Harbor-Wide
Water Quality Monitoring Report
for the New York-New Jersey Harbor Estuary

2011 Edition

New York - New Jersey Harbor Estuary Program

New Jersey Harbor Dischargers Group

New York City Department of Environmental Protection

www.nyc.gov/dep

Recreational boating has become very popular in the Estuary, as shown here in the East River (cover).
Photo courtesy of Rob Buchanan.

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June 2011

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EXECUTIVE SUMMARY

This report was developed under the auspices of the New York-New Jersey Harbor Estuary Program (HEP), and is the collaborative effort of many partners. This is the second report in what HEP envisions to be a series of water quality trend assessments for the New York-New Jersey Harbor Estuary.

The data analyzed for this report include fecal coliform, *Enterococcus*, and dissolved oxygen, and focus on the data collected in 2007-2009, similar to the last Harbor-wide Water Quality Report which reported data from years 2004-2006.

Long term monitoring programs, such as that of the City of New York, have documented dramatic improvements in water quality since implementation of the Clean Water Act began in the 1970s. With significant new investments in wastewater treatment and combined sewer infrastructure, HEP believes it is prudent to monitor the influence of these projects on ambient water quality, and to expand the monitoring to include all of the Harbor waters.

In conjunction with the monitoring and reporting contained within these pages, an assessment of pollutant load reductions that may be needed to further improve water quality in areas of the Harbor is also being undertaken under the auspices of HEP.

This Water Quality Report combines and analyzes data from New York (collected by the New York City Department of Environmental Protection (NYCDEP)) and the data from New Jersey (collected by the New Jersey Harbor Dischargers Group (NJHDG)). A continued collaboration over time will offer broader insights of the quality of the water in the NY/NJ Harbor. The total number of sampling sites in this combined Harbor region is sixty-eight (see Figure 1).

Fecal coliform bacteria are indicators of human and other warm blooded animal wastes in surface waters, and of the possible presence of pathogenic bacteria. The fecal coliform levels based on summer geometric means in the Harbor between 2006 and 2009 have shown some improvement (decrease in fecal coliform) in eighteen of the sample sites. Eight of the sample sites have shown an increase in fecal coliform during this timeframe. As expected, the fecal coliform levels in the New Jersey area (western) waters of the Harbor are generally higher than in the New York (eastern) waters, due to the influence of the heavily-urbanized tributaries. (See 2006 and 2009 Harbor-wide fecal coliform maps on page 14.)

Note that fecal coliform Water Quality Standards are based on a 30 day geometric mean of five or more samples, rather than seasonal geometric means (as presented in this report), and on a percentage of the data as compared to a target value. For all parameters presented in this report, data were collected, at most, weekly in the Harbor regions. Therefore, direct comparisons to the actual standards are not possible. Seasonal geometric means are used in this report as a basis for understanding long term trends (consistent with the 2004-2006 Harbor report).

Enterococcus bacteria are also indicators of pathogenic organisms from untreated human and animal wastes. The Harbor-wide map of the 2009 *Enterococcus* data (see page 13) shows a similar pattern to the fecal coliform map. The *Enterococcus* levels in the New Jersey area (western) waters of the Harbor are generally higher than in the New York (eastern) waters, again due to the influence of the tributaries. The trends for the summer geometric means for *Enterococcus* in the Harbor show that *Enterococcus* bacteria numbers continue to be low and stable. Improvement is shown in some regions where individual sampling site maximum values have decreased between the years 2007 and 2009. Note that *Enterococcus* values were generated only by NYCDEP through 2006. NJHDG initiated *Enterococcus* sampling in 2007, and so 2007-2009 is the only period of combined (NJHDG and NYCDEP) *Enterococcus* data. As with fecal coliform standards, *Enterococcus* Water Quality Standards are based on a 30 day geometric mean of five or more samples; and also on a single sample maximum. Therefore, comparison against the actual standards is not possible, but seasonal geometric means reflect long term trends and therefore can be used for comparison purposes. *Enterococci* are thought to have a greater correlation with swimming-associated gastrointestinal illness in both marine and fresh waters than other bacterial indicator organisms, and are more likely to survive for longer periods of time in saltwater.

EXECUTIVE SUMMARY

Bacterial trend data for years 2007-2009 for all regions remain below the best use primary contact standards, except for the fecal coliform average for the Newark Bay & Tributaries region for 2007. Note that there are only six years of data for the Newark Bay and Tributaries region, as compared to 35-50 years of data for all other regions. Therefore, evaluating trends for this region is not yet possible.

Dissolved oxygen is essential for all forms of aquatic life. The amount of oxygen that is dissolved in the water column dictates both the abundance and types of aquatic life that can survive and reproduce in a water body.

Dissolved oxygen levels throughout the Harbor continued an upward trend from 1970 to 2009. Based on seasonal averages, the Harbor generally is well oxygenated. Surface DO seasonal averages for sampling sites in 2009 were very similar to the 2006 values. Bottom DO seasonal averages improved at five of the sites (and decreased at two). The lowest DO seasonal summer averages (both surface and bottom values) continue to be from sites in the Hackensack River, the Western Long Island Sound and in Grassy Bay within Jamaica Bay. Note that dissolved oxygen Water Quality Standards are based either on daily averages or individual sampling events, rather than seasonal averages. Seasonal averages are used in this report as the basis for illustrating long term trends.

The water quality standard values for these parameters vary between the NY and NJ State standards and also between waterbody classifications. Additionally, there have been changes to the standards over time. For the sake of consistency we compared all of the data to “Best Use” Standards. These classifications and standards are for reference use only, and are not intended to indicate compliance status or to set policy. (See Tables 1 and 2; and Figures 2 and 8.)

Kayakers off Manhattan with Jersey City in the background. Photo courtesy of Stephen Stanne.

INTRODUCTION

The NY-NJ Harbor Estuary is a bi-state water-body of great importance to the well-being and economy of the 14 million people that live in close proximity to the Harbor. As the population of the region grew over the past two hundred years, the water quality of the estuary which surrounds the region began to suffer. Though great improvements in water quality resulted from the passage and implementation of the federal Clean Water Act in the 1970s, documentation of water quality trends were lacking for portions of the Harbor.

Fortunately, the City of New York has been collecting water quality information for the New York portion of the New York/New Jersey Harbor (the Harbor) for nearly 100 years. Over that time period the monitoring program in New York has been expanded and refined to reflect the City's commitment to monitoring and improving water quality in the Harbor and the associated tributaries. In 1992 the New Jersey Harbor Dischargers Group (NJHDG) was formed by the sewerage authorities which are responsible for the Publicly Owned Treatment Works (POTWs) discharging into the New Jersey portion of the Harbor and tributaries to the Harbor. NJHDG was formed to provide a unified voice from the POTW community in the arena of water quality improvement and regulatory development for the New Jersey portion of the Harbor. After a series of meetings coordinated by HEP and the IEC, NJHDG developed a long-term water quality monitoring program in 2003 for the New Jersey waters of the Harbor. The goal was for the new sampling program to be consistent with the City of New York's monitoring approach. Sampling was initiated in late 2003, and NJHDG plans to continue the program for the foreseeable future.

The parameters that are being monitored by New York City and NJHDG include fecal coliform bacteria, *Enterococcus* bacteria, dissolved oxygen (DO), temperature, salinity, pH, total suspended solids (TSS), carbonaceous biological oxygen demand (CBOD), dissolved organic carbon (DOC), nitrogen and phosphorus compounds, transparency (Secchi depth) and chlorophyll-*a*. All of these parameters have important implications regarding the overall water quality of the Harbor and the associated tributaries. This report is focused on three of those parameters: fecal coliform bacteria, *Enterococcus* bacteria and DO. These parameters are being featured in this report (as they were in the 2004-2006 report) because the bacterial indicators have the most direct impact on the recreational uses of the Harbor waters, and because adequate DO is critical to the survival, growth and reproduction of fish and other aquatic life.

The purpose of this report is to present the bacterial and DO information for the Harbor as a whole, and for the principal geographic regions of the Harbor. It is the intention of the New York-New Jersey Harbor Estuary Program (HEP) Office, and all its partners that a series of integrated (New York and New Jersey) water quality reports for the Harbor and its tributaries will be produced. Because this is the second of a series of anticipated reports involving data generated by NJHDG, there are limited trend data to report in certain areas of the Harbor. However, as more data are accumulated, it will be possible to evaluate and report on water quality trends over multi-year time frames throughout the Harbor.

The water use classifications and standards for interstate and shared waters vary. To provide a standardized view of the water quality data, comparisons are made to the highest potential use across the regions (on regional trend graphs) and to each of the standards (in the text).

The water quality standard values for these parameters vary between the NY and NJ state standards and also between waterbody classifications. Additionally, there have been changes to the standards over time. Prior to October 2006, waters classified as SE1 and FW2 were based on, in part, fecal coliform concentrations. The current standards for these waterbody classes are based on different bacteria as indicator organisms (*Enterococcus* for SE1 waters, and *E. coli* for FW2 waters). *E. coli* testing is being implemented for freshwater sites in 2011 by the NJHDG. For the sake of consistency, all of the data were compared to the "Best Use" Standards (fecal coliform: 30-day geometric mean $\leq$ 200 CFU/100mL; *Enterococci*: 30-day geometric mean $\leq$ 35 CFU/100mL; dissolved oxygen: DO $\geq$ 5.0 mg/L).

SURVEY REGIONS AND STATION SITES

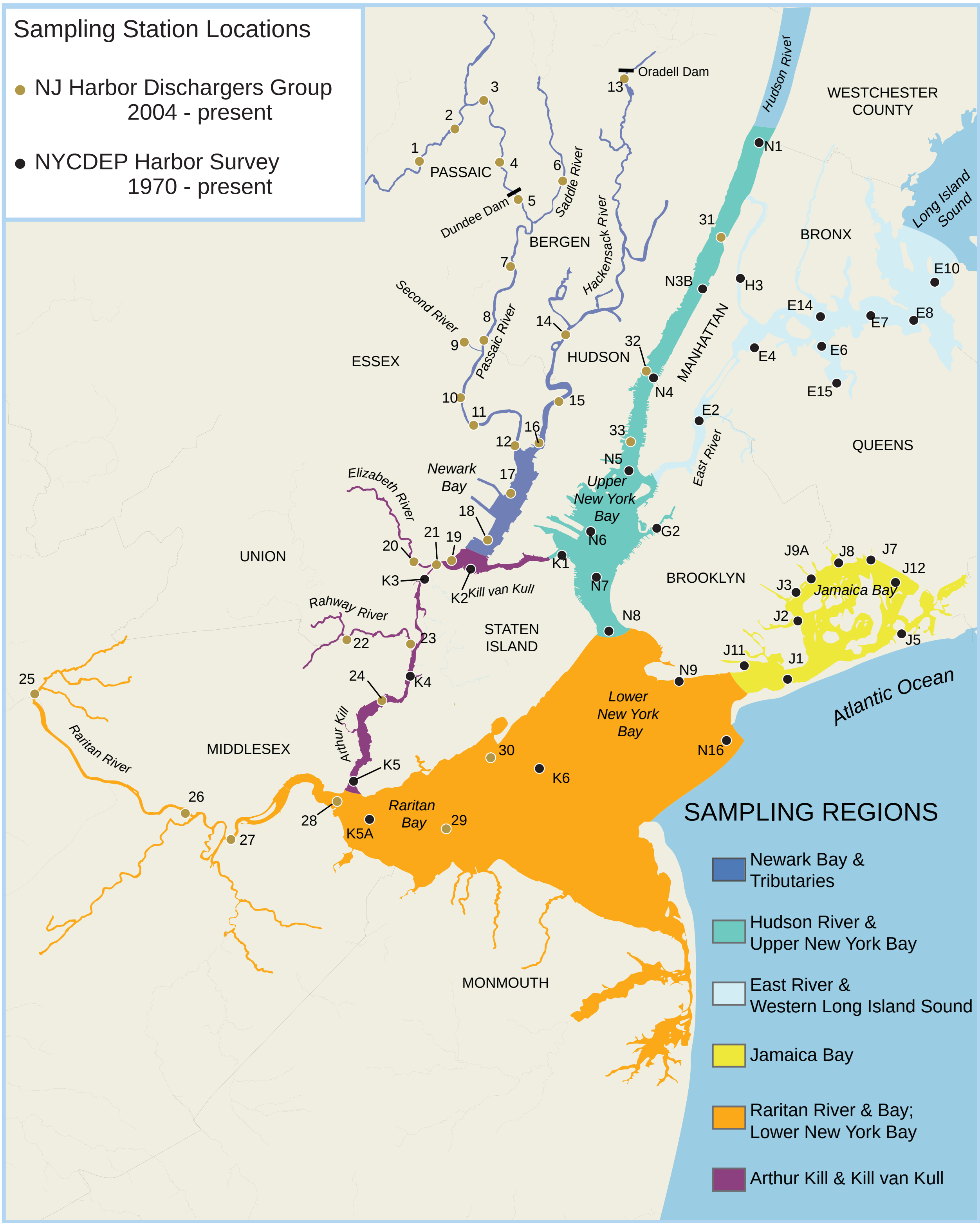


Figure 1.
Locations of the sampling stations for the Harbor-wide survey and the geographic sampling regions

MEASURED WATER QUALITY PARAMETERS

While many water quality parameters are important to accurately understand the overall condition of the Harbor and associated biota, this report is focusing on a subset of the parameters that are measured by the Harbor-wide survey. These parameters (dissolved oxygen, fecal coliform bacteria, and *Enterococcus* bacteria) are important to the health of biota living in the estuary, as well as to human use of the estuary for activities such as shellfishing and swimming. Other programs, such as the Contaminant Assessment and Reduction Project (CARP) and the Regional Monitoring and Assessment Program (REMAP) have collected information on toxic contaminants, which is presented elsewhere.

As noted in Figures 2 and 3, the specific water quality standards vary throughout the Harbor according to how the states classify those waters. For example, those areas designated for shellfishing and bathing have the most stringent standards, whereas areas designated for fish survival have the least stringent. See Tables 1 and 2 for more detail.

Dissolved Oxygen (DO)—Dissolved oxygen is essential for all forms of aquatic life. The amount of oxygen that is dissolved in the water column dictates both the abundance and types of aquatic life that can survive and reproduce in a water body. It is important to recognize that in most inshore marine waters (like the Harbor), the concentration of DO varies according to the time of day, tidal cycle, season and depth. Thus, each of these factors influence DO concentrations and the presence (or absence) and abundance of individual species. For the above reasons, the range of DO concentrations in a water body is commonly considered to be one of the key parameters that define the quality of a waterbody, and the types of species that reside in, and pass through, the waterbody.

Fecal Coliform Bacteria—Fecal coliform bacteria are indicators of human and other animal fecal wastes in surface waters, and of the possible presence of pathogenic (disease-producing) bacteria.

Enterococcus Bacteria—*Enterococcus* bacteria are also indicators of pathogenic organisms from untreated sewage. *Enterococcus* bacteria are commonly found in the feces of humans and other warm-blooded animals. Although some strains are ubiquitous and not pathogenic, their presence in water is an indication of fecal pollution and the possible presence of enteric pathogens. *Enterococcus* bacteria are much like coliform bacteria, but are thought to have a greater correlation with swimming-associated illnesses, and are more likely to survive in highly saline waters. The *Enterococcus* bacteria data in this report reflect only data gathered by NYCDEP until the year 2006. NJHDG began certified testing of *Enterococcus* samples in 2007, and those data are included in this report for years 2007-2009.

Sampling—Sampling locations were identified using latitude and longitude coordinates. Grab samples were collected approximately once per week during the summer season. Bacterial standards used for regulatory purposes are based on five samples in a 30 day period. One sample weekly, as is the case here, is not sufficient to make true comparisons between the data and the standards. These parameters may be variable throughout the water column. Shallow/flowing waters are usually well mixed, whereas still/deep waters usually have poorly mixed layers. For this reason samples were taken at both surface and bottom levels in the deeper regions, and at mid-depth in shallower waters. Deep water sites were accessed by boat, and water samples were collected one meter from the substrate (bottom samples) and one meter below the surface (surface samples). Shallow-water sites were sampled at mid-depth from the middle of the river channel and were accessed from bridges. Tidal conditions were not noted during sampling. For further details, reference the NJHDG Quality Assurance Project Plan (QAPP).

CURRENT WATERBODY CLASSIFICATIONS AND CRITERIA IN NEW YORK WATERS

SA Shellfish

The best use of Class SA waters are shellfishing for market purposes, primary and secondary contact recreation and fishing. These waters must be suitable for fish propagation and survival.

SB Bathing

The best use of Class SB waters are primary and secondary contact recreation and fishing. The waters must be suitable for fish propagation and survival.

SC Bathing/Fishing

The best use of Class SC waters is fishing. These waters must be suitable for fish propagation and survival. The water quality must be suitable for primary and secondary contact recreation, although other factors may limit the use of these purposes.

I Boating/Fishing

The best use of Class I waters are secondary contact recreation and fishing. These waters must be suitable for fish propagation and survival.

