 mg/L, with hypoxia observed at 10 of the 22 stations including open water stations A3, H-B, B1S, B2, B3M, H-C1, A5, and A4, and embayment stations 9-413, and H-D. Atmospheric temperature was slightly higher than the previous week (23-27 °C). The average surface DO concentration for was 5.67 mg/L. The lowest and highest dissolved oxygen concentrations for this run were both observed at open water station A5. Bottom DO at this location was 1.67 mg/L at 20.5 °C at a depth of 12.2 meters. Surface DO was 7.83 mg/L at 22.3 °C (~90% saturation). DO was also close to saturation in the surface water of open water station B2 (7.48 mg/L at 22.3 °C), although mid and bottom depth DO concentrations were below 3.00 mg/L.

Conditions appeared to improve during Survey Run #8 which occurred on August 15th. Atmospheric temperatures were slightly cooler, ranging between 18-24 °C. Hypoxia was observed at 8 of the 22 stations including upper East River station A2M, and open water stations A3, H-B, B1S, B2, B3M, A5 and A4. The average bottom dissolved oxygen concentration for the survey was 3.70 mg/L. The lowest DO concentration of 1.38 mg/L at 20.9 °C was found at open water station H-B at a depth of 12.2 meters. Average surface dissolved oxygen for this survey was 6.28 mg/L. The highest DO observed was 10.80 mg/L (~147% saturation at 23.4 °C) in the surface water of A5, although bottom waters at this station were hypoxic (DO of 2.46 mg/L at 21.7 °C). Dissolved oxygen was also at or above saturation in surface waters of stations HA-3, B4, and H-C1, in addition to stations H-B, B1S, B2, B3M, and A4 which exhibited hypoxia at bottom depths.

Hypoxic conditions were documented through Survey Run #9 on August 22nd. Sampling occurred during a period of heavy rain and thunderstorms with atmospheric temperatures ranging between 23-26 °C. Temperatures throughout the water column appeared somewhat consistent with an average ΔT of 0.49 °C. Delta-T values ranged between 0.0 °C (8-405 in Little Neck Bay, 2.4 meter depth; DI1 near Davids Island, 8.8 meter depth; B4 at Matinecock Point, 4.0 meter depth) and 1.4 °C (B2 at Matinecock Point, 18.9 meter depth). Hypoxia was observed

in 9 of the 22 sampling stations including Davids Island station DI2, Hempstead Harbor station H-C, and open water stations A3, H-A3, H-B, B3M, H-C1, A5 and A4. The average bottom dissolved oxygen concentration for the survey was 3.49 mg/L. The lowest DO concentration of 2.28 mg/L at 21.7 °C was found at open water station A5 at a depth of 12.8 meters. The average surface dissolved oxygen concentration was 5.01 mg/L. The highest DO observed was 7.37 mg/L (~100% saturation at 23.0 °C) in the surface water of B4 (Matinecock Point south of Gong "21"). DO at mid and bottom depths at this station were also at saturation. Dissolved oxygen was at or close to saturation in surface waters of stations B2 and H-D, in addition to stations B3M, H-C1, and A5 which exhibited hypoxia at bottom depths.

The final August survey (Run #10) took place on August 29th, with atmospheric temperatures between 22-25 °C. Due to mechanical problems with the sampling vessel, no measurements could be taken at the final 3 stations (H-C1, A5, and A4). In general, dissolved oxygen concentrations appeared to be improving. The average surface DO concentration was 6.43 mg/L. The average bottom DO for Survey Run #10 was 3.97 mg/L, and was the highest observed average bottom DO concentration since Survey Run #5 (sampled on July 25th). Hypoxia was observed at 7 of the 19 stations sampled including Manhasset Bay station 9-413, Hempstead Harbor station H-C, and open water stations A3, H-B, B1S, B2, and B3M. Both the lowest and highest observed DO concentrations for this survey were found at Manhasset Bay station 9-413. Bottom DO at this station was 1.95 mg/L at 23.6 °C at a depth of 2.7 meters. Surface water DO was 9.32 mg/L at 24.7 °C (~129% saturation). DO was also above saturation at station H-B (8.16 mg/L at 23.1 °C; ~111% saturation), although bottom DO at this station was hypoxic. Dissolved oxygen was also at or close to saturation in surface waters of stations 9-412, 9-409, 8-403, HA-3, and H-C, in addition to the other stations which exhibited hypoxia at bottom depths (A3, B1S, B2, and B3M).

