

INTERSTATE ENVIRONMENTAL COMMISSION

*A Tri-State Water and Air Pollution Control Agency
New York - New Jersey - Connecticut*



HYPOXIA IN WESTERN LONG ISLAND SOUND AND UPPER EAST RIVER

2011

STATE OF WESTERN LONG ISLAND SOUND AND UPPER EAST RIVER

Introduction

The Interstate Environmental Commission (IEC) 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—its 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 embracing a portion of the Atlantic Ocean; and south from the borders of Rockland and Westchester Counties on the Hudson River to Sandy Hook, NJ.



With a commitment to environmental management from a regional perspective and the support of 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.

Background

The Long Island Sound, an Estuary of National Significance, is known for its valuable natural resources and its beauty. It drains one of the most densely populated areas in the nation. Notwithstanding waste disposal burdens and environmental pressures stemming from intense recreational and commercial activities that have profound socioeconomic impacts, the Long Island Sound must continue to support a healthy and diverse marine community.



Hypoxia has been identified as the most pressing priority problem in the Long Island Sound. It occurs when levels of dissolved oxygen fall below 3 parts per million (mg/l). To document hypoxic conditions, the Interstate Environmental Commission has been conducting monitoring surveys in western Long Island Sound and Upper East River since 1991. These surveys were performed in support of the National Estuary Program's Long Island Sound Study (LISS). In addition to EPA's Long Island Sound office, the Commission continues to coordinate this multi-agency collaborative effort with local and state entities, including the Connecticut Department of Environmental Protection and municipal health departments.

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 unusable for spawning and feeding. Marine organisms at their early life stages are more at risk than free swimming adults because of their sensitivity to hypoxia and their inability to escape. While the criterion for the onset of hypoxia has been set to 3 mg/l, biological stresses on aquatic organisms have been observed above this value but below 5 mg/l. Dissolved oxygen concentrations at or above 5 mg/l are believed to be protective of Long Island Sound marine life.

2011 Monitoring Logistics

This year marks the 21st consecutive summer season that the Commission, in cooperation with other environmental agencies, conducted ambient water quality monitoring in western Long Island Sound and upper East River. This season, with funds provided by the Long Island Sound Study, IEC obtained access to new multi-parameter YSI Dissolved Oxygen meters which enhanced the accuracy of in-situ water quality measurements.

Dissolved oxygen concentrations reach minimum levels during summer months when warm temperatures stratify the waters of the Sound. In the absence of vertical mixing, stratification prevents atmospheric oxygen from reaching waters near the bottom of the water column, significantly limiting available oxygen at bottom depths. IEC has been conducting weekly monitoring surveys during summer in an effort to capture the transition of waters into and out of a state of hypoxia. In addition to documenting hypoxia when it is most prevalent, data collected by IEC are also used to measure the effectiveness of management activities and programs implemented under the Comprehensive Conservation and Management Plan.

IEC's 2011 survey consisted of 12 weekly trips to the western Long Island Sound and upper East River. The first trip was conducted on June 30th and the last on September 15th, 2011. In each trip, a network of 22 stations was visited and in situ measurements were made for pH, temperature, salinity, water clarity (Secchi depth) and dissolved oxygen. Measurements were taken from at least three depths: one meter (1m) below the surface, at mid-depth, and one meter (1m) above the sediment substrate. For stations deeper than 15 meters, measurements were taken at five depths—the two additional depths being one equidistant from the surface and mid-depth, and one equidistant from mid-depth and the bottom. Samples for chlorophyll *a*, a pigment in aquatic plants used as an indicator of algal production, were collected one meter below the surface on alternate runs at all stations.

