METHODS

Sampling

New York City DEP personnel sampled surface and bottom waters at each of 53 stations (**Figure 4**) approximately 2-4 times per month. Additional year-round sampling (two times per month) for many parameters has been performed since October 1990. Unless noted otherwise, all methods conformed to Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1985). A synopsis of the Harbor Survey sampling plan, aspects of which was initiated as early as 1909, is presented in **Table 2**.

Water samples were collected from onboard the Harbor Survey Vessel, the Osprey, an aluminum-hulled 55-foot twin-engine diesel craft. Stations are located in the field by loran, latitude-longitude and line-of-site.

Some changes to station locations have been made in recent years. For example, due to shoaling at the mouth of Fresh Creek, station J9 was relocated to ~100 meters south of the mouth and renamed J9A in 1990 (**Figure 4**). Shoaling has also forced the abandonment of E12 at the mouth of the Hutchinson River. In 1996 it was relocated south to Eastchester Bay and renamed E12A. This site provides better coverage for the Bronx private beaches. Finally, a new station, N8A, was added in 1996 to provide better coverage of the northern Staten Island beaches.

Crew members collecting water samples from stern of Osprey

Water samples were collected from surface waters (1 meter below the water surface), using a 3.2 liter Kemmerer sampler. Bottom waters (1 meter above the sediment surface) were collected using 5 liter Teflon-lined Niskin and Go-Flo samplers. Blank analyses and duplicate sampling were performed daily to insure data quality.

The below listed parameters are measured at 53 sampling stations, 2-4 times per month, at both surface and bottom waters, unless otherwise noted. (Summer sampling began in 1909. Monthly sampling began in 1990.)

Fecal Coliform

The membrane filter (MF) technique has been used to determine fecal coliform concentrations in Harbor waters since 1974. Prior to 1985, daily surface and bottom water samples at each site were composited; since 1985, surface and bottom samples have been analyzed separately. Samples were aseptically filtered on-board through 0.45 micron membrane filters with the aid of a vacuum pump. The amount of sample filtered was determined based on expected

