2016

New York Harbor Water Quality Report

NYC Environmental Protection

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2016

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Introduction

The City of New York's Harbor Survey Program has been in existence since 1909, a span of 107 years of almost uninterrupted monitoring of the waterways of New York Harbor. The Harbor Survey evolved from the initial efforts carried out by the Metropolitan Sewerage Commission during 1909 in response to public complaints of degraded water quality affecting their quality of life.

The Harbor Survey has grown into a survey program that consists of 89 stations in 2016. Forty of the stations are located throughout the open-waters and have historical water quality data recorded since 1909; most of the other 49 stations are located in tributaries and were added in recent years. The number of water quality parameters measured has increased from five in 1909, to 27 at present. Harbor water quality has improved dramatically since the early surveys. Infrastructure improvements and the capture and treatment of sewage that was discharged into the harbor are the primary reasons for this improvement.

During the last decade, water quality in New York Harbor has improved to the point that many waterways are now utilized for recreation and commerce throughout the year. The City is working with Environmental Quality regulations to further improve water quality throughout New York Harbor. The New York City DEP's Long Term Control Plan (LTCP) has begun to focus on those areas within the harbor that do not currently meet water quality standards. These plans will be evaluating all waterbodies and their drainage basins, and will develop a comprehensive plan for each waterbody to attain its "best use" classification.

The water quality data collected by the NYC DEP during the summer of 2016 will be presented in four sections, each delineating a geographic region within the harbor. The water quality parameters that will be used as indicators of water quality for this report are bacteria (fecal coliform and enterococcus), dissolved oxygen, chlorophyll 'a' and Secchi transparency. These parameters and their relevance are explained in the synopsis that follows. We have also added an additional section to discuss nitrogen.

The Harbor Survey program has been modified as needed due to regulatory direction. Regarding the LTCP, this harbor survey has added multiple sampling locations to incorporate data collection over the last seven years.

Synopsis of Four Major Indicators of Environmental Change

Dissolved Oxygen - The oxygen dissolved in the water column is critical to respiration in most aquatic life forms, including fish and invertebrates such as crabs, clams, and zooplankton. Because oxygen is essential for much ocean life, dissolved oxygen is one of the important indicators of overall water quality. Where geography allows, DEP scientists measure the amount of oxygen dissolved in water at both the surface and the bottom of the water column.

Bacteria - Concentrations of certain bacteria are measured as human health-related indicators of harbor water quality. DEP scientists measure concentrations of two groups of bacteria. Fecal coliform bacteria are found in human and animal intestines and are associated with wastewater. These bacteria are widely used to indicate the possible presence of pathogenic (disease-producing) bacteria. Enterococci are a subgroup within the fecal streptococcus group and are distinguished by their ability to survive in salt water. The US Environmental Protection Agency recommends enterococci as the best indicator of health risk in salt water used for recreation. Bacteria counts are calculated as summer geographic means for May to October.

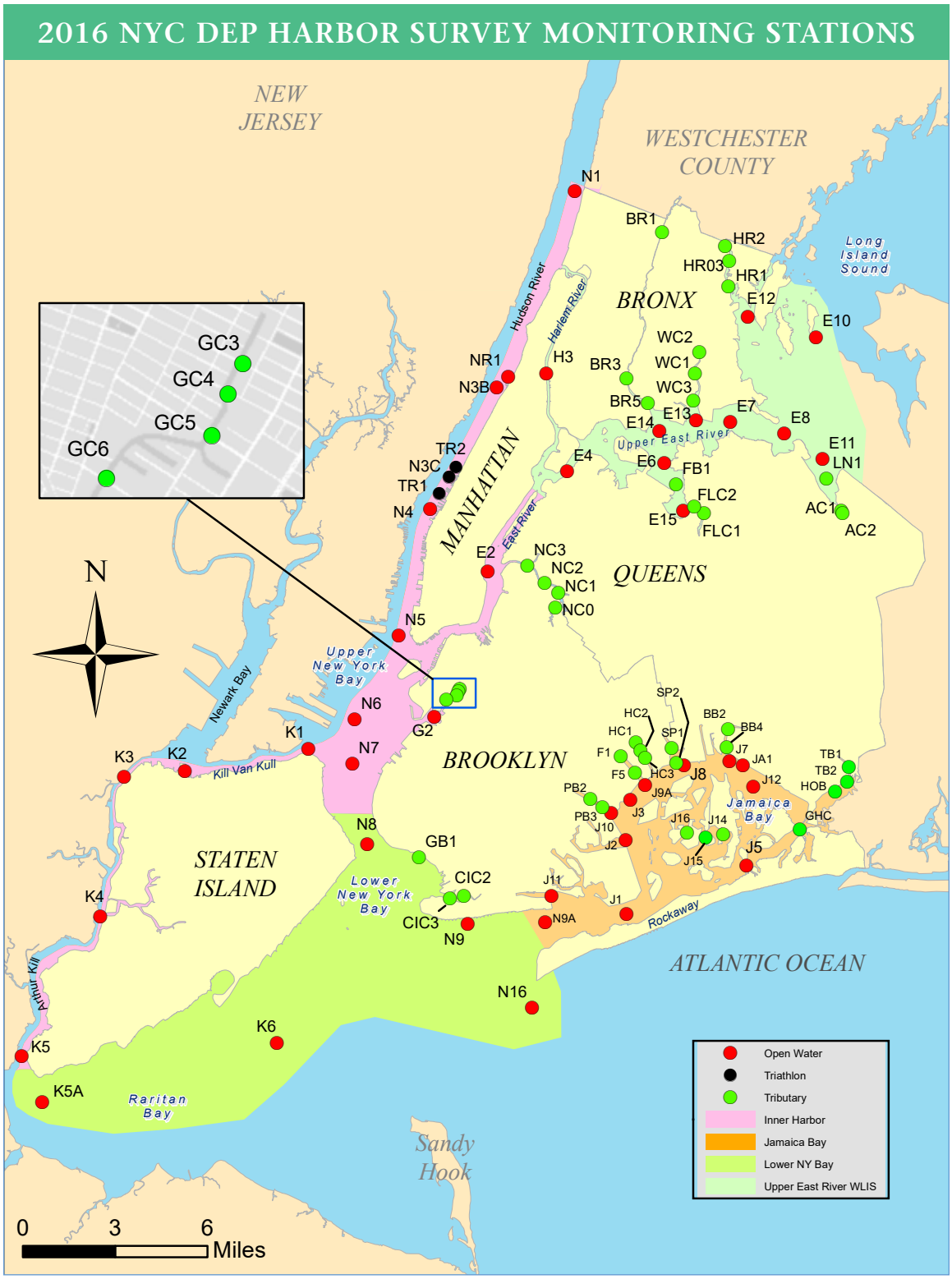
Secchi Transparency - To estimate the clarity of surface waters, DEP scientists record the visibility of Secchi disks lowered into the water. High Secchi transparency (greater than 5.0 feet) indicates of clear water, and reduced transparency is typically due to high suspended solids concentrations or plankton blooms. These conditions lead to light-limiting conditions, which affect primary productivity and nutrient cycling.

Chlorophyll 'a' - Chlorophyll 'a' is a green pigment found in most plants, algae, and phytoplankton. It is vital for photosynthesis, which allows plants to obtain energy from light. Chlorophyll 'a' can be used as an indicator of the health of an aquatic ecosystem's primary producers, which are the base of the food chain. Overgrowth of primary producers can indicate eutrophication, a high concentration of nutrients like nitrogen and phosphorus in a body of water. Excess nutrients can cause high growth rates of phytoplankton and algae, which can lead to negative secondary impacts like reduced light penetration, low dissolved oxygen, and the formation of hypoxic or "dead" zones. In coastal ecosystems, nitrogen is the limiting nutrient, so sources of nitrogen discharge are important to understanding eutrophication in salt water.

