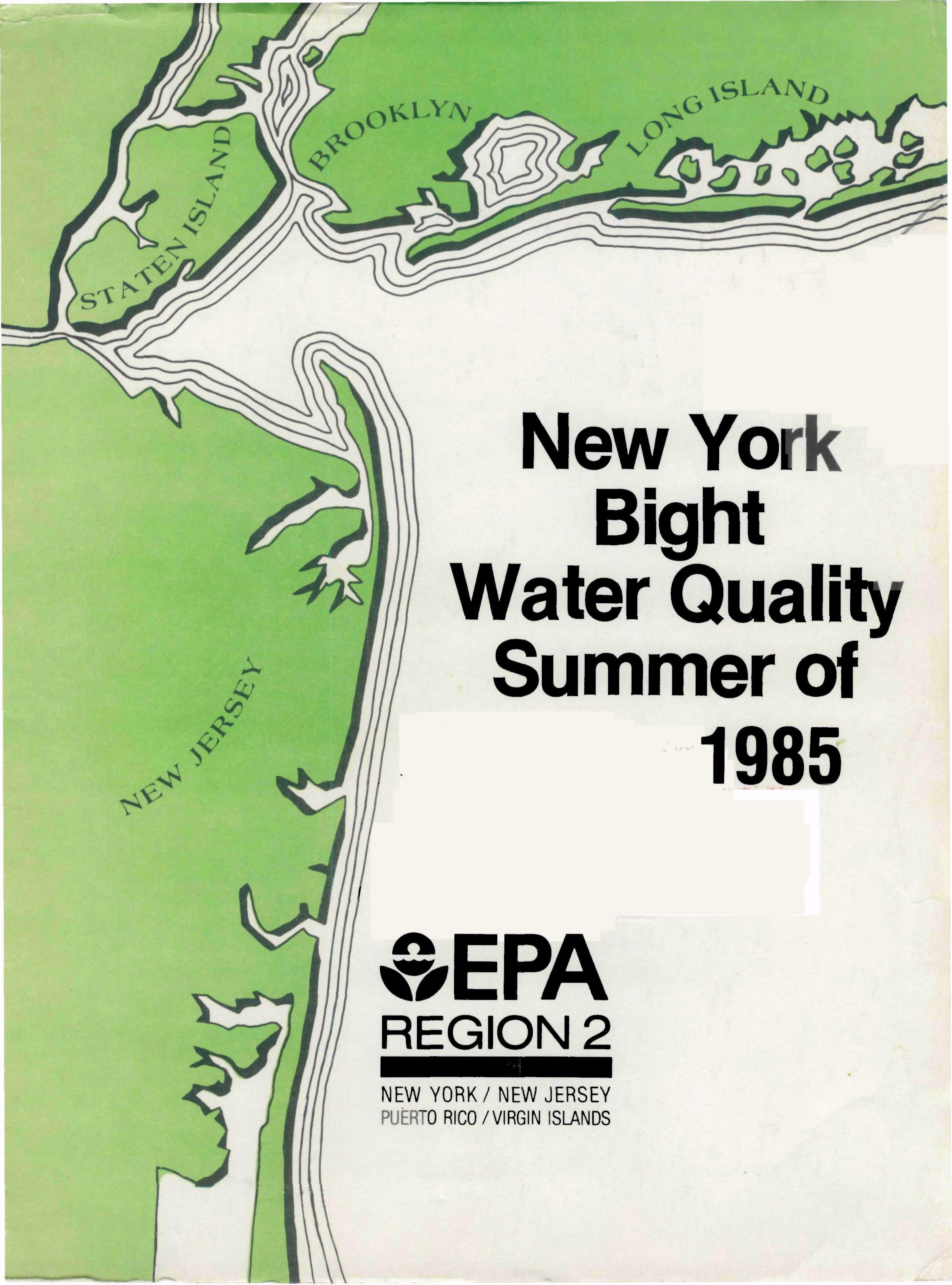

New York Bight Water Quality Summer of 1985

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

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1985

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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 1985 New York Bight Water Quality Monitoring Program. The monitoring program was conducted using the EPA helicopter for water quality sample collection. During the summer period of May 16 to October 17, 1985, approximately 140 stations were sampled each week, weather permitting. The Bight sampling program was conducted 5 days a week, 6 days a week in July and August, and consisted of five separate sampling networks.

Bacteriological data indicated that, generally, 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. However, on two occasions along the New Jersey coast county health officials closed bathing beaches in parts of Monmouth and Cape May Counties due to elevated fecal coliform densities. Enterococci densities exceeded EPA's criterion of 35 enterococci/100 ml only three times during the summer along the New Jersey coast and not at all along the Long Island coast.

Dissolved oxygen water quality was generally good along the Long Island coast. From mid to late summer stressful dissolved oxygen conditions were found at many of the New Jersey perpendicular stations and a few of the New York Bight Apex stations. These stressed conditions were the worst experienced since the anoxia of 1976. The depressed levels existed for extended periods (up to 2 months), and at times covered large areas (approximately 1600 square miles); however, no extensive fishkills were reported. As in previous years, the depressed dissolved oxygen levels

were temporary. 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 organic material and dead 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. The dissolved oxygen levels increased considerably in mid-September during periods of high winds, cold temperatures and local storms.

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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 twelfth in a series and reflects the monitoring period between May 16, 1985 and October 17, 1985. 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 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 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, to investigate the origins of these crises, and to direct any decisions regarding protection of the Bight's water quality.

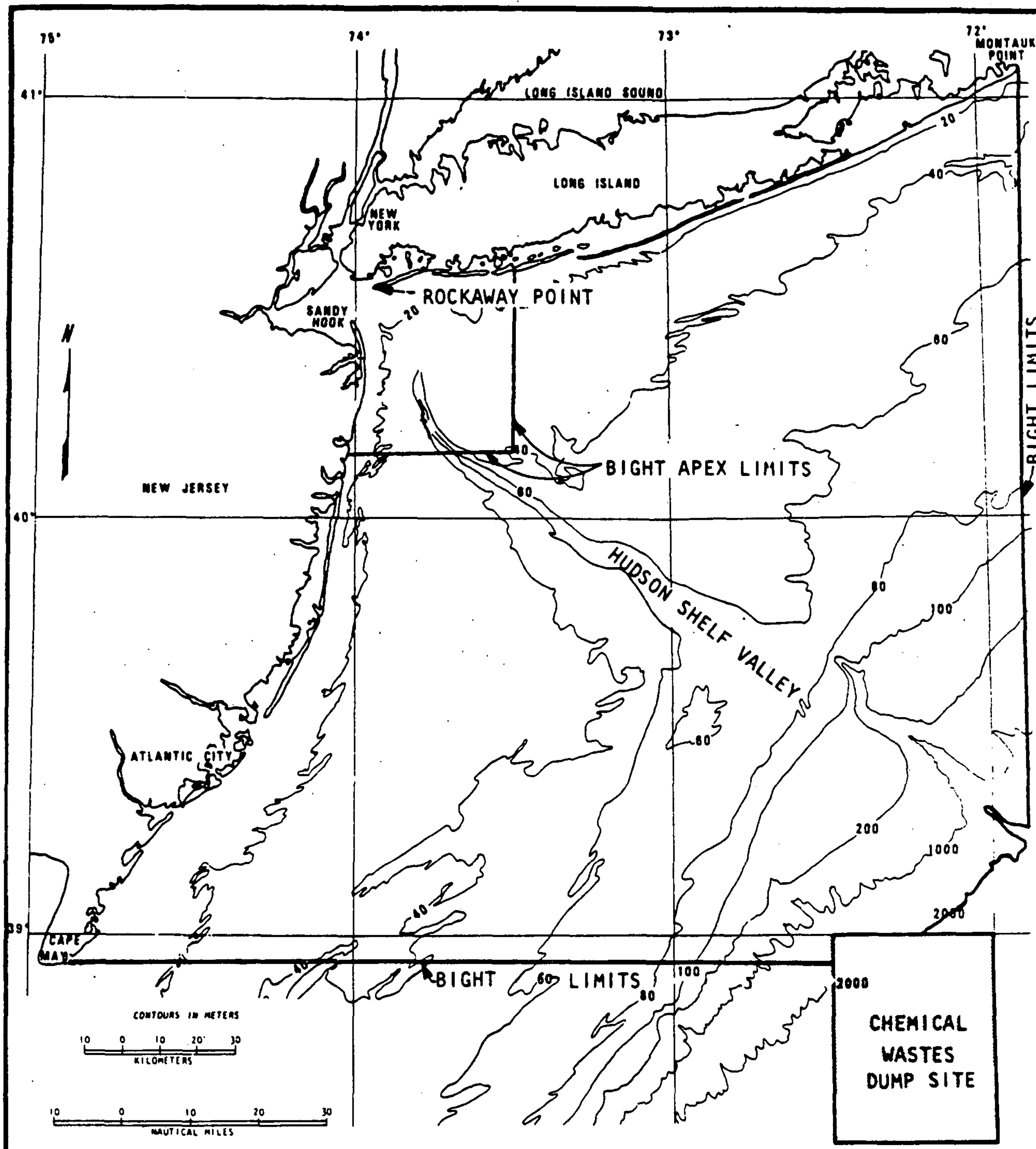


FIGURE 1

THE NEW YORK BIGHT

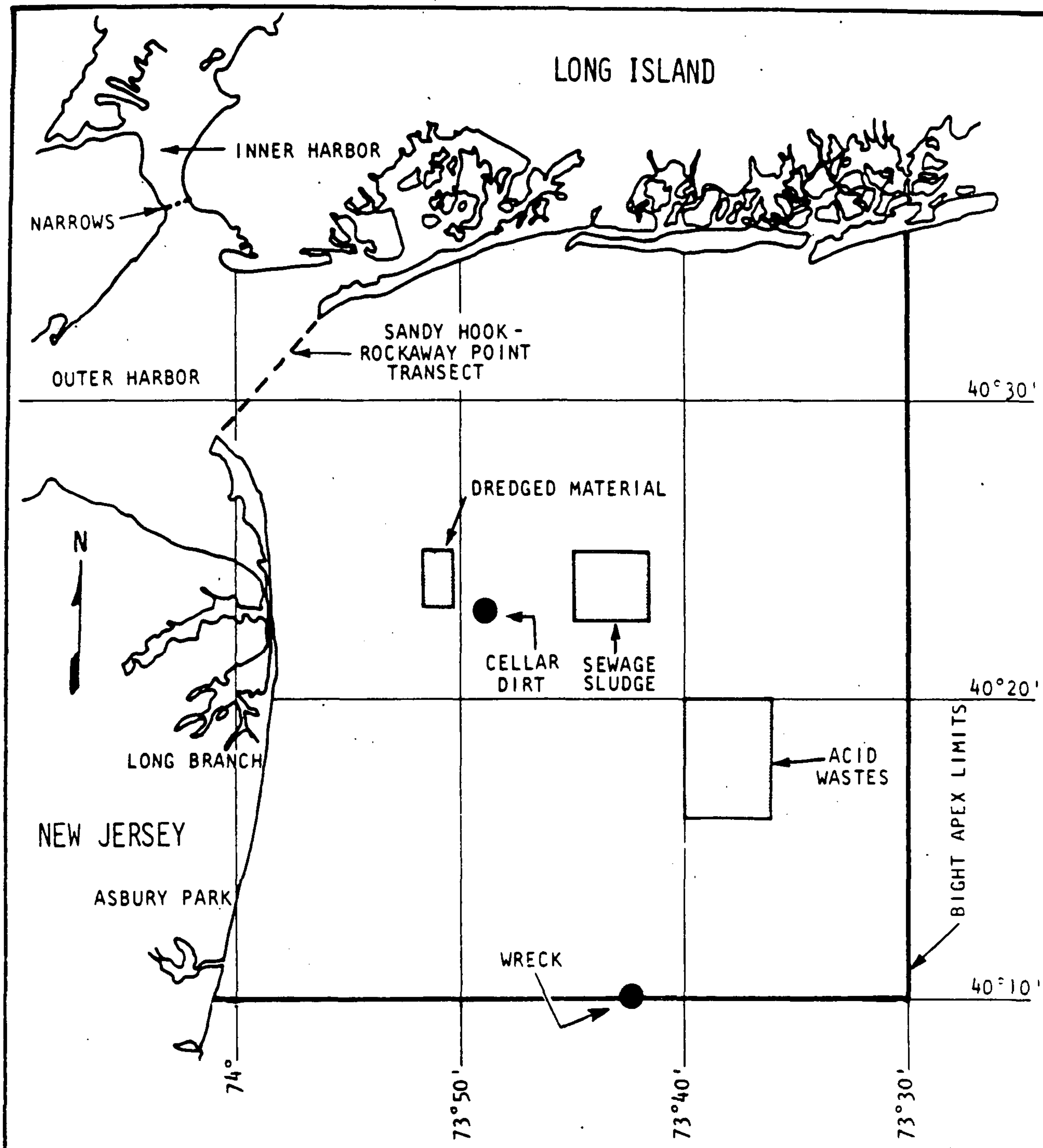
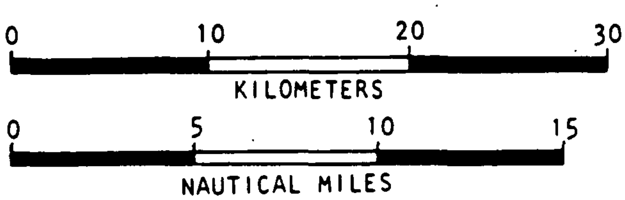


FIGURE 2

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 "Anderson" 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.

In 1985 stations analyzed for fecal coliform densities were additionally analyzed for enterococci bacteria densities. Enterococci bacteria are members of the fecal streptococci group. Enterococci density determinations were added because studies show that this group of indicator organisms has a better correlation, than fecal coliforms, to swimming-associated illness in marine waters. Currently, New York and New Jersey do not have a water quality standard for enterococci bacteria. EPA criterion of 35 enterococci/100 ml for primary contact recreation was published in the Federal Register on March 7, 1986.

II. SAMPLE COLLECTION PROGRAM

During the period of May 1985 through October 1985, water quality monitoring was carried out primarily using the EPA Huey helicopter. Major repair work on the EPA Huey helicopter at the end of July necessitated the rental of a Bell Jet Ranger II helicopter and the use of EPA's vessel "Clean Waters" to complete the summer sampling. 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 1985 sampling program. Table 2 lists the parameters analyzed for each group of stations. The major repair work on the Huey at the end of July made it inherently difficult to adhere to the weekly sampling frequency and protocol (only bottom samples were collected from August to mid-September). Furthermore, as the dissolved oxygen concentrations along the central and southern New Jersey coast became critically low, sampling was concentrated in the affected areas.

The monitoring program was composed 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.

Table 1

Outline of 1985 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 Perpendic- ulars (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	
Enterococci	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.

The New York Bight Contingency Network consisted of 24 stations which were sampled for dissolved oxygen, and fecal coliform and entercocci 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.

The weekly sampling program averaged approximately 140 stations. Beach stations along New York and New Jersey were sampled once a week for fecal coliform and enterococci 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 and enterococci 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 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 bottle for fecal coliform and entercocci analyses. 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 was added and the samples were titrated 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 necessitated the establishment of a fourth sampling component; a 24-station network was developed and sampled twice a week for dissolved oxygen and once a week for fecal coliform and entercocci densities. Part of the sampling requirements for the New York Bight contingency plan were 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 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 conducted 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 up the phytoplankton samples 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

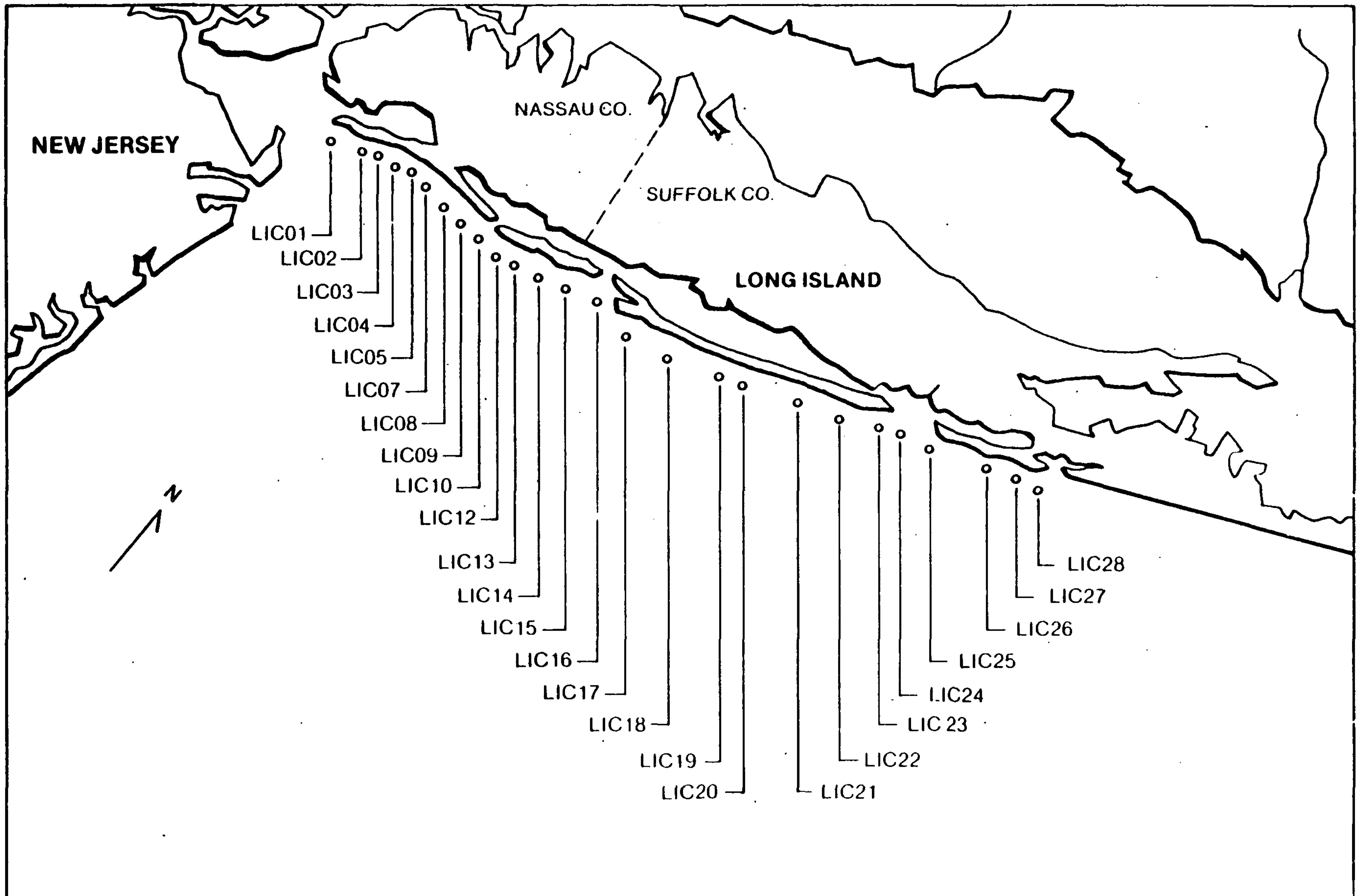


FIGURE 3
LONG ISLAND COAST STATION LOCATIONS

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
26A	" Shark River Inlet S. of Asbury Park
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 Heights, between the amusement piers
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	Long Beach	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