Dissolved Oxygen in September

NEIWPCC's Interstate Environmental Commission District completed its 23rd consecutive summer monitoring and assessment of hypoxic conditions in western Long Island Sound and upper East River, with its eleventh and final run of monitoring on Thursday, September 12, 2013. Due to mechanical issues with the sampling vessel, sampling was not conducted the week of September 5th.

Photo 5: NEIWPCC-IEC District Analyst collects a sample to be analyzed for chlorophyll *a*. This pigment found in aquatic plants serves as an indicator of algal production and is used to assess the overall health of Long Island Sound.

Figure 12: Observed minimum dissolved oxygen concentrations at IEC District's 22 sampling stations in September 2013. One survey was completed in the month of September.

By the final survey, instances of hypoxia had decreased dramatically, with only one station exhibiting hypoxia: Manhasset Bay station 9-413 (Figure 12). Atmospheric temperatures for the run were between 24-29 °C. The average bottom dissolved oxygen concentration was 4.00 mg/L. Average surface DO was 5.47 mg/L. The lowest DO of 2.61 mg/L at 22.5 °C was observed at station 9-413 at a depth of 2.1 meters. The highest DO concentration was 7.03 mg/L (~96% saturation at 23.2 °C) and was observed at Hempstead Harbor station H-C. Dissolved oxygen was at or close to saturation in the surface waters of open water stations B1S, B2, B3M, and B4.

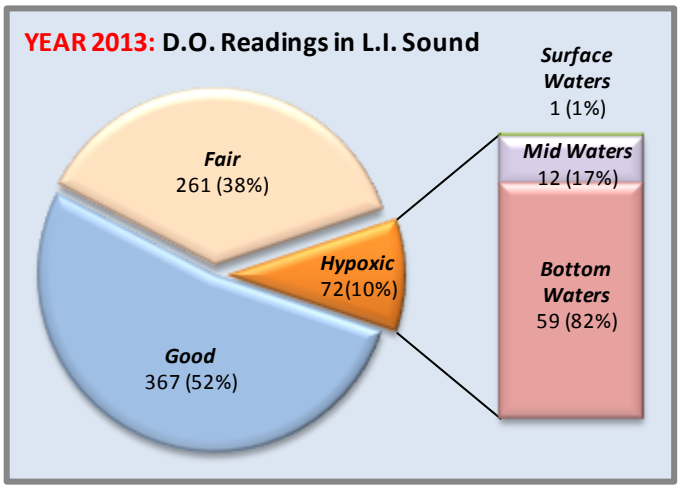
Compliance with Applicable Dissolved Oxygen Standards

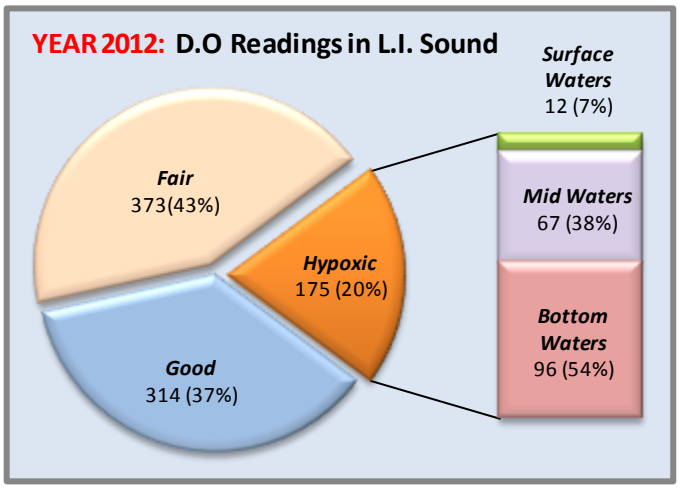
The Interstate Environmental Commission District and the State of New York have overlapping jurisdictions and each entity its own dissolved oxygen standards in the waters of the upper East River and western Long Island Sound. While both the IEC District and New York dissolved oxygen standards were developed to serve the same function—to protect the uses assigned to these waters and maintain or improve their quality—there are notable differences between them. IEC District's dissolved oxygen standard for Class A waters are concentrations of no less than 5 mg/L at any time. New York adopted dissolved oxygen standards for Classes SA, SB and SC based on the US EPA's Ambient Water Quality Criteria for DO (Saltwater): Cape Cod to Cape Hatteras published in the Federal Register on November 30, 2000. In February 2008, amendments to the water quality standards

