U.S. ENVIRONMENTAL PROTECTION AGENCY

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1989

ENVIRONMENTAL SERVICES DIVISION
REGION 2
NEW YORK, NEW YORK 10278

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1989

Prepared By: United States Environmental Protection Agency
Region II - Surveillance and Monitoring Branch
Edison, New Jersey 08837

Regina Mulcahy 8/9/90
Regina Mulcahy, Environmental Scientist

Helen Taylor 8/9/90
Helen Taylor, Environmental Scientist

ABSTRACT

The purpose of this report is to disseminate technical information gathered by the U.S. Environmental Protection Agency (EPA), Region 2, during the 1989 New York Bight Water Quality Monitoring Program. The monitoring program was conducted using the EPA helicopter for water quality sample collection. During the period from May 18 to September 25, 1989, approximately 160 stations were sampled each week, weather permitting. The Bight sampling program consisted of five separate sampling networks. Sampling was conducted 5 days a week and extended to 6 days a week in July and August.

Bacteriological data indicated that fecal coliform densities at the beaches along both the New Jersey and Long Island coasts were well within the acceptable Federal guidelines and State limits for primary contact recreation (a geometric mean of 200 fecal coliforms/100ml). A total of 353 samples were collected for fecal coliform and enterococcus analysis along the New Jersey coast. Except for two occasions, fecal coliform densities along the New Jersey coast were all below the New Jersey bathing water quality standard of 200 fecal coliforms/100ml. A total of 131 samples were collected for fecal coliform and enterococcus analysis along the Long Island coast. The highest density recorded was 26 fecal coliforms/100ml. The recommended EPA criterion for enterococci in marine waters

is a geometric mean of 35 enterococci/100ml. Individual enterococcus densities exceeded 35 enterococci/100ml only twice during the summer along the New Jersey coast, and only three times along the Long Island coast. However, all the geometric means were below the criterion.

Dissolved oxygen levels in 1989 were typical in comparison to previous years. The average dissolved oxygen concentrations along the New Jersey perpendiculars, the Long Island perpendiculars and in the New York Bight Apex remained above 4.5 mg/l, with the exception of the northern New Jersey perpendiculars which had some lower values. The northern perpendiculars declined steadily from early August through mid September, but values remained in the "borderline to healthy" range (4-5 mg/l) for aquatic organisms. Averages for the Bight Apex and the northern New Jersey coast were somewhat lower than preceding years. However, values have remained higher than those of 1985 when, in mid to late summer, approximately 1600 square miles of ocean bottom off New Jersey were plagued with dissolved oxygen concentrations considered stressful for aquatic life, over extended periods of time.

During the summer, phytoplankton blooms were observed over extensive areas. During the summer, most beaches along New Jersey were affected by blooms of short duration. Algal blooms of longer duration occurred in the intercoastal bays of New Jersey and Long Island. Red algal blooms were predominant in Raritan and Sandy Hook Bays. A summary of bloom incidence is presented in Appendix A. The green tide, which occurred along the southern New Jersey coast in 1984 and 1985, did not recur in 1989. The 1984 and 1985 blooms were caused by the organism Gyrodinium aureolum.

Beach closures due to wash-ups of floatable debris were less frequent in 1989 than in 1988. This was largely due to the initiation of a short term action plan aimed at addressing floatable debris in the New York Harbor Complex. This was, and will continue to be, a cooperative monitoring and response effort on the part of various federal, state and local government agencies. Beaches in New Jersey were closed only on two occasions due to floatable debris. Appendix B presents a summary of the season's floatable observations.

TABLE OF CONTENTS

LIST OF FIGURES

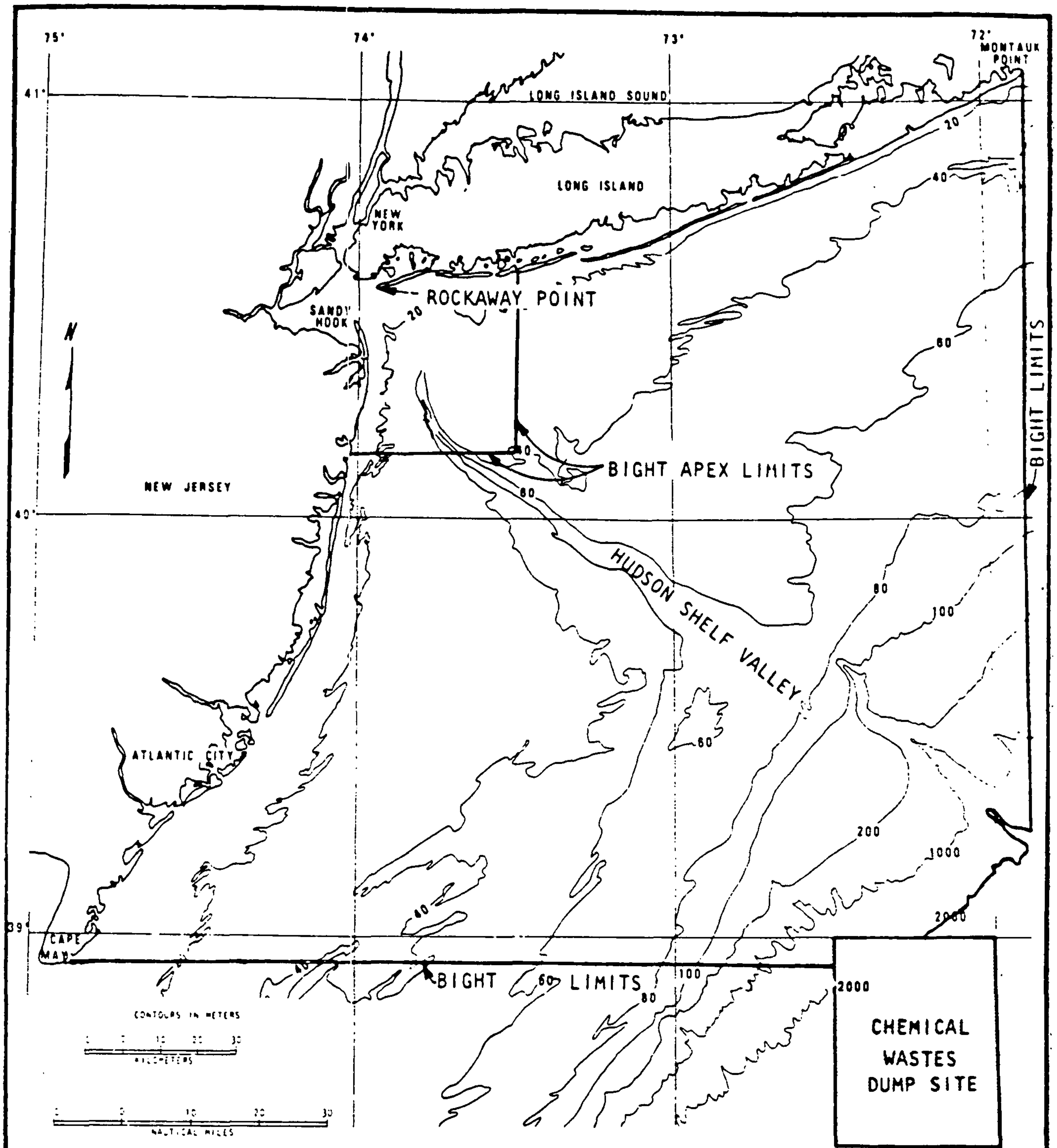
LIST OF TABLES

I. INTRODUCTION

The U.S. Environmental Protection Agency has prepared this report to disseminate environmental data for the New York Bight Apex and the shorelines of New York and New Jersey. The New York Bight is an area of ocean bounded on the northwest by Sandy Hook, the northeast by Montauk Point, the southeast by the 2000 meter contour line, and the southwest by Cape May. Figure 1 shows the limits of the New York Bight. The New York Bight Apex, which contains the inactive sewage sludge and acid waste disposal sites, and the active dredged material and cellar dirt disposal sites, is shown in Figure 2.

This report is the sixteenth in a series and reflects the monitoring period between May 23, 1989 and September 25, 1989. The New York Bight Water Quality Monitoring Program is EPA's response to its mandated responsibilities as defined under the Marine Protection, Research and Sanctuaries Act of 1972, the Water Pollution Control Act Amendments of 1972 and 1977, and the Water Quality Act of 1987.

Since its initiation in 1974, the New York Bight Water Quality Monitoring Program has been modified several times to be more responsive to the needs of the general public, the states, the counties, and EPA; and to concentrate on specific areas of concern during the critical summer



THE NEW YORK BIGHT

Figure 1

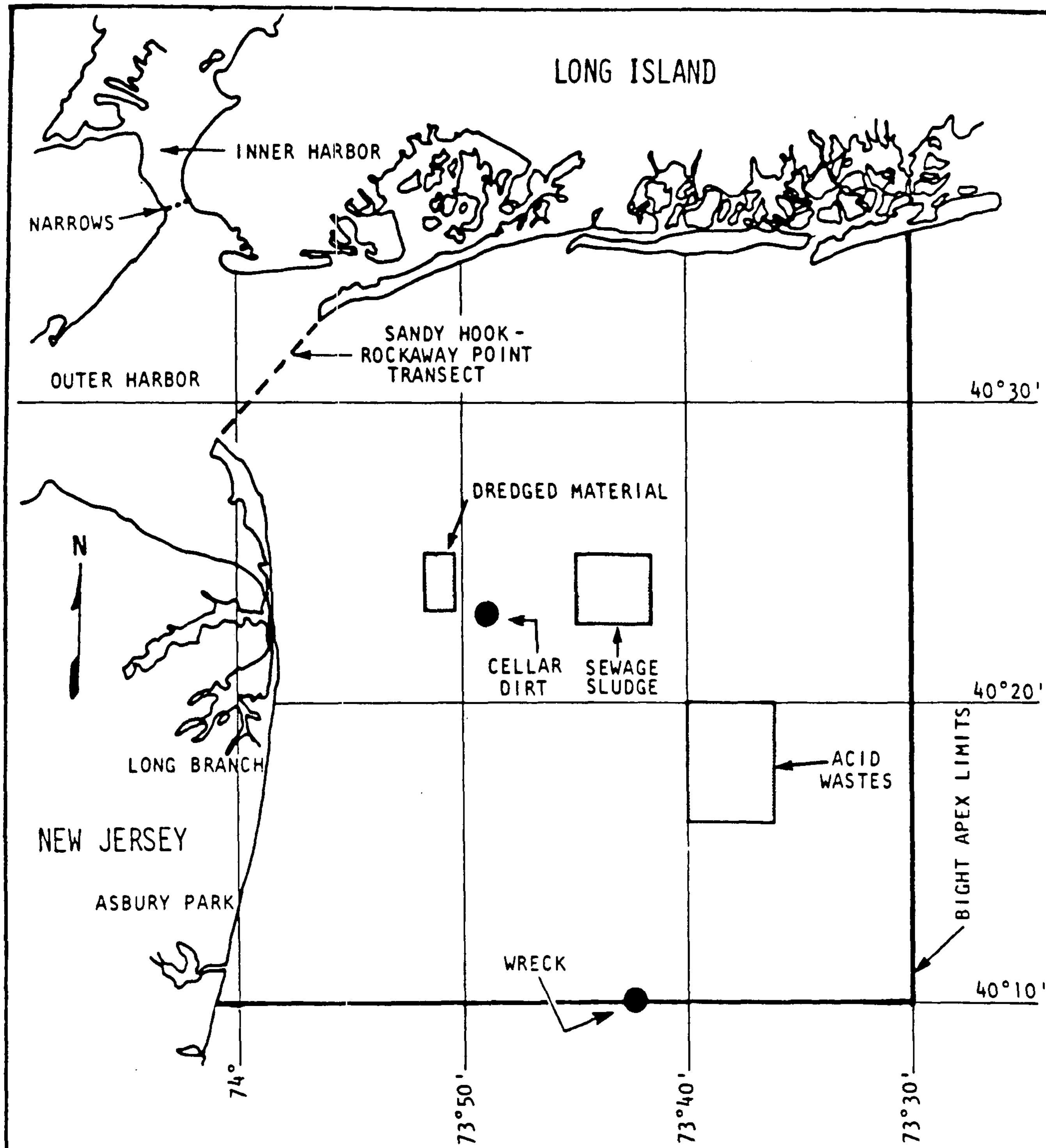
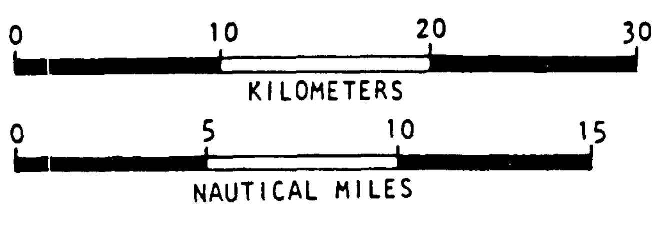


Figure 2

BIGHT APEX AND EXISTING DUMP SITES



period. Most of these changes occurred after the summer of 1976, when anoxic conditions caused a fishkill in the Bight and an unusually heavy wash-up of debris occurred on Long Island beaches. It was clear that summer conditions in the Bight called for more intensive monitoring in order to predict environmental crises, investigate the origins of these crises, and direct any decisions regarding protection of the Bight's water quality.

In 1986, the monitoring program was modified to intensify sampling activities along the southern New Jersey beaches. During mid to late summer in 1985, beaches along the southern New Jersey coast were affected by algal blooms, which caused "green tide", and high bacterial counts which resulted in beach closings. To improve monitoring coverage, four additional beach stations between Long Beach Island and Wildwood were sampled weekly for phytoplankton. In addition, bacteria samples were collected weekly rather than bimonthly along the southern New Jersey beaches.

Since 1987, phytoplankton, chlorophyll a, and nutrient samples have been collected at all Long Island beach stations and Long Island perpendicular stations. During 1989, the nutrient samples were deleted.

In August 1987, a 50-mile slick of garbage washed ashore along mid to southern New Jersey. This precipitated the need for daily floatables observations to be recorded from the helicopter during 1988. This surveillance was carried over into 1989 in response to the "Short Term Action Plan for Addressing Floatables Debris in the New York Bight" (USEPA, 1988). Essentially, a monitoring and response network was established to locate and coordinate cleanup operations for slicks found in the New York Harbor Complex. The intent was to prevent slick materials from escaping the harbor and potentially stranding on regional beaches. Details can be found in the action plan. Appendix B contains a report summarizing the surveillance observations.

II. SAMPLE COLLECTION PROGRAM

During the period of May 1989 through September 1989, water quality monitoring was carried out primarily using a Bell Jet Ranger helicopter. Under the established protocol, sampling normally occurred 5 days a week and was extended to 6 days a week during July and August. Table 1 outlines the 1989 sampling program. Table 2 lists the parameters analyzed for each group of stations.

The monitoring program was composed of four separate sampling networks. The beach station network was sampled to gather bacteriological water quality information at 26 Long Island coast stations and 46 New Jersey coast stations. The New York Bight station network was sampled to gather chemical information at 20 stations in the inner New York Bight. The perpendicular station network consisted of 12 transects extending from the New Jersey and Long Island coasts. Three transects extended south from the Long Island coast, with 4 stations in each transect, and 9 transects extended east from the New Jersey coast, with 5 stations in each transect. The transects covered the inner Bight from Jones Beach on Long Island to Strathmere, on the New Jersey coast. Samples were collected for dissolved oxygen and temperature. The phytoplankton sampling network consisted of 53 stations. Samples for phytoplankton identification were collected

Table 1

Outline of 1989 Sampling Program

Station Group	Frequency per Week	Parameter	Sample Depth
Long Island Beaches (Rockaway Pt. to Shinnecock Inlet)	1	Bacteriological Phytoplankton Chlorophyll	Top[1]
New Jersey Beaches (Sandy Hook to Cape May)	1	Bacteriological	Top[1]
Long Island Perpendiculars	1	Dissolved Oxygen Phytoplankton Chlorophyll Temperature	Top[1], Bottom[2]
North Jersey Perpendiculars (Long Branch to Strathmere)	1	Dissolved Oxygen Temperature	Top[1], Bottom[2]
New Jersey Phytoplankton Station Network	1	Phytoplankton Chlorophyll	Top[1]
Inner New York Bight	1	Temperature Dissolved Oxygen	Top[1], Bottom[2]

[1] One meter below the surface
[2] One meter above the ocean floor

Table 2

Parameters evaluated for each station group

Parameters	L.I. & N.J. Beaches[1]	L.I. & N.J. Perpendiculars[2]	N.Y. Bight[2]	Phytoplankton[1]
Fecal Coliform	X		X	
Enterococcus	X			
Temperature		X	X	
Dissolved Oxygen (DO)		X	X	
Plankton		X[4]		X
Chlorophyll	X[3]	X[4]		X

[1]Sample Depth: 1 meter below the surface
[2]Sample Depth: 1 meter below the surface and 1 meter above the ocean floor
[3]Long Island beach stations and select New Jersey beach stations only
[4]Long Island perpendiculars only

along the New Jersey coast and in Raritan Bay, Barnegat Bay and Delaware Bay at 15 stations, along the Long Island coast at 26 stations, and at the 12 Long Island perpendicular stations. The weekly sampling program averaged approximately 160 stations.

Beach stations along New York and New Jersey were sampled once a week for fecal coliform and enterococcus bacteria densities. This portion of the sampling program totaled 72 stations per week. At the beach stations, samples were collected just offshore in the surf zone, while the helicopter hovered approximately 3 meters from the surface. Sampling was accomplished by lowering a 1-liter Kemmerer sampler approximately 1 meter below the water surface. The sample was transferred to a sterile plastic container, iced and subsequently transported (within 6 hours) to the Edison Laboratory for fecal coliform and enterococcus analyses.

The twenty stations in the Bight Apex were sampled once a week. Depending upon sea conditions, the EPA helicopter hovered or landed at the designated station and a 1-liter Kemmerer sampler was used to obtain water samples. Normally, samples are taken at 1 meter below the surface and 1 meter above the ocean bottom. However, due to the space and weight limitations of the Bell Jet Ranger, only bottom samples were collected. After collection, the water sample was transferred to a BOD bottle for dissolved oxygen analysis. The dissolved oxygen sample was immediately fixed at the station by the addition of 2 ml of manganous sulfate followed by 2 ml of alkali-iodide-azide reagent. The sample was shaken to facilitate floc formation and then placed in a metal rack. The samples were held for less than 6 hours before returning to the laboratory, where 2 ml of sulfuric acid were added, and the samples were titrated with 0.0375N sodium thiosulfate.

The third scheduled sampling portion of the program consisted of sampling perpendicular stations once a week for dissolved oxygen and temperature. Again, as with the inner Bight stations, samples were collected while hovering or landing, at 1 meter above the ocean bottom.

The fourth routinely scheduled sampling component involved the collection of water samples for phytoplankton identification and quantification, and chlorophyll analysis. Phytoplankton and chlorophyll samples collected along the New Jersey coast were analyzed by the New Jersey Department of Environmental Protection (NJDEP). Phytoplankton and chlorophyll samples collected along the Long Island coast were analyzed by the Nassau County Health Department. The samples were collected as close to the surface as possible, using 1-liter Kemmerer samplers. A 1-liter plastic cubitainer was filled for phytoplankton analysis. The phytoplankton samples for NJDEP were cooled to $4^{0}C$ for preservation. The phytoplankton samples for the

Nassau County Health Department were not preserved. The NJDEP picked up their phytoplankton samples at our Edison laboratory within 24 hours of collection. At the laboratory, the NJDEP removed an aliquot of sample from the cubitainer for chlorophyll analysis. Along the Long Island beaches, a 500 ml dark brown plastic bottle was filled for chlorophyll analysis. The Nassau County Health Department samples were delivered to the Health Department's laboratory within 4 hours of collection. The results of NJDEP's analyses are contained in Appendix A. A report from the Nassau County Health Department has not been completed.

III. DESCRIPTION OF SAMPLING STATIONS

Beach Stations

A total of 72 bathing beach areas were sampled routinely for bacteriological water quality along the Long Island and New Jersey coastlines. The Long Island sampling stations extend from the western tip of Rockaway Point 130 km eastward to Shinnecock Inlet for a total of 26 stations (LIC 01-LIC 28). Sample station locations, nomenclature, and descriptions are given in Table 3 and Figure 3. There are 46 New Jersey coast stations, beginning at Sandy Hook extending south to Cape May Point (JC 01A-JC 99). These stations are described and identified in Table 4 and in Figures 4 and 5.

New York Bight Stations

The New York Bight stations, established as part of the original ocean monitoring program, cover the inner Bight area in approximately 3 km intervals via three transects as follows: New Jersey Transect (NYB 20-NYB 27), extending from Sandy Hook 20 km eastward to the sewage sludge dump site; Raritan Bay Transect (NYB 32-NYB 35), projecting along the Ambrose Channel from the mouth of Raritan Bay, southeast to the sewage sludge dump site; and the Long Island Transect (NYB 40-NYB 47), extending from Atlantic Beach, Long Island, southward to just beyond the sewage sludge dump site. The locations of the New York Bight stations are shown in Figure 6.

Table 3

Long Island coast station locations

Station No.	Location
LIC 01	Rockaway Point, Breezy Point Surf Club
LIC 02	Rockaway, off foot of B169 Road
LIC 03	Rockaway, off foot of B129 Road
LIC 04	Rockaway, off foot of B92 Road
LIC 05	Far Rockaway, off foot of B41 Road
LIC 07	Atlantic Beach, Silver Point Beach Club
LIC 08	Long Beach, off foot of Grand Avenue
LIC 09	Long Beach, off foot of Pacific Boulevard
LIC 10	Point Lookout, off Hempstead public beach
LIC 12	Short Beach (Jones Beach), off "West End 2" parking lot
LIC 13	Jones Beach
LIC 14	East Overlook
LIC 15	Gilgo Beach
LIC 16	Cedar Island Beach
LIC 17	Robert Moses State Park
LIC 18	Great South Beach
LIC 19	Cherry Grove
LIC 20	Water Island
LIC 21	Bellport Beach
LIC 22	Smith Point County Park
LIC 23	Moriches Inlet West
LIC 24	Moriches Inlet East
LIC 25	West Hampton Beach
LIC 26	Tiana Beach
LIC 27	Shinnecock Inlet West
LIC 28	Shinnecock Inlet East

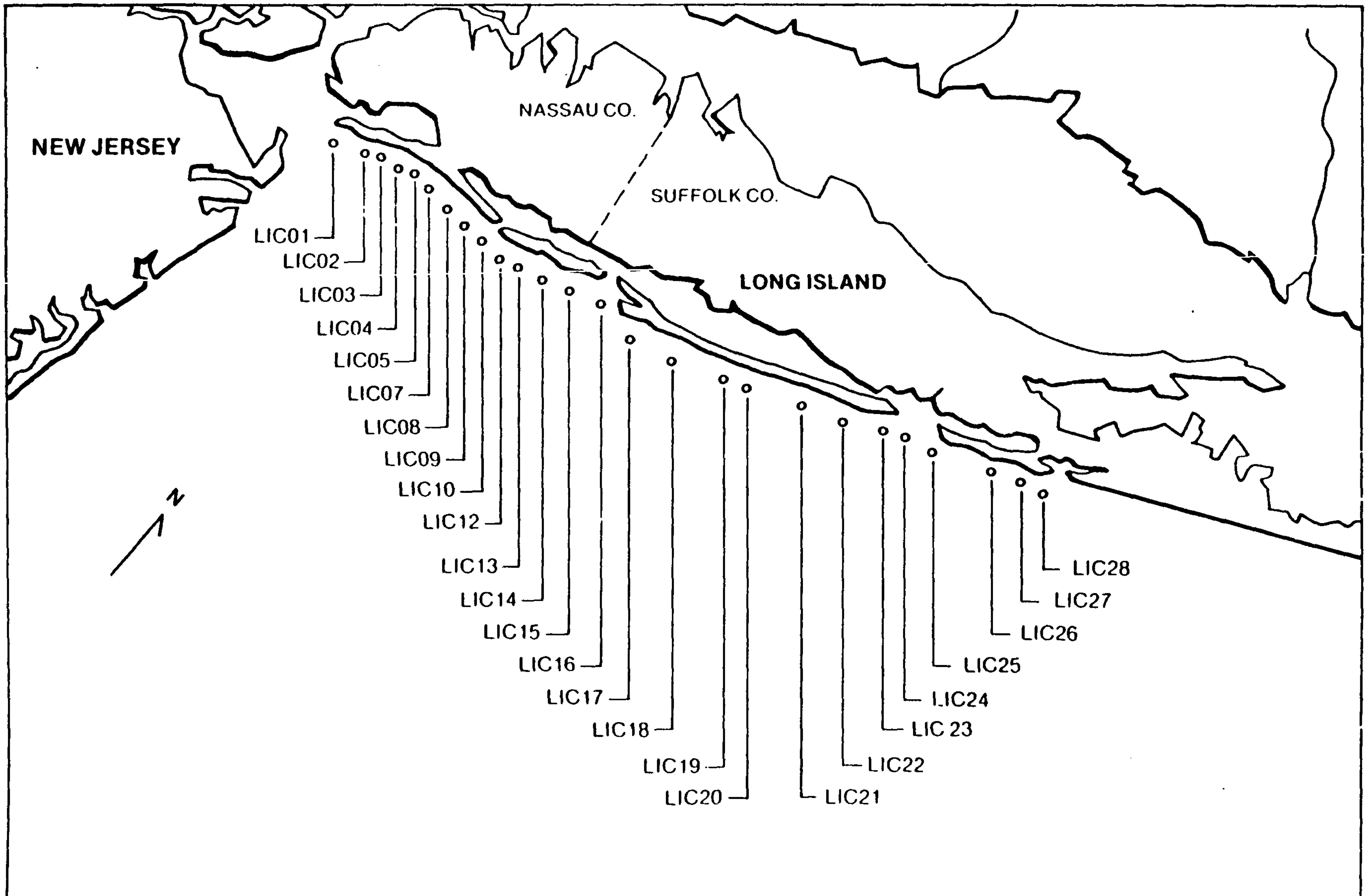


FIGURE 3
LONG ISLAND COAST STATION LOCATIONS

Table 4

New Jersey coast station locations

Station No.	Location
JC 01A	Sandy Hook, 1.2 km south of tip
JC 03	Sandy Hook, off Nature Center building (tower)
JC 05	Sandy Hook, just north of Park entrance
JC 08	Sea Bright, at public beach
JC 11	Monmouth Beach Bath & Tennis Club
JC 13	Long Branch, Chelsea Avenue
JC 14	Long Branch, off foot of S. Bath Avenue
JC 21	Asbury Park, off building north of Convention Hall
JC 24	Bradley Beach, off foot of Cliff Avenue
JC 26	Shark River Inlet
JC 27	Belmar, off the "White House" near fishing club pier
JC 30	Spring Lake, south of yellow brick building on beach
JC 33	Sea Girt, off foot of Chicago Avenue
JC 35	One block north of Manasquan Inlet
JC 36	Manasquan Inlet, off Third Avenue
JC 37	Point Pleasant, south of Manasquan Inlet
JC 41	Bay Head, off foot of Johnson Street
JC 44	Mantoloking, off foot of Albertson Street
JC 47A	Silver Beach, off foot of Colony Road
JC 49	Lavallette, off foot of Washington Avenue

Table 4 (continued)

Station No.	Location
JC 53	Seaside Heights, between the amusement piers
JC 55	Island Beach State Park, off white building north of Park Headquarters
JC 57	Island Beach State Park, between two main parking lots in center of park
JC 59	Island Beach State Park, off white house next to the lookout tower
JC 61	Barnegat, first rock jetty south of Barnegat Inlet
JC 63	Harvey Cedars, opposite Harvey Cedars standpipe
JC 65	Ship Bottom, opposite Ship Bottom water tower
JC 67	Beach Haven Terrace, opposite standpipe
JC 69	Beach Haven Heights, opposite the most southern water tower on Long Beach Island
JC 73	Brigantine, off large hotel on beach
JC 74	Absecon Inlet
JC 75	Atlantic City, off the Convention Center
JC 77	Ventnor City, just north of fishing pier
JC 79	Longport, off water tower
JC 81	Ocean City, opposite large apartment building
JC 83	Peck Beach, opposite large blue water tower
JC 85	Strathmere, off blue standpipe
JC 87	Sea Isle City, opposite blue water tower with bridge in the background
JC 89	Avalon, off beige building on the beach

Table 4 (continued)

Station No.	Location
JC 91	Stone Harbor, off large blue water tower
JC 92	Hereford Inlet
JC 93	Wildwood, off northern amusement pier
JC 95	Two mile beach, opposite radio tower
JC 96	Cape May Inlet
JC 97	Cape May, off white house with red roof on the beach
JC 99	Cape May Point, opposite lighthouse

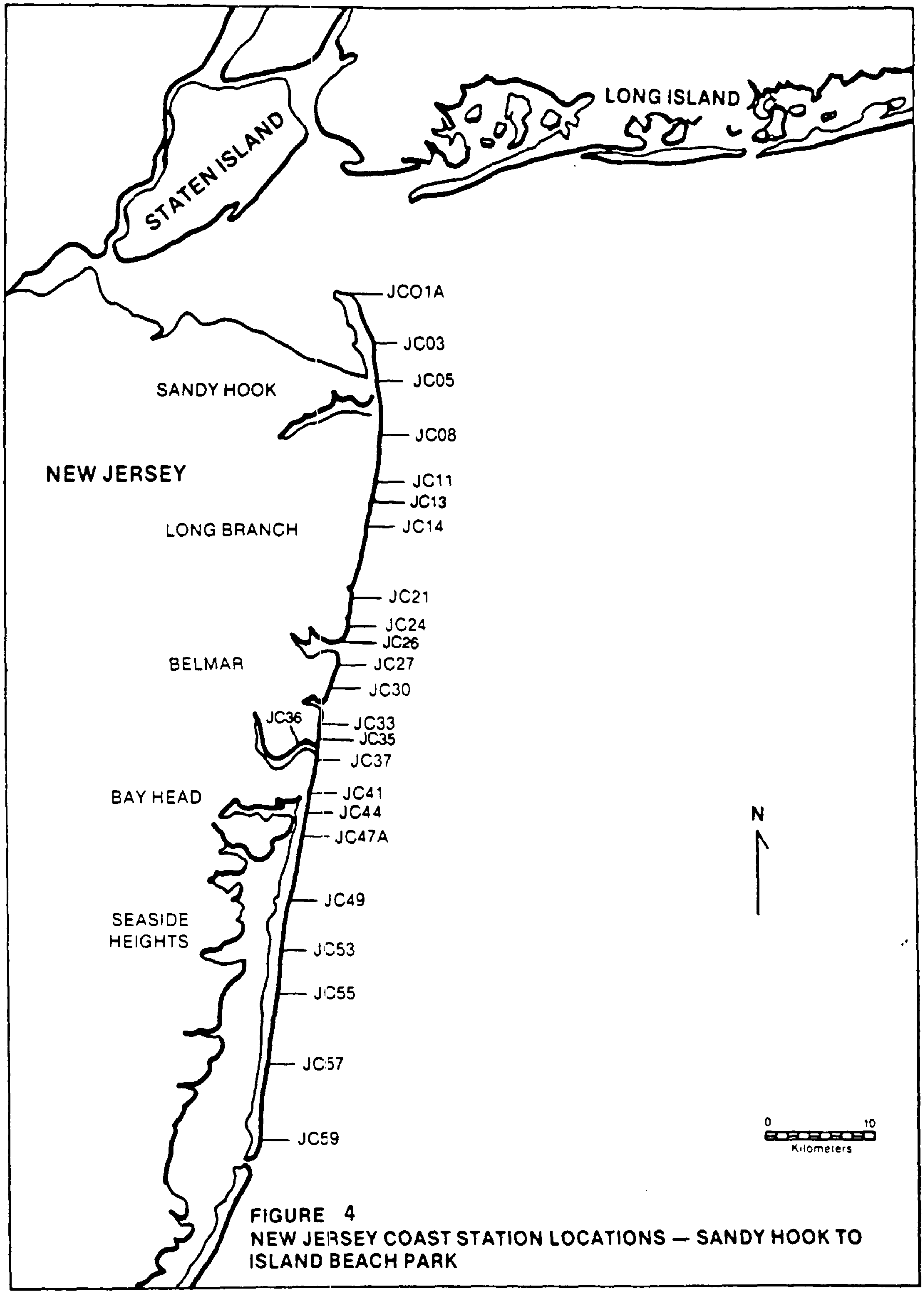


FIGURE 4
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

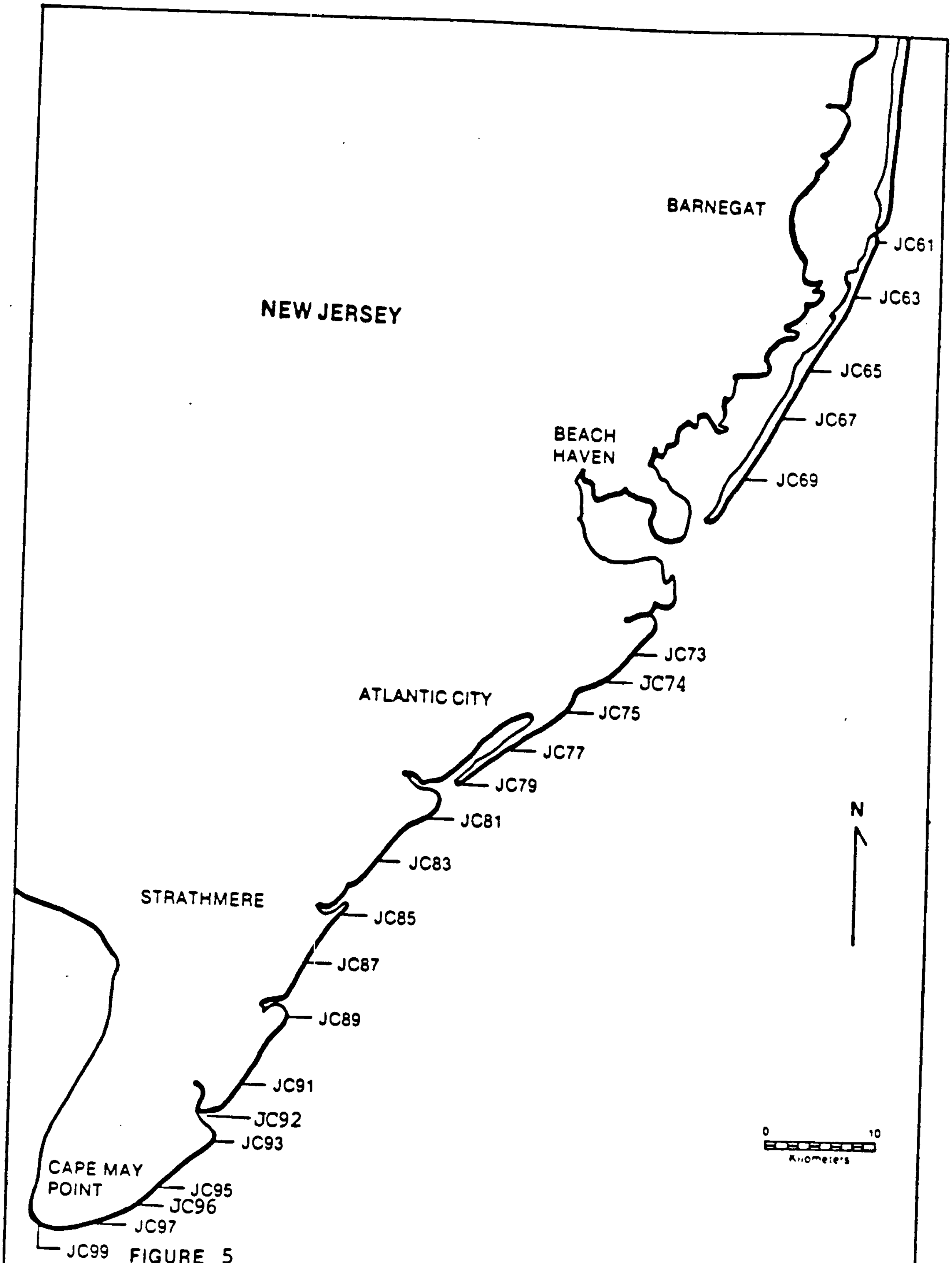


FIGURE 5
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

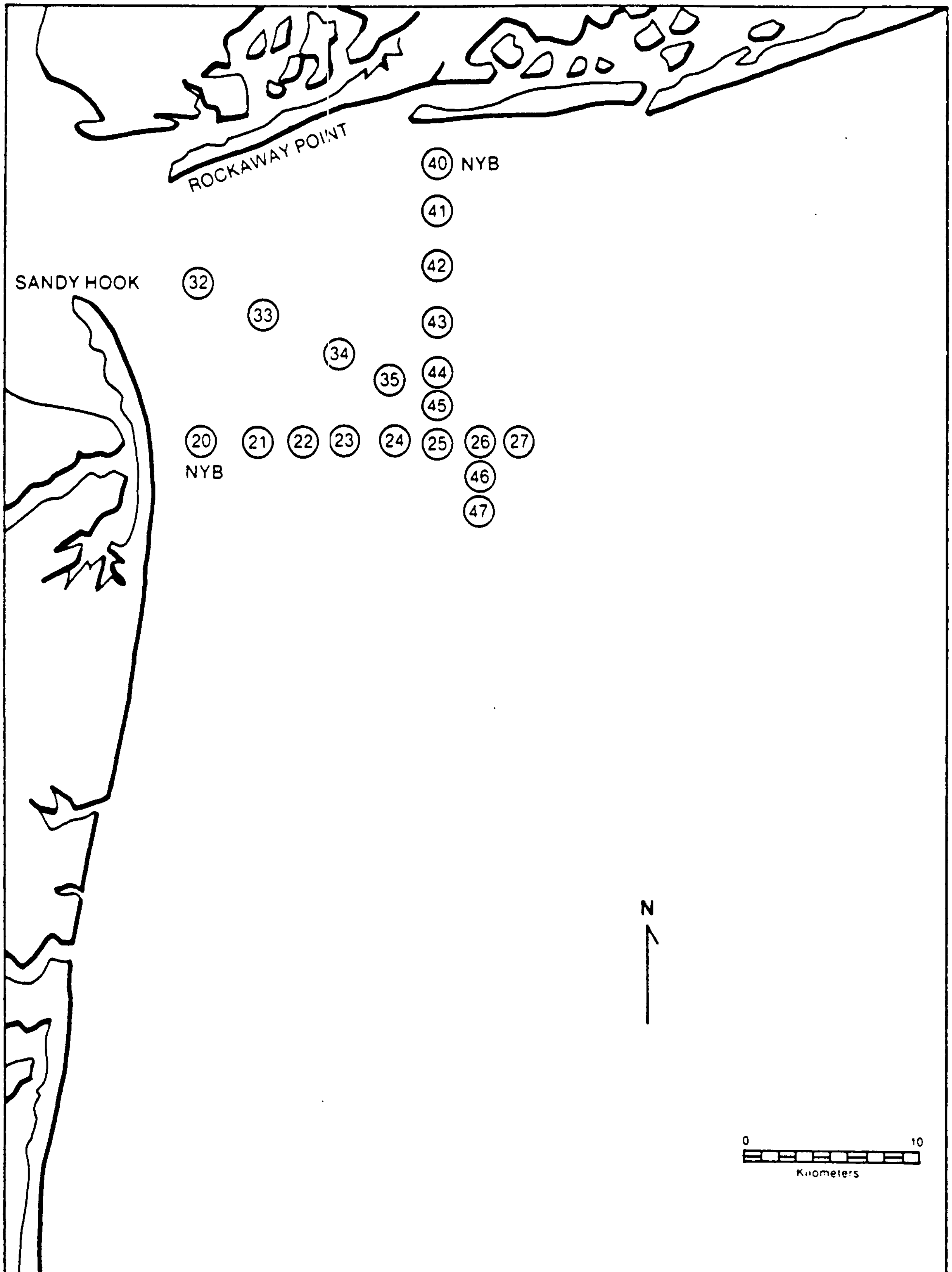


FIGURE 6
NEW YORK BIGHT STATION LOCATIONS

Perpendicular Stations

Sampling stations perpendicular to the Long Island coastline are 1.85 km, 5.55 km, 9.25 km, and 12.95 km [1, 3, 5, and 7 nautical miles (nm)] offshore. Sampling stations perpendicular to the New Jersey coastline start at 1.85 km and are spaced every 1.85 km out to 18.5 km (1 nm, with 1 nm increments, to 10 nm) offshore. These stations are identified by suffixes E through M, with the exception of the Manasquan (MAS) perpendicular stations which have corresponding suffixes 1 through 9. Normally, only every other New Jersey perpendicular station (3.7 km intervals) was sampled; the intermediate stations remained available should dissolved oxygen conditions warrant more intensive sampling.