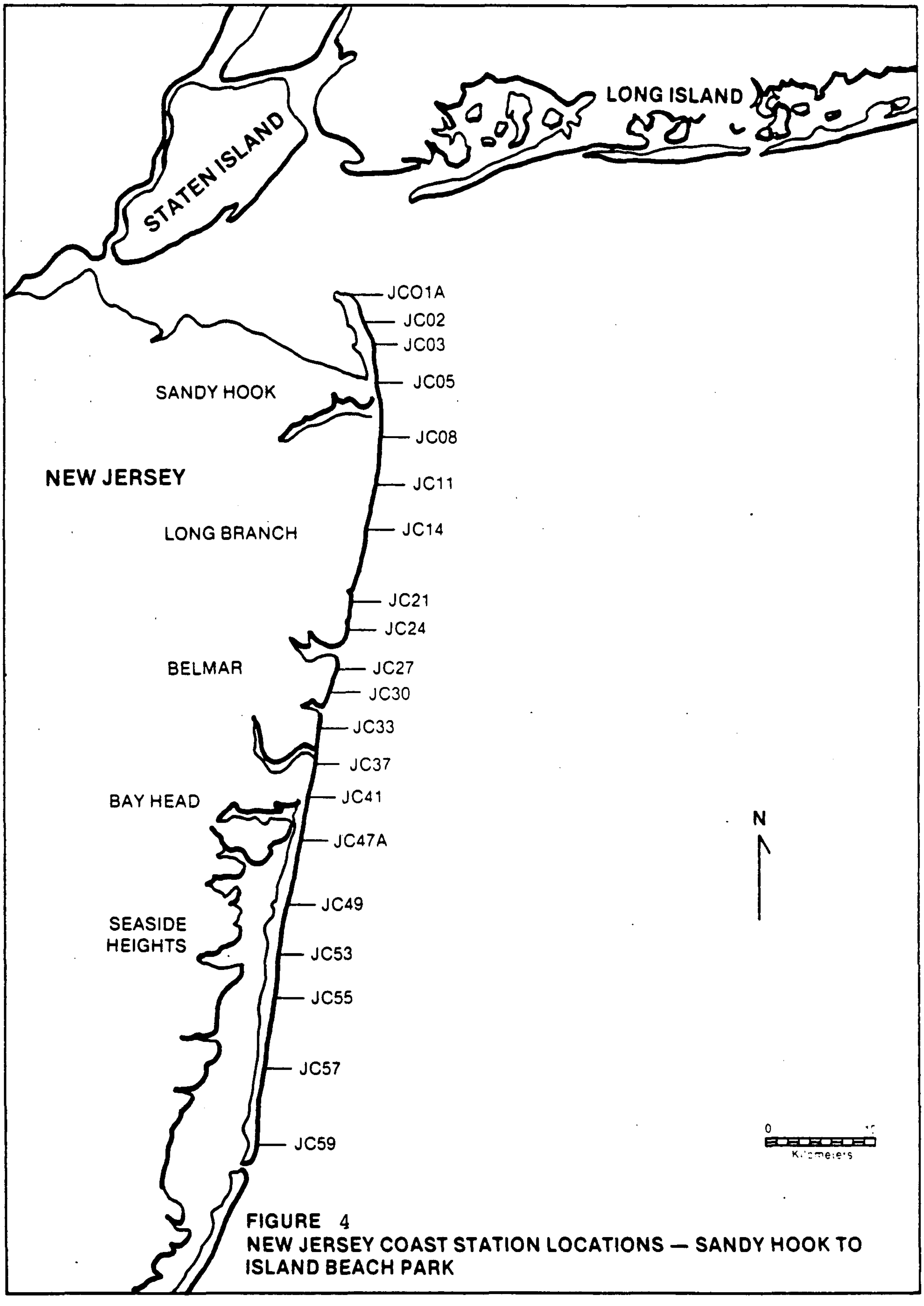


FIGURE 4
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

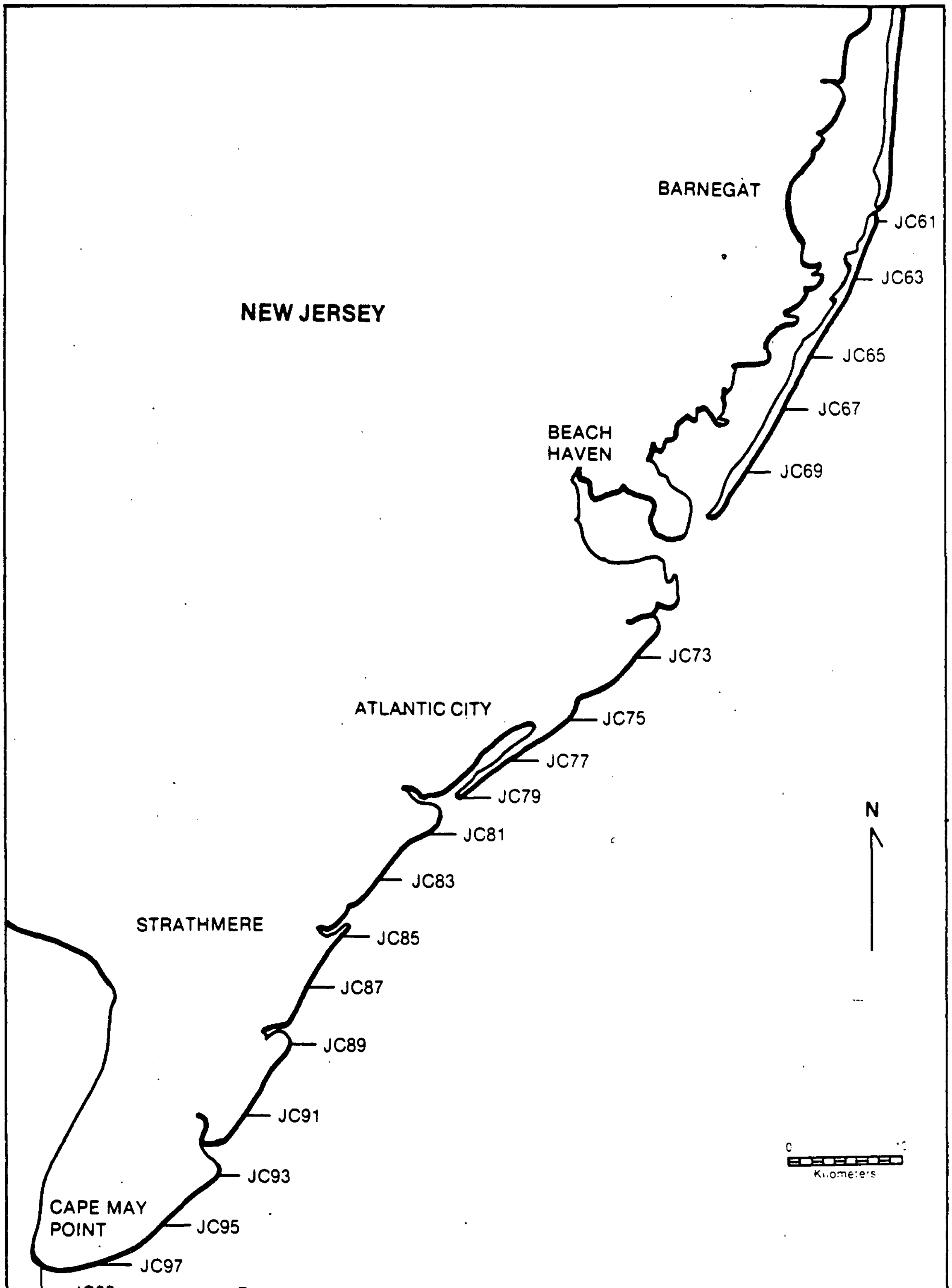


FIGURE 5
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

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.

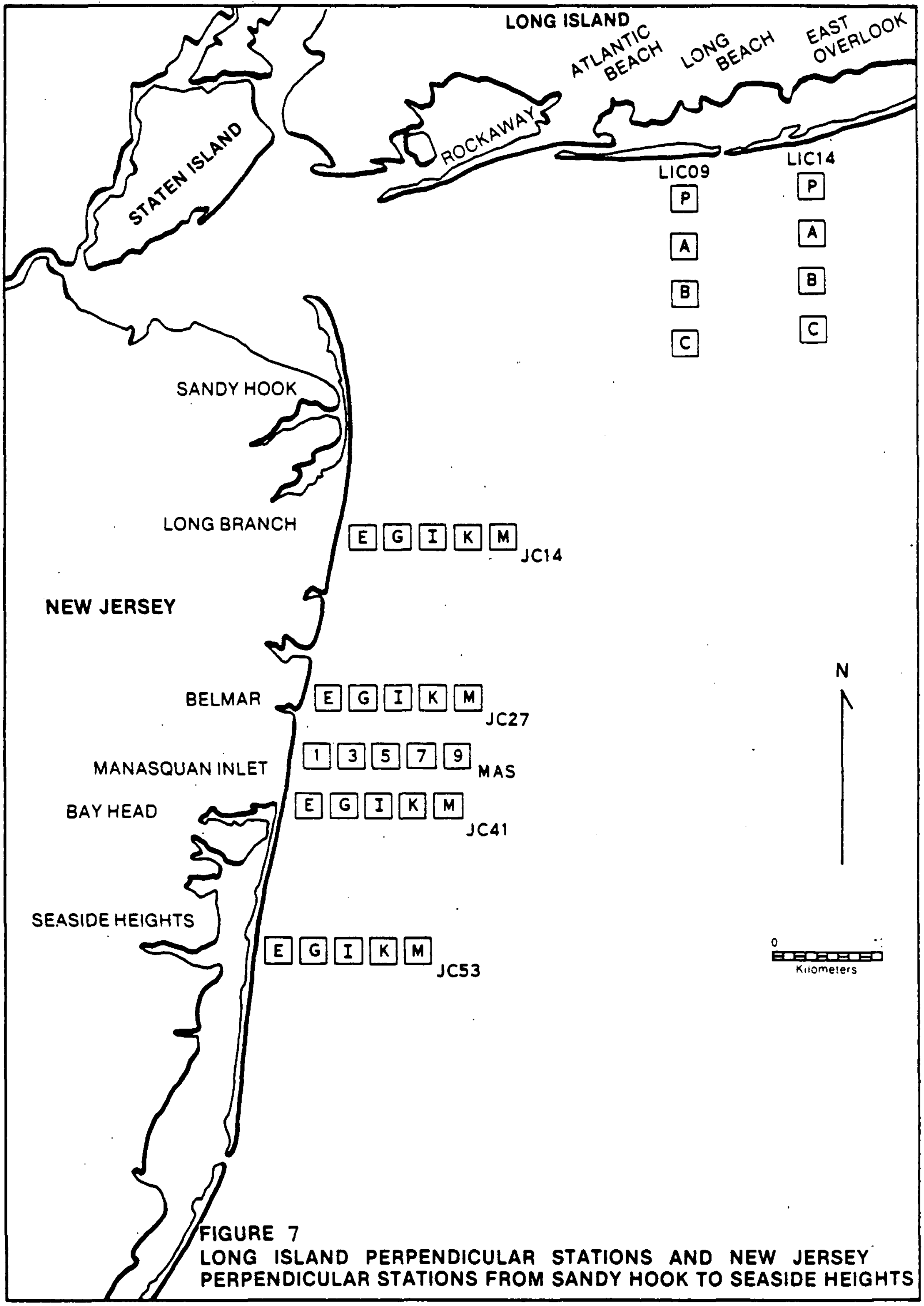


FIGURE 7
LONG ISLAND PERPENDICULAR STATIONS AND NEW JERSEY PERPENDICULAR STATIONS FROM SANDY HOOK TO SEASIDE HEIGHTS

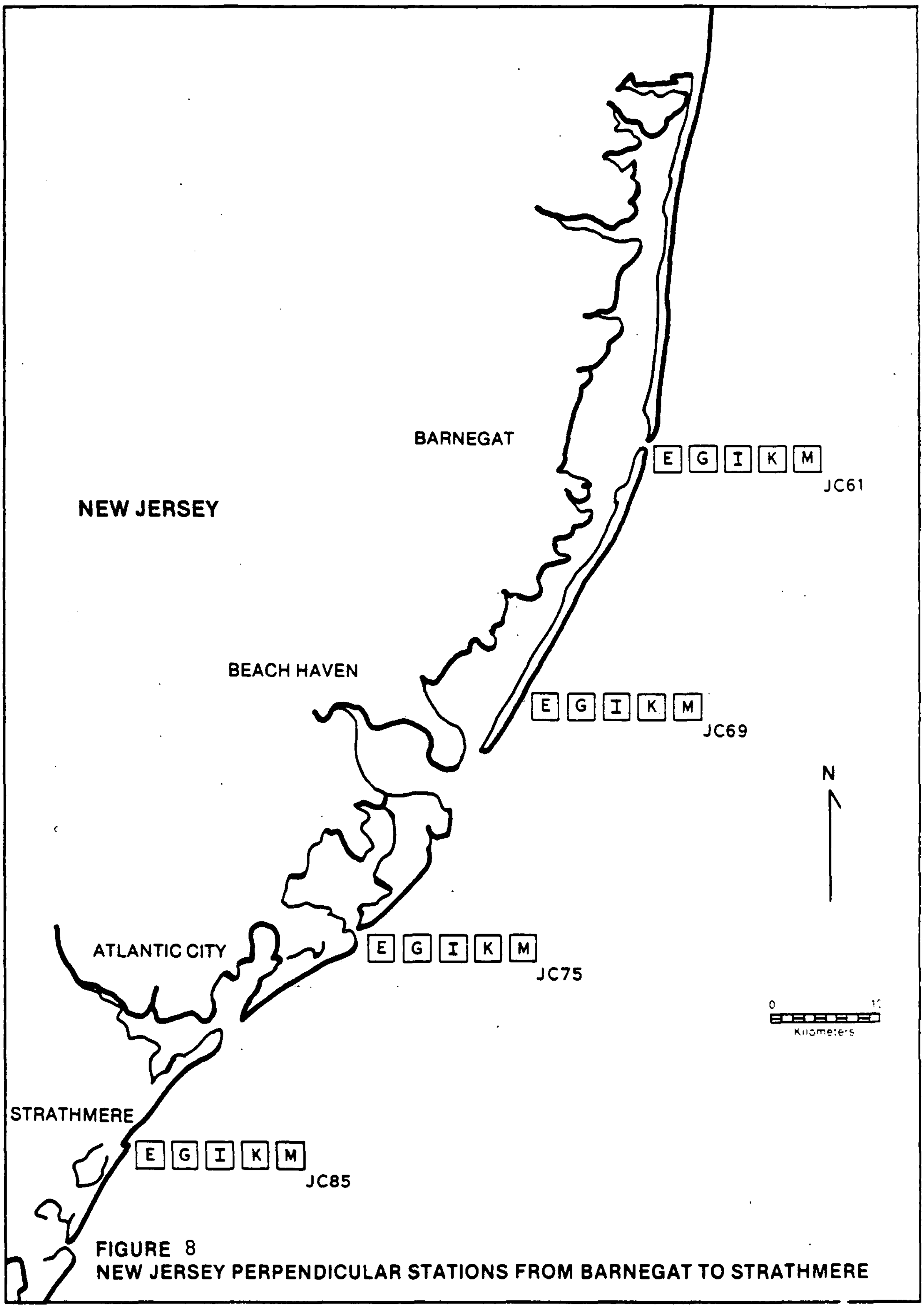


FIGURE 8
NEW JERSEY PERPENDICULAR STATIONS FROM BARNEGAT TO STRATHMERE

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 cooler bottom 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 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.