Coliform and dissolved oxygen indicators are used in New York State Department of Environmental Conservation (NYSDEC) standards to quantify ecosystem health or degradation. NYSDEC standards reflect a range of acceptable water quality conditions corresponding to the State-designated "best usage" of the water body. Common uses and NYSDEC standards for fecal coliform enterococcus and dissolved oxygen are noted in the following chart.

Common Water Use And NYSDEC Standards For Saline Waters

Class	Best Usage of Waters	Fecal Coliform	Dissolved Oxygen (never-less-than)	Enterococcus
SA	Shellfishing and all other recreational use	No standard	5.0 mg/L	
SB	Bathing and other recreational use	Monthly geometric mean less than or equal to 200 cells/100 mL from 5 or more samples	5.0 mg/L	(monthly gepmetric mean) < 35 Cells / 100ml
I	Fishing or boating	Monthly geometric mean less than or equal to 2,000 cells/100 mL from 5 or more samples	4.0 mg/L	(single sample) Max 104 Cells / 100ml
SD	Fish survival	No standard	3.0 mg/L	


2016 NYC DEP HARBOR SURVEY MONITORING STATIONS
NEW JERSEY
WESTCHESTER COUNTY
BRONX
MANHATTAN
QUEENS
BROOKLYN
STATEN ISLAND
ATLANTIC OCEAN
Long Island Sound
Hudson River
Harlem River
East River
Upper East River
Upper New York Bay
Lower New York Bay
Newark Bay
Kill Van Kull
Arthur Kill
Raritan Bay
Sandy Hook
Rockaway
Jamaica Bay
N1
BR1
HR2
HR03
HR1
E12
E10
WC2
WC1
WC3
BR3
BR5
E13
E7
E8
E14
E11
LN1
E6
FB1
FLC2
E15
FLC1
AC1
AC2
E4
H3
NR1
N3B
TR2
N3C
TR1
N4
E2
NC3
NC2
NC1
NC0
N5
N6
K1
G2
N7
K3
K2
SP2
HC2
HC1
SP1
BB2
BB4
F1
F5
HC3
J8
J7
JA1
J12
TB1
TB2
HOB
PB2
PB3
J10
J2
J3
J9A
J16
J14
J15
J5
GHC
N8
GB1
CIC2
CIC3
N9
J11
J1
N9A
K4
N16
K6
K5
K5A
GC3
GC4
GC5
GC6
N
0
3
6
Miles
Open Water
Triathlon
Tributary
Inner Harbor
Jamaica Bay
Lower NY Bay
Upper East River WLIS


NYC DEP WASTEWATER POLLUTION CONTROL PLANTS AND CSOs
N
WESTCHESTER COUNTY
NEW JERSEY
BRONX
Long Island Sound
Harlem River
North River
Hunts Point
Upper East River
Tallman Island
Hudson River
MANHATTAN
Wards Island
Bowery Bay
East River
Newtown Creek
QUEENS
Red Hook
Upper New York Bay
26th Ward
Jamaica
Kill Van Kull
BROOKLYN
Jamaica Bay
Port Richmond
Owls Head
STATEN ISLAND
Coney Island
Lower New York Bay
Rockaway
Rockaway
Oakwood Beach
Arthur Kill
ATLANTIC OCEAN
Raritan Bay
Sandy Hook
0
2.5
5
10
Miles
2016 WWTPs Flow (MGD)
16 - 50
51 - 100
101- 150
200 - 234
CSOs

Inner Harbor Area

The Inner Harbor is defined as the area including: the Hudson River from the NYC-Westchester line, through the Battery to the Verrazano Narrows; the Lower East River to the Battery; and the Kill Van Kull-Arthur Kill system. This area contains 22 Harbor Survey monitoring stations that have been grouped together due to common water uses and functions as well as similarities in point-source loadings. Waters of the Inner Harbor are often continuous, through connecting branches or straits, and cover a large and diverse geographic expanse.

Most of the Inner Harbor Area, excluding the Kills, is classified by NYSDEC as I, for uses such as fishing or boating. Most of the area in the Kills is classified for fish survival only (SD), with the exception of the far southern reach of Arthur Kill, which is designated as Class I. The Hudson River, from North of Spuyten Duyvil to Westchester County, is designated for bathing (SB).

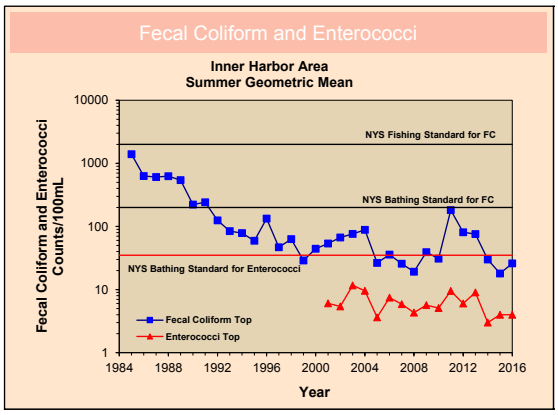
BACTERIA

Water quality as estimated by fecal coliform (FC) concentrations was superior for the Inner Harbor in the summer of 2016. The regional summer geometric mean was 26 cells/100mL for fecal coliform. All 14 historical/open-water monitoring sites complied with the monthly FC Bathing Standard of 200 cells/100mL.

Past data has indicated that the Inner Harbor is prone to episodic degradation following rain events due to additional FC loadings from storm drains and combined sewer overflows (CSOs). Water quality as estimated by Enterococcus concentrations was also superior for the Inner Harbor in 2016. The regional summer geometric mean was 4 cells/100 mL; all 14 historical/open-water monitoring sites had averages < 10 cells/100mL, which complied with the Bathing Standard of 35 cells/100mL for Enterococcus.

TRENDS

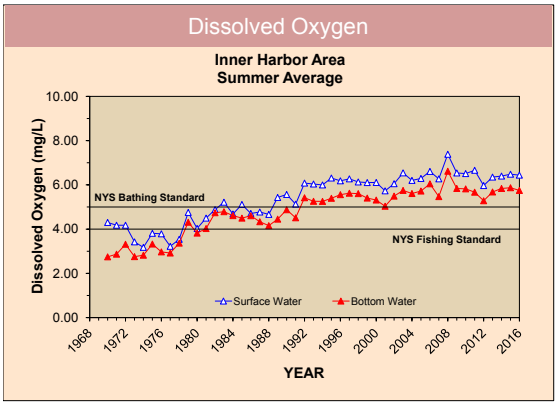
Fecal coliform levels in the Inner Harbor have dramatically declined over the last three decades, with levels since 1992 well below the Bathing Standard. The averaged FC counts have declined from levels in the mid-80s that were well in excess of the standards to the current levels well below Bathing Standard of 200 cells/100mL. This improvement has allowed for the opening of Inner Harbor waters to most recreational activities. The progress has been attributed to the cessation of raw sewage dumping through the full build-out of New York City's Wastewater Treatment Plants (WWTPs), the elimination of illegal discharges into the waterbody and the reduction of CSOs.



Enterococcus levels in the Inner Harbor have been monitored since 2001. The averages for the past 15 years have consistently been well below the Bathing Standard of 35 cells/100mL.

DISSOLVED OXYGEN

Average summer dissolved oxygen (DO) values in the Inner Harbor were 6.44 mg/L at the surface and 5.75 mg/L in bottom waters. Every sampling station in this region except K1 had at least one summer sample that fell below the state DO standard. Sites such as E2, K2, K5 and N3B had several sub-standard samples. There does not appear to be any significant grouping of these sampling stations in relation to the region. The sub-standard sites range from the Hudson River to Raritan Bay and include the East River and Kill Van Kull.