The perpendicular stations were established to gather surface and bottom dissolved oxygen values in the critical areas of the New York Bight nearshore waters. Previous agreements had been made with the National Oceanic and Atmospheric Administration (NOAA) to provide dissolved oxygen profiles from stations further out in the Bight in conjunction with their existing programs.

The perpendicular stations described above are plotted in Figures 7 and 8. Tables 3 and 4 describe the shore station locations from which the perpendicular stations originate.

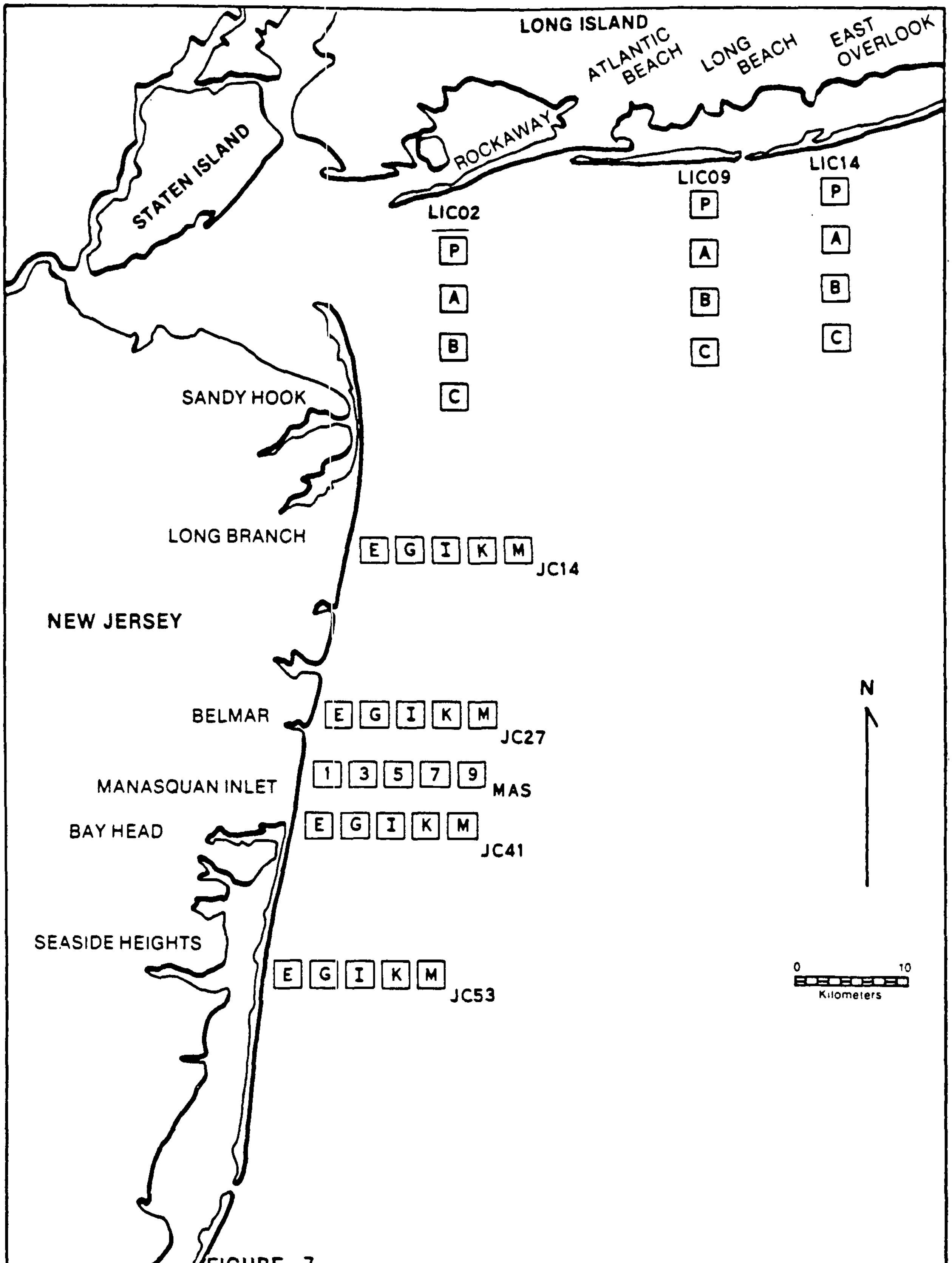


FIGURE 7
LONG ISLAND PERPENDICULAR STATIONS AND NEW JERSEY PERPENDICULAR STATIONS FROM SANDY HOOK TO SEASIDE HEIGHTS

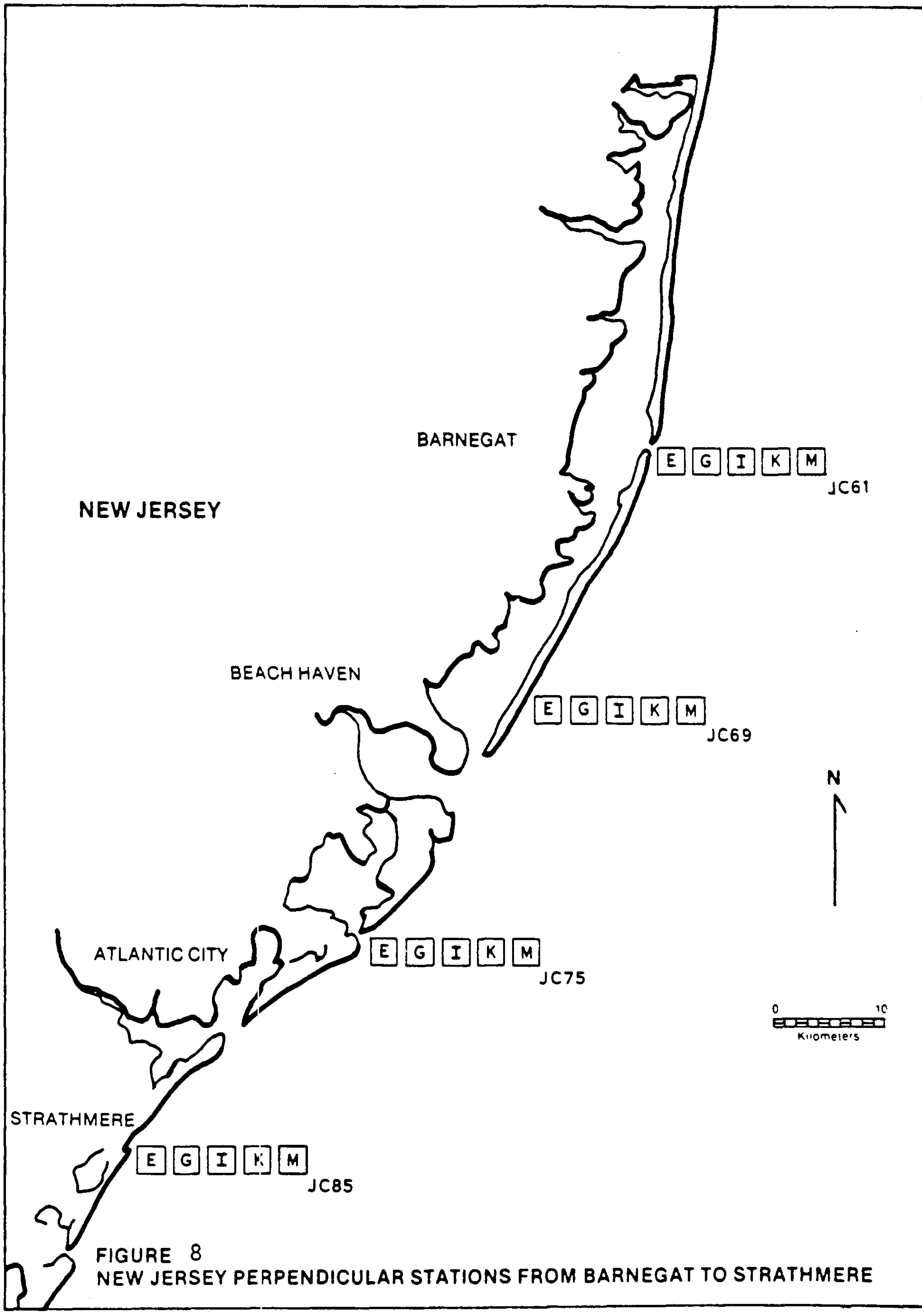


FIGURE 8
NEW JERSEY PERPENDICULAR STATIONS FROM BARNEGAT TO STRATHMERE

Phytoplankton Stations

Phytoplankton samples were collected once a week along the New Jersey coast and in Raritan Bay, Barnegat Bay, Great Egg Harbor and Delaware Bay at the following stations:

RB 32	JC 14	JC 65	BB 1
RB 24	JC 30	JC 75	GE 2
RB 15	JC 41	JC 83	DB 1
JC 08	JC 57	JC 91	

A discussion of phytoplankton dynamics and bloom incidence in New Jersey waters is presented in Appendix A.

Phytoplankton samples were collected at all Long Island beach stations once a week. A report on these samples has not been prepared.

IV. DISSOLVED OXYGEN RESULTS AND DISCUSSION

Normal Trends in the Ocean

Two major processes act to replenish dissolved oxygen in the water column of the New York Bight. These are: the photosynthetic conversion of carbon dioxide to molecular oxygen, and the mechanical reaeration of oxygen across the air-water interface. Subsequent turbulent diffusion then distributes the dissolved oxygen throughout the water column or into the upper warmer surface layer when stratified conditions prevail. Concurrent oxygen utilization (depletion) processes, such as bacterial respiration and sediment oxygen demand, act to influence the amount of oxygen in the water column at any one time or location.

A general description of the oxygen cycle during a calendar year is as follows:

> In early January, the waters of the Bight are completely mixed throughout the water column with temperatures ranging from 4^0C to 10^0C while dissolved oxygen values are between 8 and 10 mg/l with slightly depressed values at the sediment-water interface. The warm spring air temperatures and solar heating increase the temperature of the upper water layer and, in the

absence of high energy input from local storms or tropical hurricanes, a thermally stratified water column develops. This stratification effectively blocks the free transport of the oxygen-rich upper layer into the cool oxygen-poor bottom waters.

As hot summer weather conditions set in, the warmer upper layer of water remains completely mixed and rich in oxygen (7 to 9 mg/l). This upper layer ranges from 20 to 60 meters in depth depending on time and location. The cooler bottom water is effectively isolated from the upper layer by a 10^0C temperature gradient. Respiration of bottom organisms, bacterial action on algal remains and detritus, and sediment oxygen demand depress the residual dissolved oxygen values in the bottom waters. In a typical year, the dissolved oxygen concentration in the bottom waters of the Bight reaches a minimum in mid to late summer of approximately 4 mg/l. At this time, cool evenings and reduced solar input cause the upper waters to cool, decreasing the temperature gradient between the two water masses. As the two masses become closer and closer in temperature, the energy required to break down the thermocline becomes less and less until finally, in many instances after a local storm, there is a complete mixing of the water column with concomitant reoxygenation of the bottom waters. The annual cycle begins again. Figure 9 depicts a representative history of dissolved oxygen concentration in the general ocean area off of New Jersey, New York, and New England.

Dissolved Oxygen Criteria

The dissolved oxygen levels necessary for survival and/or reproduction vary among biological species. Sufficient data have not been accumulated to assign definitive limits or lower levels of tolerance for each species at various growth stages. Rough guidelines are available for aquatic species for purposes of surveillance and monitoring. These are as follows:

5 mg/l and greater	healthy
4 - 5 mg/l	borderline to healthy
3 - 4 mg/l	stressful if prolonged
2 - 3 mg/l	lethal if prolonged
less than 2 mg/l	lethal in a relatively short time.

These criteria are consistent with biological information recorded in the New York Bight over the past 15-20 years. Most data concerning the lower tolerance levels were recorded during the summer of 1976. In 1976, widespread and persistent dissolved oxygen levels between 0.0 and 2.0 mg/l occurred over a large area of the Bight. This resulted in extensive fishkills and benthic organism mortality.

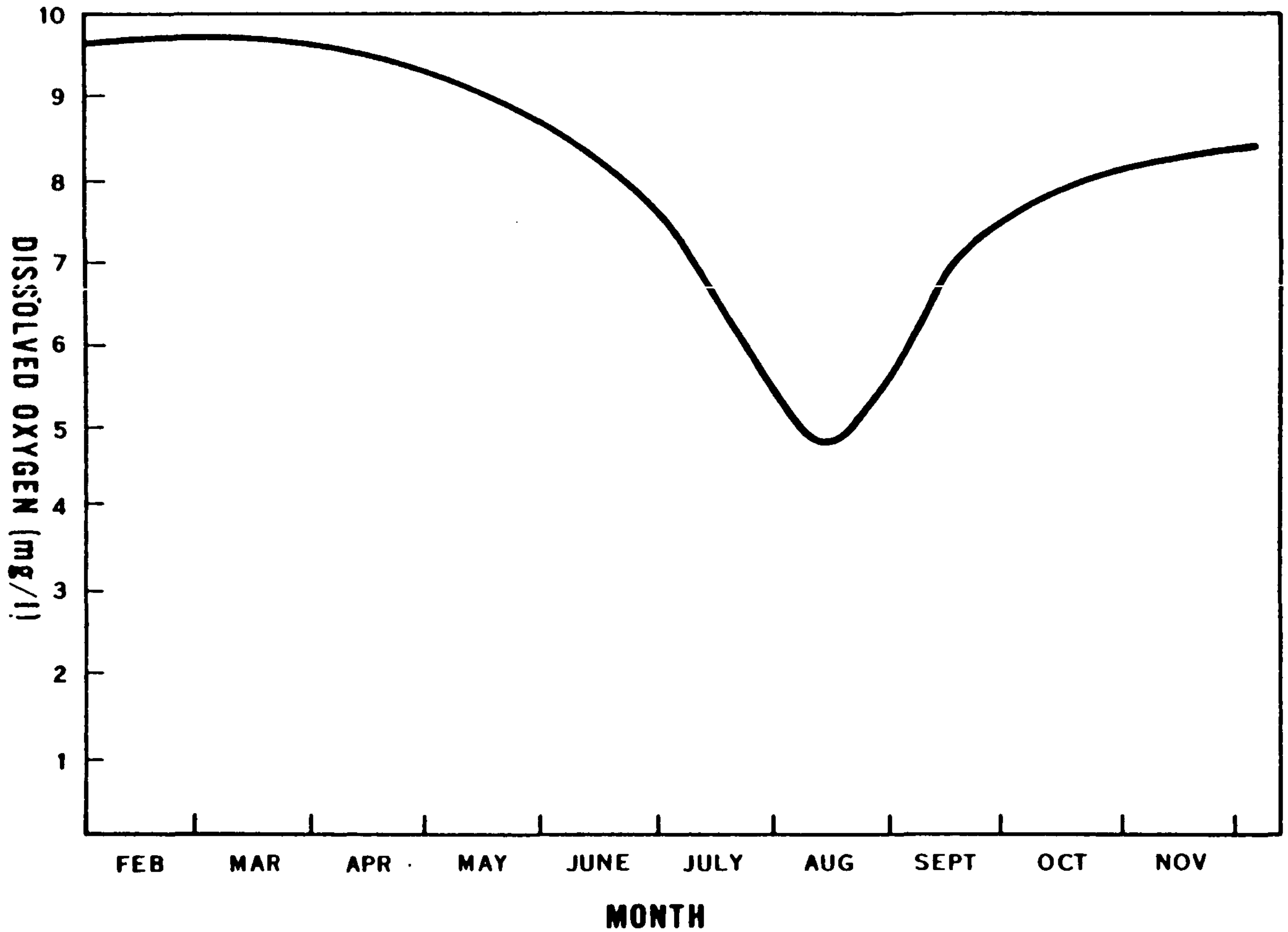


FIGURE 9
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

Surface Dissolved Oxygen - 1989

During the 1989 sampling period, May 18 through September 25, surface dissolved oxygen samples were not taken. Space and weight limitations of the aircraft precluded the collection of both surface and bottom samples. In past years, the upper water column has remained completely mixed with dissolved oxygen levels at or near saturation during the entire sampling period. Due to an above average amount of storms promoting reaeration, there is no reason to suspect that 1989 was any different.

Bottom Dissolved Oxygen - 1989

Long Island Coast

Long Island perpendiculars LIC02, LIC09 and LIC14 were sampled 3 times during the 1989 sampling period. A total of 38 bottom samples were collected for dissolved oxygen. None were below the 4 mg/l "borderline to healthy" guideline. Based on these data, dissolved oxygen remained well above the concentrations considered stressful to aquatic life. The dissolved oxygen concentrations, with the exception of September, remained in the 5-10 mg/l range. In September, two dissolved oxygen concentrations were below 5 mg/l. These two values were:

Station	Date	Dissolved Oxygen (mg/l)
LIC02B	9/28/89	4.6
LIC14B	9/28/89	4.7

These values are within the "borderline to healthy" dissolved oxygen guideline, and are consistent with the normal dissolved oxygen sag curve in the New York Bight Apex. No samples were collected in July or August along perpendiculars LIC02, LIC09 and LIC14. Therefore, it is possible that dissolved oxygen concentrations may have been lower than 5 mg/l during this time. There were no reported fishkills in the ocean off Long Island, and it is probable that prolonged periods of very low dissolved oxygen concentrations did not occur. Additionally, data from previous years indicate that the dissolved oxygen averages off Long Island generally remain well above 4 mg/l. There is no reason to suspect that 1989 was any different.

New York Bight Apex

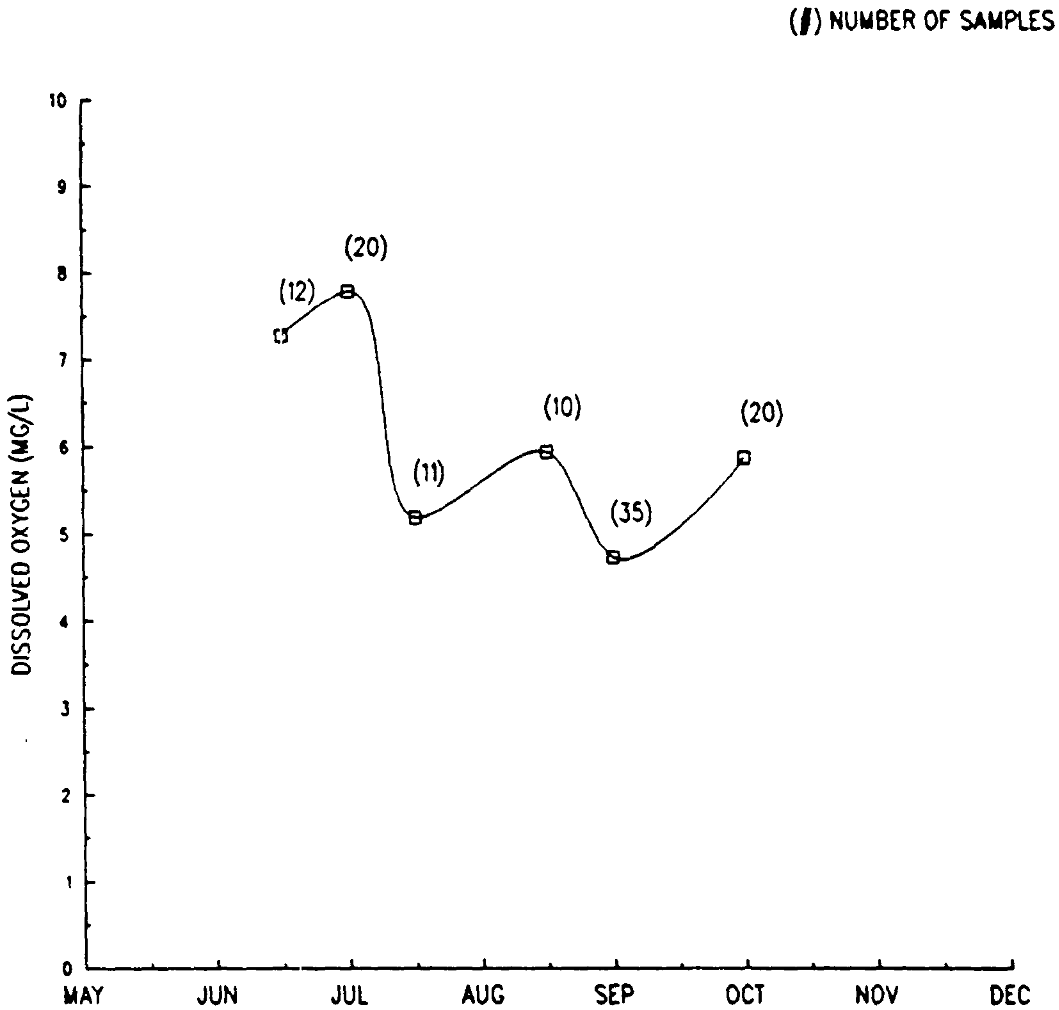
Figure 10 illustrates the semimonthly dissolved oxygen averages at the New York Bight Apex stations from June to October, 1989. A "double minima" was observed. The dissolved oxygen average decreased from 7.6 mg/l in late June to 5.1 mg/l in mid July. It then increased to 5.8 mg/l in mid August and subsequently declined to a second minimum of 4.6 mg/l in early September. Recovery likely occurred after cessation of sampling sometime in October.

A total of 108 samples were collected in the New York Bight Apex from June 1 to September 28 and measured for dissolved oxygen. Twenty-one dissolved oxygen values, or 19.4 percent, were between 4-5 mg/l. Six samples, or 5.6 percent, were between the 3-4 mg/l level considered "stressful if prolonged" for aquatic life, and two dissolved oxygen values were in the 2-3 mg/l level considered "lethal if prolonged" for aquatic life. The eight dissolved oxygen values below 4 mg/l were:

Station	Date	Dissolved Oxygen (mg/l)
NYB 23	8/24/89	3.9
NYB 44	8/26/89	3.6
NYB 22	8/31/89	2.4
NYB 23	8/31/89	2.5
NYB 24	8/31/89	3.5
NYB 26	8/31/89	3.7
NYB 27	8/31/89	3.9
NYB 41	8/31/89	3.9

This is consistent with the normal dissolved oxygen sag curve in the New York Bight Apex.

Figure 10



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1989.
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS

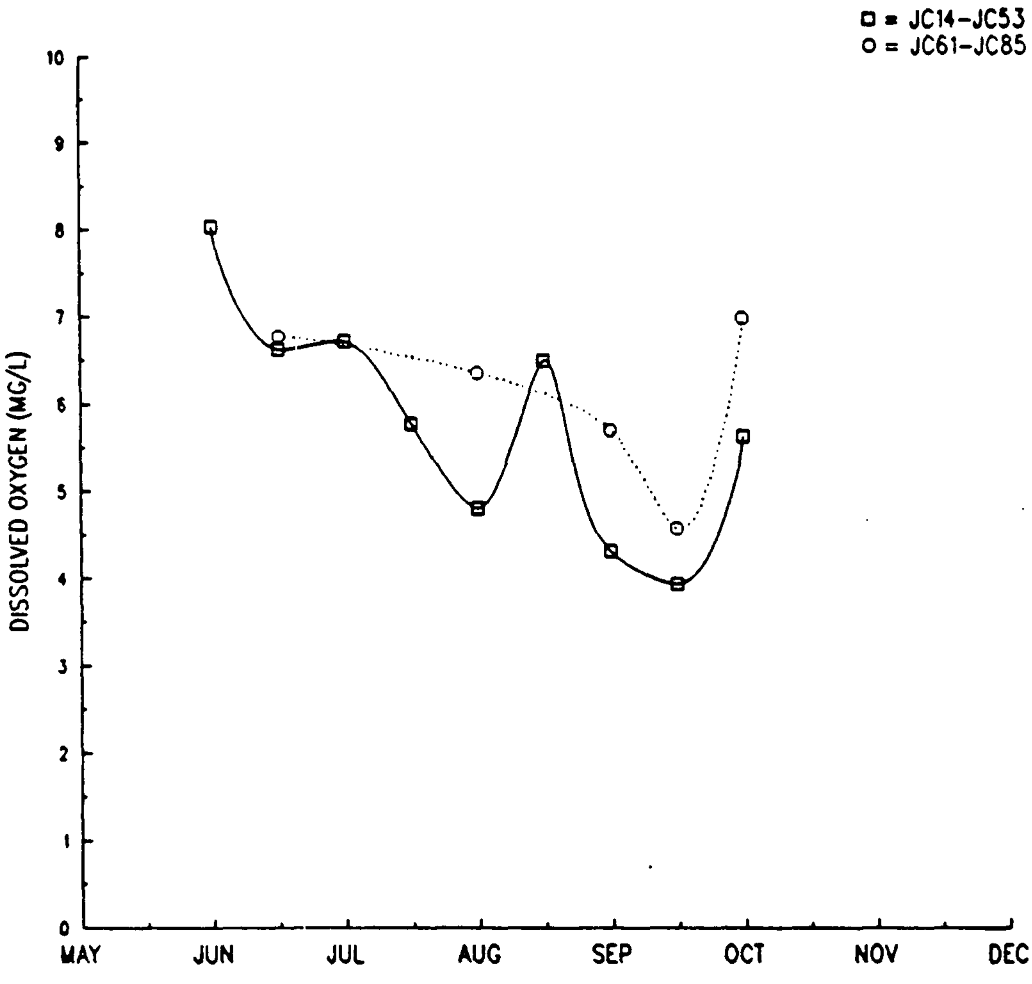
NOAA has reported significant improvement in the Bight Apex since the cessation of sewage sludge disposal in 1987 at the 12-mile dumpsite. A recent report indicated that dissolved oxygen values at station NY6, located 1.6 km downslope of the area where heaviest dumping occurred, "have not been less than 4 mg/l since the reduction of sludge volume" (NOAA, 1989). Prior to that time values of < 0.5 mg/l were reported. Generally, EPA data support this finding.

New Jersey Coast

Figure 11 illustrates the semimonthly dissolved oxygen average off the New Jersey coast during the summer of 1989, with separate lines for the northern (JC 14-JC 53) perpendiculars and the southern (JC 61-JC 85) perpendiculars. The dissolved oxygen average along the northern perpendiculars exhibited a "double minima" effect. In early June, the dissolved oxygen average was approximately 8.0 mg/l and decreased to 6.5 mg/l in late June and early July. The dissolved oxygen average then reached the first low of 4.7 mg/l in early August, followed by an increase to 6.6 mg/l in mid August. It subsequently declined until the second low, of approximately 4.0 mg/l, was reached in mid September. Recovery occurred in early October. Along the southern New Jersey perpendiculars, the dissolved oxygen average was between 6.0 and 7.0 mg/l from mid June to early September. The average decreased to a low of 4.5 mg/l in mid September. This was followed by a strong dissolved oxygen recovery in early October.