SD Fish Survival

The best use of Class SD waters is fishing. These waters must be suitable for fish survival. This classification may be given to those waters that (because of natural or man-made conditions), cannot meet the requirements for primary and secondary contact recreation and fish propagation.

Figure 2.
Waterbody classifications in New York waters

Table 1. New York Water Quality Standards

New York State Saline Surface Water Quality Criteria (from NYDEC Surface and Groundwater Quality Standards, 6NYCRR Part 703, unless otherwise noted)				
Water Class Use	**Fecal Coliform Bacteria[5] CFUs/100mL**	***Enterococcus***	**DO mg/L (2004-2005)**	**DO mg/L (Proposed 2006; adopted 2008)**
SA – Shellfish Site 30	Geomean*[2] ≤14; 90%≤49[1] Geomean*[3] ≤88; 90%≤300[1]	Geomean* ≤35[4]; Never >104[7]	Not less than 5.0 at any time	Not less than a daily average of 4.8, with excursions between 4.8 and 3.0 allowed for a period of time[6]
SB – Bathing Sites J1-J5, J7, J8, J9A, J11, J12, E7, E8, E10, N1, K5A, K6, N9, and N16	Geomean*[3] ≤200	Geomean*≤35[4]; Never >104[7]	Not less than 5.0 at any time	Not less than a daily average of 4.8, with excursions between 4.8 and 3.0 allowed for a period of time[6]
I – Fishing Sites E2, E4, E6, E14, E15, H3, K5, N3B, N4-N7, K1, N8, and 31-33	Geomean* ≤2000	--	Not less than 4.0 at any time	Not less than 4.0 at any time
SD – Fish Survival Sites G2, K2-K4, 19, 21, 23, and 24	--	--	Not less than 3.0 at any time	Not less than 3.0 at any time

* Geomean - Monthly geometric means based on a 30-day geometric mean of 5 or more samples
[1] Based on total number of samples in a 30-day period: 100 mL sample
[2] Based on National Shellfish Sanitation Program standards for shellfish water, direct harvest
[3] Based on National Shellfish Sanitation Program standards for shellfish waters, depuration
[4] Federal Register, 40 CFR 131, Water Quality Standards for Coastal and Great Lakes Recreational Waters; Final Rule. Nov. 16, 2004
[5] When disinfection is required or when determined necessary to protect human health
[6] See Amendment to 6 NYCRR Part 703 for DO limited period of time formula
[7] For beach notification purposes only
Note: There are currently no NJHDG or NYDEP SC sites

New Jersey State Surface Water Quality Criteria
(from NJDEP Surface Water Quality Standards, N.J.A.C. 7:9B, unless otherwise noted)

Water Class Use	Bacteria CFUs/100mL 8/2004 and 6/2005		Bacteria CFUs/100mL (10/2006)		DO mg/L
FW2-NT (Non-trout Fishing/ Propagation/Bathing) Sites 1-9, 25	Fecal coliform	Geomean* ≤200; 90%<400[1]	--	--	24hr Ave≥5.0[4]; Never <4.0
	Enterococci	Geomean* ≤33; Never >61	--	--	
	--	--	*E. coli*	Geomean* ≤126; Never >235[5]	
SE1 (Shellfish/Bathing) Sites 13, 26-27	Fecal coliform	Geomean* ≤200; 90%<400[1]	--	--	24hr Ave≥5.0[4]; Never <4.0
	Enterococci	Geomean* ≤35; Never >104	*Enterococci*	Geomean* ≤35; Never >104[5]	
SE2 (Fishing/Fish Propagation) Sites 14, 15, 31-33, K1, K5, N3B, N4-N6	Fecal coliform	Geomean* ≤770	Fecal coliform	Geomean* ≤770;	Never <4.0
SE3 (Fishing/Fish Migration) Sites 10-12, 16-24, K2-K4	Fecal coliform	Geomean* ≤1500	Fecal coliform	Geomean* ≤1500;	Never <3.0
SE1 (Shellfish/Bathing) Sites 28-29, K5A	Fecal[2] coliform	Geomean* ≤14; 90%≤49[1]	Fecal[2] coliform	Geomean* ≤14; 90% ≤49[1]	24hr Ave≥5.0[4] Never <4.0
	Fecal[3] coliform	Geomean* ≤88; 90%≤300[1]	Fecal[3] coliform	Geomean* ≤88; 90%≤300[1]	
	Enterococci	Geomean* ≤35; Never >104	*Enterococci*	Geomean* ≤35; Never >104[5]	

* Geomean - Monthly geometric means based on a 30-day geometric mean of 5 or more samples
[1] Based on total number of samples in a 30-day period: 100 mL sample
[2] Based on National Shellfish Sanitation Program standards for shellfish water, direct harvest
[3] Based on National Shellfish Sanitation Program standards for shellfish waters, depuration
[4] Supersaturated DO values must be expressed as their corresponding 100% saturation values for purposes of calculating 24-hr. averages
[5] For beach notification purposes only
Note: There are currently no NJHDG or NYDEP SC sites

Table 2. New Jersey Water Quality Standards

CURRENT WATERBODY CLASSIFICATIONS AND CRITERIA IN NEW JERSEY WATERS

SE1 Shellfish/Bathing

Shellfish harvesting; maintenance, migration,and propagation of the natural and established biota; primary and secondary contact recreation; and any other reasonable uses.

SE2 Fishing/Fish Propagation

Maintenance; migration and propagation of the natural and established biota; migration of diadromous fish; maintenance of wildlife; secondary contact recreation; and any other reasonable uses.

SE3 Fishing/Fish Migration

Secondary contact recreation; maintenance and migration of fish populations; migration of diadromous fish; maintenance of wildlife; any other reasonable uses.

SC Shellfish/Bathing/Fishing

Shellfish harvesting; primary and secondary contact recreation; maintenance, migration and propagation of the natural and established biota; and any other reasonable uses.

FW2-NT Fishing/Fish Propagation/Bathing

Maintenance; migration and propagation of the natural and established biota; primary and secondary contact recreation; industrial and agricultural water supply; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses.

Figure 3.
Waterbody classifications in New Jersey waters

FACTORS THAT AFFECT WATER QUALITY IN THE HARBOR

POINT SOURCES OF POLLUTION

Publicly Owned Treatment Works

The most commonly recognized point source discharges to the Harbor are the municipal wastewater treatment plants or Publicly Owned Treatment Works (POTWs), 14 of which are in New York City, and 11 of which are in New Jersey. In addition to POTW point source discharges to the Harbor, there are combined sewer overflow (CSO) discharges and stormwater outfalls (SWOs) discharges (discussed below). (See Figure 4.)

New York City's 14 POTWs treat the industrial, commercial and residential sewage from the City. The infrastructure includes over 6,000 miles of collection system pipes, 130,000 catch basins, and 5,000 seepage basins. The total amount of sewage treated is over one billion gallons per day (BGD). In contrast to New York where there is a single municipal authority responsible for the POTWs, there are 11 New Jersey POTWs discharging to the Harbor, collectively treating 500 MGD of residential and industrial/commercial sewage from 175 separate communities in the vicinity of the Harbor.

All of the wastewater treated by each of these New York and New Jersey POTWs receives both primary and secondary treatment. Primary treatment refers to the removal of coarse material by screening and settling, while secondary treatment refers to the biological and chemical removal of organic matter, followed by final clarification. Finally the wastewater is disinfected with chlorine to remove pathogenic bacteria before being discharged to the Harbor.

Combined Sewer Overflows/Stormwater Outfalls

There are two basic types of sewer systems that are used to accommodate wet weather flows: combined sewer systems (CSOs) and separate sewer systems.

In the case of combined sewer systems, rainfall and/or snowmelt combined with sanitary flows may exceed the capacity of either the sewer pipes or the POTWs (or both). In order to prevent flooding in streets and houses and operational problems at the treatment plants, combined sewer systems are designed to release the excess wet weather flows to the Harbor waters through CSOs.

In contrast to combined sewer systems, separate sewer systems are designed to address wet weather flows by segregating the sanitary and wet weather flows. Thus, when it is raining and/or snow is melting, the stormwater flows are collected in a series of separate sewer lines (which are the responsibility of the municipalities), and discharged directly to the waters of the Harbor through stormwater outfalls (SWO)s. Therefore, the sanitary flows to the POTWs remain largely unaffected (except for infiltration) during wet weather events. The entirely separate sewer systems in New Jersey include Linden-Roselle, Rahway Valley, Joint Meeting, North Hudson, Edgewater, Secaucus and West New York.

CSO and SWO discharges contain stormwater, and therefore can convey large quantities of floatable materials into the Harbor waters. Floatable debris, which can contribute to beach closures, can also interfere with navigation, have a negative effect on the well being of wildlife, and is aesthetically undesirable. All New Jersey CSO permittees must capture and remove solids/floatables which cannot pass through a one- half inch bar screen. In the NY/NJ Harbor Estuary Complex, 83% of New Jersey's CSOs have long- term CSO solids/floatable control measures constructed and operational. To help measure the effectiveness of the multiple control programs and to target improvements to priority waterbodies, New York City is implementing a Harbor-wide floatables monitoring program, which complements the City's longstanding street litter cleanliness rating system to track landside debris. Finally, the City conducts multiple public education programs and clean-up programs that address floatables control.

Figure 4.
NY-NJ Harbor areas CSOs, POTWs, bathing beaches and shellfishing regions

*Open to commercial shellfish harvest for depuration

FACTORS THAT AFFECT WATER QUALITY IN THE HARBOR

Both CSOs and SWOs contribute to increased pathogen concentrations in the Harbor during and after wet weather events. The States of both New York and New Jersey have programs in place to decrease the impacts of CSOs on water quality throughout the Harbor.

In both New York and New Jersey, programs are in place to reduce the abundance of floatable materials discharged from CSOs. In New York City, 70-80 percent of the sewer system was built as a combined system. Among the NJHDG members, the PVSC, BCUA, North Bergen and MCUA systems were designed as either entirely or partially combined sewer systems.

NON-POINT SOURCES OF POLLUTION

Non-point source pollutants enter the Harbor via diffuse sources (other than discharge pipes) during rainfall and snowmelt events. Residential and commercial properties, roadways and parking lots, agricultural operations, faulty septic systems, construction sites and direct deposition from the atmosphere are all examples of the broad source category referred to as non-point source pollution. Fine and coarse grained sediments, fertilizers, pathogens (bacteria and viruses), salt, oils and grease, high molecular weight organic compounds and heavy metals are widely-recognized as non-point source pollutants.

Many of the pollutants that enter the Harbor as non-point source pollutants originally are transported to the Harbor watershed via atmospheric deposition (both wet and dry). Some of these pollutants are from regional sources, while others are deposited as a consequence of long-range atmospheric transport.

Catch and release recreational fishing has become popular once again in the Harbor. Photo courtesy of Ellen McCarthy.

A PROGRAM TO EVALUATE AND IMPROVE WATER QUALITY IN THE HARBOR

The New York/New Jersey Harbor Estuary Program (HEP), EPA Region II, and the States of New Jersey and New York, are in the process of implementing a comprehensive program to assess and improve water quality throughout the Harbor. The program is a component of a national effort to comply with the "fishable/swimmable" goal of the federal Clean Water Act. In an effort to achieve that goal, EPA, the states, dischargers and other stakeholders, under the auspices of HEP, are in the process of developing "total maximum daily loads" (TMDLs) for pathogens (bacteria), oxygen-demanding substances (nutrients and organic matter), and toxics. This process is being coordinated through multi-stakeholder work groups for pathogens, nutrients, and toxics. In order to develop the total maximum daily loads for the various substances, a series of computer-based water quality models has been developed. These predictive water quality models, which are state-of-the-art mathematical models, take into consideration the existing water and sediment quality characteristics, as well as the current and anticipated future point and non-point source discharges to the Harbor to determine the types and magnitudes of pollutant load reductions that will be required to achieve state water quality standards.

Currently the Pathogens, Nutrients and Toxics Work Groups are evaluating the model products, and will ultimately be responsible for determining the pollutant load reduction goals that will be implemented through the New York and New Jersey National Pollutant Discharge Elimination System (NPDES) permitting programs. Most of the water quality modeling/projections have been completed, and HEP and the States of New York and New Jersey are considering implementation options.

The data provided in this report are not currently used in modeling water quality. At this time, these data are only being used to assess long-term water quality trends.

With improved water quality, public access, such as at this site on the Hackensack River, has become very popular. Photo courtesy of Hackensack Riverkeeper.

HARBOR-WIDE WATER QUALITY TRENDS

HARBOR-WIDE BACTERIA

The fecal coliform levels based on the summer geometric means in the Harbor between years 2006 and 2009 have shown some improvement (decrease in fecal coliform) at 18 of the 68 sampling sites. Eight of the sample sites show an increase in fecal coliform values during this timeframe. (See 2006 and 2009 Harbor-wide fecal coliform maps, Figures 6 and 7.) The Harbor-wide average fecal coliform value decreased from 106 CFUs/100 mL in 2006 to 55 in 2009. Long term trends show decreasing levels of fecal coliform in all regions.

Enterococcus bacteria results for the Harbor based on the summer geometric means have increased slightly between years 2006 and 2009. The Harbor-wide average *Enterococcus* value increased from 6 CFUs/100 mL in 2006 to 11 in 2009.

The regional long term trends show mostly steady or slightly decreasing *Enterococcus* values across the Harbor, except for the Raritan River – Raritan Bay and the Arthur Kill – Kill Van Kull. These two regions show slightly increasing trends from 2001 to 2009. Despite the increasing trends, the average seasonal values for these regions remain well below the *Enterococcus* Best Use Standard.

It is encouraging to note that the seasonal summer averages for all but one region remain well below the *Enterococcus* Best Use Standard. The Newark Bay and Tributary region is the exception to this with its regional yearly averages above the Best Use Standard (see Figure 5, *Enterococcus* Seasonal Geometric Means for 2009). It is important to note, however, that NJHDG began sampling for *Enterococcus* in 2007, and the *Enterococcus* data has shown decreasing levels in this region between 2008 and 2009.

As expected, the fecal coliform and *Enterococci* levels in the New Jersey area (western) waters of the Harbor are generally higher than in the New York (eastern) waters, particularly in the tributaries. Since there are only fecal coliform data for years 2004-2009, and *Enterococcus* data for years 2007-2009 for the New Jersey portion of the Harbor, it is not feasible to evaluate historical trends in the New Jersey waters. However, the NJHDG water quality monitoring program is ongoing, and future data will provide for long term trend analyses of water quality for the entire NY/NJ Harbor.