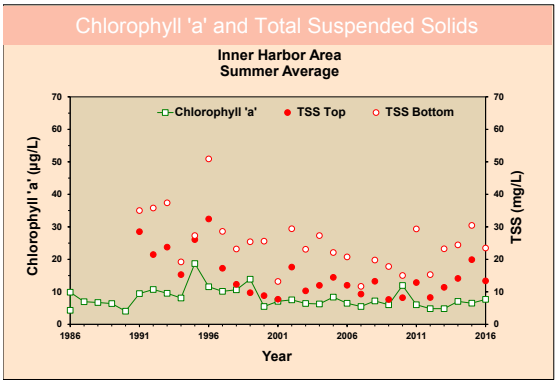
TRENDS

The gradual increase since 1970 in average DO levels apparent in the graph are a result of the important steps taken in New York City after the 1972 Clean Water Act. This includes the building and operating of the NC4R4 wastewater treatment plants, and the upgrade of the NC wastewater treatment plant to secondary treatment. Since 1992, no average summer DO value has fallen below the state's Bathing Standard of 5.0 mg/L.

Inner Harbor Area

CHLOROPHYLL 'a'

The Inner Harbor region encompasses the lower Hudson River Estuary, the Staten Island Kills, as well as the upper portion of New York Bay. As a result of this spatial diversity, the physical and chemical oceanographic conditions which affect chlorophyll 'a' in the area also vary widely. A station such as K5 located at the edge of Raritan Bay averaged 15 ug/L of chlorophyll 'a' during the summer. At the opposite edge of the region N1, a brackish water station, averaged 9.72 ug/L of chlorophyll 'a'. There is also great variability during the course of the summer as phytoplankton blooms intensify and subsequently diminish.



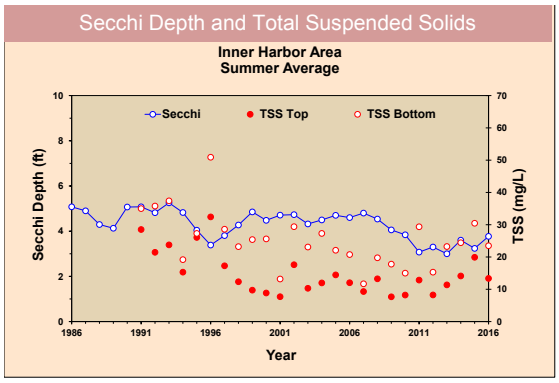
TRENDS

The 2016 summer chlorophyll 'a' average of 7.69 ug/L was fairly consistent with the past five years' average. In fact, since 1986 there are few instances of great yearly variation in chlorophyll 'a'. Massive water flow into the region from the Hudson River has been thought to be a stabilizing factor.

SECCHI TRANSPARENCY

No official water quality standards exist for the Secchi transparency. In general, high Secchi readings (depths of five feet or greater) are associated with clearer water, while low Secchi numbers (depths of three feet or less) are indicative of turbid (or light limiting) waters. In the summer of 2016, the average Secchi reading was 3.8 feet in the Inner Harbor area. The marine conditions vary substantially in this region. N1 in the turbid Hudson River averaged 2.4 ft. Secchi depth while further down the estuary at N7 the average was 4.3 ft.

Secchi Depth and Total Suspended Solids



TRENDS

Since 2010 there have been consistently lower Secchi averages in this region. Over the long term there has been little variation in the Secchi depth averages. This is likely due to the regular, normal flow from the Hudson River.

Upper East River – Western Long Island Sound

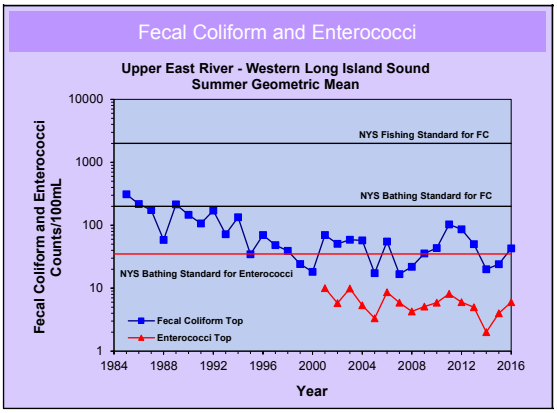
The Upper East River–Western Long Island Sound (UER-WLIS) represents the northeastern portion of NY Harbor, from Hell Gate in the East River, up into the Western Long Island Sound (WLIS). ***The Harbor Survey Program*** *provides coverage of this area, including the Harlem River and the East River, from Roosevelt Island to Hart Island at the NYC–Westchester County boundary. This area contains 26 Harbor Survey monitoring stations. Waters of this vicinity, though divergent in salinity and depth, share similarities in pollutant loadings and are targeted for management efforts as part of the* ***Long Island Sound National Estuary Program****.*

About half of the Upper East River–Western Long Island Sound area is classified as I, for uses such as fishing or boating, with the area east of the Bronx-Whitestone Bridge designated for bathing (SB).

BACTERIA

In 2016, water quality continued to be superior for the Upper East River–Western Long Island Sound (UER- WLIS). Fecal Coliform (FC) concentrations for all 11 historical/open-water monitoring sites except one at Flushing Creek (E15) were in compliance with their specified "best use" classifications for bathing and fishing. The summer geometric mean for this region was 43 cells/100 mL. Nine out of eleven historical/open-water sites had averages < 100 cells/100 mL.

Enterococcus concentrations were also superior for the area in 2016. The regional summer geometric mean was 6 cells/100 mL. All 11 monitoring sites in the area complied with the Bathing Standard of 35 cells/100 mL.



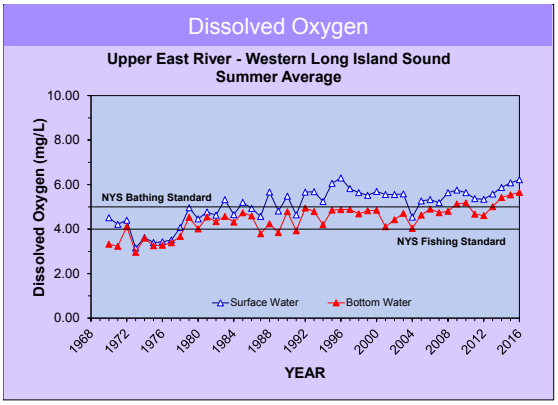
TRENDS

Bacteria concentrations have shown a downward trend for more than 20 years in the UER-WLIS region. The recent slight upward tick in the bacteria levels seems to have more to do with how superior the waters were the previous seasons than any systematic change.

Enterococcus levels in the UER-WLIS have been monitored since 2001. The averages for the past 15 years have been consistently well below the Bathing Standard.

DISSOLVED OXYGEN

Average summer surface and bottom water DO values for the UER-WLIS region exceeded the state Bathing Standard. Of the sites tested in 2016, 9% of the total samples were below the NY Sate Fishing Standard of 4.0 mg/l threshold. Deep water sites that do not experience mixing with surface waters such as E10 (~90ft) commonly yield bottom DO values as low as 2.23 mg/L in the mid- and late summer.



TRENDS

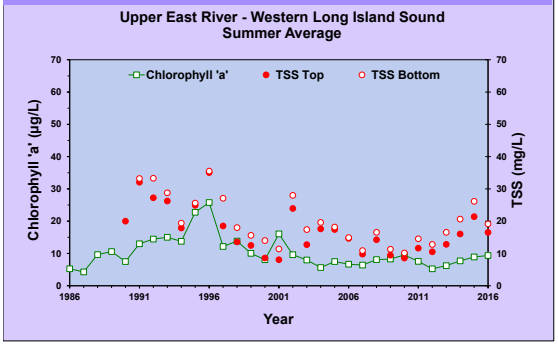
The most important trend in this region is the improvement of bottom waters that hovered near or below the Bathing Standard for over 40 years. There has been a consistent increase in average DO values since 2012. Surface water averages have not been below the Bathing Standard since 2004.