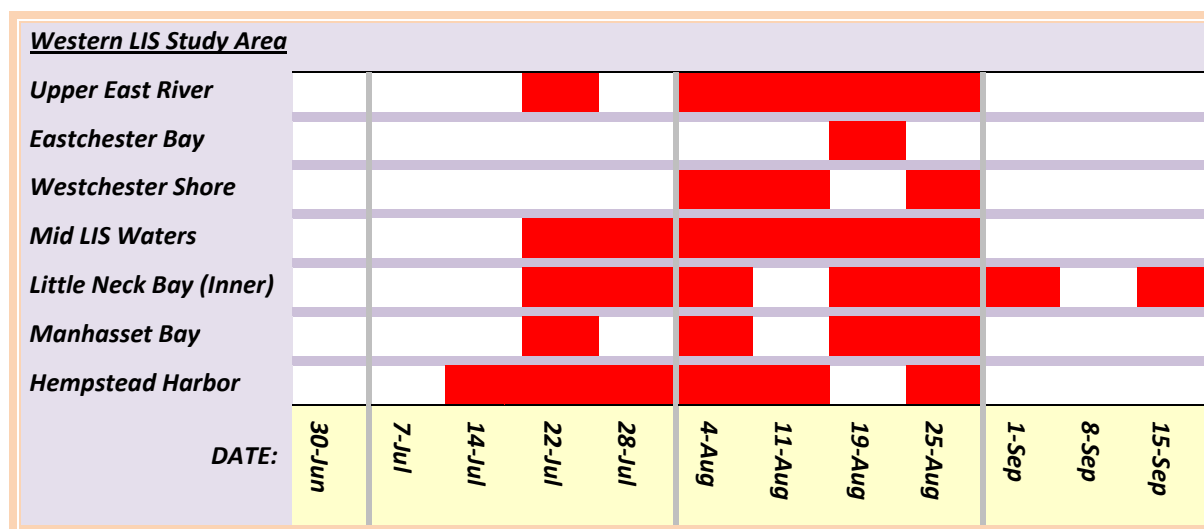
Station	Depth (m)	Description
E-12	4	Eastchester Bay mid-channel at N 6
A1	26	East of Whitestone Bridge
A2M	35	East of Throgs Neck Bridge
8-403	3	Little Neck Bay ~0.2 nm W of yellow nun "B"
8-405	3	Little Neck Bay ~0.15 nm N of mid-channel buoy
A3	12	Hewlett Point South of FI G 4 Sec "29"
9-409	4	Manhasset Bay
9-412	4	Manhasset Bay
9-413	3	Manhasset Bay
A4	35	East of Sands Point, mid-channel
A5	13	~2.6 nm East of Execution Lighthouse
B1S	15	Porgy Shoal South of FI 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"
DI1	10	Davids Island North of Nun "10A"
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 FI R 4 Sec
H-C	8	Hempstead Harbor East of R Bell "6"
H-C1	11	Hempstead Harbor ~ 2.0 nm East of Sands Point
H-D	7	Hempstead Harbor East of Can "9"



Temporal and Spatial Dissolved Oxygen Variations

As in previous years, the Commission's 2011 monitoring survey focused on documenting and estimating the duration of hypoxia in 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 in most inshore waters varies according to the time of day, tidal cycle, depth, as well as the water's temperature and salinity. The chart below traces hypoxia in certain segments of the study area. Western LIS embayments, the upper East River, Westchester shore and the waters along the