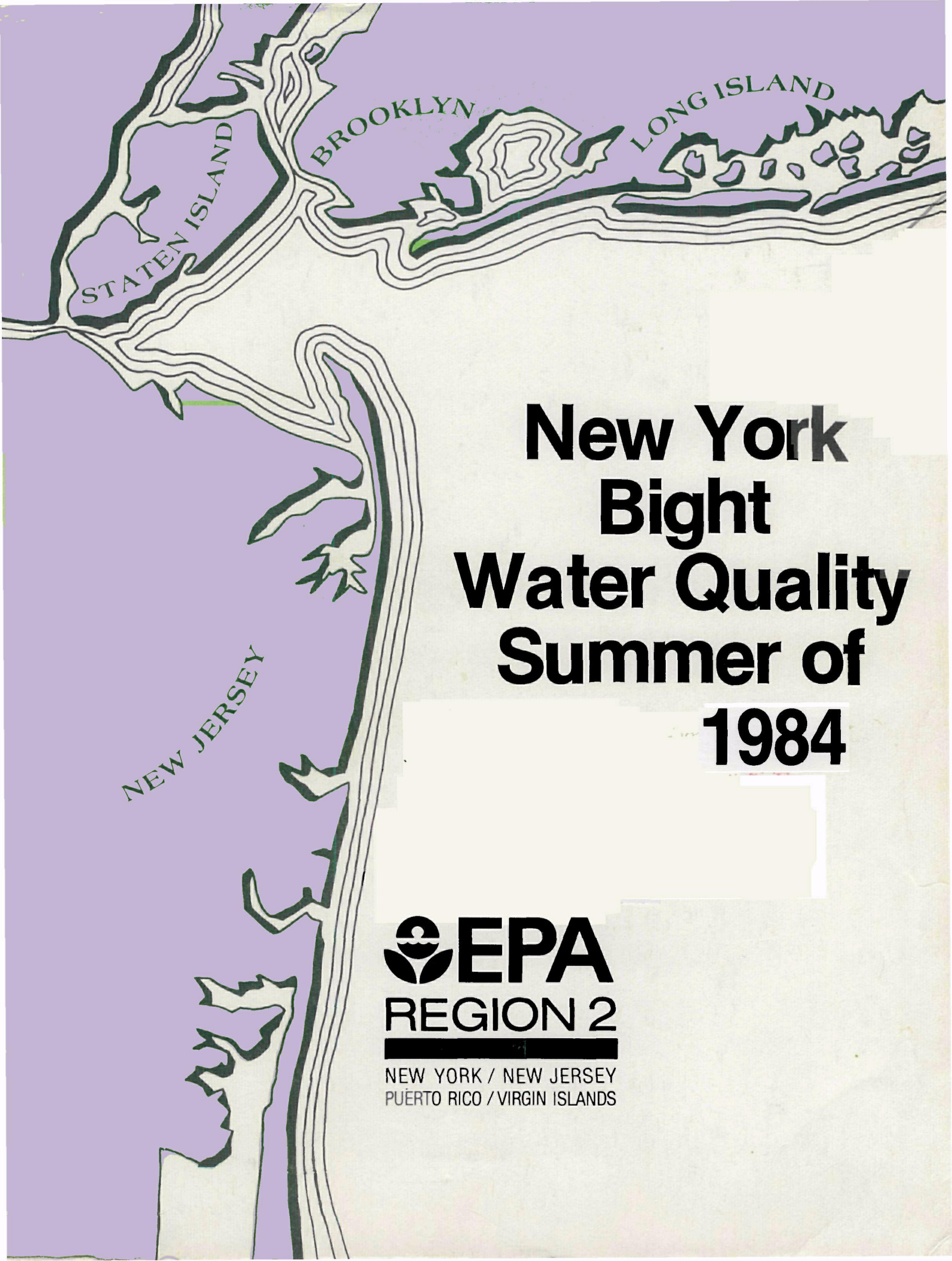

New York Bight Water Quality Summer of 1984

EPA
REGION 2
NEW YORK / NEW JERSEY
PUERTO RICO / VIRGIN ISLANDS

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1984

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ABSTRACT

The purpose of this report is to disseminate technical information gathered by the U.S. Environmental Protection Agency, Region II, during the 1984 New York Bight Water Quality Monitoring Program. The monitoring program was conducted using an EPA helicopter for water quality sample collection. During the summer period of April 9 to September 26, 1984, approximately 140 stations were sampled each week, weather permitting. The Bight sampling program consisted of five separate sampling networks.

The beach station network was sampled to gather bacteriological water quality information at 26 Long Island coast stations and 40 New Jersey coast stations. The New York Bight station network was sampled to gather chemical and bacteriological 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 New York Bight Contingency Network consisted of 24 stations which were sampled for dissolved oxygen and fecal coliform densities. Samples for phytoplankton identification and nutrient analysis were collected along the New Jersey coast and in Raritan Bay at 9 stations comprising the phytoplankton sampling network.

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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 sewage sludge, dredged material, acid waste, and cellar dirt dump sites, is shown in Figure 2.

This report is the eleventh in a series and reflects the monitoring period between April 9, 1984 and September 26, 1984. The New York Bight monitoring program is EPA's response to its mandated responsibilities as defined under the Marine Protection, Research and Sanctuaries Act of 1972 and the Water Pollution Control Act Amendments of 1972 and 1977.

Since its initiation in 1974, the New York Bight ocean monitoring program has been modified several times to be more responsive and to concentrate on specific areas of concern during the critical summer period. Most of these changes occurred after the summer of 1976, when anoxic conditions caused a fishkill in the Bight and an unusually heavy washup 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, to investigate the origins of these crises, and to use data gathered from New York Bight monitoring to guide and direct any decisions regarding protection of the Bight's water quality.

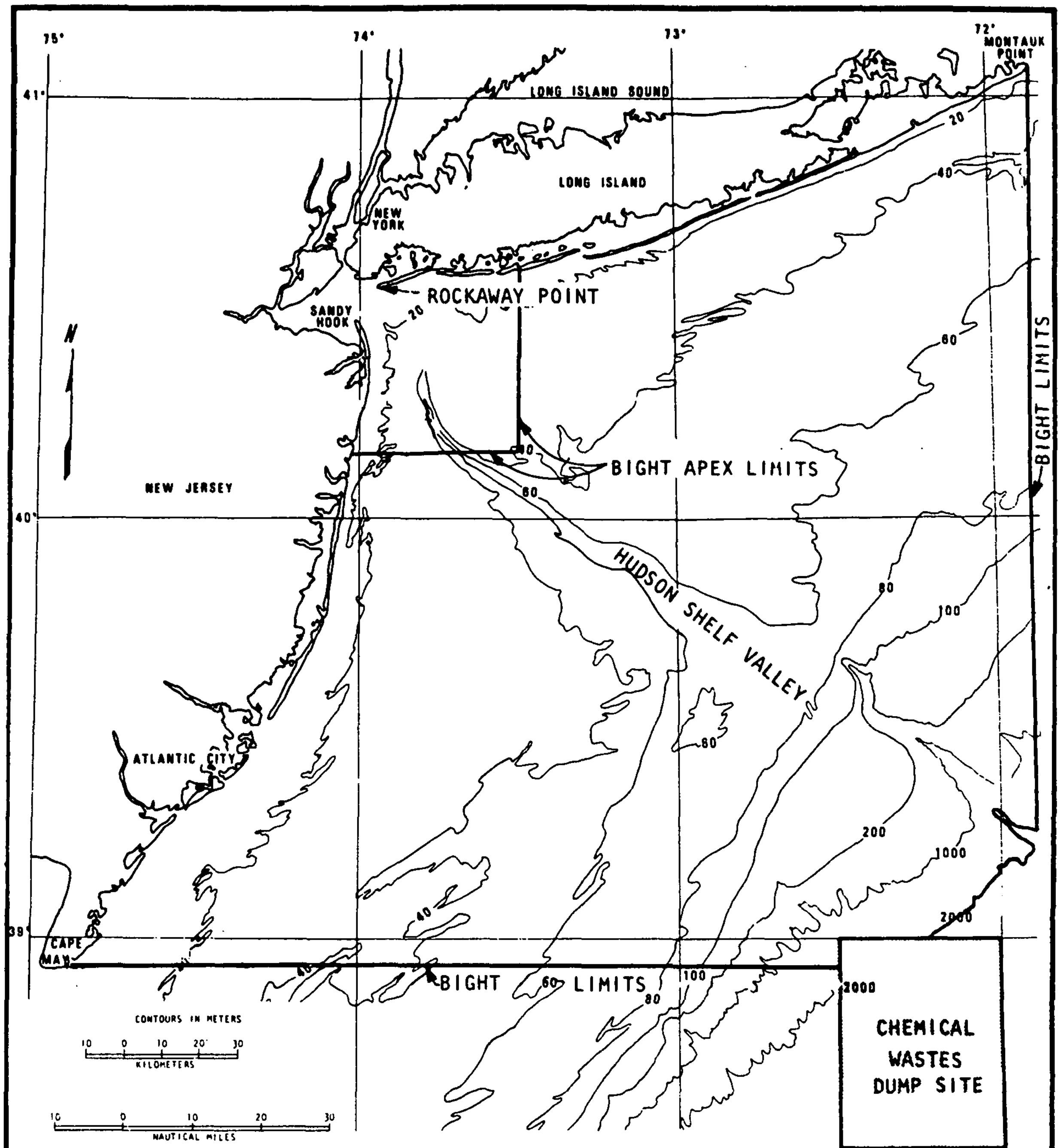


FIGURE 1

THE NEW YORK BIGHT

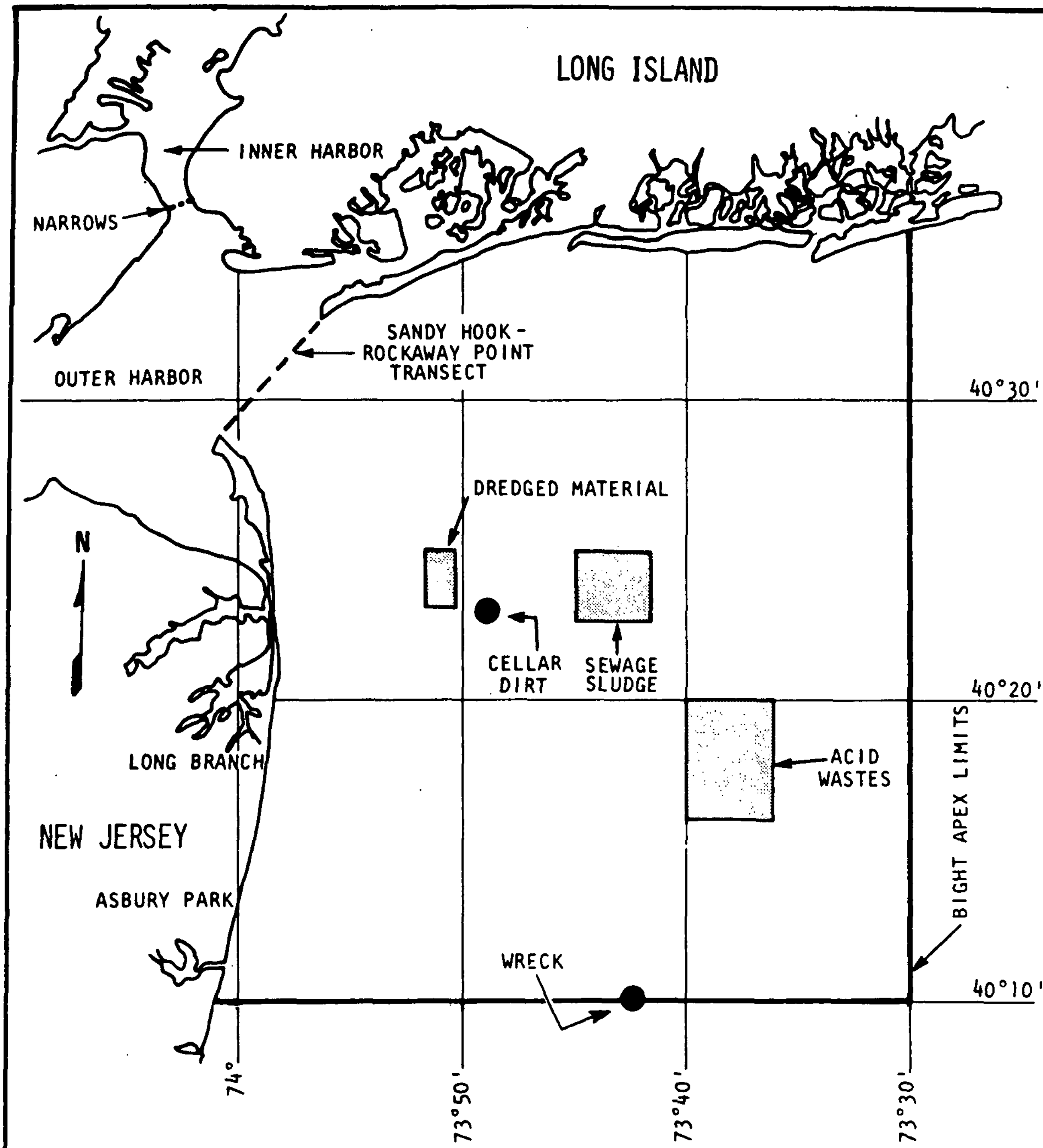
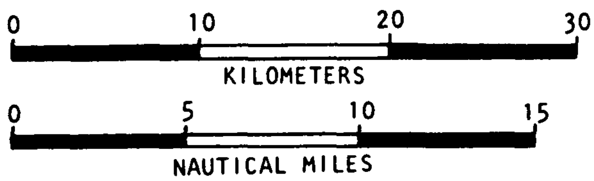


FIGURE 2

BIGHT APEX AND EXISTING DUMP SITES



In recent years, monitoring has been expanded to include analyses of Bight sediments for heavy metals, toxics, and benthic organisms for species diversity and number, and analyses of water in the sewage sludge disposal area for viruses and pathogens. The sediment and benthic organism samplings were conducted from EPA's ocean survey vessel "Antelope" and the data will be presented in separate reports. Ongoing revisions to the program are intended to improve the EPA's ability to track pollution sources and to protect New York Bight water quality.

As in previous years, results indicated that New York Bight water quality was generally good during the summer sampling period. Some stressful dissolved oxygen conditions were found at a few New Jersey perpendicular stations and New York Bight Apex stations. These depressed levels occurred in specific isolated areas. It is not certain if these conditions persisted over extended time periods. However, no extensive fishkills were reported. Therefore, as in previous years, the depressed dissolved oxygen levels were both temporary and transitory. The low dissolved oxygen in certain areas of the Bight is attributed to the combined effects of the respiration of organisms in organic-rich sediments, the decomposition of the algal blooms which occur in the nutrient-rich areas of the Bight, thermal water column stratification, and no vertical mixing due to a lack of storm activity.

Bacteriological data indicated that fecal coliform densities at the beaches along both the New Jersey and Long Island coasts were well within the acceptable limits for primary contact recreation.

II. SAMPLE COLLECTION PROGRAM

During the period of April 1984 through September 1984, water quality monitoring was carried out using the EPA Huey helicopter. Under the established protocol, sampling normally occurs 5 days a week and is extended to 6 days a week during July and August. Table 1 outlines the 1984 sampling program. Table 2 lists the parameters analyzed for each group of stations. Unscheduled maintenance on the helicopter during the latter half of July and most of August and September made it inherently difficult to adhere to a weekly sampling frequency. Rental of a Bell Jet Ranger II helicopter during that period facilitated sampling of the beaches; however, due to limitations of the aircraft, offshore sampling was not possible.

The weekly sampling program averages approximately 140 stations. Beach stations along New York and New Jersey were sampled once a week for fecal coliform bacteria densities. This portion of the sampling program totaled 66 stations one week and 34 stations the following 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 dropping a 1-liter Kemmerer sampler approximately 1 meter below the water surface. The sample was transferred to a sterile plastic container and subsequently transported (within 6 hours) to the Edison Laboratory for fecal coliform analysis.

Twenty stations in the apex of the Bight were scheduled to be 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 at 1 meter below the surface and 1 meter above the ocean bottom. After collection, portions of the water sample were transferred to a BOD bottle for dissolved oxygen analysis, and a sterile plastic

Table 1

Outline of 1984 sampling program

Station Group	Frequency per Week	Parameter	Sample Depth
Long Island Beaches (Rockaway Pt. to Fire Island Inlet)	1	Bacteriological	Top[1]
North Jersey Beaches (Sandy Hook to Barnegat)	1	Bacteriological	Top[1]
Long Island Beaches (Fire Island Inlet to Shinnecock Inlet)	Bimonthly	Bacteriological	Top[1]
South Jersey Beaches (Barnegat to Cape May)	Bimonthly	Bacteriological	Top[1]
Long Island Perpendiculars	1	Dissolved Oxygen	Top[1], Bottom[2]
North Jersey Perpendiculars (Long Branch to Seaside)	1	Dissolved Oxygen	Top[1], Bottom[2]
South Jersey Perpendiculars (Barnegat to Strathmere)	Bimonthly	Dissolved Oxygen	Top[1], Bottom[2]
Bight Contingency	2	Dissolved Oxygen	Top[1], Bottom[2]
Bight Contingency	1	Bacteriological	Top[1], Bottom[2]
Phytoplankton	1	Phytoplankton, Nutrients	Top[1]
Inner New York Bight	1	Bacteriological 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*	L.I. & N.J. Perpendiculars**	N.Y. Bight**	Bight Contingency**	Phytoplankton*
Fecal Coliform	X		X	X	
Salinity Chlorinity					X
Temperature		X	X	X	
Dissolved Oxygen (DO)		X	X	X	
Total Phosphorus (TP)					X
Phosphate Phosphorus (PO_4-P)					X
Ammonia Nitrogen (NH_3-N)					X
Nitrite Nitrogen (NO_2-N)					X
Nitrate Nitrogen (NO_3-N)					X
Silica (SiO_2)					X
Plankton					X

*Sample Depth: 1 meter below the surface
**Sample Depth: 1 meter below the surface and 1 meter above the ocean floor.

bottle for fecal coliform 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 and returned to the laboratory for analysis. The samples were held for less than 6 hours before returning to the laboratory for analysis by addition of 2 ml of sulfuric acid and titration with 0.0375M 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 below the surface and 1 meter above the bottom.

As part of the "Environmental Impact Statement on Ocean Dumping of Sewage Sludge in the New York Bight", a Bight Contingency Plan was developed in which criteria were established for the relocation of the sewage sludge dumpsite, if necessary. This called for the establishment of a fourth sampling component, a 24-station network to be sampled twice a week for dissolved oxygen and once a week for fecal coliform densities. Part of the sampling requirements for the New York Bight contingency plan were to be satisfied by the regularly scheduled Bight and perpendicular sampling runs. Bacteriological samples for LIC 09, LIC 14, JC 14, and JC 27 perpendiculars were taken on the dissolved oxygen runs for those stations. The bacteriological requirements for NYB 20, 22, 24, and the NYB 40, 42 and 44 transects were met by the regular Bight sampling since bacteriological assays were performed for all Bight stations. Additional sampling of dissolved oxygen for the 24 stations was to have been carried out once a week.

The fifth routinely scheduled sampling component involved the collection of water samples for phytoplankton identification and quantification and nutrient analysis. The phytoplankton analysis was done by the New Jersey Department of Environmental Protection (NJDEP) and the nutrient analysis was done by EPA. 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 sample was preserved with Lugols solution and kept at 4°C. A 1-liter plastic cubitainer was filled for nutrient analysis and kept at 4°C. The NJDEP picked the phytoplankton samples up within 24 hours of collection. The results of these analyses are contained in Appendix A.