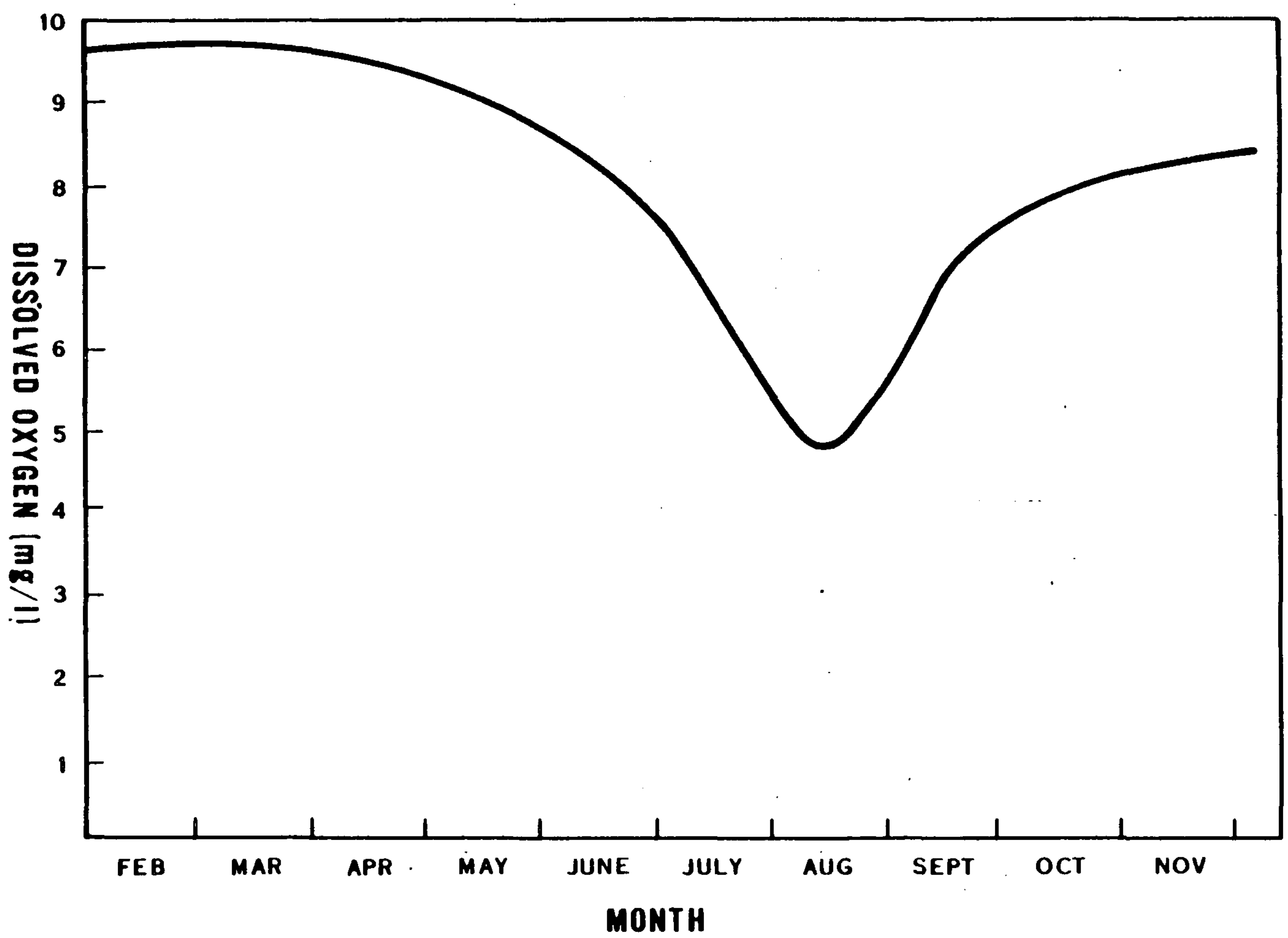


FIGURE 9
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

Dissolved Oxygen Criteria

The dissolved oxygen levels necessary for survival and/or reproduction vary among biological species. 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/1	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 benthic organism mortality.

Surface Dissolved Oxygen - 1985

The completely mixed upper water layer had dissolved oxygen levels at or near saturation during the entire sampling period, May 20, 1985 through October 17, 1985, therefore no further discussion of surface dissolved oxygen will be presented in this report.

Bottom Dissolved Oxygen - 1985

Long Island Coast

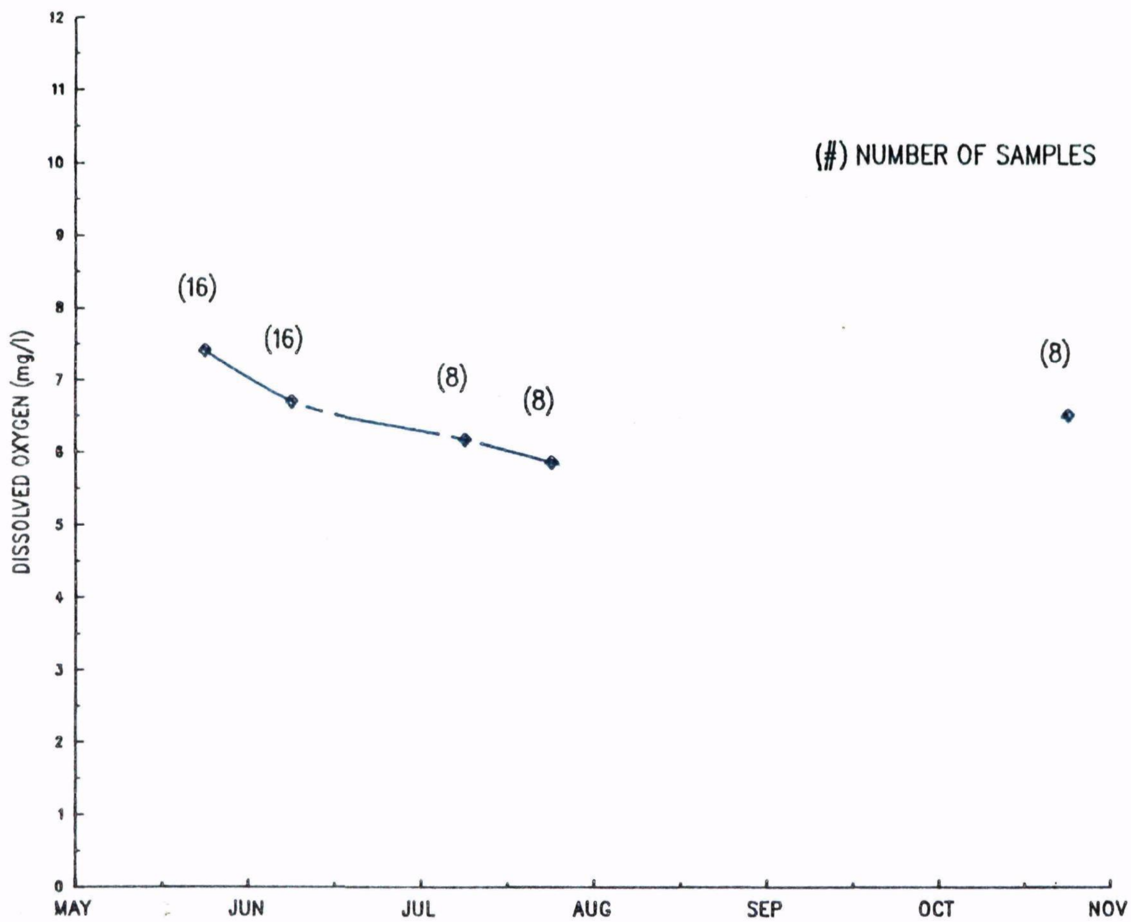
During the sampling period, no dissolved oxygen levels below the 4 mg/l "borderline to healthy" guideline were recorded off the Long Island coast. However, due to helicopter maintenance problems, from mid-July to mid-October no dissolved oxygen samples were collected along the Long Island perpendiculars. In previous years, dissolved oxygen values off the Long Island coast below 4 mg/l occurred in August and September. Therefore, it is likely that dissolved oxygen levels below 4 mg/l existed at some stations but were not documented.

Figure 10 shows the semi-monthly averages of dissolved oxygen values found from May through October, 1985. The dissolved oxygen average from May through July is consistent with averages from previous years, remaining in the 6-7 mg/l range. No data were collected in late July, August, September and early October.

New York Bight Apex

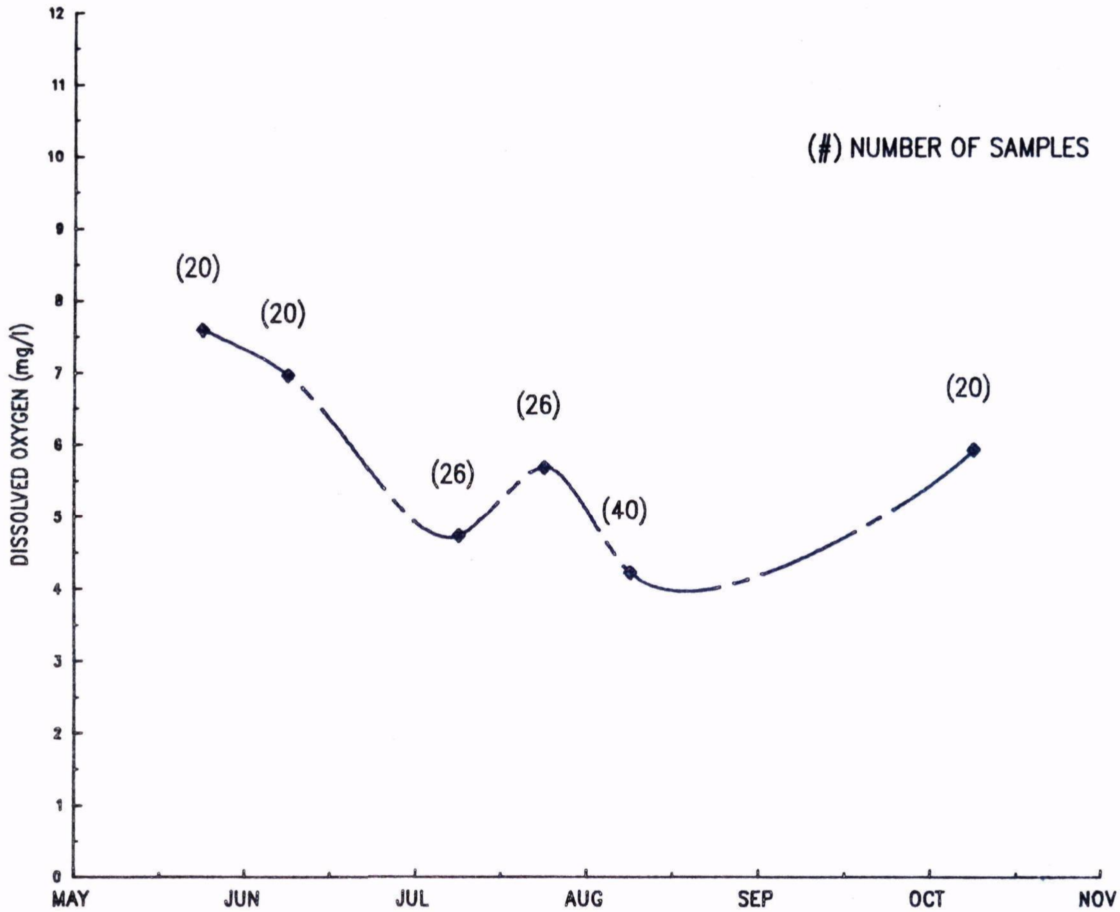
Figure 11 illustrates the semi-monthly dissolved oxygen averages at the New York Bight stations from May through October, 1985. A dissolved oxygen "double minima" is observed. This "double minima" has occurred in most years, except in 1982 and 1984. The first dissolved oxygen low occurred in early July, followed by a 1 mg/l increase in late July. The second low occurred in early August. This was followed by a strong recovery in late summer into October.

FIGURE 10



LONG ISLAND COAST BOTTOM DISSOLVED OXYGEN, 1985
SEMIMONTHLY AVERAGE OF ALL LONG ISLAND PERPENDICULAR STATIONS.

FIGURE 11



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1985
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

Out of 152 samples collected in the New York Bight from May 21 to October 9 and measured for dissolved oxygen, 22 samples, or 14.5 percent, were between the 3-4 mg/l level considered "stressful if prolonged" for aquatic life, and 4 samples, or 2.6 percent, were less than the 2 mg/l level considered "lethal in a relatively short time".

Table 5 summarizes the dissolved oxygen values below 4 mg/l in the New York Bight during the Summer 1985.

Table 5 - Dissolved oxygen (D.O.) concentrations less than 4 mg/l in the New York Bight Apex, summer 1985

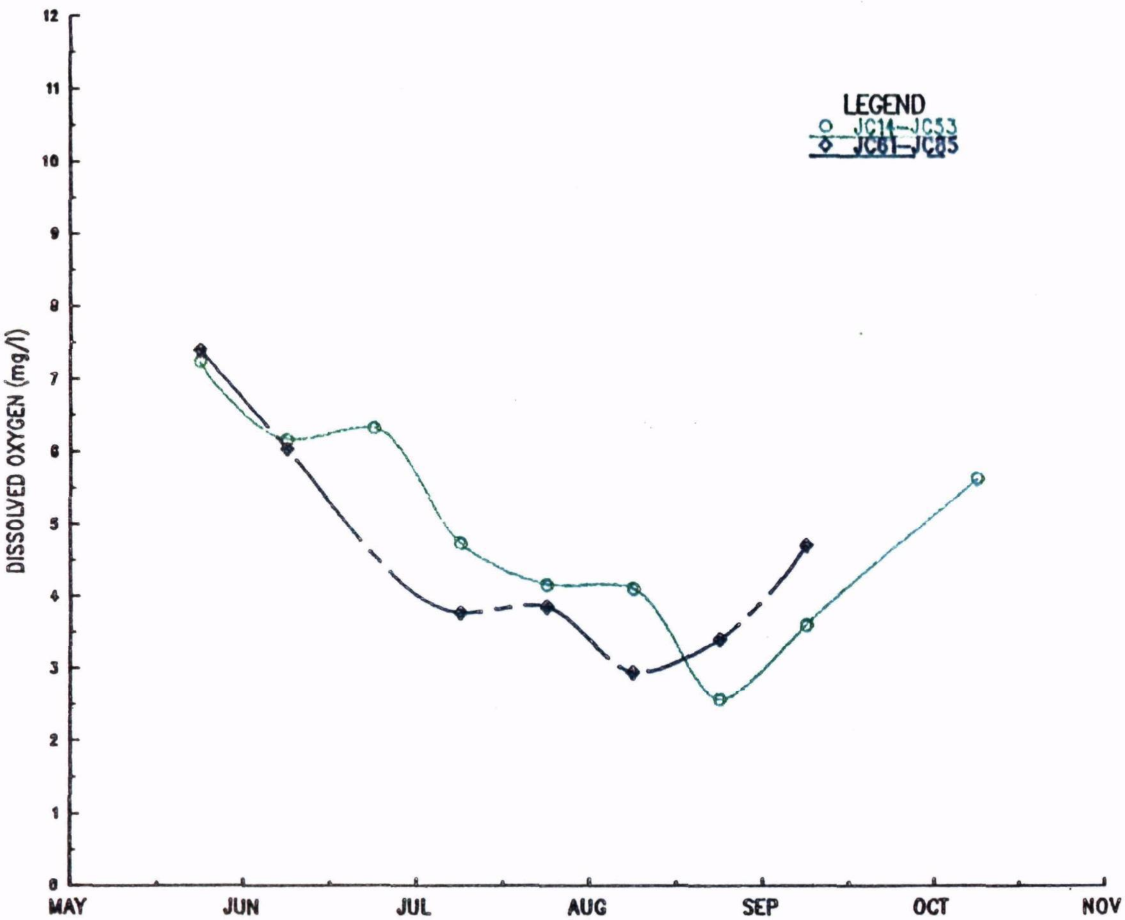
DATE	STATION	D.O. (mg/l)
7/12	NYB 44	3.1
7/15	NYB 22	3.5
7/15	NYB 23	3.1
7/15	NYB 24	3.9
7/15	NYB 34	3.6
7/15	NYB 35	2.5
7/15	NYB 43	3.0
7/20	NYB 22	3.7
7/20	NYB 40	3.9
8/6	NYB 25	2.7
8/6	NTB 26	3.9
8/6	NYB 46	3.1
8/14	NYB 20	2.7
8/14	NYB 21	3.3
8/14	NYB 22	3.5
8/14	NYB 24	2.7
8/14	NYB 25	3.9
8/14	NYB 26	3.4
8/15	NYB 32	3.7
8/15	NYB 33	3.3
8/15	NYB 34	3.1
8/15	NYB 35	3.0
8/15	NYB 41	3.1
8/15	NYB 42	3.6
8/15	NYB 43	3.1
10/8	NYB 20	3.3

New Jersey Coast

Figure 12 illustrates the semi-monthly dissolved oxygen averages off the New Jersey coast during the summer of 1985, 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 declined between late May and early July to 4.0 mg/l and remained at 4.0 mg/l throughout July. The concentrations then decreased to an average low of 3.0 mg/l in early August and recovered in September. The dissolved oxygen average along the northern perpendiculars did not show the "double minima" phenomenon in 1985, which occurred in all other years, with the exception of 1982. The dissolved oxygen average was 7.3 mg/l in late May, dropped to 6.3 mg/l in early June and remained at approximately this level into late June. A decrease occurred throughout July and August with an average low of 2.7 mg/l in late August. This was followed by a rapid recovery in September and October.

Table 6 summarizes the dissolved oxygen values for the New Jersey coast perpendiculars. During the sampling period there were 107 values (16.9 percent) between 4-5 mg/l, 244 values (38.4 percent) between 2-4 mg/l and 40 values (6.3 percent) between 0-2 mg/l. The dissolved oxygen levels in 1985 were considerably lower than those observed during the past few years. Dissolved oxygen levels reached a minimum in late August/early September due to a lack of reaeration, sediment oxygen demand, and biodegradation of dead algal blooms. The values improved in late September/early October due to lower air temperatures, increased winds, and storm activity causing the water column to "turn over".

FIGURE 12



NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1985. SEMIMONTHLY AVERAGES OF ALL NORTHERN (JC14–JC53) AND SOUTHERN (JC61–JC85) PERPENDICULAR STATIONS.

TABLE 6

Dissolved Oxygen Distribution (Bottom Values)

New Jersey Coast Perpendiculars

1985

Station	May 20	May 24	May 30	Jun 3	Jun 11	Jun 14	Jun 17	Jul 1	Jul 8	Jul 12	Jul 13	Jul 18	Jul 19	Jul 20	Jul 22	Jul 23	Jul 24	Jul 25	Jul 29	Jul 30	Aug 7	Aug 8	Aug 12	Aug 24	Aug 28	Aug 29	Aug 31	Sep 5	Sep 6	Sep 10	Sep 12	Sep 13	Sep 14	Sep 15	Oct 10
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 13, 14, 15, 16, 17, and 18 present dissolved oxygen profiles along the New Jersey coast from May through October. The profiles show that during May and June, Figures 13 and 14, dissolved oxygen concentrations were high. Major declines in dissolved oxygen levels occurred in July, Figure 15, and remained depressed into September, Figures 16 and 17. At the four northern perpendiculars, from June through August, Figures 14, 15 and 16, the dissolved oxygen concentrations increased with distance offshore. At the four southern perpendiculars during this same time the dissolved oxygen levels, for the most part, were higher closer to shore. During October, Figure 18, only the two northern most perpendiculars were sampled. The dissolved oxygen values were much higher than in September.