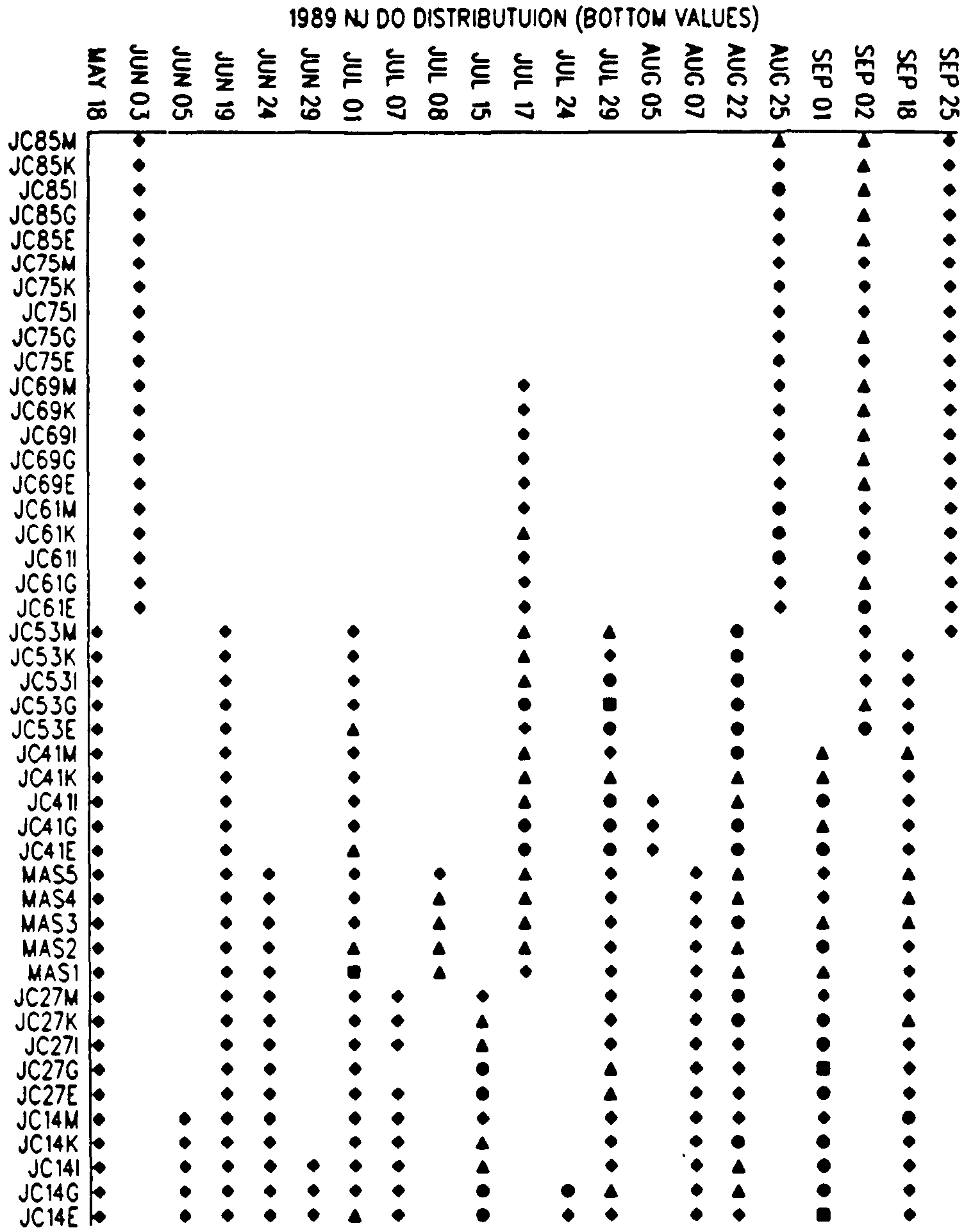
Table 5 summarizes the bottom dissolved oxygen values for the New Jersey coast perpendiculars. There were 347 samples collected along the New Jersey perpendiculars between May 18 and September 25, 1989 and analyzed for dissolved oxygen. Of these samples, 106 values (30.5 percent) were below 5 mg/l. Of the 106 samples, 60 values (17.3 percent of all samples collected) were between

Figure 11



NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1989.
SEMIMONTHLY AVERAGES OF ALL NORTHERN (JC14-JC53)
AND SOUTHERN (JC61-JC85) PERPENDICULAR STATIONS

Table 5



KEY: ◆ - > 5 mg/L ▲ - 4-5 mg/L ● - 2-4 mg/L ■ - 0-2 mg/L

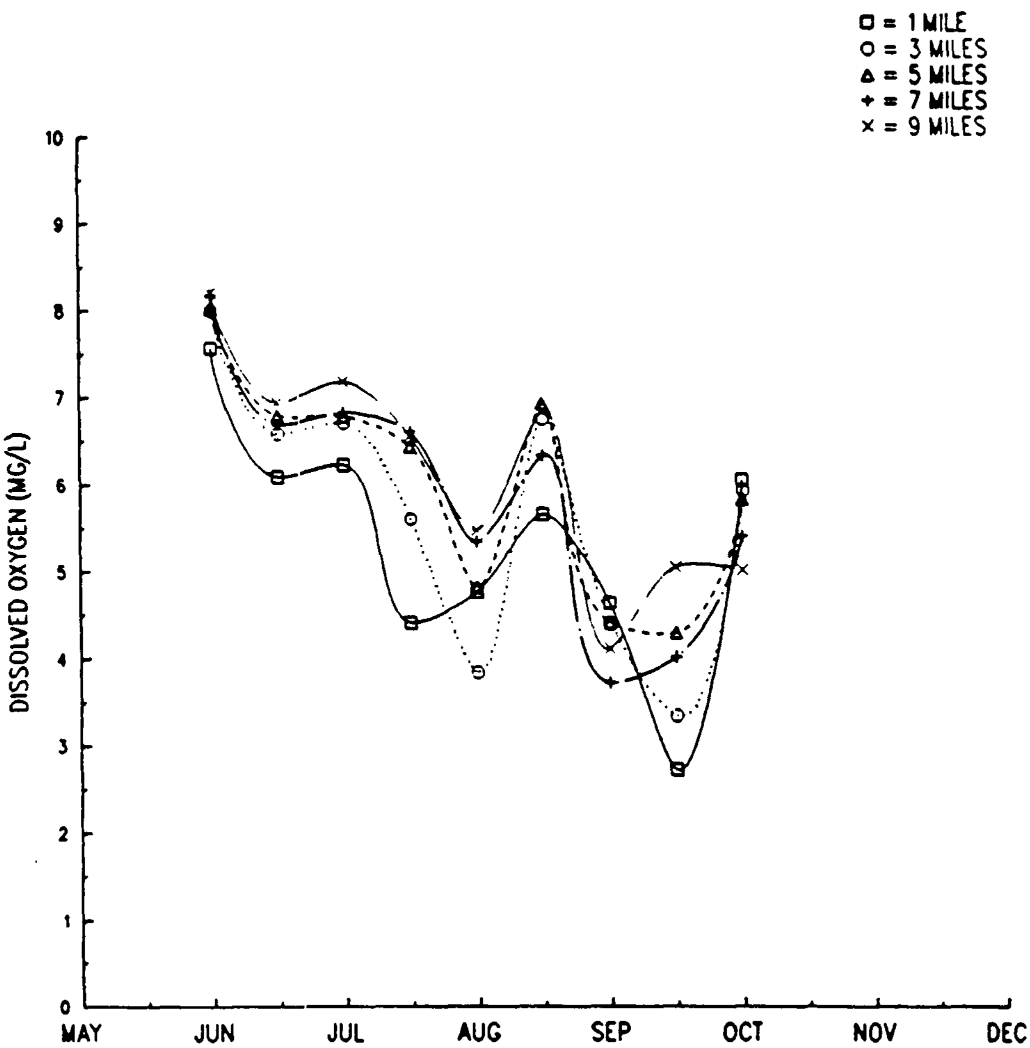
4-5 mg/l, and 42 values (12.1 percent) were between 2-4 mg/l. There were four values (1.2 percent) between 0-2 mg/l. In comparison, during the summer of 1988, 478 samples were collected. A total of 165 values (34.5 percent) were below 5 mg/l. Of these, 122 values (25.5 percent of all samples) were between 4-5 mg/l, 51 values (10.7 percent) were between 2-4 mg/l, and two values (0.4 percent) were between 0-2 mg/l. Overall, dissolved oxygen values in 1989 were slightly higher than those encountered in 1988.

Figures 12 and 13 compare the shore to seaward distribution of dissolved oxygen along the northern New Jersey perpendiculars and the southern New Jersey perpendiculars, respectively. Generally, along northern New Jersey (Figure 12) the dissolved oxygen values increased with distance offshore from June through late July. This pattern has been observed over the past five years. The lower values at the nearshore stations in northern New Jersey are attributed to the influence of river discharges, treatment plant effluents, stormwater runoff, benthic oxygen demand from inlet dredged material disposal sites, and the plume from the Hudson-Raritan River Estuary system. A "double minima" occurred at all distances from shore. The first minima at the 1 mile station occurred in mid July. At the remainder of the offshore stations, the first low occurred in early August. This was followed by all values increasing 1-3 mg/l by mid

August. The second low for 7 and 9 miles offshore occurred in early September, and in mid September for 1, 3 and 5 miles offshore. All values increased in early October.

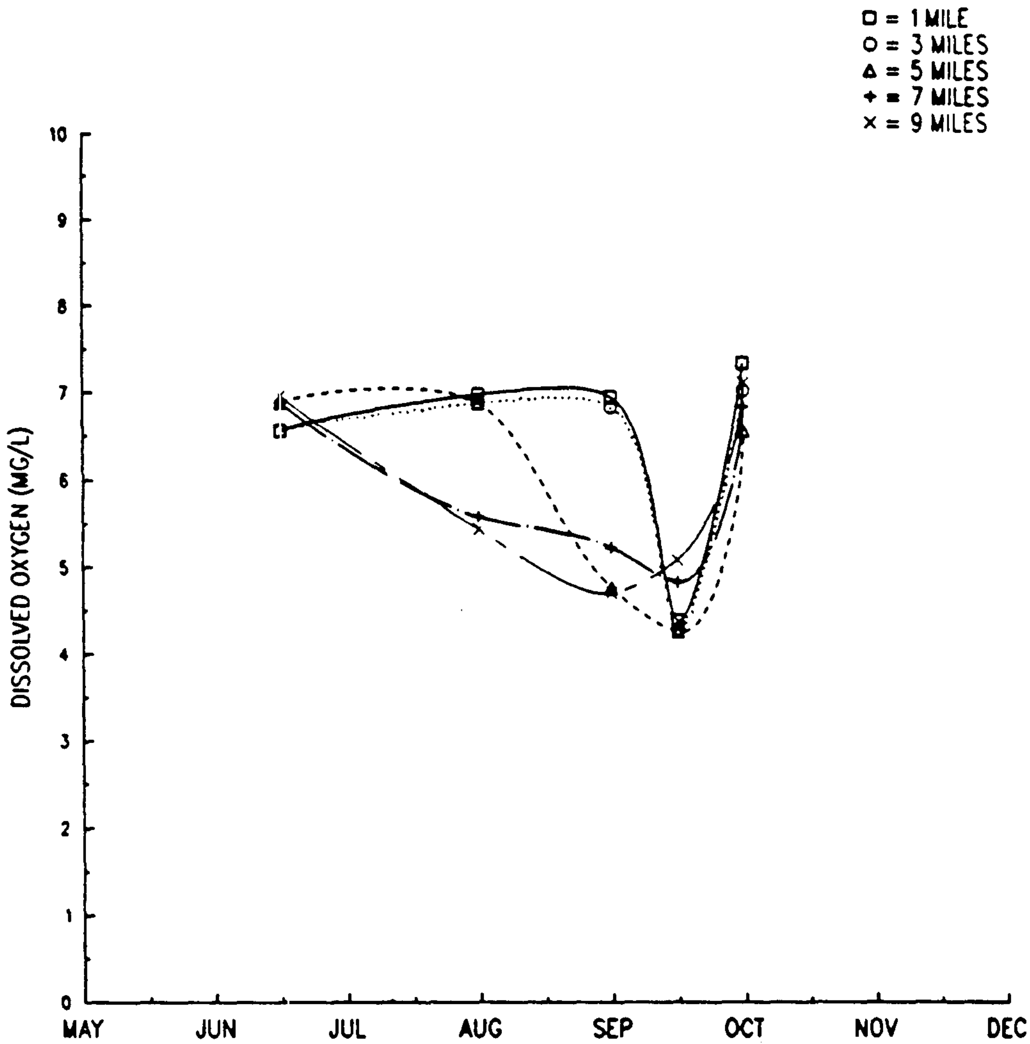
In 1989, dissolved oxygen averages along the southern New Jersey coast generally decreased with increasing distance offshore, Figure 13. This pattern has been observed in 1985, 1986 and 1988. However, in those years the trend initially followed a pattern similar to the northern perpendiculars - dissolved oxygen increased with increasing distance offshore. As summer progressed, this trend reversed itself by late July, early August. All dissolved oxygen values significantly increased by early October. During the summers of 1985-1987 a pronounced "double minima" occurred 1 mile offshore. This effect was not evident in 1988 nor 1989, and may be due to the decrease in sampling frequency for these two years.

Figure 12



SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1989. SEMIMONTHLY AVERAGES OF ALL NORTHERN PERPENDICULAR STATIONS (JC14-JC53), AT FIXED DISTANCES FROM SHORE

Figure 13



SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1989. SEMIMONTHLY AVERAGES OF ALL SOUTHERN PERPENDICULAR STATIONS (JC61-JC85), AT FIXED DISTANCES FROM SHORE

Dissolved Oxygen Trends

Figures 14, 15 and 16 display the number of dissolved oxygen observations below 4 mg/l during July, August and September 1985-1989, for each perpendicular. Since 1985, dissolved oxygen values have shown significant improvement with few values below 4 mg/l. This improvement may be partially attributed to the increased storm activity in subsequent years, promoting reaeration; and, the absence of a significant green tide event since 1985.

Figure 17 displays the five year dissolved oxygen arithmetic mean of all semimonthly averages for the northern New Jersey perpendicular stations. The average dissolved oxygen in early May was 6.7 mg/l. From May to June the dissolved oxygen increased to 7.8 mg/l, then decreased gradually to 5.2 mg/l in late July. The dissolved oxygen remained at this level in early August and then decreased to a low of 4.5 mg/l in early September. During September and October, there was a rapid dissolved oxygen recovery.

Figure 18 displays the five year dissolved oxygen arithmetic mean of all semimonthly averages for the southern New Jersey perpendicular stations. In early May, the dissolved oxygen average was 8.3 mg/l. From May to mid June, the dissolved oxygen gradually decreased to 6.5 mg/l and remained at that level during June. Values continued to decline through July until a low of 4.6 mg/l was reached in mid August. During mid September and October, the

Figure 14

DISSOLVED OXYGEN CONCENTRATIONS
BELOW 4 MG/L
NEW JERSEY COAST
JULY 1989

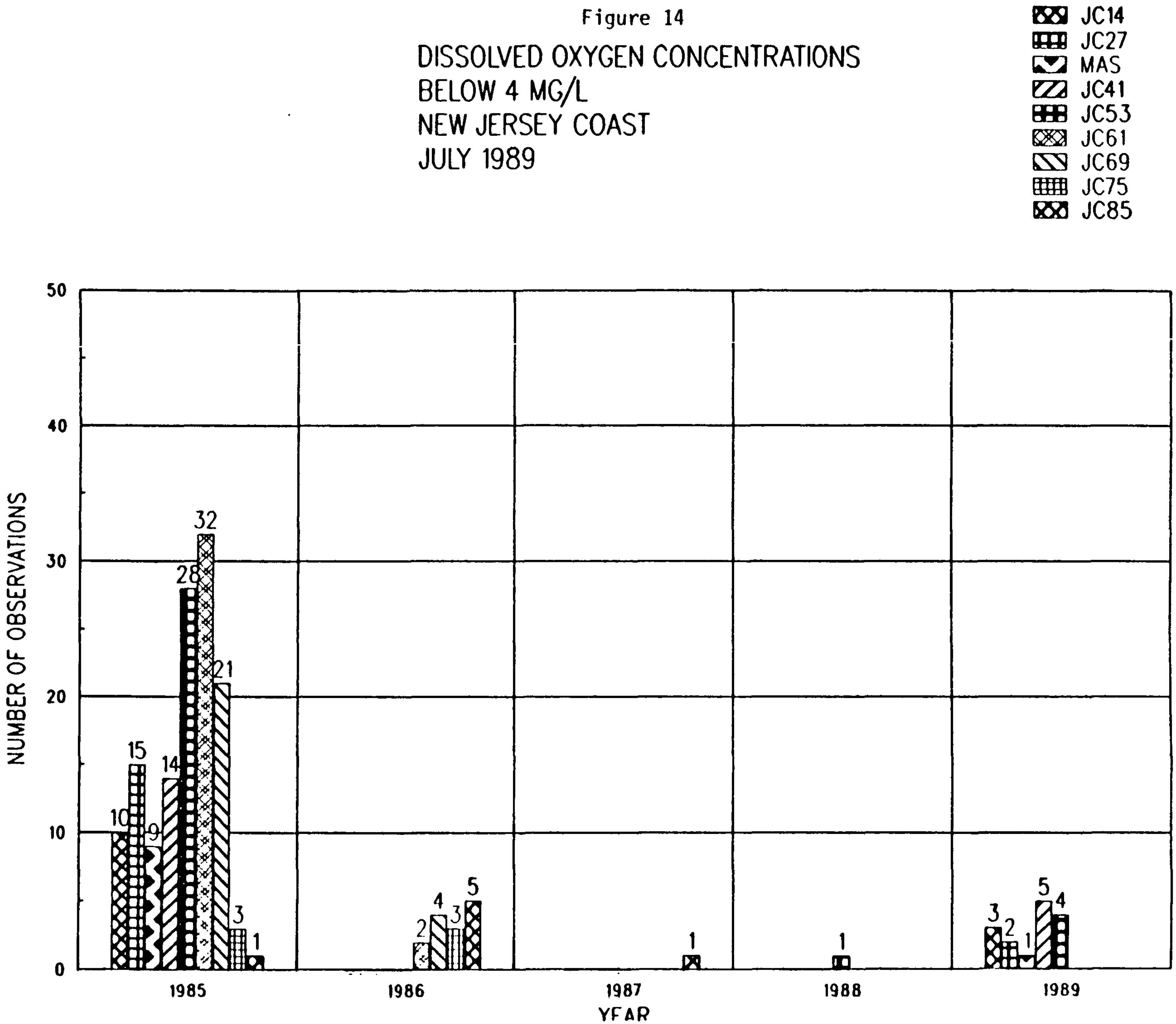


Figure 15

DISSOLVED OXYGEN CONCENTRATIONS
BELOW 4 MG/L
NEW JERSEY COAST
AUGUST 1989

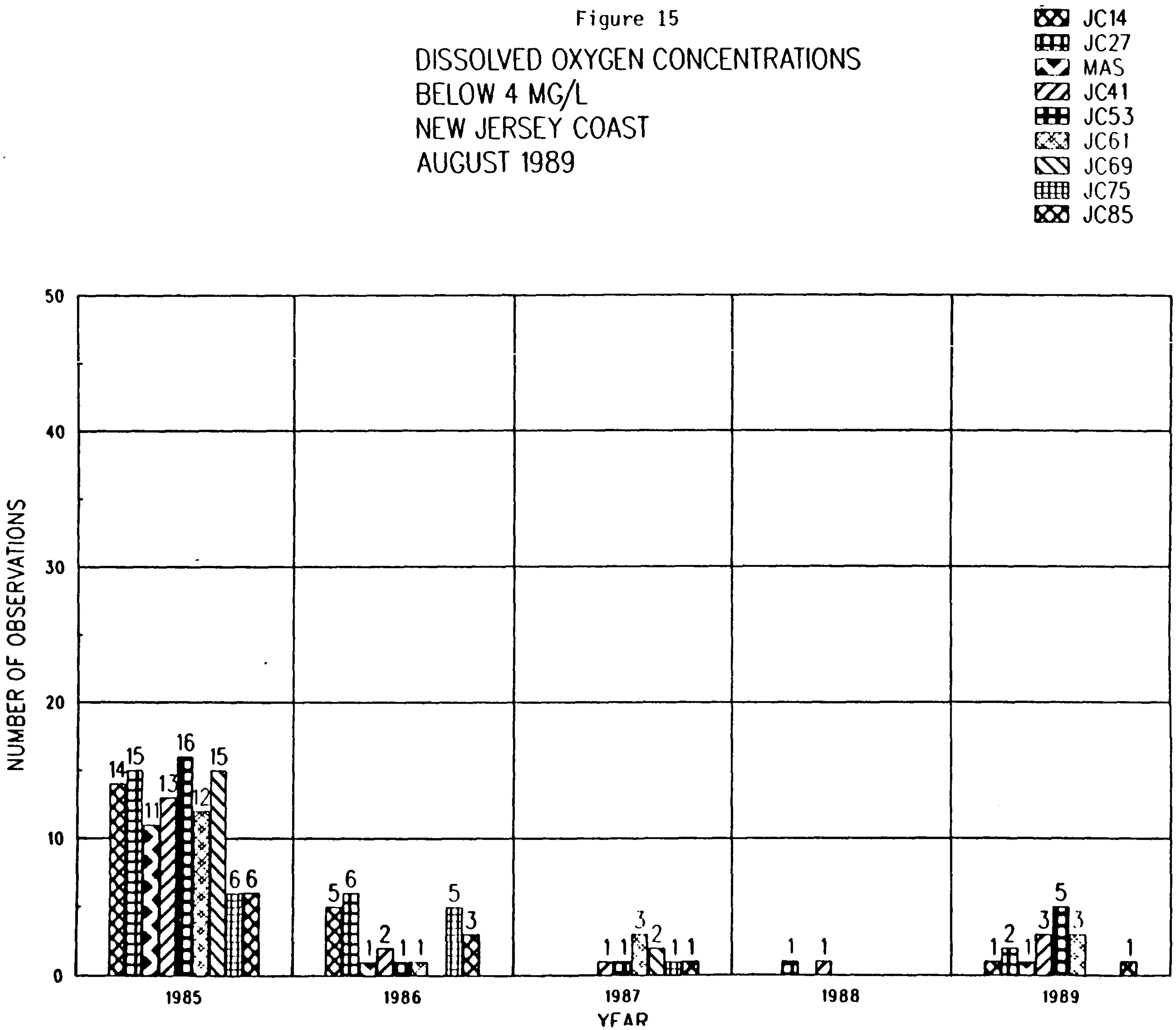


Figure 16

DISSOLVED OXYGEN CONCENTRATIONS
BELOW 4 MG/L
NEW JERSEY COAST
SEPTEMBER 1989

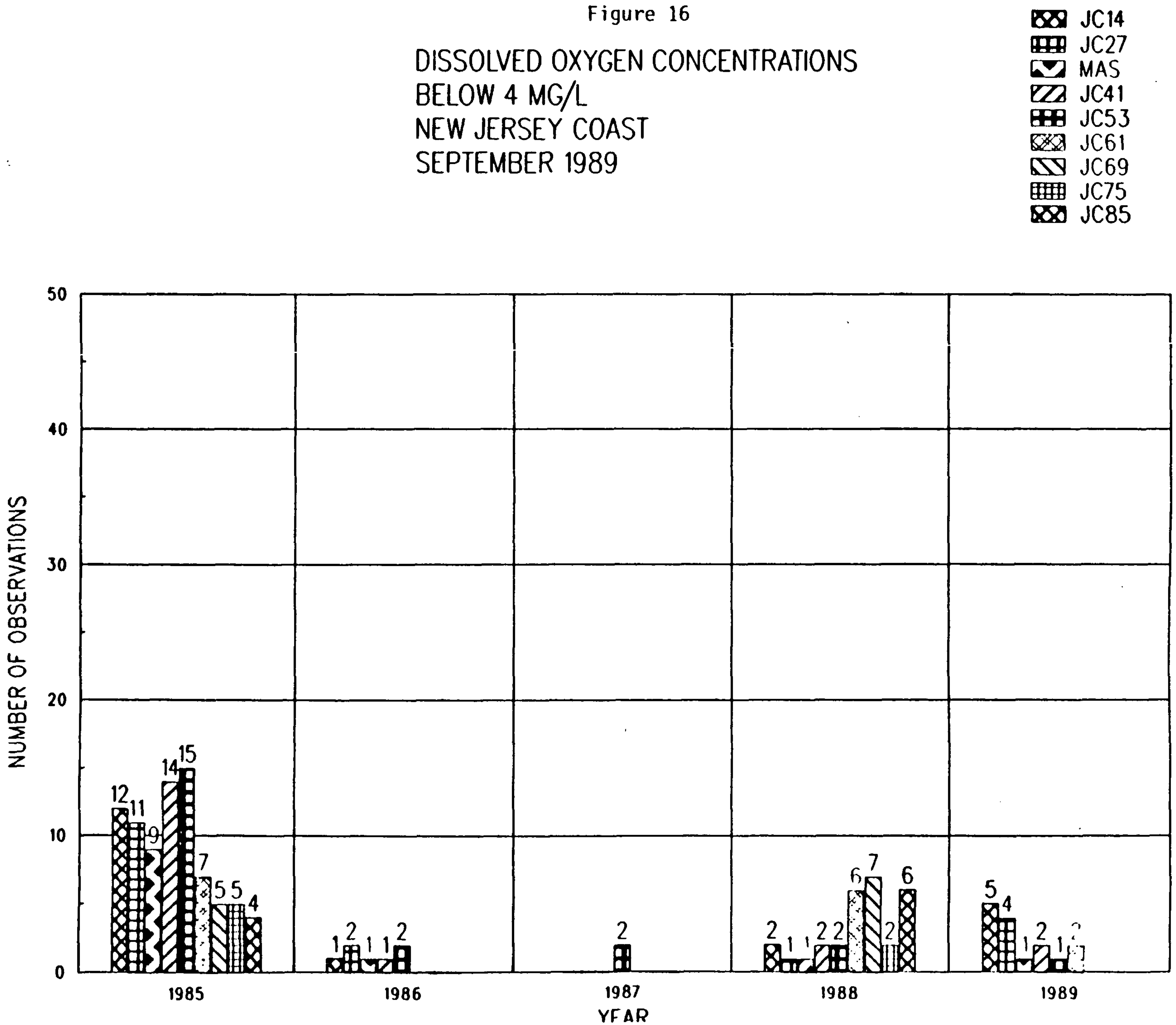
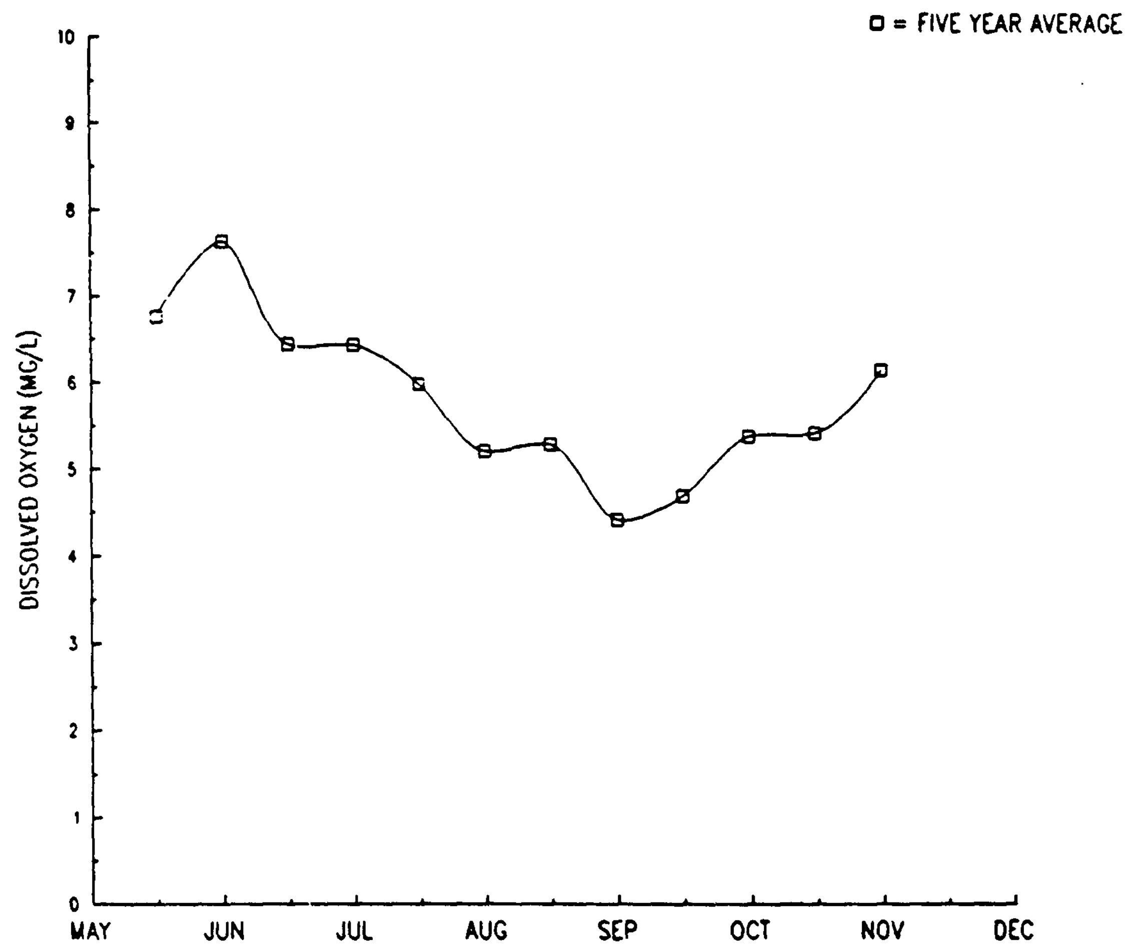
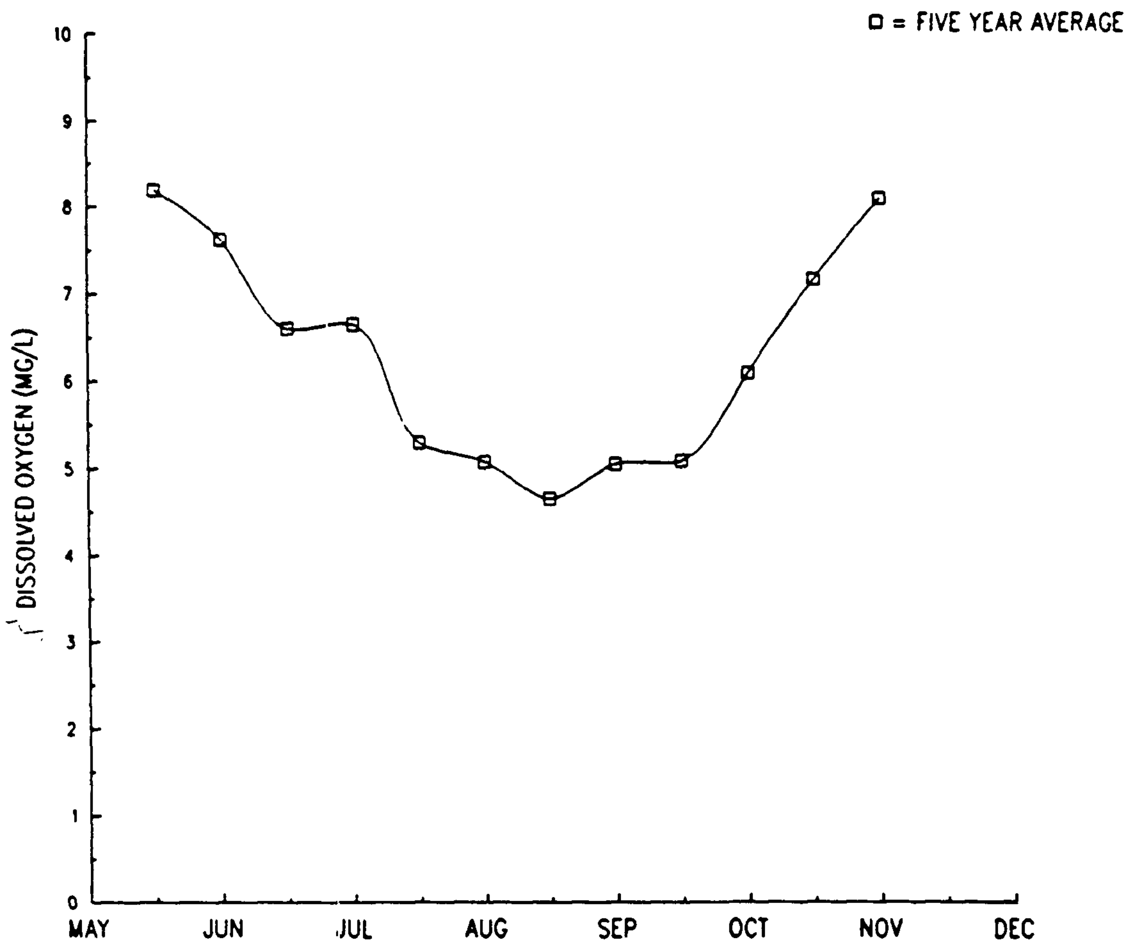


Figure 17



NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1985 TO 1989

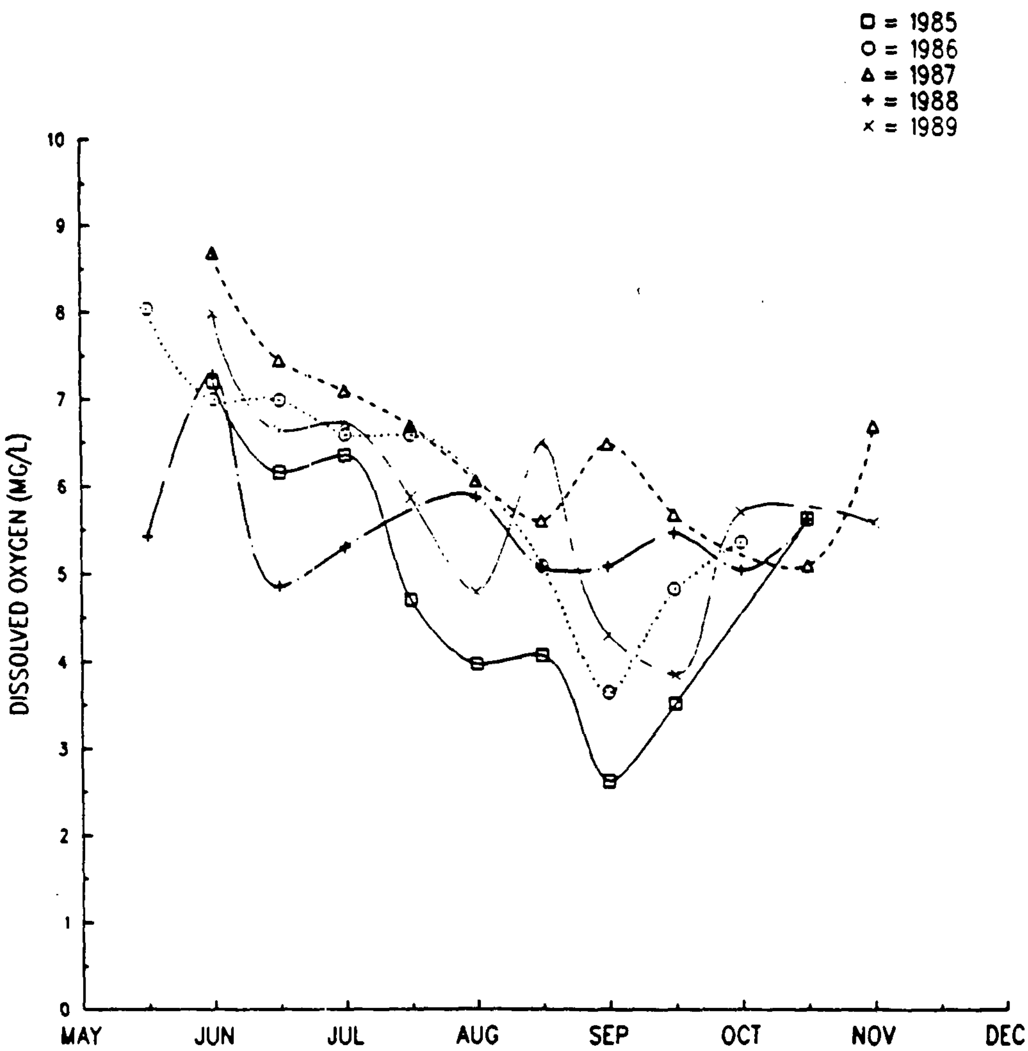
Figure 18



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1985 TO 1989 dissolved oxygen increased gradually, and was followed by rapid recovery after October. The five year average for southern New Jersey generally follows the dissolved oxygen cycle for the northeast United States (Figure 9).