center of the Sound were examined separately. Dissolved oxygen measurements were obtained from two or more stations within the aforementioned areas, with the exception of Eastchester Bay, which was represented by only one station.

DURATION OF HYPOXIA



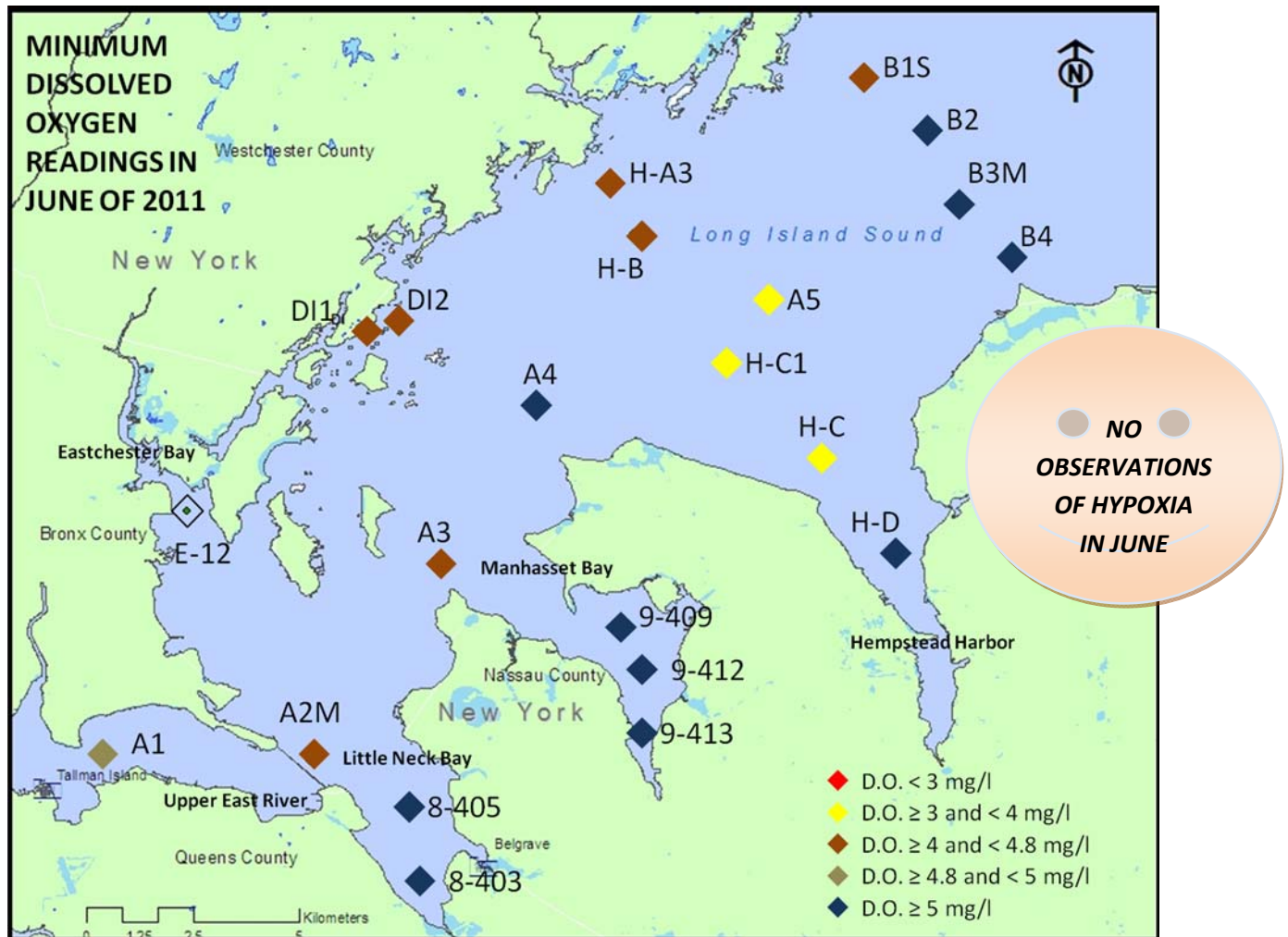
It is important to note that hypoxia was observed predominantly in Bottom-Waters (one meter above the sediment). Just a few hypoxic readings were recorded in Surface-Waters (one meter below the water's surface). Hypoxia appeared more frequently in inner Little Neck Bay, in Hempstead Harbor and in the waters along the middle of the Sound compared to the rest of the study sites. From the perspective of duration, hypoxia was least severe in Eastchester Bay where only one reading of 2.8 mg/l was recorded. Continued incidences of hypoxia were limited to mid-Sound waters where readings below 3 mg/l were obtained from the middle of July until the end of August. Hypoxia occurred intermittently in all other areas. Furthermore, the most severe instances of hypoxia were observed in the middle of the Sound where nine DO readings of less than 2 mg/l and several just above 2 mg/l were recorded in the Bottom-Waters. Following hurricane Irene (August 26-28, 2011), hypoxic conditions were noted only within inner Little Neck Bay.