III. DESCRIPTION OF SAMPLING STATIONS

Beach Stations

A total of 66 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. Forty New Jersey coast stations, from Sandy Hook at the north to Cape May Point at the south (JC 01A through JC 99), 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

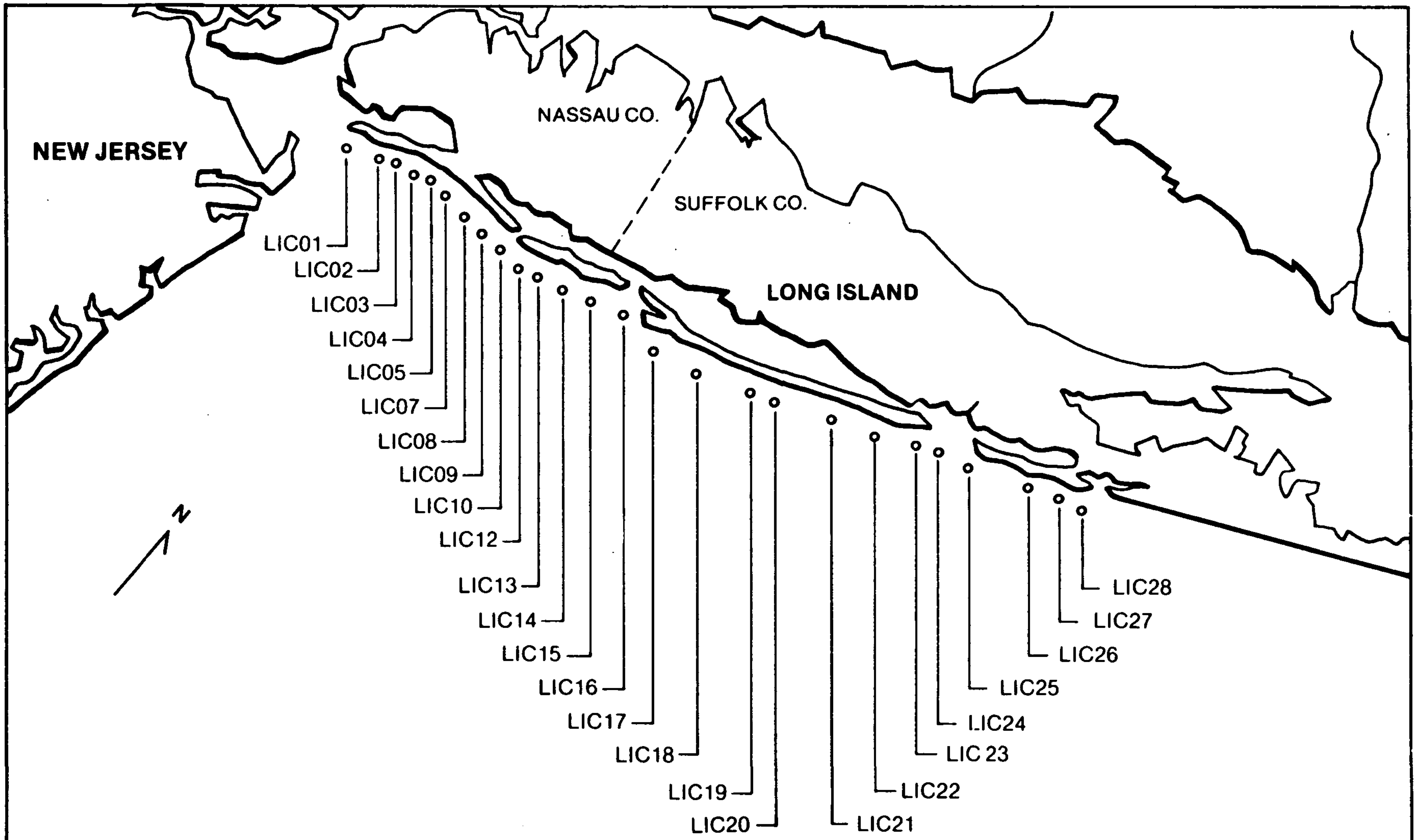


FIGURE 3
LONG ISLAND COAST STATION LOCATIONS

Table 4

New Jersey coast station locations

Station No.	Location
JC 01A	Sandy Hook, 1.2 km south of tip
JC 02	Sandy Hook, off large radome
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 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 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 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
JC 53	Seaside Park, off foot of 5th Avenue
JC 55	Island Beach State Park, off white building north of Park Hq.
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

Table 4 (Continued)

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

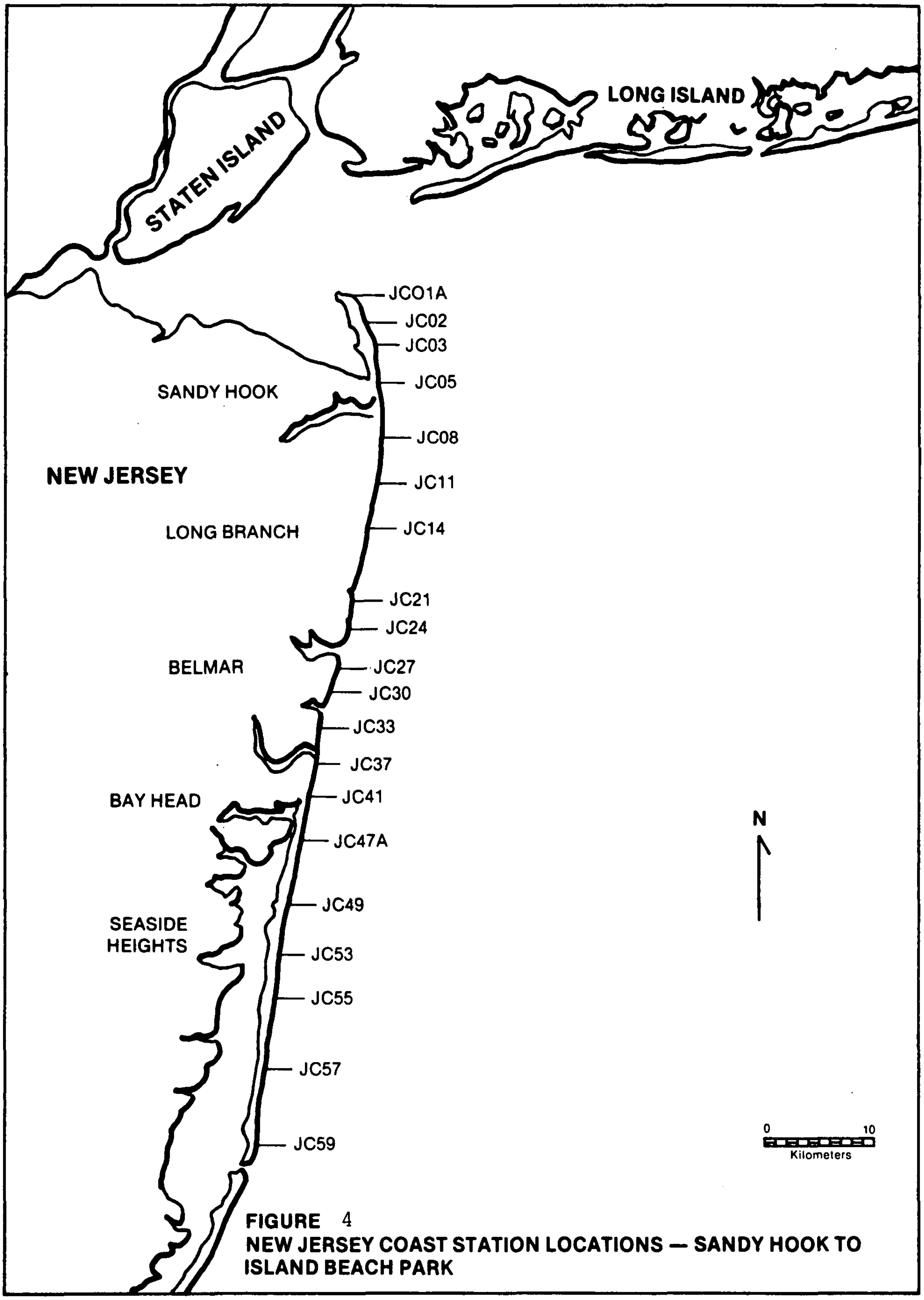


FIGURE 4
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

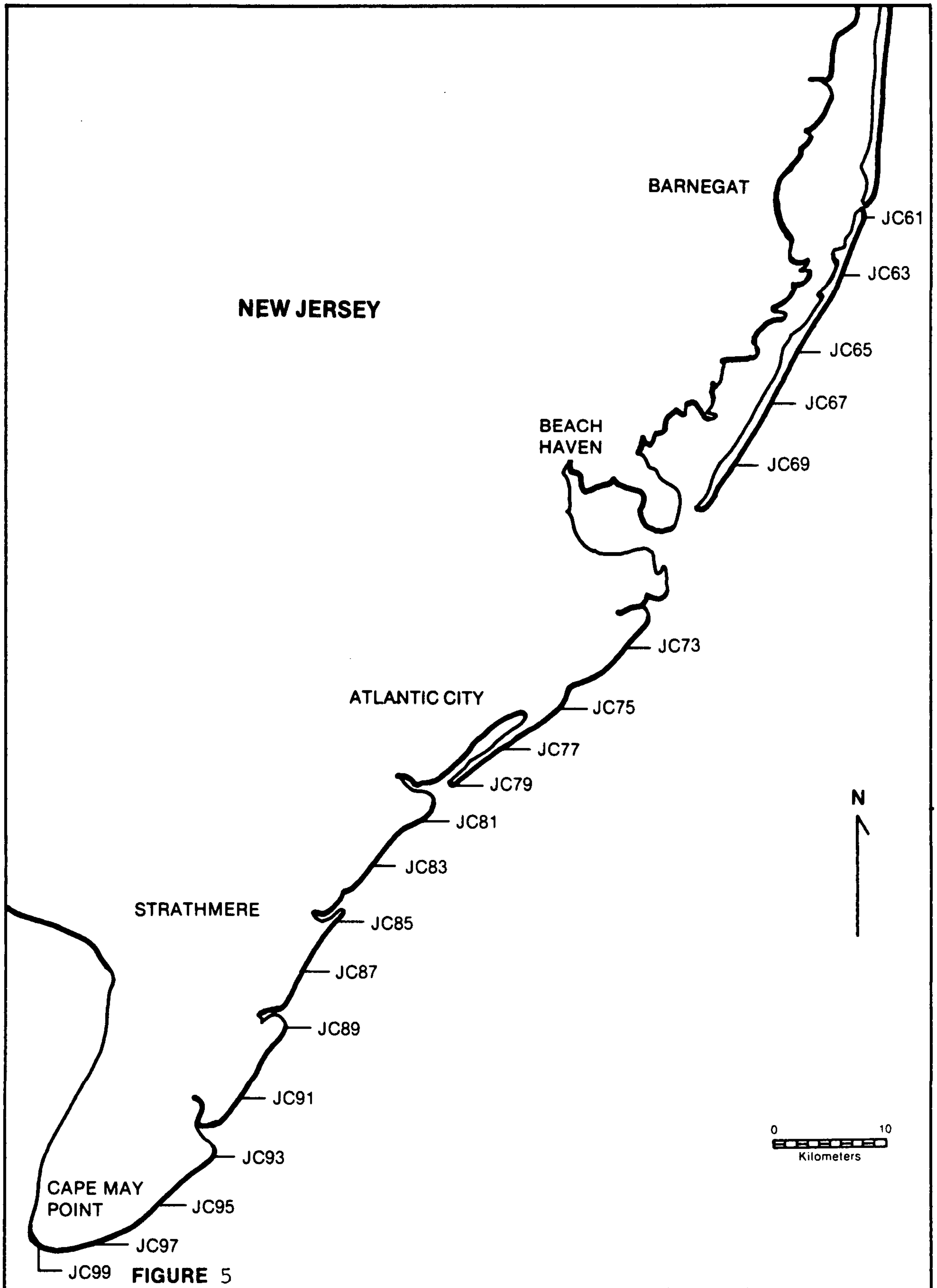


FIGURE 5
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

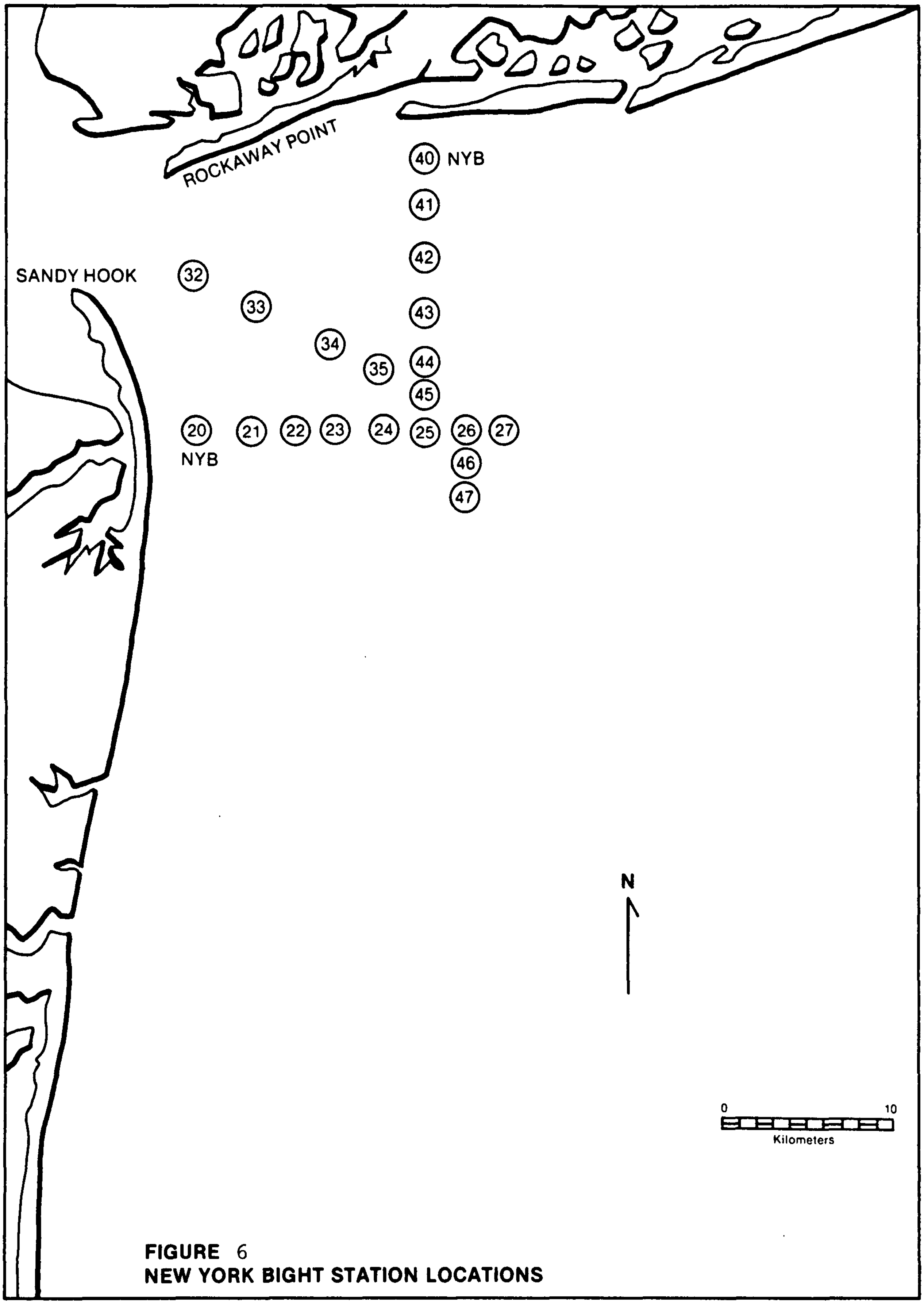


FIGURE 6
NEW YORK BIGHT STATION LOCATIONS

Perpendicular Stations

Sampling stations perpendicular to the Long Island coastline are 5.4 km, 12.6 km, 19.8 km, and 27 km (3, 7, 11, and 15 nautical miles) offshore. Sampling stations perpendicular to the New Jersey coastline start at 1.8 km and are spaced every 1.8 km out to 18 km (1 nautical mile 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 (3.6 km intervals) was sampled; the intermediate stations remained available should dissolved oxygen conditions warrant more intensive sampling.

The perpendicular stations were established to gather near-surface and near-bottom dissolved oxygen values in the critical areas of the New York Bight nearshore waters. Previous agreements had been made with NOAA to provide dissolved oxygen profiles from stations further out in the Bight in conjunction with their MESA project and Marine Fisheries Laboratory activities.

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.

New York Bight Contingency Plan Stations

The 24 stations sampled are:

NYB 20, 22, 24, 40, 42, 44,
LIC 09P, A, B, and C
LIC 14P, A, B, and C
JC 14E, G, I, K, and M
JC 27E, G, I, K, and M

Their locations are shown in Figures 6 and 7.

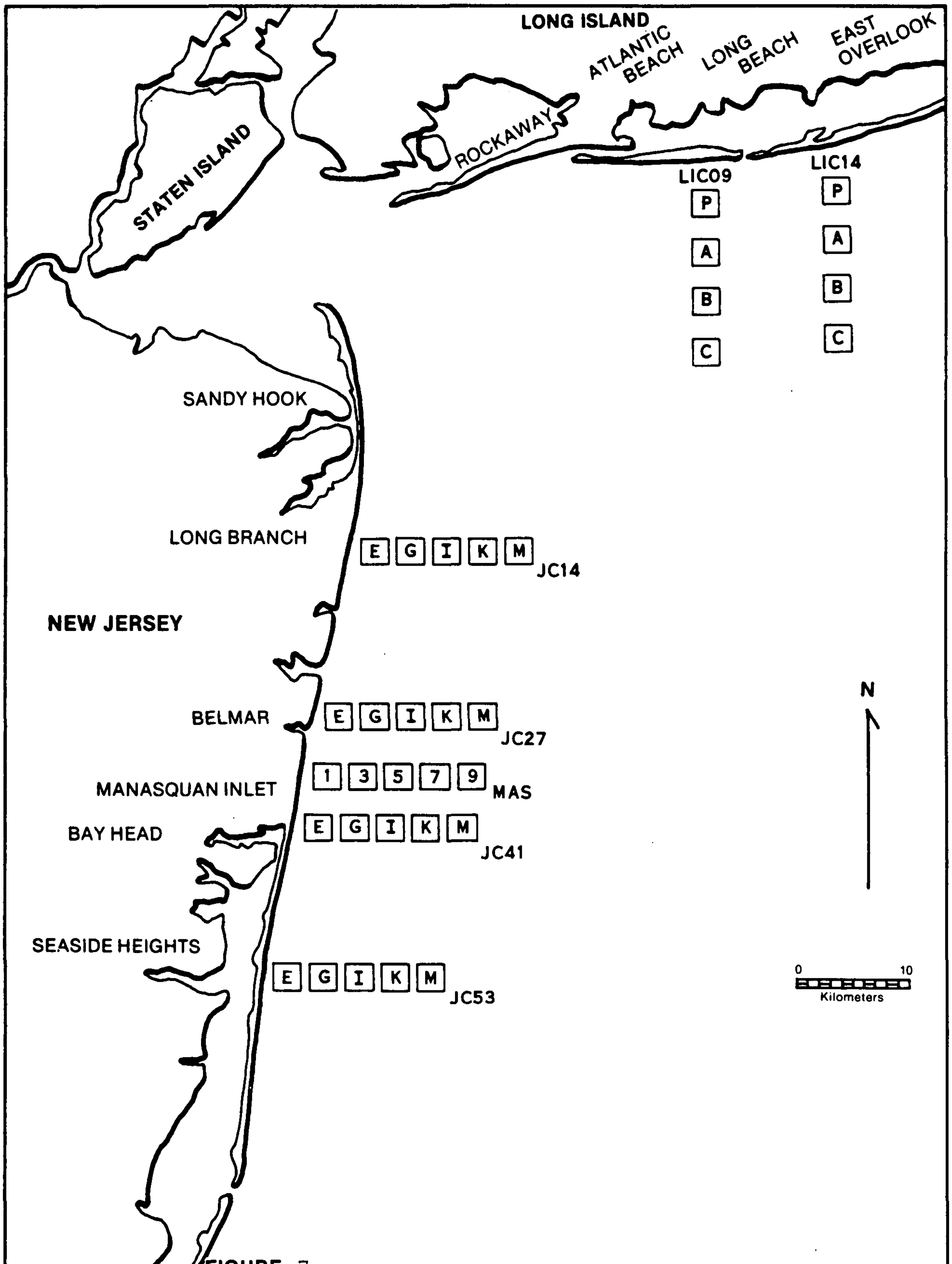


FIGURE 7
LONG ISLAND PERPENDICULAR STATIONS AND NEW JERSEY PERPENDICULAR STATIONS FROM SANDY HOOK TO SEASIDE HEIGHTS

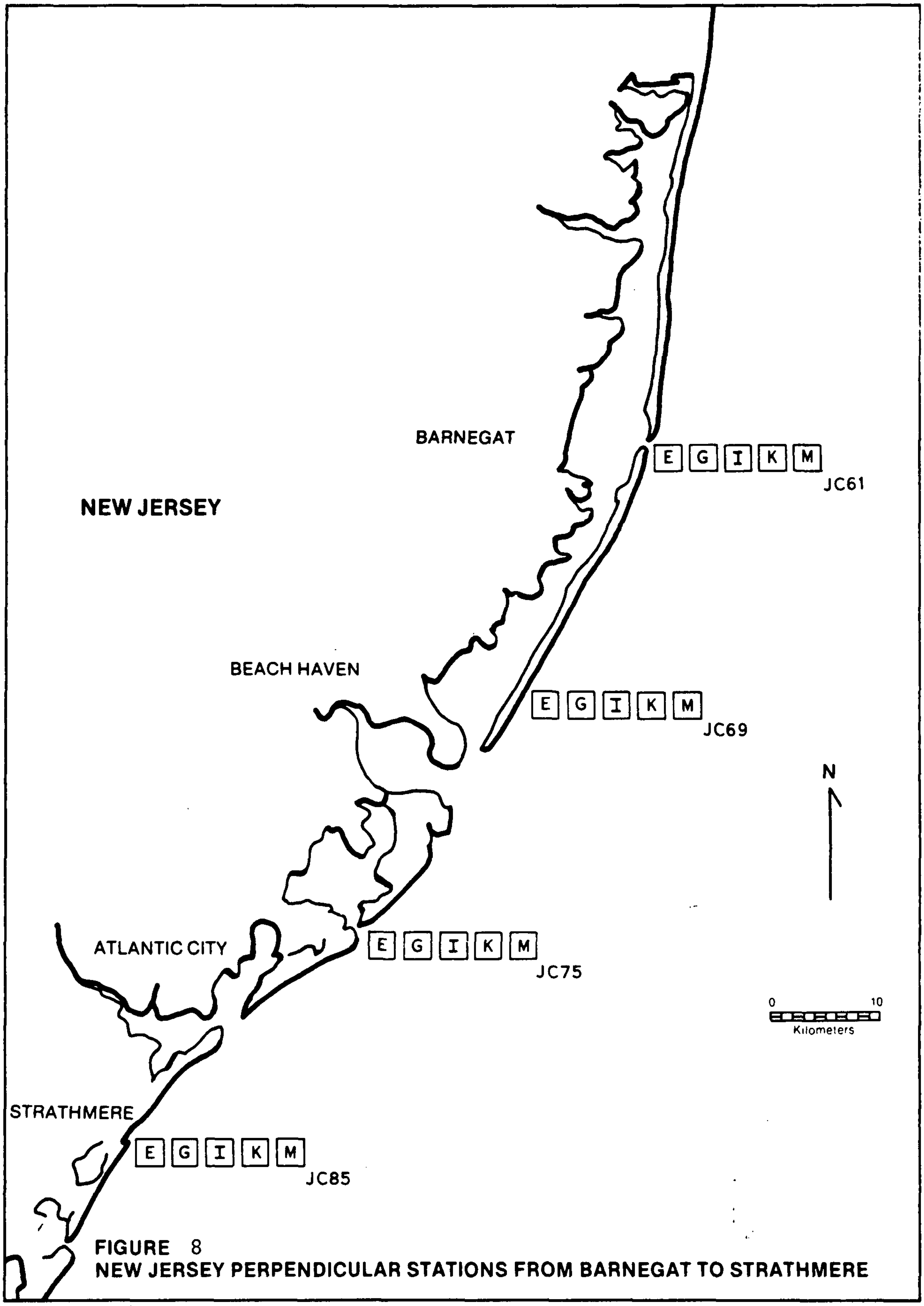


FIGURE 8
NEW JERSEY PERPENDICULAR STATIONS FROM BARNEGAT TO STRATHMERE

Phytoplankton Stations

Phytoplankton samples were collected once a week along the New Jersey coast at the following stations:

JC 05	JC 57
JC 11	NYB 20
JC 21	RB 32
JC 30	RB 15
JC 37	

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

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 area. 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°C to 10°C 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 bottom cooler water is effectively isolated from the upper layer by a 10°C 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 causes 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.