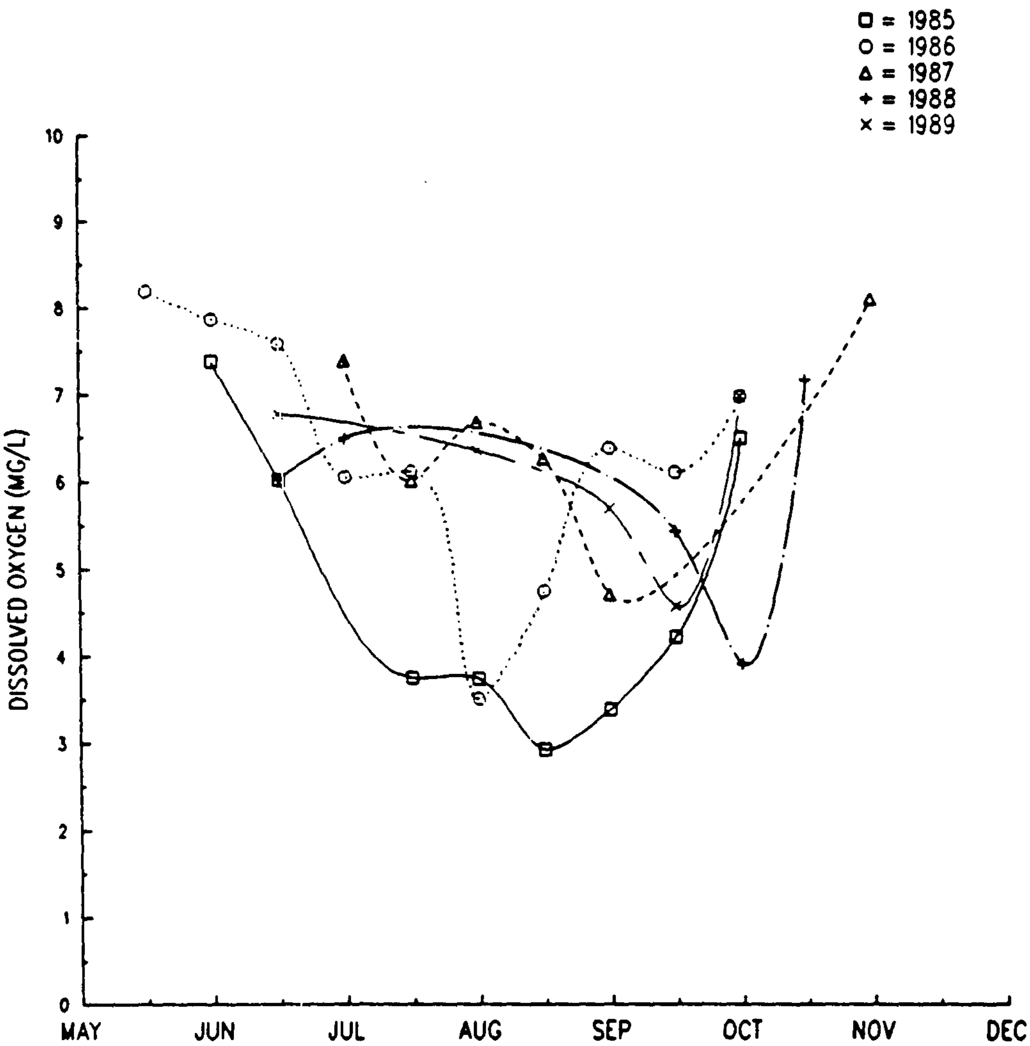
Figures 19 and 20 illustrate the dissolved oxygen trends over the past five years for the New Jersey perpendicular stations. Figure 19 shows that in 1987 and 1989 a dissolved oxygen "double minima" occurred along the northern New Jersey perpendiculars. During 1987, the first low occurred in mid August, followed by a second low in mid October. The "double minima" in 1989 was more pronounced than in 1987, with the first low occurring in late July, early August followed by a second low in mid September. The summers of 1987 and 1988 have been the best in terms of dissolved oxygen averages since 1985. Averages, with the exception of mid June 1988, remained at or greater than 5 mg/l. During 1985, 1986 and 1989, the lowest values occurred between late August and mid September. In late August 1985, the average dissolved oxygen concentration dropped to a low of 2.5 mg/l. Averages since then have not dropped below 3.5 mg/l, even during the critical late summer period. In 1989, dissolved oxygen averages fluctuated more sharply than in previous years. The sharp increase in mid August was probably due to storm activity. Except in those instances when a "double minima" occurred, dissolved oxygen along the northern New Jersey perpendiculars declined steadily throughout the summer,

Figure 19



NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN 1985–1989 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC14–JC53 PERPENDICULAR STATIONS

Figure 20

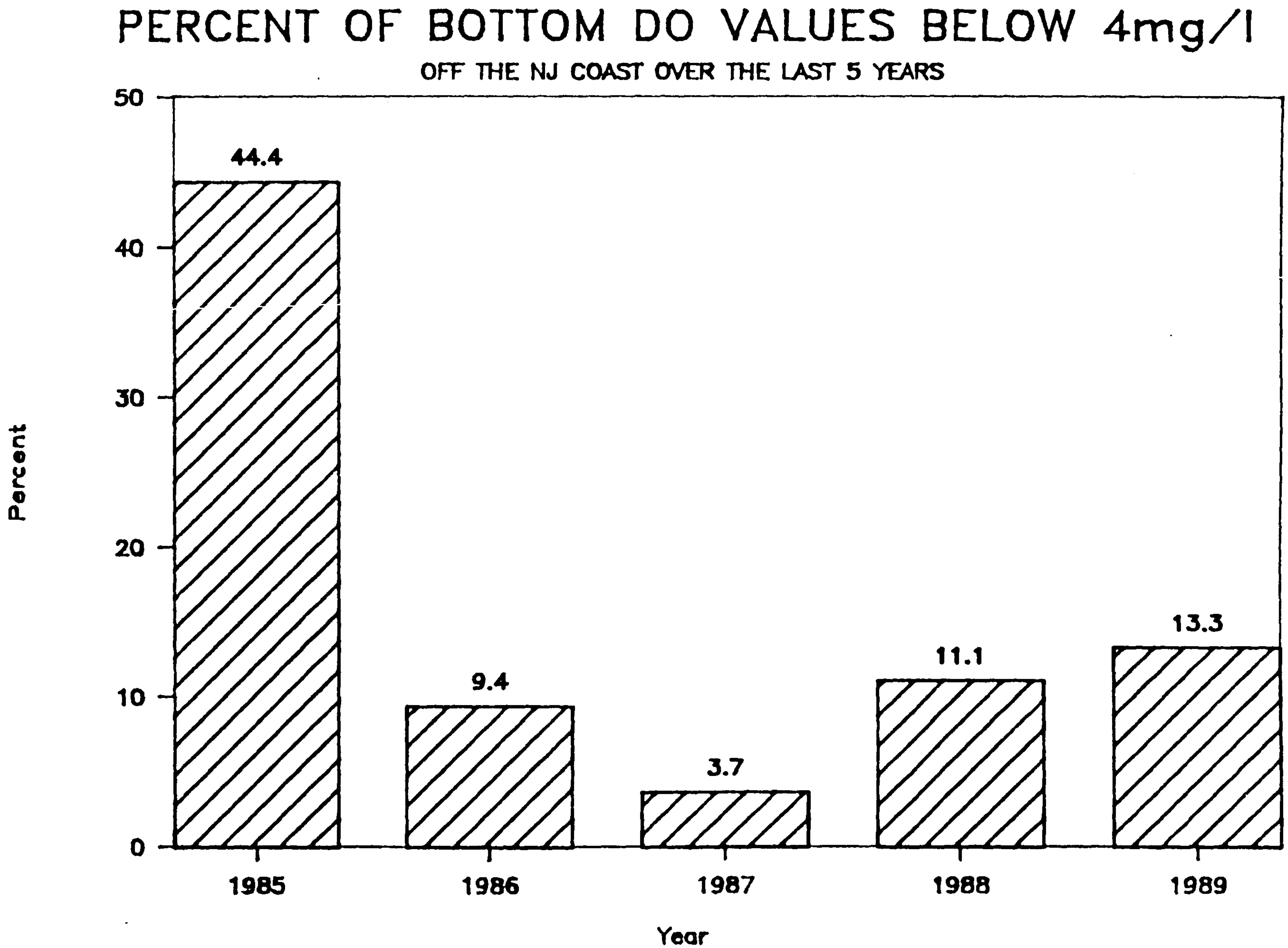


SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1985–1989 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC61–JC85 PERPENDICULAR STATIONS reaching a low in late summer, followed by a rapid recovery in October.

Figure 20 illustrates that, for the most part, the lowest dissolved oxygen levels along the southern New Jersey perpendicular stations during the last five years occurred in 1985. The dissolved oxygen levels along the southern New Jersey perpendiculars in 1989 were approximately equal to or above the dissolved oxygen averages of the previous four years. Based on the data collected, the lowest value in 1989 was 4.5 mg/l in mid September. The remainder of the period averages were greater than 5 mg/l.

Figure 21 displays the percentages of bottom dissolved oxygen samples with concentrations below 4 mg/l along the New Jersey perpendiculars over the last five years. The highest percentage of low dissolved oxygen values, 44.4 percent, occurred in 1985. Of the past 5 years, 1987 has the smallest percentage of low dissolved oxygen values, only 3.7 percent. The graph indicates that in 1989 there was an increase in the percentage of low dissolved oxygen values to 13.3 percent. In general, the percentage of dissolved oxygen values below 4 mg/l fluctuates from year to year. In 1985, the percentage of dissolved oxygen concentrations below 4 mg/l was significantly greater than in the other years. Since 1985 there have not been any prolonged periods of low dissolved oxygen over an extensive area. This may be partially attributed to the absence of a

Figure 21



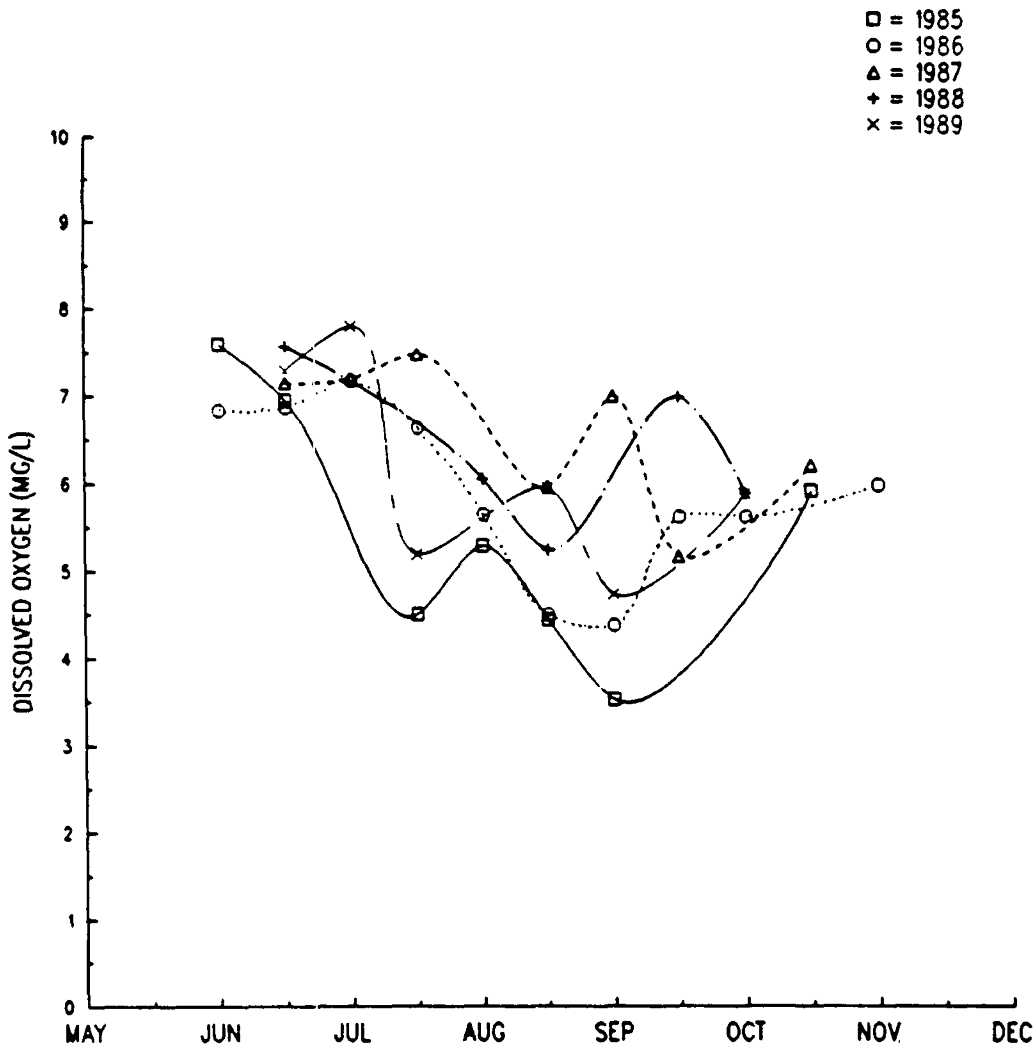
PERCENT OF BOTTOM DO VALUES BELOW 4mg/l
OFF THE NJ COAST OVER THE LAST 5 YEARS
50
40
30
20
10
0
Percent
44.4
9.4
3.7
11.1
13.3
1985
1986
1987
1988
1989
Year

major green tide event in subsequent years.

Figure 22 shows a five year comparison of the semimonthly averages for the New York Bight Apex stations for the years 1985-1989. The average dissolved oxygen concentrations remained above 4 mg/l throughout the five year period, except for early September in 1985 when the dissolved oxygen average fell to 3.5 mg/l. A dissolved oxygen "double minima" has been observed each year except 1986. In general, the New York Bight Apex dissolved oxygen levels have improved since 1985. The highest dissolved oxygen averages in the Apex occurred in 1987. Dissolved oxygen concentrations in 1988 and 1989 were generally lower than in 1987. The first and second low of the "double minima" occurred earlier in 1989 as compared to 1987 and 1988. Except that the average values are higher in 1989, the graphs for 1989 and 1985 follow a similar pattern. The first low occurs in mid July followed by a second low in early/mid September.

All of the dissolved oxygen trend graphs for the New Jersey perpendicular stations show considerable improvement in dissolved oxygen concentrations since 1985, when an unusually large number of low concentrations were reported. Dissolved oxygen concentrations were slightly lower in 1989 and 1988 than in 1986 and 1987, but considerably higher than in 1985. The prolonged depressed dissolved oxygen levels in 1985 were attributed to the decomposition of the organisms responsible for the numerous algal blooms that

Figure 22



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1985–1989 COMPARISON. SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS occurred, the lack of meteorological events favoring reaeration, such as substantial winds and storm activity, and the presence of a strong thermocline. During the summers of 1986 and 1987, fewer algal blooms were observed, higher winds occurred, and there were numerous storms promoting reaeration. Not as many storms occurred in 1988 and algal blooms were observed throughout the summer. This probably contributed to the lower dissolved oxygen concentrations in 1988 compared to 1986 and 1987. While storm activity was fairly frequent in 1989 wind activity may not have been strong enough to have significantly influenced reaeration.

BACTERIOLOGICAL RESULTS

FECAL COLIFORMS

New Jersey

Table 6 presents a summary of the fecal coliform data collected along the coast of New Jersey between June 28, 1989 and September 6, 1989. The geometric mean for each station is plotted in Figure 23. The overall State water quality standard for New Jersey is 50 fecal coliforms/100ml for the protection of shellfish waters. The State standard for primary contact recreation along the New Jersey coast is a geometric mean of 200 fecal coliforms/100ml based on five or more samples analyzed within a 30 day period. However, for the protection of public health, the State will close the beaches if individual values exceed 200 fecal coliforms/100ml for two consecutive days.

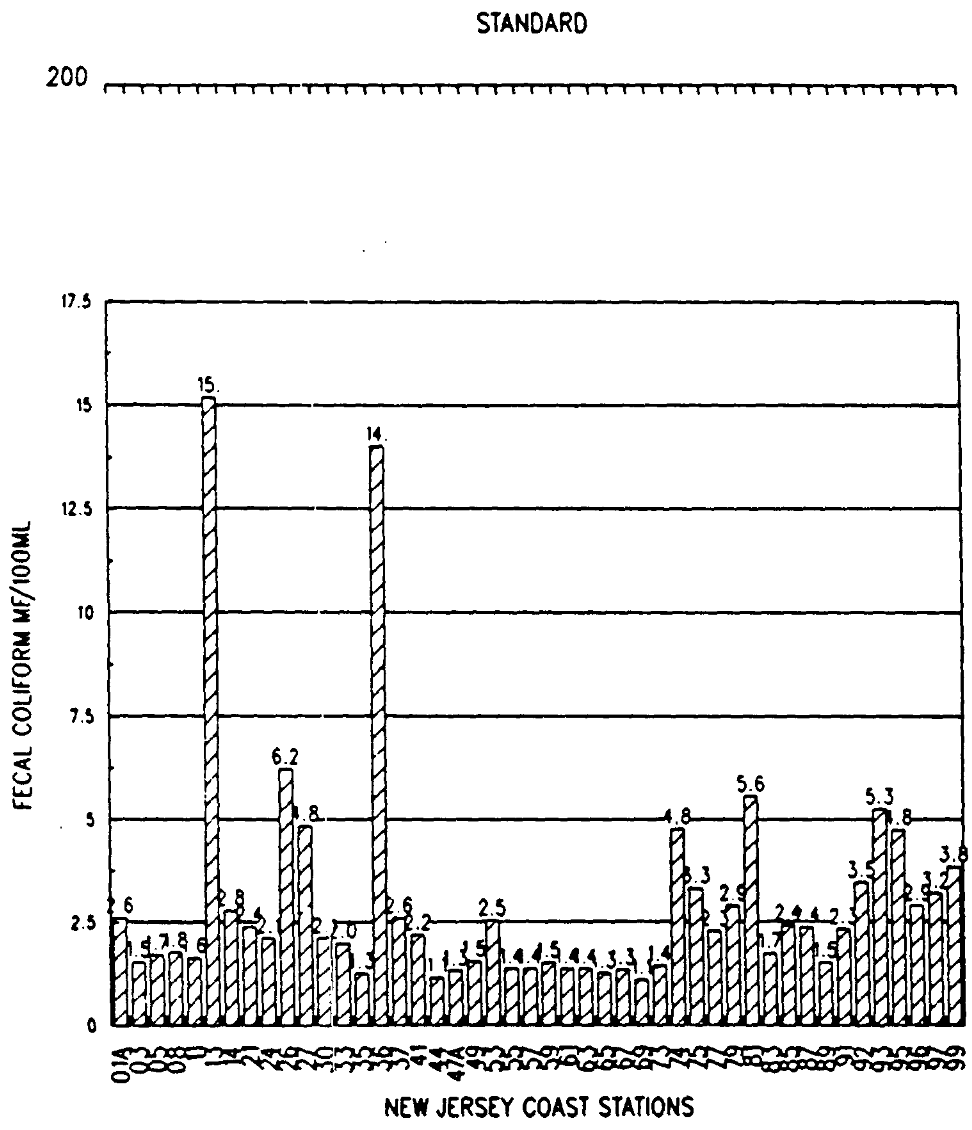
Due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The highest geometric mean, 15.2 fecal coliforms/100ml, was at station JC 13 at Long Branch City, off Chelsea Avenue. The second highest geometric mean, 14.0 fecal coliforms/100ml, was at station JC 36 in Manasquan Inlet. All of the geometric means are very low. Figure 23 shows that the New Jersey coastal stations are well below the bacteriological standard. Based on fecal coliform data, New Jersey coastal waters have excellent water quality.

Table 6

Summary of fecal coliform data collected along the New Jersey coast June 28, 1989 through September 6, 1989

Station	Number of Samples	Maximum Value (Fecal Coliform/100ml)	Geometric Mean (Fecal Coliform/100ml)
JC 01A	9	67	2.6
JC 03	10	7	1.5
JC 05	10	4	1.7
JC 08	10	73	1.8
JC 11	10	63	1.6
JC 13	10	80	15.2
JC 14	9	26	2.8
JC 21	9	27	2.4
JC 24	8	11	2.1
JC 26	8	112	6.2
JC 27	7	16	4.8
JC 30	8	5	2.1
JC 33	8	6	2.0
JC 35	8	3	1.3
Jc 36	8	212	14.0
JC 37	8	29	2.6
JC 41	8	9	2.2
JC 44	8	3	1.1
JC 47A	8	3	1.3
JC 49	8	8	1.5
JC 53	8	6	2.5
JC 55	8	4	1.4
JC 57	8	4	1.4
JC 59	8	9	1.5
JC 61	8	12	1.4
JC 63	8	4	1.4
JC 65	8	6	1.3
JC 67	8	5	1.3
JC 69	8	2	1.1
JC 73	7	3	1.4
JC 74	7	84	4.8
JC 75	7	15	3.3
JC 77	7	5	2.3
JC 79	7	8	2.9
JC 81	7	96	5.6
JC 83	7	4	1.7
JC 85	6	17	2.4
JC 87	6	10	2.4
JC 89	6	4	1.5
JC 91	6	2	2.3
JC 92	6	284	3.5
JC 93	6	55	5.3
JC 95	6	80	4.8
JC 96	6	50	2.9
JC 97	6	24	3.2
JC 99	6	16	3.8

Figure 23



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTED ALONG THE COAST OF NEW JERSEY, JUNE 28, 1989 TO SEPTEMBER 6, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

Throughout the summer sampling period, a total of 353 samples were collected for fecal coliform analysis along the New Jersey Coast. Of the 353 samples, 12 or 3.4 percent were above 50 fecal coliforms/100ml. Only two samples, 0.57 percent, were above 200 fecal coliforms/100ml. The two samples were collected on July 19, at Hereford Inlet (JC 92), and on August 16, at Manasquan Inlet (JC 36). The densities were 284 and 212 fecal coliforms/100ml, respectively. On July 20, beaches were closed at Wildwood, Wildwood Crest and North Wildwood due to elevated bacteria counts recorded for samples taken by the local health department.

Long Island

Table 7 presents a summary of the fecal coliform data collected along the coast of Long Island from May 23, 1989 through September 5, 1989. The geometric mean for each station is plotted in Figure 24. The New York State standard for primary contact recreation along the Long Island coast is 200 fecal coliforms/100 ml. This value is a monthly geometric mean of five or more samples. As with the New Jersey data, due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The highest geometric mean was 5.5 fecal coliforms/100ml, which occurred at station LIC 05, Far Rockaway Beach. The second highest geometric mean was 4.1 fecal coliforms/100ml, which occurred at LIC 10, Hempstead Beach. From Figure 24, it is apparent that the standard was not approached. Based on fecal coliform data, the New York coastal waters along Long Island are of excellent quality.

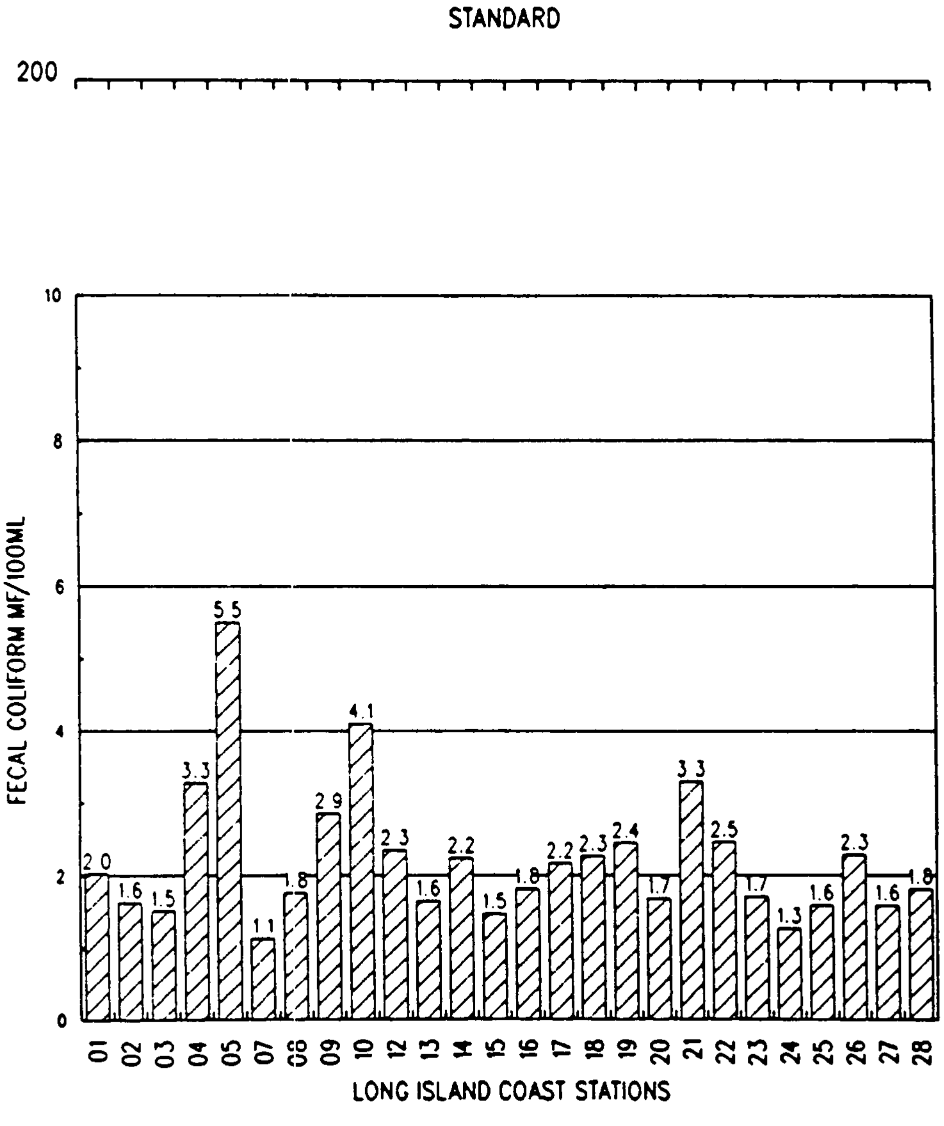
A total of 131 samples were collected during the summer along the coast of Long Island and analyzed for fecal coliform bacteria. None of the densities exceeded 200 fecal coliforms/100ml. The highest density found all summer, 26 fecal coliforms/100 ml, was at station LIC 04, Rockaway, off the foot of B92 Road, on July 18, 1989. This value is well below the New York State standard.

Table 7

Summary of fecal coliform data collected along the coast of Long Island May 23, 1989 through September 5, 1989

Station	Number of Samples	Maximum Value (Fecal Coliform/100ml)	Geometric Mean (Fecal Coliform/100ml)
LIC 01	8	4	2.0
LIC 02	7	5	1.6
LIC 03	7	18	1.5
LIC 04	6	26	3.3
LIC 05	7	13	5.5
LIC 07	6	2	1.1
LIC 08	6	10	1.8
LIC 09	6	13	2.9
LIC 10	6	11	4.1
LIC 12	6	21	2.3
LIC 13	6	10	1.6
LIC 14	6	16	2.2
LIC 15	6	5	1.5
LIC 16	6	6	1.8
LIC 17	5	6	2.2
LIC 18	5	5	2.3
LIC 19	4	6	2.4
LIC 20	4	4	1.7
LIC 21	3	18	3.3
LIC 22	3	5	2.5
LIC 23	3	5	1.7
LIC 24	3	2	1.3
LIC 25	3	4	1.6
LIC 26	3	3	2.3
LIC 27	3	2	1.6
LIC 28	3	3	1.8

Figure 24



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTED ALONG THE COAST OF LONG ISLAND, MAY 23, 1989 TO SEPTEMBER 5, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

ENTEROCOCCI

The 1989 sampling program marked the fifth year that samples were collected for enterococci bacteria. Enterococci bacteria are members of the fecal streptococci group. The occurrence of fecal streptococci in bathing waters indicates the presence of fecal contamination from warm-blooded animals. The enterococcus group of bacteria includes the following species: Streptococcus faecales; S. faecalis, subsp. liquefaciens; S. faecalis, subsp. zyogenes; and S. faecium. Past research (Cabelli 1982, 1983) has demonstrated that enterococci bacteria show a better correlation than fecal coliforms, to gastroenteritis caused by swimming in contaminated water. The EPA criterion for marine waters, a geometric mean of 35 enterococci bacteria/100ml, was published in the Federal Register on March 7, 1986.

New Jersey

Table 8 presents a summary of the enterococci data collected along the New Jersey coast from June 28 to September 6, 1989. The State of New Jersey does not have a water quality standard for enterococci bacteria. As mentioned previously, the EPA criterion for enterococci in marine waters is 35 enterococci bacteria/100ml. This criterion is based on a geometric mean of a statistically sufficient number of samples - generally not less than five samples equally spaced over a thirty day period. Due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The geometric mean for each station is plotted in Figure 25. Figure 25 shows that the geometric mean of enterococci densities at each station is well below the EPA criterion. All the geometric means are low. The highest mean, 4.2 enterococci/100ml, occurred at station JC 13, Long Branch, off Chelsea Avenue.

A total of 353 samples were analyzed for enterococcus bacteria along the New Jersey coast. Three individual values were greater than 35 enterococci bacteria/100ml. These samples were:

Station	Date	Enterococci/100ml
JC 95	6/28/89	160
JC 92	7/19/89	37
JC 96	7/19/89	77

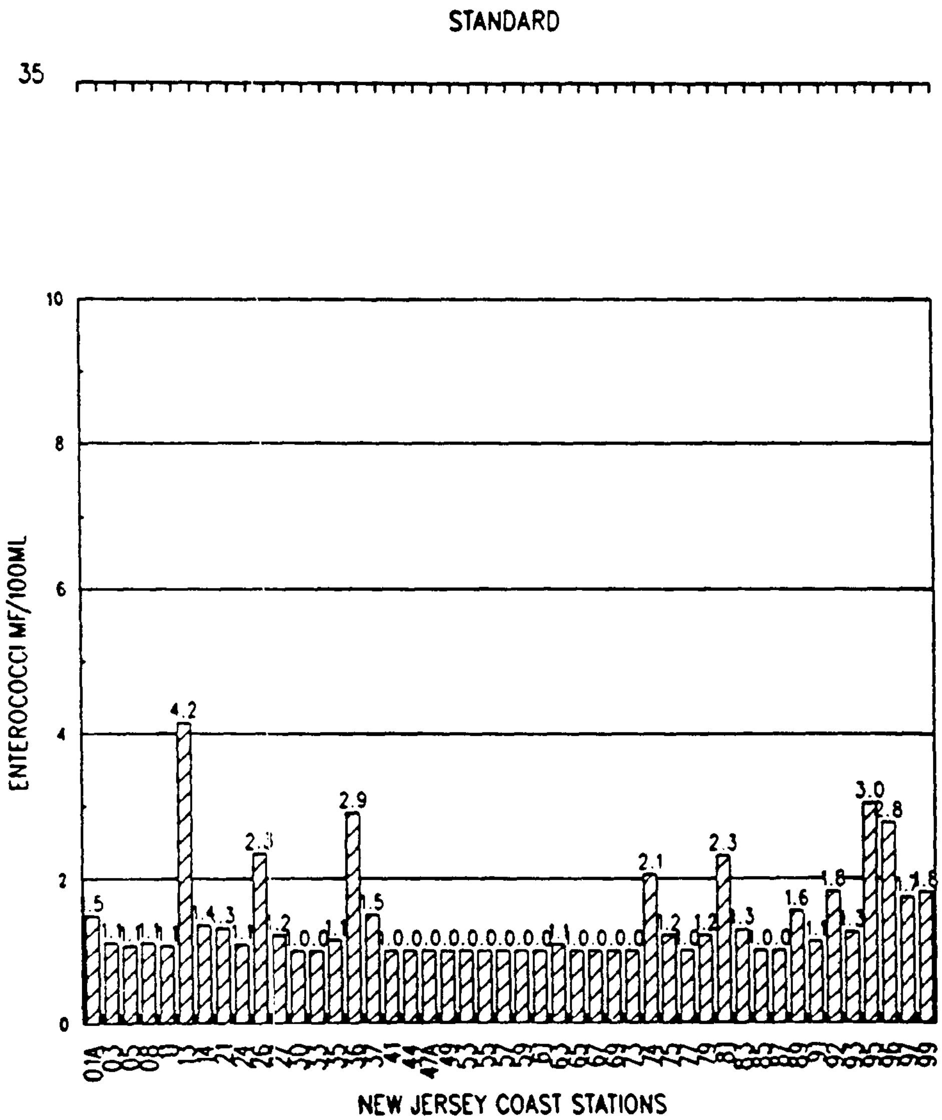
The cause of these elevated values may be related to runoff and/or discharges to inland waterways. Both JC 92 and JC 96 stations are located in inlets.

Table 8

Summary of enterococci data collected along the New Jersey coast
June 28, 1989 through September 6, 1989

Station	Number of Samples	Maximum Value (Enterococci/100ml)	Geometric Mean (Enterococci/100ml)
JC 01A	9	12	1.5
JC 03	10	3	1.1
JC 05	10	2	1.1
JC 08	10	3	1.1
JC 11	10	2	1.1
JC 13	10	26	4.2
JC 14	9	8	1.4
JC 21	9	3	1.3
JC 24	8	2	1.1
JC 26	8	22	2.3
JC 27	7	2	1.2
JC 30	8	1	1.0
JC 33	8	1	1.0
JC 35	8	3	1.1
JC 36	8	13	2.9
JC 37	8	26	1.5
JC 41	8	1	1.0
JC 44	8	0	1.0
JC 47A	8	1	1.0
JC 49	8	1	1.0
JC 53	8	1	1.0
JC 55	8	0	1.0
JC 57	8	1	1.0
JC 59	8	1	1.0
JC 61	8	1	1.0
JC 63	8	2	1.1
JC 65	8	1	1.0
JC 67	8	1	1.0
JC 69	8	1	1.0
JC 73	7	1	1.0
JC 74	7	10	2.1
JC 75	7	2	1.2
JC 77	7	1	1.0
JC 79	7	2	1.2
JC 81	7	13	2.3
JC 83	7	3	1.3
JC 85	6	1	1.0
JC 87	6	0	1.0
JC 89	6	14	1.6
JC 91	6	2	1.1
JC 92	6	37	1.8
JC 93	6	2	1.3
JC 95	6	160	3.0
JC 96	6	77	2.8
JC 97	6	7	1.7
JC 99	6	6	1.8

Figure 25



GEOMETRIC MEANS OF ENTEROCOCCI DATA COLLECTED ALONG THE COAST OF NEW JERSEY, JUNE 28, 1989 TO SEPTEMBER 6, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

Long Island

Table 9 presents a summary of the enterococci data collected along the Long Island coast from May 23, 1989 to September 5, 1989. The geometric mean for each station is plotted in Figure 26. New York State does not have a water quality standard for enterococci bacteria. As with the New Jersey data, the enterococci data along the Long Island coast are compared to the EPA criterion of 35 enterococci/100ml. Due to the low values found and the relatively small number of samples collected per station, only one geometric mean was calculated for each station over the summer. The highest geometric mean, 2.7 enterococci/100ml, occurred at three stations: LIC 05, Far Rockaway Beach, LIC 10, Point Lookout off Hempstead public beach, and LIC 21, Bellport Beach. Figure 26 shows that all of the geometric means are well below the EPA criterion.

A total of 131 enterococci samples were collected along the coast of Long Island during the summer. The highest density found during the summer season, 20 enterococci/100ml, was at Bellport Beach on September 5. Based on the enterococci densities, the water quality off the Long Island coast is excellent.

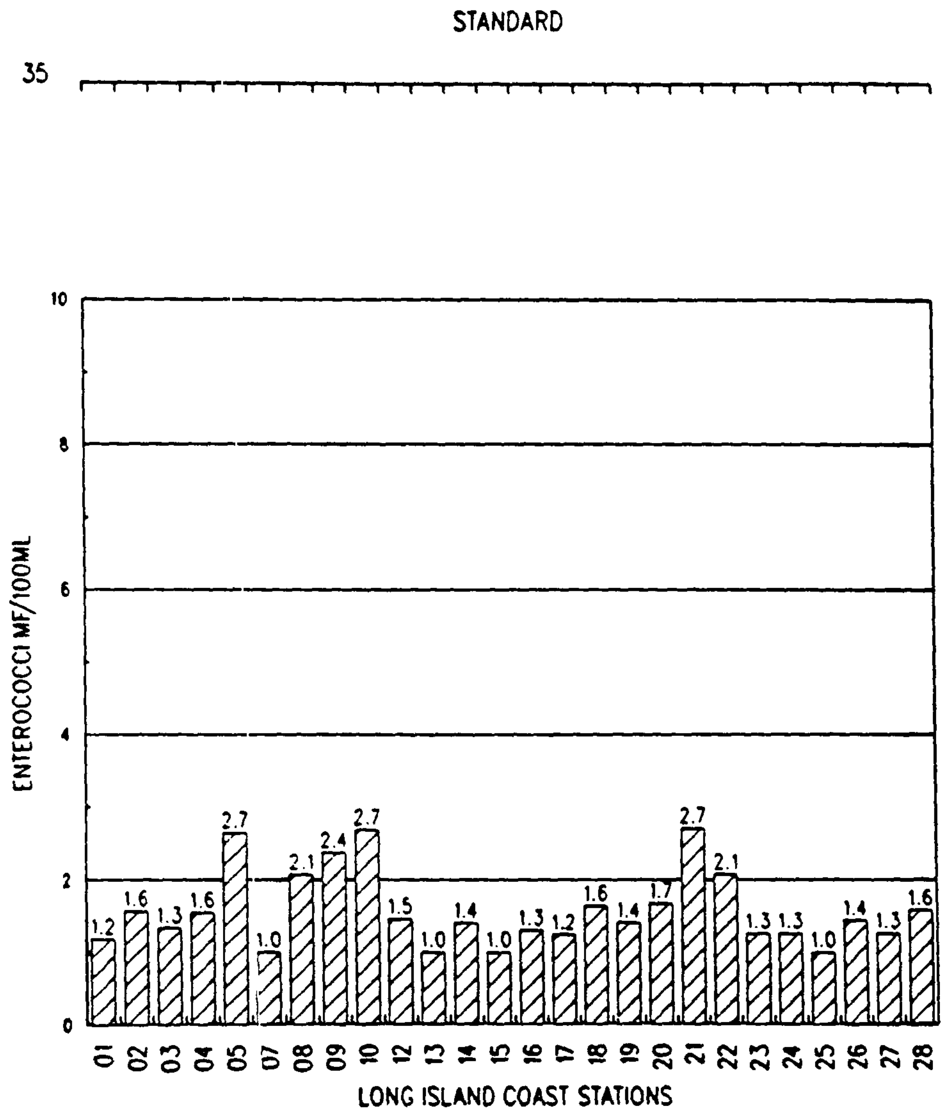
A further discussion of the bacteriological data prepared by the EPA Regional laboratory, which includes a discussion of the standards, indicator bacteria, materials, methods, and results, is presented in Appendix C.