Dissolved Oxygen in June

The Commission's 2011 monitoring effort began in June with only one monitoring trip performed during the last week of that month. The minimum dissolved oxygen (DO) readings obtained in June were plotted on the map

below. The location of monitoring stations is identified by markers and the color of each marker depends on the minimum DO reading obtained from that station in June. Each color represents a specific range of dissolved oxygen concentrations. Red color is used to highlight hypoxic readings ($\text{DO} < 3 \text{ mg/l}$). The absence of red markers from the map below denotes that all dissolved oxygen measurements were above 3 mg/l , anywhere in the study area in June. Although not hypoxic, the lowest dissolved oxygen measurements were taken from the Bottom-Waters in the middle of the Sound near the mouth of Hempstead Harbor (3.56 and 3.75 mg/l at stations H-C1 and A5, respectively), and from the mouth of Hempstead Harbor (3.80 mg/l at station H-C).

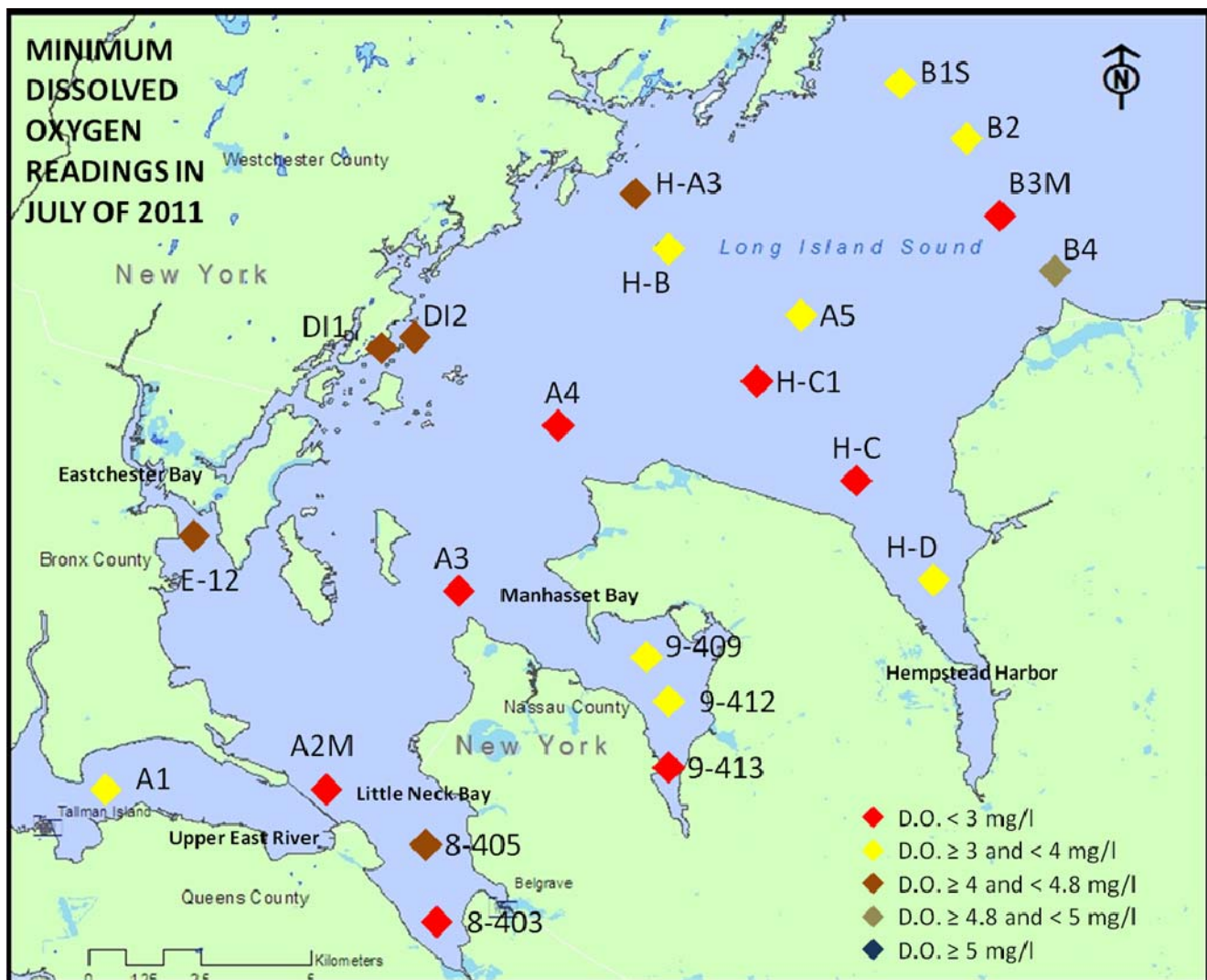


* Station E-12 was not sampled in June

Accounting for DO readings at all depths, it was noteworthy that DO levels at or near saturation were reached in the Surface-Waters of Long Island embayments, primarily because of intense photosynthetic activity. Specifically, Surface-Waters dissolved oxygen concentrations in inner Little Neck Bay, Manhasset Bay and Hempstead Harbor reached 11.37 , 10.82 and 10.26 mg/l respectively. Dissolved oxygen levels at or near saturation were also observed in the Surface-Waters of nearly all other stations, with the exception of those in the vicinity of Upper East River (A1, A2M and 8-405) and two stations near the Westchester Shoreline (DI1 and DI2). Overall, fair conditions were prevalent throughout the study area in June, with no hypoxia incidents and only 1 Surface-Waters DO measurement below 5 mg/l (4.61 mg/l at A2M, just east of Throgs Neck Bridge). Still though, 11 out of the 21 DO readings in Bottom Waters were below 5 mg/l , IEC's applicable DO standard, but only 2 of those 11 were below 4 mg/l .