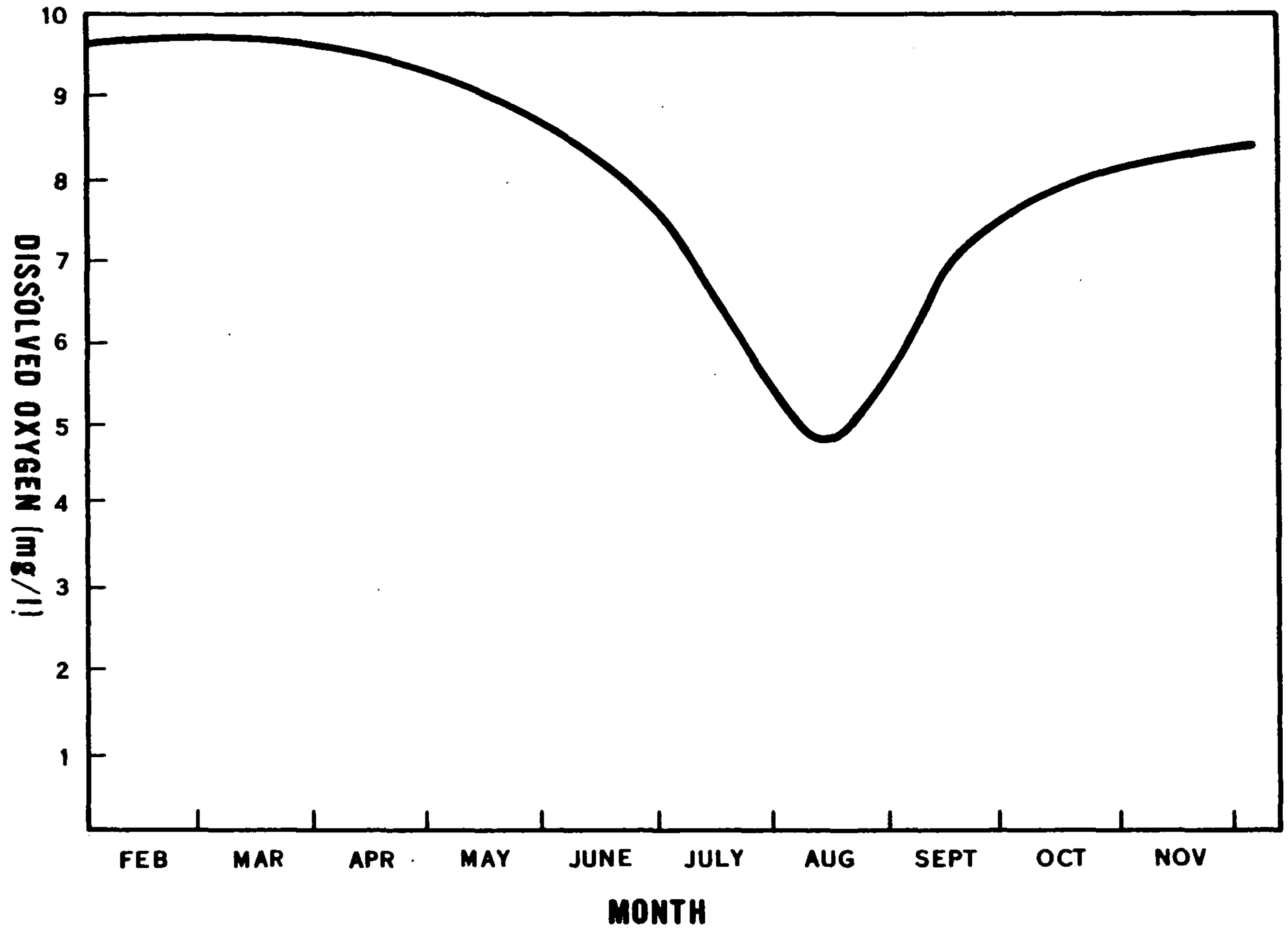


FIGURE 9
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

Dissolved Oxygen Criteria

The dissolved oxygen levels necessary for survival and/or reproduction vary among biological species. Insufficient data have 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 several 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 fish kills and bottom dwelling organism mortality.

Surface Dissolved Oxygen - 1984

The completely mixed upper water layer had dissolved oxygen levels at or near saturation during the entire sampling period, April 9, 1984 through September 26, 1984, therefore no further discussion of surface dissolved oxygen will be presented in this report.

Bottom Dissolved Oxygen - 1984

Long Island Coast

Long Island perpendiculars 09 and 14 were sampled four times during the summer sampling period - April 19, June 28, July 10 and September 26. Perpendicular LI 02 was sampled once during this same period - September 26. The dissolved oxygen concentrations were above the 4 mg/l "borderline to healthy guideline" on all dates, except September 26. On September 26, 6 of the 12 samples collected were below 4 mg/l.

While the dissolved oxygen data for Long Island in 1984 were minimal, the data were not atypical. Data from previous years show dissolved oxygen levels off the Long Island coast usually remain above 4 mg/l. The depressed levels of dissolved oxygen which occurred on September 26 were consistent with low values observed along these perpendiculars in previous years. This condition is temporary. There were no samples collected along the Long Island perpendiculars after September 26, therefore recovery was not documented. Table 5 summarizes the dissolved oxygen values below 4 mg/l off the Long Island coast during the summer of 1984.

Table 5

Dissolved oxygen concentrations less than 4 mg/l found off the Long Island coast, summer 1984.

Date	Station	D.O. (mg/l)
9/26	LIC 02A	3.5
9/26	LIC 09P	1.9
9/26	LIC 09A	3.8
9/26	LIC 09B	2.6
9/26	LIC 09C	3.0
9/26	LIC 14P	2.8

New York Bight Apex

In previous years, with the exception of 1982, a dissolved oxygen "double minima" has been observed in the New York Bight during the summer months. Generally, the average bottom dissolved oxygen concentration in late May and early June is approximately 8 mg/l. It slowly declines to approximately 5.0-6.0 mg/l in mid-July and is followed by a rise to 6.5-7.0 mg/l in early August. A subsequent second decline to 5.0-6.0 mg/l occurs in mid-September, followed by steady recovery throughout the remainder of September and October. The Bight Apex was sampled four times - April 17, June 20, June 27 and September 24-25. Not enough data were generated to determine if a dissolved oxygen "double minima" occurred in 1984.

Out of 80 samples collected in the New York Bight from April 17 - September 25 and measured for dissolved oxygen, 11 samples, or 8.75 percent, were between the 3-4 mg/l level considered "stressful if prolonged" for aquatic life, and 1 sample, or 1.3 percent, was less than the 2 mg/l level considered "lethal in a relatively short time".

Table 6 summarizes the dissolved oxygen values below 4 mg/l in the New York Bight during the Summer 1984.

Table 6 - Dissolved oxygen concentrations less than 4 mg/l in the New York Bight Apex, summer 1984

DATE	STATION	D.O. (mg/l)
6/20	NYB40	3.3
6/27	NYB45	3.8
9/24	NYB20	3.2
9/24	NYB21	3.1
9/25	NYB33	3.2
9/25	NYB40	1.7
9/25	NYB41	3.2
9/25	NYB42	3.7

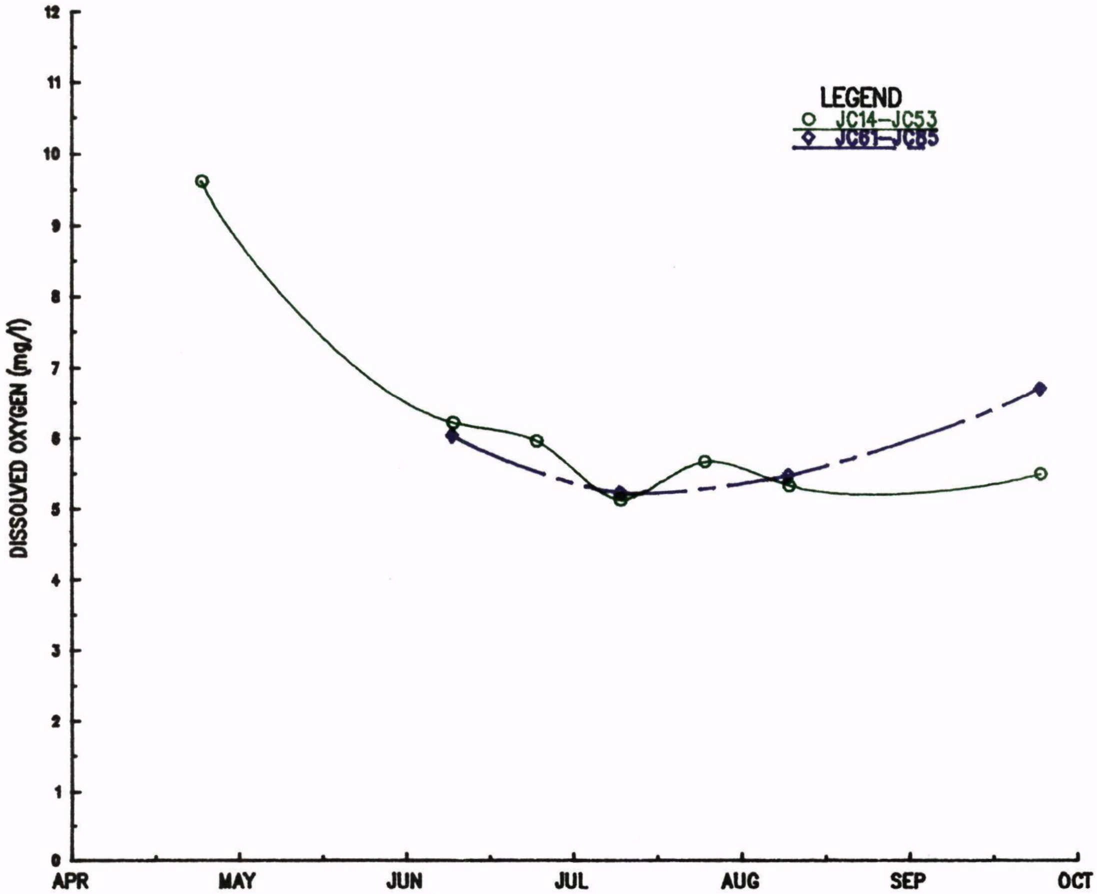
New Jersey Coast

The northern New Jersey perpendicular network (JC 14-53) was sampled 8 times throughout the summer sampling period - April 18, June 14, June 19, July 2, July 14, July 16, August 11 and September 19. The southern New Jersey perpendiculars (JC 61-85) were sampled four times - June 15, July 3, August 11 and September 20. A majority of the semi-monthly averages presented in the graphs to follow, are based on only one data value. This should be kept in mind when reading subsequent discussions and reviewing the dissolved oxygen data.

Figure 10 illustrates the semi-monthly dissolved oxygen averages off the New Jersey coast during the summer of 1984, with separate lines for the northern (JC 14-JC 53) perpendiculars and the southern (JC 61-JC 85) perpendiculars. The average dissolved oxygen values along the southern perpendiculars remained between 5.0 - 6.0 mg/l during June, July and August and increased to about 6.7 mg/l during September. The northern perpendicular dissolved oxygen average exhibited the "double minima" phenomenon which occurred in previous years, with the exception of 1982. An average low of 5.2 mg/l occurred in early July, followed by a slight recovery in late July and a second low of about 5.3 mg/l in early August.

Table 7 summarizes the dissolved oxygen values for all the New Jersey coast perpendiculars. During the summer there were 44 values between 4-5 mg/l, 16 values between 2-4 mg/l and 1 value between 0-2 mg/l. Dissolved oxygen at the bottom reaches a minimum in late August/early September due to a lack of reaeration and sediment oxygen demand. Values usually improve later in the season when storms and/or increased winds aid reaeration.

FIGURE 10



NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1984. SEMIMONTHLY AVERAGES OF ALL NORTHERN (JC14–JC53) AND SOUTHERN (JC61–JC85) PERPENDICULAR STATIONS.

TABLE 07

Dissolved Oxygen Distribution (Bottom Values)

New Jersey Coast Perpendiculars

1984

Station	Apr 18	Jun 14	Jun 15	Jun 19	Jul 2	Jul 3	Jul 14	Jul 16	Aug 11	Sep 19	Sep 20
JC85M			◆			▲			●		◆
JC85K			◆			◆			●		◆
JC85I			◆			◆			▲		◆
JC85G			◆			▲			◆		◆
JC85E			◆			▲			◆		◆
JC75M			◆			▲			●		◆
JC75K			◆			▲			◆		◆
JC75I			◆			▲			▲		◆
JC75G			◆			▲			●		◆
JC75E			◆			▲			◆		◆
JC69M			◆			▲			◆		◆
JC69K			▲			◆			◆		◆
JC69I			▲			▲			◆		◆
JC69G			◆			◆			▲		◆
JC69E			◆			◆			◆		◆
JC61M			◆			◆			◆		◆
JC61K			◆			◆			◆		◆
JC61I			◆			◆			▲		◆
JC61G			◆			◆			▲		◆
JC61E			◆			◆			●		◆
JC53M		◆		◆	◆				◆	●	
JC53K		◆		◆	◆				◆	◆	
JC53I		◆		◆	◆		▲		◆	◆	
JC53G		◆		◆	◆		●		●	◆	
JC53E		▲		▲			●		◆	◆	
JC41M		◆		◆	◆		◆		◆	▲	
JC41K		◆		◆	▲		▲		◆	▲	
JC41I		◆		◆	◆		▲		◆	▲	
JC41G		◆		▲	◆		▲		●	◆	
JC41E		◆		◆	▲		●		■	◆	
JC27M	◆	◆		◆	▲			◆		▲	
JC27K	◆	◆		◆	●			◆		●	
JC27I	◆	◆		◆	▲			◆		◆	
JC27G	◆	◆		◆	●			◆		●	
JC27E	◆	▲		◆	▲			◆		◆	
JC14M	◆	◆		◆	◆			◆		◆	
JC14K	◆	◆		◆	◆			◆		●	
JC14I	◆	◆		◆	◆			◆		◆	
JC14G	◆	◆		◆	◆			◆		◆	
JC14E	◆	◆		◆				▲		▲	

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

Figures 11, 12, 13 and 14 show dissolved oxygen profiles along the coast for June, July, August, and September. The profiles show that, generally, dissolved oxygen increased with distance offshore. Of the thirty profiles presented in Figures 11, 12, 13, and 14, twenty exhibit the trend of increasing dissolved oxygen with distance offshore, seven show increasing dissolved oxygen closer to shore, and three show no apparent trend. The profiles show a slow dissolved oxygen decline from June through August and a slight increase in September. In Figure 13 there are no profiles for the Long Branch and Belmar perpendiculars because no data were collected along these two perpendiculars during August.

There were 233 samples collected along the New Jersey perpendiculars between April 18 and September 25, 1984 and analyzed for dissolved oxygen. Of these, 17 samples, or 7.3 percent, were below 4 mg/l (Table 7).

Figure 15 compares the shore to seaward distribution of dissolved oxygen values along the northern New Jersey perpendiculars. This graph shows the following:

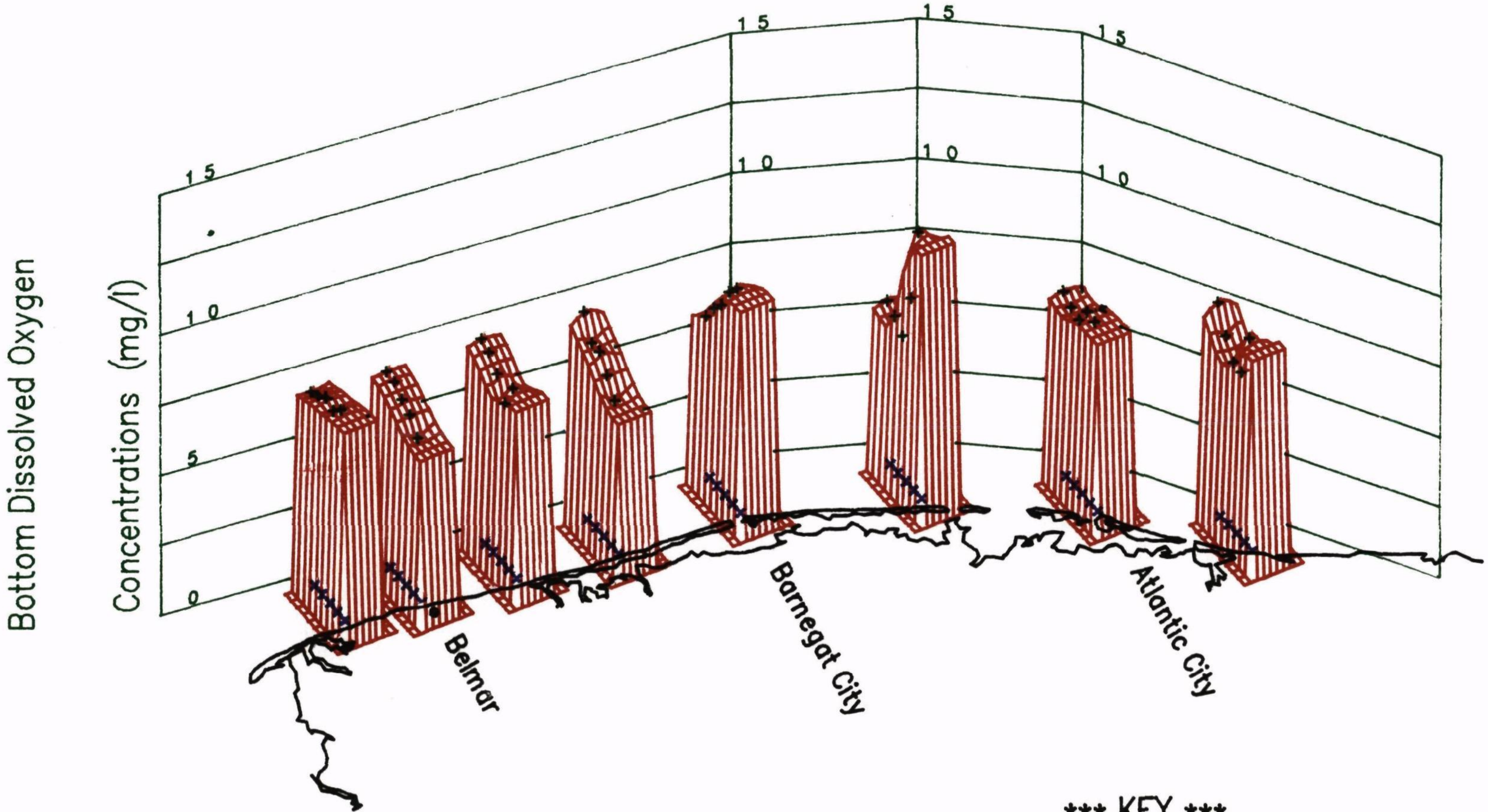
- A dissolved oxygen "double minima" occurred along the northern New Jersey coast. Dissolved oxygen lows were recorded in early July at 1, 3, 7 and 9 miles offshore, followed by an improvement in mid-July, with a subsequent second minima occurring in early August at 1 and 3 miles offshore, and in late September at 7 and 9 miles off the coast. A "double minima" is not obvious 5 miles offshore.
- The northern New Jersey perpendicular stations that are 1 and 3 miles offshore had average dissolved oxygen values slightly lower than the stations 5, 7 and 9 miles offshore. This difference was most pronounced in August. In general, the lower dissolved oxygen values found at the