regulations (6 NYCRR Parts 700-704) were adopted by New York State Department of Environmental Conservation. New York's DO standards consist of an acute standard of never less than 3 mg/L and a chronic standard of 4.8 mg/L with allowable excursions to not less than 3 mg/L for limited periods of time. Ongoing discussions between NEIWPCC-IEC District, US EPA, and the states of NY, NJ, and CT have occurred in an effort to adopt consistent standards.

The quality of Long Island Sound waters can be characterized by comparing DO measurements to IEC's standards. Dissolved oxygen measurements are categorized as "Good" when the DO is greater or equal to 5 mg/L, "Hypoxic" when the DO is less than 3 mg/L and "Fair" for values in between (Table 3). Hypoxic readings are further subdivided depending on the depth they were obtained from ("Surface", "Mid" or "Bottom Waters").

Table 3: TWO YEAR COMPARISON OF DISSOLVED OXYGEN READINGS IN RELATION TO IEC DISTRICT'S WATER QUALITY STANDARDS





Compliance with IEC Standards

In 2013 dissolved oxygen at or above 5 mg/L make up 52% (367 out of 700) of all measurements obtained during IEC District's 11 surveys (Table 3). These measurements comply with IEC's applicable DO standard of "Never Less Than 5 mg/L." All other DO readings in 2013 (48%) fail to satisfy IEC's DO standard. Of these, ten percent were hypoxic (below 3 mg/L), the majority (59 out of 72) of which were found in bottom waters.

Compliance with New York State Standards

- **48% of DO measurements in 2013 were lower than IEC's standard**
- **AT LEAST 10% of all DO measurements in 2013 were lower than NY's standard**
- **35% of all DO measurements in 2013 cannot be assessed against NY's standard**

As previously noted, New York's dissolved oxygen standard in the study area is not less than 4.8 mg/L with allowable excursions to not less than 3.0 mg/L for limited periods of time. Dissolved oxygen readings below 3 mg/L confirm noncompliance with NY's "not less than 3 mg/L at any time" standard. Consequently, 10% (72 out of 700) of all DO readings in 2013—labeled "Hypoxic" in the 2013 pie chart in Table 3—do not satisfy the State's acute standard of never less than 3 mg/L. Additional data analysis (not depicted in the 2013 pie chart above) showed that 55% (387 out of 700) of all DO readings collected in 2013 satisfy New York State's "equal to or greater than 4.8 mg/L" standard. The remaining 35% (242 out of 700) of IEC District's 2013 DO readings—those in the range of ≥3.0 to <4.8 mg/L—cannot be assessed against NY's applicable DO standard because the standard is based on daily averages and variation patterns. The weekly frequency of data collection in IEC District's monitoring study does not allow for the determination whether observed measurements in this range comply with New York's chronic DO standard.