Upper East River – Western Long Island Sound

CHLOROPHYLL 'a'

The stations in the UER-WLIS generally have low chlorophyll 'a' averages (< 10 ug/L). Some stations located in the Long Island Sound bays can average as high as 25.65 ug/L (E15 Flushing Bay) with single samples as high as 73 ug/L. The head of Flushing Bay receives nutrient rich water from non-point-source runoff in Flushing Creek. E11 in Little Neck Bay had a more modest average of 14.66 ug/L. The regional average in this area was 9.37 ug/L.

Chlorophyll 'a' and Total Suspended Solids

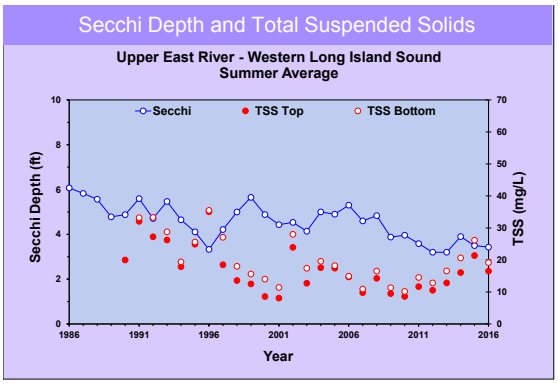


TRENDS

In the mid-90's the DEP began implementation of nitrogen removal processes in each of the four Upper East River wastewater treatment plants in order to reduce nutrient discharges. Since 2002, the summer regional chlorophyll 'a' average has been below 10 ug/L with little variation.

SECCHI TRANSPARENCY

In the summer of 2016, the average Secchi transparency in the UER-WLIS was 3.43 ft. All of the open-water historical sites in this region averaged between 3 and 4 feet except E15 (average Secchi of 2.61 ft.). E15 is located near the head of Flushing Bay and receives nutrient-rich tributary flow from Flushing Creek.



TRENDS

Average Secchi depths have not varied substantially since 2009.

Jamaica Bay

Jamaica Bay is located at the south-western end of Long Island. This urban, estuarine embayment and national park consists primarily of tidal wetlands, upland areas and open-waters. The Bay and its drainage area are almost entirely within the boroughs of Brooklyn and Queens, except for a small area at the eastern end that is in Nassau County. Jamaica Bay joins the New York Harbor to the west via the Rockaway Inlet at the tip of Breezy Point and includes the Rockaway Peninsula, which forms the southern limit of the Bay and separates it from the Atlantic Ocean. This estuarine water body, consisting of approximately 20 square miles of open-water, is covered by 30 Harbor Survey monitoring stations.

Open waters of Jamaica Bay are classified for bathing or other recreational use (SB). Areas within the Bay's tributaries and dead-end canals are prone to reduced water quality due to direct surface runoff and poor flushing. These areas are designated for secondary contact use (I), such as fishing or boating.

BACTERIA

In 2016, water quality was superior for Jamaica Bay with summer bacterial geometric means below 200 cells/100 mL, the Bathing Standard for all 12 historical/open-water stations. The regional summer geometric mean for fecal coliform was 12 cells/100mL.

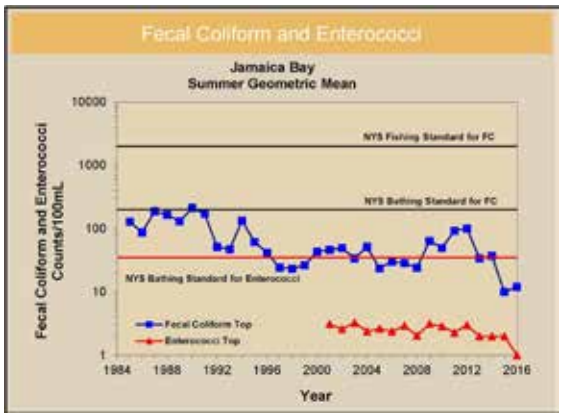
Under wet weather conditions, the Bay experiences localized degradation. At these times, spikes in FC may temporarily exceed the Bathing Standard of 200 cells/100 mL for the entire northern portion of the Bay. This decrease in water quality is limited to the Bay proper, as Lower New York Bay waters are not typically affected by wet weather events.

Enterococcus concentrations were also superior for Jamaica Bay in 2016. The regional summer geometric mean was 1 cells/100mL; all 12 monitoring sites complied with the Bathing Standard of 35 cells/100 mL.

TRENDS

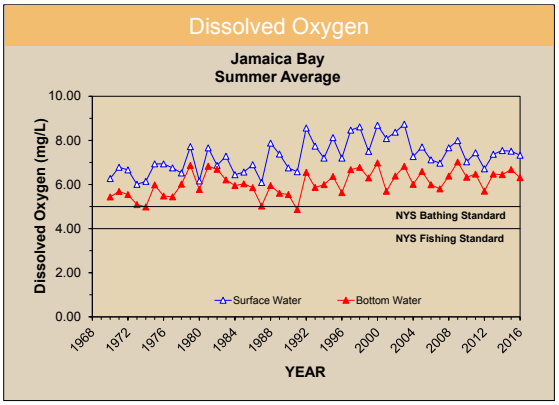
Summer geometric mean bacterial levels in Jamaica Bay as a whole have been below standards for more than 30 years.

The DEP continues to improve its sewage system. The operation of CSO storage tanks continues in two Jamaica Bay tributaries. Additionally, DEP skimmer vessels work to control floatable debris in Jamaica Bay, as part of the “Boom and Skim” program.



DISSOLVED OXYGEN

Of all the city’s regions, Jamaica Bay had the highest surface water DO summer average (7.33 mg/L). Stations J2, J3, J5, J7, J8, J9A and JA1 all had several samples that were below the state bathing DO standard (5.0 mg/L). Stations J1, J11 and N9A did not have any samples all summer below that standard. On the other hand, at J12 there were several samples below 3.0 mg/L. The stations near the mouth of the bay where there is more exchange with ocean waters generally tend to have better DO values than the stations in the northern and eastern sections of the bay where there is less mixing.



TRENDS

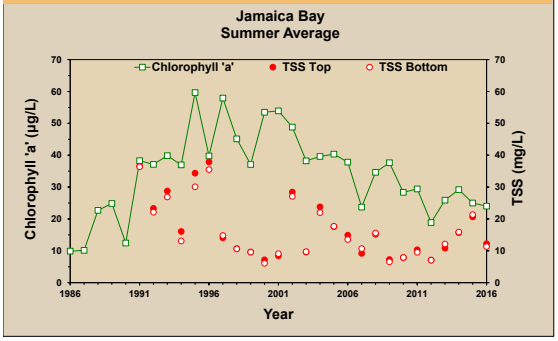
After decades of year-to-year variations in average summer DO values, it appears there currently is a period of stability. From 2013 to 2016, both surface and bottom water averages have varied very little. The longer term perspective generally shows a slight increase in DO averages over time since the early 1970s.

Jamaica Bay

CHLOROPHYLL 'a'

Jamaica Bay typically has the highest chlorophyll 'a' averages of all the city's marine waters. This year was no exception, with an average of 24.03 ug/L. Only one open-water historical station in Jamaica Bay (N9A) averaged less than 20 ug/L in 2016. Stations in the northeastern portion of the Bay (J7, J8, J12 and JA1) all averaged over 25 ug/L. The stations located at the mouths of various tributaries in the bay are often eutrophic in summer months. For example, J7 at the mouth of Bergen Basin had a summer average of 38.64 ug/L. Slow turnover of water within the bay and the nutrient-rich tributaries feeding it allow for the development of large standing phytoplankton populations.