Table 9

Summary of enterococci data collected
along the Long Island coast
May 23, 1989 through September 5, 1989

Station	Number of Samples	Maximum Value (Enterococci/100ml)	Geometric Mean (Enterococci/100ml)
LIC 01	8	2	1.2
LIC 02	7	4	1.6
LIC 03	7	8	1.3
LIC 04	6	7	1.6
LIC 05	7	11	2.7
LIC 07	6	1	1.0
LIC 08	6	10	2.1
LIC 09	6	6	2.4
LIC 10	6	8	2.7
LIC 12	6	5	1.5
LIC 13	6	1	1.0
LIC 14	6	2	1.4
LIC 15	6	1	1.0
LIC 16	6	5	1.3
LIC 17	5	3	1.2
LIC 18	5	4	1.6
LIC 19	4	4	1.4
LIC 20	4	4	1.7
LIC 21	3	20	2.7
LIC 22	3	3	2.1
LIC 23	3	2	1.3
LIC 24	3	2	1.3
LIC 25	3	1	1.0
LIC 26	3	3	1.4
LIC 27	3	2	1.3
LIC 28	3	2	1.6

Figure 26



GEOMETRIC MEANS OF ENTEROCOCCI DATA COLLECTED ALONG THE COAST OF LONG ISLAND, MAY 23, 1989 TO SEPTEMBER 5, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

BIBLIOGRAPHY

1. Cabelli, V. J., A. P. Dufour, L. J. McCabe, M. A. Levin, "A Marine Recreational Water Quality Criterion Consistent with Indicator Concepts and Risk Analysis", Journal WPCF, Volume 55, November 10, 1983.

2. Cabelli, V. J., A. P. Dufour, L. J. McCabe, M. A. Levin, "Swimming-Associated Gastroenteritis and Water Quality", American Journal of Epidemiology, Volume 115, No. 4, 1982.

3. National Advisory Committee on Oceans and Atmosphere, "The Role of the Ocean in a Waste Management Strategy", Washington, D.C., January 1981.

4. U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), "Response of the Habitat and Biota of the Inner New York Bight to Abatement of Sewage Sludge Dumping", 2nd Annual Progress Report--1988, NOAA Technical Memorandum NMFS-F/NEC-67, July 1989.

5. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1984", Environmental Services Division, Region 2, Edison, New Jersey, August 1985.

6. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1985", Environmental Services Division, Region 2, Edison, New Jersey, August 1986.

7. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1986", Environmental Services Division, Region 2, Edison, New Jersey, July 1987.

8. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1987", Environmental Services Division, Region 2, Edison, New Jersey, July 1988.

9. U.S. Environmental Protection Agency; "Short-term Action Plan for Addressing Floatable Debris in the New York Bight", prepared by Batelle Ocean Sciences, Contract No. 68-03-3319, Work Assignment No. 2-147, March 1989.

APPENDIX A

Summary of Phytoplankton Blooms and Related Conditions

in New Jersey Coastal Waters

Summer of 1989

ANNUAL SUMMARY OF PHYTOPLANKTON BLOOMS AND RELATED CONDITIONS IN NEW JERSEY COASTAL WATERS, SUMMER OF 1989

New Jersey Department of
Environmental Protection
Division of Water Resources
Geological Survey

Annual Summary of Phytoplankton Blooms and Related Conditions in New Jersey Coastal Waters, Summer of 1989

SYNOPSIS

Phytoplankton/water-quality data for the New Jersey coastal region, as part of the USEPA New York Bight Water Quality Survey, are summarized for 1989. The earliest blooms causing concern were red tides dominated by the dinoflagellate, _Katodinium rotundatum_ in the Hudson-Raritan estuary, with cell counts exceeding 50,000/ml, in late June - early July. Unlike the few previous years when they recurred through out the summer in the Raritan - Sandy Hook Bay sector, the 1989 bloom persisted only a week but it extended throughout the entire estuary. It was dissipated prior to July 4 by changing weather conditions; consequently, diatoms of several species (especially _Skeletonema costatum_) dominated the phytoplankton in the entire survey region for the balance of summer. Maximum chlorophyll _a_ levels (>100 mg/m^3) were from Raritan-Sandy Hook Bay, thus reflecting hypertrophic conditions in this portion of the estuary. High chlorophyll _a_ values were also attained from an isolated flagellate bloom in Delaware Bay. As in previous years lowest chlorophyll _a_ values were obtained from the central N.J. (Ocean County) coast reflecting the cleaner water quality in this sector. The intense bloom of _Nannochloris atomus_ in Barnegat Bay, which has recurred at least since 1985, persisted again in 1989 with maximum cell counts approaching 1.5 million/ml and chlorophyll _a_ levels consistently over 20 mg/m^3). A significant phytoflagellate red tide, covering a coastal area from at least from Asbury Park to Barnegat Inlet and to five miles offshore, was observed in late October following substantial rains and abnormally warm weather. No significant fauna kills attributable to hypoxia were reported in 1989.

INTRODUCTION

Chronic summer algal blooms in the Hudson - Raritan estuary and adjacent New Jersey coastal waters have been observed at least since the early 1960's (Mahoney and McLaughlin, 1977). Several phytoflagellate species, primarily _Katodinium rotundatum_, _Olisthodiscus luteus_ and _Prorocentrum_ spp. have been responsible for most of these red tides. Cell counts sometimes exceeding 100,000/ml reflected excessive nutrient concentrations with dramatically intense primary production. Hydrography in the region was such that most of the phytoplankton accumulated along the south side of the estuary (e.g. in Raritan and Sandy Hook Bays) and often washed out with tidal action around Sandy Hook southward to Sea Bright or beyond (Ketchum et al 1951; Jeffries, 1961). Higher runoff from the Hudson River could augment this and, coupled with local drainage, the blooms could be sustained even farther southward. Adverse effects were usually aesthetic in nature with suspended masses or shoreline deposits of flocculent, stringy or foamy material from decomposition being the most common problem; there were also occasional fish kills due to anoxia when blooms collapsed (Ogren and Chess, 1969). Historical perspective of New Jersey phytoplankton blooms, given in Figure 1, was taken from Olsen (1989). Fortunately, none of these blooms were of the acutely toxic varieties; however, in 1968 an extensive and persistent red tide of Prorocentrum micans along the Monmouth County coast was associated with complaints of irritation or discomfort by bathers.

Following the 1968 event, the Interagency Committee on Marine Phytoplankton Blooms was formed to respond to such problems. A subsequent study and an intensive survey were conducted cooperatively by the New Jersey Department of Environmental Protection and the National Marine Fisheries Service, Sandy Hook Lab. From these studies respectively, the red tides were associated with hypertrophication (Mahoney and McLaughlin, 1977) and a comprehensive phytoplankton species inventory of the region was compiled (Olsen and Cohn, 1979). In 1976, the first massive offshore bloom recorded for the New York Bight (that of Ceratium tripos) occurred resulting in widespread anoxia and consequent fish kills (Mahoney and Steimle, 1979; Swanson and Sindermann, 1979). This event also prompted interagency response, and seasonal helicopter surveillance of the N.Y. Bight was instituted by the USEPA Region II. In 1977, phytoplankton sampling of the N.J. northern estuarine and coastal region, south to Island Beach, was added to the routine schedule (see USEPA 1978 - 89, inc.). In 1984 and 1985, the first major phytoplankton blooms causing concern in southern N.J. coastal waters occurred resulting in brilliant green water discoloration, especially in the greater Atlantic City area. The causative species was identified as Gyrodinium aureolum (Mahoney et al, 1990). Following these events, in 1986, routine phytoplankton sampling was expanded to include the New Jersey coast from Long Beach Island to Cape May (see Fig. 2).

Recent Trends

Although major red or green tides have not occurred in the coastal waters since about 1985, chronic blooms have persisted in the bays and estuaries. Red tides have occurred primarily in the Hudson-Raritan estuary; these have been dominated by the dinoflagellate, Katodinium rotundatum, while species formerly dominant such as Olisthodiscus and Prorocentrum spp; have been subdominant. Some localized fauna kills, probably due to anoxia from collapse of these blooms, have been seen along the south shore of the estuary.

While the red tides were composed mainly of phytoflagellates (see USEPA, 1978-1989, inc.), considerably smaller (primarily chlorophycean) forms were found to be dominant in the region and responsible for greenish water discoloration (Patten, 1962; McCarthy, 1965). The major species was identified as Nannochloris atomus. These blooms occurred primarily in the Hudson - Raritan estuary and adjacent coastal waters, but in 1985-86 they were prevalent in the N.Y. Bight both offshore and along the entire N.J. coast. Also in 1985, conspicuous yellow-brown water discoloration caused apparently by N. atomus was first noted from Barnegat Bay (see Mountford, 1971; Olsen, 1989); this was concurrent with the "brown tides" which devastated shellfisheries in Rhode Island and eastern Long Island, N.Y. embayments (Cosper et al, 1987). The causative species in the brown tides was identified as Aureococcus anophagefferens (Sieburth et al, 1988); its presence was detected in 1988 as a relatively small component of the phytoplankton biomass in the Barnegat Bay blooms (Anderson et al, 1989) which have persisted since 1985. Adverse effects on New Jersey resources thus far have not been documented.

The past few summers have also seen substantial blooms of diatoms (the normal plankton flora during the cooler months); these have apparently been responsible for incidence of brown water and consequent flocculent masses and shoreline foam deposits in Raritan - Sandy Hook Bay and adjacent N.Y. Bight areas. Occasionally these conditions were seen intermittently along the entire New Jersey coast indicating that blooms were of neritic or offshore, rather than estuarine, origin. This has been most obvious during the month of May due to blooms of Cerataulina pelagica, but the condition has also resulted from the abundance of other species such as Skeletonema costatum and Thalassiosira spp.

The present report documents and chronologizes the phytoplankton-related phenomena of the region for the 1989 season.

METHODS

The basic sampling scheme includes at least twelve New Jersey coastal and estuarine sites from the USEPA New York Bight helicopter station network, plus supplementary sites in Barnegat Bay, Great Egg Harbor and Delaware Bay (Figure 2). In 1989, station RB24 (off Keansburg) was added and station JC53 was deleted. Frequency of collection is usually weekly from mid-May to September or early October. Exceptions occur when the helicopter is detained because of weather, logistics or other reasons. During 1989, the helicopter logistical situation prevented sampling before late June and caused sampling to cease prematurely in September. Collections are made from the helicopter using a Kemmerer sampler; because these waters are generally shallow and well-mixed, surface samples taken at 1m depth are considered representative. Clear plastic cubitainers, holding approximately one liter, are employed for chlorophyll a and phytoplankton samples. Field collections are made by members of the USEPA Region II Surveillance Unit in accordance with NJDEP, Division of Water Resources (DWR) standard methods (NJDEP, 1987). Analyses are performed by personnel of the NJDEP, DWR Biomonitoring Unit. Samples are transported and analyzed in accordance with Standard Operating Procedures of the DWR Biomonitoring Laboratory (NJDEP, unpublished document). A comprehensive reference collection for marine phytoplankton identification is maintained in the Biomonitoring Laboratory; reference lists are given in Olsen and Cohn (1979) and Marshall (1986).

RESULTS AND DISCUSSION

Species Composition - 1989 Highlights

A list of dominant species in the major segments of the survey region, showing seasonal succession and bloom incidence is given in Table 1. Summer of 1989, as in other recent years, was highlighted by the occurrence of dense phytoflagellate red tides in the major estuarine complex at the northern extreme of the New Jersey coast. These were again dominated by *K. rotundatum* with *Eutreptia lanowii* (a euglenoid) subdominant. *Olisthodiscus luteus* and *Prorocentrum* spp., species subdominant in recent years, were less abundant in 1989. During the previous year (1988) a red tide dominated by all four species continued intermittently from June through early August in the southern portion of the estuary (e.g. in Raritan-Sandy Hook Bay). The 1989 bloom(s), however, persisted only about a week in early summer but extended throughout the entire Hudson-Raritan estuary and, to a lesser degree, along the adjacent oceanfront southward to Manasquan

Inlet. The red tide was most intense June 26-28 in Sandy Hook Bay, with maximum observed cell counts of the dominant species exceeding 50,000/ml. It was dispersed just prior to July 4 apparently by changing weather conditions. Diatoms, especially Skeletonema costatum, dominated the phytoplankton for the balance of summer in the estuary and along the coastline.

Other than that of S. costatum, noteworthy diatom blooms in the vicinity during 1989 included those of Cylindrotheca closterium, Thalassiosira spp. and Hemiauluas sinensis (see Table 1.) Maximum observed cell counts (of S. costatum and C. closterium) approached 50,000/ml in Raritan - Sandy Hook Bay. S. costatum subsequently became abundant along the entire N.J. coast southward to Cape May indicating that the bloom was of neritic or offshore, rather than estuarine origin. Delaware Bay, at the southern extreme, experienced early-to- midsummer blooms of S. costatum (exceeding 50,000 cells/ml) as well as some red tides. The red-water blooms were dominated by Gyrodinium estuariale and O. luteus ; these, however, occurred within the context of a rich and diverse flora, and thus were isolated and apparently benign. The coccoid chlorophytes, primarily Nannochloris atomus, which are unusually numerically preponderant in the survey region, again became dominant throughout from mid to late summer. The intense Nannochloris blooms in the Barnegat Bay system, ongoing each summer at least since 1985, persisted again in 1989; maximum observed cell counts were about 1,500,000/ml, well exceeding N. atomus concentrations in the other estuarine as well as coastal areas.

Notable blooms occurred within the survey region before and after the routine sampling period (see Tables 1 and 2). The earliest confirmed were observed May 20-22 by personnel of the Monmouth County Health Department. These were apparently localized in Sandy Hook Bay, and were dominated by a chlorophyte (Chlorella sp.) and a phytoflagellate (Cryptomonas sp); several diatom species and the dinoflagellate, Prorocentrum minimum, were abundant. Conversely, the last event of the season occurred near the end of October, considerably later than routine sampling is normally carried on. This late bloom produced an extensive red tide over the N.J. shore north from at least Asbury Park, south to Island Beach (a distance of over 25 miles), and from the beach to at least five mile offshore between Manasquan and Barnegat Inlets; dominant species were phytoflagellates including K. rotundatum, E. lanowii, G. estuariale and Chroomonas amphioxiea. The bloom occurred during an abnormally warm period preceded by a coastal storm with heavy rains; this, plus the presumed occurrence of the autumn turnover, probably served to replenish the nutrient supply in the nearshore photic zone.

Outside of our survey region, in March-April 1989, a developing bloom of the dinoflagellate Ceratium tripos was reported offshore of Ocean City, Maryland. The presence of the species, however, was not detected in water-column samples subsequently taken nearshore off New Jersey in mid-May. In 1976, C. tripos had bloomed over a vast area of the New York Bight causing widespread anoxia and consequent fish kills (Mahoney and Steimle, 1979; Swanson and Sindermann, 1979).

Chlorophyll a

Results of phytoplankton chlorophyll a analysis for routine samples are given in Table 3. Seasonal fluctuations for the major geographical segments of the survey region are presented in Figure 3. As expected, the estuarine areas exhibit substantially higher values over the sampling period than do the coastal areas. Considerable variation between sampling dates is noted in Raritan-Sandy Hook Bay and Delaware Bay; this probably reflects tidal differences as well as the incidence of intense blooms in these estuaries. Barnegat Bay exhibits relatively high chlorophyll a levels with visibly less variation, probably due to the lack of flushing in this barrier island embayment. Although phytoplankton cell counts are much higher in Barnegat Bay, the minute cell size of the dominant species there (Nannochloris atomus)) represents considerably less biomass than the flagellate and diatom blooms in the other estuaries. Mean chlorophyll a values for each station are shown in Figure 4. The highest value (>50 mg/m^3) is derived from station RB24 at the confluence of Raritan and Sandy Hook Bays; this reflects the extreme hypertrophication characteristic of those waters. Coastal areas, especially Ocean County, have substantially lower chlorophyll levels than the estuarine areas. Somewhat higher values at station JC08 in Monmouth County, and also the stations in the Atlantic-Cape May County region, reflect estuarine contribution in these coastal segments which are proximate to the major estuaries or smaller coastal inlets.

Environmental Factors

The profound effects of meteorological conditions (e.g. temperature, light, precipitation, wind direction and velocity) on phytoplankton dynamics are evident in our monitoring results; this can be seen particularly in the year-to-year variations in species composition. Although apparently little change in the variety of species present has occurred over the past decade or more, a few shifts in species dominance have been observed (Olsen & Cohn, 1979; USEPA 1978-89, inc.). This has been more pronounced in the coastal waters of the New York Bight than in the relatively sheltered confines of the estuaries. Macronutrients to support phytoplankton growth are usually available in the region, especially in the bays and estuaries. Phytoflagellate blooms are normally associated with periods of quiescence, especially in offshore and coastal regions (see USEPA, 1986). Table 5 shows surf and nearshore temperature differences between 1988 and 1989. Both summers were characterized by relatively turbulent conditions (NOAA, 1988, 1989). Upwelling of cooler bottom water along the N.J. coast in 1988 was probably caused by the persistent southwesterly winds during that summer (see Ingham and Eberwine, 1984); coincidentally, phytoflagellate blooms were persistent in Raritan - Sandy Hook Bay but diatoms were prevalent in the coastal waters. The summer of 1989 saw greater incidence of onshore breezes and coastal storms; concomitantly, surf temperatures for most of the season were above the 70°F criteria for comfortable bathing (Table 5). In 1989, diatoms dominated the phytoplankton both in the coastal waters and in the Hudson -Raritan estuary, while phytoflagellate blooms occurred in the estuary primarily in early summer. Complaints of seaweed and floating debris along the New Jersey surfline were less frequent in 1989 than in 1988. Small invertebrates were not abundant in the surf zone in 1989 (nor in 1988) as they were in 1987 when clear, warm Gulfstream-like water was adjacent to our coast for a period in summer (USEPA, 1978-89, inc.).

REFERENCES

Anderson, D.M., D.M. Kulis, C.M. Cetta and E.M. Cosper. 1989 immunoflourescent detection of the brown tide organism, Aureococcus anophagefferens. In: Novel phyhtoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms. pp. 213-228. E.M. Cosper, E.J. Carpenter and V.M. Bricelj, eds. Coastal and estuarine studies. Springer-Verlag, Berlin.

Cosper, E.M., W. C. Dennison, E.J. Carpenter, V.M. Bricelj, J.G. Mitchell, S.H. Kuenstner, D. Culflesh and M. Dewey. 1987. Recurrent and persistent brown tide blooms perturb coastal marine ecosystem. Estuaries 10(4):284-290.

Ingham, M.C. and J. Eberwine. 1984. Evidence of nearhshore summer upwelling off Atlantic City, New Jersey. NOAA Tech. Memo. NMFS-F/NEC-31. U.S. Dept. of Comm., 10 pp.

Jeffries, H.P. 1962. Environmental charactistics of Raritan Bay, a polluted estuary. Limnol. and Oceanogr. 7:21-30.

Ketchum, B.H., A.C. Redfield and J.C. Ayers, 1951. The Oceanography of the New York Bight. Pap. Phys. Oceanogr. Meteor. 12(1):1-46.

Mahoney, J.B. and J.J.A. McLaughlin, 1977. The Association of phytoflagellate blooms in Lower New York Bay with hypertrophication. J. Exp. Mar. Biol. Ecol. 28:53-65.

Mahoney, J.B. and F.W. Steimle, Jr. 1979. A mass mortality of marine animals associated with a bloom of Ceratium tripos in the New York Bight. In: Toxic dinoflagellate blooms. pp. 225-230. D.L. Taylor and H.H. Seliger, eds. Elsevier, N Y.

Mahoney, J.B., Olsen, P. and M. Cohn 1990. Blooms of a dinoflagellate Gyrodinium cf aureolum in New Jersey coastal waters and their occurrence and effects worldwide. J. Coastal Res. 6:121-135.

Marshall, H.G. 1986. Identification manual for phytoplankton of the United States Atlantic coast. EPA-600/4-86-003. U.S. Environmental Protection Agency, Cincinnati, O. 132 pp.

McCarthy, A.J. 1965. An ecological study of phytoplankton of Raritan Bay. Fordham Univ. Ph.D. Thesis, 96 pp.

Mountford, K. 1971. Plankton studies in Barnegat Bay. Rutgers Univ. Ph.D. Thesis, 147 pp.

National Oceanic and Atmospheric Administration (NOAA). 1988 and 1989. Weather data, monthly summaries. Nat Weather Service, Atlantic City, NJ.

New Jersey Department of Environmental Protection (NJDEP). 1987. Field procedures manual for water data acquistion. Div. of Water Res., Trenton, 106 pp. and appendices.

New Jersey Department of Environmental Protection (NJDEP). unpublished report. Standard operating procedures for the biomonitoring laboratory. Division of Water Resources Trenton, 23 pp.

Ogren, L. and J. Chess. 1969. A marine kill on New Jersey wrecks. Underwater Natur. 6:4-12.

Olsen, P. and M. S. Cohn. 1979. Phytoplankton in Lower New York Bay and adjacent New Jersey estuarine and coastal areas. Bull. N.J. Acad. Sci. 24:59-70.

Olsen, P.S. 1989. Development and distribution of a brown-water algal bloom in Barnegat Bay, New Jersey, with perspective on resources and other red tides in the region. In: Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms, pp 189-212. E.M. Cosper, E.J. Carpenter and V. M. Bricelj, eds. Coastal and estuarine studies. Springer-Verlag, Berlin.

Patten, B.C. 1962. Species diversity in net phytoplankton of Raritan Bay. J. Mar. Res. 20:57-75.

Sieburth, J. McN., P.W. Johnson and P.E. Hargraves. 1988. Charcterization of Aurecoccus anophagefferens. gen. et. sp. nov. (Chrysophyceae): The Bloom in Narragansett Bay, Rhode Island. J. Phycol. 24:416-425.

Swanson, R. L. and C. J. Sindermann (eds.). 1979. Oxygen depletion and associated benthic mortalities in the New York Bight, 1976. NOAA Prof. Pap No. 11. Rockville, MD., 345 pp.

U.S. Environmental Protection Agency (EPA). 1978-1989 (inclusive). New york Bight Water Quality, annual reports, summers of 1977-1988 (inc.). Region II, Surveillance and Monitoring Branch, Edison, NJ.

U.S. Environmental Protection Agency (EPA). 1986. An Environmental inventory of the New Jersey coast/New York Bight relevant to green tide occurrence. Prepared by Science Applications International Corp. for USEPA, Region II, New York, NY, 156 pp.

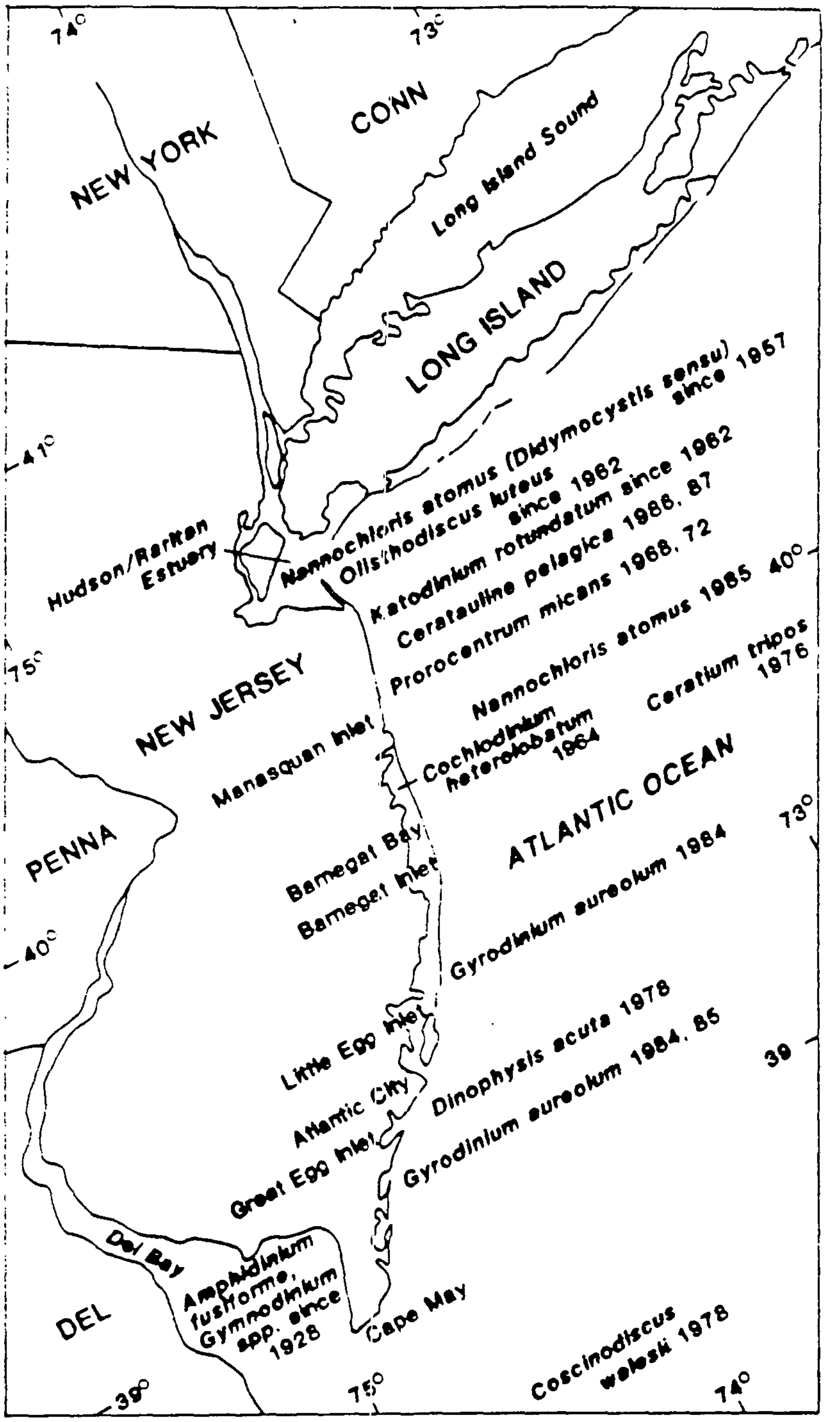


Figure 1. Historical perspective of major phytoplankton blooms causing red tides in the New York Bight and adjacent New Jersey coastal region.

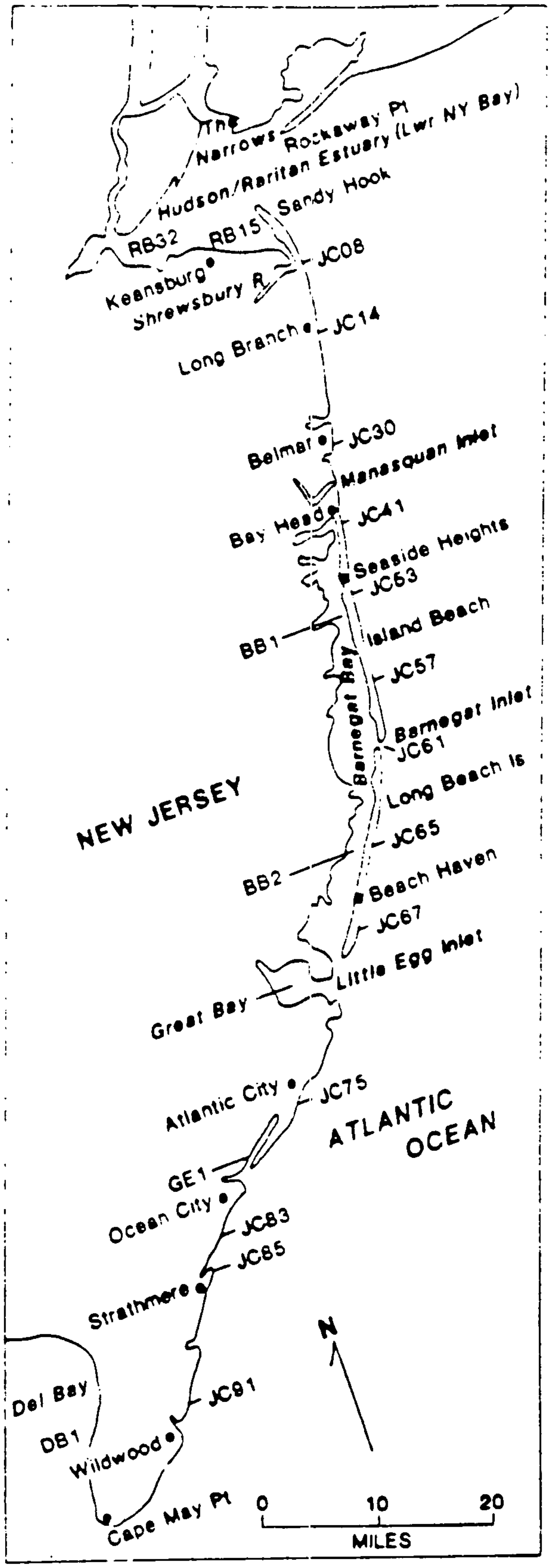
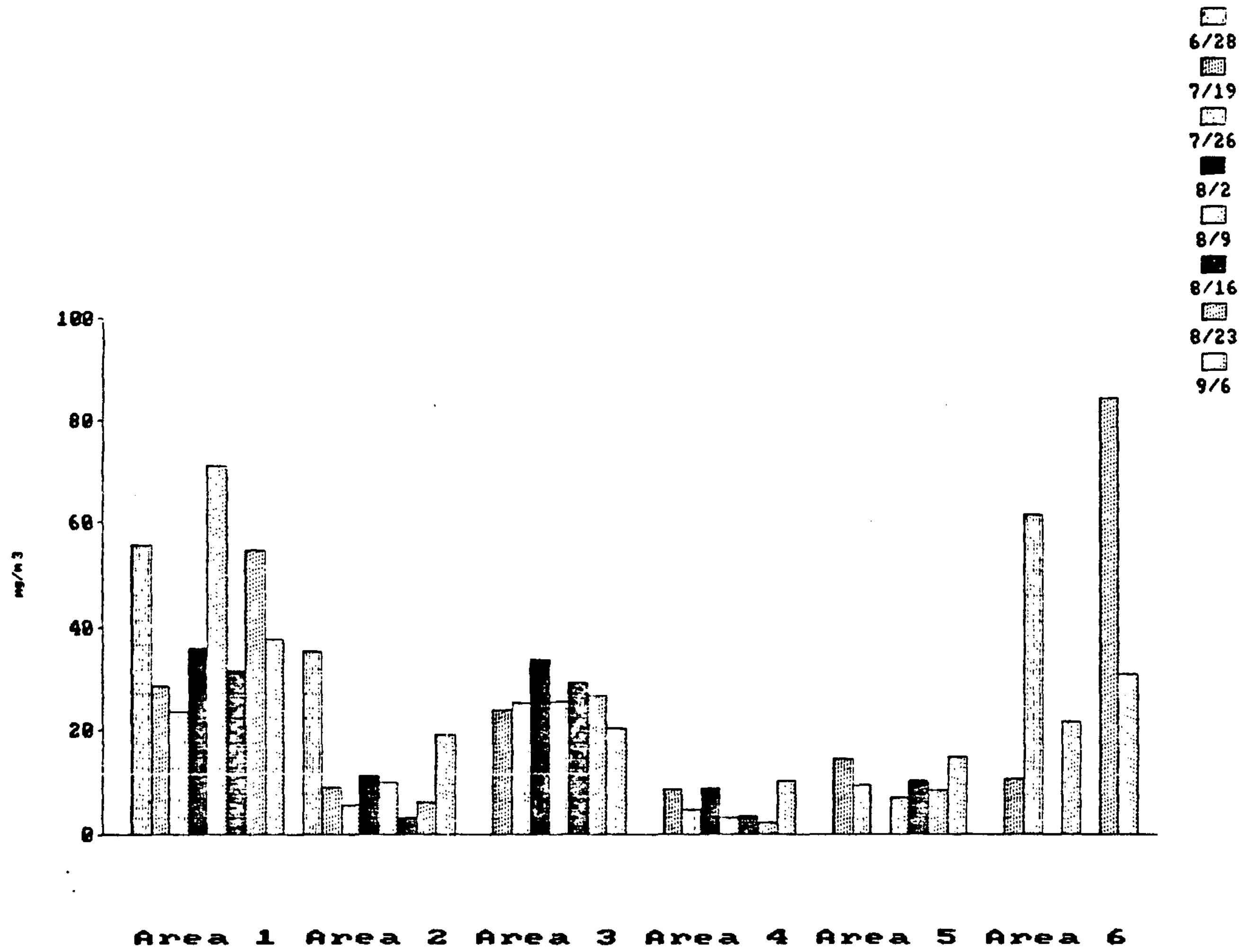


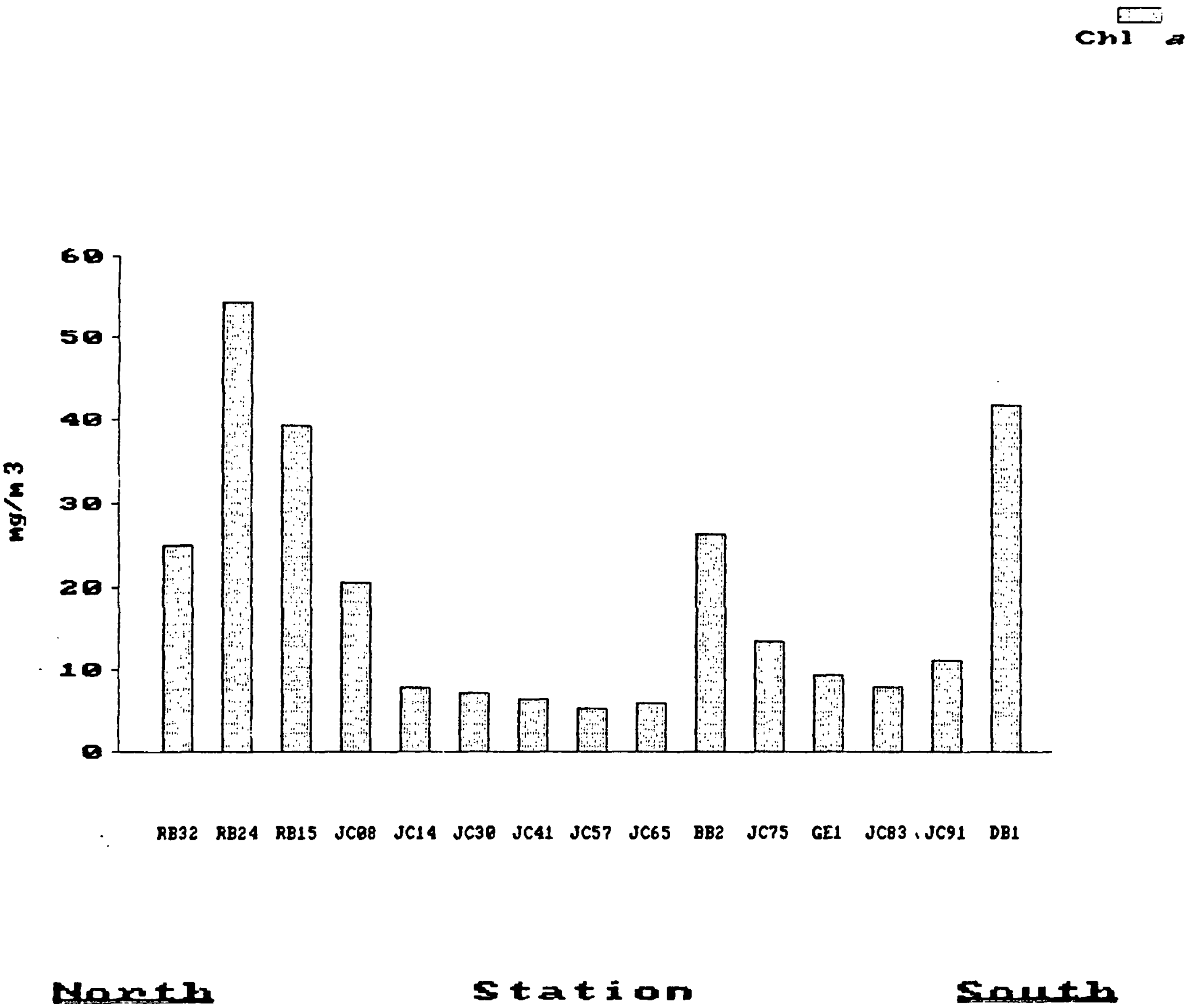
Figure 2 . New Jersey coast station locations, Sandy Hook to Cape May.