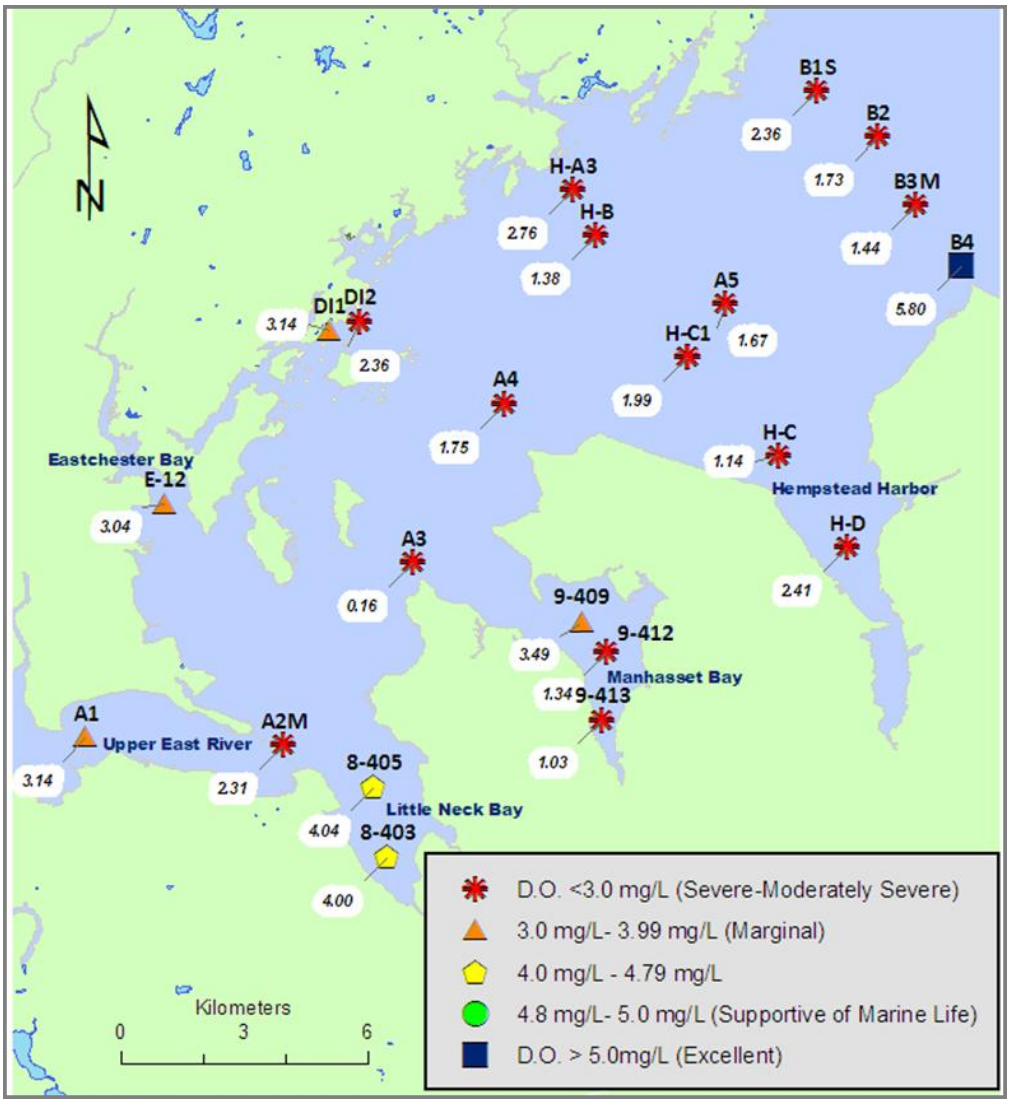


Figure 13: Observed dissolved oxygen minimums for NEIWPCC-IEC District's 2013 sampling season. The lowest dissolved oxygen concentrations observed at each station is displayed in mg/L. The figure incorporates data from the 11 survey runs completed in 2013.

A Historical Perspective

Figure 14 incorporates 22 seasons of IEC District's dissolved oxygen measurements from bottom waters and illustrates the historical variation of the percentage of those readings that were hypoxic (% of D.O. < 3 mg/L). In 2004, the percent of bottom waters dissolved oxygen measurements that were below 3 mg/L was at its maximum (69%). This year, 25% of bottom-water measurements were hypoxic (59 out of 239 readings taken). This is a considerable improvement from last year, where 36% of bottom-water measurements were hypoxic.