Chlorophyll 'a' and Total Suspended Solids

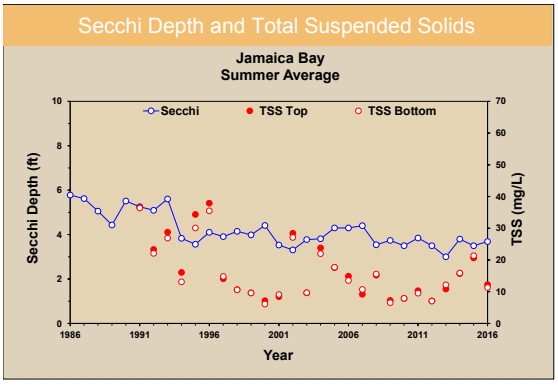


TRENDS

Average chlorophyll 'a' concentrations have fluctuated greatly over the past 30 years, particularly in the mid 90s. Since the summer average of 53.91 ug/L in 2001, the concentrations have decreased gradually. The completed carbon addition facility (using carbon for Biological Nitrogen Removal [BNR]) at the 26th Ward Wastewater Treatment Plant (WWTP) in 2012 was implemented in part to fulfill a commitment to reducing nitrogen discharges into Jamaica Bay by more than 50% over 10 years. In addition to BNR upgrades to 26th Ward, BNR improvements are progressing at the Jamaica WWTP, Coney Island WWTP and Rockaway WWTP in Queens. All BNR improvements are expected to be completed by 2020.

SECCHI TRANSPARENCY

The 2016 average summer Secchi depth of 3.69 ft. represented a slight increase from the prior year. All of the open-water historical sites in Jamaica Bay averaged between three and four feet except N9A (Secchi depth of 4.9 ft.). This site is located near the outfall of the Coney Island WWTP. Often, low individual Secchi readings are paired with particularly high chlorophyll 'a' concentrations representative of a phytoplankton bloom. For example at J7, Secchi depths of 1.0 and 1.5 ft. were measured when corresponding chlorophyll 'a' samples were 102 ug/L and 177 ug/L respectively.



TRENDS

After 1993, average Secchi depths in Jamaica Bay have remained fairly stable. Throughout this relatively stable period, average chlorophyll 'a' concentrations and total suspended solids have varied substantially.

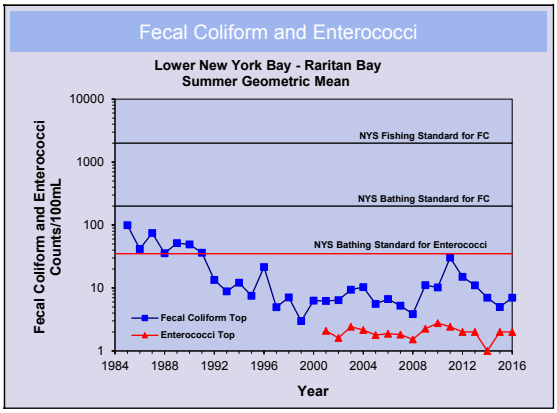
Lower New York Bay – Raritan Bay

The Lower NY Bay–Raritan Bay (LNYB-RB) vicinity represents the most oceanic portion of the ***Harbor Survey Program****. This area of 100 square miles is represented by eight Harbor Survey monitoring stations and is composed mostly of open shallow waters, partially confined by Brooklyn's Coney Island to the north, Staten Island to the north-west, and New Jersey's Middlesex and Monmouth counties and Sandy Hook to the south. The remainder of its eastern boundary is open to Rockaway Inlet and the greater Atlantic Ocean.*

BACTERIA

In 2016, water quality as estimated by fecal coliform (FC) had the lowest values in the Lower New York Bay – Raritan Bay (LNYB-RB) as compared to other waterbodies around New York City. Summer geometric mean for FC numbers show waters of the LNYB-RB meet and surpass NYS Standard of 200 cells/100mL for this area. All five historical/open-water stations had summer geometric means ≤ 12 cells/100 mL. Their monthly geometric mean all met standards.

Enterococcus concentrations were also superior for the Lower New York Bay – Raritan Bay in 2016. The regional summer geometric mean was 2 cells/100mL; all five monitoring sites complied with the Bathing Standard of 35 cells/100 mL.



TRENDS

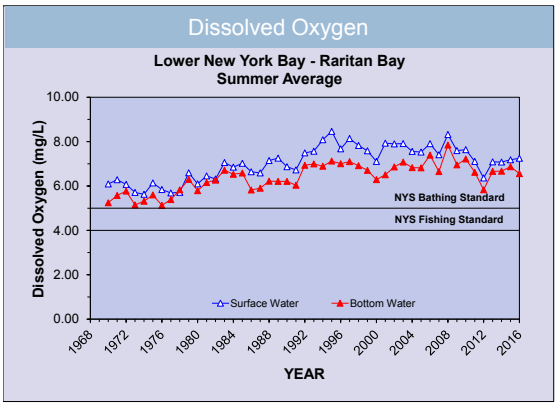
Fecal coliform (FC) concentrations for LNYB-RB show significant decline from the mid-1980s to the present time.

These improvements have allowed for the opening of all NYC public beaches since 1992 and the lifting of wet weather swimming advisories.

Enterococcus levels in the LNYB-RB have been consistently well below the Bathing Standard.

DISSOLVED OXYGEN

Average dissolved oxygen values in the LNYB-RB are relatively high when compared to other regions (7.25 mg/L and 6.56 mg/l for the surface and bottom water respectively). One surface water sample taken under the Verrazano Bridge (N8) was less than the state Bathing Standard. Several samples in Raritan Bay (K5A) from late July to early September were below the state's fishing or Bathing Standard.



TRENDS

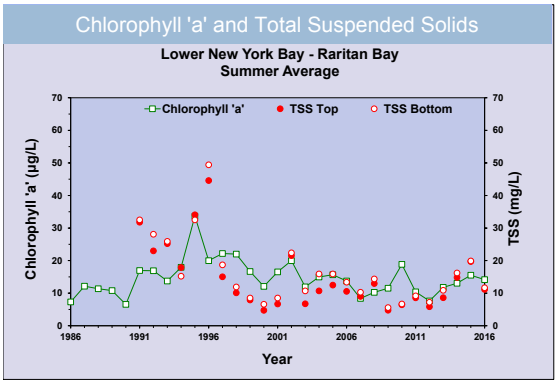
Since 1970, most of the improvement in the LNYB-RB area is attributed to decreased waste loading into the Arthur Kill and the Raritan River. It wasn't until 1979 when the upgrading of secondary treatment at most of the city's wastewater treatment plants (including Oakwood Beach and Port Richmond) was completed. The Owls Head Plant was upgraded later. These upgrades are reflected in the steady rise in average summer DO values after this time period.

Lower New York Bay – Raritan Bay

CHLOROPHYLL 'a'

This large region is represented by five open-water historical survey stations. The three stations in the eastern side of the region (Lower Bay) typically have low average chlorophyll 'a' concentrations (all 10 ug/L). These waters are among the clearest in the city and are represented by sampling stations at the Verrazano Narrows (N8), Coney Island Beach (N9) and Rockaway Inlet (N16). Conversely, the Raritan Bay stations on the southeast shore of Staten Island have averages of 17.69 ug/L (K5A) and 25.95 ug/L (K6).

Raritan Bay appears to have a natural configuration ideal for the promotion of phytoplankton blooms not only in the summer, but in the winter as well. The relatively shallow area's main source of fresh water is New Jersey's Raritan River, an impaired waterway. Flushing from the Hudson River is inhibited by surrounding shoals, such as Old Orchard Shoal. Tidal exchange with oceanic waters does occur, but is inhibited somewhat by Sandy Hook.