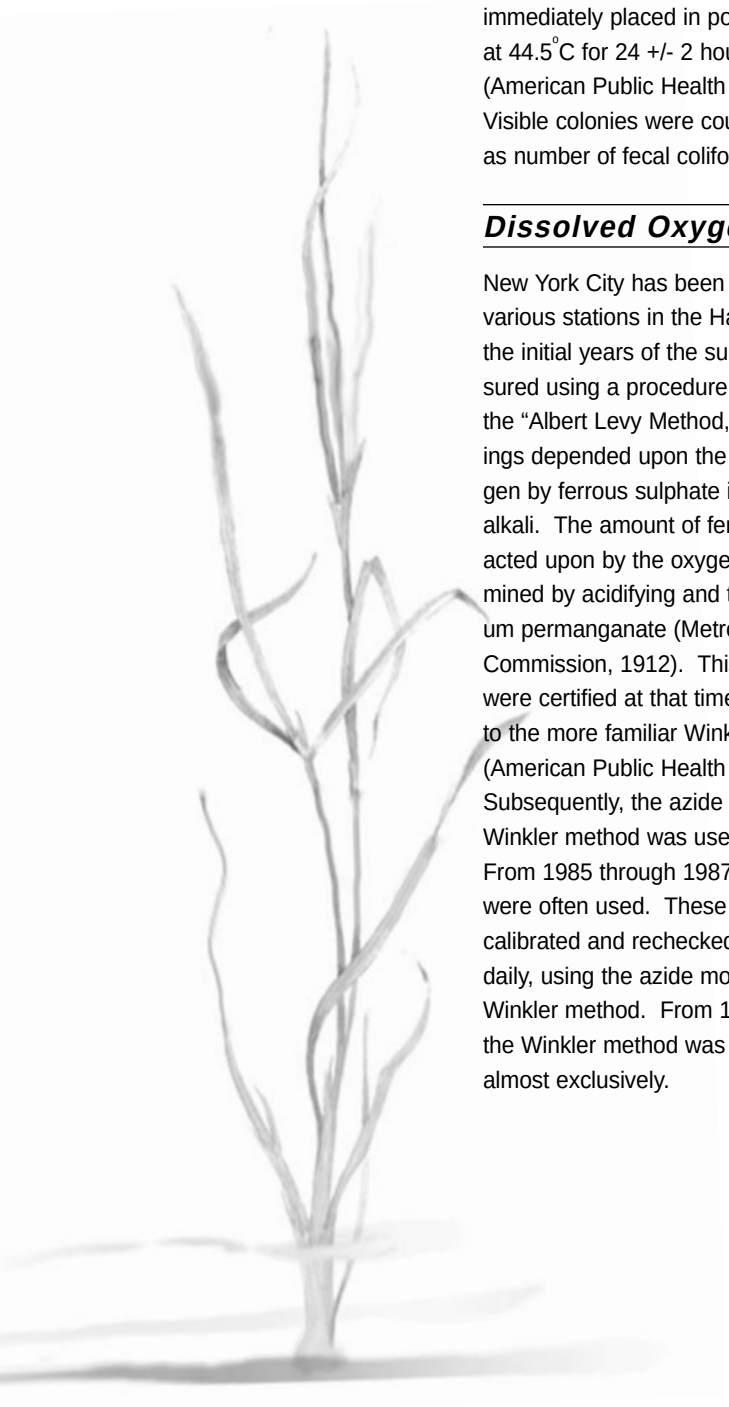
TABLE 2

NYC DEP New York Harbor Water Quality Survey Program

Analysis	Year Started & Initial # of Sites	Status
Dissolved Oxygen	1909 at 12 sites	Ongoing
Temperature/Salinity	1914 at 18 sites	Ongoing
BOD (5 day)	1935 at 33 sites	Discontinued in 1997
Tidal Cycle Studies	1923 at 3 sites	Discontinued in 1996
Total Coliform	1935 at 33 sites	Discontinued in 1997
Fecal Coliform (MF)*	1974 at 40 sites	Ongoing
Nutrients†	1974 at 40 sites	Ongoing
Plankton†	1978 at 40 sites	Ongoing at 27 sites
Chlorophyll 'a'†	1986 at 52 sites	Ongoing
pH	1985 at 52 sites	Ongoing
Secchi Transparency	1985 at 52 sites	Ongoing
CTD	1990 at 52 sites	Ongoing
TSS	1990 at 52 sites	Ongoing

* *Coliform is only measured June - September*
MF *Membrane Filter Method*
† *Nutrients, Plankton and Chlorophyll 'a' measured only in surface waters*
CTD *Conductivity, Temperature and Depth (transmissometer and fluorometer added in 1992)*

Priority pollutants, i.e., volatile organics in water and metals in sediment, have also been measured infrequently (see earlier Harbor Survey Reports).



fecal coliform concentrations. The membrane was aseptically removed from the filter holder and placed into a 47 mm petri dish containing M-FC media. Petri dishes were immediately placed in portable incubators at 44.5°C for 24 +/- 2 hours of incubation (American Public Health Association, 1985). Visible colonies were counted and reported as number of fecal coliform/100 ml.

Dissolved Oxygen

New York City has been monitoring DO in various stations in the Harbor since 1909. In the initial years of the survey, DO was measured using a procedure sometimes called the "Albert Levy Method," in which DO readings depended upon the absorption of oxygen by ferrous sulphate in the presence of an alkali. The amount of ferrous sulphate not acted upon by the oxygen was then determined by acidifying and titrating with potassium permanganate (Metropolitan Sewerage Commission, 1912). This method's results were certified at that time to be identical to the more familiar Winkler method (American Public Health Association 1985). Subsequently, the azide modification of the Winkler method was used through 1984. From 1985 through 1987, YSI DO meters were often used. These DO meters were calibrated and rechecked two or three times daily, using the azide modification of the Winkler method. From 1988 through 1997, the Winkler method was once again used almost exclusively.

Nutrients

Sampling for ammonium (NH4-N), nitrate-nitrite (NO3-N and NO2-N), total phosphorus, and orthophosphate (PO4-P), has increased from a single sample per site each summer (1974-1983) to monthly surface and bottom sampling in 1985, 1986 and 1987. Laboratory constraints in 1988 forced a decrease in sampling to half the stations monthly, as top and bottom composites. From 1989 to 1997, in an effort to assess the within-season variability of these nutrients, surface waters were sampled at all stations twice per month. In 1996, analysis of Total Kjehldahl Nitrogen (TKN) was added.