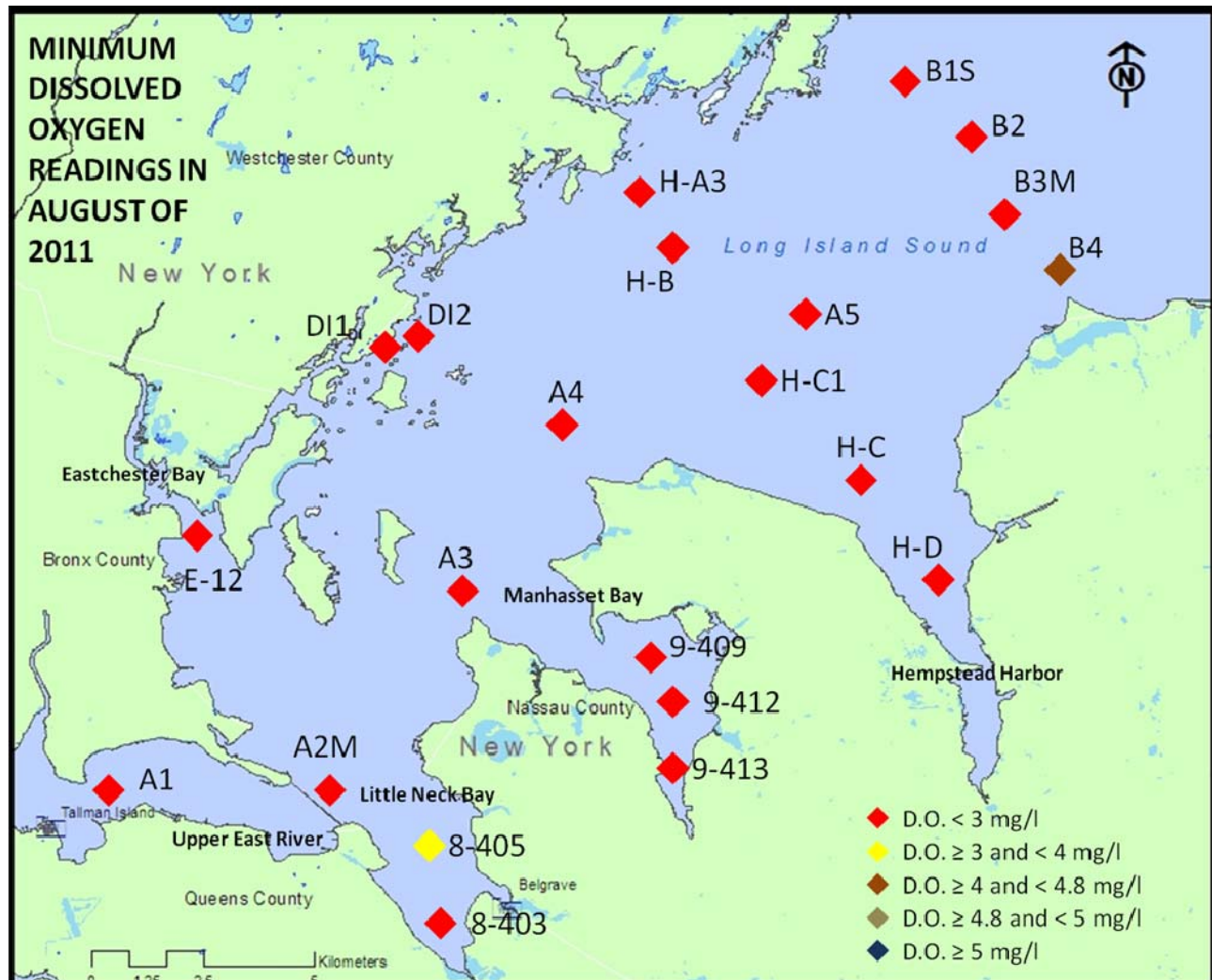
Dissolved Oxygen in July

In July, IEC staff completed four more monitoring trips to the Long Island Sound and Upper East River. Hypoxic occurrences ($\text{DO} < 3 \text{ mg/l}$) progressively increased towards the end of the month. Out of the twenty two stations visited in each of the 4 July runs, dissolved oxygen measurements of less than 3 mg/l were recorded in none of the stations on the 1st run (July 7th), in one station on the 2nd run (July 14th), in 5 and then again 5 stations on the 3rd and 4th runs (July 22 and 28), respectively. In other words, the first incidence of hypoxia this season was noted during the second run of July at station H-C1 (near the mouth of Hempstead Harbor). Subsequently, waters slowly transitioned into a state of hypoxia. All together, eight different stations—representing the majority of the study area—demonstrated hypoxic conditions in July. Most importantly, dissolved oxygen measurements of less than 2 mg/l were recorded in inner Manhasset Bay (1.29 and 1.47 mg/l on July 22 at station 9-413), in mid-Long Island Sound near the NY-CT border (1.98 mg/l on July 28 at the Bottom-Waters of station B3M), as well as in the open waters of the Sound near the mouth of Manhasset Bay (1.52 mg/l on July 28 at the Bottom-Waters of station A3).



Dissolved Oxygen in August

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. With the exception of station B4 at Matinecock Point and station 8-405 in Little Neck Bay, hypoxia was detected in all other 20 stations, at least once out of the 4 times that they were visited in August.



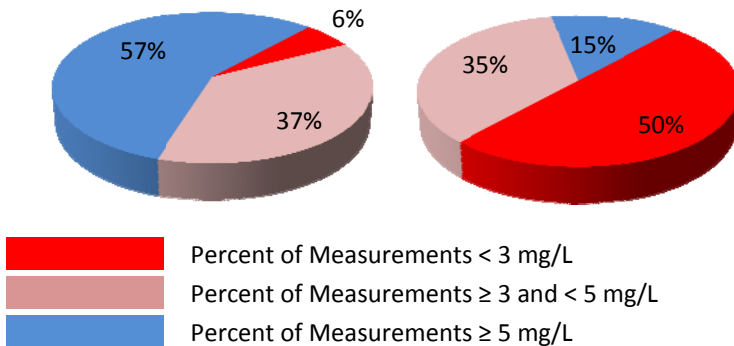
Worst conditions were identified at the Bottom-Waters of nearly all stations along the middle of the Sound where extremely low dissolved oxygen concentrations ($DO < 2$ mg/l) were recorded. In particular, three mid-channel stations, namely, A2M (just East of Throgs Neck Bridge), A4 (just east of Sands Point) and A3 (Hewlett Point), reflected continuous hypoxia in Bottom-Waters throughout August. Under such chronic hypoxic conditions, dissolved oxygen can dictate the behavioral patterns, abundance, and also, the diversity of aquatic life that can survive and reproduce in the study area. In contrast, hypoxia in Surface-Waters was observed only in the inner portion of Manhasset Bay

(station 9-413) during the first of the four August runs and at station A2M (just east of Throgs Neck Bridge) in all four August runs.