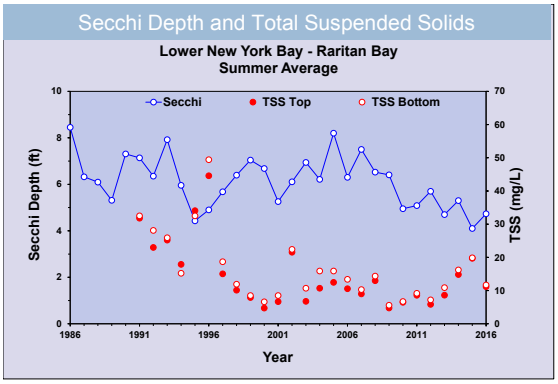


TRENDS

Given the propensity for algae blooms in Raritan Bay, this region as a whole still has a history of having fairly low summer chlorophyll 'a' averages. In fact, over the past 30 years, all but three years (1995, 1997 and 1998) had averages below 20 ug/L (see figure). In 2016, the chlorophyll 'a' average was 14.17 ug/L.

SECCHI TRANSPARENCY

The 2016 average summer Secchi depth in the LNYB-RB region was 4.73 ft. This is an increase from a historical low of 4.1 ft. in 2015. The five sites in this region mirror the layout described in the Chlorophyll 'a' section above. Sites on the eastern side of the region that have low chlorophyll 'a' concentrations also have high average Secchi depths (5.7 ft. for N9 and 6.6 ft. for N16). N16 is an open-water site with very clear ocean water. Raritan Bay stations K6 and K5A on the other hand, had average Secchi depths of 3.5 and 3.7 ft. respectively.



TRENDS

Though variable on a year to year basis, this region historically has the highest Secchi depth averages in the city. One noticeable dip in the Secchi depth average occurred in the summer of 1995 and was associated with the highest chlorophyll 'a' average and a high TSS average.

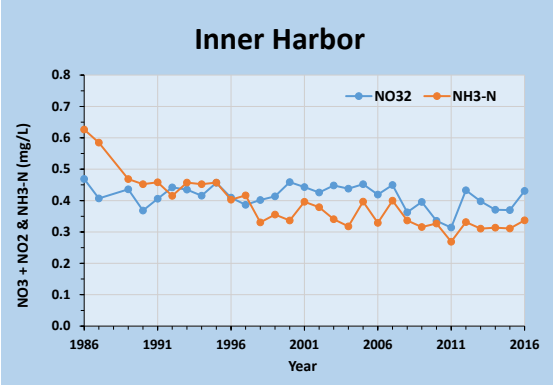
Nitrogen

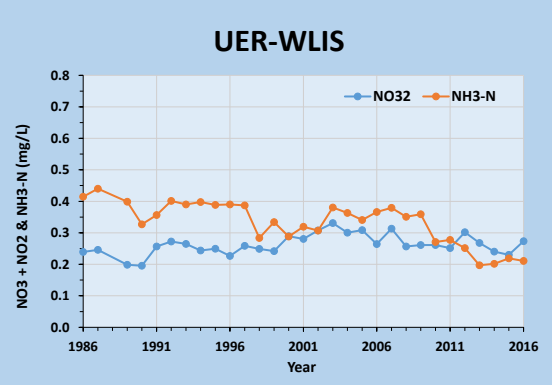
Nitrogen is the most common element in the Earth's atmosphere. It is a major building block of plant and animal proteins, as well as a key nutrient for all types of life. Because some nitrogen-based molecules have nutrient properties, they are commonly used as fertilizers. However, excess nitrogen in runoff and wastewater effluent can promote the growth of harmful algae and reduce levels of dissolved oxygen, limiting the ability of the waterbody to sustain a healthy ecosystem.

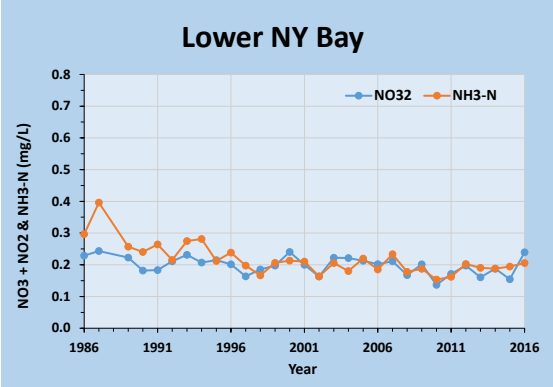
Nitrogen is not a pathogen and poses no threat to human health, so the wastewater treatment plants were not originally designed to remove it from effluent. In the 1980s, the City and environmental groups grew concerned about the impact of nitrogen on New York Harbor, especially as the total nitrogen discharged was expected to increase due to nationwide changes in sludge handling laws. In the early 1990s, the City developed a Nitrogen Control Action Plan to reduce the total nitrogen discharge into two ecologically sensitive waterbodies, the Upper East River and Jamaica Bay. Since 2002, the City has invested $1.2 billion in upgrades to wastewater treatment plants to remove nitrogen from plant effluent and has allocated $97 million over the next decade to construct additional nitrogen control facilities (estimates do not include costs for future chemical usage during operations).

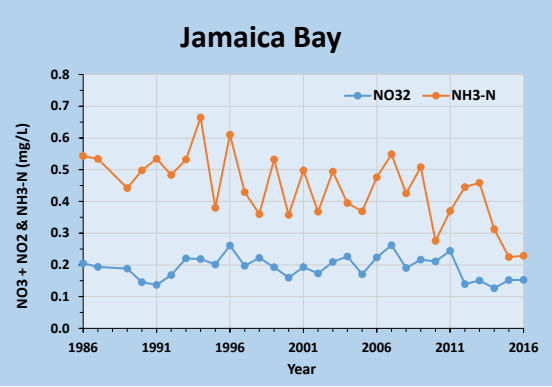
NYC DEP has initiated a comprehensive program to reduce nitrogen discharges to comply with maximum monthly and twelve month rolling average limits for Total Nitrogen, and to comply with the special conditions anticipated under the revised State Pollution Discharge Elimination System (SPDES) Permit. The ability to meet these goals is especially challenging at the WPCPs that perform centralized sludge dewatering operations. The nitrogen load, mostly in the form of ammonium, contributed from the centrate produced during sludge dewatering can account

for as much as 30% of the total nitrogen load on the secondary treatment system at the WPCP. The Upper and Lower East River final combined total nitrogen limit is 12-month rolling average limit of 44,325 lbs/day. This became effective January 1, 2017. The DEP met and continues to meet this limit. And the current limit for Jamaica Bay as of November 1, 2013 is a 12-month rolling average of 36,400 lbs/day Total Nitrogen. DEP is also meeting this limit.









Harbor-Wide Improvements

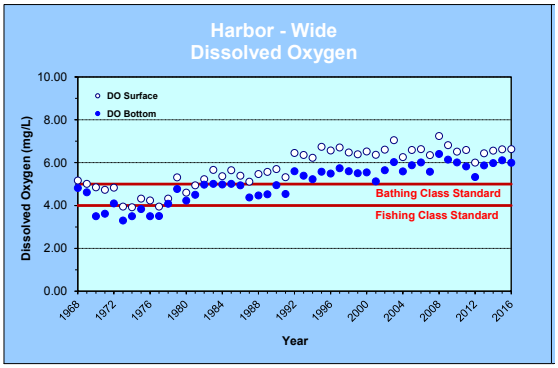
Water quality conditions in 2016 have remained stable or have improved slightly. Harbor-wide summer (May–Oct) average Dissolved Oxygen (DO) for both surface and bottom waters remained at record highs, 6.6 mg/L and 6.0 mg/L, respectively. Fecal Coliform (FC) and Enterococci summer geometric means were well below the New York State Department of Environmental Conservation Standards for bathing and all recreational use (200 cells/ 100mL for FC and 35 cells/100 mL for Entero). Chlorophyll 'a', Secchi Depth and Total Suspended Solids in the harbor have remained stable with slight fluctuations.