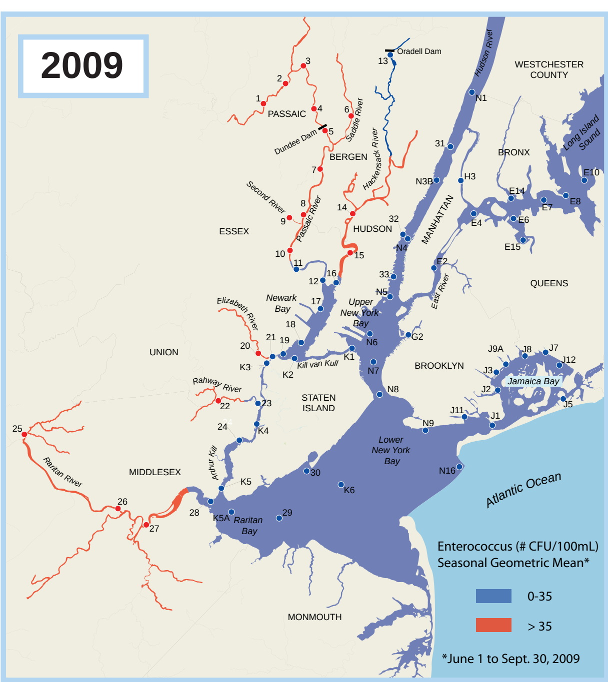


Figure 5.
Map of Harbor-wide *Enterococcus* 2009

HARBOR-WIDE WATER QUALITY TRENDS

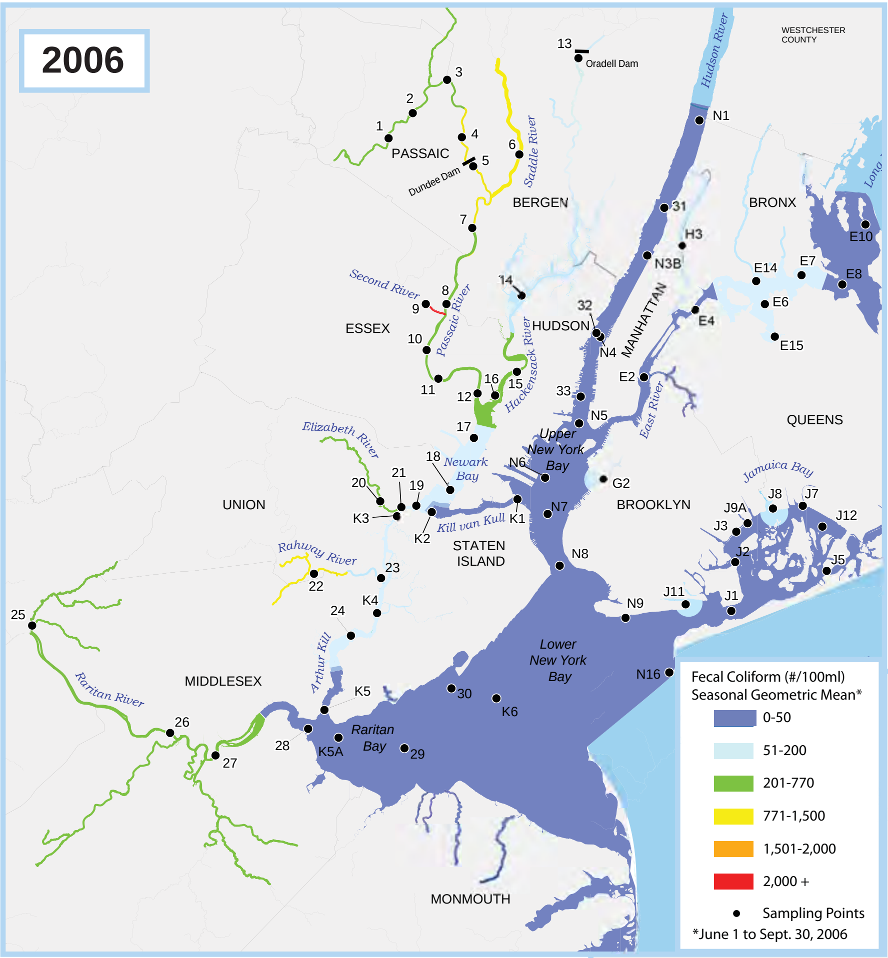


Figure 6.
Map of Harbor-wide fecal coliform 2006

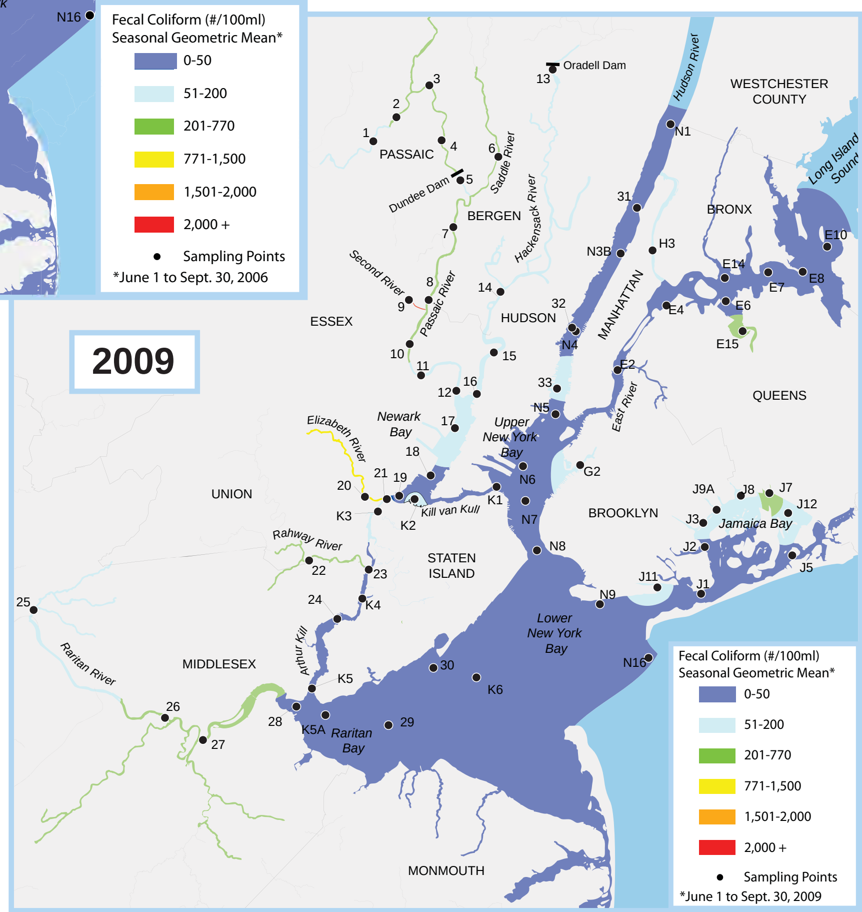


Figure 7.
Map of Harbor-wide fecal coliform 2009

HARBOR-WIDE WATER QUALITY TRENDS

HARBOR-WIDE BACTERIA

It is interesting to note that the two sites with the highest fecal coliform concentrations (Second River and Elizabeth River) are in areas with separate sewer systems, and therefore are not under the influence of wet weather discharges from combined sewer overflows. However, these areas do have SWOs, and would therefore be affected by wet weather runoff.

The average 2007 through 2009 Harbor-wide bacterial results (from both NYCDEP and NJHDG) were low in relation to most of the water quality standards, and showed modest fluctuations from year-to-year. The bacteria results, reported in colony forming units (CFUs), are the geometric means of the summer season data (June 1 through September 30). Samples were grab samples collected approximately once per week throughout the season.

Precipitation levels in the Harbor were significantly higher during years 2007-2009 as compared to years 2004-2006. Higher *Enterococcus* seasonal average values corresponded with the increase in precipitation amounts, however fecal coliform seasonal average values did not (see Table 3). In exploring precipitation trends in the Harbor area, no reason is apparent at this time for the lower fecal coliform concentrations that were observed during the times of higher precipitation from 2007-2009.

Table 3. Comparison data for bacteria and precipitation

Harbor-wide Fecal Coliform and *Enterococcus* Bacteria Surface Seasonal Average and Precipitation Data								
	Units	**Data Span**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Fecal coliform[2]	(CFUs/100mL)	June 1 - Sept. 30	107	48	106	43	41	55
Enterococcus Bacteria	(CFUs/100mL)	June 1 - Sept. 30	6[1]	3[1]	6[1]	12[2]	8[2]	11[2]
Harbor Seasonal Precipitation[3]	inches	June 1 - Sept. 30	12.49	8.13	23.07	24.45	24.05	29.36
Harbor Annual Precipitation[3]	inches	Jan. 1 - Dec. 31	32.78	36.93	59.40	66.11	60.13	63.16
[1]NYCDEP data only, [2]Combined NYCDEP and NJHDG data (bacteria data values are the geometric means from June 1 - Sept. 30), [3]PVSC precipitation data (at the plant)								

HARBOR-WIDE DISSOLVED OXYGEN

Dissolved oxygen levels in the Harbor were reasonably consistent throughout the 2007 to 2009 monitoring period, and showed apparent slight improvements since 2004 (see Table 4).

Areas of lowest DO in the Harbor were observed in the Upper East River/Western Long Island Sound region, Jamaica Bay, and the Hackensack River, a tributary to Newark Bay. Grab samples were collected approximately once weekly throughout the summer season (June 1 through September 30). Figures 9 and 10 show 2009 average summer levels for surface and bottom dissolved oxygen. Figures 11 and 12 show surface and bottom dissolved oxygen summer minimum levels for 2009.

Comparison of dissolved oxygen surface seasonal averages from 2006 to 2009 showed improvement of DO at one sampling site (site 15), and a decrease at one site (site 13). (See Figures 8 and 11). Comparison of dissolved oxygen bottom seasonal average data showed improvement at 5 sites (two in the Hackensack River, two in the Upper East River, and one in Jamaica Bay), and a decrease at 2 sites (Oradell Dam, site 13; and site E14 in the Upper East River).

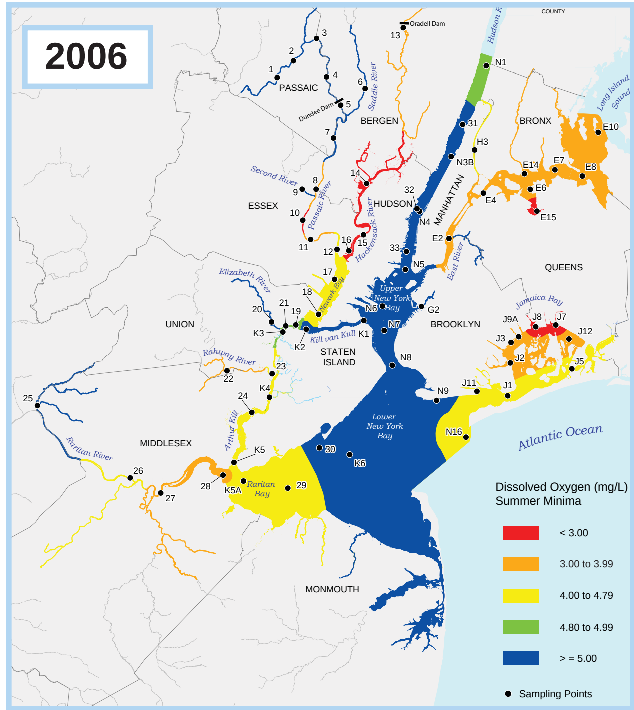


Figure 8.
2006 Minimum DO levels in surface waters

All regional surface seasonal averages showed long term upward trends, despite small fluctuations from year to year. All regional surface DO averages have been above the DO Best Use Standard since 2004 when the East River – Western Long Island Sound region dipped below the current standard. This DO bottom seasonal summer average for this same region has increased to above 5.0 mg/L for the first time in 10 years.

Table 4. Comparison data for surface and bottom DO for 2004 through 2009 summer seasons

Harbor-wide Surface and Bottom Dissolved Oxygen Seasonal Average						
	2004	2005	2006	2007	2008	2009
DO Surface mg/L	6.4	6.4	6.8	6.6	6.9	7.0
DO Bottom mg/L	5.5	5.6	5.9	5.6	6.1	6.1
All data are combined NYCDEP and NJHDG arithmetic means from June 1 - Sept. 30						