Total phosphorus and TKN samples were placed directly in sample-rinsed 125 ml polypropylene bottles, acidified with sulfuric acid to pH <2, and placed in coolers for transport back to the Wards Island laboratory. For ammonium, nitrate-nitrite, and orthophosphate samples, 250 ml were immediately filtered on-board through pre-rinsed 0.45 micron membrane filters, preserved with sulfuric acid in polypropylene bottles, and transported back to the lab. Prior to 1989, nutrient concentrations were measured using a Technicon Auto Analyzer II, according to Methods for Chemical Analysis of Water and Wastes (US EPA, 1979). Since 1989, a TRAACS 800, using the modified Industrial Method (Bran and Luebbe, Inc., 1986) has been used.

In support of modeling and clean-up activities associated with the Long Island Sound Study, and at the bequest of USEPA and NYSDEC, the Harbor Survey Program has been expanded since 1989 to include more intensive monitoring of the East River-Long Island Sound transect. In coordination with the Connecticut Department of Environmental Protection (CT DEP) and the Interstate Sanitation Commission (ISC), monthly monitoring of the entire Long Island Sound, from the Battery to the Race, is performed year-round. Samples collected for this program are analyzed by CT DEP's contractor laboratory and provide data on particulate and dissolved carbon, nitrogen, phosphorus, silica, chlorophyll 'a', total suspended solids, 5-day BOD, DO, and conventional parameters.

Chlorophyll 'a' and Plankton

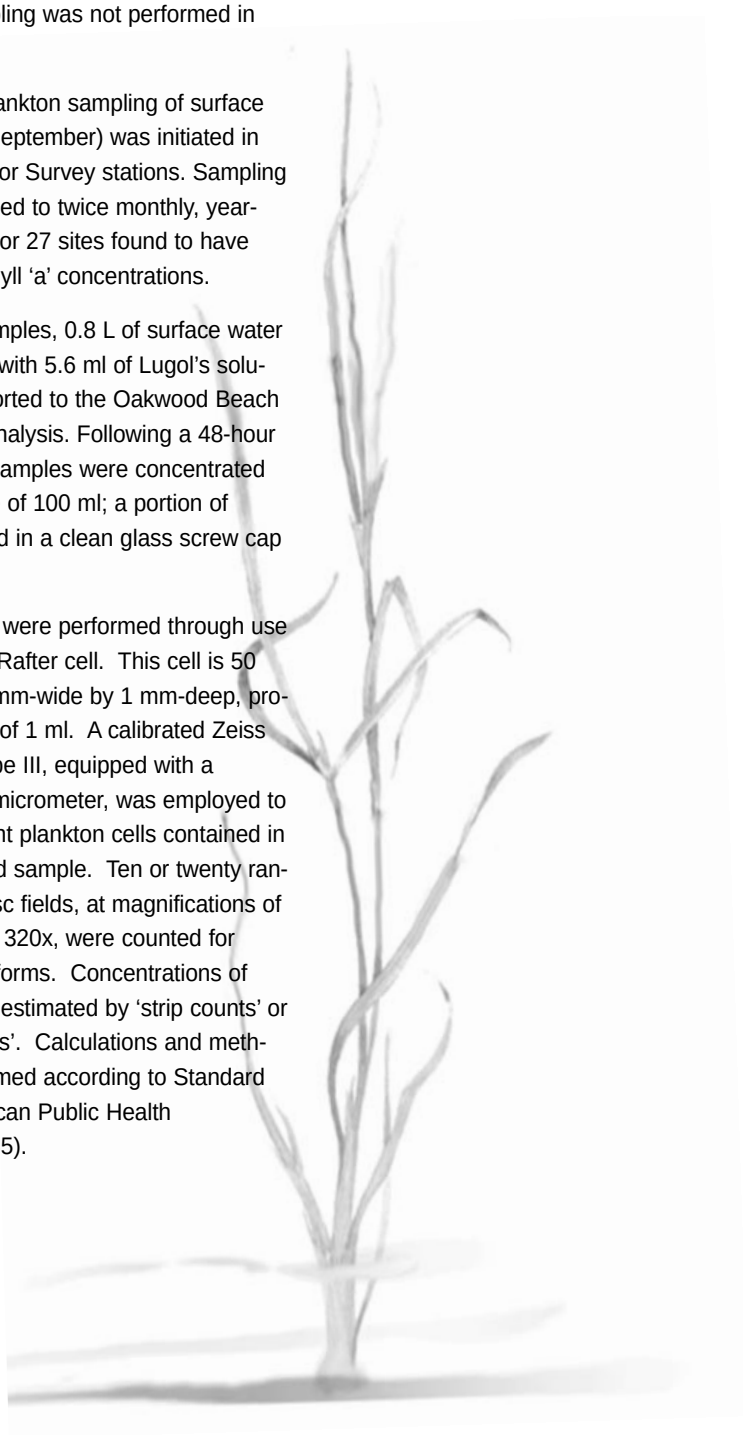
Chlorophyll 'a' is measured and plankton samples are taken from surface waters only. Chlorophyll 'a' (corrected for phaeophytin) is determined fluorometrically following on-board filtration of 250 ml through a 0.45 micron membrane filter and extraction in aqueous acetone, as detailed in Standard Methods (American Public Health Association 1985).