DISSOLVED OXYGEN IN AUGUST 2011

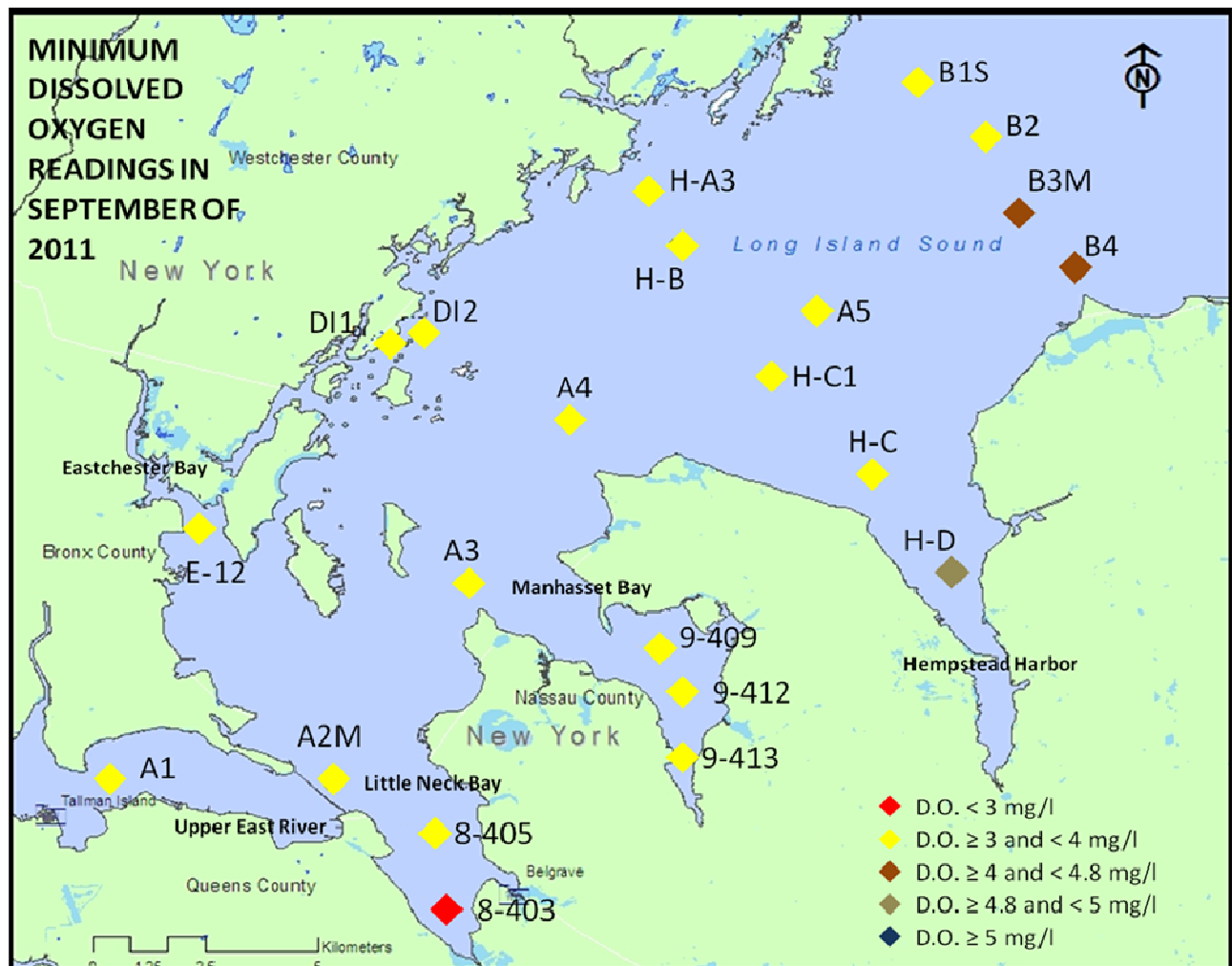
Surface Waters	Bottom Waters
----------------	---------------



Overall, at the Bottom-Waters of all stations, a substantial percentage (50%) of dissolved oxygen measurements taken in August (44 out of the total of 88) were below 3 mg/l (hypoxic) and just 15% were above, or equal to 5 mg/l, the IEC’s applicable DO standard. Surface-Waters appear to be fairly oxygenated, but still, 38 out of the total of 88 dissolved oxygen measurements at the Surface-Waters of all stations (43%) were below the IEC’s applicable DO standard.

Dissolved Oxygen in September

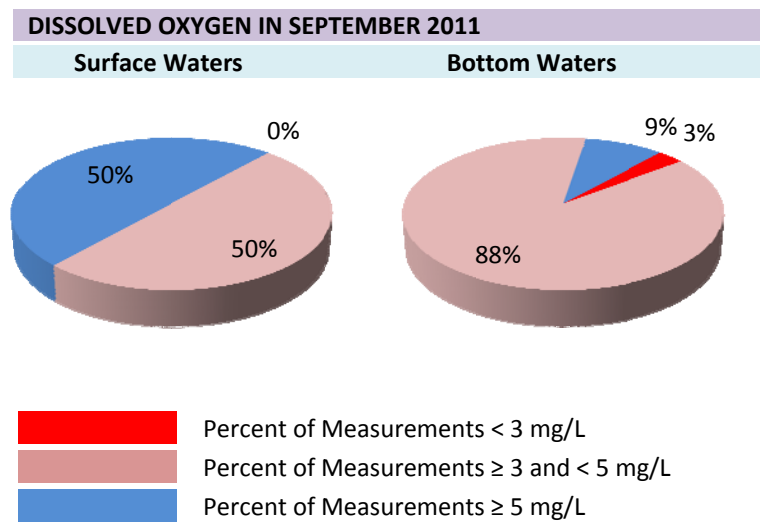
During the first three weeks of September, three monitoring trips were performed by IEC. With the exception of a singular occurrence, hypoxia had largely dissipated by the end of September, mainly because of cooler temperatures, as well as water turbulence caused by hurricane Irene, tropical storm Lee and subsequent



significant rainfall events. Apart from inner Little Neck Bay (station 8-403), where the dissolved oxygen concentration was just below 3 mg/l (2.92 mg/l) during the final survey run (Sept. 15), DO measurements at all other sites returned to levels that were lower but comparable to those observed at the beginning of the 2011 monitoring season.