FIGURE 11

Dissolved Oxygen Concentration Profiles

New Jersey Coast

June 1984



***** KEY *****

+ = Average DO Concentration per Station
× = Actual Location of each Station

FIGURE 12

Dissolved Oxygen Concentration Profiles

New Jersey Coast

July 1984

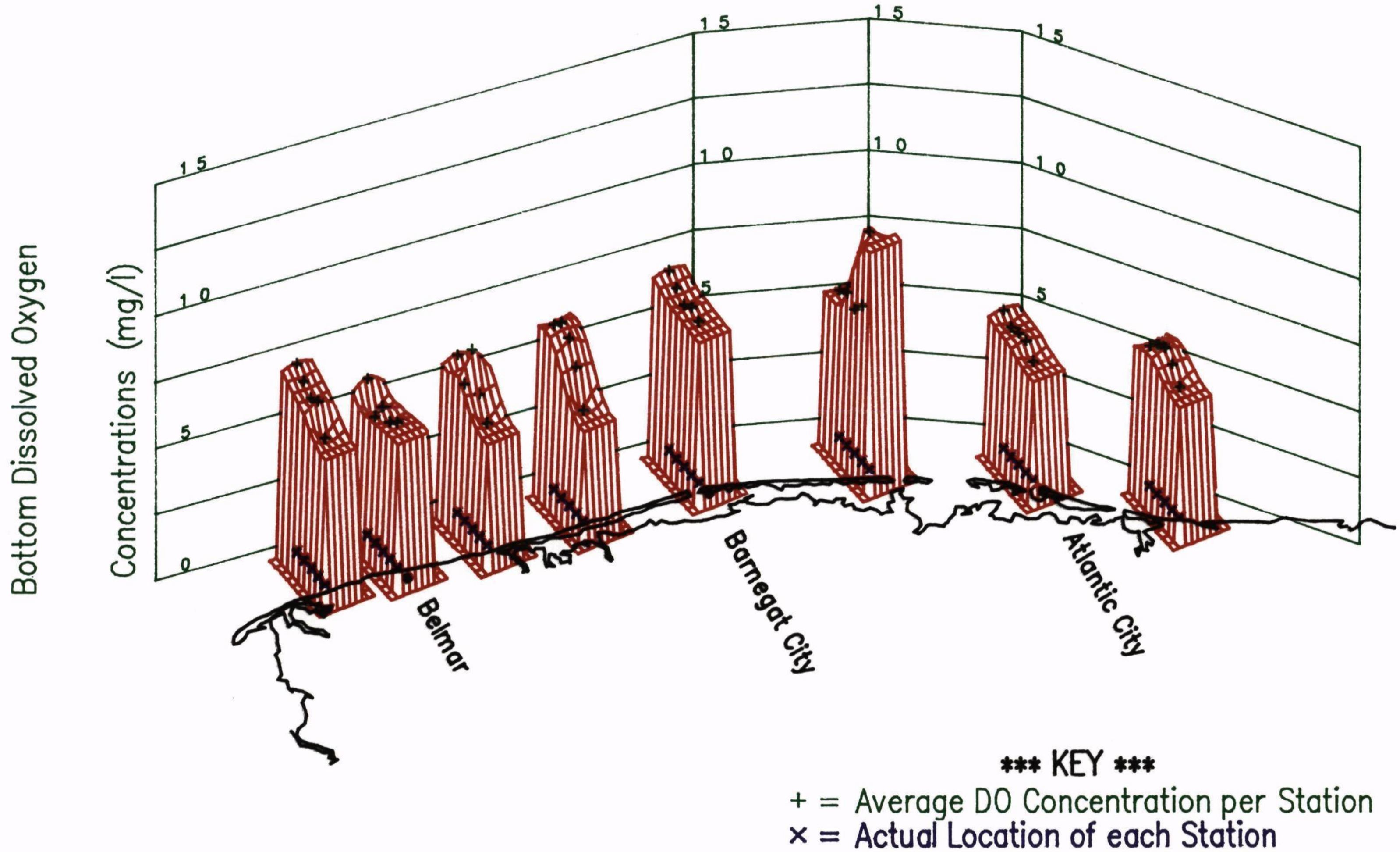


FIGURE 13

Dissolved Oxygen Concentration Profiles

New Jersey Coast
August 1984

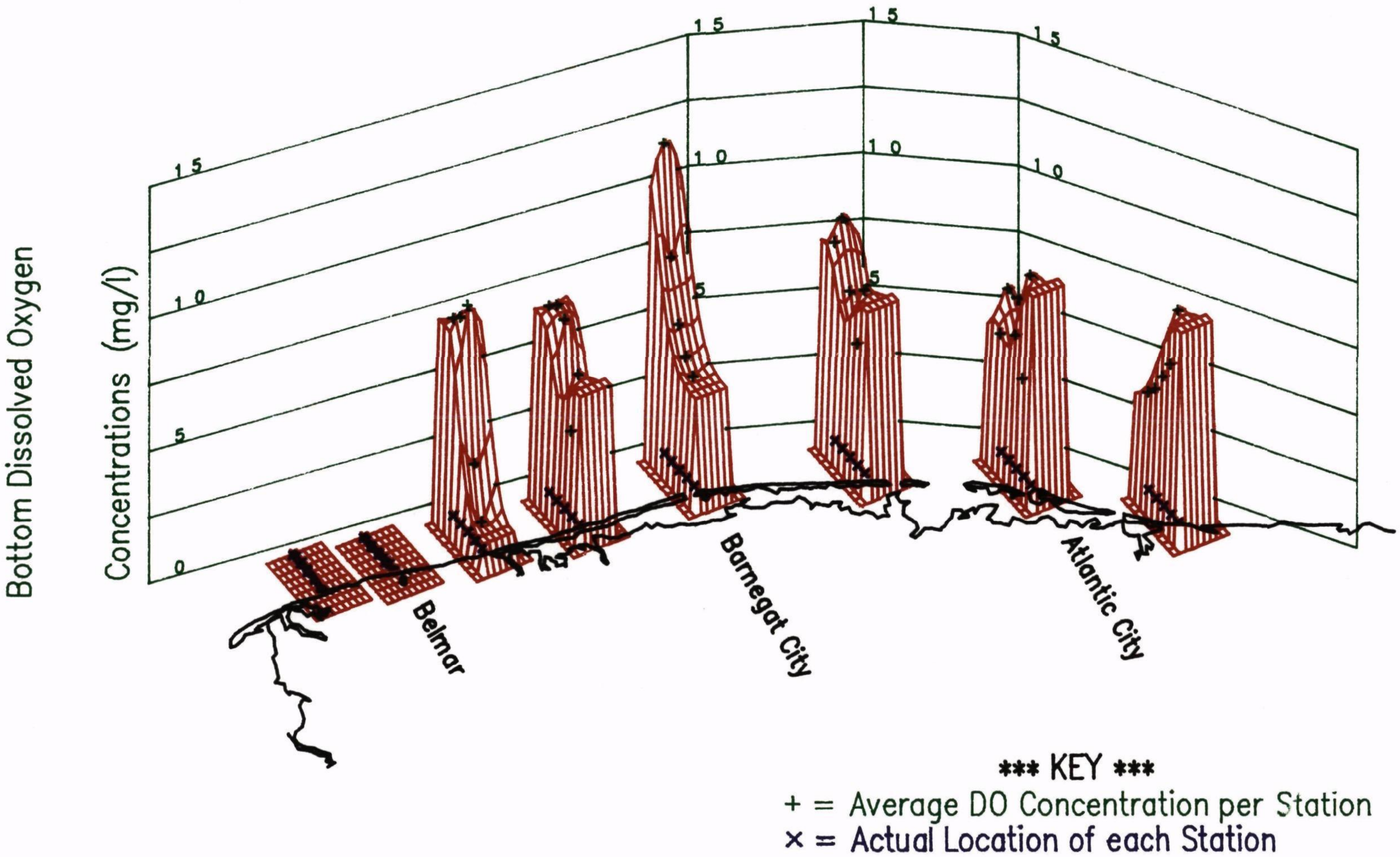


FIGURE 14

<u>Dissolved Oxygen Concentration Profiles</u>

New Jersey Coast

September 1984

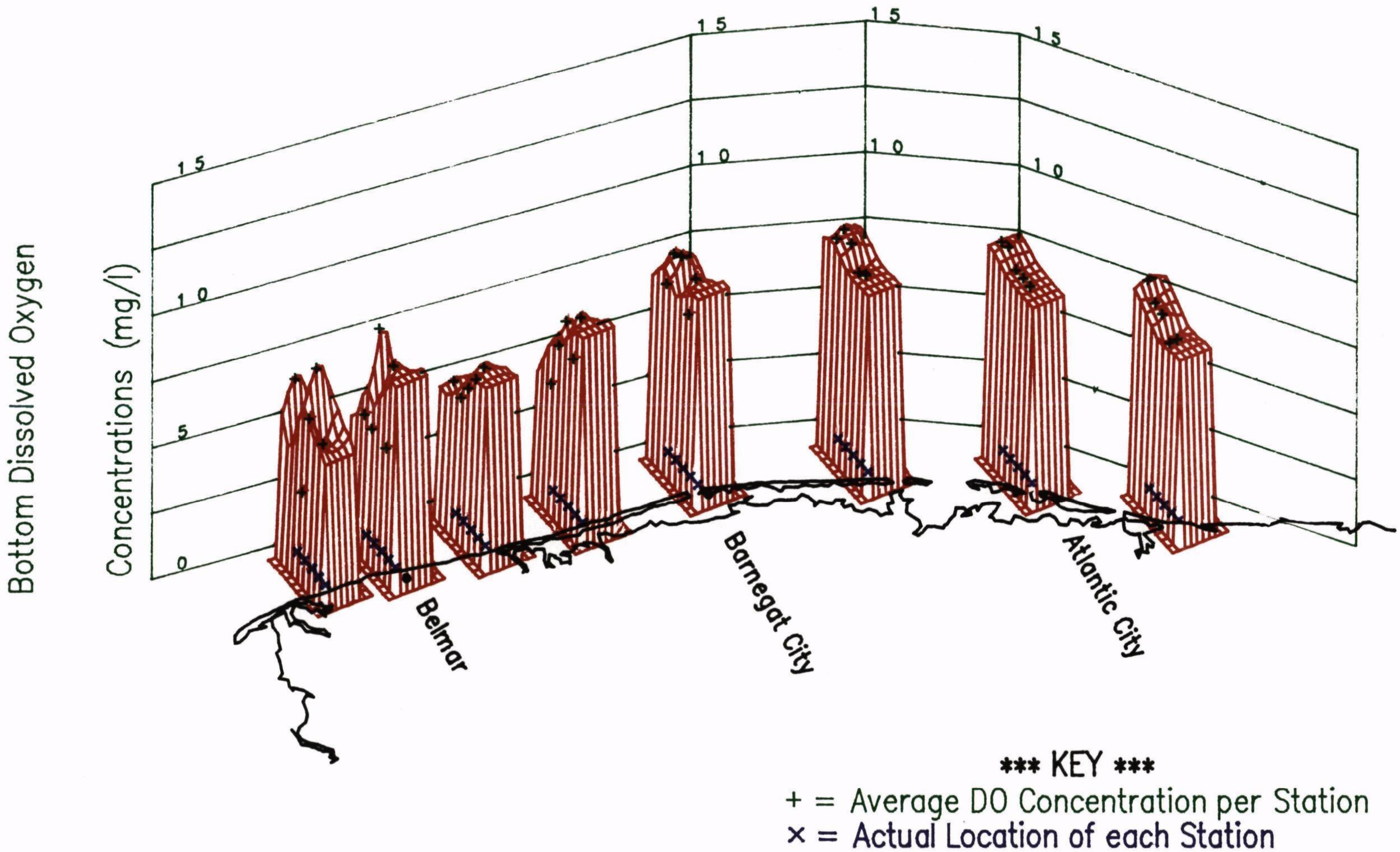
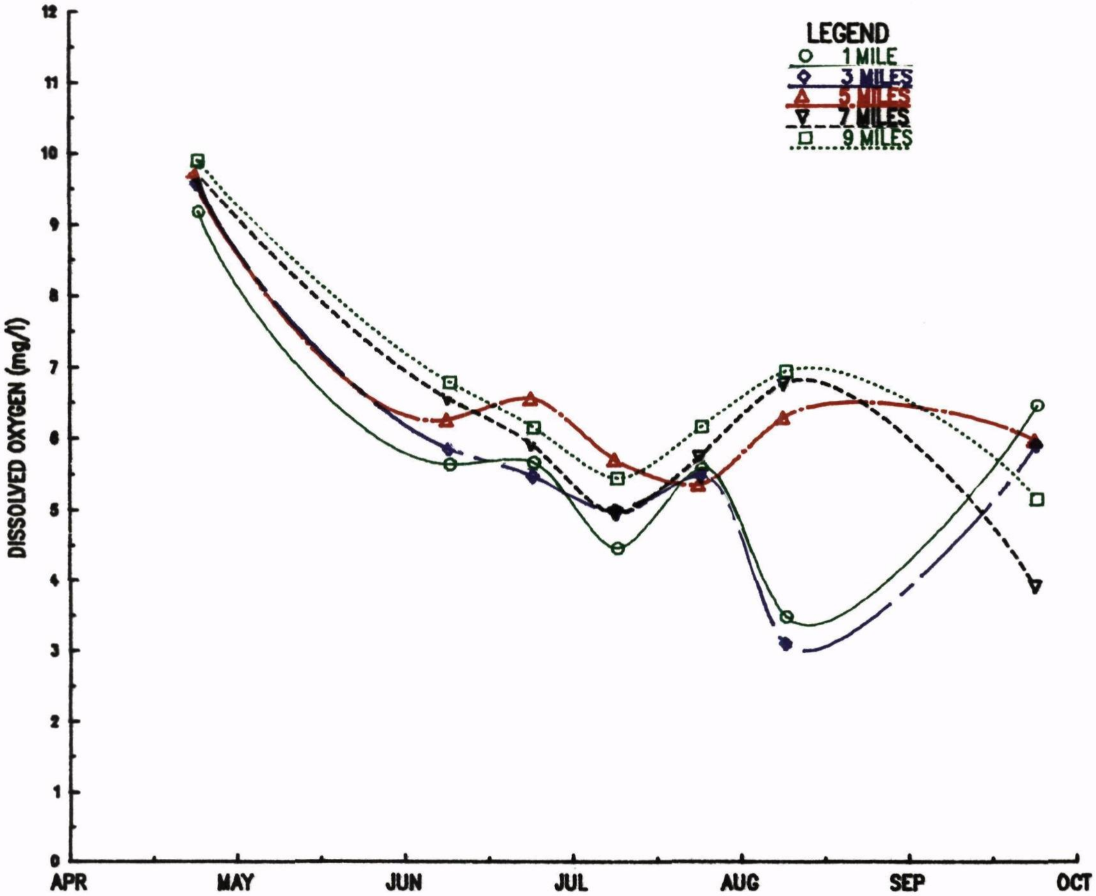


FIGURE 15

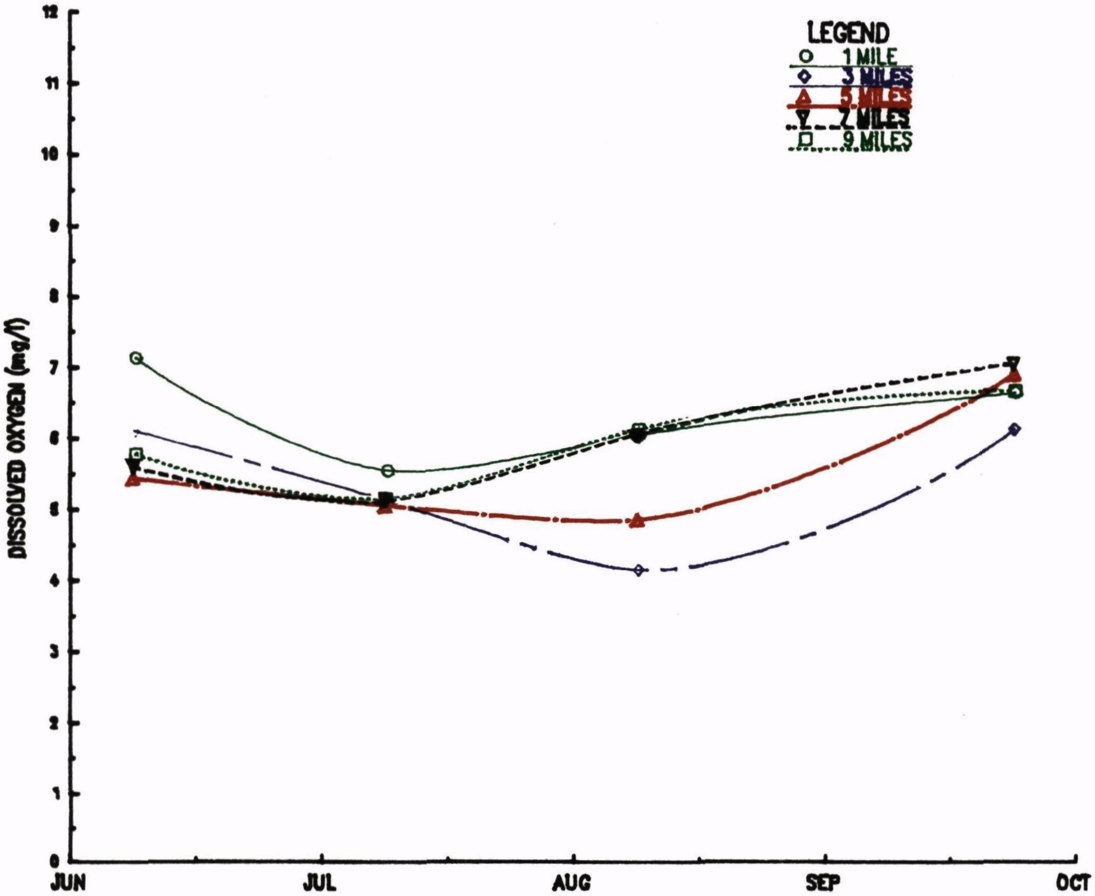


SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1984
SEMIMONTHLY AVERAGES OF ALL NORTHERN PERPENDICULAR STATIONS (JC14-JC53), AT FIXED DISTANCES FROM SHORE.

nearshore stations may be attributed to the influence of river runoff, treatment plant effluent, inlet dredged material disposal sites, and the Hudson Estuary system on the water along the New Jersey coast.

Figure 16 compares the shore to seaward distribution of dissolved oxygen values along the southern New Jersey perpendiculars. The dissolved oxygen values at all locations were 5.0 mg/l or greater on all sampling dates except at the stations 3 and 5 miles offshore in August, where the dissolved oxygen was approximately 4.3 mg/l, 3 miles offshore, and 4.9 mg/l, 5 miles offshore. All stations exhibited a slight decline from June to July. After July, dissolved oxygen increased at the stations 1, 7 and 9 miles off the coast thru August and September, with values between 6-7 mg/l. Dissolved oxygen values 5 miles offshore show little variation from June thru August, and then increased to 6.5 mg/l in September. The dissolved oxygen values 3 miles offshore slowly declined to an August minimum of 4.3 mg/l, then increased to 5.5 mg/l in September. The "double minima" which has occurred at some stations in previous years is not evident in Figure 16.

FIGURE 16



SHORE–TO–SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1984
SEMIMONTHLY AVERAGES OF ALL SOUTHERN PERPENDICULAR STATIONS (JC61–JC85), AT FIXED DISTANCES FROM SHORE.

Dissolved Oxygen Trends

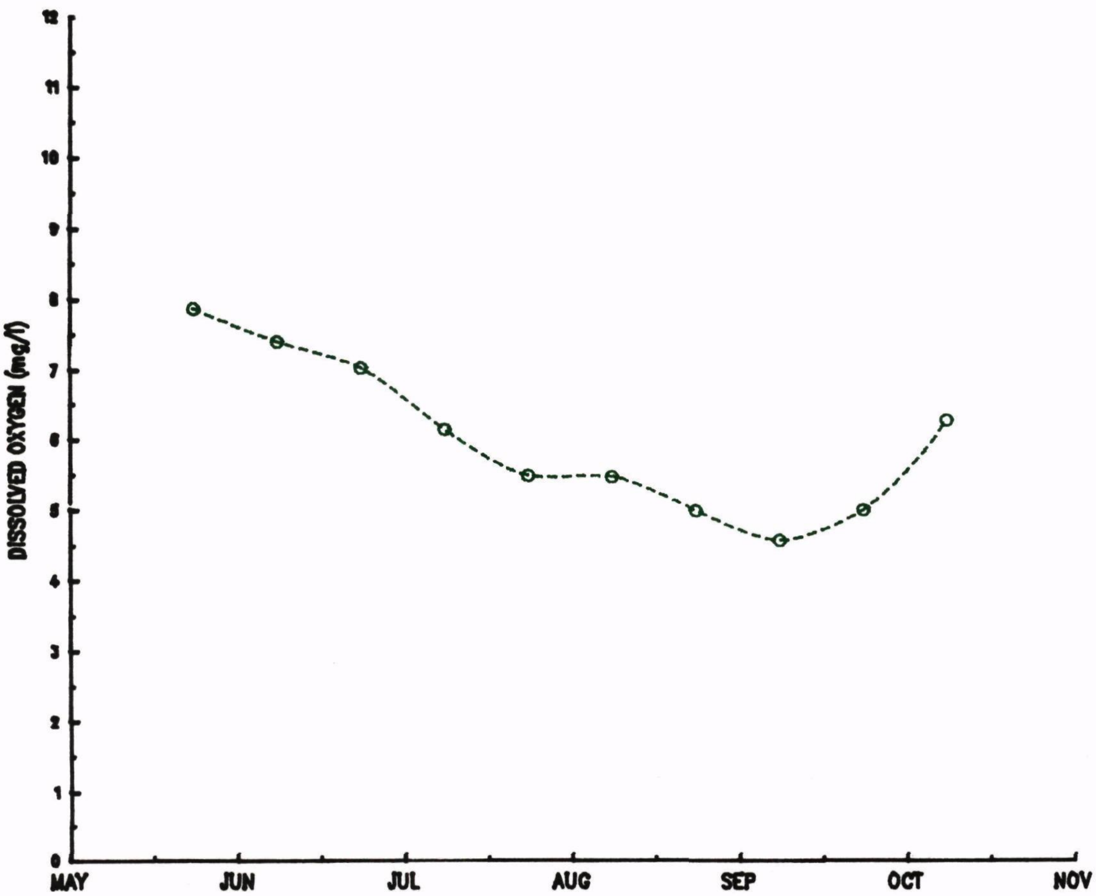
Figure 17 shows the five year average, made up of the arithmetic mean of all semimonthly averages, for the northern New Jersey perpendicular stations. The dissolved oxygen starts off at approximately 8 mg/l in late May and drops at a fairly constant rate to approximately 5.5 mg/l in late July. It remains at 5.5 mg/l until mid-August when it begins dropping to a low of 4.5 mg/l in early September. Throughout the remainder of September and into October the dissolved oxygen begins to recover, rising quite rapidly in October.