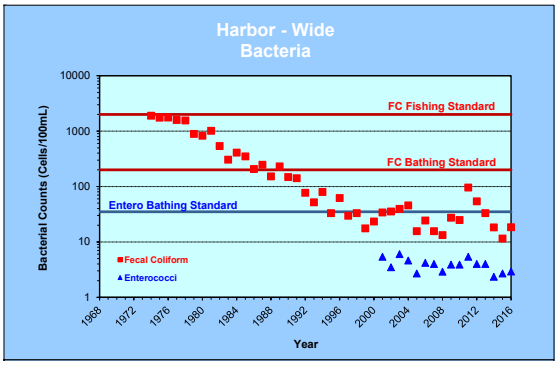
Since 1968, summer average dissolved oxygen (DO) in the 40 historical/open-water sites of the New York City harbor have increased from 5.0 to 6.5 mg/L for surface waters and from 4.5 to 6.0 mg/L for bottom waters. Average DO levels remained above the NYSDEC Bathing Standard of 5.0 mg/L for the past 25 years.

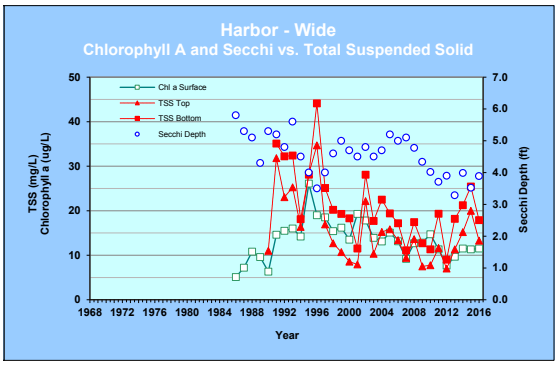
The harbor-wide summer geometric means for FC count has decreased and remained below the levels and within compliance with the NYSDEC Bathing Standard for the past three decades. All historical/open-water stations had average FC counts well below the Bathing Standard in 2016. Most high FC counts were found in tributaries located at Coney Island Creek (CIC2), Flushing Creek (FLC1) and Alley Creek CSO outfall (AC2). Short-term spikes do occur after rain events due to combined sewer overflow (CSO) discharges.

Over the last 16 years, harbor-wide Enterococcus summer geometric means have been relatively stable, with spikes similar in size and frequency to the fecal coliform levels. High summer average Enterotocci were found at Alley Creek mouth (AC1), Alley Creek CSO outfall (AC2) and 233rd street and Bronx River (BR1).

The NYC DEP's Long Term Control Plans (LTCP) are ongoing efforts to begin addressing the effects of CSOs and stormwater runoff. In the summer of 2016, the harbor-wide chlorophyll 'a' average remained at the same level as in 2014 and 2015; increased Secchi depth correlated with both the surface and bottom Total Suspended Solids' dropping. The Harbor Survey has begun its integration with the LTCPs.There were a total of 89 sites included in the survey for 2016.