Following hurricane Irene, large amounts of floating debris (wood stumps and branches) were observed at stations HA-3 (Delancey Point) and B2 (Matinecock Point) toward the north-eastern side of the study area. An 8' tree branch was also pulled out of the water near station A3 (Hewlett Point) to ensure safe navigation. Despite the heavy rain, Secchi depth measurements were satisfactory.

Throughout the whole study area, hypoxia in Surface-Waters was not observed in September. Overall, Surface-Waters seem to continue to be oxygenated relatively well, but still, 50% (33 out of the total of 66) of dissolved oxygen measurements were below 5 mg/l, the IEC's applicable DO standard. In Bottom-Waters, a small percent of dissolved oxygen measurements (3%) was below 3 mg/l, though just 9% of them were at or above 5 mg/l.

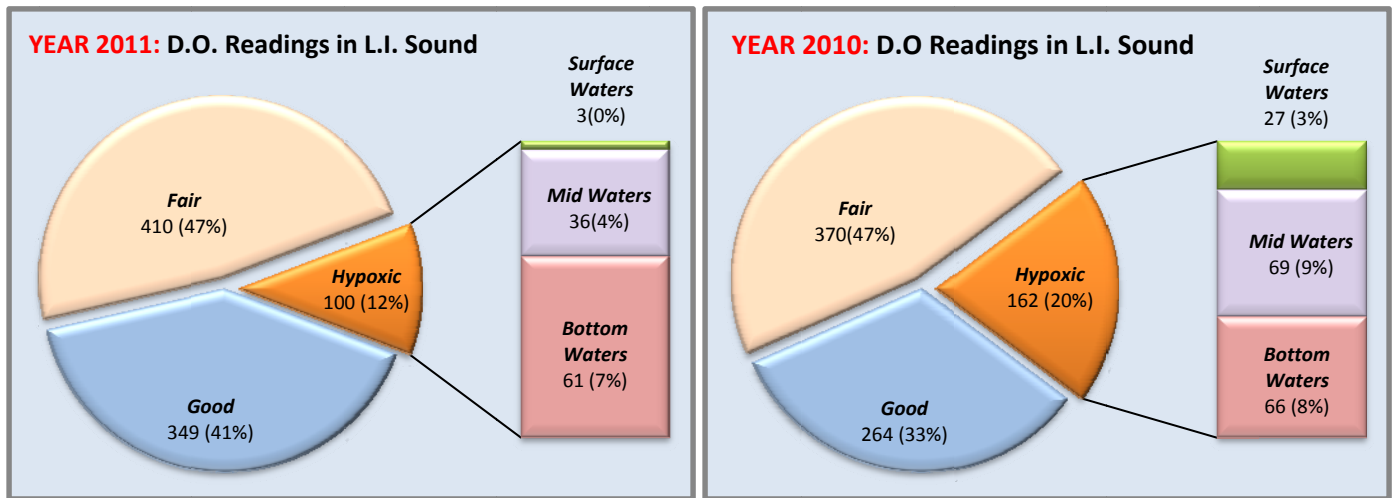


Compliance with Applicable DO Standards

The Interstate Environmental Commission and the State of New York have overlapping jurisdictions, and each entity, its own dissolved oxygen (DO) standards in the waters of the upper East River and western Long Island Sound. While both IEC and New York DO standards were developed to serve the same function—that is, to protect the uses assigned to these waters and maintain or improve their quality—there are notable differences between them. As stated previously, the IEC’s dissolved oxygen standard for Class A waters is not less than 5 mg/L at any time. New York adopted revised dissolved oxygen standards for Classes SA, SB and SC based on the U.S. EPA’s Ambient Water Quality Criteria for DO (Saltwater): Cape Cod to Cape Hatteras, noticed on November 30, 2000 in the Federal Register. New York’s DO standards consist of an acute standard of never less than 3 mg/l and a chronic standard of greater than or equal to 4.8 mg/L with allowable excursions to not less than 3.0 mg/L for limited periods of time.



Water quality is measured against applicable standards. In the pie charts below, all DO measurements obtained in 2011 and 2010 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 all other DO values ($3 \leq \text{DO} < 5$ mg/l). Hypoxic readings are further subdivided depending on the depth they were obtained from (Surface, Mid or Bottom Waters). Interestingly, the percent of “Fair” readings was the same in 2010 and 2011.