HARBOR-WIDE DISSOLVED OXYGEN

2009 SUMMER AVERAGE
Dissolved Oxygen in Surface and Bottom Waters

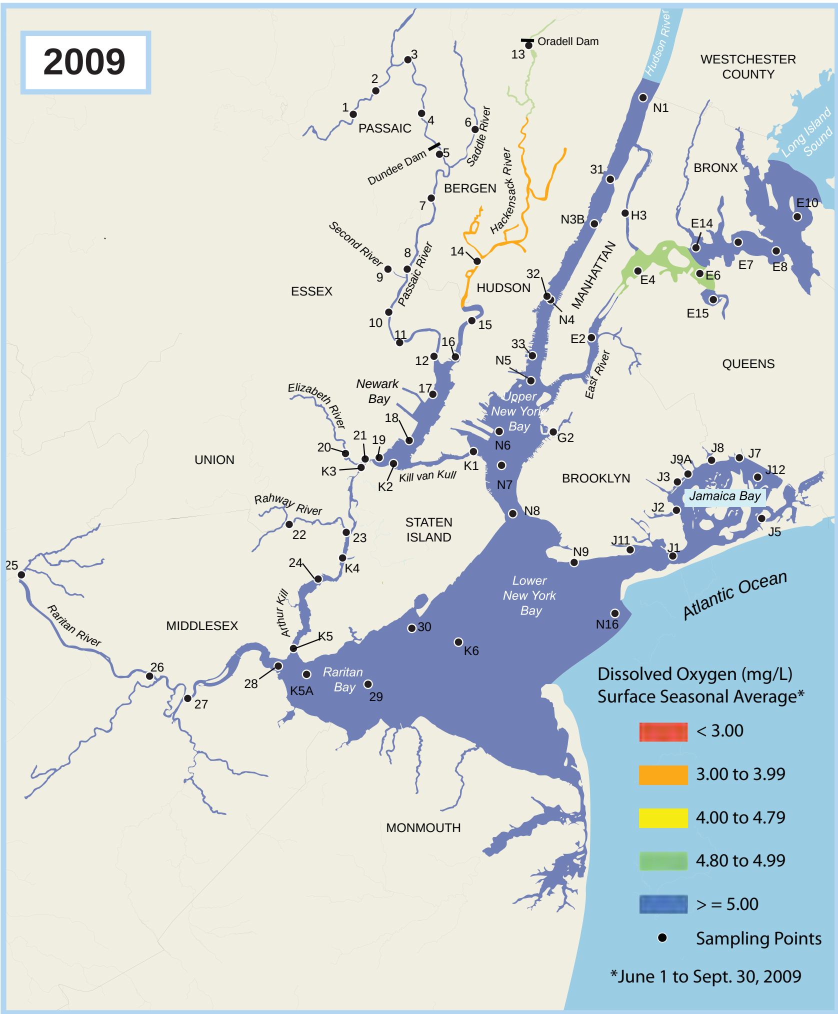


Figure 9.
Average DO levels in surface waters

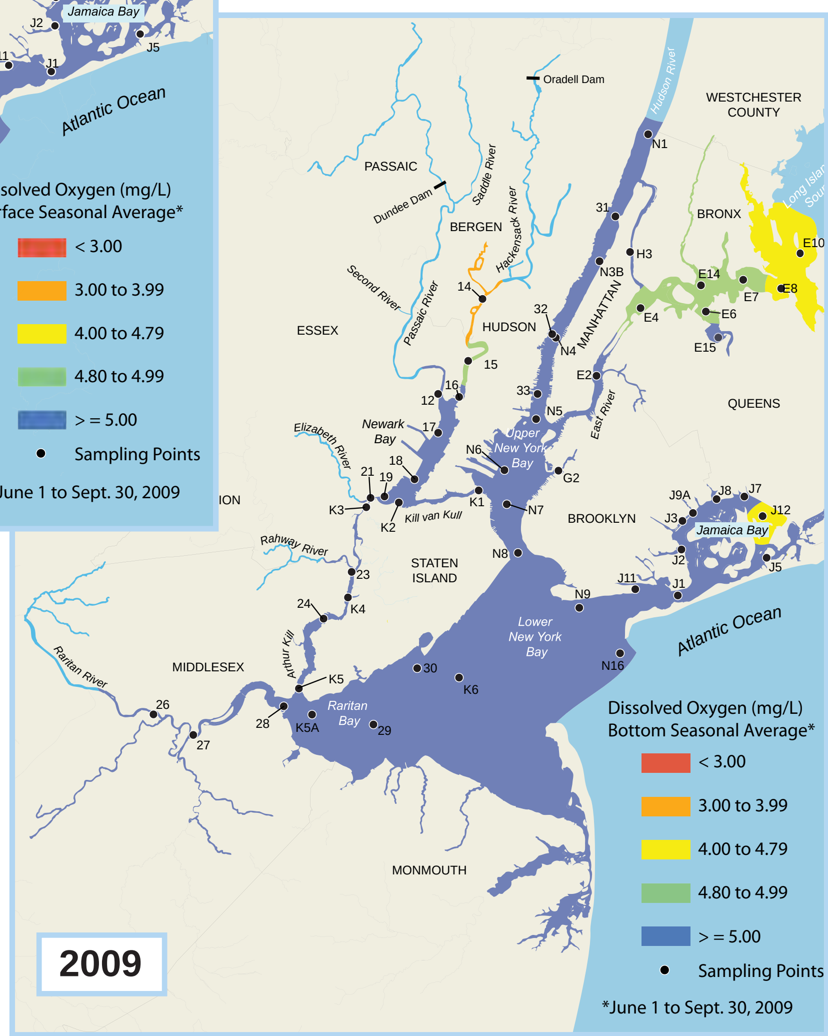


Figure 10.
Average DO levels in bottom waters

HARBOR-WIDE DISSOLVED OXYGEN

2009 SUMMER MINIMUM
Dissolved Oxygen in Surface and Bottom Waters

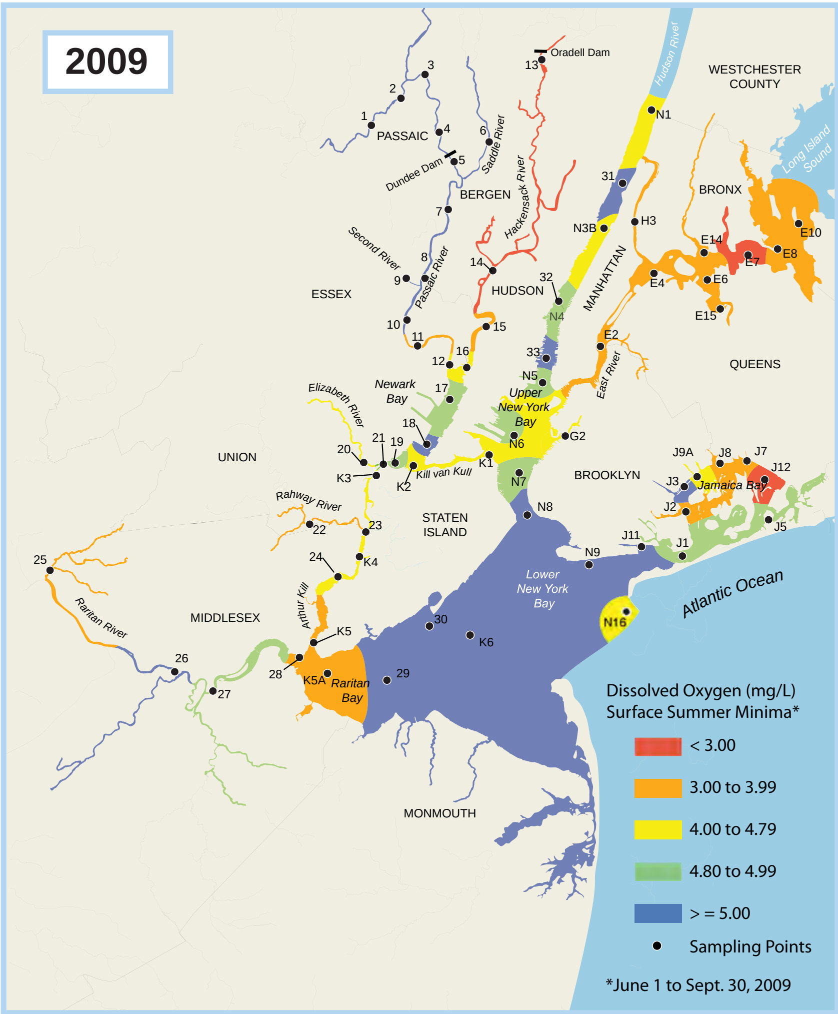


Figure 11.
Minimum DO levels in surface waters

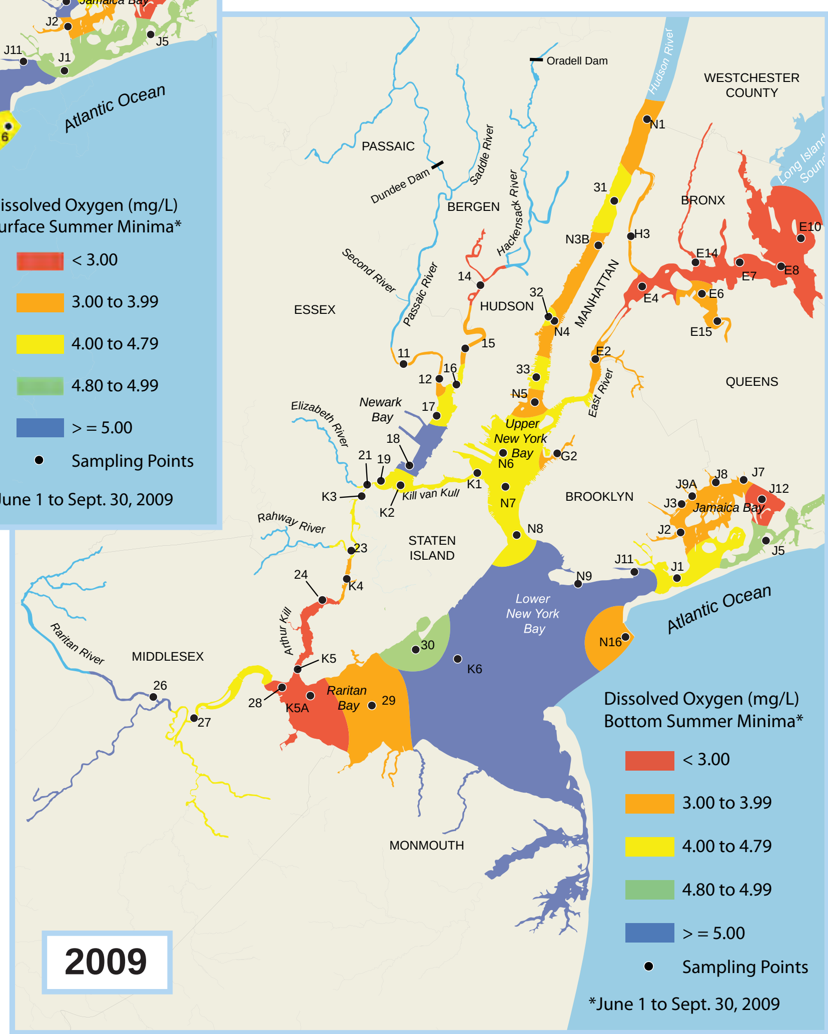


Figure 12.
Minimum DO levels in bottom waters

2009 REGIONAL SUMMARIES

Water Quality Standards (WQS): Throughout the regional summaries, details are given primarily for the 2009 data, as these are the most recent and provide focus. For perspective, sampling site-specific data are compared to the best use standards. All trends discussed in the text are base on the visual analyses of trend lines generated by Microsoft Excel.

However, it is important to note that the fecal coliform and *Enterococcus* Water Quality Standards are based on a 30-day geometric mean with a minimum of five samples, rather than the seasonal (June 1 - Sept. 30) geometric means presented throughout this report. Sampling were collected approximately weekly throughout the summer season, rarely providing five samples in a 30-day period, as specified by the WQS. Similarly, seasonal averages for dissolved oxygen are presented in this report to provide consistency when comparing trend data with past analyses. Samples (grab samples) were generally collected and analyzed weekly throughout the summer season (June 1 - Sept. 30). Note that DO water quality standards are based on daily averages, individual sampling events, and/or limited periods of time. Therefore, the data presented in this report cannot be used to evaluate compliance with water quality standards.

JAMAICA BAY

Jamaica Bay is located at the southwestern end of Long Island. This urban, estuarine embayment and national park consists primarily of tidal wetlands, upland areas and approximately 20 square miles of 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.

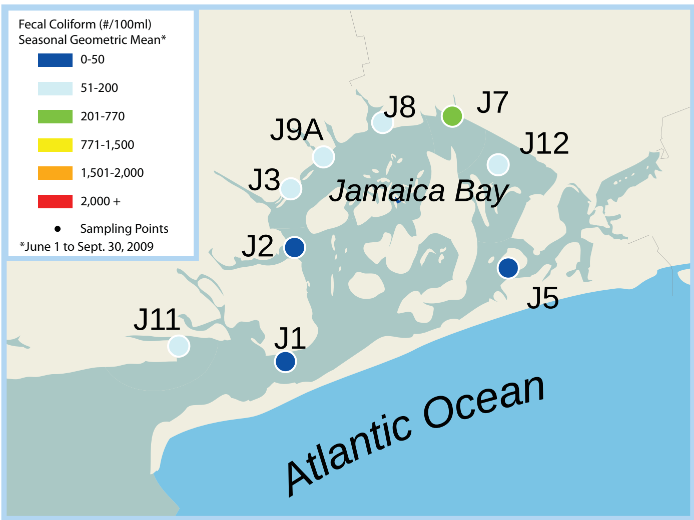
Jamaica Bay joins the New York Harbor to the west via the Rockaway Inlet at the tip of Breezy Point. The Bay includes the Rockaway Peninsula, which forms the southern limit of the Bay, and separates Jamaica Bay from the Atlantic Ocean.

BACTERIA

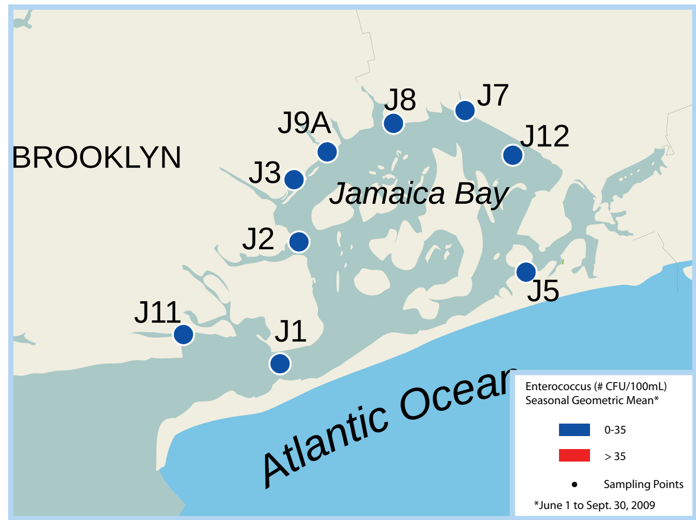
The Jamaica Bay regional fecal coliform summer geometric means ranged from 24 CFUs/100mL to 64 CFUs/100mL between years 2007 and 2009. In 2009, sampling site J7 had the highest summer geometric mean of this region at 402 CFUs/100mL. In 2009 the individual sampling site maximums ranged from 1180 to 2000, except for J5, with its maximum value for the season of 72 CFU/100mL. Despite the recent increase in the region’s seasonal average (64 CFUs is the highest seasonal average in this region since 1994), the region continues to show a decreasing long term trend.

Enterococci levels for the entire Jamaica Bay region were found to be stable, with regional summer geometric averages of 2 to 3 CFUs/100mL for each of the nine years sampled. Seasonal means of individual sampling sites ranged from 2 to 8 CFUs/100mL. Individual sampling site maximums ranged from 6 (site J1) to 1500 CFU/100mL (site J8). The region's seasonal averages remained steady, with a very slight downward trend.

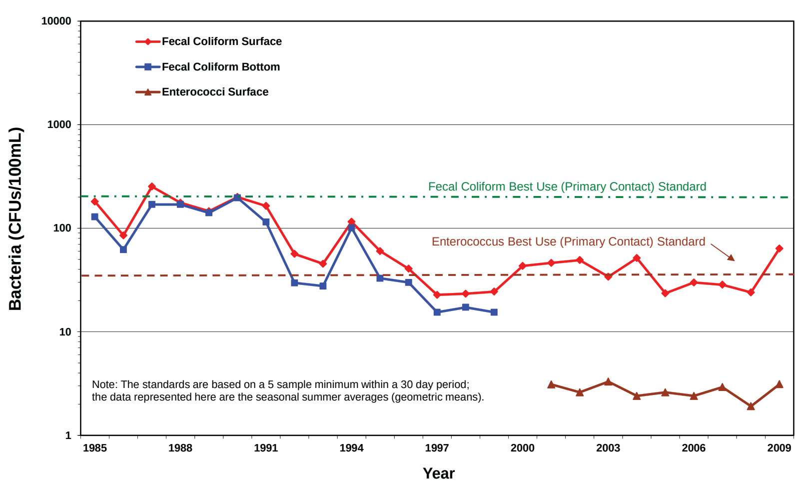
FECAL COLIFORM
2009 Summer Geomean (Surface)
Jamaica Bay



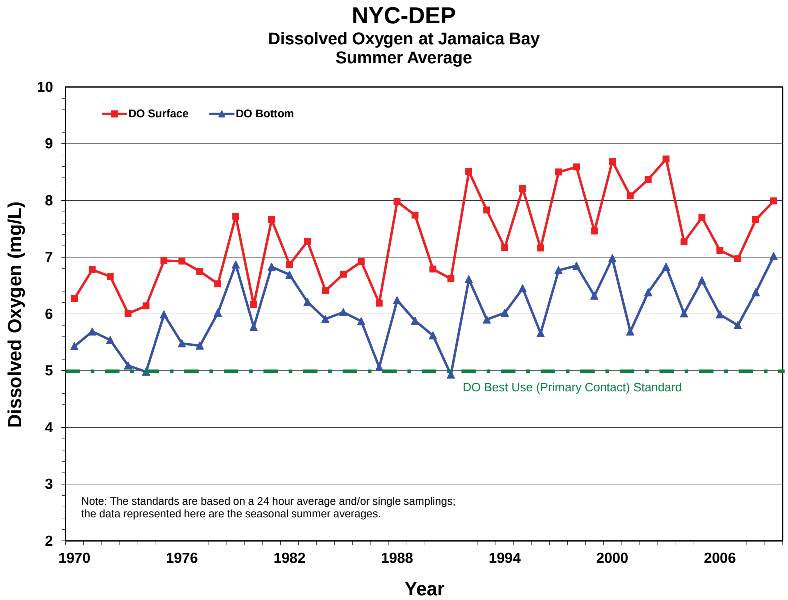
ENTEROCOCCUS
2009 Summer Geomean (Surface)
Jamaica Bay



NYC-DEP
Bacteria at Jamaica Bay
Summer Geometric Mean



Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).



DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

The Jamaica Bay summer regional average DO levels for surface and bottom samples were 7.0 mg/L and 5.8 mg/L, respectively, in 2007; rising to 8 and 7.0 mg/L in 2009. Despite a drop in the surface sampling values from above 8.0 mg/L for the seasonal average values from years 1997 through 2003, DO for Jamaica Bay continues on an upward trend.

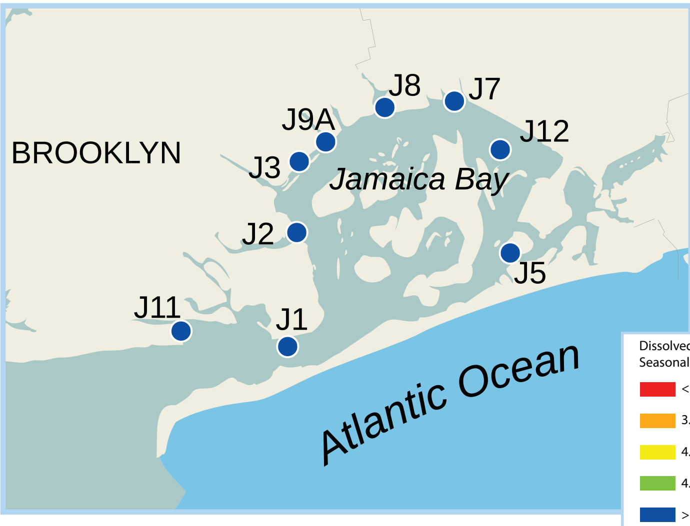
2009 Surface DO: Individual site seasonal averages for surface samples ranged from 7.6 to 8.5 mg/L. The DO at seven out of nine sampling sites in Jamaica Bay dropped below 5.0 mg/L on at least one sampling event during the season. The DO at five out of nine sampling sites in Jamaica Bay dropped below 4.8 mg/L for at least one event, four out of nine sites dropped below 4.0 mg/L for at least one sampling, and at site J12 the DO dropped below 3.0 mg/L for at least one event.

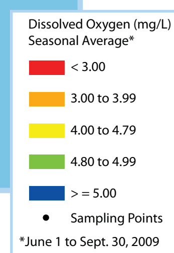
2009 Bottom DO: Site J12 was the only site that had a seasonal summer average of below 5.0 mg/L (4.1). All other sites ranged from 6.8 to 8.5 mg/L. All but two of the nine sampling sites had a DO sampling event below 4.8 mg/L (sites J11 and J5 did not); all but three sites dropped below 4.0 mg/L. Only one site, J12, had a DO that dropped below 3.0 mg/L for at least one event. (This is down from five sites that dropped below 3.0 mg/L in 2006.) The minimum DO value at site J12 was 1.1 mg/L in 2009. In past seasons this site has occasionally had 0.0 mg/L as its lowest tested value.

The Jamaica Bay region, in general, is prone to high variability in DO levels. Algal blooms are common in the Bay, which frequently result in large diurnal variations in DO. Sampling site J12 is a deep area of the Bay that was created by excavation for the construction of the Kennedy Airport. During much of the year the site is stratified due to poor water circulation, causing oxygen depletion (anoxia) in the bottom layer of this site (hypolimnion).

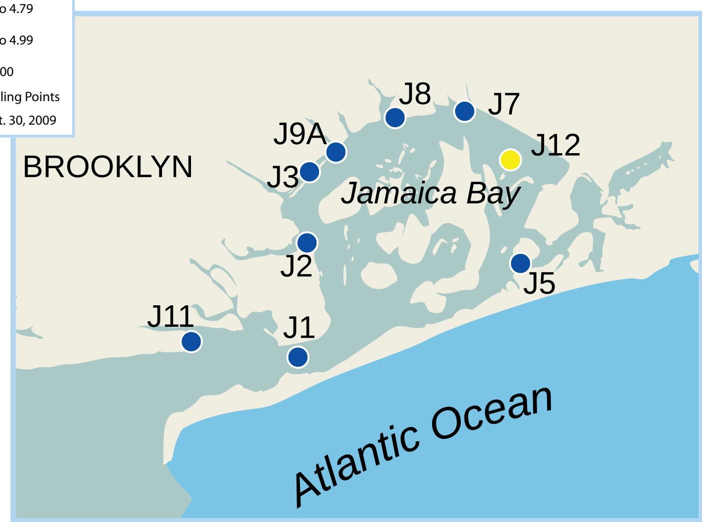
Although the DO values measured in 2007 were slightly lower than was the case in 2006, they increased again in 2008 and 2009. The overall long term trend shows that DO levels in the Jamaica Bay region have been steadily increasing since 1970.