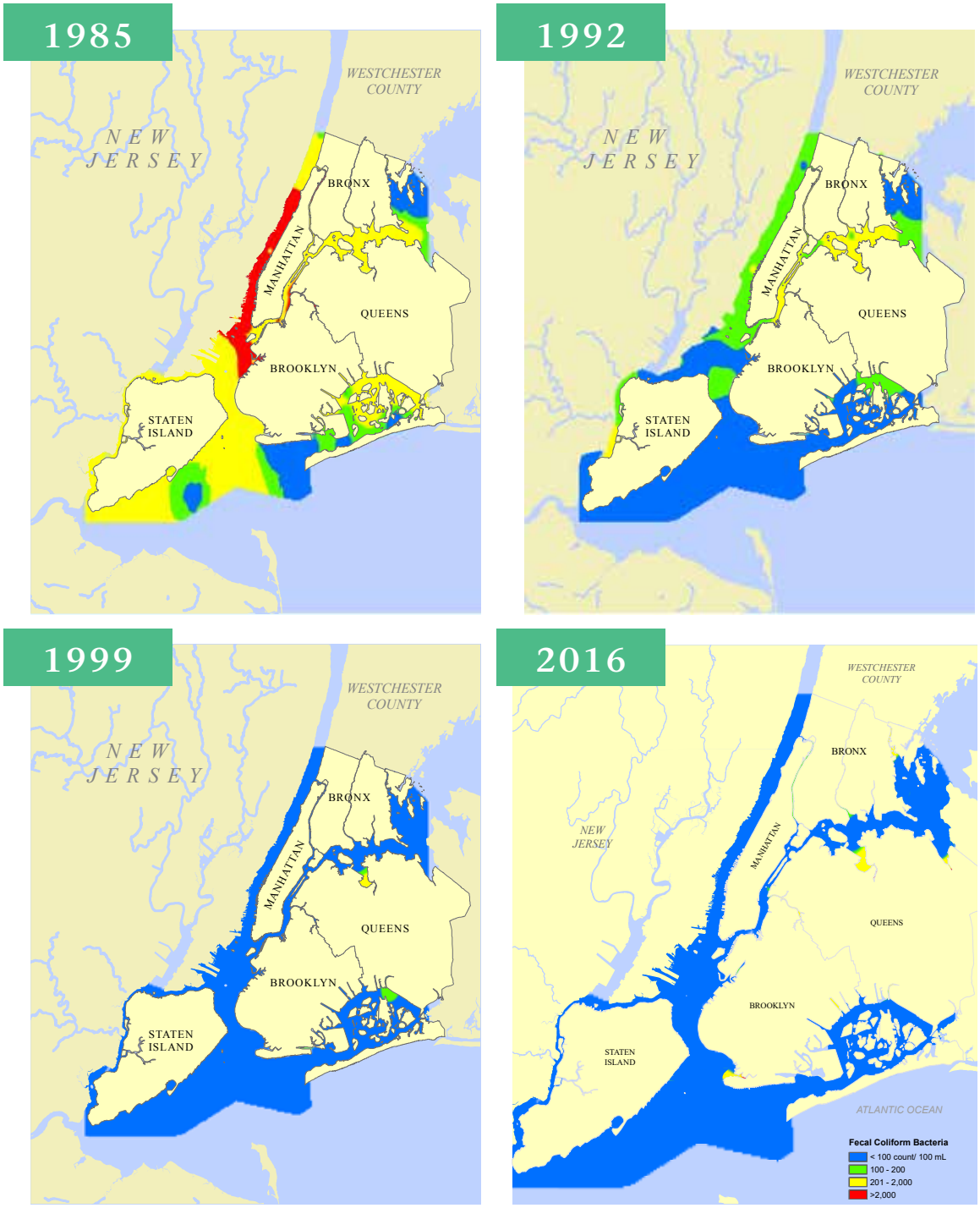






Harbor-Wide Water Quality Improvements Over Four Time Periods

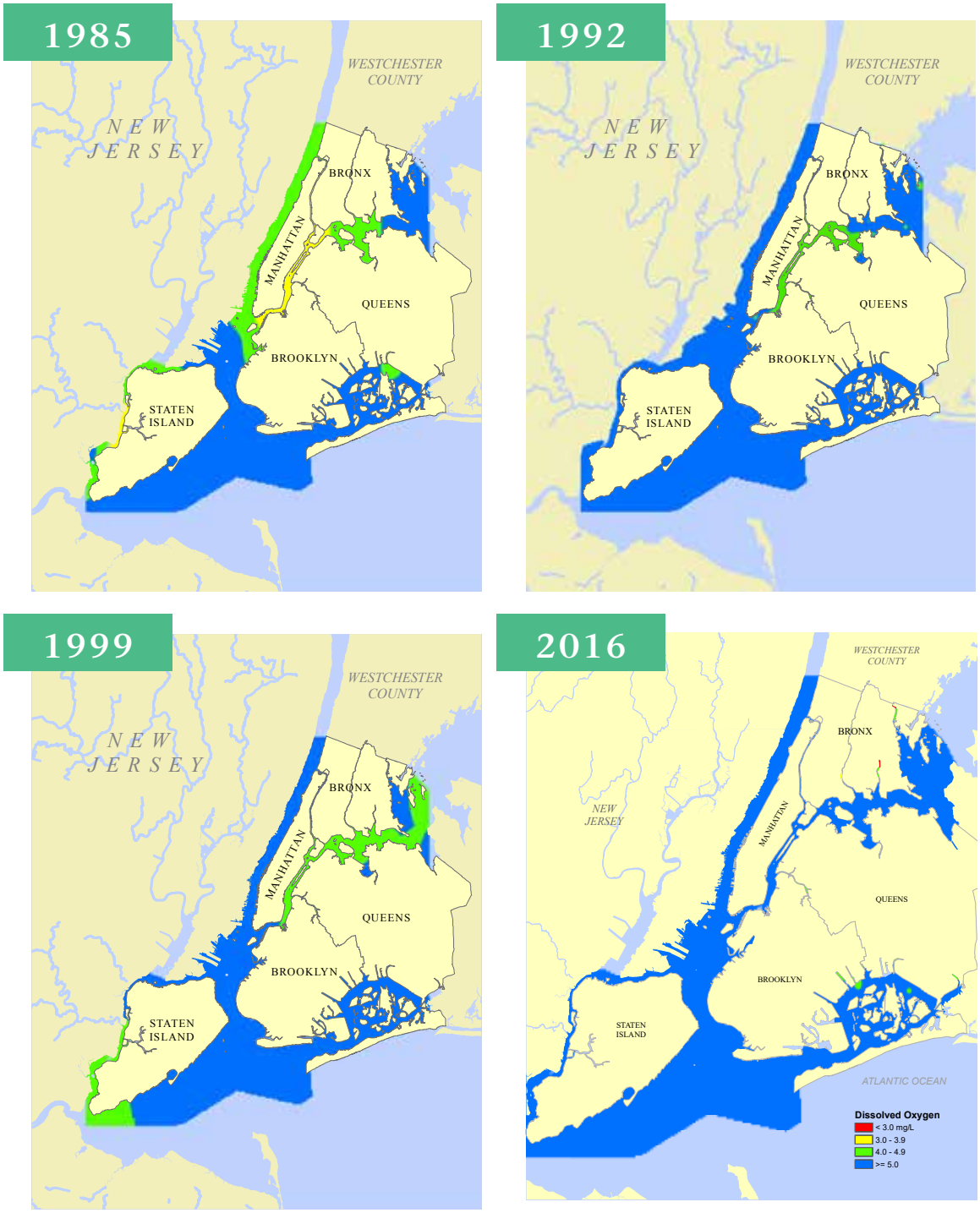
SUMMER GEOMETRIC MEANS FOR
FECAL COLIFORM IN SURFACE WATERS



NYS Best-Use Classifications: 200 FC/100 mL=SB (Bathing); 2000 FC/100 mL=I (Fishing).
NYC DOH requirements preclude bathing near sewer outfalls and where rainfall may substantially increase coliform levels.

Harbor-Wide Water Quality Improvements Over Four Time Periods

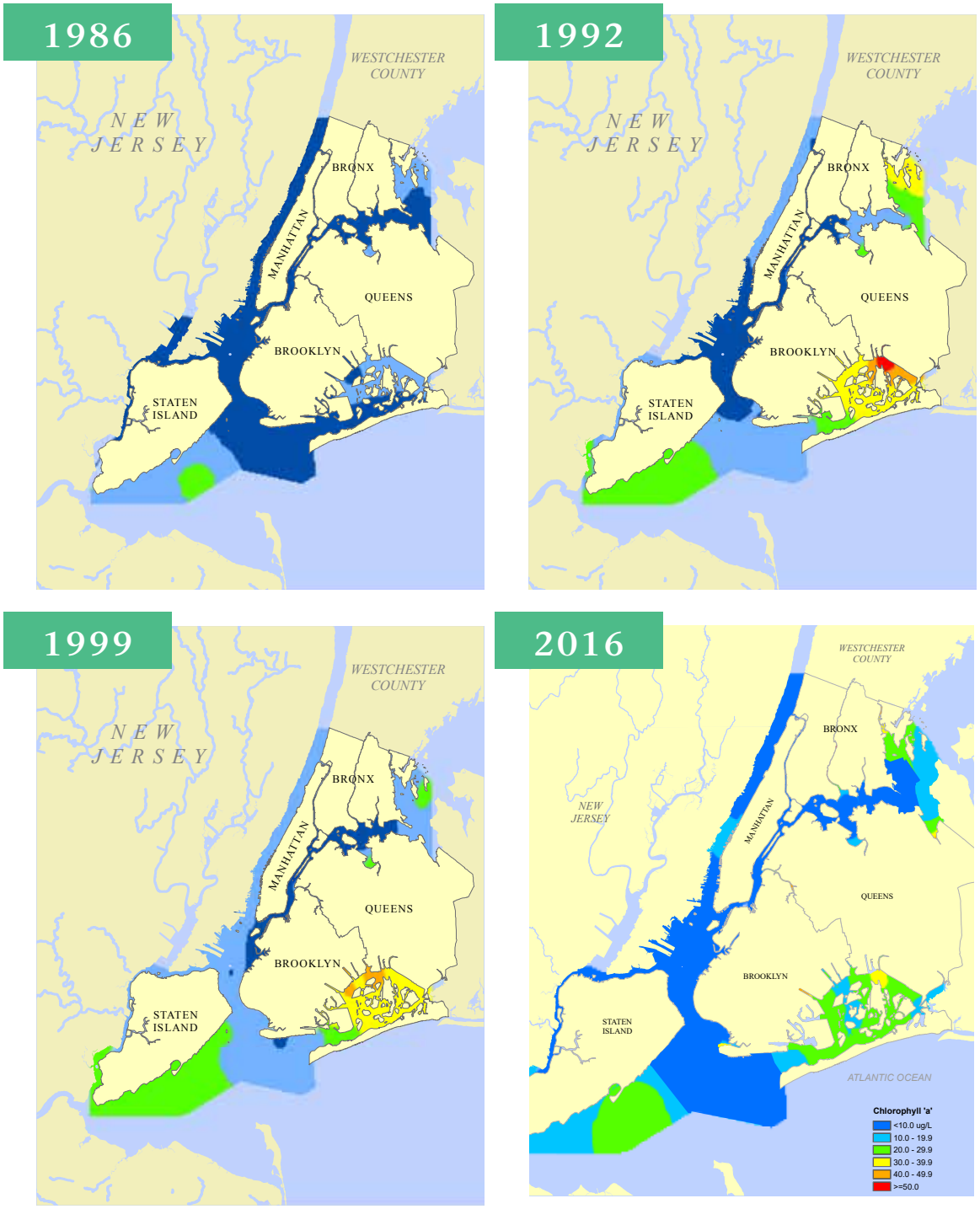
SUMMER AVERAGES FOR
DISSOLVED OXYGEN IN BOTTOM WATERS



NYS Best-Use Classifications: DO > 5 mg/L=SB (Bathing); DO > 4 mg/L=I (Fishing); DO > 3 mg/L=SD (Fish Survival)

Harbor-Wide Water Quality Improvements Over Four Time Periods

SUMMER AVERAGES FOR
CHLOROPHYLL 'a' IN SURFACE WATERS



Chlorophyll 'a' > 20 ug/L = Eutrophic conditions

Acknowledgments

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