Figure 18 shows the five year average, made up of the arithmetic mean of all semimonthly averages, for the southern New Jersey perpendicular stations. The dissolved oxygen starts off in June at approximately 7.0 mg/l and increases slightly to 7.5 mg/l in late June. At this point it drops fairly rapidly to about 5.5 mg/l in early July. It remains between 5.0 - 5.5 mg/l until late August when it drops to about 4.5 mg/l in early September. It rises steadily through September and into October.

Figures 19, 20 and 21 illustrate the five year trends in dissolved oxygen for northern New Jersey perpendiculars, southern New Jersey perpendiculars and New York Bight Stations, respectively.

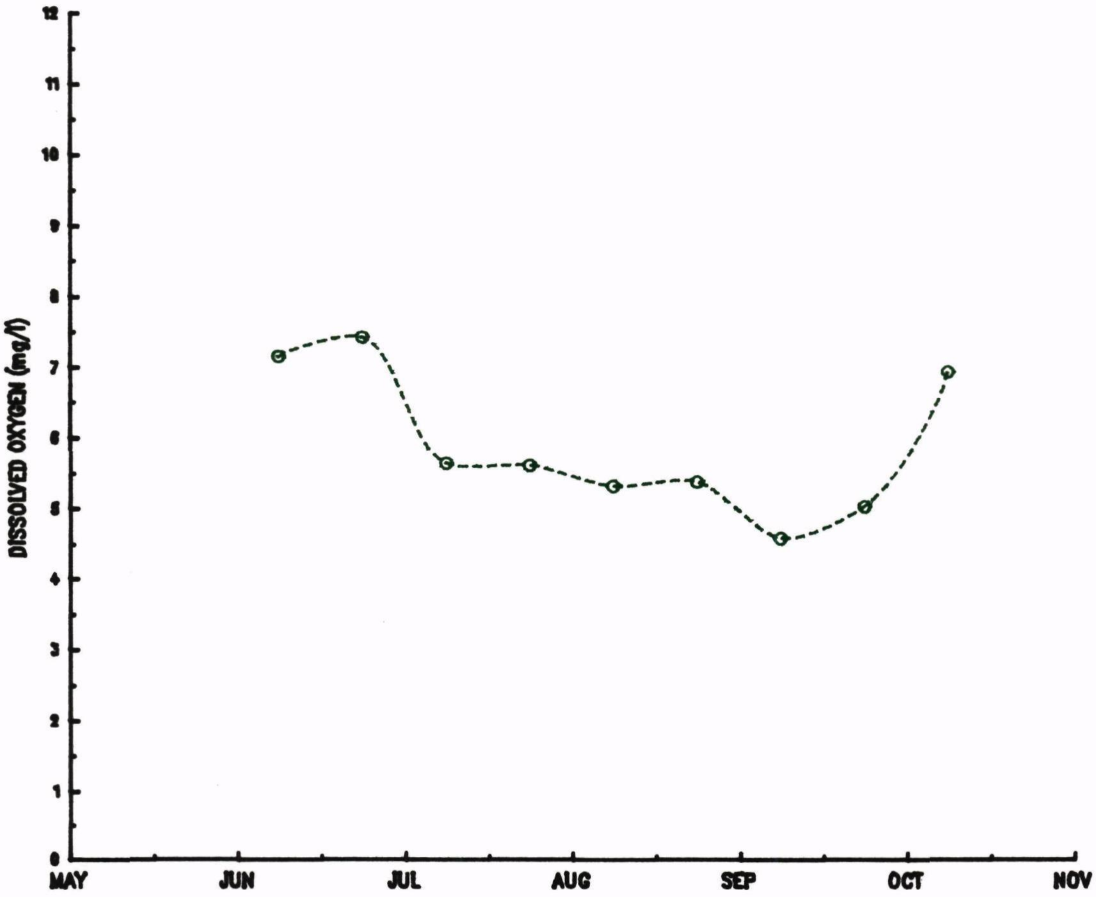
Figure 19 shows a dissolved oxygen "double minima" occurring in 1980 and 1983 with an initial low occurring in late July, followed by a small recovery and then a second low in early to mid-September. In 1981 and 1982 there was one low occurrence each, in early August 1981 and early September 1982. In 1984, a minimum in dissolved oxygen was reached in early July, followed by recovery in mid-July, with little variation during August and September.

FIGURE 17



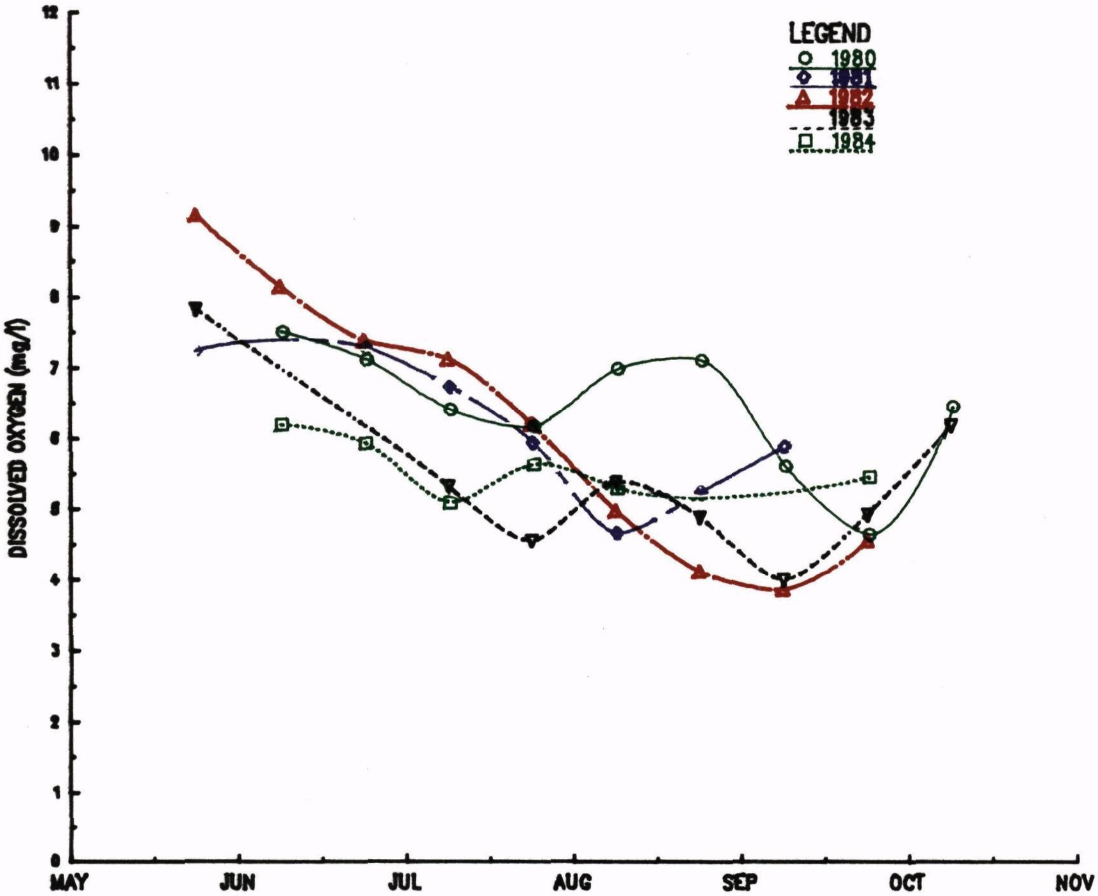
NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1980 TO 1984

FIGURE 18



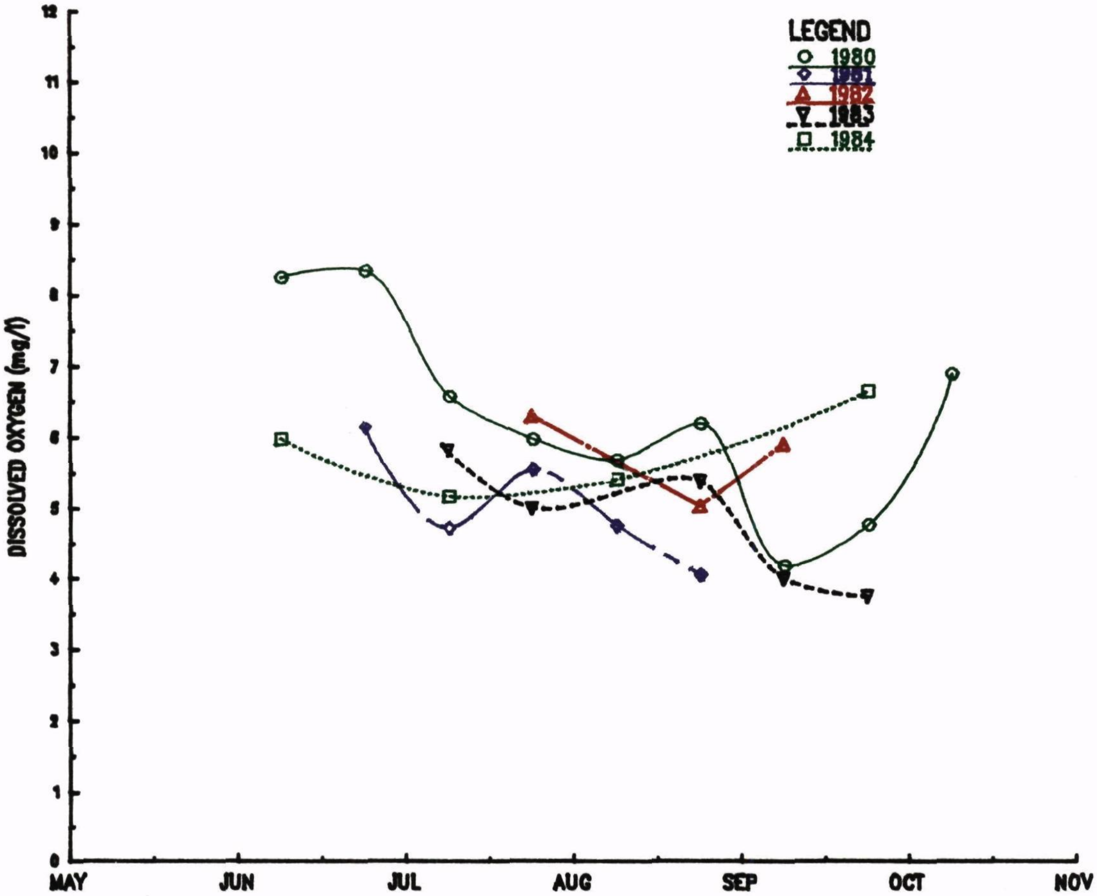
SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1980 TO 1984

FIGURE 19



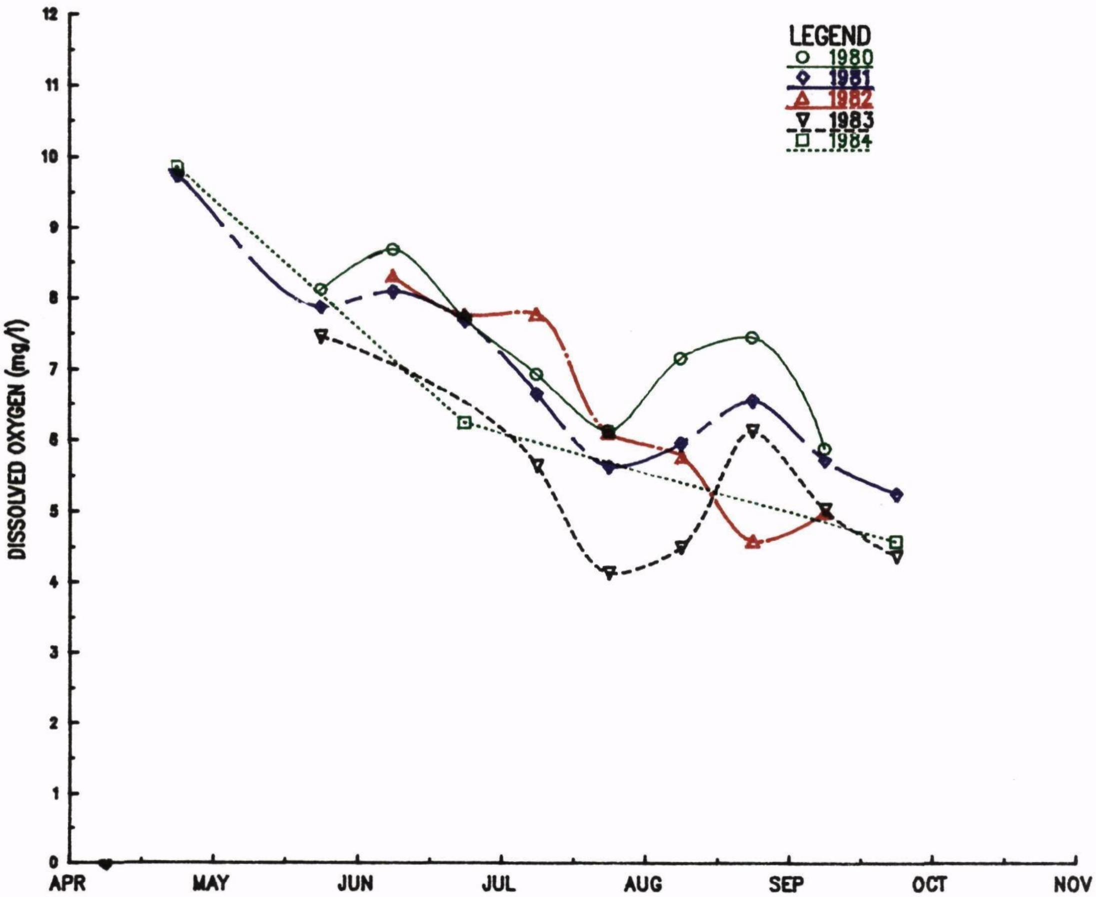
NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1980–1984 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC14–JC53 PERPENDICULAR STATIONS.

FIGURE 20



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1980–1984 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC61–JC85 PERPENDICULAR STATIONS.

FIGURE 21



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1980–1984 COMPARISON.
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

In 1984, along the southern New Jersey perpendiculars (Figure 20), the average dissolved oxygen started at about 6.0 mg/l in early June and dropped to about 5.5 mg/l in early July. It then slowly increased to 6.5 mg/l in late September. Figure 20 shows no obvious trends over the years.

In Figure 21 a comparison of all New York Bight stations is shown for the years 1980-1984. In 1984 dissolved oxygen concentrations were approximately 9.8 mg/l in late April, dropped to about 6.2 mg/l in mid-June and further declined to an average of 4.5 mg/l in late September. Fall recovery was not documented. The "double minima" which is evident for 1980, 1981, and 1983 was not observed during 1984, probably due to the reduced number of samples collected in 1984.

V. BACTERIOLOGICAL RESULTS

New Jersey

Table 8 presents a summary of the fecal coliform data collected along the coast of New Jersey between April 10, 1984 and September 10, 1984. The geometric mean for each station is plotted in Figure 22. The State standard for primary contact recreation along the New Jersey Coast is a geometric mean of 50 fecal coliforms/100 ml based on five or more samples analyzed within a 30 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 highest geometric mean, 2.5, is at station JC 99 at Cape May Point. Stations JC 97 at Cape May and JC 85 at Strathmere have geometric means of 2.4 and 2.3, respectively. All of the geometric means are very low. Figure 22 clearly 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.

Throughout the summer sampling period, a total of 419 samples were collected for fecal coliform analysis along the New Jersey Coast. None of the densities were above 50 fecal coliforms/100 ml.

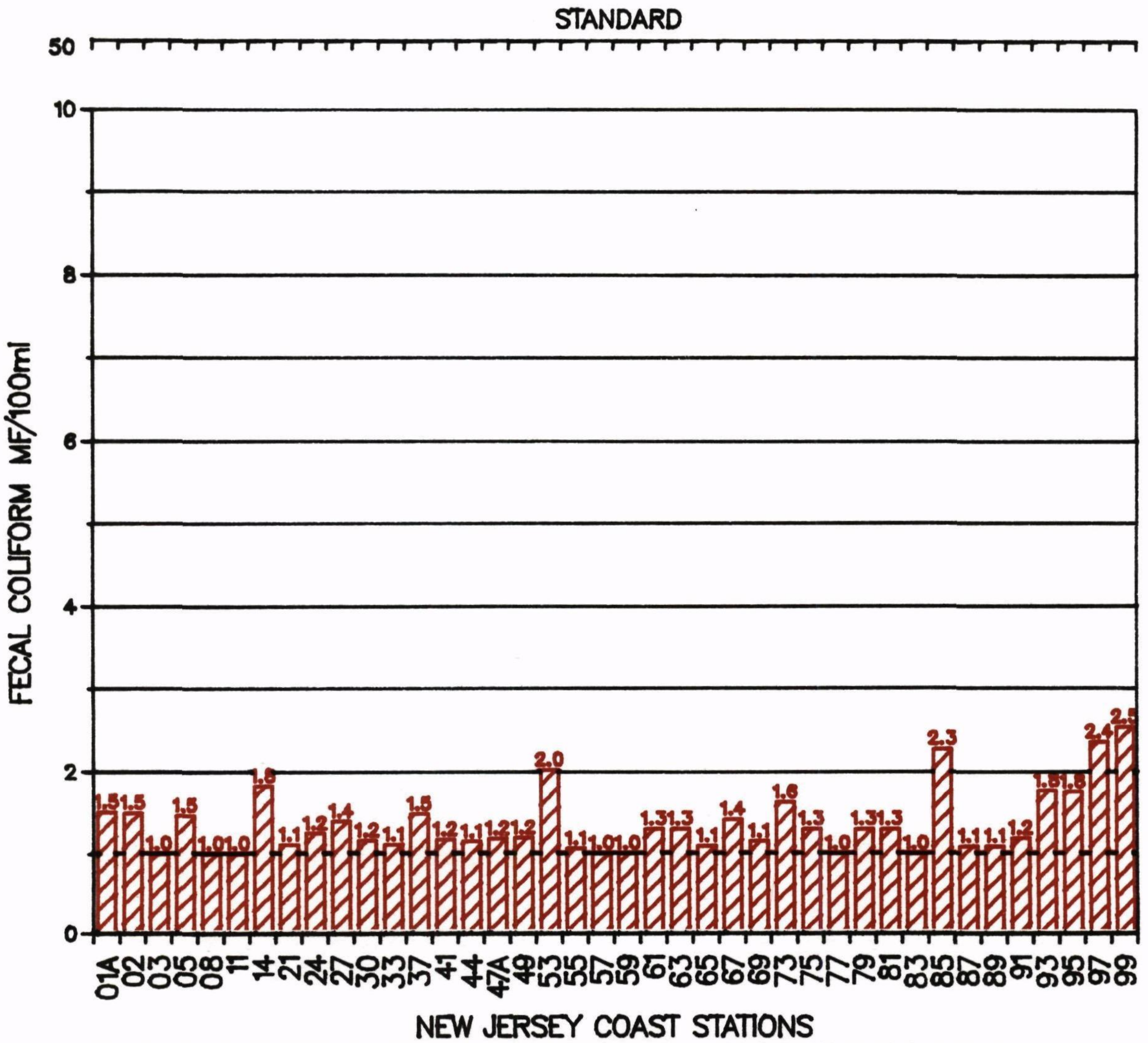
TABLE 8

Summary of bacteriological data
collected along the New Jersey coast
April 10, 1984 through September 10, 1984

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean* Fecal Coliform/100 ml
JC01A	13	7	1.5
JC02	13	6	1.5
JC03	13	1	1.0
JC05	13	9	1.5
JC08	13	1	1.0
JC11	13	1	1.0
JC14	13	11	1.8
JC21	13	4	1.1
JC24	13	3	1.2
JC27	13	11	1.4
JC30	13	7	1.2
JC33	13	4	1.1
JC37	13	7	1.5
JC41	13	4	1.2
JC44	13	3	1.1
JC47A	13	3	1.2
JC49	13	5	1.2
JC53	13	17	2.0
JC55	12	2	1.1
JC57	12	0	1.0
JC59	8	1	1.0
JC61	8	4	1.3
JC63	8	4	1.3
JC65	8	2	1.1
JC67	8	4	1.4
JC69	8	3	1.1
JC73	8	4	1.6
JC75	8	4	1.3
JC77	8	1	1.0
JC79	8	4	1.3
JC81	8	8	1.3
JC83	8	0	1.0
JC85	8	22	2.3
JC87	8	2	1.1
JC89	8	2	1.1
JC91	8	4	1.2
JC93	8	24	1.8
JC95	8	30	1.8
JC97	8	13	2.4
JC99	8	10	2.5

*Geometric means were calculated using the natural log.