DISSOLVED OXYGEN
2009 Summer Average – Surface
Jamaica Bay

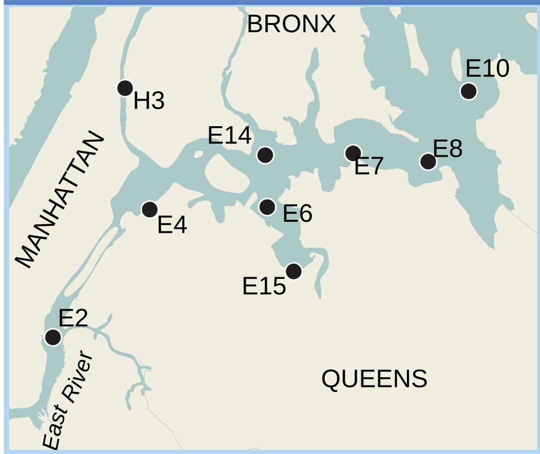




DISSOLVED OXYGEN
2009 Summer Average – Bottom
Jamaica Bay



EAST RIVER – WESTERN LONG ISLAND SOUND



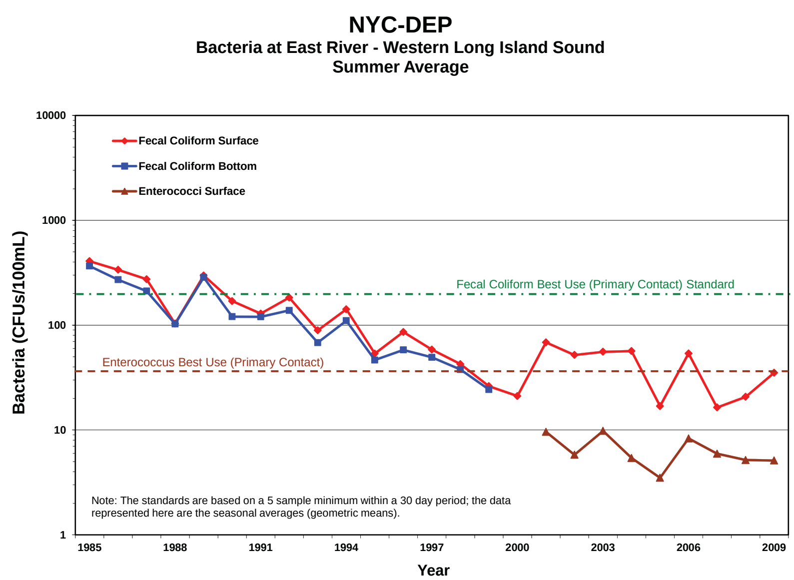
The East River—Western Long Island Sound region represents the northeast portion of NY Harbor, extending from the point where the East River joins the Upper New York Bay (including the East River and the Harlem River), and continuing north-easterly into the Long Island Sound.

The area includes Flushing Bay, Bowery Bay, the Bronx and Hutchinson Rivers, Eastchester Bay, and Little Neck Bay.

BACTERIA

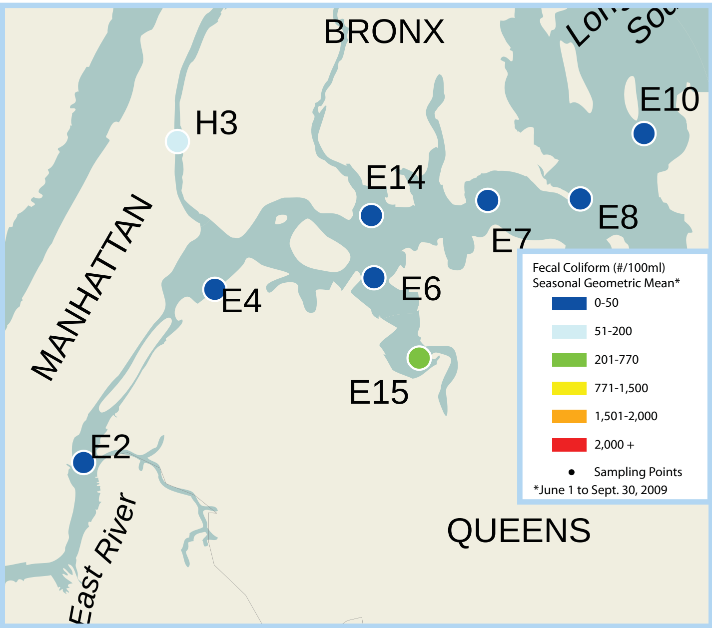
The East River—Western Long Island Sound regional fecal coliform summer geometric mean in 2007 was 16 CFU/100mL; in 2008 it was 21; and in 2009 it was 35, as compared to 54 in 2006. In 2009, sampling site E15 had the highest summer geometric mean in the region at 484 CFUs/100mL. The seasonal mean values of all the other sites fell to below 60 CFUs/100mL. All sites except E10, with a maximum of 36, had maximum individual sampling events ranging from 510-4000 CFUs/100mL. The region continues its long-term downward trend.

The seasonal geometric mean *Enterococci* level for the region averaged about 5 CFUs/100mL for years 2008 and 2009, and 6 CFUs in 2007. These numbers are down from 8 in 2006. In 2009, sampling site H3 had the highest summer geometric mean in the region at 21 CFUs/100mL. The seasonal means for all the other sites ranged from 2-12 CFUs/100mL. All sites except E10, with a maximum sampling event value of 10 CFUs/100mL, had maximum individual samples with values ranging from 50-1080 CFUs/100mL. Interestingly, the site with the highest individual sampling maximum (site E15 with 1080 CFUs/100mL) was not the site with the highest seasonal geometric mean (site H3 with 21 CFUs). The seasonal averages for the region remain steady, with a very slight downward trend.

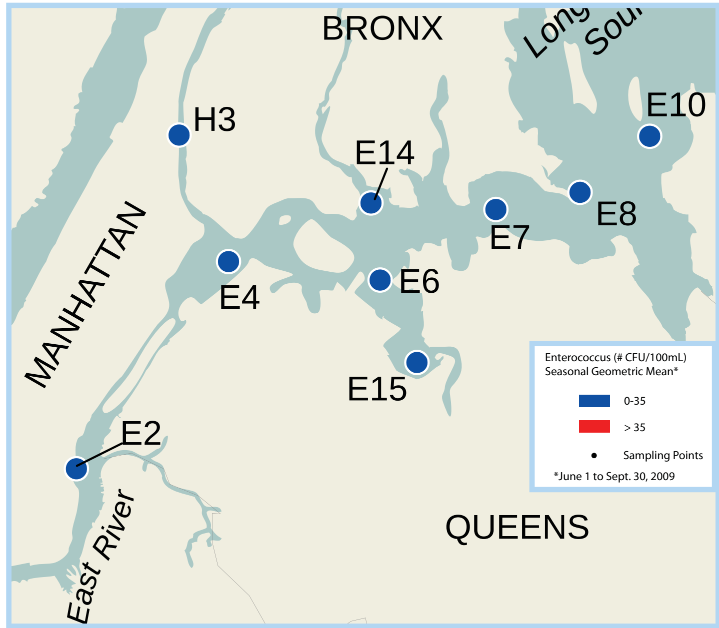


Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).

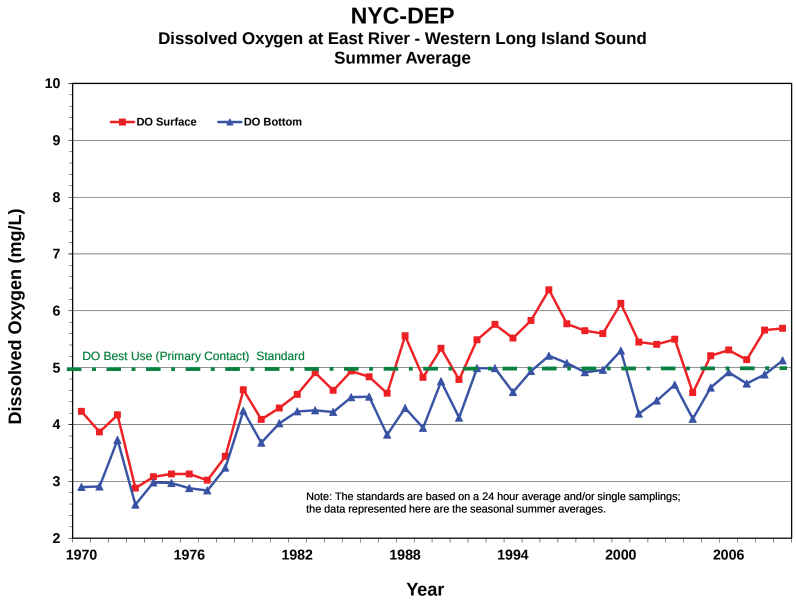
FECAL COLIFORM
2009 Summer Geomean (Surface)
East River–Western Long Island Sound



ENTEROCOCCUS
2009 Summer Geomean (Surface)
East River–Western Long Island Sound



Preparing to venture out from Hallets Cove in Queens on one of the student built East River Crew boats. Photo courtesy of Rob Buchanan.



DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

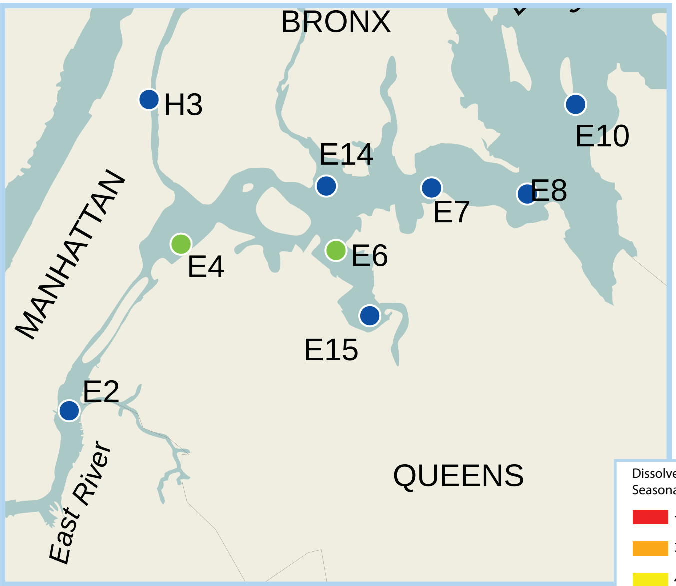
In the East River – Western Long Island Sound, the region's average 2009 surface DO level was 5.7 mg/L, and 5.1 mg/L for bottom DO. DO levels slightly improved each year from to 2007 to 2009. It is especially notable that this is the first year since 2000 that the bottom seasonal average is above 5.0 mg/L. Additionally, this is only the 4th time since 1970 that this has been the case. All but two sites have a seasonal average (surface sampling) above 5.0 mg/L; E4 and E6 did not, but were close with values of 4.9 and 4.9 mg/L, respectively.

2009 Surface DO: All sampling sites for surface DO dropped below 4.0 mg/L for at least one sampling event. For individual samples, Site E7 was the only site where the DO value dropped below 3.0 mg/L.

2009 Bottom DO: All sampling sites had bottom DO levels that were found to be below 4.0 mg/L for at least one event. Five sites dropped below 3.0 mg/L for at least one sampling event, and E10 had the lowest minimum sample out of this region's sites, with 1.8 mg/L on August 31, 2009. By September 8 it was back up to 4.8 mg/L.

Although DO levels in the East River and Western Long Island Sound continue to be the lowest throughout the NY waters of the Harbor, and are slightly down from the late 1990's, the long term trend from the 1970's remains positive.

DISSOLVED OXYGEN
2009 Summer Average – Surface
East River–West Long Island Sound



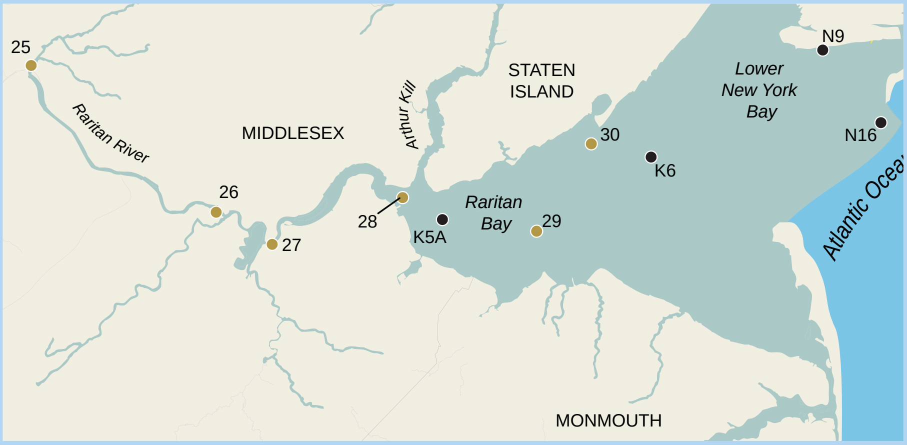
Dissolved Oxygen (mg/L)
Seasonal Average*

- < 3.00
- 3.00 to 3.99
- 4.00 to 4.79
- 4.80 to 4.99
- > = 5.00
- • Sampling Points

*June 1 to Sept. 30, 2009

DISSOLVED OXYGEN
2009 Summer Average – Bottom
East River–West Long Island Sound

RARITAN RIVER BAY – LOWER NEW YORK BAY



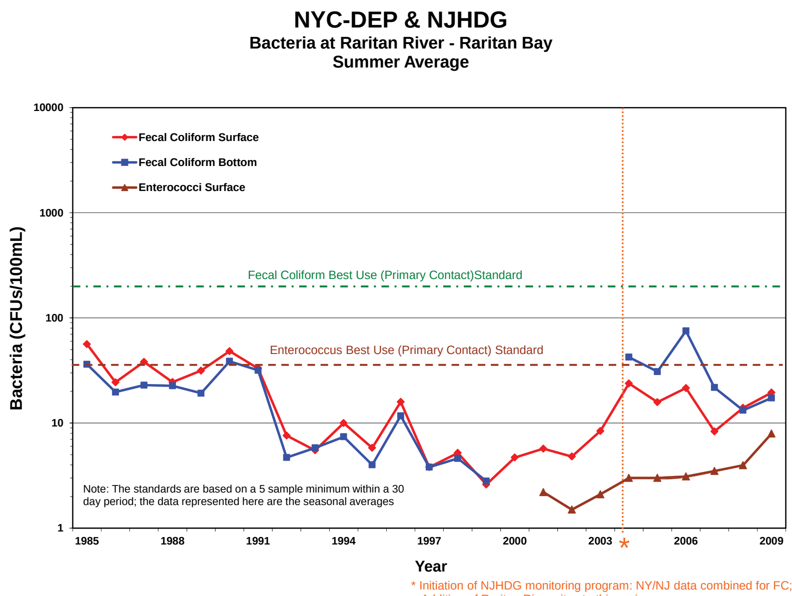
The Raritan River and Bay – Lower New York Bay region represents the most oceanic portion of the Harbor. This is the largest region in the Harbor, and is represented by ten survey stations. Six of the stations are in mostly open shallow waters, from Brooklyn's Coney Island to the north, Staten Island to the north and west, and New Jersey's Middlesex and Monmouth Counties.

The most southeastern portion of the region includes the Shrewsbury and Navesink Rivers. This sub-region is a tidal estuary system that connects the two rivers and drains into Raritan Bay through Sandy Hook Bay. The remainder of the region's eastern boundary is open to Rockaway Inlet and the greater Atlantic Ocean. The other four survey stations extend from the mouth of the Raritan River upstream about 15 miles.

BACTERIA

In the Raritan River and Bay – Lower New York Bay region the fecal coliform summer regional geometric means ranged from 8 to 19 CFUs/100mL for the 2007 to 2009 period. Most of the individual sampling sites in 2009 in the Raritan Bay part of the region had summer geometric means between 3 and 39. Not surprisingly, the Raritan River sites 25, 26, and 27 had the highest seasonal means, 126, 352, and 255 respectively. Six of the ten sites had individual sampling events where fecal coliform rose above 200 CFUs/100mL for at least one event, ranging from 228 (N9) to 1500 (site 26).

The long term trend for fecal coliform in this region has shown an overall decrease from 1985 to 2009. The increased values observed during 2004-2009 can be mostly attributed to the expansion of this region to include the Raritan River. The 2009 fecal coliform and *Enterococcus* averaged values for the Raritan Bay sites only were 8 and 2 CFUs/100mL, respectively. The fecal coliform and *Enterococcus* averaged values from the Raritan River sites only were 47 and 25 CFUs/100mL, respectively.



Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).

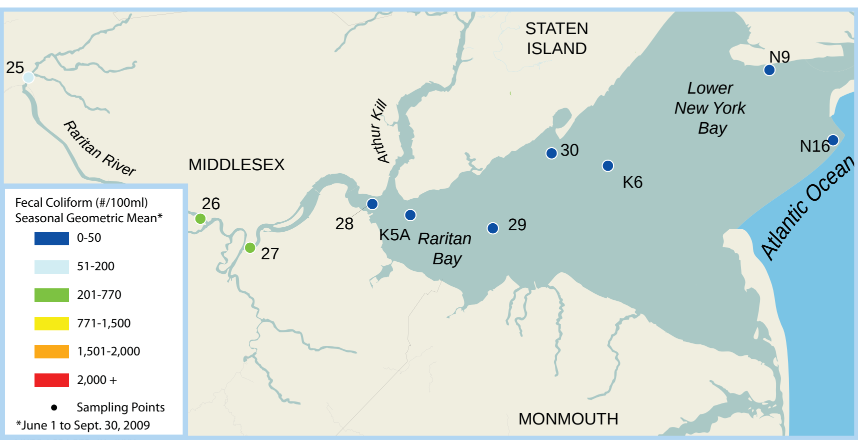
Enterococci levels for the entire Raritan Bay region have been stable, with regional geometric means ranging from 1 to 8 CFUs/100mL for the nine years that the area was sampled (2001 through 2009).