Compliance with IEC Standards

In 2011, as illustrated in the pie chart above on the left, dissolved oxygen measurements at or above 5 mg/l make up 41% (349 out of 859) of all readings. Those are in compliance with IEC’s applicable DO standard of “Never Less Than 5 mg/l” and all other DO readings in 2011 (59%) fail to satisfy it. 12% of all non-compliant DO measurements in 2011 were hypoxic (below 3 mg/l) and the majority of those (61 out of 100) was taken from Bottom Waters.

Compliance with NY Standards

As stated earlier, New York’s dissolved oxygen standard in the study area is: 4.8 mg/l with allowable excursions to not less than 3.0 mg/L for limited periods of time.

- ◆ 59% of all DO readings in 2011 were lower than IEC’s standard
- ◆ AT LEAST 12% of all DO readings in 2011 were lower than NY’s standards
- ◆ 41% of all DO readings in 2011 cannot be assessed against NY’s standards

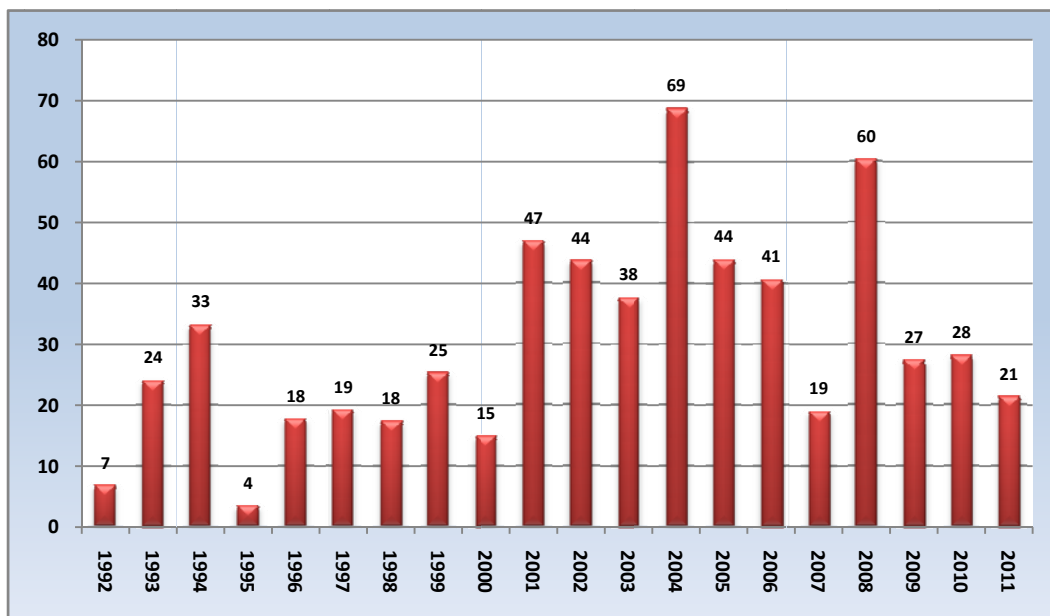
- Dissolved oxygen readings below 3 mg/l confirm noncompliance with NY’s “not less than 3 mg/l at any time” standard. Consequently, 12% (100 out of 859) of all DO readings in 2011—labeled “Hypoxic” in the 2011 pie chart above on the left—do not satisfy NY’s acute standard of never less than 3 mg/l.
- Furthermore, additional data analysis (not depicted in the 2011 pie chart above) yields that 47% (404 out of 859) of all DO readings collected in 2011 satisfy NY’s “equal to or greater than 4.8 mg/l” standard.
- So, 12% of all DO readings in 2011 do not comply with NY’s acute standard of “never less than 3 mg/l” and 47% of all DO readings in 2011 do comply with NY’s “equal to or greater than 4.8 mg/l” standard. The remaining 41% of IEC’s 2011 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 precise variation patterns. The frequency of data collection in IEC’s monitoring study (weekly excursions) makes it impossible to determine whether measurements in the range of 3.0 to 4.8 mg/l do or do not comply with New York’s chronic DO standard.

A historical Observation

The chart below analyzes dissolved oxygen measurements from Bottom-Waters only and illustrates the historical variation of the percentage of those readings that were less than 3 mg/l (% of D.O. < 3 mg/l). Although the total number of Bottom-Waters DO readings was fairly consistent throughout the years, the aforementioned percentage, despite being considerably high in most years, does not establish any type of tendency. In 2004, the percent of Bottom -Waters dissolved oxygen measurements that were below 3 mg/l was at its maximum (69%).

BOTTOM-WATERS

% OF DISSOLVED OXYGEN READINGS BELOW 3 mg/l FROM 1992 TO 2011



CONTACT INFORMATION:

IEC's OFFICE: 311 West 43rd Street, Suite 201, New York, NY 10036

Phone: (212) 582-0380 (preferred), Fax: (212) 581-5719, E-mail: iecmail@iec-nynjct.org

IEC's LAB: 2800 Victory Blvd (College of Staten Island Campus), Bldg 6S - Room 106, Staten Island, NY 10314

Phone: (718) 982-3792 (preferred), Fax: (718) 698-8472, E-mail: ieclab@iec-nynjct.org