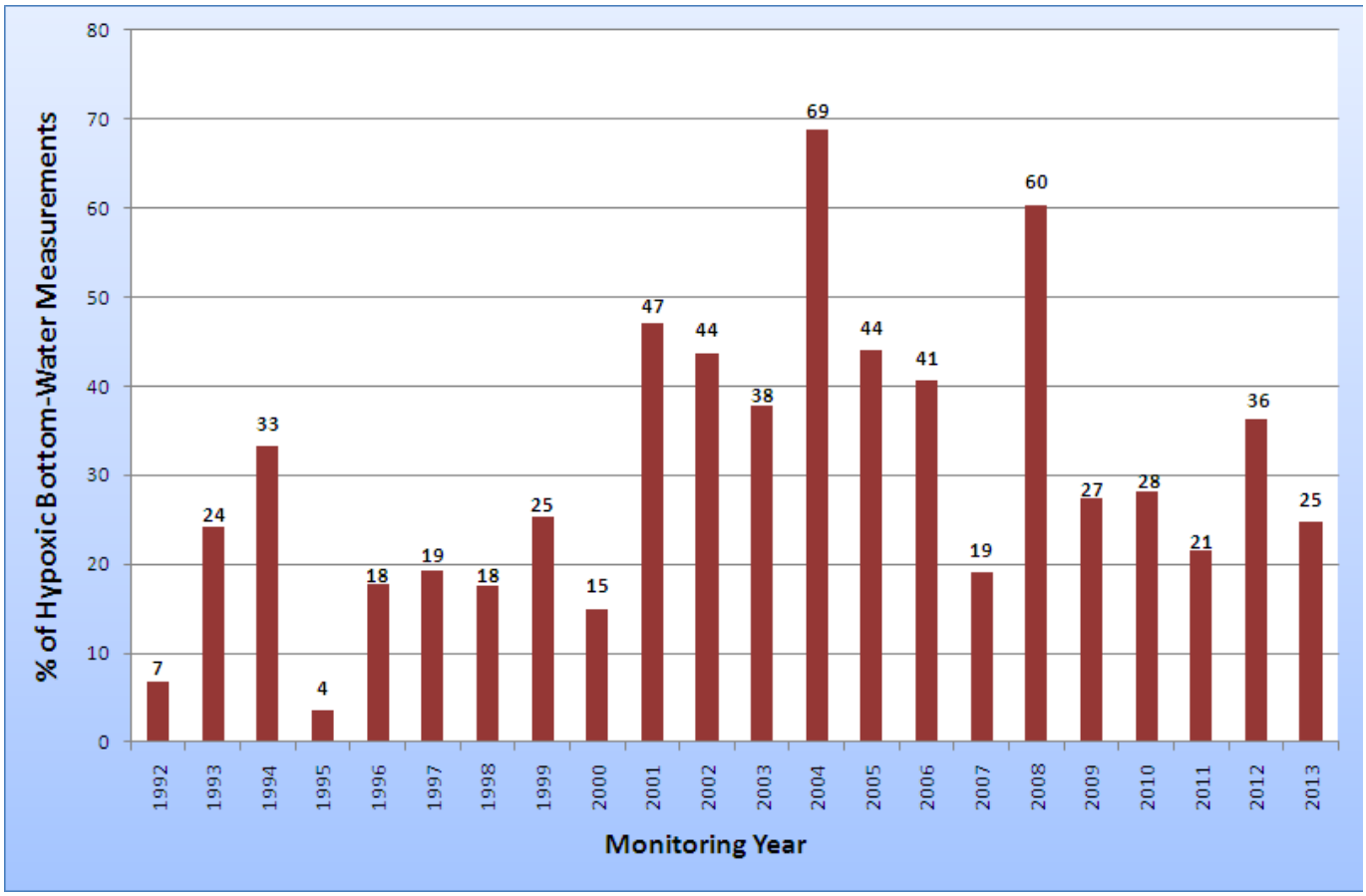


Figure 14: Tracing hypoxia in bottom waters of the upper East River and western Long Island Sound from 1992 to 2013, this figure displays the percentage of measurements with DO below 3.00 mg/L.

NEIWPCC-IEC District Contact Information:

OFFICE: 247 West 30th Street, Suite 6B, New York, NY 10001
Phone: (212) 967-1414, Fax: (212) 967-1430, E-mail: iecmail@iec-nynjct.org

LAB: 2800 Victory Blvd (College of Staten Island Campus), Bldg 6S, Room 106, Staten Island, NY 10314
Phone: (718) 982-3792, Fax: (718) 698-8472, E-mail: ieclab@iec-nynjct.org