FIGURE 22



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF NEW JERSEY, APR 10, 1984 TO SEP 10, 1984.
(ACTUAL VALUES PRINTED ABOVE BARS)

Long Island

Table 9 presents a summary of the fecal coliform data collected along the coast of Long Island from April 9, 1984 through September 13, 1984. The geometric mean for each station is plotted in Figure 23. 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. Only seven samples were collected all summer at stations LIC 17-28, therefore this portion of the graph represents a geometric mean of only seven data points at each station. 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 is 2.5, which occurred at station LIC 10. Station LIC 10 also had the highest geometric mean in 1980, 1981, 1982, and 1983. LIC 10 is under the direct influence of any poorly treated sewage that may flow out of Jones Inlet. From Figure 30, it is apparent that the standard is not approached. Based on bacteriological data, the New York coastal waters along Long Island are of excellent quality.

A total of 221 samples were collected during the summer along the coast of Long Island and analyzed for fecal coliform bacteria. The highest density found all summer, 16 fecal coliforms/100 ml, was at station LIC 10. This value is well below the State standard.

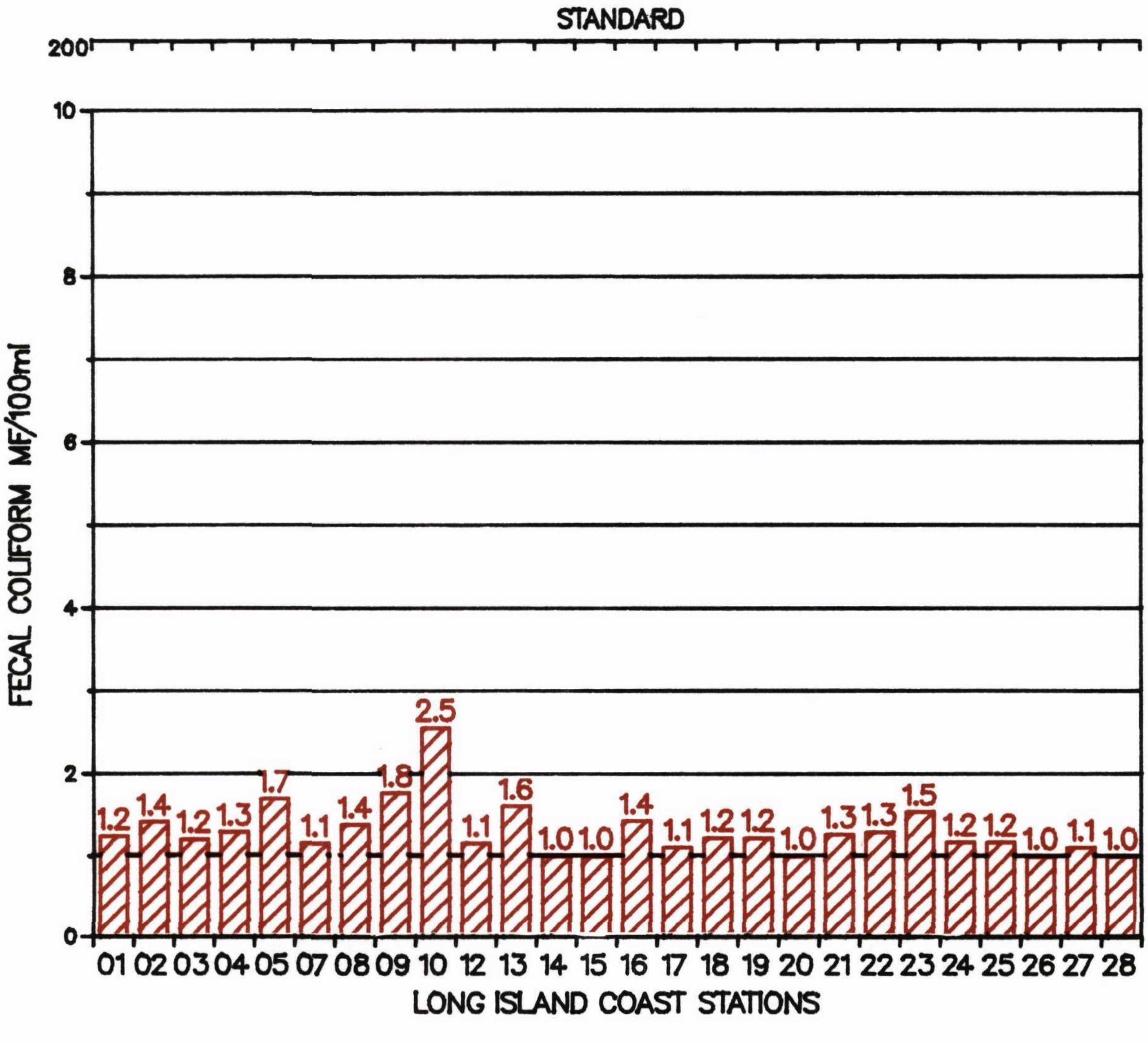
TABLE 9

Summary of bacteriological data collected along the coast of Long Island April 9, 1984 through September 13, 1984

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean* Fecal Coliform/100 ml
LIC01	10	4	1.2
LIC02	10	5	1.4
LIC03	10	6	1.2
LIC04	10	4	1.3
LIC05	10	8	1.7
LIC07	10	2	1.1
LIC08	10	4	1.4
LIC09	10	4	1.8
LIC10	10	16	2.5
LIC12	10	4	1.1
LIC13	10	14	1.6
LIC14	10	1	1.0
LIC15	8	1	1.0
LIC16	9	6	1.4
LIC17	7	2	1.1
LIC18	7	4	1.2
LIC19	7	4	1.2
LIC20	7	1	1.0
LIC21	7	5	1.3
LIC22	7	3	1.3
LIC23	7	10	1.5
LIC24	7	3	1.2
LIC25	7	3	1.2
LIC26	7	0	1.0
LIC27	7	2	1.1
LIC28	7	0	1.0

*Geometric means were calculated using the natural log.

FIGURE 23



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF LONG ISLAND, APR 9, 1984 TO SEP 13, 1984.
(ACTUAL VALUES PRINTED ABOVE BARS)

New York Bight Apex

During the summer of 1984 a total of 232 samples were collected in the inner New York Bight for fecal coliform analysis. The stations sampled were the 20 inner NYB series stations, the LIC 09 and LIC 14 perpendicular stations, and the JC 14 and JC 27 perpendicular stations. Of the 232 samples collected, one had a fecal coliform density in excess of 50 fecal coliforms/100 ml. This represents 0.4 percent of the samples. There is no fecal coliform standard for the New York Bight Apex waters. The value of 50 fecal coliforms/100 ml was chosen for use in comparison with previous years. In 1979, 1980, 1981, 1982 and 1983 the percentage of samples having densities above 50/100 ml was 2.3, 0.4, 0.7, 2.1 and 0.9, respectively. The one high value found this past summer was a surface sample collected at NYB 32 on June 20, which had 70 fecal coliforms/100ml.

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

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APPENDIX A

SUMMARY OF
PHYTOPLANKTON DYNAMICS
AND BLOOM INCIDENCE
IN NEW JERSEY COASTAL WATERS
1984

New Jersey Department of Environmental
Protection
Division of Water Resources
Bureau of Monitoring and Data Management
Biological Services Unit

SYNOPSIS

Weekly during the summer, the NJDEP monitors the development and extent of marine phytoplankton blooms historically responsible for the recurrence of red tides in New Jersey's northern shore waters. Samples are routinely collected by the USEPA, Region II, helicopter surveillance unit as part of their New York Bight Water Quality Monitoring Program (Figure 1). Samples are analyzed in accordance with standardized procedures (see previous reports) by the DEP Division of Water Resources' Biological Unit. Although the red tides off New Jersey are not the acutely toxic variety, such as occur in New England, concern exists over resources as well as public health.

At least since 1968, several different phytoflagellate species, most notably *Olisthodiscus luteus* and *Prorocentrum micans*, have been responsible for red tides. During the last few years, blooms of *O. luteus* in the Sandy Hook vicinity have been less prominent than in the past. In 1983, a bloom of *P. micans* in the Belmar vicinity was reminiscent of more extensive blooms of that species in 1968 and 1972, which were associated with superficial irritation and respiratory discomfort to bathers. Frequently, extensive blooms, not producing conspicuous water coloration, have been more evident when the algae decompose and wash onto the beach as an unaesthetic, flocculent mass strongly resembling sewage. Although red tides vary in color, 1984 featured the first extensive "green tide" on record, caused by another dinoflagellate (*Gymnodinium* sp.). The green tide was unusual in that it was most extensive south of our routine sampling area (to Cape May County); but it was far more widespread, being reported from Long Island, New York, to Delaware, and it persisted from mid-August to mid-September.

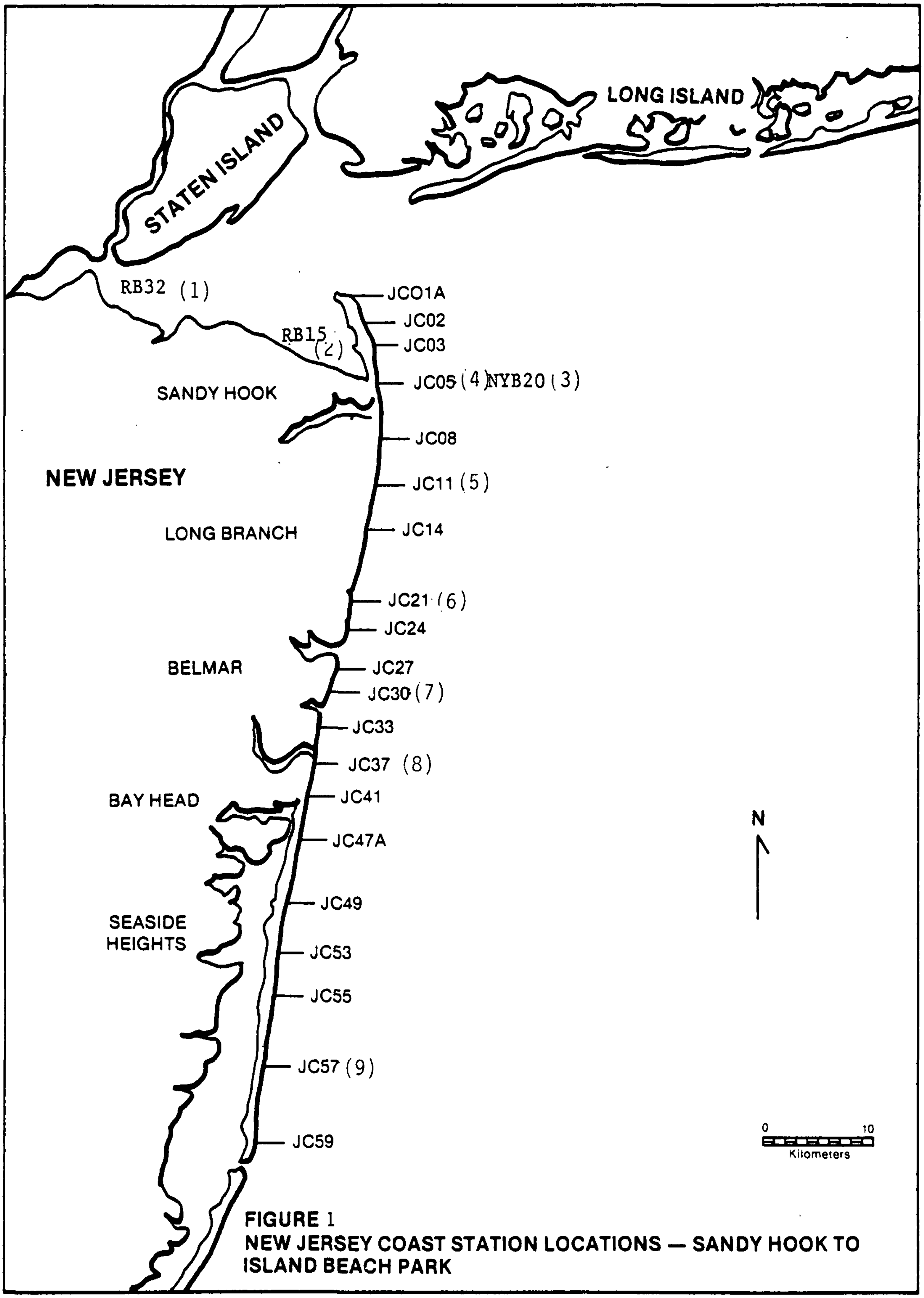

FIGURE 1
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

Numbers in parentheses indicate stations where phytoplankton samples are taken.

1984 Highlights

Phytoplankton species' densities are summarized in Tables I and II. Results of nutrient analyses are presented in Table III and other significant events in Table IV.

Diatoms annually form the largest component of the overall phytoplanton community, usually with peak densities occurring in early spring "flowerings". Since routine sampling commences in late May or early June, population peaks of certain species normally abundant, such as *Asterionella glacialis* and *Thalassionema nitzschioides*, are unrepresented in the data. However, other diatom species normally abundant in these waters maintained periods of dominance intermittently throughout the summer (Table II).

In waters adjacent to Sandy Hook, *Thalassiosira nordenskioldii* dominated the plankton in mid-June followed by *Cyclotella* sp., a similar form. In stations south of Sandy Hook, *T. gravida* was dominant from late June to early July. In July, *Skeletonema costatum* became dominant from Sandy Hook to Manasquan. In early August a substantial diatom bloom occurred, including *S. costatum*, *T. gravida*, *Cerataulina pelagica* and *Chaetoceros* sp., along most of Monmouth County (Table II). This greater than usual abundance of diatoms in summer is attributable to certain weather and hydrographic patterns sustaining relatively cool inshore water temperatures through the period.

Periods of abundance of other species overlapped that of the diatoms. In early June, following a rapid but brief warming trend, the dominance of small chlorophytes (*Chlorella* ? and *Nannochloris* sp.) was noted with highest concentrations in Sandy Hook Bay. During June, several phytoflagellate species, along with *Nannochloris*, typically became abundant especially in stations from JC 11 north (Table II). A corresponding red tide was observed from the EPA helicopter on June 21 (Table IV). In early to mid-July, *Nannochloris* and *Cholorella* sp. bloomed again in Sandy Hook Bay and adjacent stations, while numbers of other species were somewhat reduced.

A data gap in routine sampling occurred from July 17 to August 1, however, a few incidents of discolored water were independently reported from July 17 to 23 in the Sandy Hook to Long Branch sector. The number of abundant phytoflagellate species increased again during the August diatom bloom. From mid to late August, inshore water temperatures increased considerably, while another gap in routine sampling occurred from August 10 to September 6.

Through August the number of events reported independently of routine sampling increased significantly. During the first two weeks, several instances of tainted water, often with deposits on the beach, were reported from Long Branch to Belmar (Table IV). From August 4 to 9, Belmar beaches were temporarily closed due to "unaesthetic" conditions. Some of these occurrences may have been associated with the diatom bloom ongoing the second week in August. Surf samples taken by the Monmouth County Health Department during this period revealed an abundance of diatoms in some samples as well as an isolated bloom of *Olisthodiscus luteus*, a species which has been responsible for past red tides. On August 19 (as reported to the

TABLE 1

Major phytoplankton species found in the 1984 survey. Those seasonally dominant (+) often attained cell densities greater than 1000/ml (10,000 for *Nannochloris* sp.). Other species (-) appeared frequently but usually in lower numbers. Those with no designation appeared only occasionally.

Diatoms (Bacillariophyceae)

Leptocylindrus danicus
Skeletonema costatum (+)
Cyclotella sp. (+)
Thalassiosira sp.
T. nordenskioldii (+)
T. gravida (+)
Coscinodiscus sp.
Biddulphia sp.
Eucampia zoodiacus (-)
Certaulina pelagica (+)
Chaetoceros sp. (-)
Rhizosolenia sp.
Guinardia flaccida
Asterionella glacialis (-)
Thalassionema nitzschioides
Cocconeis sp.
Navicula sp.
Nitzschia seriata
Phaeodactylum tricornutum
Cylindrotheca closterium (-)

Dinoflagellates (Dinophyceae)

Prorocentrum micans (-)
P. minimum (+)
Amphidinium fusiforme
Gymnodinium sp. (+)
G. amplinucleum
G. danicans
G. nelsoni
Gyrodinium sp.
G. estuariale
G. uncatenum
Katodinium rotundatum (+)
Heterocapsa triquetra (-)
Oblea rotunda
Diplopsalis lenticula
Peridinium sp.
P. excavatum
P. trochoideum
Gonyaulax sp.
G. scrippsae
Ceratium minutum

Other Phytoflagellates (Chrysophyceae, Haptophyceae, Prasinophyceae, Euglenophyceae, Cryptophycea)

Ochromonas sp.
Olisthodiscus luteus (+)
Calycomonas gracilis (-)
C. ovalis (-)
Ebria tripartita
Chrysochromulina sp.
Pavlova sp.
Bipedinimonas sp (-)
Pyramimonas sp. (-)
P. grossii (-)
P. micron
Tetraselmis sp.
Eutreptia sp.
E. lanowii (-)
E. viridis (-)
Euglena sp.
E. proxima
Chroomonas sp. (-)
Rhodomonas minuta (+)
R. amphioxiea (+)
Cryptomonas sp.

Chlorophytes (Chlorophyceae)

Chlamydomonas vectensis
Chlorella sp. (+)
Ankistrodesmus convolutus
Nannochloris sp.
N. atomus (+)

TABLE II

Succession of dominant phytoplankton species in 1984. Dominance (+) was attained when cell counts of a particular species exceeded 10^3/ml (10^4 for Nannochloris sp.); sub-dominance (-) was noted when cell densities approached but did not exceed 10^3/ml. Blooms (*) became apparent when cell counts greater than 10^4/ml (10^5 for Nannochloris) produced visible water coloration.

		SAMPLING LOCATION[a]								
Date	Species	1	2	3	4	5	6	7	8	9
June										
12	Skeletonema costatum	+								
	Thalassiosira nordenskioldii			-	+		-		-	
	Cerataulina pelagica				+		+			
	Olisthodiscus luteus		+	-						
	Chlorella sp.		*	+						
	Nannochloris sp.	+	+	-					-	
21	T. nordenskioldii		+	+	*		-	+		-
	C. pelagica		+	-				-		-
	Chaetoceros sp.				+	+	+			
	Prorocentrum minimum		+	-	-	-	-	-		
	Katodinium rotundatum	-	+							
	Heterocapsa triquetra		+	-	-					
	Olisthodiscus luteus	+	+		-	-	-		-	-
	Rhodomonas minuta	+	+	-	+		-	-		
	Nannochloris sp.	+	+	+	+	+	-		+	
26	Cyclotella sp.	+	-	*	+				-	
	Thalassiosira gravida		+		+	+	+	+	-	
	C. pelagica		+	-	-	-	-	-	-	
	P. minimum		-	+	+	+	-	+		
	Peridinium trochoideum				+	-				
	O. luteus					+				
	Euglena / Eutreptia sp.	-	-	+	-		+	+	-	
	Pyramimonas sp.		-	+	+		-	-	+	-
	Nannochloris sp.	+	+	+	+	+	-	+	-	

TABLE II (Continued)

Date	Species	SAMPLING LOCATION[a]								
		1	2	3	4	5	6	7	8	9
July 5	*T. gravida*			-	+	-	-	+	-	
	Euglena / *Eutreptia* sp.		+	-					-	
	Rhodomonas sp.	+	+	-	-	+				
	Nannochloris sp.	+	*	+	+	-	-	+	+	-
12	*S. costatum*					+	*	+	+	
	T. gravida									+
	Chaetoceros sp.						+	-		
	Nitzschia seriata			+	+	-				
	Chlorella sp.	-	*		-					
	Nannochloris sp.	+	*	-	-	-				
17	*S. costatum*			+	+	+	+			
	Chaetoceros sp.		+					+		
	Calycomonas gracilis	-	+		+					
	Chroomonas / *Rhodomonas* sp.	+		-	+		-		-	-
	Nannochloris sp.	+	+	+	+	+	-	-	-	-
August 1	*S. costatum*		-		+	+	+			
	O. luteus				-	-				
	Chlorella sp.		+		+	-		-	-	
	Nannochloris sp.		+		+	+	-		-	
10	*S. costatum*			*	*	*	+	*	*	
	T. gravida	+	+	*	+	*		-	+	
	C. pelagica		+	+	-		-	-		
	Chaetoceros sp.		+	+		*			+	
	Prorocentrum micans			-						-
	Peridinium trochoideum	+				-				
	Gymnodinium sp.			-	+			-	-	-
	Nannochloris sp.	+	+	+	+	+	+	+	-	-

TABLE II (Continued)

Date	Species	SAMPLING LOCATION[a]								
		1	2	3	4	5	6	7	8	9
Sept.										
6	*Leptocylindrus danicus*						+	+		
	C. pelagica			+				-		-
	Cylindrotheca closterium	+			-					
	P. micans		-	-			-			
	Gymnodinium sp. "G"[b]		+	-	+	+	*	+	+	-
	O. luteus	-	-	-	-					
	Nannochloris sp.	+	+	+	+	-		-		
10	*Cyclotella* sp.	+	+							
	S. costatum	+			+					
	T. gravida	+	+		-					
	C. pelaqica			-	-	-				
	Gymnodinium sp. "G"			+	+	*	+	-	+	*
	Nannochloris sp.	+	+	-				-		

a) See Figure 1.

b) This species was responsible for widespread "green tides" extending southward from our routine sampling area.