In 2009, similar to fecal coliform trends, the highest seasonal geometric means for *Enterococcus* for this region are in sites 25, 26 and 27, with *Enterococcus* values of 217, 68, and 58 CFUs/100mL respectively. These sites also had the highest individual sampling event values of the region, 10300, 2380 and 2300 respectively.

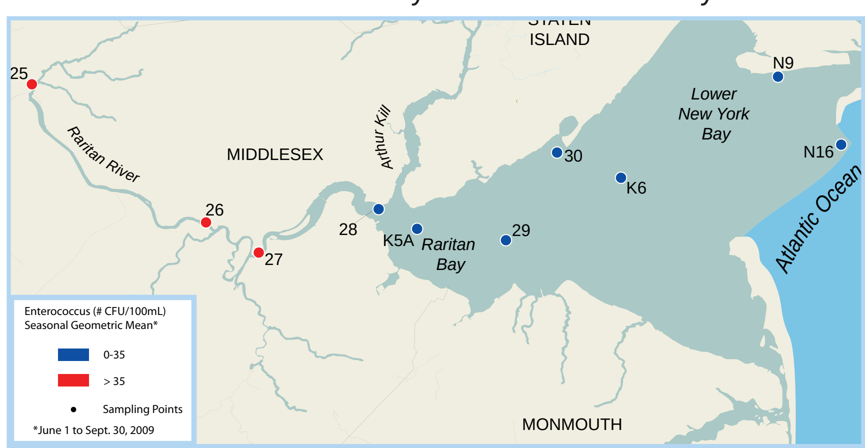
Site 25, with a maximum individual sampling event of 10300 CFUs/100mL, was the site with the highest level found among all of the sites, in all regions of the Harbor where *Enterococcus* was measured.

Five of the ten sites had individual sampling events that were higher than the 35 CFU/100mL Best Use Standard for *Enterococcus*. This region and Arthur Kill/Kill Van Kull are the only two regions in the Harbor where the *Enterococci* data is showing an upward long term trend, probably because of the inclusion of the high values measured at the Raritan River.

FECAL COLIFORM
2009 Summer Geomean (Surface)
Raritan River Bay–Lower New York Bay

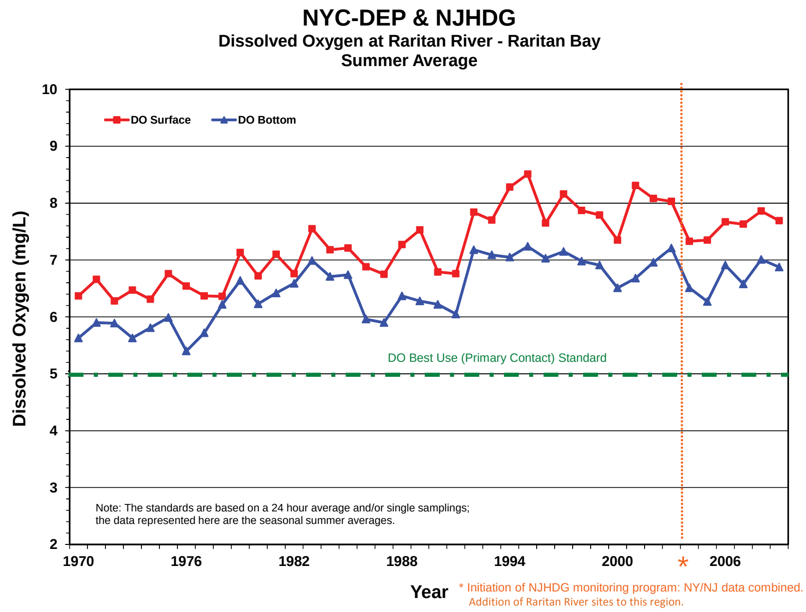


ENTEROCOCCUS
2009 Summer Geomean (Surface)
Raritan River Bay–Lower New York Bay



For Raritan River and Bay — Lower New York Bay the regional average for 2009 surface DO levels was 7.7 mg/L, and 6.9 mg/L for bottom DO levels. This is a slight improvement from years 2004 and 2005 (when the decrease in DO was mostly attributed to the expansion of this region to include the Raritan River water quality values).

2009 Surface DO: All of the individual sampling sites had seasonal averages between 6.1 and 9.2 mg/L. The surface DO at five of the ten sampling sites dropped below 5.0 mg/L for at least one sampling event. Four sites dropped below 4.8 mg/L for at least one event; three sites had 4.0 mg/L for at least one event. No sites had measured values below 3.0 mg/L.



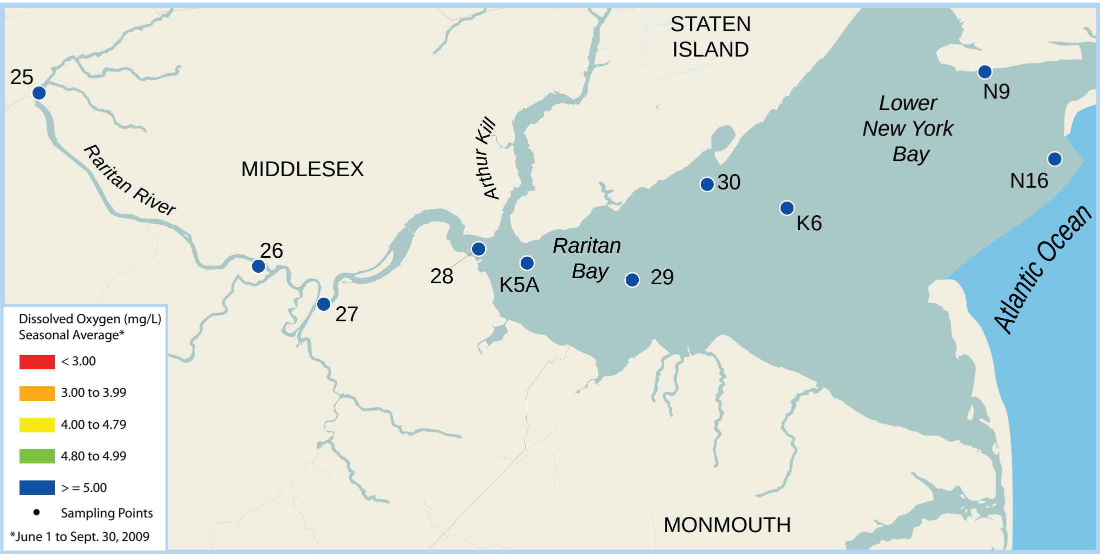
DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

2009 Bottom DO: All of the individual sampling sites had seasonal averages between 5.1 and 8.3 mg/L. The bottom DO at six of the sampling sites dropped below 5.0 mg/L for at least one sampling event, while five sites dropped below 4.8 mg/L for at least one event, and four sites had 4.0 mg/L for at least one event. Two sites had measured values below 3.0 mg/L (sites K5A and 28). Average DO levels were the highest throughout this region at stations K6 and 30, while the average DO levels were found to be lowest at sites 27 and 28.

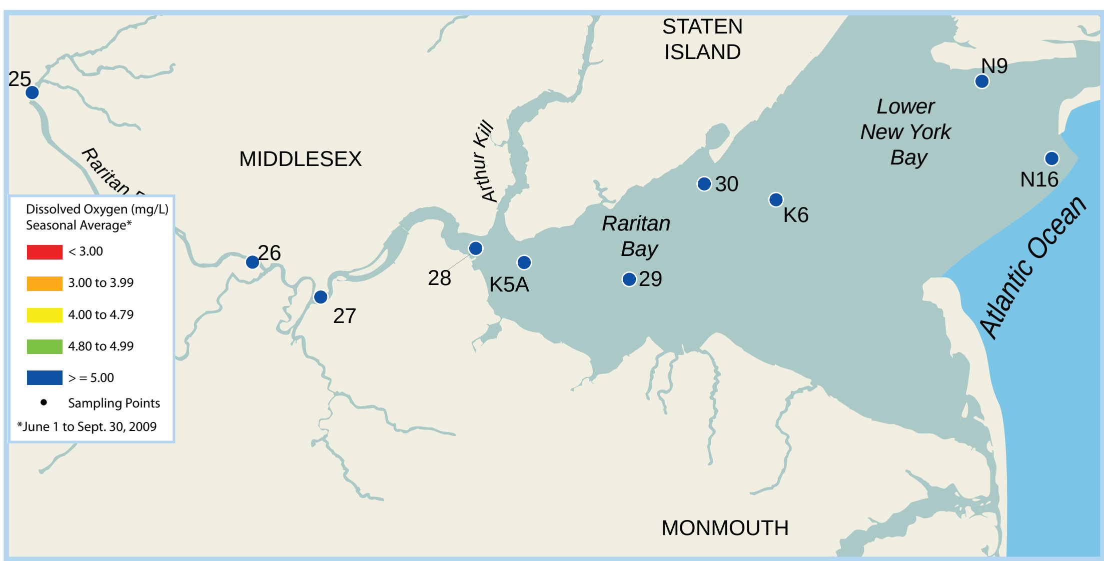
The region continues to show improving DO values from 1970 to the present.

Rowing on the East River.
Photo courtesy of Mary Nell Hawk.

DISSOLVED OXYGEN
2009 Summer Average – Surface
Raritan River Bay – Lower New York Bay



DISSOLVED OXYGEN
2009 Summer Average – Bottom
Raritan River Bay – Lower New York Bay



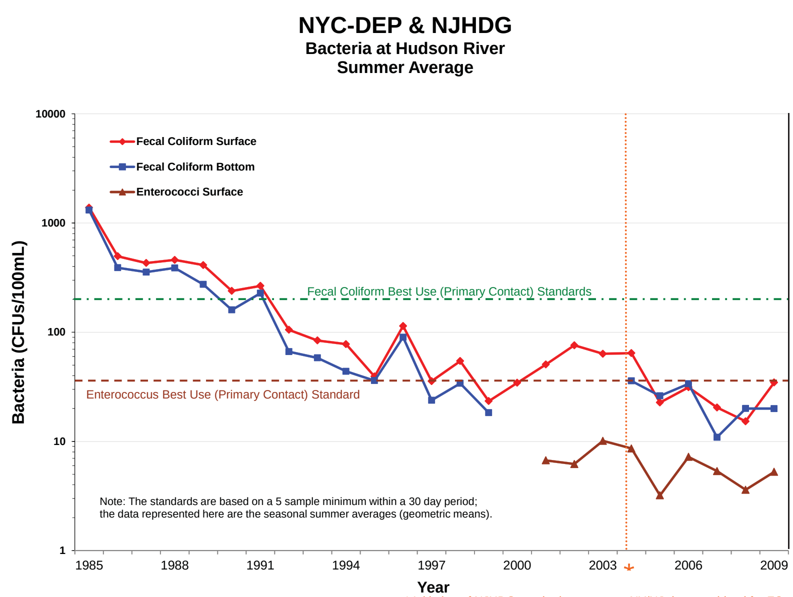
HUDSON RIVER – UPPER NEW YORK BAY

The Hudson River—Upper New York Bay area includes: the Hudson River from just north of the NYC-Westchester line through the Battery to the Verrazano Narrows; it joins with and parallels the Lower East River, and also connects to the Kill van Kull-Arthur Kill system. This area contains 12 survey stations.

BACTERIA

In the Hudson River and Upper New York Bay region the summer geometric mean fecal coliform value in 2009 was 35 CFUs/100mL, which was similar to the 2006 value of 31 and down from 76 in 2002.

In 2009, all but one of the individual sampling sites in this region had summer geometric means of less than 55 CFUs/100mL. Site G2 was the exception, with an average of 138 CFUs/100mL. Individual maximum samples in this region ranged from 108 CFUs/100mL at site 31, to 4000 CFUs/100mL at site G2. The long term trend for fecal coliform continues to show improvement.



Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).

FECAL COLIFORM
2009 Summer Geomean (Surface)
Hudson River–Upper New York Bay

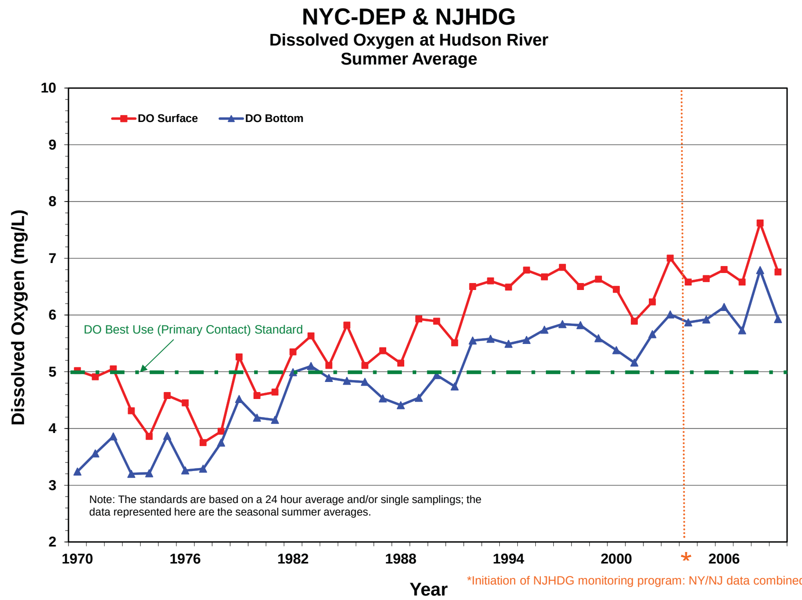
ENTEROCOCCUS
2009 Summer Geomean (Surface)
Hudson River–Upper New York Bay

Enterococci levels for the Hudson River and Upper New York Bay region were found to be stable, with regional geometric means ranging from 4 to 5 CFUs/100mL for years 2007 through 2009. Individual sampling site seasonal geometric means ranged from 3 CFUs/100mL at site 31 to 19 at site G2. The highest individual *Enterococcus* measurement at this site was 1380 CFUs/100mL, down from 3,800 in 2006. Note that this had been the highest level found among all of the sites, in all of the regions of the Harbor where *Enterococcus* was measured for that year. All individual sites except one had a sampling event with a value above 35 CFUs/100mL. The region shows a slow but steady downward long term trend.

The Hudson River and Upper New York Bay regional surface DO average in 2009 for was 6.8 mg/L, and 5.9 mg/L for the bottom DO value.

2009 Surface DO: All of the individual sampling sites had seasonal averages between 6.2 an 7.3 mg/L. The surface DO at eight of the twelve sampling sites dropped below 5.0 mg/L for at least one sampling event. Four sites dropped below 4.8 mg/L for at least one event, and no sites measured below 4.0 mg/L during the sampling season. Note that in 2006 only one site (G2) dropped below the 4.8 mg/L.

2009 Bottom DO: All twelve sampling sites were found to contain less than 4.8 mg/L for at least one event. Five sites measured less than 4.0 mg/L at least one event in the 2006 summer season. No sites measured below 3.0 mg/L.

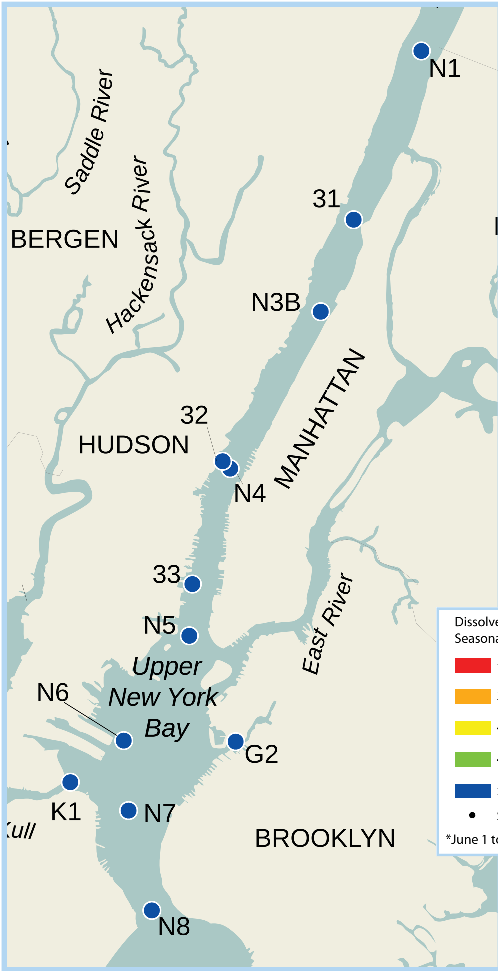


DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

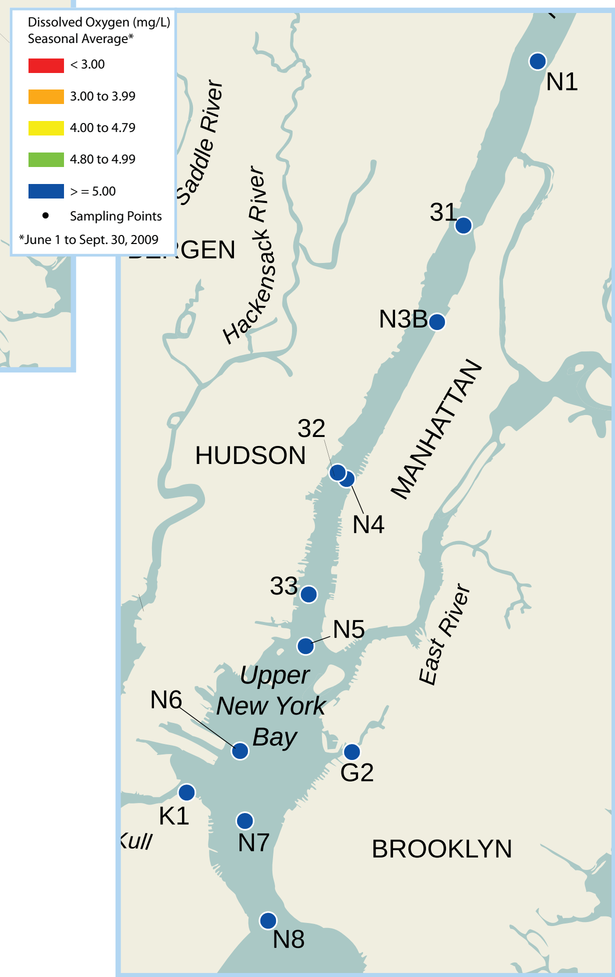
Despite some variability in the last three years, the long term trend for DO in this region continues to show improvement since the start of the monitoring program.