Figure 3. Seasonal changes of chlorophyll *a* concentrations (mg/m^3) for the 1989 New Jersey coastal and estuarine phytoplankton survey. Bars represent composite values for the major segments of the survey region.



Area 1 - Raritan - Sandy Hook Bay
Area 2 - Monmouth County coast
Area 3 - Barnegat Bay
Area 4 - Ocean County coast
Area 5 - Atlantic - Cape May County coast
Area 6 - Delaware Bay

Figure 4. Mean Chlorophyll *a* values for New Jersey coastal and estuarine stations, north to south, for the 1989 summer season.



state*	chl *a* mg/m^3
oligotrophic	0 - 3.3
mesotrophic	3.4 - 6.6
eutrophic	6.7 - 10
hypertrophic	>10

* Criteria are based on levels normally found in coastal and offshore waters.

Figure 5. Seasonal changes in surf and nearshore bottom temperatures ($^{\circ}F$) for 1988 and 1989. Surf temperatures from Island Beach State Park (mean for three-day intervals from June 24 through September 24. Bottom temperatures from USEPA transect off Seaside Park, JC53E (1 mile offshore) and JC53M (9 miles offshore).

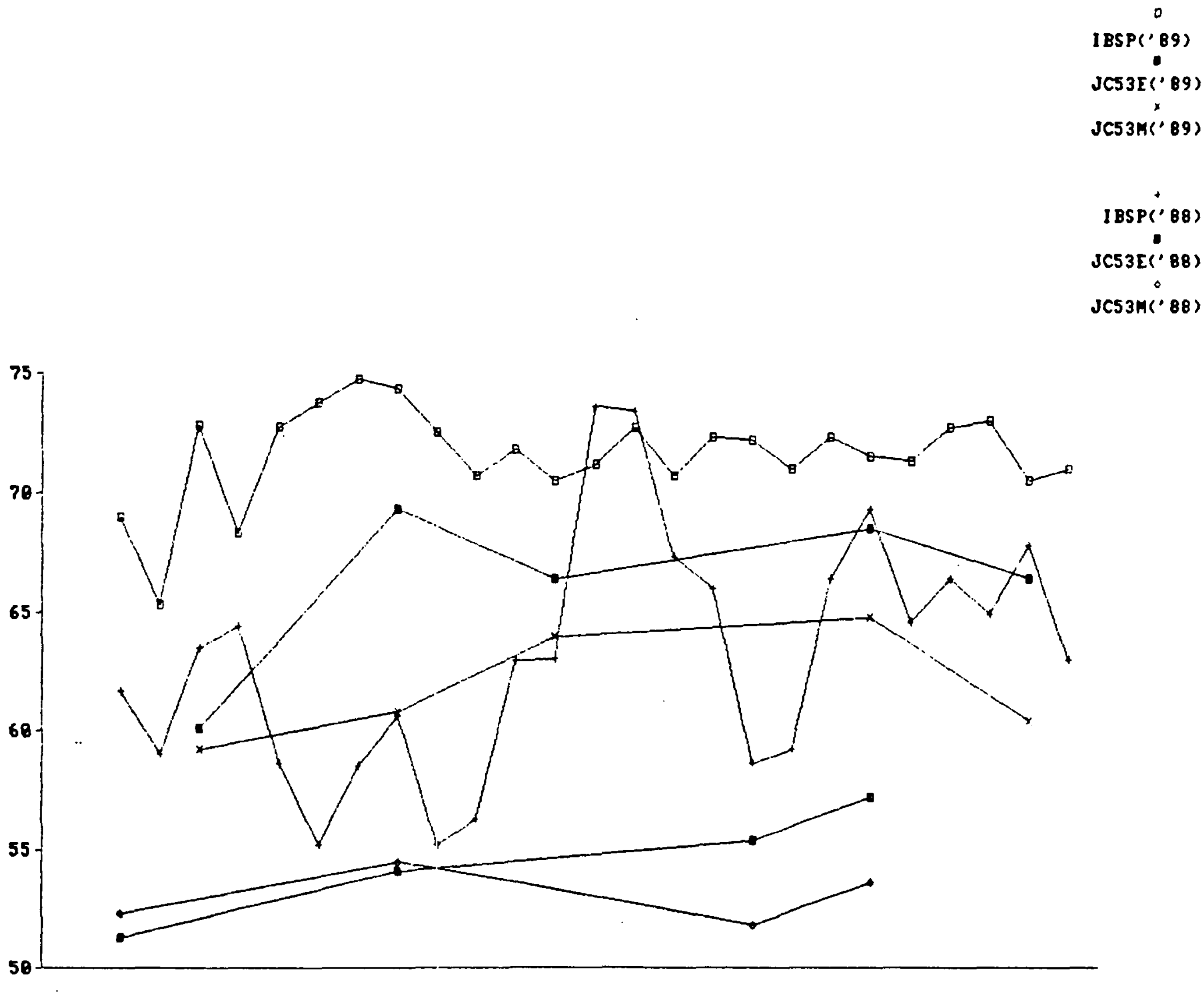


Table 1. Succession of dominant species undergoing blooms at one or more sampling stations in the regional segments of the 1989 survey of New Jersey coastal-estuarine waters. Dominant (small letters) = $>10^3$ cells/ml; bloom (capital letters) = $> 10^4$ cells/ml, which can cause visible water coloration or red tides. No designation indicates that the species was either present in low numbers or was not observed. Seasonal designations are as follows: A/a - early summer (June 23 to July 14); B/b - midsummer (July 19 to August 10); C/c - late summer (August 16 to September 6).

	North		Location			South
Bloom Species	Raritan-Sandy Hook Bay RB15-RB32	Monmouth County JC05-JC30	Ocean County JC41-65	Barnegat Bay BB2	Atlantic-Cape May County JC75-91	Delaware Bay DB1
Diatoms						
Leptocylindrus sp.	C					
Skeletonema costatum	BC	aBc	BC		bC	AB
Cyclotella sp.	BC					
Thalassiosira gravida	bC					
T. nordenskioldii	aB					
T. rotula	bc	b				
Hemiaulus sinensis	C	c	c			
Chaetoceros sp.	Bc	c				
Chaetoceros sociale	bc	b			c	
Asterionella glacialis	c					
Nitzschia sp.				c	b	bC
Cylindrotheca closterium	aBc	a		a	b	bc
Dinoflagellates						
Gyrodinium estuariale[1]		c				A
Katodinium rotundatum	Abc	Abc	c			
Other phytoflagellates						
Olisthodiscus luteus	ab	ab	b			A
Eutreptia lanowii[1]	A c	bc	bc			
Chroomonas sp. (amphioxiea[1])	ab	(c)	(c)			
Nonmotile coccoids						
Chlorella sp.[2]	a					b
Nannochloris atomus	AbC	abC	bC	ABC	bC	BC

Footnotes: 1 - dominant in extensive red tide along the Monmouth - Ocean County coast in late October after termination of routine surveillance

2 - dominant in red tide in Sandy Hook Bay in late May before commencement of routine surveillance

Table 2. Common or abundant phytoplankton species, listed by class, at selected sampling locations in the 1979 survey of the New Jersey coast and estuaries. Numbers denote frequency of occurrence in samples during the period June 25 to September 6. Letters indicate times of dominance as follows (see Table 1): a = early summer (June 23 - July 14), b = midsummer (July 19 - August 10), c = late summer (August 16 - September 6).

	RB15	RB24	JC14	JC30	JC57	JC75	DB1
BACILLARIOPHYCEAE							
Leptocylindrus minimus							2bc
Skeletonema costatum	6bc	5bc	2bc	3abc	2bc	3abc	6abc
Cyclotella sp.	1c						1c
Thalassiosira sp.							1b
T. gravida		1b					
T. nordenskioldii		1b					
T. rotula	3bc	2bc					
T. subtilis	1b		1b	1b			
Detonula confervacea		1c					
Hemiaulus sinensis	3c	3c	1c	1c			
Chaetoceros sp.				1c			
C. decipiens		1c					
C. sociale	3bc	2bc	2b				
Rhizosolenia delicatula	1a	1a			1a	1a	
Ditylium brightwellii		2c					
Asterionella glacialis	2c						
Thalassiothrix sp.						1b	1a
Thalassionema nitzschioides						1b	
Nitzschia sp.	2c					3ab	2bc
Cylindrotheca closterium	7abc	4bc				1b	3bc
CHRYSOPHYCEAE							
Calycomonas ovalis		2bc					
Mallomonas sp.	1a						
HAPTOPHYCEAE							
Chrysochromulina sp.			1c	1c	1c		
CHLOROPHYCEAE							
Chlorella sp.	1a					1b	1ab
Nannochloris atomus	11abc	5abc	2ac	4bc	5abc	7abc	6abc
PRASINOPHYCEAE							
Pyramimonas sp.		1b	1c	1c	3abc	1a	1a
Tetraselmis sp.			1c	1c	1c		
EUGLENOPHYCEAE							
Eutreptia lanowii[1]		1a	1ac	1c	2bc		
DINOPHYCEAE							
Prorocentrum minimum[2]	1ac	1c		1a			1ac
P. triestinum (redfieldi)		1c					
Gyrodinium dominans			1c	1c	1c		
G. estuariale[1]			1c	1c	1c		2a
G. pellucidum			1c	1c	1c		
Katodinium rotundatum[1]	2a	2a	2ac	2ac	1c		
Heterocapsa triquetra							1a
CRYPTOPHYCEAE							
Chroomonas amphioxiea[1]			1c	1c	1c		1a
C. minuta	2a	2ab					
C. vectensis						1b	
CHLOROMONADOPHYCEAE							
Olisthodiscus luteus[3]		1a					1a
Total	47	42	15	21	20	20	27
Frequency Index*	4.27	4.07	2.25	3.00	2.56	3.33	5.40

Footnotes: * - number of occurrences/number of samples
- dominant in extensive red tide along Monmouth - Ocean County coast in late October, after routine sampling
- abundant in red tide in Sandy Hook Bay in late May, before routine sampling

Table 3. Chlorophyll *a* data mg/m^3 for the 1959 New Jersey estuarine and coastal phytoplankton survey.

Location	6/16	6/28	6/30*	7/6	7/19	7/26	8/2	8/9	8/16	8/23	8/30	9/6	Mean
Hudson/Raritan estuary													
RB4			47.35										47.35
RB7			49.05										49.05
RB15		55.95	65.33	29.59	35.74	13.61	25.91	37.66	26.25	47.26	13.99	46.51	39.44
RB16			57.73										57.73
RB16A			57.54										57.54
RB24		45.15			24.51	33.51	55.62	136.75	52.62	74.32	16.75	45.49	54.53
RB25			99.53										99.53
RB25A			103.54										103.54
RB32		32.91		16.51	22.20		23.42	39.02	15.91	42.70	13.09	15.35	24.90
RB34						5.52							5.52
RB46			69.50										69.50
RB46A			73.79										73.79
RB50A			96.24										96.24
Leonardo*		166.10	77.12										121.61
Ideal Bch.*		54.60	163.77										109.19
Ambrose Ch.*		64.65											64.65
RB51A			112.56										112.56
RB57			100.96										100.96
RB59			50.37										50.37
Monmouth County coast													
JC03					9.50								9.50
JC05		52.10		14.02		5.33	11.02	24.45	5.32	5.65	5.53	22.32	20.56
JC11					7.57								7.57
JC14		12.39				3.42	12.34	4.36	3.17	6.75	2.79	17.20	7.50
JC26					10.57								10.57
JC30		11.29				5.11	10.63	1.60	.51	2.76		17.84	7.15
Ocean County coast													
JC41					5.05	4.54	11.65	2.36	1.53	2.36		13.73	6.36
JC57					9.55	6.24	7.17	2.34	1.75	2.00		5.01	5.30
JC62					5.26	3.32	5.15	4.51	6.67	1.93		9.19	6.00
Atlantic/Cape May county													
JC75					20.55	15.55		9.16	12.25	9.36		10.79	13.50
CE1						16.56		6.19	6.45	3.65		14.41	9.45
JC83					11.43	2.35		4.19	8.24	3.61		17.52	7.95
JC91					11.63	7.42		5.24		12.61		16.09	11.20
Barnegat Bay													
BB2					23.52	25.32	33.74	25.45	29.25	26.50		20.34	26.39
Delaware Bay													
DB1					10.73	61.75		21.74		54.41		30.55	41.90
1/3555*	72.32												72.32
2/3593B*	43.05												43.05
3/3593D*	14.91												14.91
4/3595E*	10.13												10.13

* special bloom samples (nonroutine)

APPENDIX B

New York Harbor Complex

Floatable Study

Summer of 1989

New York Harbor Complex
Floatable Study

INTRODUCTION

During the summer of 1989, the U.S. Environmental Protection Agency (EPA) conducted overflights of the New York Harbor Complex in response to the Short Term Action Plan for Addressing Floatable Debris. This Action Plan, which is part of the New York Bight Restoration Plan, was developed by an interagency Floatable Task Force in an effort to prevent the occurrence of beach closures due to floating debris, as occurred in previous years. This report specifically relates to the aerial surveillance of floatables and/or slick lines in the New York Harbor Complex.

PROCEDURES

During the period of May 15 through September 15, 1989, the NY Harbor Complex was surveyed for floatables debris via the EPA helicopter. Each day, the following information on significant floatables and/or slick lines was recorded: location, approximate dimension, relative density, time sighted, contents of slick, and condition of tide. The information was reported to a central communication response network, specifically established to coordinate cleanup efforts.

Surveillance was conducted 6 days a week, including the 4th of July. Due to bad weather conditions and/or mechanical problems with the helicopter, 73 overflights, out of a possible 104, were completed. A complete overflight of the NY Harbor Complex, included the Arthur Kill, from the Island of Meadows - north; Newark Bay, as far north as the NJ Turnpike Bridge; the Kill Van Kull; the Upper NY Harbor; the Narrows, two miles north and one mile south of the Verrazano Narrows Bridge; and the Lower Harbor, see Figure 1.

OBJECTIVE

The purposes of this report are to present a summary of the data collected, and to correlate the occurrence of a slick with the condition of the tide.

All data collected from May 15 through September 15, were summarized on a spread sheet with each page representing one week of monitoring, from Saturday to Friday, Appendix A. The summary contains the relative location, the size category of the slick, a description of contents, the time the slick was sighted, and the time of the closest condition of the tide - high or low.

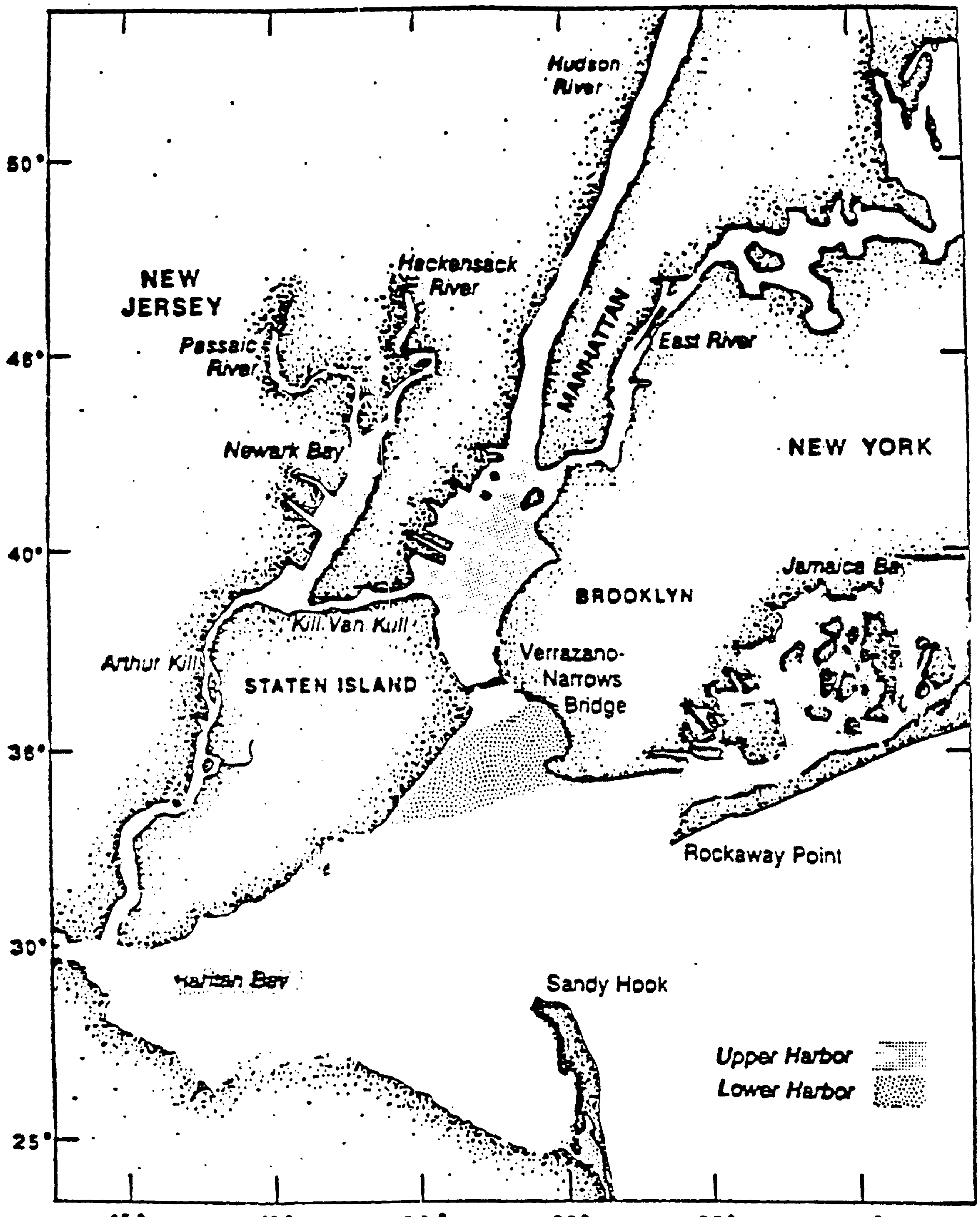


FIGURE 1. MAP OF NEW YORK HARBOR COMPLEX

In order to summarize the data collected, an understanding of the size of each slick is necessary. Therefore, each slick has been placed into a size category according to the slick's approximate dimensions, relative density and other recorded observations, see Appendix B for a list of approximate dimensions. For cleanup purposes, the Short Term Action Plan defined a "slick" as an aggregation of floating debris of indefinite width and a minimum length of approximately 400 meters. Using this as a guideline, all slicks have been divided into the following five categories (from largest to smallest):

Major: any slick over one mile in length;

Heavy: 800 meters to 1600 meters (or 1/2 of a mile to one mile);

Moderate: 400 meters to 800 meters;

Light: any slick under 400 meters;

Dispersed: any area that contains a significant amount of floatables, but no defined slick.

A slick under the categories of Light or Dispersed, is usually difficult to detect and maintain a sighting, for purposes of an efficient cleanup.

The categories of slicks are subjective. Any slick that has a relatively heavy density or extensive width, can be moved up a category; as any slick with a relative light density or is broken in places, can be moved down a category.

RESULTS AND DISCUSSION

Size Category

From May 15 through September 15, a total of 139 slicks were reported in the NY Harbor Complex, Figure 2. The highest number of slicks reported, 39 slicks, occurred in the Upper NY Harbor, and the second highest number, 34 slicks, occurred in the Newark Bay.

Figures 3 and 4 depict the number of slicks in each size category, corresponding to one of the six divisions of the NY Harbor Complex. Figure 3 shows that 20 of the 39 slicks reported in the Upper NY Harbor, were in the Light or Dispersed category. Likewise, 22 of the 34 slicks in Newark Bay, were also in these categories. Figure 4 shows slicks that meet the cleanup requirements - Major, Heavy, and Moderate - for each location. Whereas the Upper NY Harbor and the Newark Bay had the highest number of slicks, the Upper NY Harbor and the Narrows had the highest number of slicks occurring in the cleanup range, 19 and 18 slicks, respectively. Newark Bay had 12 slicks in the cleanup range.

Figure 2

NY Harbor – Total Slick Distribution

May 15 – Sept 15, 1989

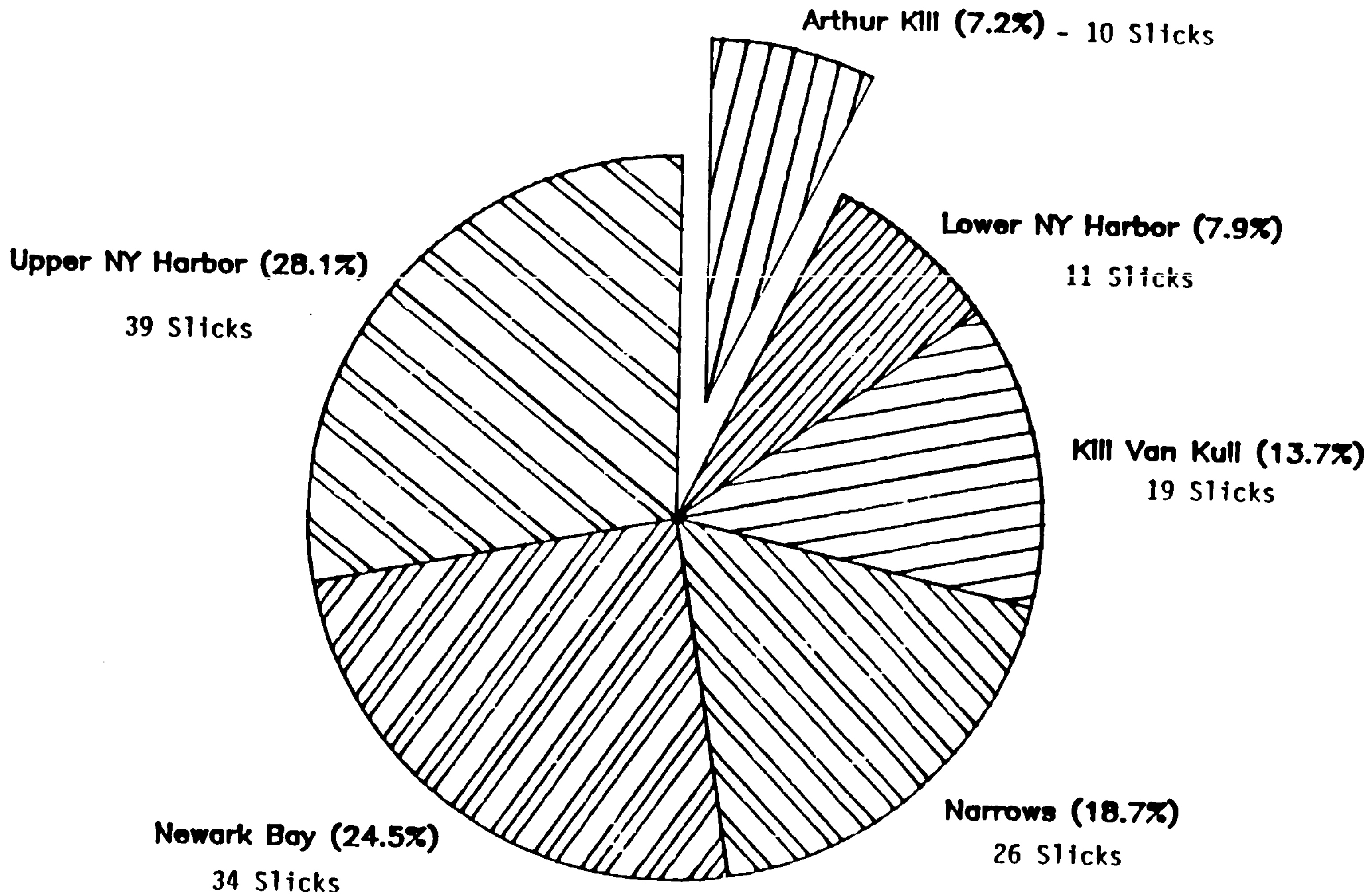


Figure 3

Total Number of Slicks Observed

May 15 – Sept 15, 1989

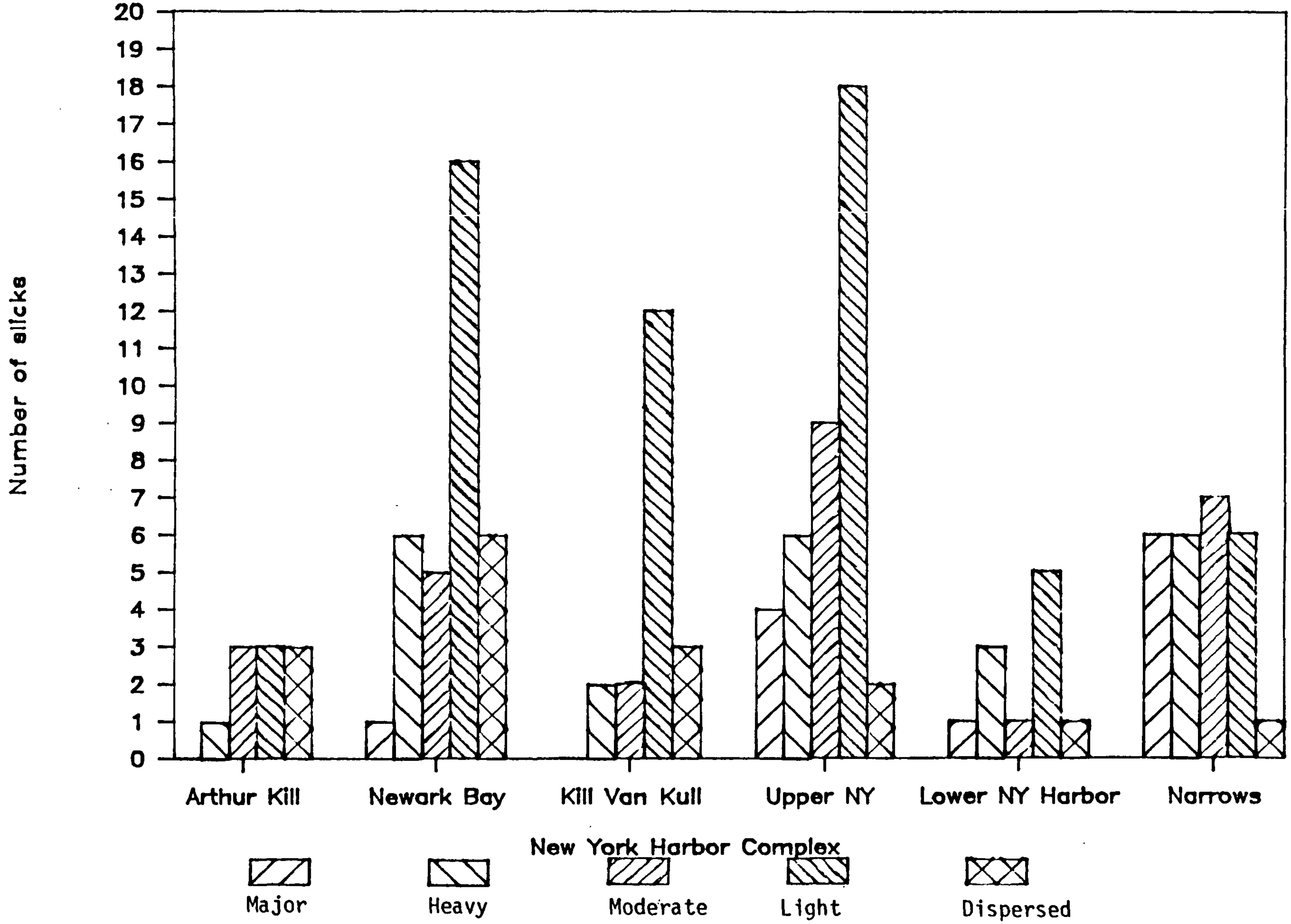
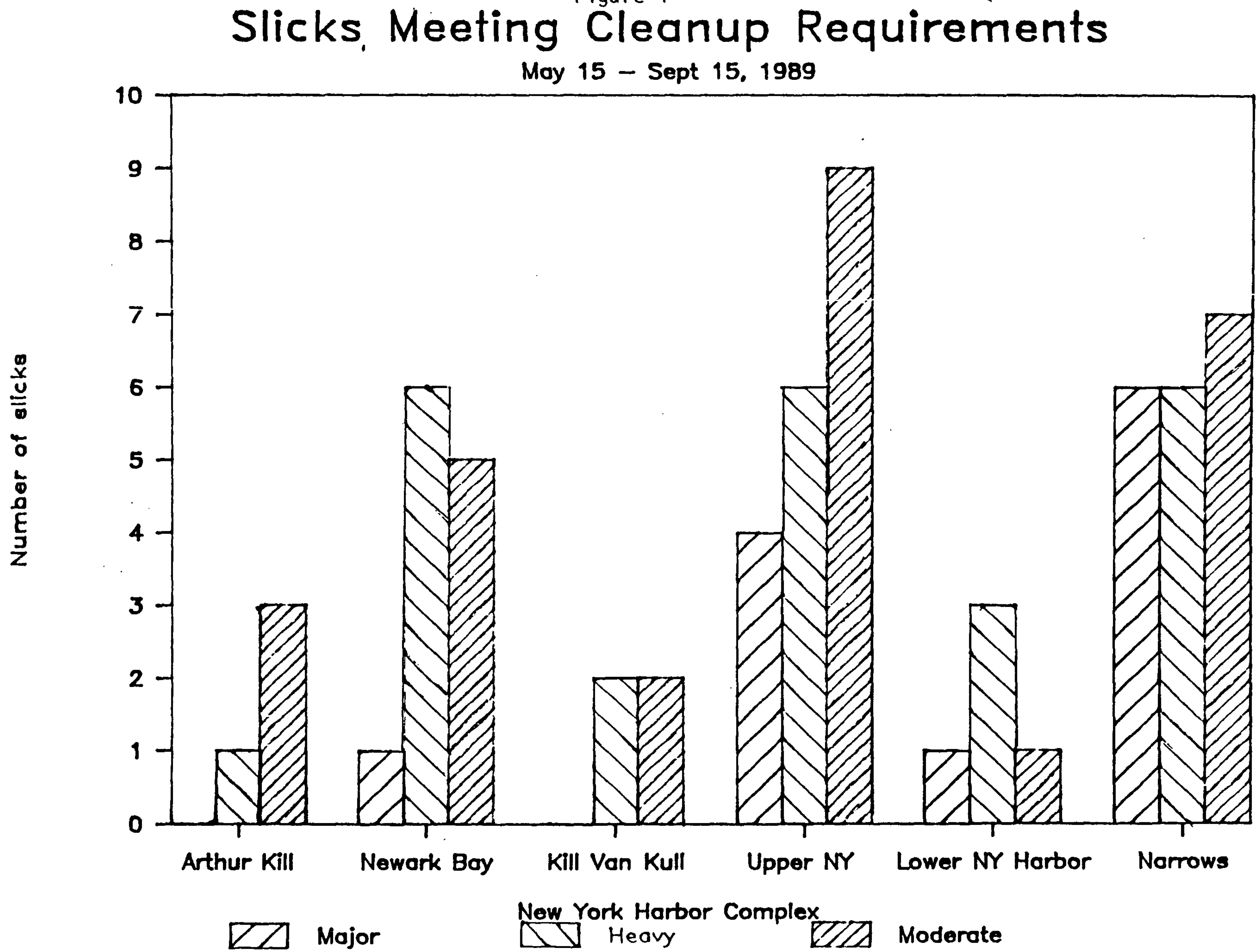


Figure 4



Slicks Meeting Cleanup Requirements
May 15 – Sept 15, 1989
Number of slicks
0
1
2
3
4
5
6
7
8
9
10
Arthur Kill
Newark Bay
Kill Van Kull
Upper NY
Lower NY Harbor
Narrows
New York Harbor Complex
Major
Heavy
Moderate

Condition of Tide

Most of the slicks observed were the result of resuspension from impacted shorelines. A slick line formed by resuspension is the result of an unusually high tide, caused by a new or full moon and/or a heavy rainfall. Therefore, the relationship between the condition of the tide and the sighting of a slick is significant. Slick lines can also be formed by other factors such as, combined sewer overflow resulting from heavy rainfall, stormwater runoff, or illegal dumping.

For each area of the NY Harbor Complex, excluding the Kill Van Kull, the time of the closest condition of the tide, high/low, during the survey, has been determined. Table 1 summarizes by location, the tidal conditions when slicks were observed, and those days which were clear of significant slicks. Newark Bay had the highest percentage of slicks, 84.8%, found during high tides, and the Narrows had the lowest percentage of slicks, 61.5%. Greater than two-thirds, 71.3%, of all slicks reported were sighted during high tides, and 62.5% of non-slick days were during low tides.

The Four Heaviest Days

The heaviest amount of reported floatables, with the indicated conditions, occurred on the following four days:

June 5 - Heavy slicks were reported in the Upper NY Harbor, the Lower NY Harbor, and the Narrows; Moderate slicks were reported in the Newark Bay and the Arthur Kill. Surveillance occurred shortly after high tide, and two days after a full moon. On June 4, New York had approximately 0.1 of an inch of rain, and New Jersey had approximately 1.0 inch.