TABLE III

NUTRIENT DATA FOR THE 1984 RED TIDE SURVEY

$NH_3 + NH_4$ / $NO_2 + NO_3$ (mg/l)

Sampling Location

DATE	1	2	3	4	5	6	7	8	9
June 12	.03/.06	.62/.28	.08/.06	.05/.05	.09/.04	.10/.04	.11/.03	.11/.03	.08/.03
21	.04/.06	.73/.29	.07/.11	.16/.07	.55/.05	.05/.03	.03/.01	.05/<.01	.04/.02
26	.06/<.01	1.08/.28	.07/.01	.07/.01	.09/.01	.10/.02	.08/<.01	.09/.02	.08/.01
July 05	.09/.12	.24/.22	.09/.10	.06/.04	.05/.03	.08/.04	.08/.03	.07/.03	.09/.03
12	.03/.29	.62/.29	.23/.13	.18/.13	.18/.09	.14/.05	.17/.04	.25/.05	.25/.03
17	.37/.21	.62/.27	.17/.12	.27/.17	.16/.02	.11/< .02	.14/<.02	.16/.03	.16/.03
Aug 01	.23/.12	--	--	.06/.06	.02/.09	.08/.03	.05/.02	.04/<.02	--
Sept 06	.31/-	.79/-	.26/-	.16/-	.23/-	.09/-	.09/-	.22/-	.07/-
10	.23/.21	.61/.38	.03/.09	.02/.09	.03/.09	.15/.09	.11/.09	.05/.09	.04/.09

TABLE IV

Blooms and Similar Events Reported Independently of Routine Sampling in 1984

DATE	LOCATION	OBSERVATION	NOTE
April			
19	Seaside Heights	stringy, greenish-brown floating material in surf, resembling sewage	followed northeast storm
June			
A rapid but brief warming trend occurred early in the month.			
21	Raritan and Sandy Hook Bay, ocean to Sea Bright	red tide (seen from EPA Helicopter)	phytoflagellate and diatom bloom
July			
2	Long Branch	patches of murky water in surf	mixture of flagellates and diatoms
5	Belmar to Sea Girt	patches of murky water in surf	mixture of flagellates and diatoms
Water temperatures erratic (mostly cool) the past month; much rainfall.			
17	Sandy Hook to Long Branch	water cloudy	detritus & Nannochloris sp. (moderate bloom)
19	Keansburg (Raritan Bay)	red tide	unconfirmed
20	Sandy Hook Bay	sea cabbage (Ulva) washed up on shore	Ulva killed by heat and sunlight at low tide
23	Horseshoe Cove (Sandy Hook Bay)	dead bunker in bay and cove	dead fish from pound nets
23	Sea Bright	brown foam in surf	brought in by onshore winds at high tide
20-26	Harvey Cedars	seaweed ("smelly") at sea wall	unconfirmed
31	Seaside Park	junk on beach throughout	cleaned up by beach patrol
August			
1	Long Branch	brown, green and white foamy substance in surf	phytoflagellate bloom
2	Long Branch	yellowish water to ½ mile out	Olisthodiscus sp + diatoms abundant in sample

TABLE IV (Continued)

DATE	LOCATION	OBSERVATION	NOTE
<u>August</u>			
4-9	Belmar and Manasquan	oily and foamy solid substance on beach; "unaesthetic" conditions come and go	Belmar beaches temporarily closed
15	Asbury Park	oily condition in surf	bloom remnants
16	Shark River Inlet	possible red tide over several square miles to one mile out	unconfirmed
15-16	Harvey Cedars	"green water" in surf, dead mussels on beach	green floc settling out in samples
16-17	Harvey Cedars to Surf City, Atlantic City-Absecon Island Ocean City - 5th to 12th Sts.	green tide densest in these areas to one-half mile out	<u>Gymnodinium</u> sp. bloom(s); cells settle out in slimy mass, shrivel up when preserved (ocean outfalls in each area)
18-20	Beach Haven, Sea Isle City to Avalon	green tide along shore	same species as above, dissipated somewhat after storm on 8/19
19	Manasquan (two miles off)	subsurface slime found by a diver	remnants of <u>O. luteus</u>/diatom bloom
22	Bay Head (two miles off)	dissolved O_2 low on bottom (0.46 ppm at 22 meters)	same vicinity as above bloom
23	Long Branch to Allenhurst	"green slime" covering 5-mile stretch (seen by a party boat)	same (<u>Gymnodinium</u>) species as in southern area
25-26	Belmar to Sea Girt (to 2 miles off)	intermittent patches (20x50 yds) of brilliant green water	seen by fishermen in a boat
26	Little Egg Inlet	small patch of "pink water"	ctenophores (½ mile out)
27	Lavalette to Beach Haven	patches of green water along beach (EPA helicopter)	densest off Ship Bottom, smaller patches north of Lavalette.
29	Mantoloking to Island Beach	brown water in surf	bloom remnants + diatoms in sample
Inshore water temperatures quite warm ($\leq 75^{\circ}F$) during this period.			
<u>Sept</u>			
1	Vicinity of Little Egg Inlet	water brownish in morning, bright green in afternoon (½ mile off Little Beach)	sky clear, bright sun (greenish color extended into Great Bay)
3	Rehobeth, Delaware and Belmar, NJ	green tide (beginning around Labor Day)	caused irritation to at least one bather

TABLE IV (Continued)

DATE	LOCATION	OBSERVATION	NOTE
Sept.			
6	Southern Monmouth County to Long Beach Island	green tide (seen from EPA helicopter)	not as dense as last week
10	Shark River	some green water off inlet (EPA helicopter)	other areas clear
13	Beach Haven to Atlantic City	green tide (seen by fishermen)	densest off Brigantine (to 3 miles out)
18	Long Island (Nassau County)	green tide continuing in this area	same species as in N.J.
Oct.			
12-14	Manasquan to Belmar	green slime washing in	bloom remnants; rough seas caused by Hurricane Josephine

National Marine Fisheries Service at Sandy Hook) subsurface slime, apparently remnant of a bloom, was found by a diver two miles off Manasquan. This was further evident in low dissolved oxygen levels found in the same vicinity on August 22.

From August 15-17, in an apparently separate event south of the routine sampling area, "green" water was reported, first from Long Beach Island, then from the Atlantic City and Ocean City areas (Table IV). Densest patches were apparently from Harvey Cedars to Surf City extending one-half mile out, with some "dead mussels and green slime on the beach", Atlantic City to Margate, and Fifth to Twelfth Streets in Ocean City. Samples were gathered with the aid of the Bureau of Shellfish Control and the Atlantic and Cape May County health agencies. On August 18-20, reports of green tide continued, including Beach Haven and Sea Isle City to Avalon. The species involved was an unarmored dinoflagellate, *Gymnodinium* sp., with yellow green chromatophores. Species identification was tentative, the cells preserved poorly, and dead cells readily settled out of the samples in gelatinous masses.

From August 23 to August 26, green water appeared to the north, within our routine sampling area, in intermittent patches between Long Branch and Belmar. On August 27, from the EPA helicopter, it was observed in patches southward again from Lavalette to Beach Haven, with the densest concentration off Ship Bottom. The green water was dissipated somewhat by local storm activity; however, it reappeared again primarily in the area from Beach Haven to Brigantine, to three miles out, and persisted sporadically until mid-September. From Labor Day to September 18, other reports of green water, with a few complaints by bathers of irritation, were received from Rehoboth, Delaware to Long Island, New York. The same species was apparently involved in all cases of green tide.

EVALUATION

Red tides caused by phytoflagellate blooms have been documented in annual occurrence in Lower New York Bay and adjacent New Jersey estuarine and coastal waters for over twenty years. The NJDEP has formally monitored phytoplankton dynamics and bloom development since 1974 (see previous reports). In recent years some of the most dramatic events have featured *Olisthodiscus luteus* (lately classified as a chloromonad), while dinoflagellate species such as *Katodinium rotundatum* and *Prorocentrum* sp. have been present in abundance as well as several others. Most of the blooms have been benign in nature; however, blooms of *P. micans* in Monmouth County were associated with respiratory discomfort and superficial irritation to bathers, particulary in 1968, but also in 1972 and 1983. Fortunately, *Gonyaulax tamarensis*, the species responsible for paralytic shellfish poisoning (PSP) in New England, has not been detected to any significant degree in New Jersey waters.

Nutrients for algal growth are normally in ample supply in these waters, especially in the estuarine complex. Since nitrogen is generally considered limiting in marine environments, attention is focused on these inorganic forms. Table III shows that ammonia and nitrate concentrations are at environmentally significant levels at most stations throughout the sampling period with the highest values in the estuary. Red tides occur when environmental factors (e.g. temperatures, sunlight, winds) are optimal for algal growth. Ammonia often becomes a more available nutrient source than nitrate, since both are assimilated by phytoplankton but the ammonia is replenished at a faster rate. Concentrations of both tend to decrease south from the Sandy Hook area. Due to the hypertrophic condition of these waters, other substances such as metals, organics and certain trace materials may have major roles in stimulating or inhibiting algal growth; therefore, further study is needed to determine the role of substances other than inorganic nitrogen and phosphorus.

Hydrographic patterns in and near the estuary tend to concentrate nutrients and phytoplankton along the south shore into Sandy Hook Bay and, from there, into adjacent ocean waters. Since bay waters warm more rapidly than the ocean, most of the earliest blooms occur in this section. Dense red tides of *O. luteus* and several associated species often form here in June, washing around the Hook with the estuarine plume and, due to Coriolis forces, curling back in toward the beach a few miles southward. From 1982 to 1984, these red tides were not as prominent as in previous years. The Hudson River plume, usually with peak discharge following that of the Raritan, also follows a trajectory southward along the New Jersey shore. Blooms are often seen in the ocean along northern Monmouth County following those originating in Sandy Hook Bay. Hydrographically, the effect of the Hudson Raritan estuary can often be seen as far south as northern Ocean County, especially with northerly winds. Conversely, easterly or southerly winds may cause an onshore drift or counter drift along the shore.

Summer blooms along the ocean front, such as that of *P. micans* in southern Monmouth County, apparently occur separately from those in the estuary. Additional sources of dissolved nutrients in ocean sewage outfalls, or the ocean dump site twelve miles off Sandy Hook, can sustain these blooms. Moderate onshore winds, typical of summer, tend to cause concentrations at or near the shoreline, giving rise to bathers' complaints in the event of a bloom.

Some blooms, which may or may not produce conspicuous water coloration, as well as visible red tides, often become more evident after the blooms cease and the algae die and settle. A gelatinous matrix around each decomposing cell may cause formation of a flocculent mass with an outwardly slimy or stringy quality. This is illustrated in the subsurface slime found by a diver on August 19 off Manasquan Inlet (Table IV). Phytoplankton concentrations that can be substantial enough to produce such a mass, as well as visible red tides, indicated by cell counts of several thousand per ml are often found in these waters (Table II). This unaesthetic material can be driven onshore by breezes or inwelling bottom currents and deposited in spots along the beach by wave action. The combined result of these processes is a sight and smell strongly resembling sewage or other decomposing organic matter. It is a condition which every summer gives rise to myriad complaints, and which may also be responsible for oxygen depletion in bottom waters at certain locations.

While red tides vary in color from yellowish to deep red or brown, 1984 saw the first extensive green tide on New Jersey's records (Table IV). Pale green water previously observed has been caused by blooms of minute chlorophytes, such as *Nannochloris* sp., in Raritan and Sandy Hook Bays; however, the 1984 event, centering off southern New Jersey, was caused by the dinoflagellate *Gymnodinium* sp. Other incidents of bright green water have been recorded in recent years, but they have been more transient and localized. On at least one such occasion, the species involved was possibly mis-identified as *G. splendens*. In samples not maintained at *in-situ* conditions, the unarmored cells readily settled out and became rounded from their original form, while standard preservatives, such as Lugols solution, caused the cells to shrivel up. In samples with very dense cell concentrations, a flocculent green mass formed at the bottom of the container.

In New Jersey, the major green tide blooms apparently originated, and were most extensive and persistent, south of the area routinely monitored for red tides. Their extent and duration surpassed that of recent red tides. The first reports were received from Long Beach Island to Cape May County around August 16 (Table IV). A week later it was seen to the north as far as Long Branch, but apparently in smaller patches. It was densest within one-half mile of the beaches, but patches were seen as far out as three miles. Between Beach Haven and Atlantic City, green tide persisted until the middle of September, at times continuous to three miles off Brigantine.

South of Barnegat Inlet, hydrography is less under the influence of the Hudson/Raritan estuary, with nutrient source less concentrated than in the northern areas. However, in the southern area, several smaller inlets, as well as Delaware Bay, discharge land and marsh drainage into the ocean. Also, regional sewage outfalls have been established in the ocean at Long Beach Island, Atlantic City and Ocean City. With discharge volumes normally elevated in summer plus warm temperatures and southerly breezes causing concentrations onshore, a situation ideal for phytoplankton development occurs.

The substantial length of coastline over which the green tide appeared suggested the importance of other factors, in addition to local conditions, contributing to the bloom. The fact that green tide was less prevalent in our northern area suggested the presence of some factor(s) inhibitory to the species. Similar factors may also have caused decreased abundance of O. luteus as compared to other years. The green tide of 1984 was similar in extent, though not in total area, to the infamous Ceratium tripos bloom of 1976. However, Gymnodinium sp. covered a narrower band much closer to shore, and was more surficial being apparently less critical to depletion of bottom dissolved oxygen than C. tripos. A few reports of irritation to bathers or of fishkills were attributable to the green water; however, most bathers were probably discouraged due to its unaesthetic qualities. In view of this situation, it would seem that further study, in addition to the present monitoring efforts, is warranted.

APPENDIX B

MICROBIOLOGICAL WATER QUALITY

NEW YORK BIGHT

SUMMER 1984

INTRODUCTION

It was acknowledged even before the microbial etiology of disease was known, that water can serve as a medium for the transfer of disease. Early investigations have shown that agents of enteric disease (E. coli, Salmonella) are excreted in large numbers in the feces of ill individuals, and are therefore potentially present in their sewage and its receiving waters. Epidemiological studies have been used to assess incidence of illness with bathing in waters containing fecal contamination. Evidence exists that there is a relationship between bacterial water quality and transmission of certain infectious diseases (Cabelli, et al, 1980).

It is common practice to use an indicator organism to detect fecal contamination instead of pathogenic organisms. Elaborate procedures are usually required for the detection of most pathogens in mixed populations making them undesirable as a routine monitoring tool. When an indicator organism is present, it is assumed that pathogens may be present and the water may be potentially harmful.

In 1976, the US EPA recommended a fecal coliform bacterial guideline for primary contact recreational waters which was subsequently adopted by most of the states. Their recommendation states that fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreational waters. As determined by MPN or MF procedures and based on a minimum of not less than 5 samples taken over not more than a 30 day period, the fecal coliform content of primary contact recreational waters shall not exceed a log mean of 200/100ml nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml (Quality Criteria for Water, 1976).

The criteria was derived from data collected by the National Technical Advisory Committee (NTAC) who conducted studies on the Great Lakes (Michigan) and the Ohio River. These studies showed an epidemiological health effect at levels of 2300-2400 coliforms/100 ml. Further studies demonstrated that 18% of the total coliform population was comprised of fecal coliforms. This would indicate that detectable health effects may occur at a fecal coliform level of about 400/100 ml. The NTAC suggested that a detectable risk was not acceptable and proposed dividing the 400/100 ml in half. They also suggested that the quality of bathing water should not be above the detectable risk level more than 10% of the time during a 30 day period.

New York State, for its primary contact recreational coastal waters, has adopted the log mean of 200 FC/100 ml as its standard. New Jersey, on the other hand, chose to adopt more stringent limits. For their coastal primary contact recreational waters, a log mean of 50 FC/100 ml was established.

Fecal coliforms are defined as gram-negative, nonspore-forming rods that ferment lactose in 24$\pm$ 2 hours at 44.5 $\pm$ 0.2°C with the production of gas in the MPN method or produce acidity with blue colonies in the MF method. This group according to traditional thinking, more accurately reflects the presence of fecal discharges from warm-blooded animals. As indicators, the bacteria 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 groups.

For more detailed information about this bacterial group, please refer to the following references:

1. Standard Methods 15th ed., 909 C (F.C.)
2. Microbiological Methods for Monitoring the Environment, Water and Wastewater. EPA-600/8-78-017, Sect C, p 124.
3. Bergey's Manual of Determinative Bacteriology, 8th ed. 1974. p 290, Members of the Enterobacteriacae, p. 295, Escherichia coli.

As part of the annual monitoring of the coastal waters off the shores of Long Island and New Jersey, a study of the density of fecal coliforms was conducted in 1984. Monitoring at selected sites in the New York Bight was also conducted. Bacterial density in this study is defined as the number of bacteria belonging to the specific indicator group (fecal coliforms) per 100 ml of water.

MATERIALS AND METHODS

Marine water samples were collected by helicopter from April to September 1984. The samples were collected using a Kemmerer sampler, transferred to 500ml sterile, wide-mouth plastic containers, and then returned to Region II Edison laboratory for analysis.

Fecal coliform determinations were conducted according to the membrane filtration (MF) procedure described in Standard Methods, 15th ed., 1980 and Microbiological Methods for Monitoring the Environment, Water and Wastewater, EPA-600/8-78-017.

RESULTS AND DISCUSSION

Along the coasts of both New Jersey and Long Island there were no fecal coliform densities greater than 50/100ml observed during the survey time period (Tables 1 and 2). The geometric mean fecal coliform densities for the New Jersey stations were all less than 2.0 and for the Long Island stations less than 2.2. These fall well below the criteria set by the two states. Figures 1 and 2 graphically display the geometric mean values of FC densities for New Jersey and Long Island.

Of all the samples collected from the New York Bight only one was observed to be greater than 50/100 ml (Table 3). This was observed at station NYB-32. NYB-32 is at the mouth of the Raritan Bay (Figure 3). The geometric mean densities of FC found in the Bight are presented in Table 4.

EPA has recently published the results of two research projects which compared the relationships between illnesses associated with bathing waters and ambient densities of indicator bacteria (Cabelli, 1980 and DuFour, in press). One study was performed on marine water beaches and one on freshwater beaches. The results of these studies have caused EPA to reevaluate the current use of fecal coliforms as an indicator organism. The studies demonstrated that enterococci have a far better correlation with swimming associated illness both in marine and fresh waters than does fecal coliforms. New methodology has made it easier to detect this organism (Levin, et al, 1975). The studies also stated the E. coli, a specific bacterial species included in the fecal coliform group, has a correlation in fresh waters equal to the enterococcus, but does not correlate as well as in marine waters.

At the present, EPA is considering recommending these organisms for inclusion into state water quality standards for the protection of primary water contact recreation uses instead of fecal coliforms. This information was published in the Federal Register on May 24, 1984 and comments were requested. No new recommendations have been issued as of this date.

If one looks at the data generated in the above survey, one must start to question the reliability of the fecal coliform data especially with the current controversy over which indicator organism is the best choice. This is not to say the data isn't valid. It was generated according to the established procedures. It is recommended that a comparison study be performed at specific stations known to have some fecal contamination (around Raritan Bay) with the current and proposed indicator organisms (enterococcus, E. coli and fecal coliforms) be tested to determine the most reliable indicator organism.

RECOMMENDATIONS

In light of the probable change of the bacteriological criteria and the data generated from the New York Bight this year and in the past few years, it is recommended that a review of the frequency of sampling and the actual stations samples should be performed.

It appears that higher fecal coliform counts are usually detected at the first 20 stations along the New Jersey coast (JC01A-JC57) and the first 13 stations along the Long Island coast (LIC01-LIC15). It is recommended that these stations be sampled twice a week and the entire coasts twice a month.

With regard to the New York Bight sludge dumpsite stations, it is recommended that stations be established in the Christiensen Basin and the Upper Hudson Shelf Valley to track the potential movement of sewage sludge. The current sampling stations do not adequately cover this area since they were established to monitor movement of contaminants from the sludge dump site towards the New Jersey and Long Island coasts. These stations should be sampled weekly.

It is further recommended that sediment samples be collected monthly at the New York Bight stations. No sediment sampling has been conducted since the New York Bight survey conducted on the OSV antelope during the summer of 1982. Such monitoring is needed, possibly with the inclusion of analyses for Clostridia spores.

REFERENCES

1. Bergey's Manual of Determinative Bacteriology, 8th ed. (1974).

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3. DuFour, A.P. Health Effects Criteria for Fresh Recreational Waters. US EPA in press.