Learn to fish programs, such as this one on the Hudson River, help teach residents about the estuary.
Photo courtesy of Ellen McCarthy.

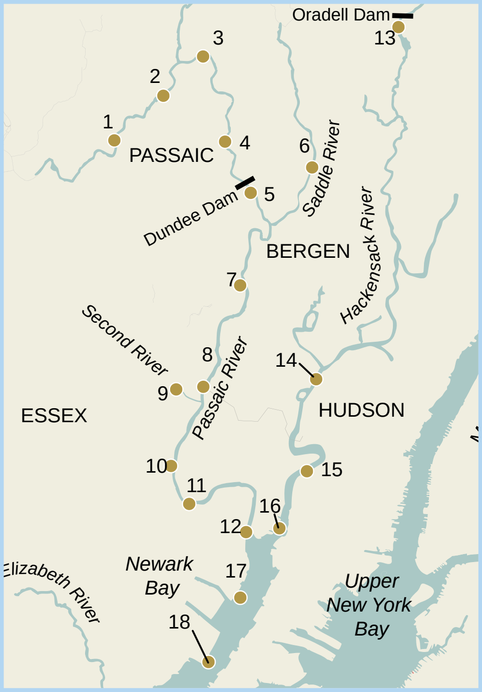
DISSOLVED OXYGEN
2009 Summer Average – Surface
Hudson River–Upper New York Bay



DISSOLVED OXYGEN
2009 Summer Average – Bottom
Hudson River–Upper New York Bay



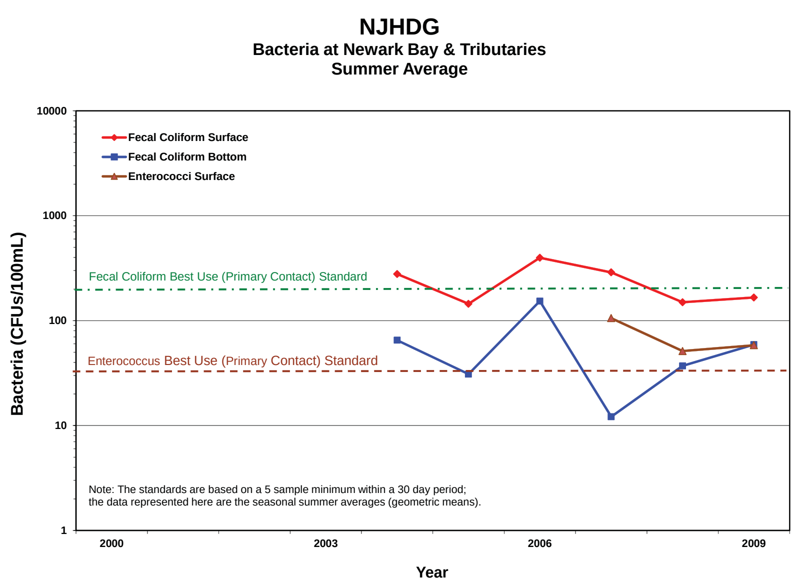
NEWARK BAY AND TRIBUTARIES



The region of the Newark Bay and tributaries connects with the Kill van Kull to the south, and includes the Hackensack and the Passaic Rivers (and most of their tributaries) to the north.

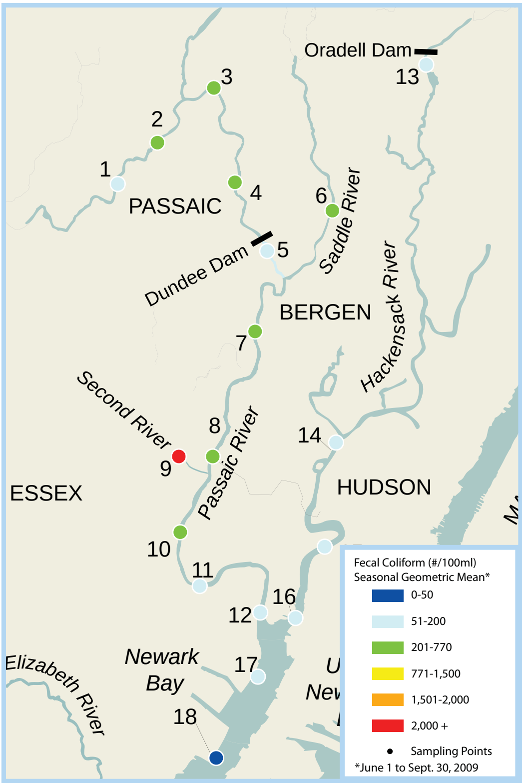
BACTERIA

In the Newark Bay and Tributaries region the fecal coliform summer geometric mean value in 2009 was 166 CFUs/100mL. This is down from 398 in 2006. In 2009, seasonal geometric means for individual sites ranged from 34 CFUs/100mL (site 18) to 759 (site 7). However, site nine (in the Second River) had a significantly higher fecal coliform average than the other sites in this region (seasonal mean of 3962 CFU/100 mL). All sites measured above the Best Use Standard for at least one sampling event. Interestingly, site 4 had a higher maximum value than site 9 (8100 CFUs/100 mL as compared to 6000). Site 9 did not have the highest maximum event during 2009 (as it did in 2006). However, the lowest sampling event value for site 9 was 1500 CFUs/100mL, greater by far than any other site in the harbor. Note that monitoring for this region only began in December of 2003.

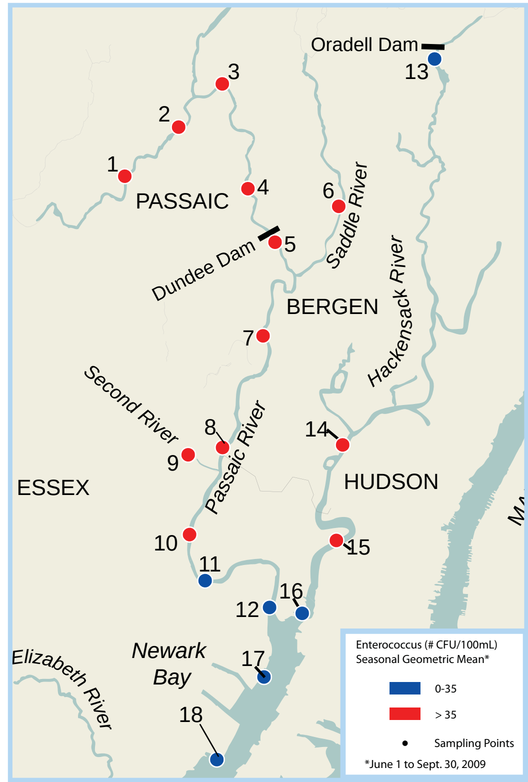


Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).

FECAL COLIFORM
2009 Summer Geomean (Surface)
Newark Bay and Tributaries



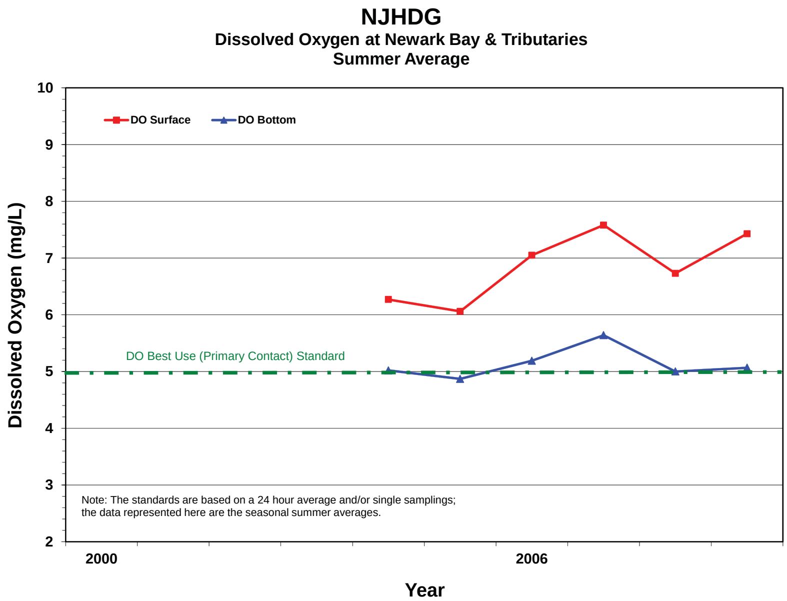
ENTEROCOCCUS
2009 Summer Geomean (Surface)
Newark Bay and Tributaries



It is interesting to note that site 6 and site 9 are in tributaries to the Passaic River (the Saddle River and the Second River) that do not have any CSOs or POTWs discharging to them. However, there are stormwater discharges which may well be responsible for these high fecal coliform values. Individual sampling sites had maximum annual values ranging from 460 to 15,000 CFUs/100mL. It is important to recognize that this region is entirely in NJ, and therefore data were collected only by NJHDG. With only three years of data collected for this region, it is too early to define any long term trend. Since this region has the highest measured fecal coliform levels, long term trend monitoring will be very important in assessing the progress of water quality.

NJHDG initiated sample collection for *Enterococcus* in the Newark Bay and Tributaries in 2007. Seasonal geometric means for this region were 106, 51, and 58 CFUs/100mL respectively for years 2007, 2008 and 2009. This is the only region where the seasonal geometric mean values were greater than the Best Use Standard of 35 CFUs/100mL for *Enterococcus*.

Similar to the fecal coliform results for this region, the individual sampling site seasonal geometric means for *Enterococcus* for 2009 were relatively high, ranging from 7 CFUs/100mL (site 18) to 284 (site 6). Site 9 had a significantly higher *Enterococcus* average than the other sites in this region with a seasonal mean of 677 CFU/100mL. All sites but three (13, 16, and 18) measured above the Best Use Standard for at least one sampling event. Site 6 had the highest individual sampling event, with a 5300 CFUs/100mL.



DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

In the Newark Bay and Tributaries region the average 2009 surface DO level was 7.4 mg/L, and 5.1 mg/L for bottom DO levels.

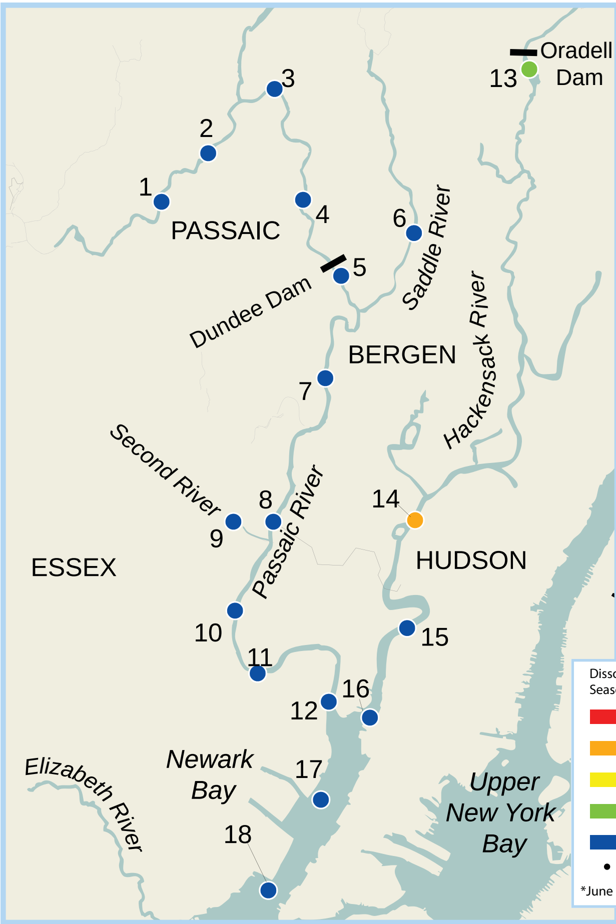
2009 Surface DO: The individual sampling sites had seasonal averages between 3.7 (site 13) and 9.7 mg/L (site 9). The surface DO at seven of the eighteen sampling sites dropped below 5.0 mg/L for at least one sampling event and six sites dropped below 4.8 mg/L for at least one event. Four sites measured below 4.0 mg/L for at least one event; and two sites measured below 3.0 mg/L.

2009 Bottom DO: Bottom DO was not measured at all sites due to the shallowness of certain sampling sites, but of the sites that were measured, five out of six had DO values below and 4.8 mg/L for at least one sampling event. Three sites dropped below 4.0 mg/L; and one site dropped before 3.0 mg/L (site 14 at 2.7 mg/L).

This region is showing an upward trend, note however, that there are only six years of data for this region. Because the Newark Bay and Tributaries region has the lowest DO of the regions in the NJ waters of the Harbor, long term trend monitoring will be very important for assessing changes in DO in this monitoring region.

Canoeing on the Passaic River in downtown Newark. Photo courtesy of Jerry Willis, National Park Service.

DISSOLVED OXYGEN
2009 Summer Average – Surface
Newark Bay and Tributaries

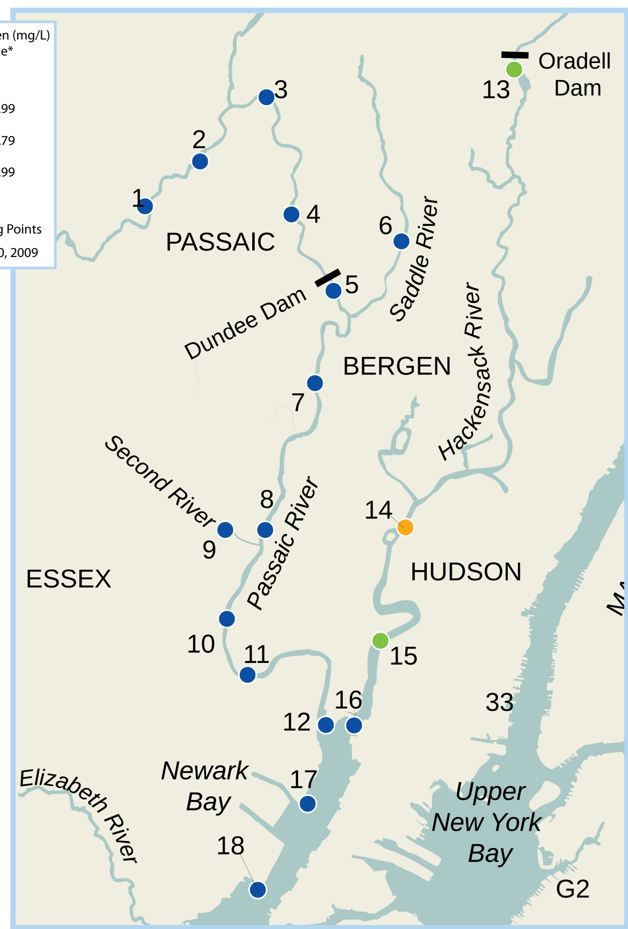


Dissolved Oxygen (mg/L)
Seasonal Average*

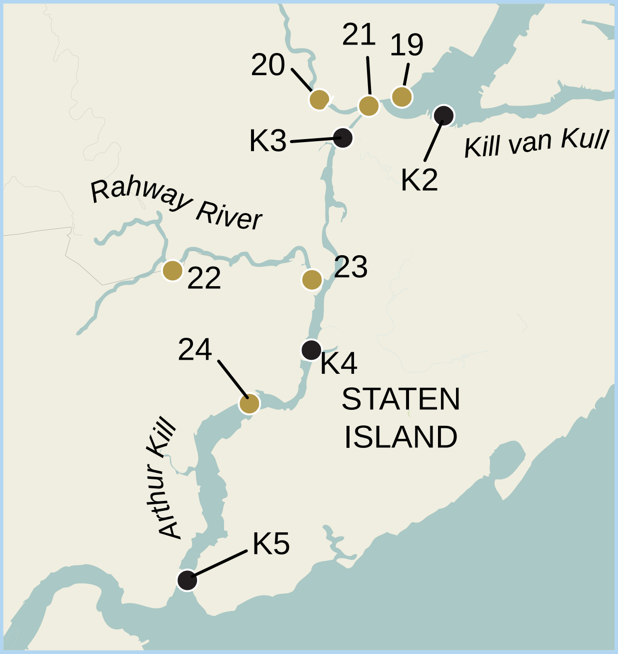
- < 3.00
- 3.00 to 3.99
- 4.00 to 4.79
- 4.80 to 4.99
- > = 5.00
- • Sampling Points

*June 1 to Sept. 30, 2009

DISSOLVED OXYGEN
2009 Summer Average – Bottom
Newark Bay and Tributaries



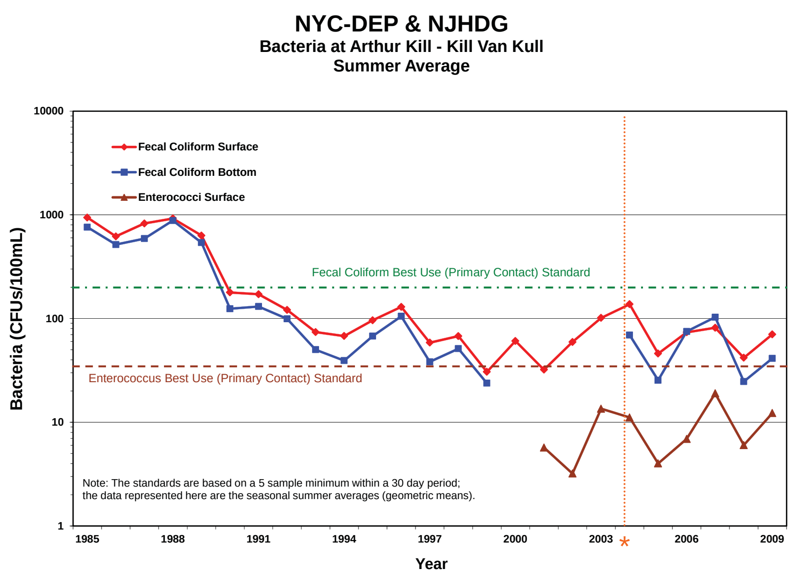
ARTHUR KILL AND KILL VAN KULL



The Arthur Kill and Kill van Kull system connects three water bodies; Upper New York Bay, Newark Bay and Raritan Bay, and includes several tributaries to the west of the Arthur Kill in Union and Middlesex counties.