There were 763 samples collected along the New Jersey perpendiculars between May 20 and October 10, 1985 and analyzed for dissolved oxygen. Of these, 334 samples, or 43.8 percent, were below 4 mg/l (Table 6).

Figure 19 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 5 miles off the coast. The first low occurred in late July, followed by an increase of 0.6 mg/l in early August. Dissolved oxygen values subsequently decreased 1.7 mg/l, reaching a second low in late August. In 1984, a dissolved oxygen "double minima" occurred at all distances from shore except 5 miles.
- From June through August, with the exception of early July, the perpendicular stations 1 and 3 miles offshore had average dissolved oxygen values approximately 0.5 to 1.5 mg/l less than the stations

FIGURE 13

Dissolved Oxygen Concentration Profiles

New Jersey Coast

May 1985

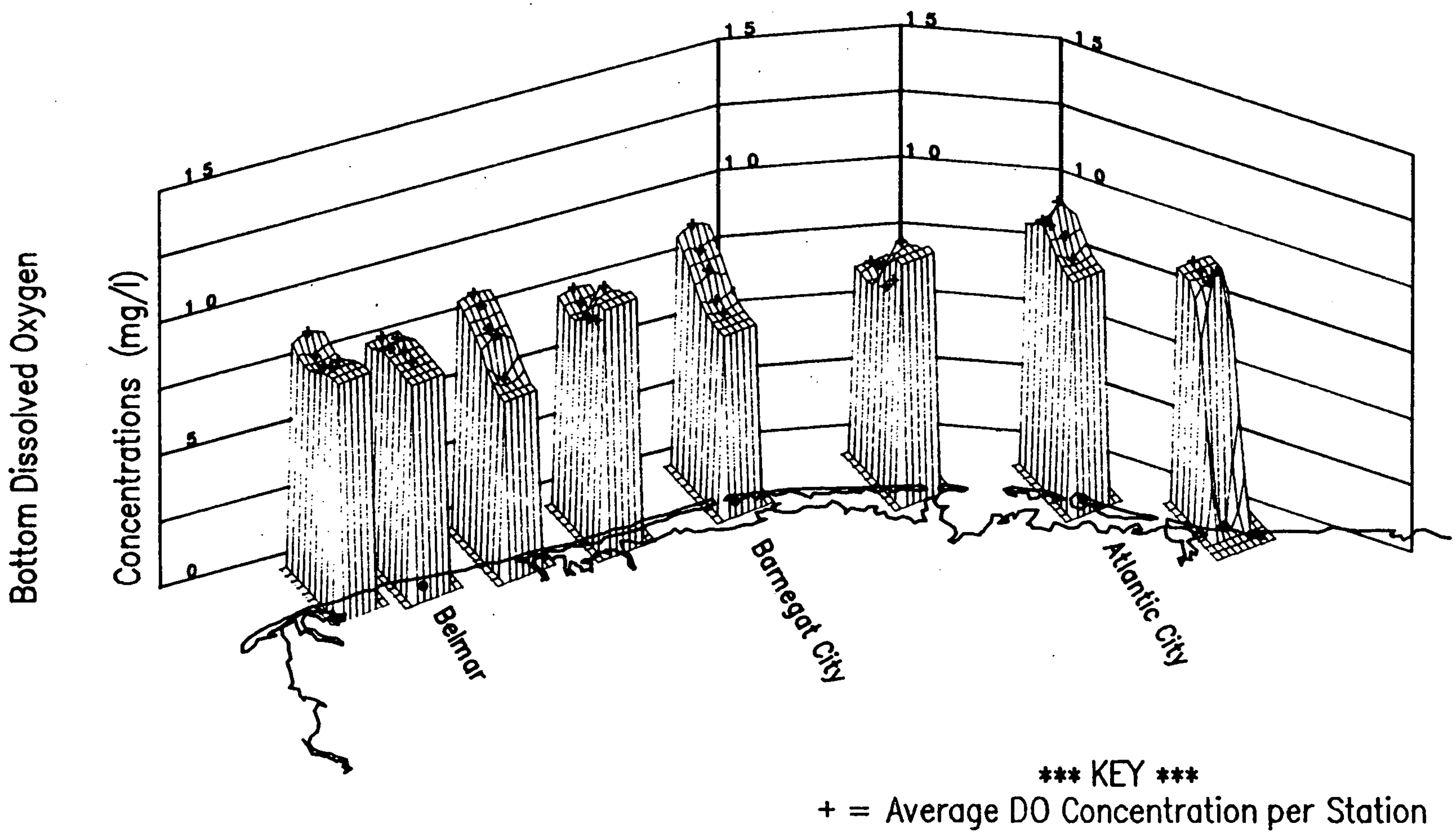


FIGURE 14

Dissolved Oxygen Concentration Profiles

New Jersey Coast

June 1985

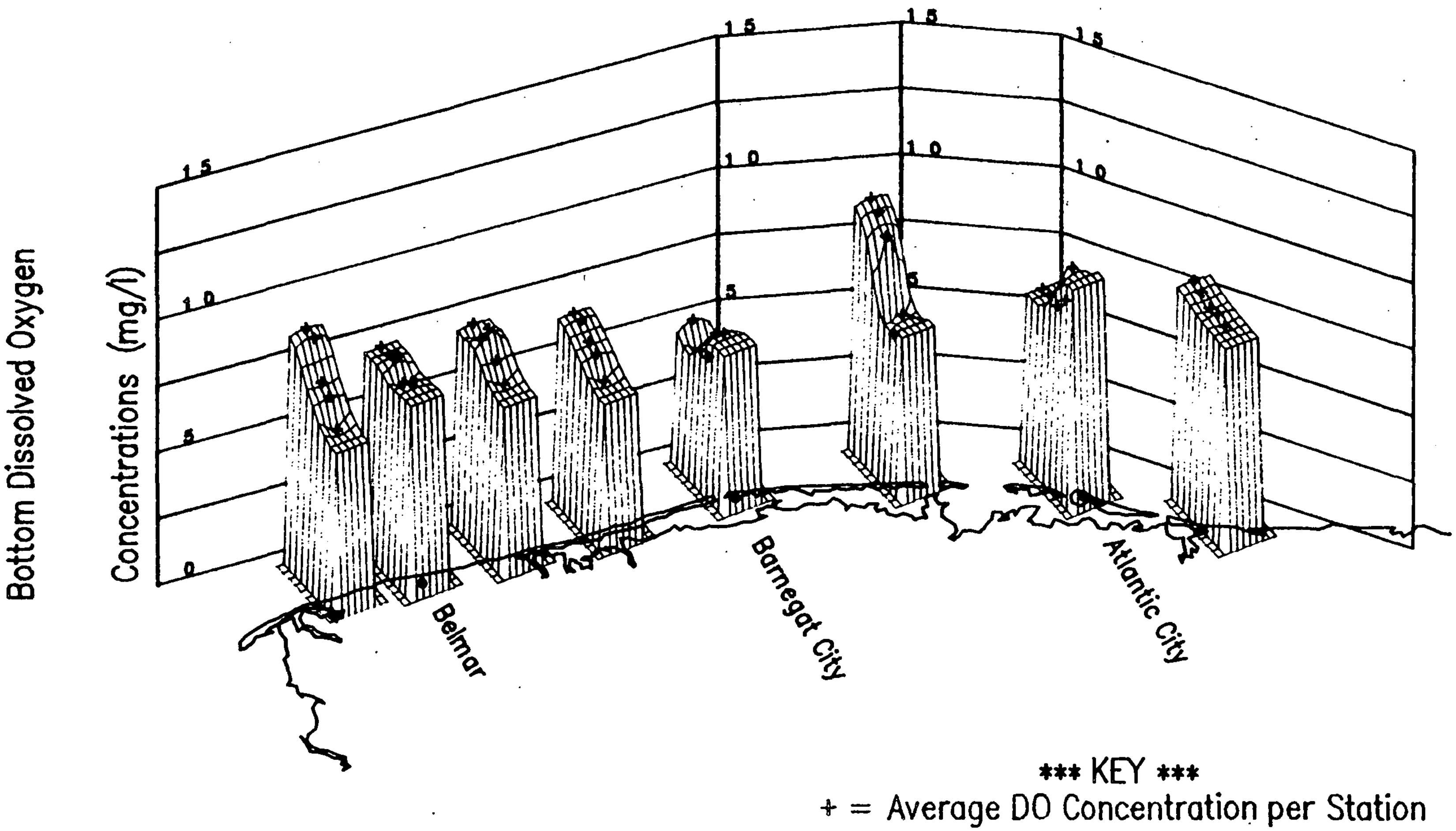
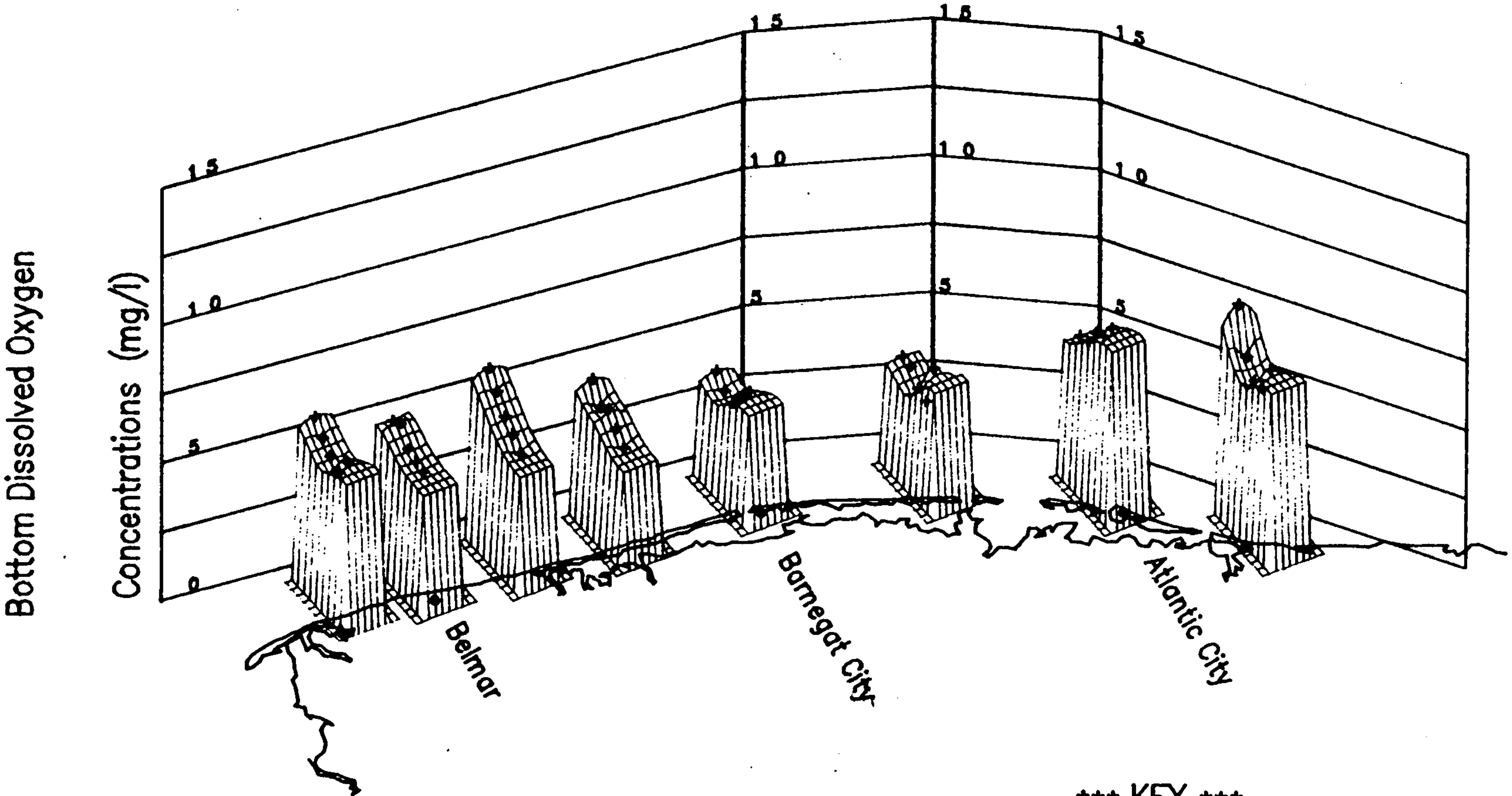


FIGURE 15

Dissolved Oxygen Concentration Profiles

New Jersey Coast

July 1985



*** KEY ***

+ = Average DO Concentration per Station

FIGURE 16

Dissolved Oxygen Concentration Profiles

New Jersey Coast

August 1985

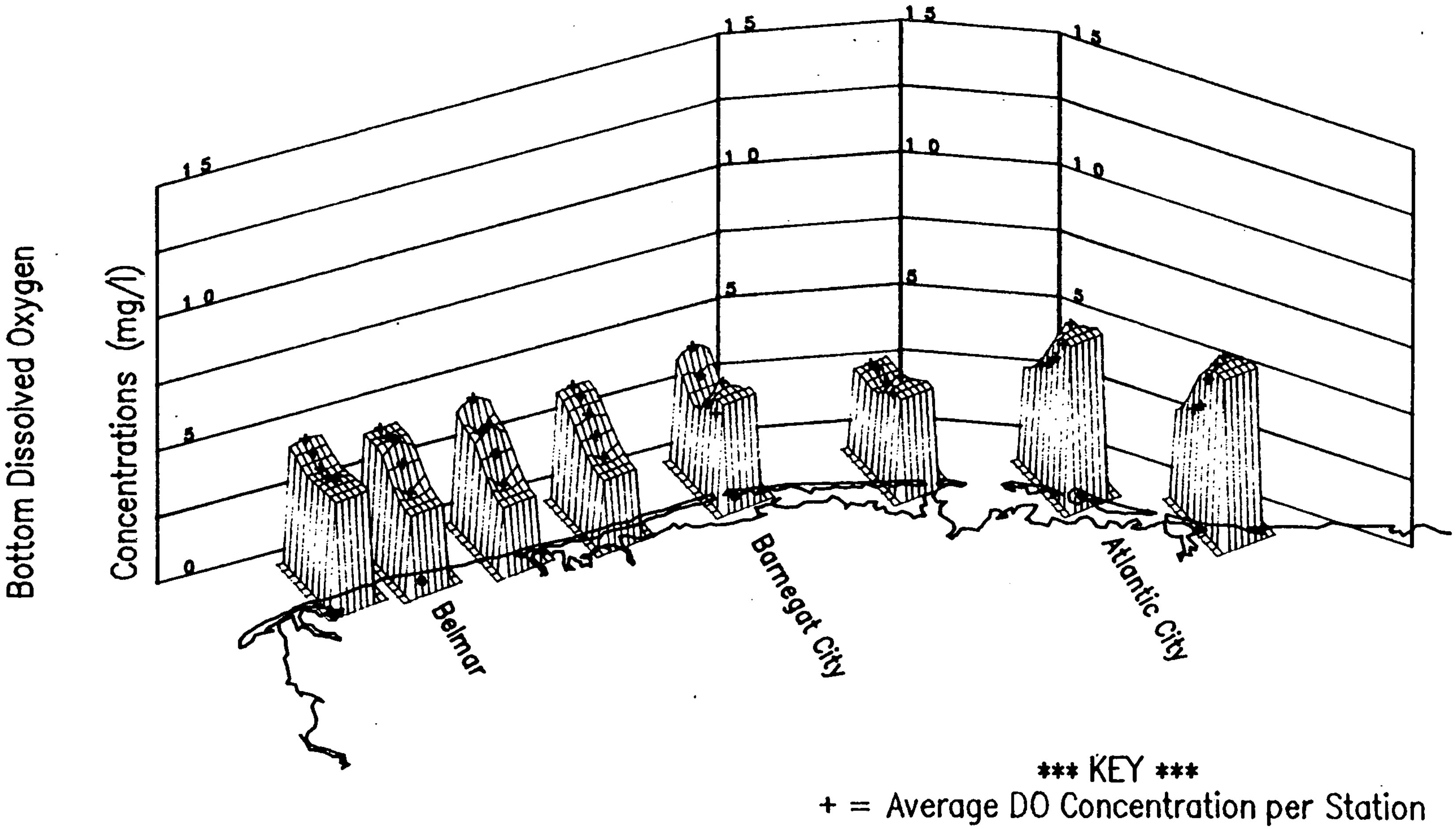
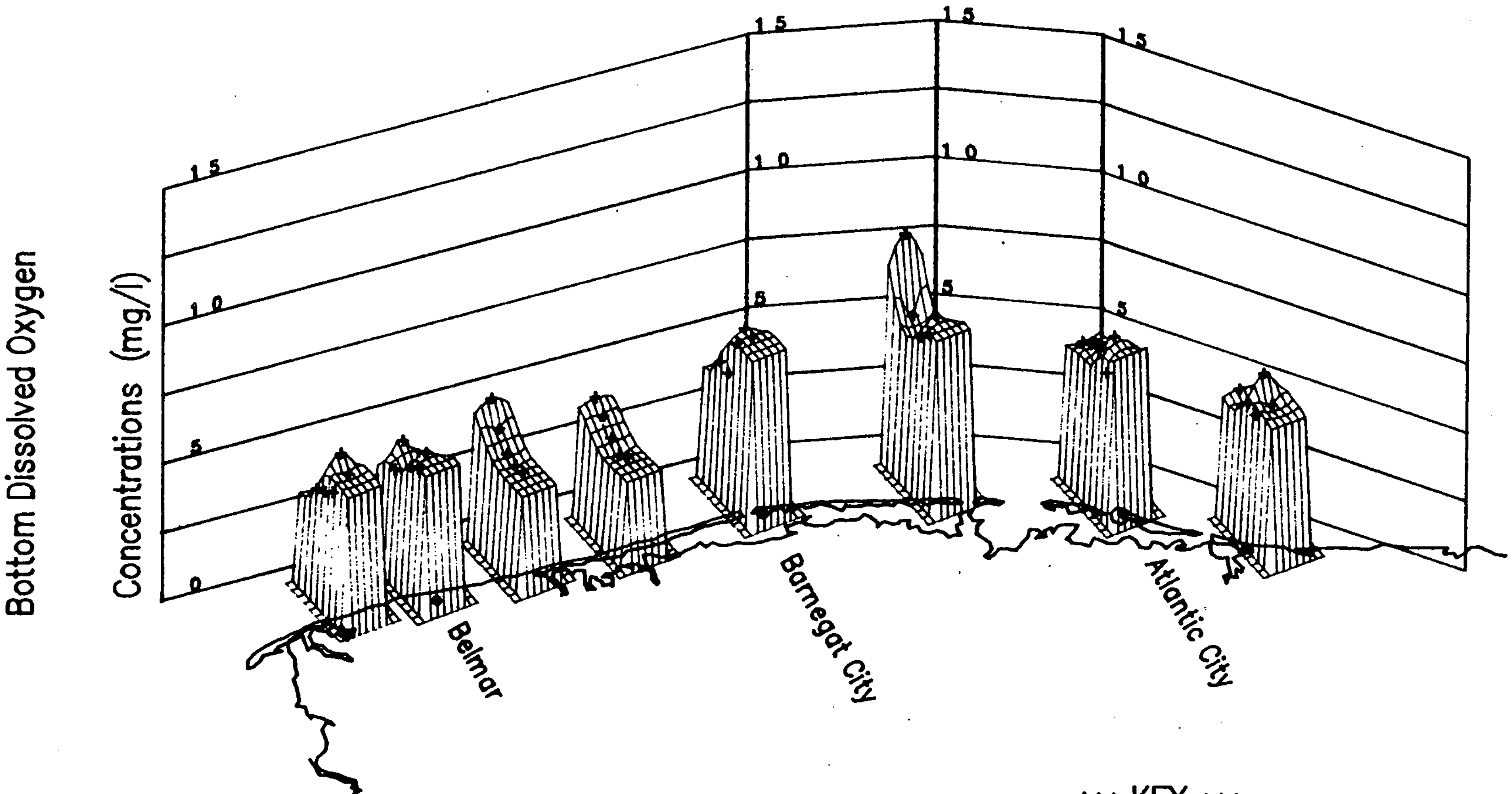