4. Levin, M.A., J. K. Fisher & V. J. Cabelli. Membrane Filter Technique for Enumeration of Enterococci in Marine Waters. APP MICRO. 30:66-71 (1975).

5. Standard Methods for the Examination of Water and Wastewater, 15th ed., American Public Health Association, Washington, D.C. (1980).

6. US Federal Register Vol 49, No. 102. May 24, 1984. Notices (1984).

7. US Environmental Protection Agency. Microbiological Methods for Monitoring the Environment, Water and Wastewater. EPA-600/8-78-017 (1978).

8. US Environmental Protection Agency. Quality Criteria for Water. EPA-440/9-76-023 (1976).

Table 1

GEOMETRIC MEANS OF BACTERIAL DENSITIES*
NEW JERSEY COAST STATIONS
SUMMER 1984

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	0.81406	0	7	13
2	JC02	0.88448	0	6	13
3	JC03	0.37701	0	1	13
4	JC05	0.87742	0	9	13
5	JC08	0.05076	0	1	14
6	JC11	0.11253	0	1	13
7	JC14	1.00821	0	11	13
8	JC21	0.40085	0	4	13
9	JC24	0.58050	0	3	13
10	JC27	0.49844	0	11	13
11	JC30	0.23773	0	7	13
12	JC33	0.25916	0	4	13
13	JC37	0.71615	0	7	13
14	JC41	0.29905	0	4	13
15	JC44	0.21064	0	3	13
16	JC47A	0.30551	0	3	13
17	JC49	0.31739	0	5	13
18	JC53	1.28637	0	17	13
19	JC55	0.09587	0	2	12
20	JC57	0.00000	0	0	12
21	JC59	0.09051	0	1	8
22	JC61	0.52982	0	4	8
23	JC63	0.40285	0	4	8
24	JC65	0.25103	0	2	8
25	JC67	0.77828	0	4	8
26	JC69	0.18921	0	3	8
27	JC73	0.78916	0	6	8
28	JC75	0.52982	0	4	8
29	JC77	0.41421	0	1	8
30	JC79	0.52982	0	4	8
31	JC81	0.56508	0	8	8
32	JC83	0.00000	0	0	8
33	JC85	1.53863	0	22	8
34	JC87	0.36426	0	2	8
35	JC89	0.25103	0	2	8
36	JC91	0.22284	0	4	8
37	JC93	1.34035	0	24	8
38	JC95	1.17238	0	30	8
39	JC97	1.85125	0	13	8
40	JC99	1.91964	0	10	8

* Geometric means calculated using log 10

Table 2

GEOMETRIC MEANS OF BACTERIAL DENSITIES *
LONG ISLAND COAST STATIONS
SUMMER 1984

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	0.40512	0	4	10
2	LIC02	0.53367	0	5	10
3	LIC03	0.60296	0	6	10
4	LIC04	0.54992	0	4	10
5	LIC05	1.04767	0	8	10
6	LIC07	0.33514	0	2	10
7	LIC08	0.85406	0	4	10
8	LIC09	1.50165	0	4	10
9	LIC10	2.18100	0	16	10
10	LIC12	0.17462	0	4	10
11	LIC13	0.71877	0	14	10
12	LIC14	0.23114	0	1	10
13	LIC15	0.09051	0	1	8
14	LIC16	0.71149	0	6	9
15	LIC17	0.16993	0	2	7
16	LIC18	0.25850	0	4	7
17	LIC19	0.38950	0	4	7
18	LIC20	0.10409	0	1	7
19	LIC21	0.29171	0	5	7
20	LIC22	0.42616	0	3	7
21	LIC23	0.81943	0	10	7
22	LIC24	0.48599	0	3	7
23	LIC25	0.21901	0	3	7
24	LIC26	0.00000	0	0	7
25	LIC27	0.29171	0	2	7
26	LIC28	0.00000	0	0	7

* Geometric means calculated using log 10

Table 3

BACTERIAL DENSITIES >50 PER 100 ML
NEW YORK BIGHT STATIONS
SUMMER 1984

OBS	STATION	DATE	DENSITY	DEPTH
1	NYB32	840620	70	S

Table 4

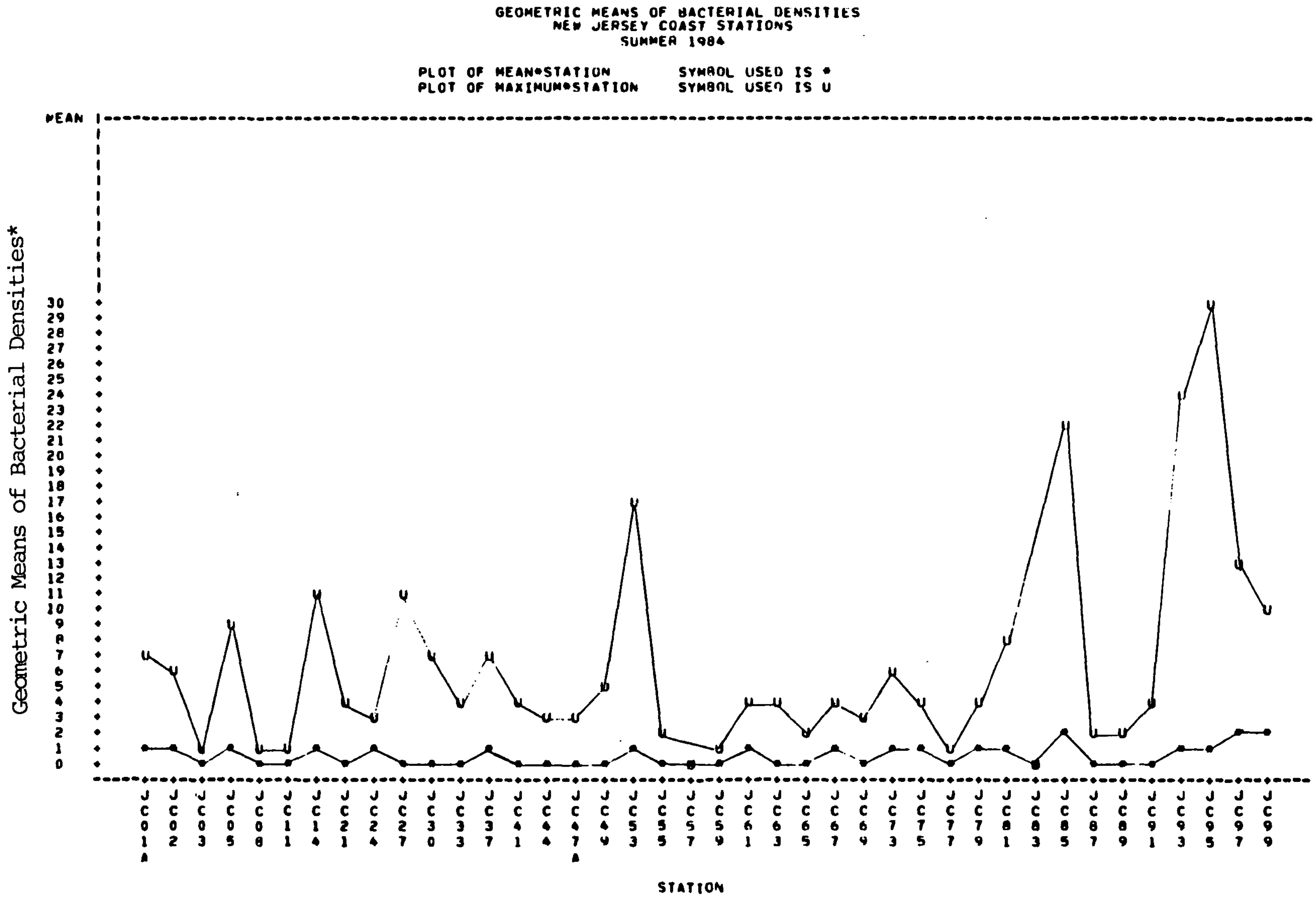
GEOMETRIC MEANS OF BACTERIAL DENSITIES *

NEW YORK BIGHT STATIONS
SUMMER 1984

OBS	DEPTH	STATION	MEAN	MINIMUM	MAXIMUM	N
1	B	NYB20	1.21336	0	5	4
2	B	NYB21	0.18921	0	1	4
3	B	NYB22	0.00000	0	0	4
4	B	NYB23	0.00000	0	0	4
5	B	NYB24	0.25992	0	1	3
6	B	NYB25	0.44225	0	2	3
7	B	NYB26	0.91293	0	6	3
8	B	NYB27	0.44225	0	2	3
9	B	NYB32	0.25992	0	1	3
10	B	NYB33	0.70998	0	4	3
11	B	NYB34	0.00000	0	0	3
12	B	NYB35	0.00000	0	0	3
13	B	NYB40	0.00000	0	0	3
14	B	NYB41	0.00000	0	0	3
15	B	NYB42	0.00000	0	0	3
16	B	NYB43	0.25992	0	1	3
17	B	NYB44	1.15443	0	4	3
18	B	NYB45	0.58740	0	3	3
19	B	NYB46	0.00000	0	0	3
20	B	NYB47	0.00000	0	0	3
21	S	NYB20	0.41421	0	3	4
22	S	NYB21	1.14070	0	6	4
23	S	NYB22	0.89883	0	12	4
24	S	NYB23	0.31607	0	2	4
25	S	NYB24	0.25992	0	1	3
26	S	NYB25	0.00000	0	0	3
27	S	NYB26	0.00000	0	0	3
28	S	NYB27	0.25992	0	1	3
29	S	NYB32	8.48011	0	70	3
30	S	NYB33	0.00000	0	0	3
31	S	NYB34	0.00000	0	0	3
32	S	NYB35	0.00000	0	0	3
33	S	NYB40	0.00000	0	0	3
34	S	NYB41	0.00000	0	0	3
35	S	NYB42	0.00000	0	0	3
36	S	NYB43	0.00000	0	0	3
37	S	NYB44	0.00000	0	0	3
38	S	NYB45	0.00000	0	0	3
39	S	NYB46	0.00000	0	0	3
40	S	NYB47	0.00000	0	0	3

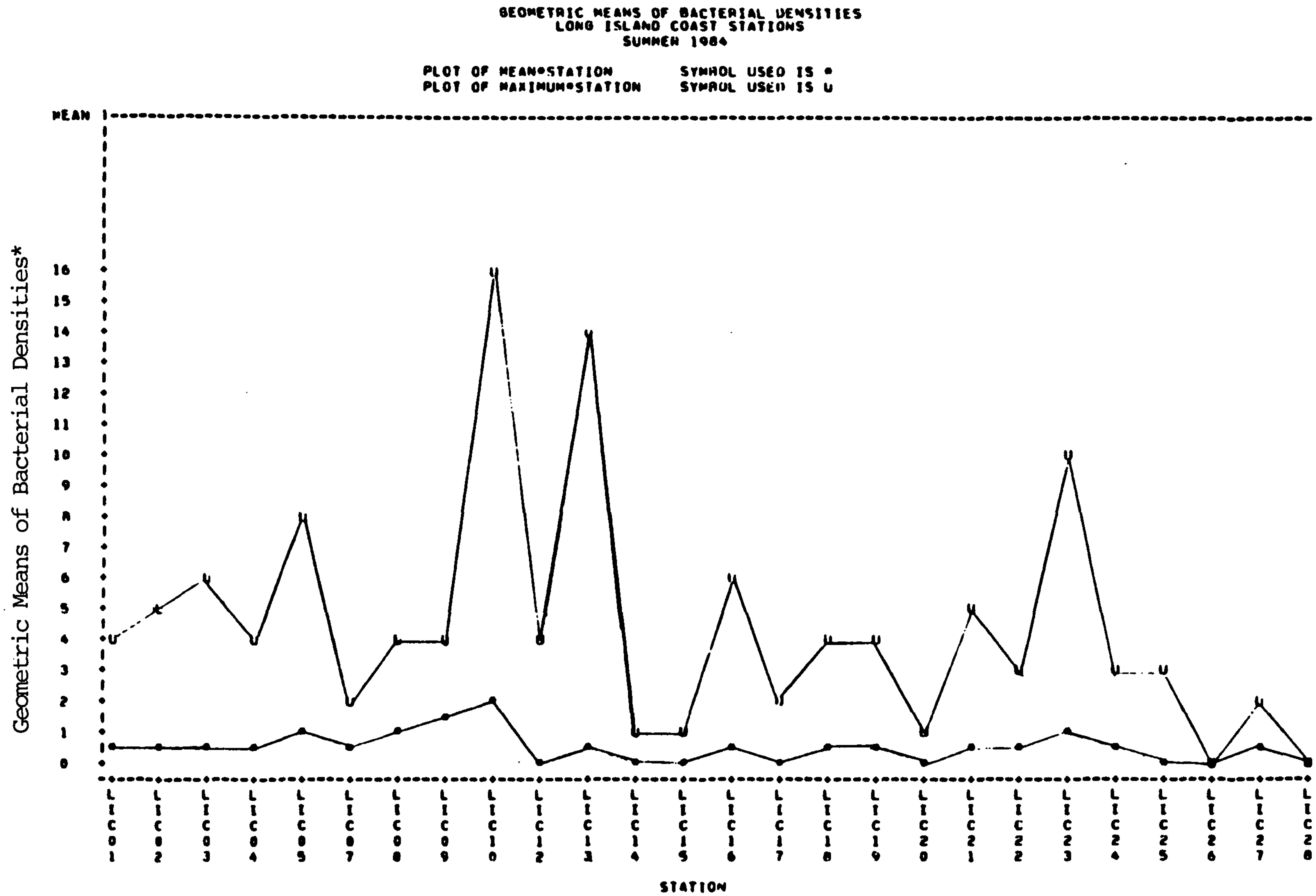
* Geometric means calculated using log 10

Figure 1



* Geometric means calculated using log 10

Figure 2



* Geometric means calculated using log 10

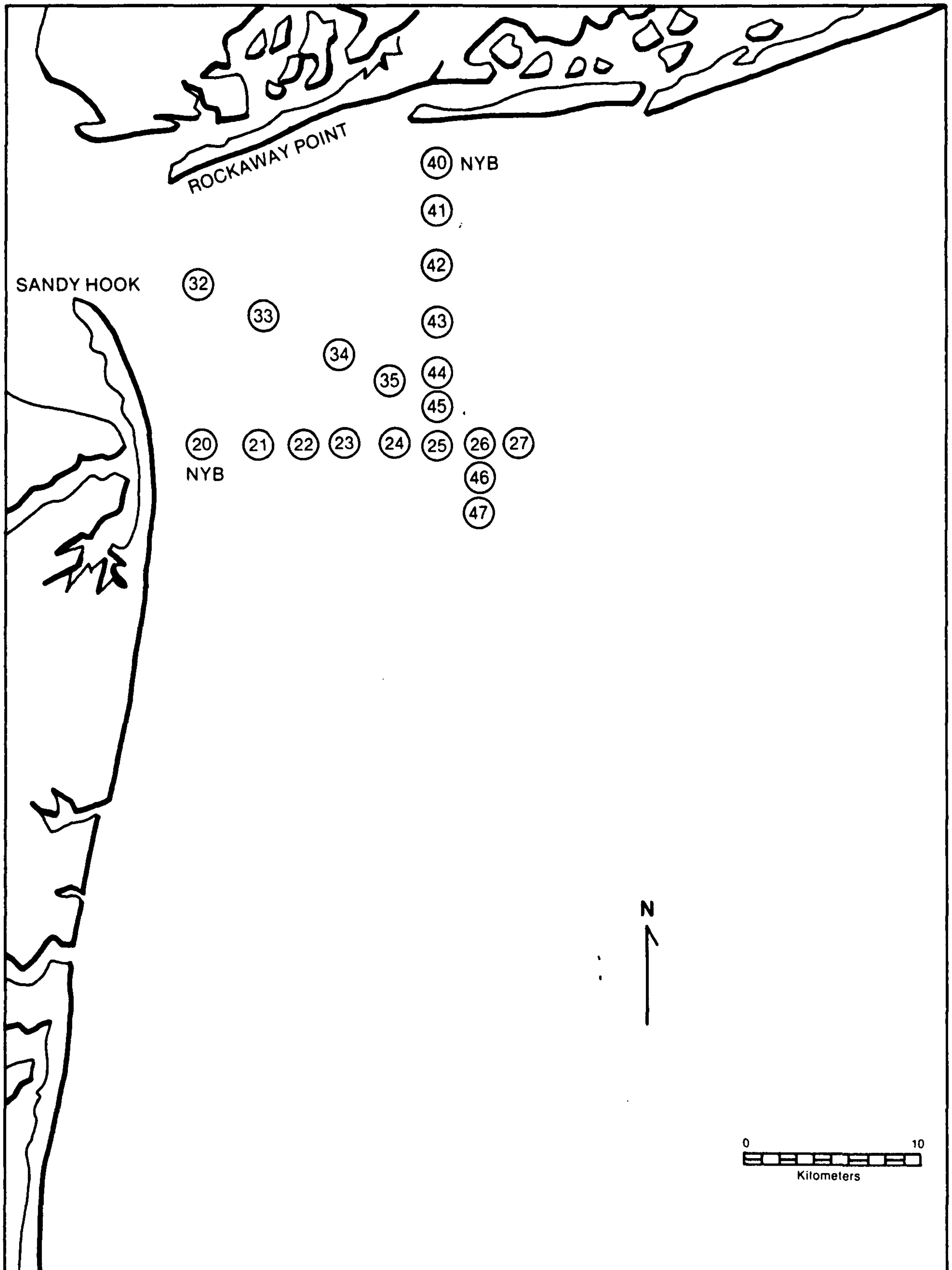


FIGURE 3
NEW YORK BIGHT STATION LOCATIONS

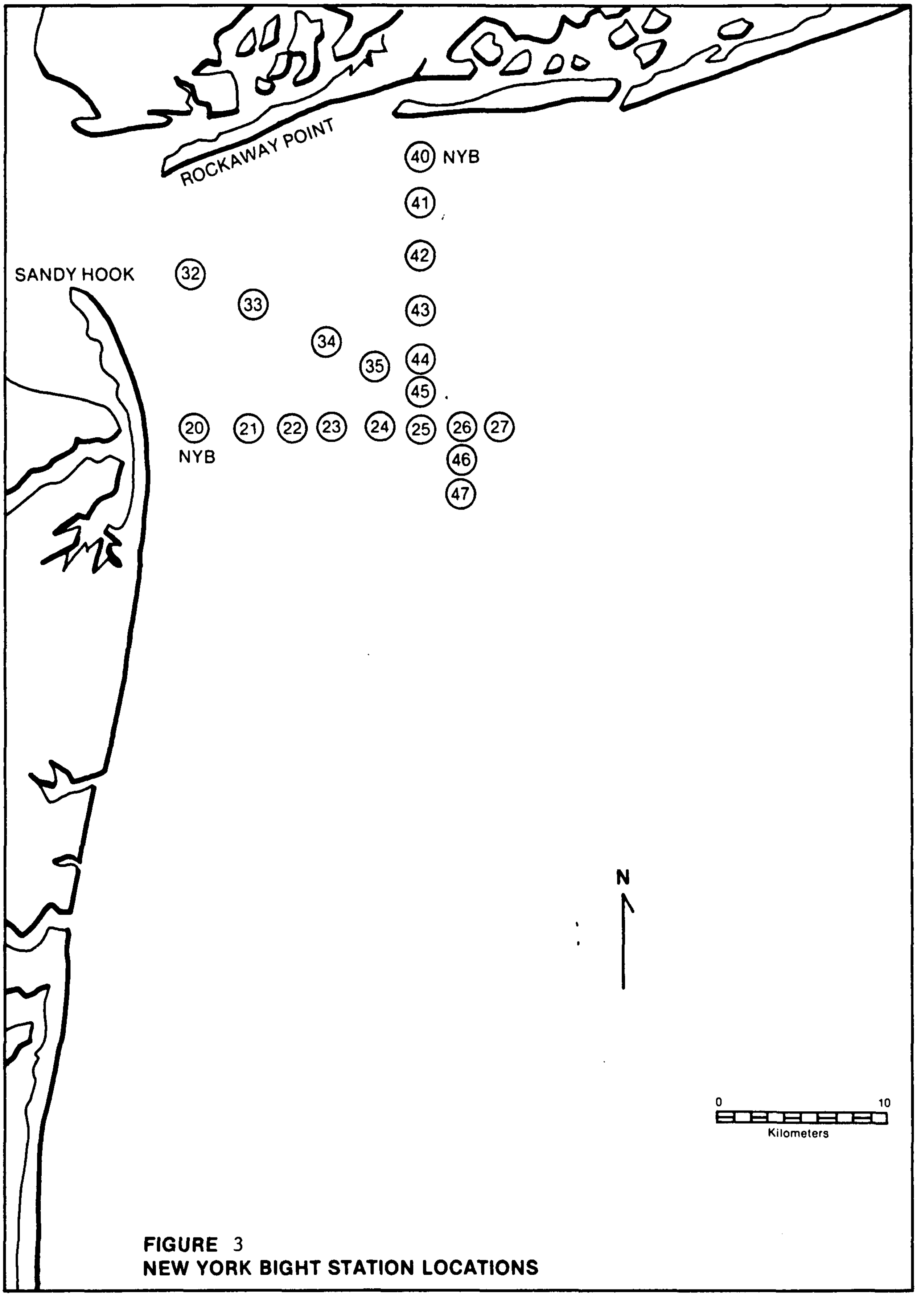


FIGURE 3
NEW YORK BIGHT STATION LOCATIONS