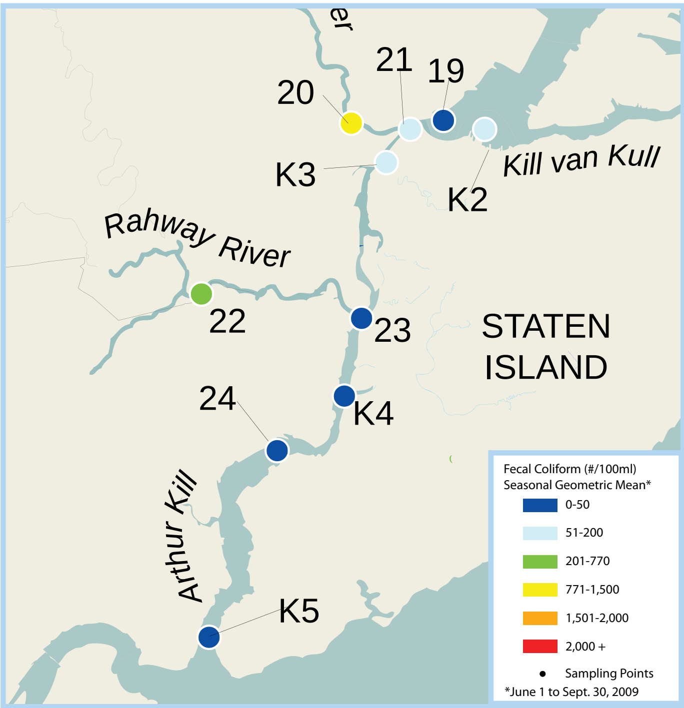
BACTERIA

In the Arthur Kill and Kill van Kull region the fecal coliform summer geometric mean in 2009 was 70 CFUs/100mL, similar to the 2006 summer geometric mean of 74 CFUs/100mL. In 2009, most of the individual sampling sites had summer geometric mean values at or below 110 CFUs/100mL, the exceptions being sites 20 and 22, with CFUs of 830 and 631, respectively. Individual site maximum fecal coliform values (CFUs/100mL) ranged from 56 at site K5, to 7,900 at site 21. In 2006, site 21 had the highest individual sampling event found among all of the sites in all of the regions of the Harbor for that year, at 3031 CFUs/100mL. The highest for 2009 was site 4 in the Passaic River (8100 CFUs/100mL). Additionally, eight sites in the harbor in 2009 had fecal coliform values greater than the 2006 maximum value of 3031CFUs/100mL. The long term trend for this region shows an overall decrease in fecal coliform levels. Note that data from the Elizabeth and Rahway Rivers were added to this region in 2004, negatively affecting the long term trend.

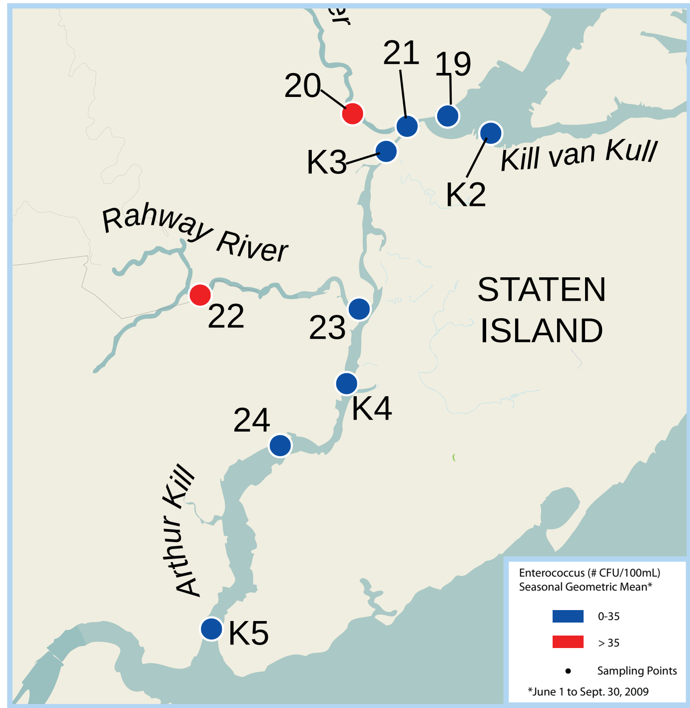


Bacteria sampling does not meet the requirements specified by the WQS (see pg. 19 for more information).

FECAL COLIFORM
2009 Summer Geomean (Surface)
Arthur Kill and Kill van Kull

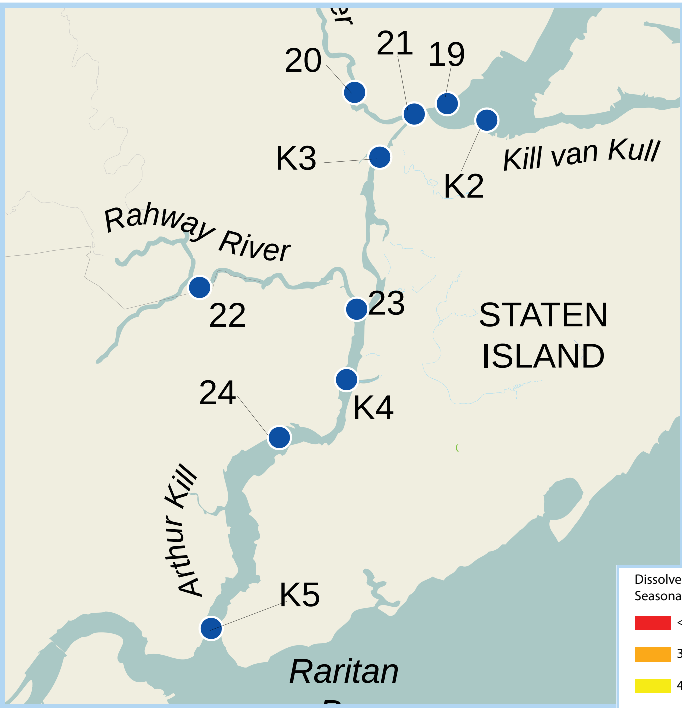


ENTEROCOCCUS
2009 Summer Geomean (Surface)
Arthur Kill and Kill van Kull

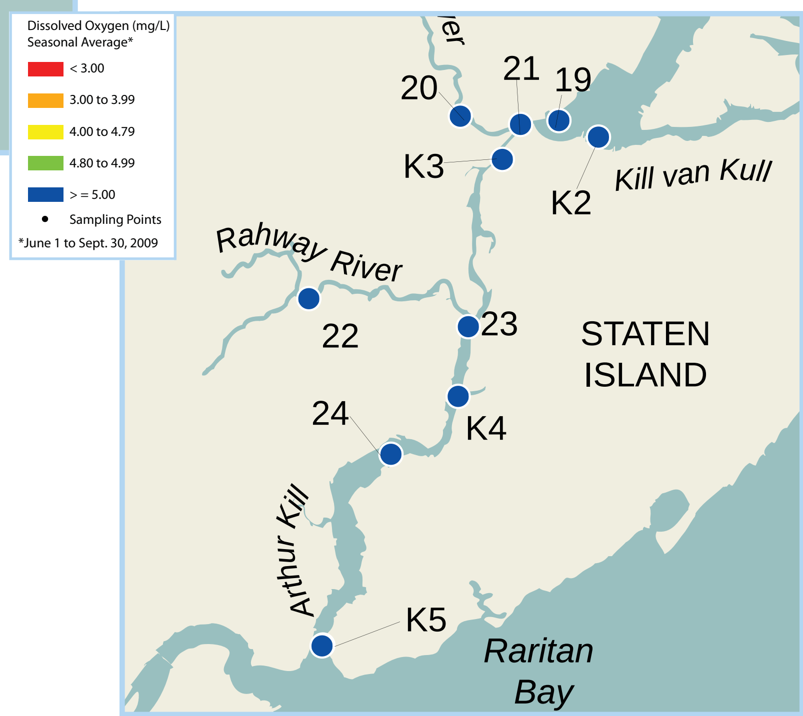


Seasonal geometric mean values for *Enterococci* levels for the Arthur Kill and Kill van Kull region were found to fluctuate slightly, with a regional geometric mean of 12 CFUs/100mL for 2009. This result compares with 7 CFUs/100mL in 2006, 19 in 2007 and 6 in 2008. Seasonal geometric mean values for most individual sampling stations ranged from 4 to 14 CFUs/100mL, except for sites 20 and 22, which had values of 191 and 330 CFUs/100mL, respectively. Individual sampling sites had maximum *Enterococci* levels that ranged from 15 at K5 to 7200 at site 22. All but two sites (K5 and 19) had individual sampling events greater than the Best Use Standard of 35 CFUs/100mL. The trend for this region, from 2001 to 2009, shows moderately increasing *Enterococci* levels. This region and Raritan River and Raritan Bay are the only two regions showing upward trends for *Enterococcus*.

DISSOLVED OXYGEN
2009 Summer Average – Surface
Arthur Kill and Kill van Kull



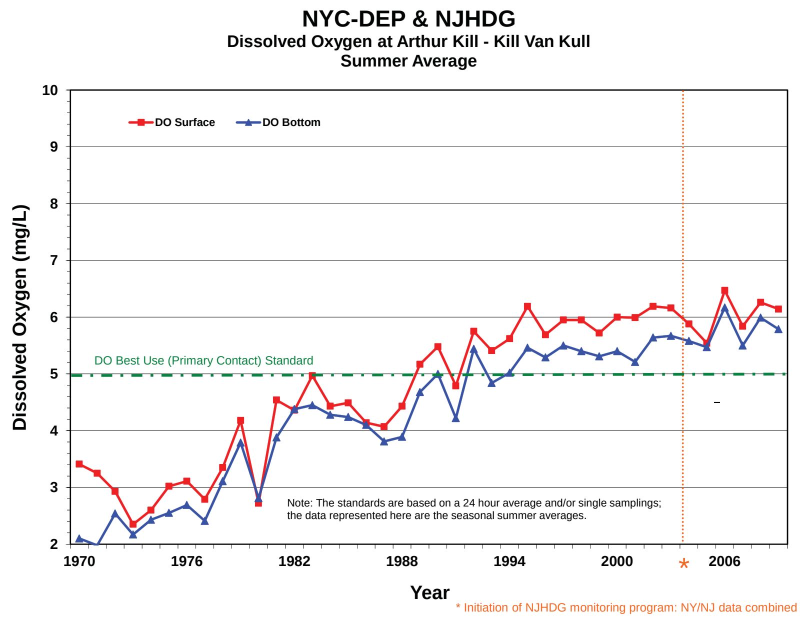
DISSOLVED OXYGEN
2009 Summer Average – Bottom
Arthur Kill and Kill van Kull



In Arthur Kill and Kill van Kull the 2009 regional average surface DO level was 6.1 mg/L, and 5.8 mg/L for bottom DO.

2009 Surface DO: The individual sampling sites seasonal averages ranged from 5.0 (site 20) to 6.8 mg/L (site K5). All ten sites dropped below 5.0 mg/mL for surface DO for at least one sampling event. Eight sampling sites dropped below 4.8 mg/L for at least one event. Only sites 22 and K5 dropped below 4.0 mg/L for one event, and no sites were found to contain less than 3.0 mg/L during the season.

2009 Bottom DO: DO was not measured on the bottom at all sites due to shallower water at certain sampling sites, but of those that were sampled (eight out of ten sites), all were found to contain less than 4.8 mg/L for at least one event. DO at three sites dropped below 4.0 mg/L for at least one sampling event. Sites K5 and 24 dropped below 3.0 mg/L. The overall trend for DO has been steadily increasing since the 1970's.



DO sampling does not meet the requirements specified in the WQS (see pg. 19 for more information).

Organized competitive swimming events have become common in the harbor. Photo courtesy of Capri Djatiasmoro, NYC Swim.

ACKNOWLEDGEMENTS

Water quality sampling in the NY-NJ Harbor. Photo courtesy of Passaic Valley Sewerage Commissioners.

Many organizations and individuals contributed to this effort, financially and with their time and data. The New York-New Jersey Harbor Estuary Program (HEP) identified the need for a Harbor-wide water quality monitoring and reporting effort that would enhance existing monitoring efforts. The Interstate Environmental Commission (IEC) formed an interagency adhoc committee to plan the sampling effort in New Jersey waters that would complement the sampling in New York waters that was being undertaken by the City of New York. Organizations represented on the adhoc committee included the New Jersey Department of Environmental Protection (NJDEP), the New York State Department of Environmental Conservation (NYDEC), the New York City Department of Environmental Protection (NYCDEP), the US Environmental Protection Agency (EPA), the Interstate Environmental Commission (IEC), the National Park Service (NPS), the New Jersey Harbor Dischargers Group (NJHDG), the Passaic Valley Sewerage Commissioners (PVSC), and the US Army Corps of Engineers (USACE). NYCDEP and NJHDG generated the data that is presented in this report. HEP was responsible for the overall coordination and funding for preparing this report. The report was prepared by the Great Lakes Environmental Center (GLEC), with administrative services provided by the New England Interstate Water Pollution Control Commission (NEIWPCC). Graphics were provided by GLEC, NYCDEP, and HydroQual Inc. Photographs were provided by Rob Buchanan, Stephen Stanne, Ellen McCarthy, Hackensack Riverkeeper, Mary Nell Hawk, Jerry Willis–National Park Service, Capri Djatiasmoro–NYC Swim, Passaic Valley Sewerage Commissioners, and Kirk Barrett–Montclair State University.

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The coordinators of the sampling and analytical programs for NJHDG and NYCDEP were Ashley Pengitore (PVSC) and Beau Ranheim (NYCDEP), respectively. The NJHDG Harbor Monitoring Program included the participation of Thomas Pietrykoski, Prudence Moon-Banks (PVSC), and the PVSC River Restoration Department; Vinny Makfinsky, David Vieira and Christine Ginn (Joint Meeting); Guy Abramowitz and Alberto Escobar (NBMUA); Ed Kochick and Janet Thevenin (RVSA); and Wale Adewunmi and John Yannuzzi (MCUA). The laboratories of PVSC, MCUA and BCUA performed most of the chemical analyses for New Jersey waters. The analyses for New York City waters were performed by NYCDEP laboratory. NJHDG data files are stored at PVSC (contact: Ashley Pengitore), and NYCDEP data files are stored at NYCDEP (contact: Beau Ranheim). This report was funded by a cooperative agreement awarded by the Environmental Protection Agency to the New England Interstate Water Pollution Control Commission in partnership with the NY-NJ Harbor Estuary Program. This report was prepared and published by GLEC in Traverse City, Michigan in June 2011.

Competititve rowing on the Passaic. Photo courtesy of Kirk Barrett, Montclair State University.

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