FIGURE 17

Dissolved Oxygen Concentration Profiles

New Jersey Coast

September 1985



*** KEY ***

+ = Average DO Concentration per Station

FIGURE 18

Dissolved Oxygen Concentration Profiles

New Jersey Coast

October 1985

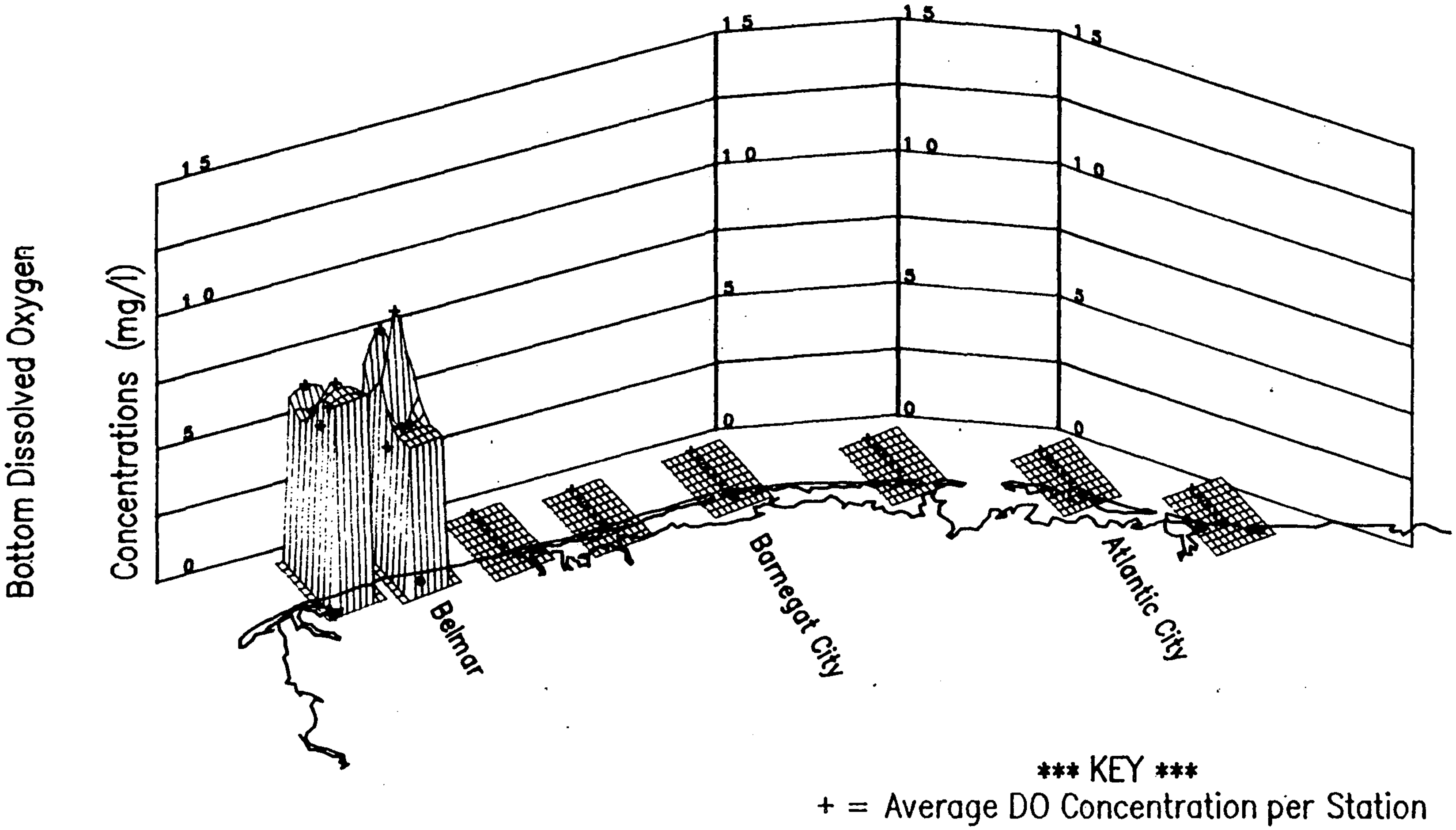
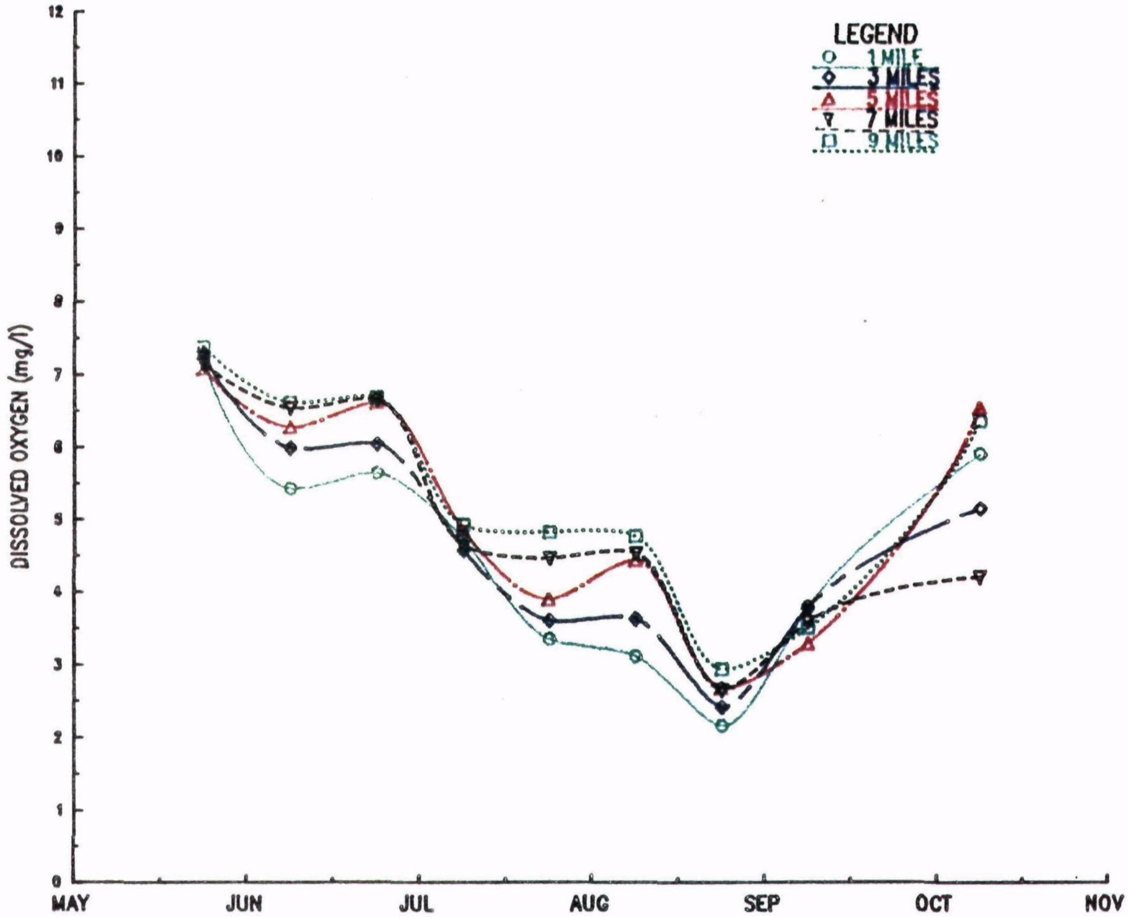


FIGURE 19



SHORE–TO–SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1985
SEMIMONTHLY AVERAGES OF ALL NORTHERN PERPENDICULAR STATIONS
(JC14–JC53), AT FIXED DISTANCES FROM SHORE.

5, 7 and 9 miles offshore. In general, the lower dissolved oxygen values found at the nearshore stations may be attributed to the influence of river discharge, treatment plant effluent, stormwater runoff, inlet dredged material disposal sites, and the Raritan-Hudson Estuary system on the water along the New Jersey coast.

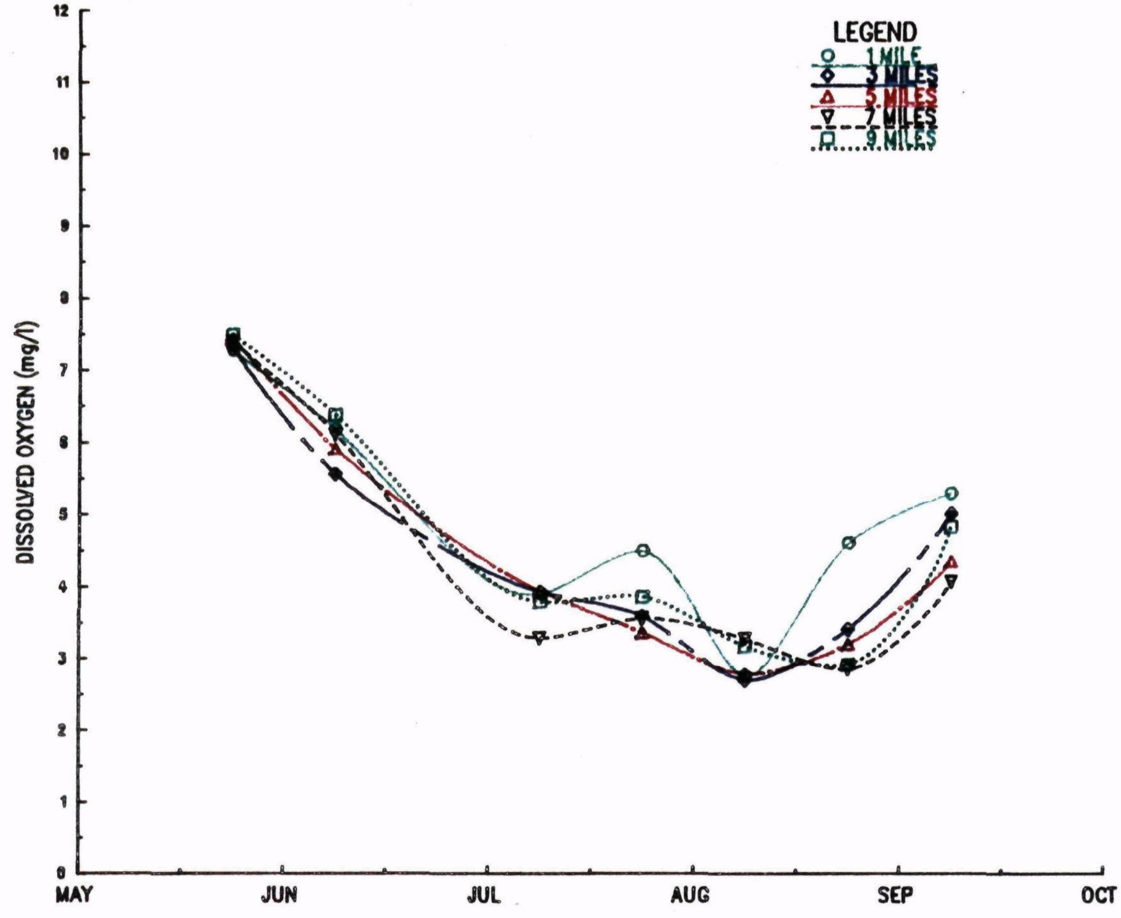
Figure 20 compares the shore to seaward distribution of dissolved oxygen values along the southern New Jersey perpendiculars. The stations 1, 3 and 5 miles offshore reached a low in early August, while the stations 7 and 9 miles offshore were lowest in late August. A dissolved oxygen recovery is evident at all distances from shore in early September. The stations 1 and 7 miles off the coast exhibited the "double minima". At both distances offshore the first low occurred in early July, with the second low appearing 1 mile offshore in early August and 7 miles offshore in late August.

Figure 21 illustrates the 1985 semimonthly average dissolved oxygen values for the northern perpendiculars as compared to the overall average. The "double minima" was observed at perpendiculars JC 27, MAS, and JC 53. The lowest dissolved oxygen values occurred in late August, with a subsequent dissolved oxygen recovery in September and October.

Figure 22 shows the dissolved oxygen values for the southern perpendiculars. Perpendiculars JC 61 and JC 75 showed a "double minima", with the first low occurring in early July and the second in late August, followed by a recovery in September. JC 85 showed a gradual dissolved oxygen decline from June to September, and it is the only perpendicular at which a recovery was not documented.

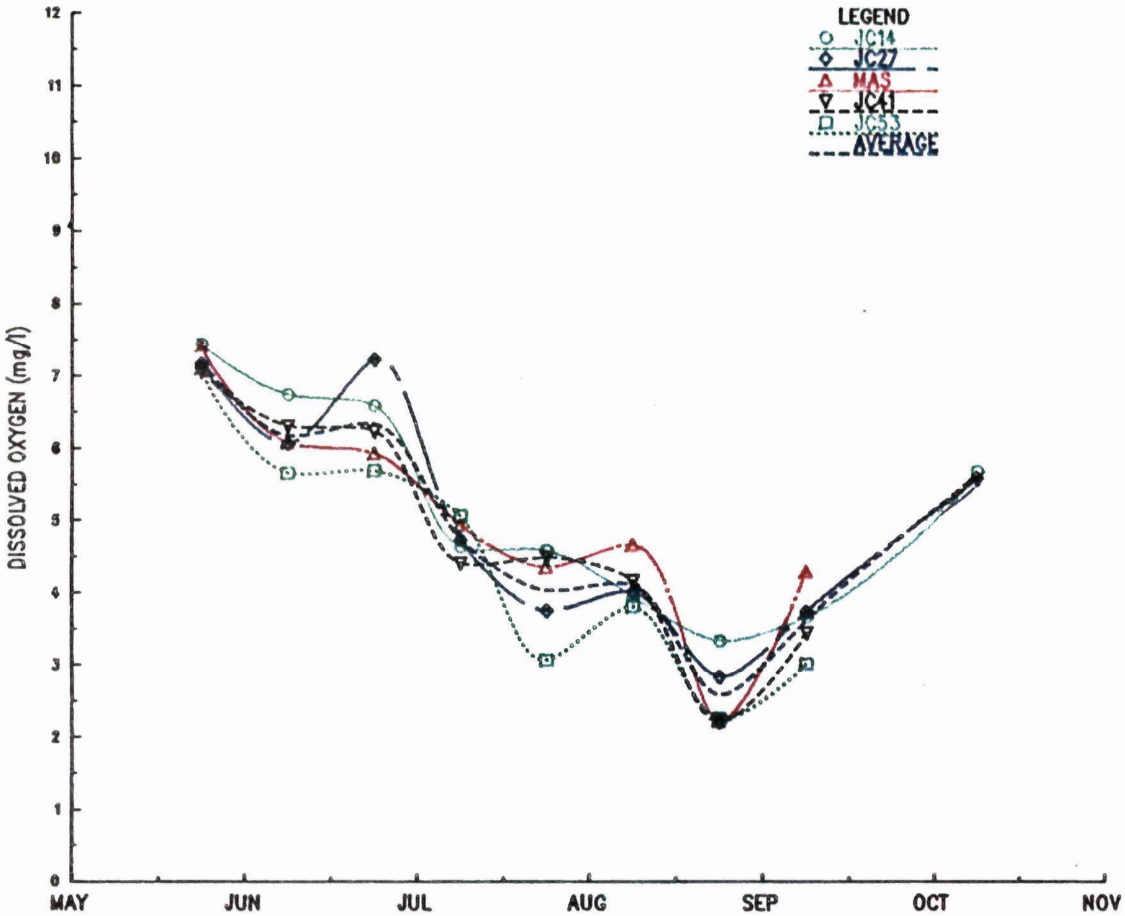
Figures 23, 24 and 25 display the number of dissolved oxygen observa-