Chlorophyll 'a' has been measured since 1986 as an estimate of phytoplankton biomass. It was recognized that the previous monthly sampling rate was often inadequate to capture natural variability for this parameter. In response, the frequency of chlorophyll collections was increased to twice per month at 26 of 52 stations starting in 1988, and for all 52 stations beginning in 1989. Sampling for chlorophyll 'a', initially conducted from June-September, was increased to year-round for years 1991-1996. November and December sampling was not performed in 1997.

Monthly phytoplankton sampling of surface waters (June - September) was initiated in 1978 at 40 Harbor Survey stations. Sampling rate was increased to twice monthly, year-round, in 1992, for 27 sites found to have highest chlorophyll 'a' concentrations.

For plankton samples, 0.8 L of surface water were preserved with 5.6 ml of Lugol's solution, and transported to the Oakwood Beach Laboratory for analysis. Following a 48-hour settling period, samples were concentrated to a final volume of 100 ml; a portion of which was stored in a clean glass screw cap vial for analysis.

Plankton counts were performed through use of a Sedgewick-Rafter cell. This cell is 50 mm long by 20 mm-wide by 1 mm-deep, providing a volume of 1 ml. A calibrated Zeiss Photo microscope III, equipped with a Whipple ocular micrometer, was employed to identify and count plankton cells contained in this concentrated sample. Ten or twenty random Whipple disc fields, at magnifications of 125x, 200x and 320x, were counted for more abundant forms. Concentrations of rare forms were estimated by 'strip counts' or by 'survey counts'. Calculations and methods were performed according to Standard Methods (American Public Health Association, 1985).



Secchi Transparency

Determination of surface water transparency has been performed since 1985 through use of a standard black and white quadrant Secchi disk. Measurements are recorded to the nearest half foot demarcation.

Temperature, Salinity, and Density

Beginning in June 1992, temperature, salinity, and density profiles of the water column for each station were obtained using a Sea-Bird SBE 25-03 Sealogger CTD (see previous Harbor Survey Reports for earlier instrumentation employed). This instrument is capable of taking four readings per second of conductivity and temperature. Software supplied by the manufacturer enables the calculation of salinity from these values. The instrument is also configured with other sensors, including a fluorometer, a 10cm wavelength transmissometer, and a polarographic dissolved oxygen sensor. These data are used to generate profiles for each parameter down through the entire water column (to within one meter of the bottom) at each sampling station. Duplicate analyses were performed at one random station per day.

Additional Parameters

For sampling and methods pertaining to additional parameters collected as part of the Harbor Survey Program (see table above), but not described in this report, the reader is referred to the 1995 Harbor Survey Report (O'Shea and Brosnan, 1997).

Marine Sciences Section personnel perform fecal filtrations aboard Osprey

Statistical Analysis and Data Presentation

Long-term linear trends were evaluated by regression analysis at a significance level of probability ($p < 0.05$), unless otherwise noted, using Statistical Analysis System (SAS). Data sets which did not display normal distributions (i.e., coliform) were log-transformed prior to trend analysis. Descriptive statistics (average, range, coefficient of variation, number of samples, etc.), as well as, raw data are available upon request.

This report displays high to low parameter gradients through use of concentration distribution maps. Concentration gradients depicted on these maps reflect standards (e.g., DO and coliform) or other environmentally meaningful concentrations, where available. Note that these concentrations are really site specific and extrapolation to other areas depicted should be interpreted with caution. Maps and waterways are not drawn to scale.

Quality Assurance/ Quality Control

Daily quality control procedures for parameters included: analysis of duplicate, spike, and blank samples, as well as, two reference standards; instrumentation check; replicated and documented calibrations of meters; and comparison of results between analysts.

Sampling Hudson River waters along side Battery Park