July 19 - Heavy slicks were reported in the Newark Bay, the Kill Van Kull, and the Narrows; Light slicks in the Upper NY Harbor and the Lower NY Harbor, and a Moderate slick in the Arthur Kill. Surveillance occurred shortly after high tide, and one day after a full moon. On July 16 and 17, New York had approximately 0.9 and 0.2 of an inch of rain respectively, and New Jersey had approximately 0.9 and 0.1 of an inch, respectively.

August 14 - A Major slick was reported in the Upper NY Harbor, a Heavy slick in the Arthur Kill, a Moderate slick in the Lower NY Harbor, and two Moderate slicks in the Narrows. Surveillance occurred shortly after high tide, and two days before a full moon. On August 11, 12, and 13, New York had approximately 1.6, 2.6, and 0.2 of an inch of rain respectively, and New Jersey had approximately 1.4, 2.0, and 1.3 inches, respectively.

Table 1

NY Harbor Complex - Floatable Survey
May 23 - Sept 15, 1989*

Total Number of Slicks by Location - According to the Closest Condition of the Tide - High/Low

	High	Low	% - High/Total
Arthur Kill	5	3	62.5
Newark Bay	28	5	84.8
Upper NY Harbor	26	11	70.3
Lower NY Harbor	7	4	63.6
Narrows	16	10	61.5
Total	82	33	
Percentages	71.3	28.7	

Total Days Clear of Significant Slicks** Throughout the NY Harbor Complex - Occurring Closest to High/Low Tide

	High	Low
Clear Days	6	10
Percentages	37.5	62.5

*The time of survey is not available for May 15 - 23, therefore the closest condition of the tide can not be determined.

**The total days clear of significant slicks is 18. The time of survey is not available for two of these days, and therefore the closest condition of the tide can not be determined.

August 17 - Two Major slicks occurred in the Upper NY Harbor, one of which extended south through the Narrows into and beyond the Lower NY Harbor; three Light slicks were observed in the Newark Bay. Surveillance occurred one to two hours after high tide, and one day after a full moon. On August 15, New York had approximately 1.5 inches of rain, and New Jersey had approximately 0.05 of an inch.

CONCLUSIONS

The number of reported slicks in the Harbor Complex was significantly greater during periods of high tide. Newark Bay showed the highest percentage, 82.4%, of slicks found during high tides. Greater than two thirds, 71.3%, of all slicks were reported at high tides, and 62.5% of days when no slicks were reported occurred during low tides.

The Upper NY Harbor and the Narrows had the greatest number of slicks meeting the cleanup requirement. Therefore, the cleanup activities and should continue to be primarily focused in these areas.

The four heaviest days occurred shortly after high tide and close to a full moon. Although one of the days, August 14, occurred two days before a full moon, there was a significant amount of rainfall to account for the increased height of the high tide.

To determine the extent of floatable debris present in the NY Harbor Complex, and direct cleanup activities, further surveillance should occur during high tides, new or full moons, and after heavy rainfalls, all year round. This surveillance should include flights over the Passaic River, the Hackensack River, the Hudson River, the East River, the remainder of the Arthur Kill, the Raritan Bay, the Sandy Hook Bay, and the Lower NY Harbor extending to the Rockaway-Sandy Hook transect.

Appendix A

Summary of Floatables Surveillance

of the NY Harbor Complex

May 15 - Sept 15, 1989

Key for abbreviation and codes:

Location: N - north
S - south
E - east
W - west
B - bridge

SI - Staten Island
SH - Sandy Hook
STP - sewage treatment plant
KVK - Kill Van Kull
LIC - Long Island beach stations

MAS 3 - approximately 6 miles off Manasquan Inlet
Gov Is - Governors Island
Verr Br - Verrazano Bridge

Size Category: Major - greater than 1 mile
Heavy - 800 - 1600 meters
Moderate - 400 - 800 meters
Light - less than 400 meters
Dispersed - no defined slick

Slick Contents: RD - Recreational debris (paper, plastics)
HD - Household debris
WD - Wood debris
SR - Sewage related (tampon applicators, condoms)
Re - Reeds
Mg - Marsh grass
P - Plant material
T - Tires

Tide H/L: H@ - High tide
L@ - Low tide

Notes:

1. An empty box denotes an area where no significant slicks were reported.
2. NA denotes that the information is not available.
3. The number preceding size category indicates the number of slicks observed.

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK ONE: May 16 - 19							
Date: 5/16/89							
Location:		North end		South of Gov Is			
Size Category		Light	Light	Heavy			
Contents							
Time Sighted		NA	NA	NA			
Tide H/L		L@ 12:31pm		L@ 11:26am			
Date: 5/17/89							
Location:				West of Gov Is			Light slick 7 miles off Pt. Pleasant
Size Category	Moderate			Light			Heavy slick at MAS 3
Contents							Dispersed floatables along North NJ Perps
Time Sighted	NA			NA			
Tide H/L	L@ 12:38pm			L@ 12:08pm			L@ 12:29pm
Date: 5/18/89							
Location:				Battery Park			
Size Category							
Contents							
Time Sighted				NA			
Tide H/L				L@ 2:04pm			

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK TWO:	May 20 - 26						
Date: 5/20/89							
Location:	North of Pralls Is						
Size Category	Light						
Contents							
Time Sighted	NA						
Tide H/L	H@ 8:32am						
	** Full Moon 5/20/89 **						
Date: 5/23/89							
Location:		South end	West end			S & N of Verr Br	LIC 02-07
Size Category		Heavy	Moderate			2-Light	Dispersed
Contents		RD, WD	RD,WD			RD, WD	plastics
Time Sighted		10:30am	10:40am			11:00am	11:30am
Tide H/L		H@ 11:11am				H@ 10:06am	
Date: 5/25/89							
Location:		North & South end	East end	Liberty Is Ellis Is			
Size Category		Heavy	2-Light	2-Light			
Contents		HD,WD	HD,WD	HD,WD			
Time Sighted		9:30am	9:45am	9:50am			
Tide H/L		H@ 12:53pm		H@ 11:48am			
Date: 5/26/89							
Location:		South end					
Size Category		Heavy					
Contents		HD,WD					
Time Sighted		9:45am					
Tide H/L		H@ 12:39pm					

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK THREE:	May 27 - June 2						
Date: 5/31/89 Location: Size Category Contents Time Sighted Tide H/L				NW & S of Gov Is 2-Light RD,HD 1:06pm L@ 11:03am		S of Verr Moderate RD,HD,WD 1:20pm L@ 11:03am	
Date: 6/1/89 Location: Size Category Contents Time Sighted Tide H/L						N of Verr Moderate HD,WD,T 9:47am L@ 11:56am	
Date: 6/2/89 Location: Size Category Contents Time Sighted Tide H/L		South of Turnpike B Moderate HD,WD,T 11:20am H@ 7:50am	West end Heavy HD,WD,T 11:20am			N of Verr Major HD,WD,R,T 12:00pm L@ 11:32am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK FOUR: June 3 - 9							
Date: 6/3/89							
Location:			East of Bayonne B			S of Verr	
Size Category			Moderate	Moderate		Dispersed	
Contents			HD,WD,T	HD,WD		HD,WD	
Time Sighted			8:49am	9:00am		9:06am	
Tide H/L				H@ 6:11am		H@ 6:11am	
** New Moon 6/3/89 **							
Date: 6/5/89							
Location:	South of Goethals B	South end		Liberty Is to Gov Is	East of Hoffman	N of Verr	
Size Category	Moderate	Moderate		Heavy	Heavy	Heavy	
Contents	WD,HD	WD,HD		HD,WD	WD,HD	WD,HD	
Time Sighted	9:40am	9:42am		10:00am	10:20am	10:10am	
Tide H/L	H@ 9:56am	H@ 10:31am		H@ 9:26am	H@ 9:26am	H@ 9:26am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK FIVE:	June 10 - 16						
Date: 6/13/89							
Location:				South of Gov Is			
Size Category				Heavy			
Contents				HD,RD			
Time Sighted				2:20pm			
Tide H/L				H@ 4:12pm			
Date: 6/14/89							
Location:		South end		South of Gov Is	Gravesend Bay		
Size Category		Light		Light	Light		
Contents		HD,WD		HD,WD	HD,WD		
Time Sighted		1:30pm		1:50pm	1:55pm		
Tide H/L		L@ 11:49am		L@ 10:44am	L@ 10:44am		
Date: 6/16/89							
Location:				West of Gov Is		N of Verr	
Size Category				Light		Light	Rockaway-Sandy Hook
Contents				HD,WD		HD,WD	transect - Dispersed
Time Sighted				10:25am		10:30	HD,WD - 10:35am
Tide H/L				L@ 12:14am		L@ 12:14am	L@ 11:27am

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK SIX: June 17 -23							
Date: 6/17/89 No significant slicks were reported. Time of survey: 8:15-8:45am. H@ 6:56am							
Date: 6/19/89							
Location:		South end		South of Ellis Is		N of Verr	
Size Category		Dispersed	Dispersed	Dispersed		Moderate	
Contents		HD,WD	HD,WD	HD,WD		HD,Mg,T	
Time Sighted		9:29am	9:42am	9:49am		9:49am	
Tide H/L		H@ 9:25am		H@ 8:20am		H@ 8:20am	
** Full Moon 6/19/89 **							
Date: 6/20/89							
Location:				Owls Head STP			
Size Category				Moderate			
Contents				HD,WD			
Time Sighted				10:50am			
Tide H/L				H@ 9:05am			
Date: 6/22/89 No significant slicks were reported. Time of survey: 2:03-2:32pm. L@ 4:23pm							

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK SEVEN: June 24 - 30							
Date: 6/24/89 Location: Size Category Contents Time Sighted Tide H/L		 Light HD,WD,oil 10:08am L@ 6:57am		 Buttermilk Channel Heavy HD 10:20am H@ 12:21pm		 Major HD,WD 10:30am H@ 12:21pm	
Date: 6/26/89 Location: Size Category Contents Time Sighted Tide H/L		 East shore Heavy RD,WD 11:10am L@ 8:49am		Liberty Is South of Gov Is 2-Moderate RD,WD 11:22am H@ 2:05pm			
Date: 6/28/89 Location: Size Category Contents Time Sighted Tide H/L				 North of Gov Is Light HD,WD,Re 10:45am L@ 9:46am			
Date: 6/29/89 No significant slicks were reported. Time of survey: 9:20-9:37am. L@ 10:41am							
Date: 6/30/89 Location: Size Category Contents Time Sighted Tide H/L	 Northern Light HD,WD,Re 11:00am L@ 12:07pm						

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK EIGHT: July 1 - 7							
Date: 7/1/89							
Location:		North end	East end			N of Verr	
Size Category		Heavy	Light			Major	
Contents		RD,HD,WD	HD,WD,T,Re			HD,WD,T,RE	
TimeSighted		9:00am	9:10am			9:25am	
Tide H/L		H@ 7:38am				H@ 6:33am	
** New Moon 7/3/89 **							
Date: 7/4/89							
Location:		Mouth of KVK				S of Verr	
Size Category		dispersed		Moderate		Moderate	Raritan Bay
Contents		HD,WD		HD,WD		HD,WD	Heavy
Time Sighted		9:54am		10:13am		10:20am	HD,WD - 10:30am
Tide H/L		H@ 10:14am		H@ 9:09am		H@ 9:09am	
Date: 7/7/89							
Location:		Throughout		N of Ellis		S of Verr	
		1-Light		Owl STP		1-Light	
Size Category		2-Moderate		2-Light		1-Heavy	
Contents		HD,WD,reed		HD,WD,Re		WD,HD,Re,T	
Time Sighted		9:45am		10:00am		10:05am	
Tide H/L		H@ 12:41am		H@ 11:36am		H@ 11:36am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK NINE: July 8 - 14							
Date: 7/8/89 No significant slicks were reported. Time of survey: 9:00-9:30am. H@ 12:21pm							
Date: 7/11/89							
Location:				South of Gov Is	Gravesend Bay		Jamacia Bay
Size Category				Light	Light		Dispersed
Contents				HD,leaves	HD,leaves		patches - leaves
Time Sighted				9:40am	9:45am		9:55am
Tide H/L				L@ 8:14am	L@8:14am		
Date: 7/12/89							
Location:		Mouth		North of Gov Is			
Size Category		Light		Moderate			
Contents		HD,wood		HD,garbage			
Time Sighted		2:45pm		3:00pm			
Tide H/L		H@ 4:21pm		H@ 3:16pm			
Date: 7/13/89							
Location:				West of Gov Is			
Size Category				Moderate			
Contents				HD, wood			
Time Sighted				3:40pm			
Tide H/L				H@ 4:12pm			
Date: 7/14/89 No significant slicks were reported. Time of survey: 10:25-10:50am. L@ 10:49am							

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK TEN: July 15 - 21							
Date: 7/17/89							
Location:		Throughout	E Bayonne Bridge				
Size Category	Dispersed	Dispersed	Dispersed				
Contents	HD,WD	HD,WD,Mg	HD				
Time Sighted	9:49am	8:56am	9:02am				
Tide H/L	H@ 7:45am	H@ 8:20am					
Date: 7/18/89							
Location:	N Goethals throughout	South	E Bayonne Bridge	buoy G3	E yellow bouy 0		
Size Category	Dispersed	2-Light	Light	Dispersed	Light		
Contents	HD,WD	HD,WD	HD,WD	HD,WD	plant		
Time Sighted	8:45am	8:47am	8:52am	9:03am	9:15am		
Tide H/L	H@ 8:28am	H@ 9:03am		H@ 7:58am	H@ 7:58am		
** Full Moon 7/18/89 **							
Date: 7/19/89							
Location:	north end	South end Bergen Pt	W Bayonne	throughout		N of Verr	
Size Category	Moderate	Heavy	Heavy	Light	Light	Heavy	
Contents	plants	marsh gras	WD,T,Mg	scum	HD	HD,Mg	
Time Sighted	8:50am	9:07am	9:14am	9:20am	9:45am	9:20am	
Tide H/L	H@ 8:14am	H@ 9:49am		H@ 8:44am	H@ 8:44am	H@ 8:44am	
Date: 7/21/89							
Location:		Southern					
Size Category		Major					
Contents		HD,T,W,Re					
Time Sighted		9:00am					
Tide H/L		H@ 11:21am					

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK ELEVEN:	July 22 -28						
Date: 7/24/89 Location: Size Category Contents Time Sighted Tide H/L					off Coney Island Dispersed WD,HD 1:05pm H@ 12:50pm		Raritan Bay - Heavy scum,plant - 1:22pm H@ 12:25pm
Date: 7/25/89 Location: Size Category Contents Time Sighted Tide H/L							Raritan Bay - Heavy HD,WD - 9:45am L@ 6:49am
Date: 7/26/89 Location: Size Category Contents Time Sighted Tide H/L						S of Verr Moderate HD, oil 9:28am L@ 8:22am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK TWELVE: July 29 - August 4							
Date: 7/29/89 No significant slicks were reported. Time of survey: 9:30-9:47am. L@ 11:26am							
Date: 7/31/89 Location: Size Category Contents Time Sighted Tide H/L			Bayonne B Light HD,WD,Re,T 11:50am				
Date: 8/1/89 Location: Size Category Contents Time Sighted Tide H/L			Bayonne B Light HD,WD,Re 9:35am				
** New Moon 8/1/89 **							
Date: 8/2/89 Location: Size Category Contents Time Sighted Tide H/L		South and central 1-Moderate 1-Light HD,WD,T,Re 8:55am H@ 9:52am	West Light HD,WD,T,Re 9:10am		Green Buoy # 21 SI Heavy HD,WD,T 9:50am H@ 8:47am	N of Verr Heavy HD,WD,T,Re 9:45am H@ 8:47am	
Date: 8/3/89 Location: Size Category Contents Time Sighted Tide H/L		S and central 2-Light WD,HD 9:15am H@ 10:36am	West Light WD,Timber 9:17am			N of Verr Heavy HD,WD 9:27am H@ 9:31am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK THIRTEEN: August 5 - 11							
Date: 8/5/89 No significant slicks were reported. Time of survey: 10:00-10:30am. H@ 10:56am							
Date: 8/7/89 No significant slicks were reported. Time of survey: 9:50-10:10am. H@ 12:14pm							
Date: 8/8/89 No significant slicks were reported. Time of survey: 8:45-9:15am. L@ 6:02am							
Date: 8/10/89 No significant slicks were reported. Time of survey not given. L@ 7:45am							

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK FOURTEEN: August 12 - 18							
Date: 8/12/89							
Location:	North end			South of Gov Is			Coney Island
Size Category	Light			2-Light			Major
Contents	HD,Re			HD,Re			HD
Time Sighted	12:00pm			12:15pm			12:30pm
Tide H/L	L@ 10:44am			L@ 10:14am			
Date: 8/14/89							
Location:	Goethals B			throughout the NE end	Gravesend Bay	N of Verr E & W	
Size Category	Heavy			Major	Moderate	2-Moderate	
Contents	WD,Re,P			RD,WD	HD,RD	HD,RD	
Time Sighted	11:40am			11:55am	12:10pm	12:05pm	
Tide H/L	L@ 12:30pm			L@ 12:00pm	L@ 12:00pm	L@ 12:00pm	
Date: 8/15/89							
Location:				7 miles long			
Size Category				Major			
Contents				WD,HD,P			
Time Sighted				2:15pm			
Tide H/L				L@ 12:51pm			

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK FOURTEEN: Continued							
Date: 8/16/89							
Location:		throughout	Bayonne Bridge				
Size Category	Dispersed	Dispersed	Light	2-Light	Heavy		
Contents	HD,Re,scum	HD,WD,Re	HD	HD,Re,scum	HD,Re,WD		
Time Sighted	8:39am	8:53am		9:10am	9:30am		
Tide H/L	H@ 8:03am	H@ 8:38am		H@ 7:33am	H@ 7:33am		
** Lunar Eclipse 8/16/89 **							
Date: 8/17/89				8 miles			* 4pm flight - Major
Location:		South end		Statue to Verr Br	continued from upper	continued from upper	slick moved from Sandy Hook-Rockaway
Size Category		3-Light		2-Major	Major	Major	to Ambrose Light *
Contents		HD,WD,Re,T		garbage	garbage	garbage	Raritan Bay 3-Light
Time Sighted		10:25am		10:40am	10:40am	10:40am	HD,WD,Re - 9:05am
Tide H/L		H@ 9:20am		H@ 8:15am	H@ 8:15am	H@ 8:15am	H@ 7:50am
Date: 8/18/89							
Location:			West of Bayonne Br	Center		S of Verr Around CI	
Size Category		Light	Light	1-Light 1-Heavy		Heavy	
Contents		HD,WD,Re	HD,WD,Re	HD,WD,Re,T		HD,WD,Re,T	
Time Sighted		9:36am	9:36am	9:45am		9:45am	
Tide H/L		H@ 10:00am		H@ 9:01am		H@ 9:01am	

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK FIFTEEN: August 19 -25							
Date: 8/22/89							
Location:			North				
Size Category			Dispersed				
Contents			HD,Re,WD				
Time Sighted			9:10am				
Tide H/L							
Date: 8/23/89							
Location:		Mouth					
Size Category		Light					
Contents		HD,scum					
Time Sighted		11:00am					
Tide H/L		L@ 7:52am					

Date: 8/24/89 No significant slicks were reported. Time of survey: 9:25-9:40am. L@ 8:03am

Date: 8/25/89 No significant slicks were reported. Time of survey: 9:02-9:24am. L@ 9:15 am

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK SIXTEEN: August 26 - September 1							
Date: 8/26/89 No significant slicks were reported. Time of survey: 8:41-9:08am. L@ 10:19am							
Date: 8/30/89							
Location:						N of Verr	
Size Category						Major	
Contents						HD,WD,Re	
Time Sighted						11:10am	
Tide H/L						L@ 1:45 pm	
Date: 8/31/89							
Location:						N of Verr	
Size Category						Light	
Contents						scum,WD	
Time Sighted						12:30pm	
Tide H/L						L@ 2:27pm	
** New Moon 8/31/89 **							
Date: 9/1/89							
Location:		Southeast		off Owls Head STP			Passaic River
Size Category		Light		Moderate			Heavy
Contents		HD,WD,Re		HD,Re,WD			HD,WD,Re
Time Sighted		9:30am		9:30am			9:10am
Tide H/L		H@ 10:02am		H@ 8:57am			

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK SEVENTEEN: September 2 - 8							
Date: 9/2/89							
Location:		Northeast		North			
Size Category		Dispersed		Light			
Contents		HD,Re		HD,WD,Re			
Time Sighted		9:01am		9:12am			
Tide H/L		H@ 10:40am		H@ 9:35am			
Date: 9/3/89							
Location:						N of Verr	
Size Category						Light	
Contents						HD,WD,Re	
Time Sighted						8:35am	
Tide H/L						H@ 10:11am	
Date: 9/4/89 No significant slicks were reported. Time of survey: 9:00-9:30am. H@ 10:45am							
Date: 9/5/89 No significant slicks were reported. Time of survey not given. H@ 11:20am							
Date: 9/7/89 No significant slicks were reported. Time of survey: 10:20-10:45am. H@ 12:37pm							
Date: 9/8/89							
Location:				South of Gov Is			
Size Category				Heavy			
Contents				WD,HD,Re			
Time Sighted				10:03am			
Tide H/L				H@ 1:27pm			

	Arthur Kill	Newark Bay	Kill Van Kull	Upper NY Bay	Lower NY Bay	The Narrows	Comments (Misc. slicks)
WEEK EIGHTEEN: September 9 - 15							
Date: 9/9/89 Location: Size Category Contents Time Sighted Tide H/L					 Gravesend Bay Light scum,WD,HD 10:05am L@ 7:48am		
Date: 9/11/89 No significant slicks were reported. Time of survey: 10:50-11:10am. L@ 10:44am							
Date: 9/13/89 No significant slicks were reported. Time of survey: 11:25-11:45am. L@ 12:27pm							
Date: 9/15/89 Location: Size Category Contents Time Sighted Tide H/L		 Southern Dispersed HD,WD,T 12:30am L@ 3:11pm	 West end Light HD,WD,T 12:30am	 N of Ellis Island Moderate HD,WD,T 12:25pm L@ 2:06pm		 SI side Major HD,WD,T 12:25pm L@ 2:06pm	

Appendix B

List of Approximate Dimensions

NY Harbor - Floatable Survey

May 15 - Sept 15, 1989

New York Harbor
Floatable Survey
1989

Major Slicks

Date	Approximate Dimensions	Location
June 2	1/2 - 1 mile by 10-50 ft	Narrows
June 24	one mile by 20-30 ft	Narrows
July 1	1/2 mile by 10-50 ft	Narrows
July 21	1 1/2 miles by 5-20 feet	Newark Bay
August 12	Length of Coney Is by 1-5 ft	Coney Is
August 14	500 yds by 500 yds-throughout NE end	Upper NY
August 15	7 miles narrow & dense	Upper NY
August 17	8 miles by 2-100 ft	Upper - Narrows - Lower
	2 miles by 2-10 ft	Upper NY
August 30	3-5 miles by 1-5 ft not very dense	Narrows
Sept 15	4 miles by 5-20 ft	Narrows

Heavy Slicks

Date	Approximate Dimensions	Location
May 16	1 1/2 miles	Upper NY
May 23	heavy concentration	Newark Bay
May 25	1-2 miles conc. throughout	Newark Bay
May 26	1/2 - 3/4 mile	Newark Bay
June 2	1-2 miles by 10 ft	Kill Van Kull
June 5	statue to Gov Is	Upper NY
	Coney Is to Hoffman by 20 ft	Lower NY
	quater acre patches	Narrows
June 13	1/2 mile by 15-50 ft	Upper NY
June 24	one mile by 15 ft	Upper NY
June 26	3/4 mile by 3 ft	Newark Bay
July 1	500 yds by 10-30 ft	Newark Bay
July 4	1 1/2 mile by 2 ft	Raritan Bay
July 7	a half mile by 10-30 ft	Narrows
July 19	1-2 miles by 2-5 ft	Newark Bay
	throughout dense	Kill Van Kull
	1-2 miles by 2-3 ft	Narrows
July 24	1/2 mile by 2-4 ft	Raritan Bay
July 25	1 1/2 miles by 10 ft	Raritan Bay
August 2	1/2 mile by 5-10 ft	Lower NY
	one mile by 10-20 ft	Narrows
August 3	one mile by 5-10 ft	Narrows
August 14	500 yds by 10 ft	Arthur Kill
August 16	one mile by 1-3 ft light density	Lower NY
August 18	2 miles by 20-30 ft	Narrows
	1/2 mile	Upper NY
Sept 1	one mile by 1-10ft	Passaic River
Sept 8	one mile by 2-5 ft	Upper NY

Moderate Slicks

Date	Approximate Dimensions	Location
May 17	moderate	Aruthur Kill
May 23	Moderate	Kill Van Kull
May 31	4 acres light	Narrows
June 1	300 ft by 400 ft	Narrows
June 2	1/2 mile	Newark Bay
June 3	1/4 mile by 2-20 ft	Upper NY
	500 ft by 1000 ft	Kill Van Kull
June 5	moderate	Newark Bay
	medium density	Arthur Kill
June 19	1/4 - 1/2 mile by 2-5 ft	Narrows
June 20	1/2 mile - light density	Upper NY
June 26	one mile broken light density	Upper NY
	1/4 mile	Upper NY
July 4	1/2 mile	Upper NY
	1/2 mile by 2 ft	Narrows
July 7	1/4 mile by 5-30 ft	Newark Bay
	1/4 mile by 5-10 ft	Newark Bay
July 12	1-2 acres	Upper NY
July 13	1-2 acres	Upper NY
July 19	length of Arthur Kill by 2-3 ft	Arthur Kill
July 26	1/2 mile by 20 ft	Narrows
August 2	1/2 mile by 5-10 ft	Newark Bay
August 14	500 yds by 100 yds light density	Lower NY
	500 yds by 10 ft	Narrows
	600 yds by 10 ft	Narrows
Sept 1	1/4 - 1/2 mile	Upper NY
Sept 15	1/2 mile by 5-15 ft	Upper NY

Light Slicks

Date	Approximate Dimensions	Location
May 16	200 ft	Newark Bay
	light	Kill Van Kull
May 17	light patches	Upper NY
May 20	200 yds	Aruthur Kill
May 23	light	Narrows - 2*
May 25	200-300 yds	Upper NY - 2
	200 yds	Kill Van Kull-2
May 31	300 ft by 1-5 ft	Upper NY
	400 ft by 10 ft	Upper NY
June 14	1/4 mile by 1-5 ft broken	Lower NY
	200 yds by 3-5 ft	Newark Bay
	1/2 not dense broken	Upper NY
June 16	200 yds by 1-2 ft	Upper NY
	200-300 yds by 1-3 ft	Narrows
June 24	100 yds	Newark Bay
June 28	200 yds by 5 ft	Upper NY
June 30	150 yds by 2-3 ft	Arthur Kill
July 1	200-300 yds by 2-5 ft	Kill Van Kull
July 7	200 yds by 0-10 ft	Upper NY
	300 yds by 5-10 ft	Narrows
	100 yds by 1-5 ft	Newark Bay
	300 yds by 5-10 ft	Upper NY
July 11	200 yds by 5 ft	Upper NY
	200 yds by 2-3 ft	Lower NY
July 12	200 yds by 5-10 ft	Newark Bay
July 18	500 ft by 5 ft	Lower NY
	200 ft by 5 ft	Kill Van Kull
	500 ft by 3-5 ft	Newark Bay - 2
July 19	100 ft by 2-5 ft	Upper NY
	200 ft by 1-3 ft	Lower NY
July 31	200-300 yds by 2-5 ft	Kill Van Kull
August 1	200 yds by 2-5 ft	Kill Van Kull
August 2	150 yds by 10 ft	Newark Bay
	100 yds	Kill Van Kull
August 3	100 yds by 5 ft	Newark Bay
	200 yds by 10 ft	Newark Bay
	200 yds by 2-3 ft	Kill Van Kull
August 12	200 - 300 yds	Upper NY - 2
	100 yds by 2-5 ft	Arthur Kill

* Numbers proceeding location indicate the number of slicks with the same approximate dimensions in that area.

Light Slicks (continued)

Date	Approximate Dimensions	Location
August 16	50-100 ft by 300-500 ft	Kill Van Kull
	50 ft by 100 ft	Upper NY - 2
August 17	100,200,300 ft by 5 ft	Newark Bay - 3
	200 yds by 1-5 ft each	Raritan Bay - 3
August 18	400-500 ft by 3-10 ft	Upper NY
	100 yds by 3-10 ft	Newark Bay
	100-200 ft by 2-3 ft	Kill Van Kull
August 23	100 yds by 20 yds	Newark Bay
August 31	200 yds by 5 ft	Narrows
Sept 1	200 yds by 5-10 ft	Newark Bay
Sept 2	40 ft by 2-3 ft	Upper NY
Sept 3	100 yds by 5 ft	Narrows
Sept 9	100 yds by 3-3 ft	Lower NY
Sept 15	200 yds by 5-15 ft	Kill Van Kull

Dispersed

Date	Approximate Dimensions	Location
May 23	lightly dispersed	LIC 02-07
June 3	1000ft by 1000ft moderate density	Narrows
June 16	3-5 acres Rockaway-Sandy Hook	Transect
June 19	length of KVK	Kill Van Kull
	throughout	Newark Bay
	not very dense	Upper NY
July 4	dispersed	Newark Bay
July 11	patches	Jamacia Bay
July 17	North end	Arthur Kill
	throughout	Newark Bay
	throughout	Kill Van Kull
July 18	large quanity	Arthur Kill
	500 ft by 500 ft	Upper NY
July 24	1000 ft by 100 ft	Lower NY
August 16	light density	Arthur Kill
	moderate	Newark Bay
August 22	quarter-half a mile	Kill Van Kull
Sept 2	50 ft by 30 ft	Newark Bay
Sept 15	above average concentration	Newark Bay

APPENDIX C

Microbiological Water Quality

New York Bight

Summer 1989

CROBIOLOGICAL WATER QUALITY

NEW YORK BIGHT

SUMMER 1989

Introduction

A study of the density* of fecal coliform and enterococcus organisms was conducted in 1989 as part of the continuing annual monitoring of the nearshore waters off the Long Island and New Jersey coasts.

By determining the bacteriological water quality, one can estimate potential health risks associated with the presence of sewage pollution. Epidemiological studies have attempted to assess the incidence of illness with bathing in water containing fecal contamination. Evidence exists that there is a relationship between bacterial water quality and transmission of certain infectious diseases (1).

Investigations have shown that agents of bacterial disease, enteropathogenic/toxigenic Escherichia coli, Pseudomonas aeruginosa, Klebsiella, Salmonella, and Shigella are excreted in large numbers in the feces of infected individuals, and are thus potentially present in sewage. It is common practice to use an indicator organism to detect fecal contamination because of the ease of isolating and quantitating certain microorganisms on membrane filters. Elaborate procedures are usually required for the detection of most pathogens in mixed populations. When numerous indicator organisms are present, the likelihood of pathogens being found is far greater.

A fecal coliform bacterial guideline for primary contact recreational waters was recommended by the U.S. Environmental Protection Agency (USEPA) in 1976, and subsequently adopted by most of the states. The EPA standard stated that fecal coliforms should be used as the indicator to evaluate the suitability of recreational waters, and recommended that fecal coliforms, as determined by MPN or MF procedure and based on a minimum of not less than five samples taken over not more than a 30-day period, shall not exceed a log mean of 200 fecal coliform per 100 ml, nor shall more than 10% of the total samples during any 30-day period exceed 400 fecal coliforms per 100 ml. The rationale for the limits was developed using data collected from studies at the Great Lakes (Michigan) and the Inland River (Ohio) which showed an epidemiological detectable health effect at levels of 2300-2400 coliforms/100 ml. Subsequent investigations conducted on the Ohio River suggested that fecal coliforms represent 18% of the total coliforms. This would indicate that detectable health effects may occur at a fecal coliform level of approximately 400/100 ml. A limit of 200 fecal coliforms per 100 ml would therefore provide a quality of water which should exceed that which would cause a detectable health effect (10).

* Bacterial density in this study is referred to as the number of fecal coliforms and enterococci per 100 ml of water.

New York State, for its primary contact recreational coastal waters, adopted the standard of 200 fecal coliforms/100 ml, provided that the log mean is not exceeded during 5 successive sets of samples. New Jersey also has the standard of 200 fecal coliforms/100 ml. By 1978, most of the states adopted the fecal coliform indicator with geometric mean limits at 200 fecal coliforms/100 ml.

Fecal Coliform Indicator Bacteria

Fecal coliforms comprise all of the coliform bacteria that ferment lactose at 44.5 $\pm$0.2°C. This group, according to traditional theory, more accurately reflects the presence of fecal discharges from warm-blooded animals. As an indicator, fecal coliforms have the advantage of being less subject to regrowth in polluted waters. Their increased specificity to fecal sources made them the choice over other coliform organisms.

Enterococcus Group: Indicator Bacteria

Enterococci are a subgroup of the fecal streptococci. The occurrence of fecal streptococci in water indicates fecal contamination from warm-blooded animals. One is able to pinpoint the source of fecal contamination (such as human, equine, bovine, avian) by identifying the species utilizing biochemical tests. The enterococcus group includes the following species: Streptococcus faecalis; Streptococcus faecalis, subspecies liquefaciens; Streptococcus faecalis, subspecies zymogenes; and Streptococcus faecium. Streptococcus faecalis, one of the group D streptoccal species, grows in broth containing 6.5% NaCl, hydrolyzes arginine and utilizes pyruvate (2-4). Streptococcus faecium grows in 6.5% NaCL broth, hydrolyzes arginine, but does not utilize pyruvate. Streptococcus bovis does not grow in 6.5% NaCl broth, does not hydrolyze arginine, and does not utilize pyruvate. These are the three most common species of group D streptococci found as pathogens in human infection. Streptococcus durans is located occasionally, and Streptococcus equinus is found rarely (5).

EPA has recently published the results of two research projects which compared the relationship between illnesses associated with bathing in recreational waters and ambient densities of several indicator organisms (6). One study was performed on marine bathing beaches and one on freshwater beaches. Studies at marine and fresh water bathing beaches indicated that gastroenteritis is directly related to the quality of the bathing water and that enterococci is a better indicator of water quality than fecal coliforms (1, 10).

EPA has issued a criteria guidance document recommending enterococci and Escherichia coli for inclusion into state water quality standards for the protection of primary contact recreational uses in lieu of fecal coliforms. The EPA (1986) recommended criterion for enterococci for marine waters is 35/100 ml. This information was published in the Federal Register on March 7, 1986.

Materials and Methods

Marine water samples were collected by helicopter from May to September 1989. The samples were collected using a Kemmerer sampler and transferred to 500 ml sterile, wide-mouthed plastic containers, and then transported in an ice chest to the Region II Edison laboratory for analysis.

Fecal coliform determinations were conducted according to the membrane filtration (MF) procedures described in Standard Methods, 17th edition, 1989 and Microbiological Methods for Monitoring the Environment, Water and Wastewater, EPA-600/8-78-017, 1978. Enterococci determinations were conducted according to the MF procedure described by Levin (8), and DuFour (9), using the modified mE media. Confirmation of enterococci colonies were conducted following procedures outlined in Microbiological Methods for Monitoring the Environment, Water and Wastewater, EPA-600/8-78-017, 1978.