FIGURE 20



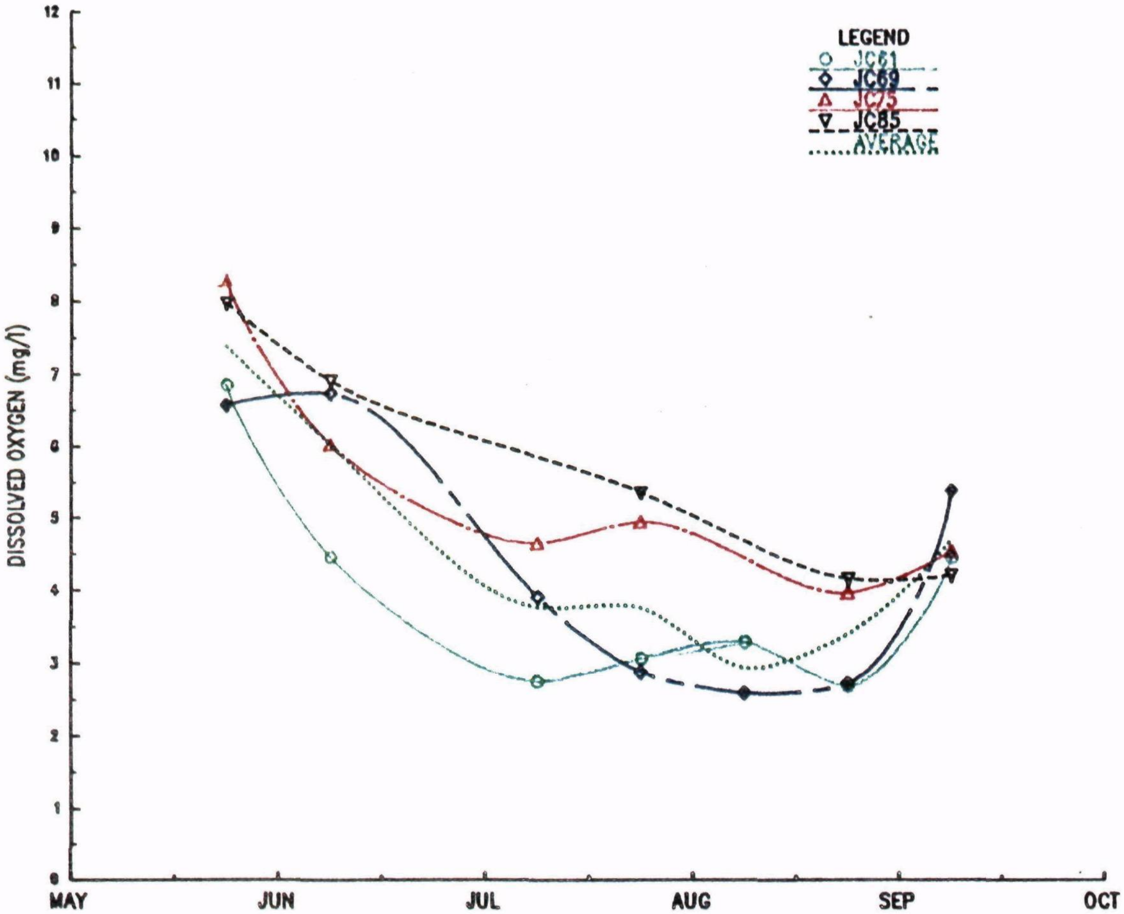
SHORE–TO–SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1985
SEMIMONTHLY AVERAGES OF ALL SOUTHERN PERPENDICULAR STATIONS
(JC61–JC85), AT FIXED DISTANCES FROM SHORE.

FIGURE 21



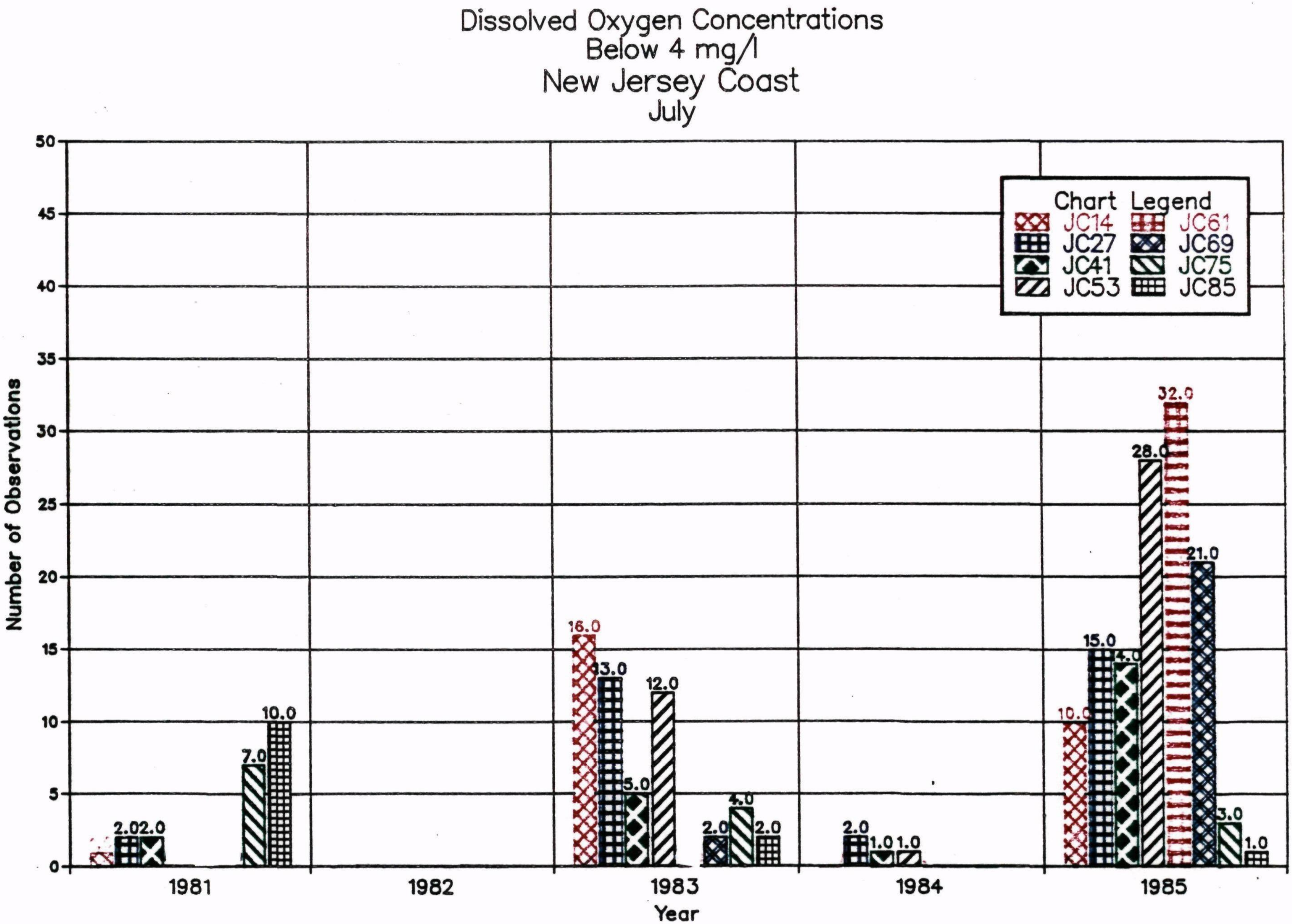
NORTH–SOUTH BOTTOM DISSOLVED OXYGEN DISTRIBUTION FOR NORTHERN NEW JERSEY, 1985. SEMIMONTHLY AVERAGES ALONG PERPENDICULARS JC14–JC53, COMPARED TO THEIR AVERAGE.

FIGURE 22



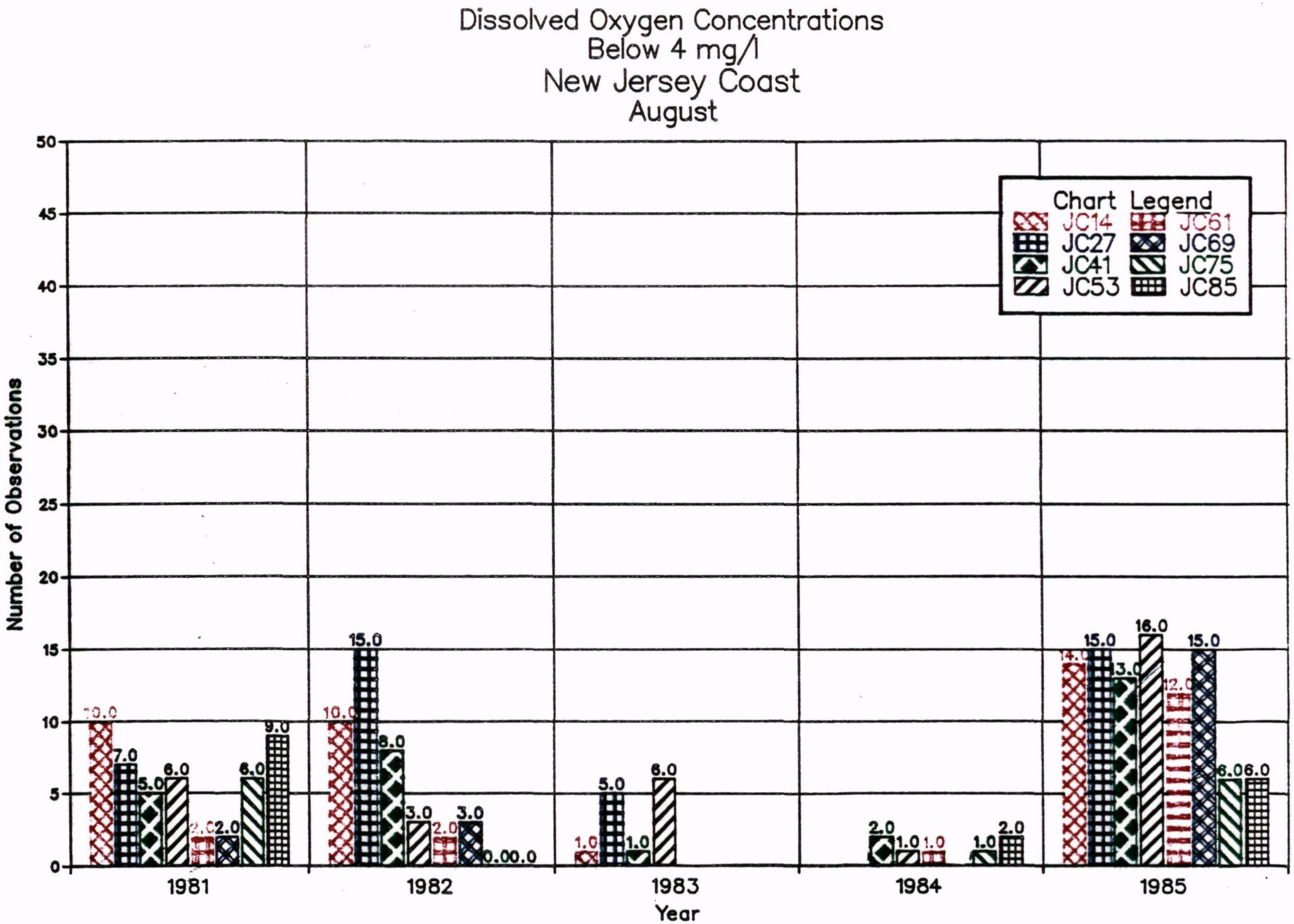
NORTH–SOUTH BOTTOM DISSOLVED OXYGEN DISTRIBUTION FOR SOUTHERN NEW JERSEY, 1985. SEMIMONTHLY AVERAGES ALONG PERPENDICULARS JC61–JC85, COMPARED TO THEIR AVERAGE.

FIGURE 23



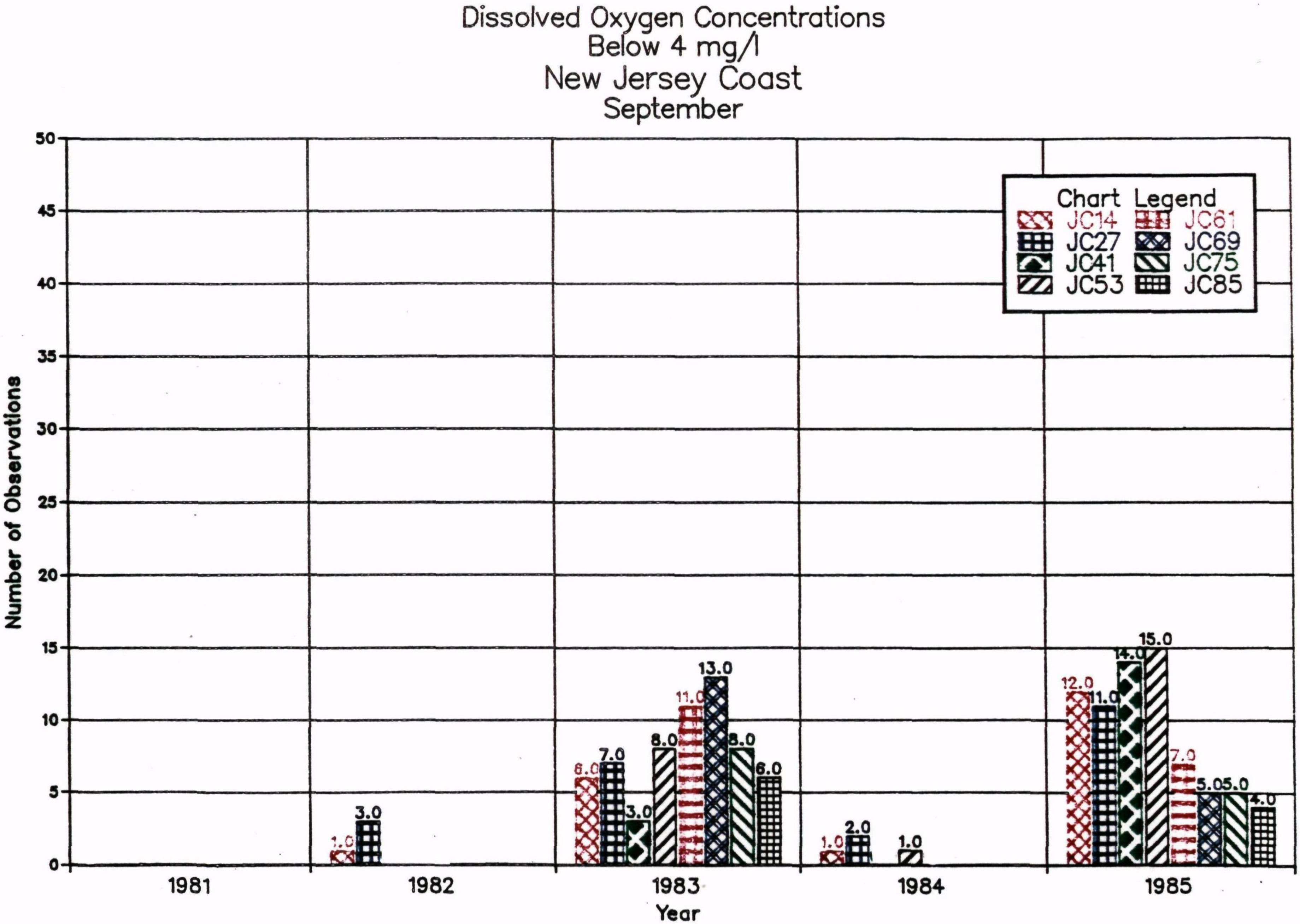
Dissolved Oxygen Concentrations
Below 4 mg/l
New Jersey Coast
July
Chart Legend
JC14
JC61
JC27
JC69
JC41
JC75
JC53
JC85
Number of Observations
Year
1981
1982
1983
1984
1985
2.0
2.0
7.0
10.0
16.0
13.0
5.0
12.0
2.0
4.0
2.0
2.0
1.0
1.0
10.0
15.0
14.0
28.0
32.0
21.0
3.0
1.0

FIGURE 24



Dissolved Oxygen Concentrations
Below 4 mg/l
New Jersey Coast
August
Chart Legend
JC14
JC61
JC27
JC69
JC41
JC75
JC53
JC85
Number of Observations
Year
1981
1982
1983
1984
1985

FIGURE 25



Dissolved Oxygen Concentrations
Below 4 mg/l
New Jersey Coast
September
Chart Legend
JC14
JC27
JC41
JC53
JC61
JC69
JC75
JC85
Number of Observations
50
45
40
35
30
25
20
15
10
5
0
1.0
3.0
6.0
7.0
3.0
8.0
11.0
13.0
8.0
6.0
1.0
2.0
1.0
12.0
11.0
14.0
15.0
7.0
5.0
5.0
4.0
1981
1982
1983
1984
1985
Year

tions below the 4 mg/l level, during July, August and September 1981-1985, for each perpendicular, except perpendicular MAS. From these figures, it is evident that 1985 had the greatest number of dissolved oxygen values less than 4 mg/l. The highest number of observations below 4 mg/l was 32, recorded in July 1985 at perpendicular JC 61. During July, August and September 1985, the northern perpendiculars had more low dissolved oxygen values than the southern perpendiculars, with JC 53 exhibiting the lowest values.

Tables 7 and 8 give additional meaning to Figures 23, 24 and 25. Table 7 summarizes the dissolved oxygen values below 4 mg/l during July, August and September along the New Jersey perpendiculars during the last 5 years. The percentage of samples below 4 mg/l was highest in 1985. In July, August and September 1985, the percentages were 49.2%, 82.2% and 60.3%, respectively. The highest percentages below 4 mg/l in the previous 4 years were 27.8% in July 1983, 34.8% in August 1981, and 51.7% in September 1983. Table 8 presents the percentage of the dissolved oxygen samples collected each year during the last 5 years along the New Jersey perpendiculars that were below 4 mg/l. The highest percentage was 59.9% in 1985, while the next highest percentage was 34.8% in 1983.

The dissolved oxygen values in 1985 were the worst that have been observed since the anoxia of 1976. Based on the data, an estimated 1,600 square miles of ocean off the New Jersey coast had stressful bottom dissolved oxygen conditions for extended periods of time.

Table 7

Dissolved oxygen (D.O.) values below 4 mg/l during July, August, and September along the New Jersey perpendiculars during the last 5 years (1981-1985)

July

Year	Number of samples collected	Number of D.O. values below 4 mg/l	Percent of samples below 4 mg/l
1981	115	21	18.3
1982	94	0	0.0
1983	194	54	27.8
1984	56	4	7.1
1985	252	124	49.2

August

Year	Number of samples collected	Number of D.O. values below 4 mg/l	Percent of samples below 4 mg/l
1981	135	47	34.8
1982	137	41	29.9
1983	57	13	22.8
1984	30	7	23.3
1985	118	97	82.2

September

Year	Number of samples collected	Number of D.O. values below 4 mg/l	Percent of samples below 4 mg/l
1981	10	0	0.0
1982	41	4	9.8
1983	120	62	51.7
1984	40	4	10.0
1985	121	73	60.3

Table 8

Percent of dissolved oxygen (D.O.) values below 4 mg/l along the New Jersey perpendiculars during the last 5 years (1981-1985)

Year	Number of D.O. samples collected	Number of samples below 4 mg/l	Percent of samples below 4 mg/l
1981	260	68	26.2
1982	272	45	16.5
1983	371	129	34.8
1984	126	15	11.9
1985	491	294	59.9

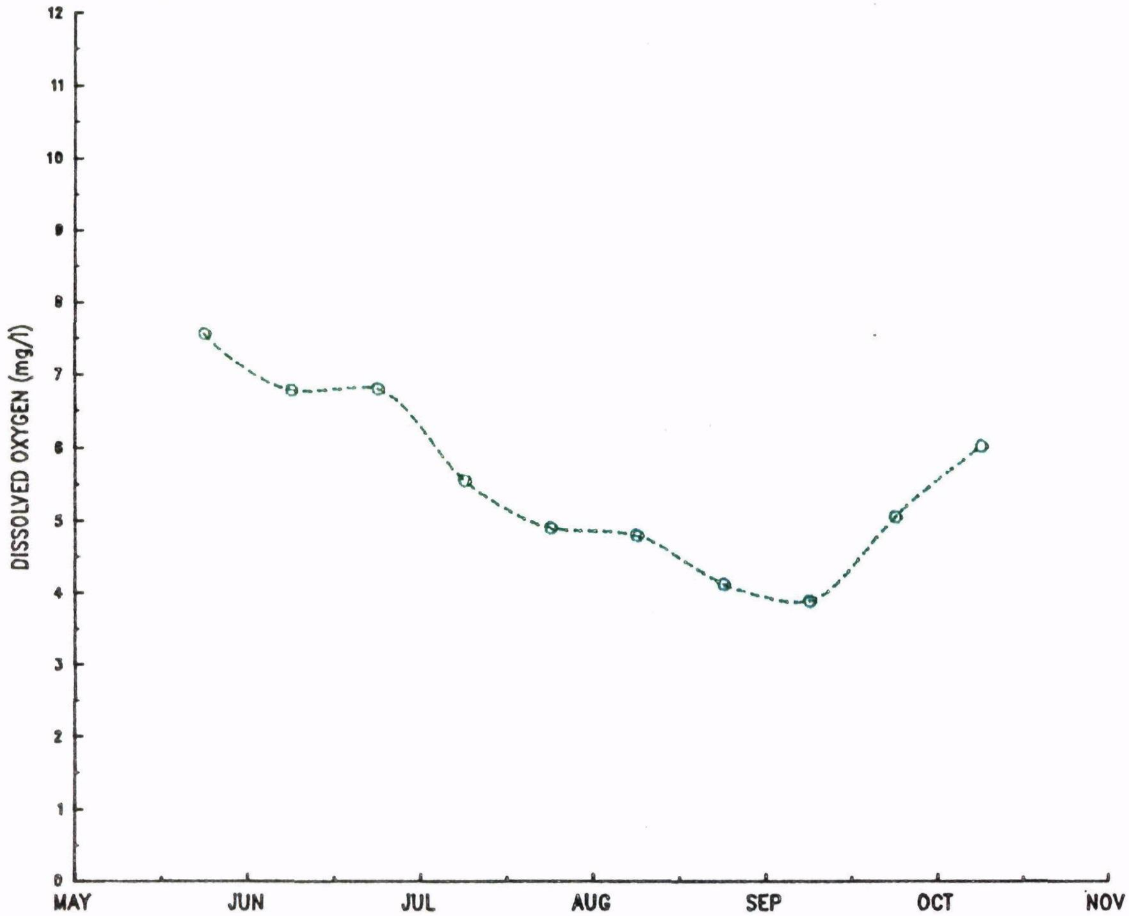
Dissolved Oxygen Trends

Figure 26 shows the five year dissolved oxygen average for the northern New Jersey perpendicular stations, made up of the arithmetic mean of all semimonthly averages. The average dissolved oxygen starts off at 7.5 mg/l in late May, drops to 6.8 mg/l in June and remains constant until late June. It then slowly declines to a low of 4.0 mg/l in early September and is followed by a rapid increase into October.

Figure 27 shows the five year dissolved oxygen average, made up of the arithmetic mean of all semimonthly averages, for the southern New Jersey perpendicular stations. In late May, the dissolved oxygen is 7.5 mg/l, decreases to 6.0 mg/l in early June, and is followed by a slight rise into late June. The dissolved oxygen then decreases slowly into late August reaching a low of 4.0 mg/l. A gradual recovery occurs in September and October.

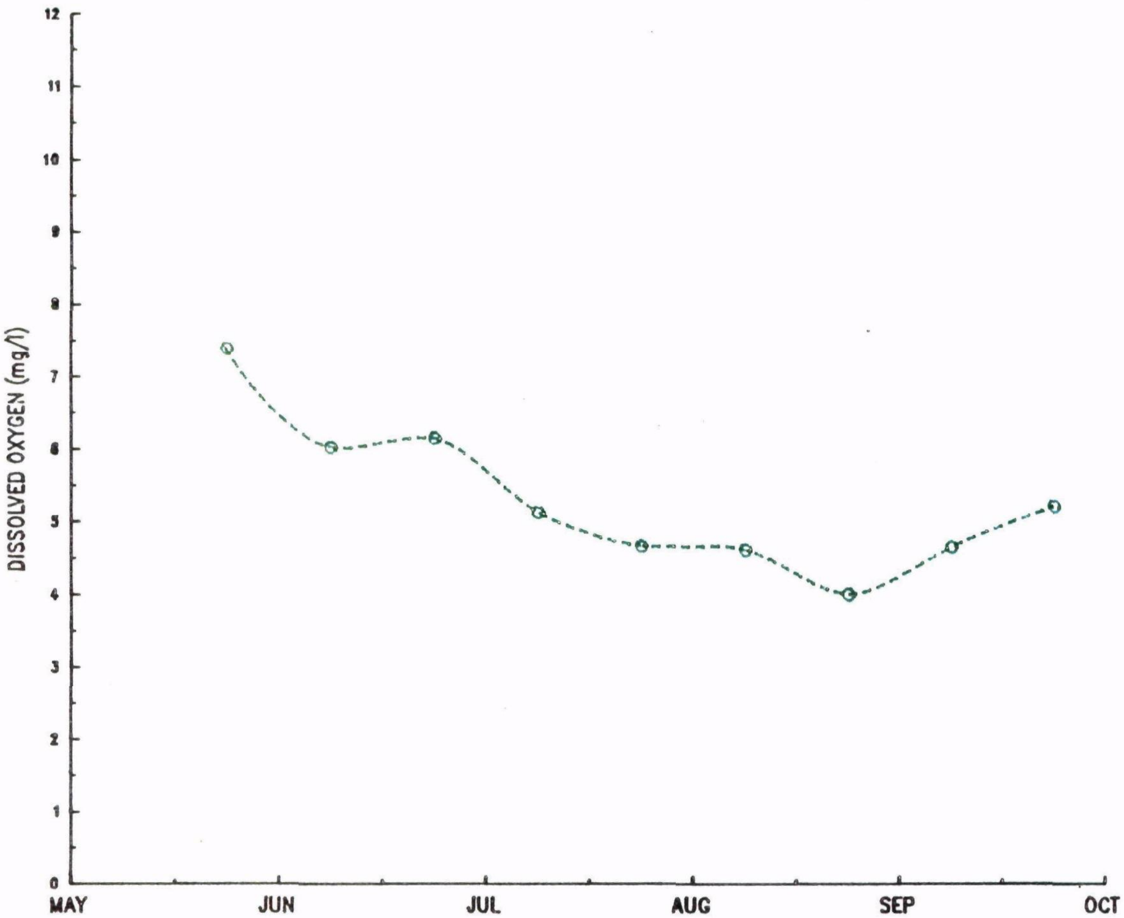
In comparing Figures 26 and 27 to Figure 12, the dissolved oxygen levels off the New Jersey coast in 1985 were substantially lower than the five year average.

FIGURE 26



NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1981 TO 1985

FIGURE 27



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1981 TO 1985

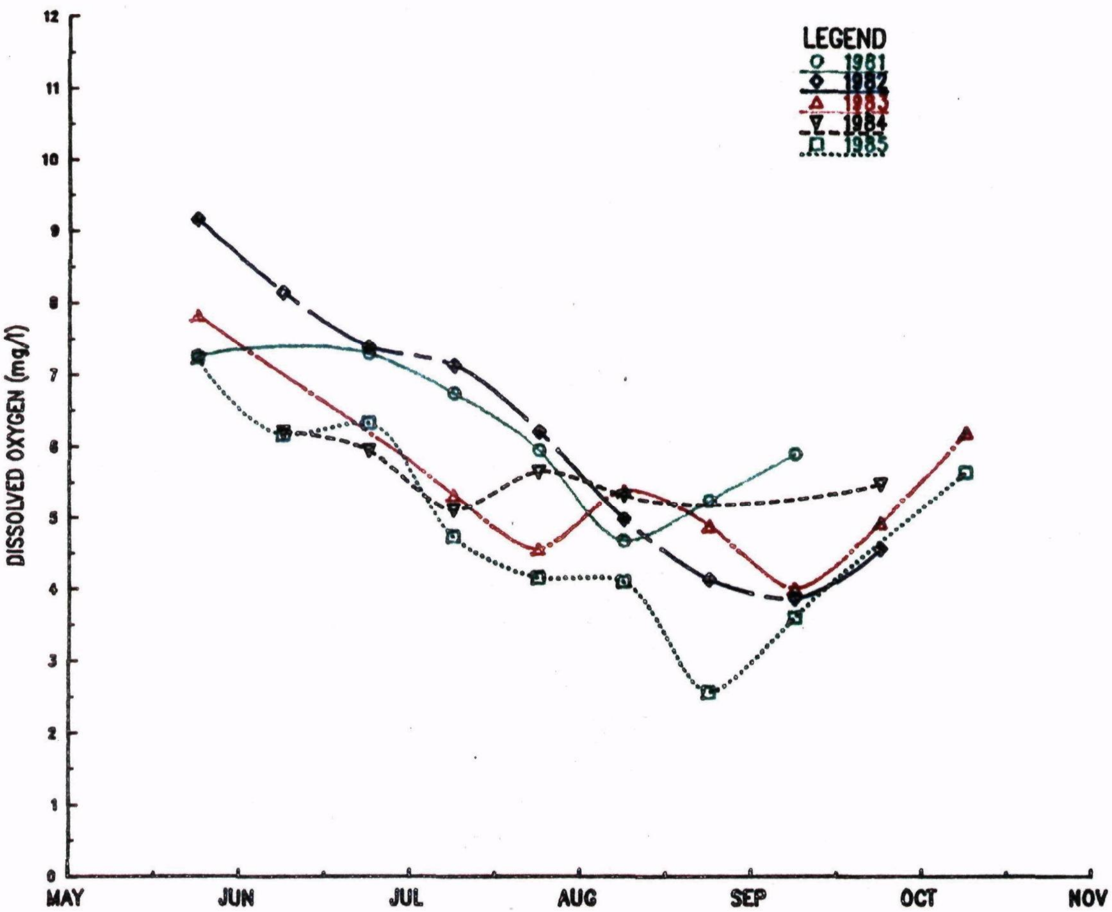
Figures 28, 29 and 30 illustrate the five year trends in dissolved oxygen for northern New Jersey perpendiculars, southern New Jersey perpendiculars and New York Bight stations, respectively.

Figure 28 illustrates that a dissolved oxygen "double minima" occurred in 1983 and 1984 along the northern New Jersey perpendiculars. During 1983, the first low occurred in late July, followed by the second low in early September. The "double minima" observed in 1984 was not as prominent as in 1983, with the first low occurring in early July and the second in early August. A "double minima" did not occur in 1981 or 1982. In both years the dissolved oxygen values declined gradually throughout the summer, reaching a low in early August 1981 and early September 1982. In 1985, the average dissolved oxygen values from early July to mid-September were approximately 1-3 mg/l lower than in the previous four years.

In 1985, along the southern New Jersey perpendiculars, Figure 29, the average dissolved oxygen started at 7.5 mg/l in late May, dropped to a low of 3.0 mg/l in early August, and was followed by an increase to 5.0 mg/l in early September. The only year a "double minima" was observed was 1981. Figure 29 illustrates that, for the most part, the southern New Jersey dissolved oxygen values in 1985 were lower than in the previous four years.

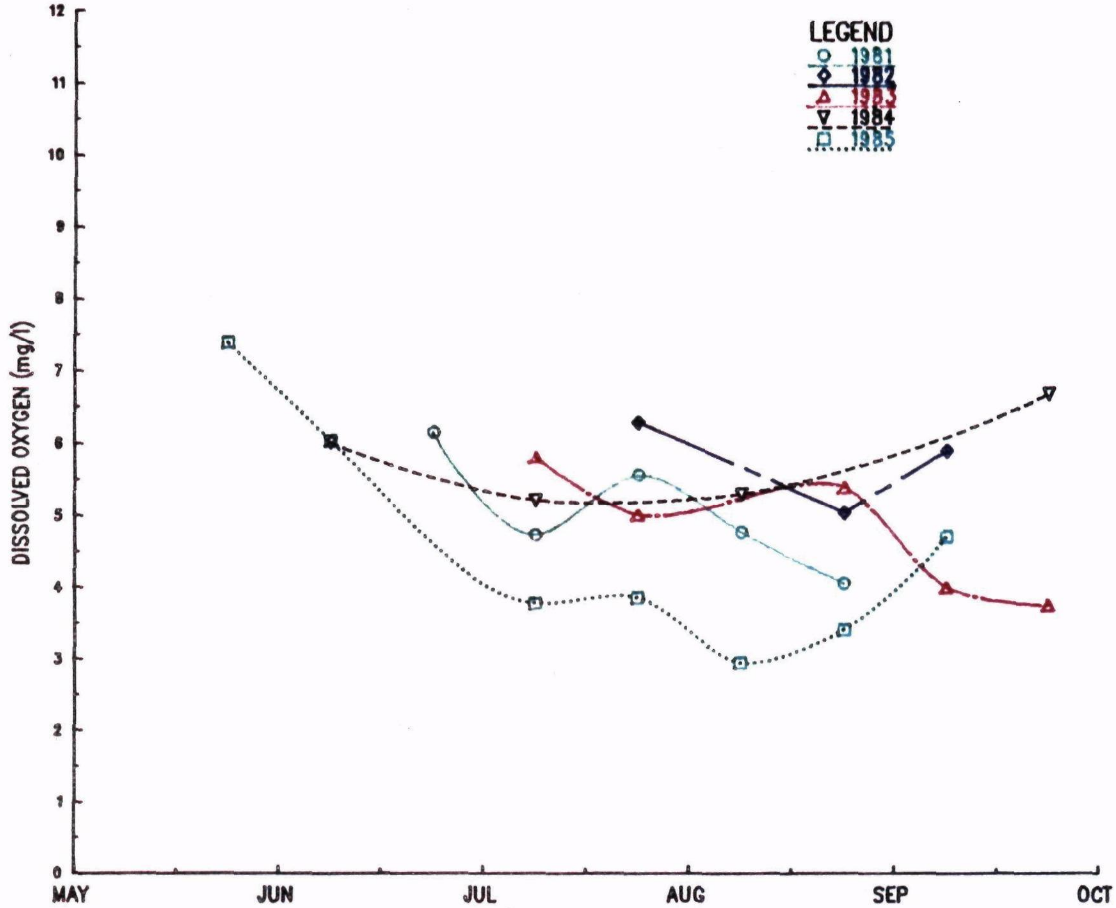
Figure 30 shows a comparison of all New York Bight stations for the years 1981-1985. In 1985, the dissolved oxygen was 7.7 mg/l in late May with an initial low of 4.6 mg/l occurring in early July, followed by a 1.0 mg/l recovery and then a second low of 4.1 mg/l in early August. A dissolved oxygen "double minima" was observed in 1981, 1983 and 1985. The dissolved oxygen average in 1985 was generally lower than the previous four years.