Results and Discussion

Fecal Coliform - NJ

Along the New Jersey Coast, fecal coliform densities equal to or greater than 50/100 ml occurred on 12 occasions at 11 different stations (Tables 1 & 2 and Figure 1). The observations were made at stations JC-01A (Sandy Hook, 1.2 km south of the tip), JC-08 (Sea Bright, at the public beach), JC-11 (Monmouth Beach Bath & Tennis Club), JC-13 (Chelsea Ave., 1st street South of the Burnt Fisher Pier, Long Branch), JC-26 (Shark River Inlet), JC-36 (Manasquan Inlet off of Third Avenue), JC-74 (Absecon Inlet), JC-81 (Ocean City, opposite the large apartment building), JC-92 (Hereford Inlet), JC-93 (Wildwood, off of the northern amusement pier), and JC-96 (Cape May Inlet).

Fecal Coliform - Long Island

Fecal coliform densities greater than 50/100 ml did not occur (Table 5 and Figures 3, 6 and 7). The highest fecal coliform count occurred at LIC-04 (Rockaway, off the foot of B92 Road) which had a maximum of 26 per 100 ml.

Enterococci - New Jersey

Enterococci densities exceeding the standard of 35/100 ml (10) (Tables 3 & 4 and Figure 2) were observed on two occasions at station JC-92 and JC-96.

Enterococci - Long Island

The standard enterococci density of 35/100 ml were not exceeded. The maximum density of 20/100 ml occurred at station LIC-21 (Bellport Beach) (Table 6 and Figures 4 and 6).

For the majority of New Jersey and Long Island Coastal Stations low fecal coliform geometric mean densities per 100 ml were observed. This profile is visually presented in the geometric mean value of FC densities in Figures 1 and 3.

Geometric mean densities for enterococci along the New Jersey and Long Island Coastal Stations were even lower. These profiles are visually evident in Figures 2 and 4.

REFERENCES

1. Cabelli, V.J. et al. 1979. Relationship of Microbial Indicators to Health at Marine Bathing Beaches. American Journal of Public Health. 69:690.

2. Standard Methods for the Examination of Water and Wastewater. 1989. 17th ed., American Public Health Association. Washington, DC.

3. U.S. Environmental Protection Agency. 1978. Microbiological Methods for Monitoring the Environment - Water and Wastewater. EPA-600/8-78-017.

4. Bergey's Manual of Systematic Bacteriology. 1984. Volume I. Williams & Wilkins, Baltimore, MD.

5. Facklam, R.R. 1980. Isolation and Identification of Streptococci. Department of Health, Education & Welfare, CDC, Rev. 1.

6. DuFour, A.P. 1984. Health Effects Criteria for Fresh Recreational Waters. EPA-600/1-84-004.

7. Ringen, L.M. & C.H. Drake. 1952. J. Bact. 64:841.

8. Levin, M.A., J.K. Fisher & V.J. Cabelli. 1975. Membrane Filter Technique for Enumeration of Enterococci in Marine Waters. Appl. Microbiol. 30:66-71.

9. DuFour, A.P. 1980. Abstracts Annual Meeting American Society for Microbiology, Q69.

10. Cabelli, V.J. 1983. Health Effects Criteria for Marine Recreational Waters, EPA-600/1-80-031.

TABLE 1

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1989

Station	Number of Samples	Maximum Value (Fecal Coliform/100ml)	Geometric Mean (Fecal Coliform/100ml)
JC 01A	9	67	2.6
JC 03	10	7	1.5
JC 05	10	4	1.7
JC 08	10	73	1.8
JC 11	10	63	1.6
JC 13	10	80	15.2
JC 14	9	26	2.8
JC 21	9	27	2.4
JC 24	8	11	2.1
JC 26	8	112	6.2
JC 27	7	16	4.8
JC 30	8	5	2.1
JC 33	8	6	2.0
JC 35	8	3	1.3
JC 36	8	212	14.0
JC 37	8	29	2.6
JC 41	8	9	2.2
JC 44	8	3	1.1
JC 47A	8	3	1.3
JC 49	8	8	1.5
JC 53	8	6	2.5
JC 55	8	4	1.4
JC 57	8	4	1.4
JC 59	8	9	1.5
JC 61	8	12	1.4
JC 63	8	4	1.4
JC 65	8	6	1.3
JC 67	8	5	1.3
JC 69	8	2	1.1
JC 73	7	3	1.4
JC 74	7	84	4.8
JC 75	7	15	3.3
JC 77	7	5	2.3
JC 79	7	8	2.9
JC 81	7	96	5.6
JC 83	7	4	1.7
JC 85	6	17	2.4
JC 87	6	10	2.4
JC 89	6	4	1.5
JC 91	6	2	2.3
JC 92	6	284	3.5
JC 93	6	55	5.3
JC 95	6	80	4.8
JC 96	6	50	2.9
JC 97	6	24	3.2
JC 99	6	16	3.8

TABLE 2
FECAL COLIFORM DENSITIES > 50 PER 100ML
NEW JERSEY COAST STATIONS
SUMMER 1989

OBS	STATION	DATE	VALUE
1	JC01A	070689	67
2	JC08	072689	73
3	JC11	072689	63
4	JC13	080289	80
5	JC13	081689	51
6	JC26	081689	112
7	JC36	081689	212
8	JC74	081689	84
9	JC81	090689	96
10	JC92	071989	284
11	JC93	071989	55
12	JC96	071989	50

TABLE 3

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1989

Station	Number of Samples	Maximum Value (Enterococci/100ml)	Geometric Mean (Enterococci/100ml)
JC 01A	9	12	1.5
JC 03	10	3	1.1
JC 05	10	2	1.1
JC 08	10	3	1.1
JC 11	10	2	1.1
JC 13	10	26	4.2
JC 14	9	8	1.4
JC 21	9	3	1.3
JC 24	8	2	1.1
JC 26	8	22	2.3
JC 27	7	2	1.2
JC 30	8	1	1.0
JC 33	8	1	1.0
JC 35	8	3	1.1
JC 36	8	13	2.9
JC 37	8	26	1.5
JC 41	8	1	1.0
JC 44	8	0	1.0
JC 47A	8	1	1.0
JC 49	8	1	1.0
JC 53	8	1	1.0
JC 55	8	0	1.0
JC 57	8	1	1.0
JC 59	8	1	1.0
JC 61	8	1	1.0
JC 63	8	2	1.1
JC 65	8	1	1.0
JC 67	8	1	1.0
JC 69	8	1	1.0
JC 73	7	1	1.0
JC 74	7	10	2.1
JC 75	7	2	1.2
JC 77	7	1	1.0
JC 79	7	2	1.2
JC 81	7	13	2.3
JC 83	7	3	1.3
JC 85	6	1	1.0
JC 87	6	0	1.0
JC 89	6	14	1.6
JC 91	6	2	1.1
JC 92	6	37	1.8
JC 93	6	2	1.3
JC 95	6	160	3.0
JC 96	6	77	2.8
JC 97	6	7	1.7
JC 99	6	6	1.8

TABLE 4
ENTEROCOCCUS DENSITIES > 35 PER 100ML
NEW JERSEY COAST STATIONS
SUMMER 1989

OBS	STATION	DATE	VALUE
1	JC92	071989	37
2	JC96	071989	77

TABLE 5

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1989

Station	Number of Samples	Maximum Value (Fecal Coliform/100ml)	Geometric Mean (Fecal Coliform/100ml)
LIC 01	8	4	2.0
LIC 02	7	5	1.6
LIC 03	7	18	1.5
LIC 04	6	26	3.3
LIC 05	7	13	5.5
LIC 07	6	2	1.1
LIC 08	6	10	1.8
LIC 09	6	13	2.9
LIC 10	6	11	4.1
LIC 12	6	21	2.3
LIC 13	6	10	1.6
LIC 14	6	16	2.2
LIC 15	6	5	1.5
LIC 16	6	6	1.8
LIC 17	5	6	2.2
LIC 18	5	5	2.3
LIC 19	4	6	2.4
LIC 20	4	4	1.7
LIC 21	3	18	3.3
LIC 22	3	5	2.5
LIC 23	3	5	1.7
LIC 24	3	2	1.3
LIC 25	3	4	1.6
LIC 26	3	3	2.3
LIC 27	3	2	1.6
LIC 28	3	3	1.8

TABLE 6

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND COAST
SUMMER 1989

Station	Number of Samples	Maximum Value (Enterococci/100ml)	Geometric Mean (Enterococci/100ml)
LIC 01	8	2	1.2
LIC 02	7	4	1.6
LIC 03	7	8	1.3
LIC 04	6	7	1.6
LIC 05	7	11	2.7
LIC 07	6	1	1.0
LIC 08	6	10	2.1
LIC 09	6	6	2.4
LIC 10	6	8	2.7
LIC 12	6	5	1.5
LIC 13	6	1	1.0
LIC 14	6	2	1.4
LIC 15	6	1	1.0
LIC 16	6	5	1.3
LIC 17	5	3	1.2
LIC 18	5	4	1.6
LIC 19	4	4	1.4
LIC 20	4	4	1.7
LIC 21	3	20	2.7
LIC 22	3	3	2.1
LIC 23	3	2	1.3
LIC 24	3	2	1.3
LIC 25	3	1	1.0
LIC 26	3	3	1.4
LIC 27	3	2	1.3
LIC 28	3	2	1.6

Figure 1

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES

NEW JERSEY COAST STATIONS
SUMMER 1989

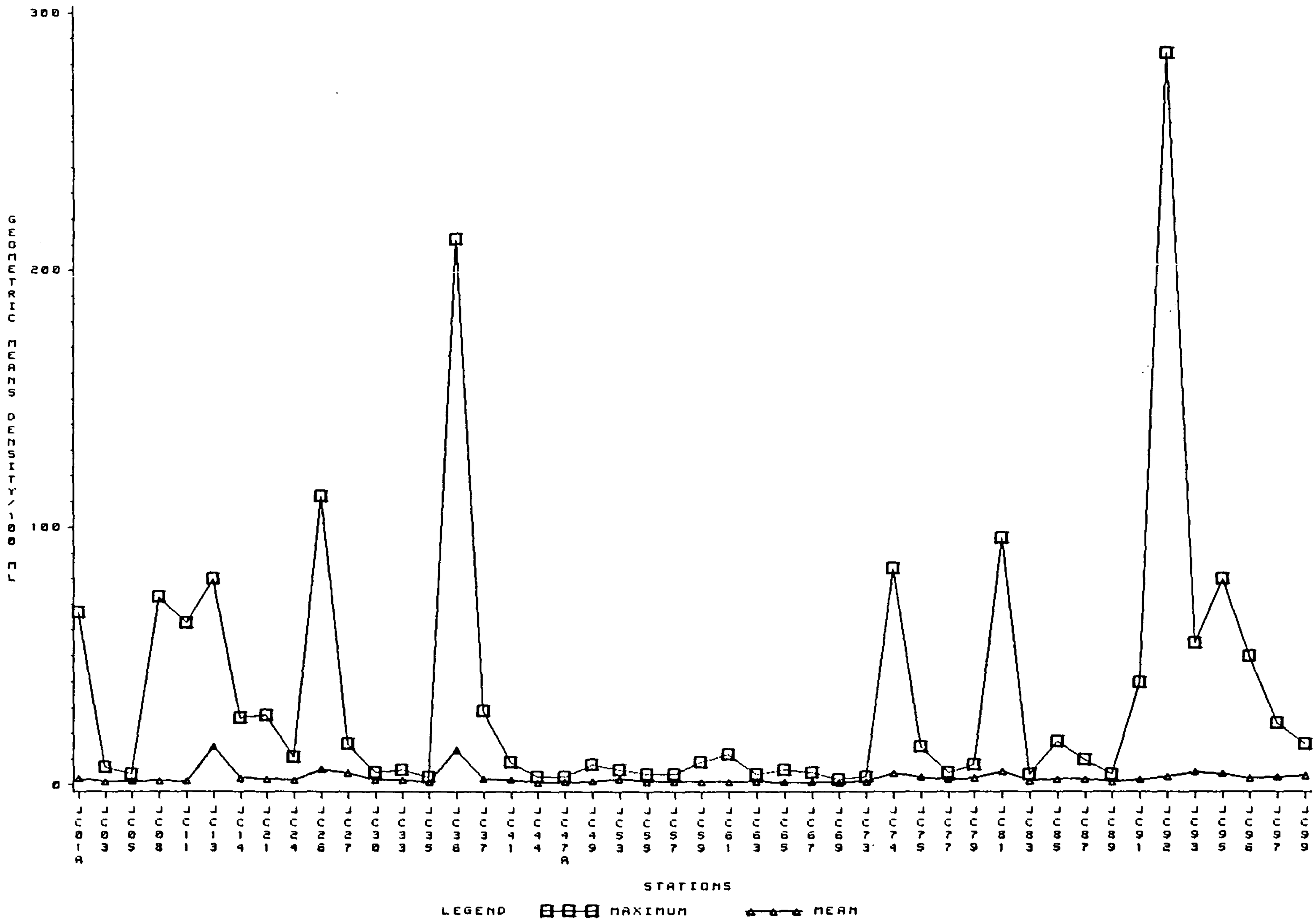


Figure 2

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES

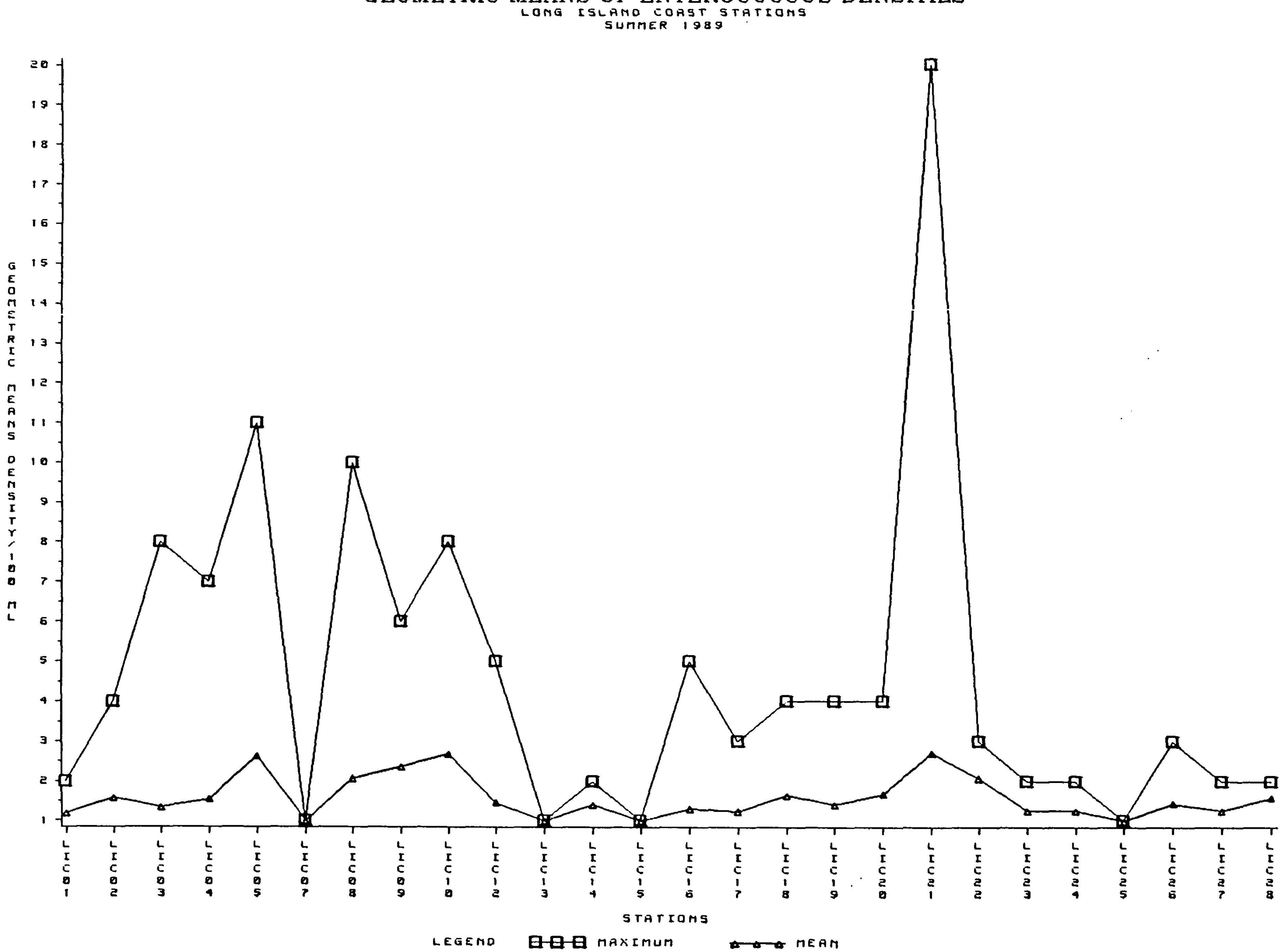


Figure 3

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES

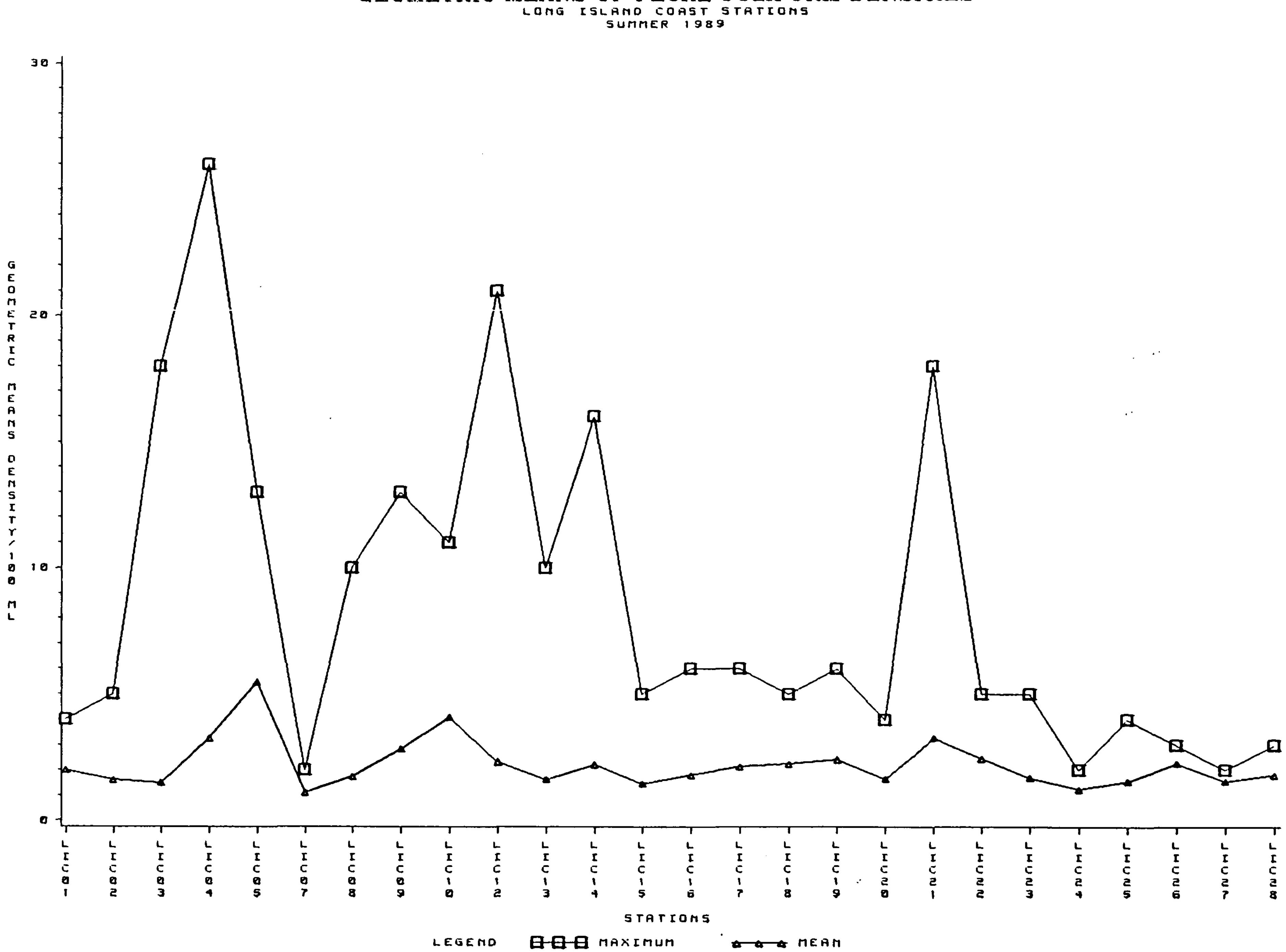


Figure 4

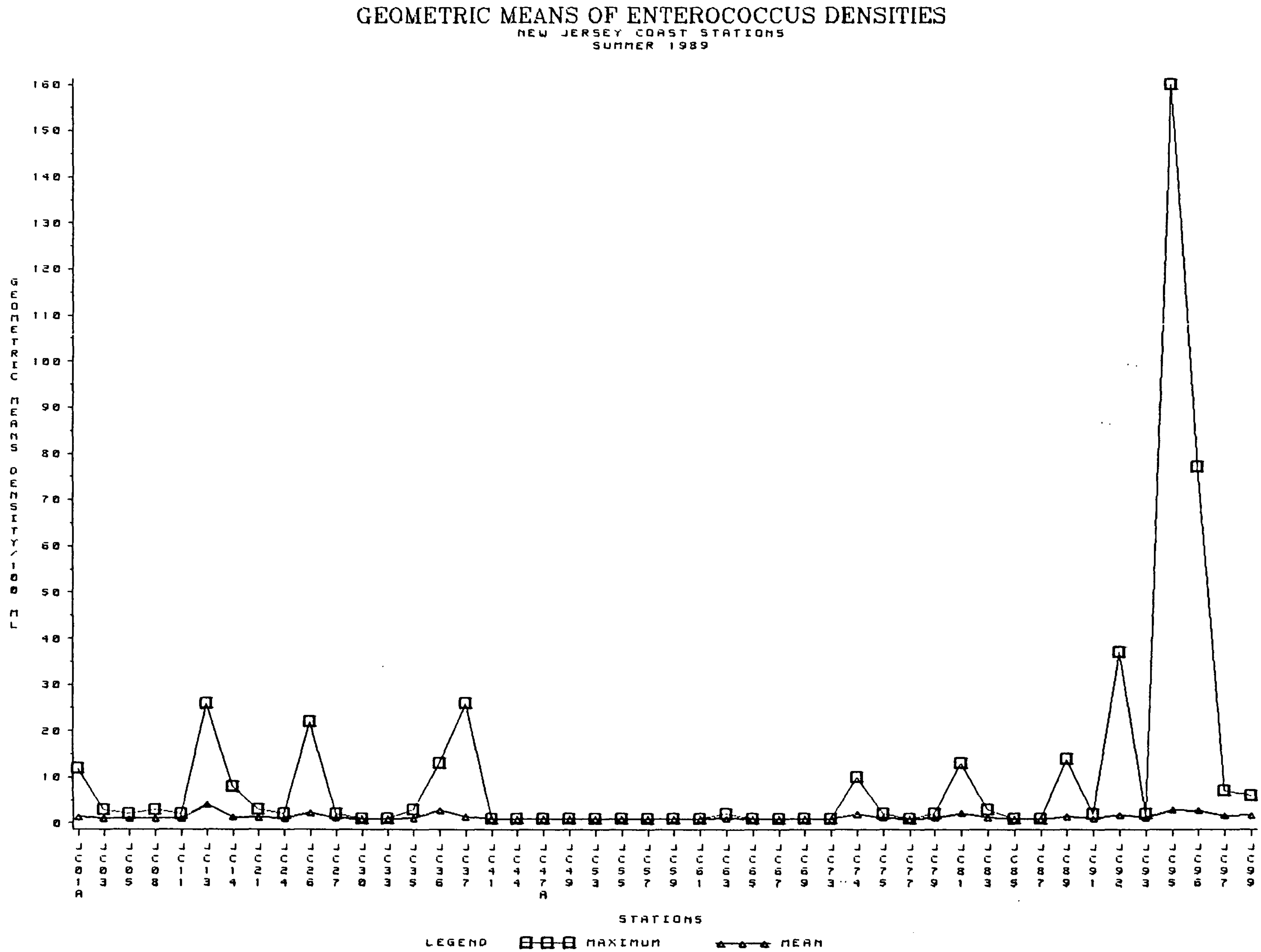
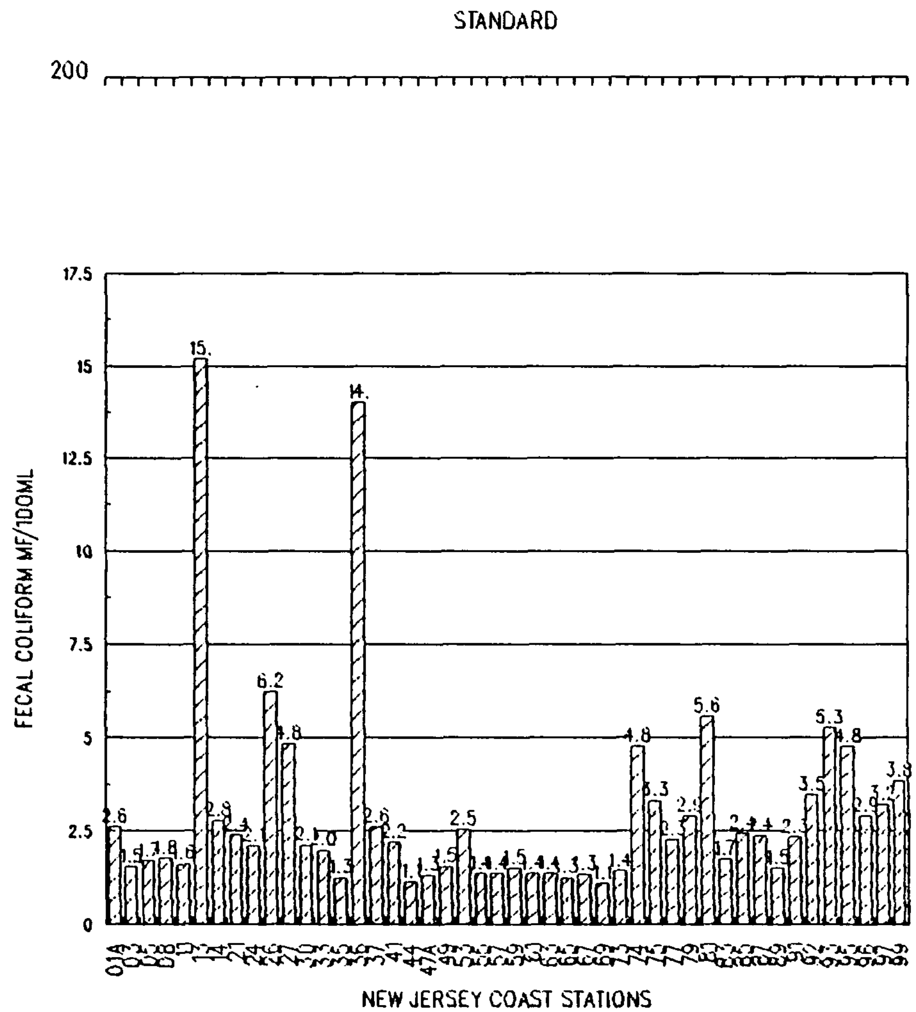
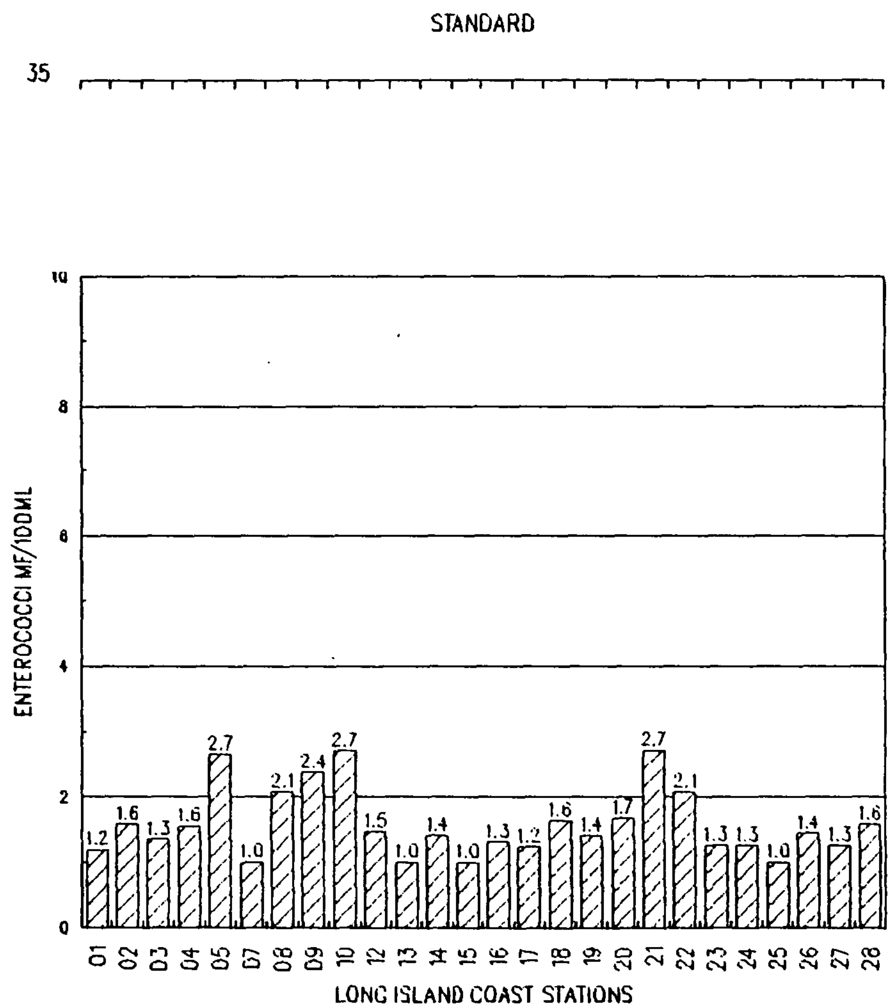

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1989
GEOMETRIC MEANS DENSITY/100 ML
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
JC01A
JC03
JC05
JC08
JC11
JC13
JC14
JC21
JC24
JC26
JC27
JC30
JC33
JC35
JC36
JC37
JC41
JC44
JC47A
JC49
JC53
JC55
JC57
JC59
JC61
JC63
JC65
JC67
JC69
JC73
JC74
JC75
JC77
JC79
JC81
JC83
JC85
JC87
JC89
JC91
JC92
JC93
JC95
JC96
JC97
JC99
STATIONS
LEGEND
MAXIMUM
MEAN

FIGURE 5



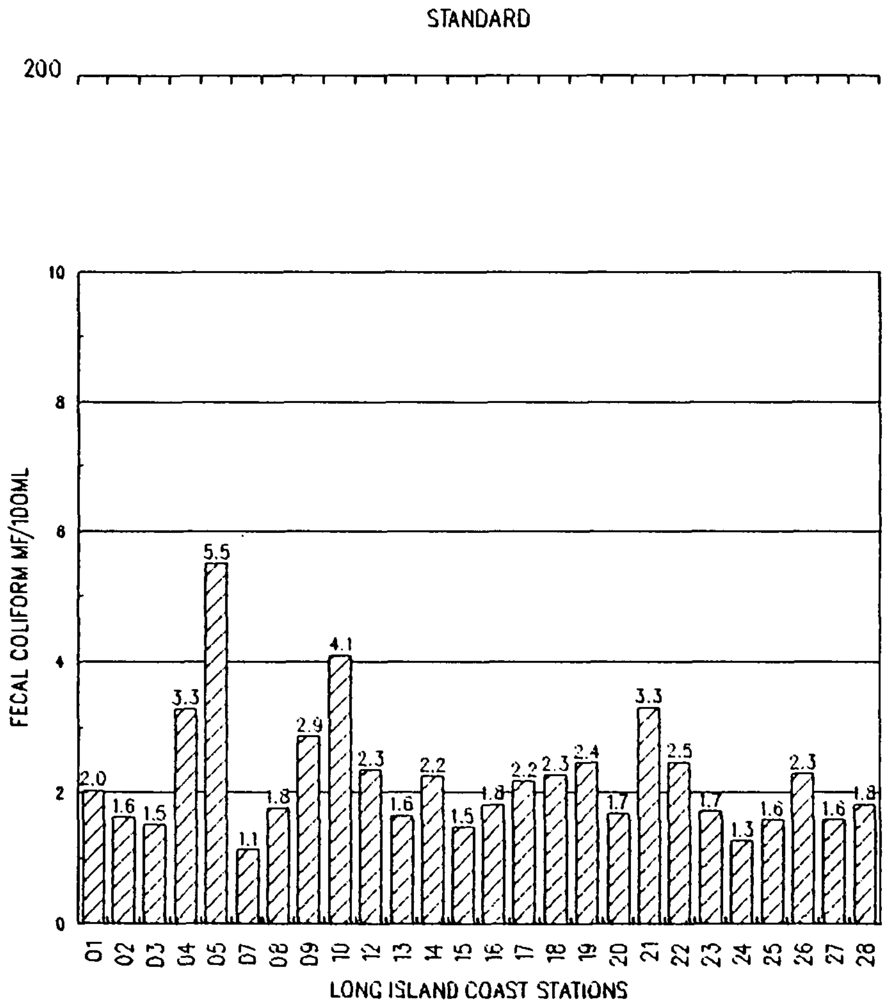
GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTED ALONG THE COAST OF NEW JERSEY, JUNE 28, 1989 TO SEPTEMBER 6, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

FIGURE 6



GEOMETRIC MEANS OF ENTEROCOCCI DATA COLLECTED ALONG THE COAST OF LONG ISLAND, MAY 23, 1989 TO SEPTEMBER 5, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

FIGURE 7



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTED ALONG THE COAST OF LONG ISLAND, MAY 23, 1989 TO SEPTEMBER 5, 1989.
(ACTUAL VALUES PRINTED ABOVE BARS)

subject file

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION II

DATE: JAN 02 1991

SUBJECT: New York Bight Report 1989

FROM: Constantine Sidamon-Eristoff
Regional Administrator

TO: Regina Mulcahy
Helen Taylor

I finally got around to carefully reading your report of last August entitled "New York Bight Water Quality, Summer 1989", and just wanted to thank you both for all of your good work. Keep it up.

cc: W. Muszynski
B. Metzger
R. Hemmett

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II

DATE: September 25, 1990

SUBJECT: New York Bight Report 1989

FROM: Regina Mulcahy, Environmental Scientist R Mulcahy
Environmental Services Division
Ambient Monitoring Section

TO: See Addressees Below

Enclosed for your information is a copy of our most recent New York Bight report entitled "New York Bight Water Quality, Summer 1989".

Enclosure

Addressees

C. Sidamon-Eristoff, 2RA
W. Muszynski, 2DRA
M. Torrusio, 2ARA
B. Metzger, 2ESD
J. Marshall, 2OEP
M. Randol, 2OEP
K. Bricke, 2WMD
T. Davies, WH-556F
C. Vogt, WH-556F
K. Klima, WH-556F

cc: w/enclosure
R. Hemmett, 2ESD-SMB
G. McKenna, 2ESD-TSB
L. Bevilacqua, 2ESD-MMB
M. DelVicario, 2WMD-MWPB
H. Phillips, 2OEP (6 copies)
D. Adams, 2ESD-SMB
H. Taylor, 2ESD-SMB
R. Braun, 2ESD-SMB
I. Katz, 2ESD-TSB
M. Simkovich, 2ESD-TSB