FIGURE 28



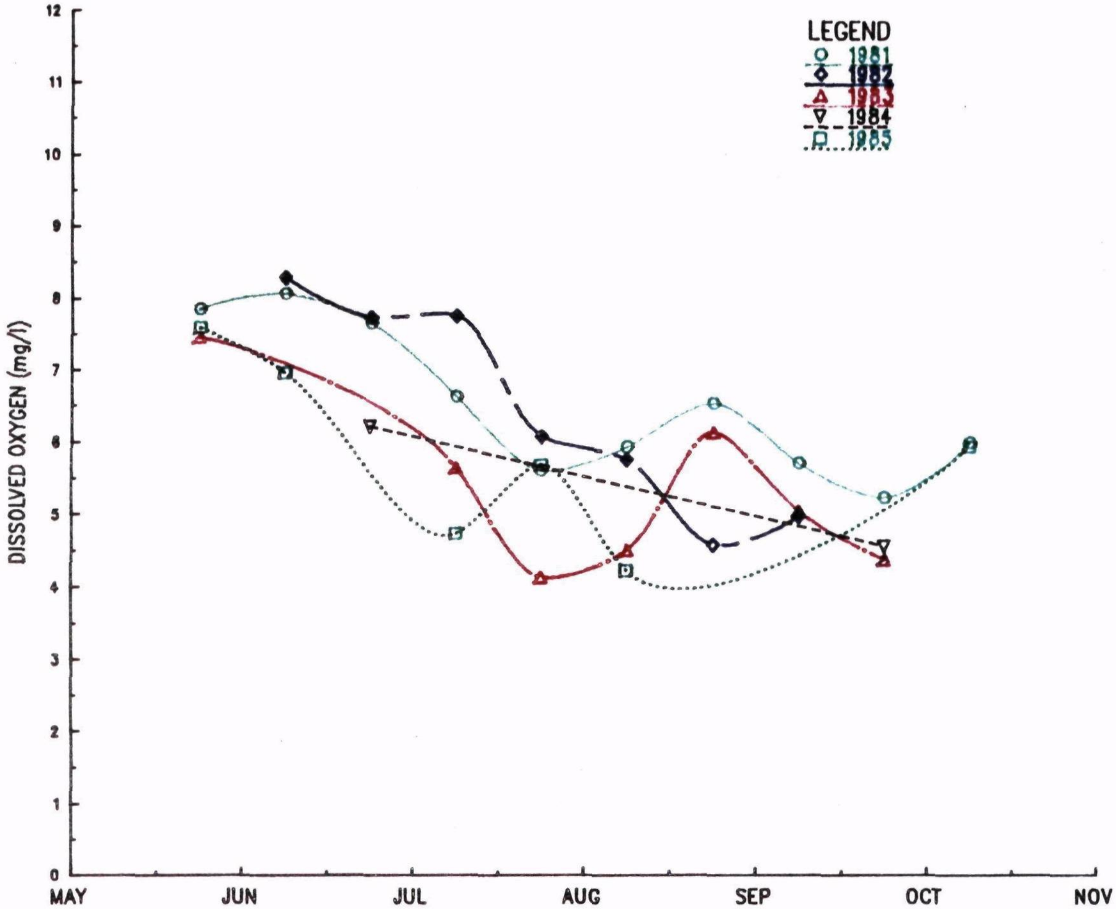
NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1981–1985 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC14–JC53 PERPENDICULAR STATIONS.

FIGURE 29



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1981–1985 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC61–JC85 PERPENDICULAR STATIONS.

<u>FIGURE 30</u>



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1981–1985 COMPARISON.
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

During the summer, the flight crew reported seeing discolored water, either red, green, or brown, on almost a daily basis. When the organisms responsible for the coloration died and sank to the bottom, they decomposed. This oxygen depleting process, combined with the lack of substantial winds and storm activity to aid reaeration, and the presence of a strong thermocline all contributed to the lower than normal dissolved oxygen concentrations experienced in 1985.

V. BACTERIOLOGICAL RESULTS

New Jersey

Table 9 presents a summary of the fecal coliform data collected along the coast of New Jersey between May 28, 1985 and September 9, 1985. The geometric mean for each station is plotted in Figure 31. The overall water quality standard for New Jersey is 50 fecal coliforms/100ml. The State standard for primary contact recreation along the New Jersey Coast is a geometric mean of 200 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, 8.0, was at station JC 93 at Wildwood. Stations JC 53 at Seaside Heights and JC 99 at Cape May Point had geometric means of 4.8 and 4.4, respectively. All of the geometric means are very low. Figure 31 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 279 samples were collected for fecal coliform analysis along the New Jersey Coast. Of the 279 samples, two or 0.7 percent were above 50 fecal coliforms/100ml. These samples were:

Station	Date Sampled	Fecal Coliforms/100ml
JC 21	8/26/85	104
JC 47A	8/26/85	70

The cause of the elevated value at JC 21 was probably poorly treated sewage from the Asbury Park Sewage Treatment Plant.

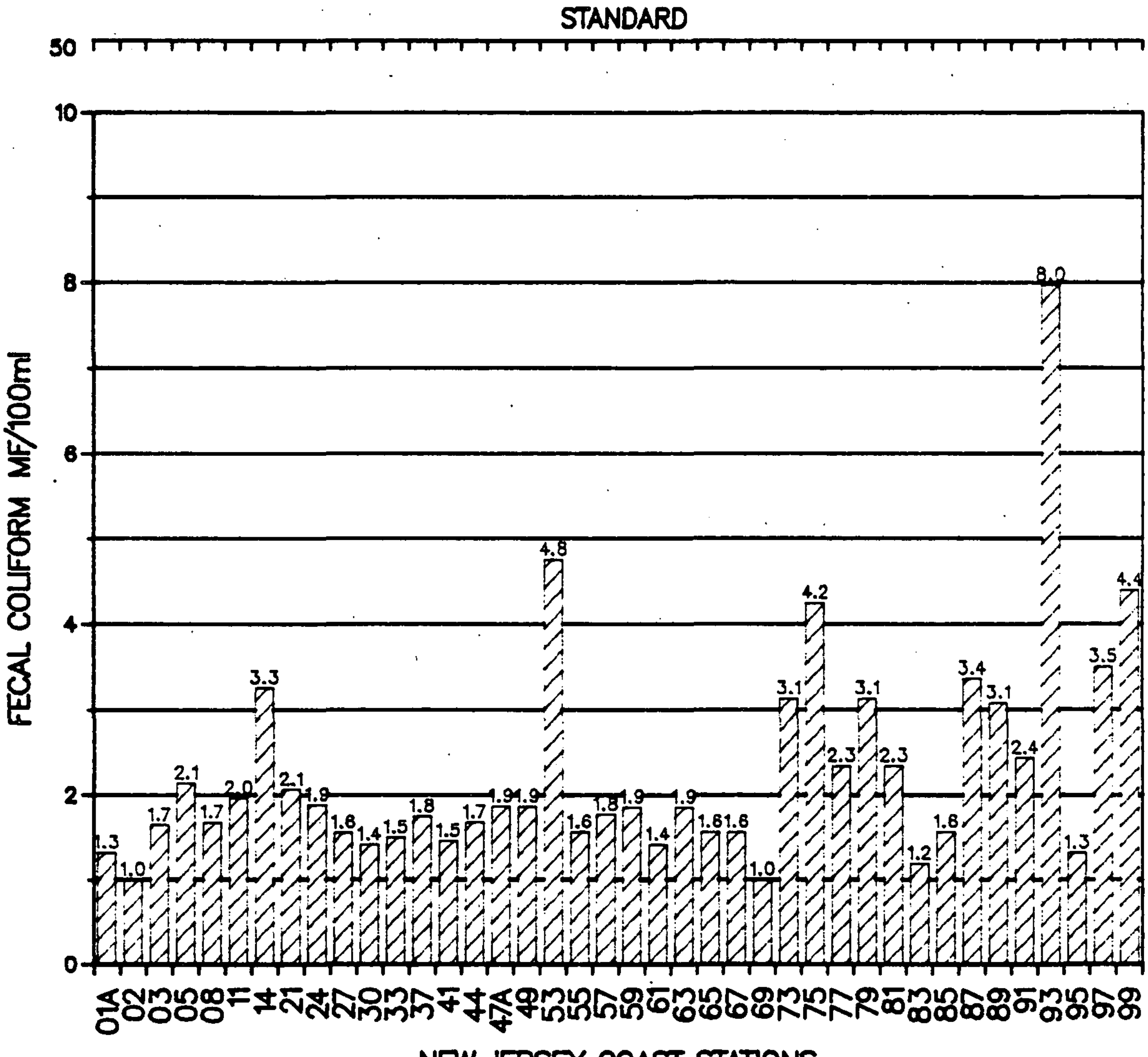
TABLE 9

Summary of bacteriological data collected along the New Jersey coast May 28, 1985 through September 9, 1985

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean* Fecal Coliform/100 ml
JC 01A	10	4	1.3
JC 02	10	1	1.0
JC 03	10	19	1.7
JC 05	11	40	2.1
JC 08	11	17	1.7
JC 11	11	19	2.0
JC 14	11	41	3.3
JC 21	11	104	2.1
JC 24	11	10	1.9
JC 27	10	7	1.6
JC 30	10	4	1.4
JC 33	10	29	1.5
JC 37	10	34	1.8
JC 41	9	6	1.5
JC 44	9	6	1.7
JC 47A	9	70	1.9
JC 49	9	46	1.9
JC 53	9	16	4.8
JC 55	9	14	1.6
JC 57	9	25	1.8
JC 59	4	12	1.9
JC 61	4	4	1.4
JC 63	4	6	1.9
JC 65	4	6	1.6
JC 67	4	3	1.6
JC 69	4	0	1.0
JC 73	4	12	3.1
JC 75	4	9	4.2
JC 77	4	30	2.3
JC 79	4	8	3.1
JC 81	4	5	2.3
JC 83	4	2	1.2
JC 85	4	6	1.6
JC 87	4	16	3.4
JC 89	4	9	3.1
JC 91	4	7	2.4
JC 93	4	42	8.0
JC 95	4	3	1.3
JC 97	4	25	3.5
JC 99	4	31	4.4

*Geometric means were calculated using the natural log.

FIGURE 31



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF NEW JERSEY, MAY 28, 1985 TO SEP 9, 1985.
(ACTUAL VALUES PRINTED ABOVE BARS)

Long Island

Table 10 presents a summary of the fecal coliform data collected along the coast of Long Island from May 16, 1985 through August 27, 1985. The geometric mean for each station is plotted in Figure 32. 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 during the 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 2.4, which occurred at station LIC 10. Station LIC 10 also had the highest geometric mean the last five years. LIC 10 is under the direct influence of any poorly treated sewage that may flow out of Jones Inlet. From Figure 32, 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 224 samples were collected during the summer along the coast of Long Island and analyzed for fecal coliform bacteria. The highest density found all summer, 18 fecal coliforms/100 ml, was at station LIC 16. This value is well below the New York State standard.

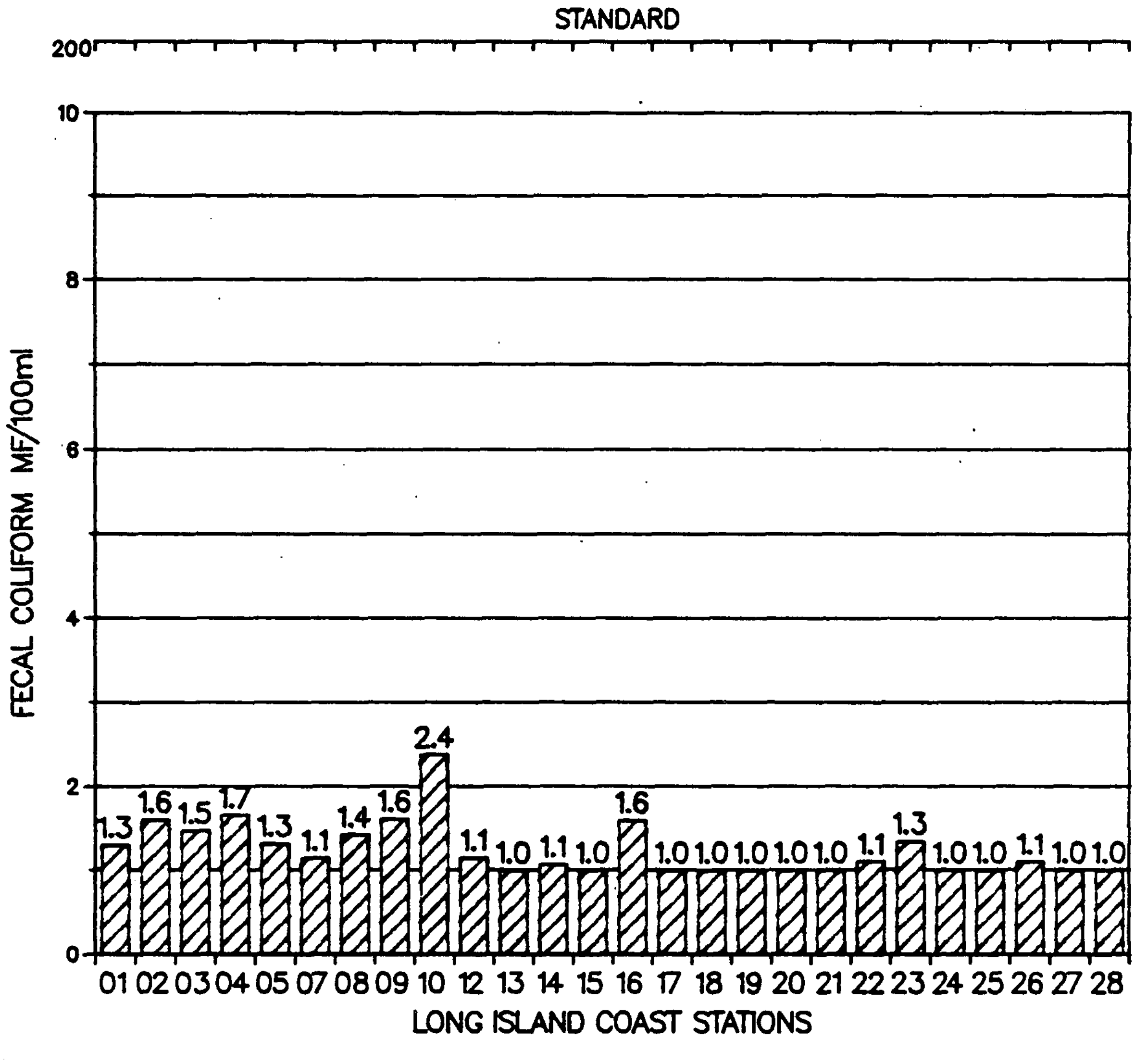
TABLE 10

Summary of bacteriological data collected along the coast of Long Island May 16, 1985 through August 27, 1985

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean* Fecal Coliform/100 ml
LIC 01	10	14	1.3
LIC 02	10	7	1.6
LIC 03	10	6	1.5
LIC 04	10	5	1.7
LIC 05	10	4	1.3
LIC 07	10	2	1.1
LIC 08	10	12	1.4
LIC 09	10	5	1.6
LIC 10	10	8	2.4
LIC 12	10	2	1.1
LIC 13	10	0	1.0
LIC 14	10	2	1.1
LIC 15	10	1	1.0
LIC 16	10	18	1.6
LIC 17	7	0	1.0
LIC 18	7	1	1.0
LIC 19	7	0	1.0
LIC 20	7	1	1.0
LIC 21	7	1	1.0
LIC 22	7	2	1.1
LIC 23	7	8	1.3
LIC 24	7	0	1.0
LIC 25	7	1	1.0
LIC 26	7	2	1.1
LIC 27	7	1	1.0
LIC 28	7	1	1.0

*Geometric means were calculated using the natural log.

FIGURE 32



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF LONG ISLAND, MAY 15, 1985 TO AUG 28, 1985. (ACTUAL VALUES PRINTED ABOVE BARS)

New York Bight Apex

During the summer of 1985 a total of 390 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 390 samples collected, five had a fecal coliform densities in excess of 50 fecal coliforms/100 ml. This represents 1.3 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 1980, 1981, 1982, 1983 and 1984 the percentage of samples having densities above 50/100 ml was 0.4, 0.7, 2.1, 0.9 and 0.4, respectively. The five high values found this past summer were:

Station	Date Sampled	Sample Depth (feet)	Fecal coliforms/ 100ml of sample
NYB 45	7/15/85	88	60
NYB 32	10/9/85	2	216
NYB 32	10/9/85	24	176
NYB 33	10/9/85	2	100
NYB 45	10/9/85	90	160

The elevated densities at station NYB 45 were probably due to recent disposal of sewage sludge at the sewage sludge disposal site. Stations NYB 32 and NYB 33 are under the direct influence of flow from the New York Harbor and Raritan Bay estuaries, both of which frequently have elevated fecal coliform densities.

Enterococci

The 1985 sampling program marked the first time 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: S. faecales; S. faecalis, subsp. liquefaciens; S. faecalis, subsp. zyogenes; S. faecium. Recent research has shown that enterococci bacteria show a better correlation than fecal coliforms to gastroenterologic illness caused by swimming in contaminated water. EPA criterion for marine waters of 35 enterococci bacteria/100ml was published in the Federal Register on March 7, 1986.

New Jersey

Table 11 presents a summary of the enterococci data collected along the New Jersey coast from May 28 to September 9, 1985. The arithmetic mean for each station is plotted in Figure 33. Figure 33 shows that the arithmetic mean of enterococci densities at each station is below the proposed criteria. The highest arithmetic mean, 23.3, occurred at station JC 99, Cape May Point. However, this station, as well as the other southern New Jersey coast beach stations, was sampled only four times during the summer. Slightly elevated enterococci densities occurred at JC 21, Asbury Park, and JC83, Peck Beach, with arithmetic means of 11.2 and 11.0, respectively. Based on enterococci data, the quality of New Jersey coastal waters is excellent.

A total of 279 samples were collected for enterococci analysis along the coast of New Jersey. Of the 279 samples, three or 1.1 percent were above the proposed criteria of 35 enterococci/100ml. The three samples

Table 11

Summary of enterococci data
collected along the New Jersey coast
May 28, 1985 through September 9, 1985

Station	Number of Samples Collected	Maximum Value Enterococci/100ml	Arithmetic Mean Enterococci/100ml
JC 01A	10	4	1.1
JC 02	10	15	2.2
JC 03	10	11	2.1
JC 05	11	6	1.0
JC 08	11	4	1.5
JC 11	11	8	2.4
JC 14	11	30	4.5
JC 21	11	92	11.2
JC 24	11	18	3.3
JC 27	10	6	2.1
JC 30	10	3	0.7
JC 33	10	32	5.2
JC 37	10	20	4.2
JC 41	9	17	3.6
JC 44	9	9	1.3
JC 47A	9	28	4.9
JC 49	9	20	3.1
JC 53	9	32	6.1
JC 55	9	16	1.9
JC 57	9	10	2.8
JC 59	4	5	1.5
JC 61	4	2	0.8
JC 63	4	4	2.3
JC 65	4	9	5.0
JC 67	4	2	0.5
JC 69	4	5	1.3
JC 73	4	4	1.3
JC 75	4	5	2.0
JC 77	4	17	4.3
JC 79	4	8	3.3
JC 81	4	4	1.3
JC 83	4	36	11.0
JC 85	4	29	8.5
JC 87	4	9	2.3
JC 89	4	16	7.3
JC 91	4	6	2.8
JC 93	4	15	5.0
JC 95	4	5	2.0
JC 97	4	20	6.3
JC 99	4	84	23.3

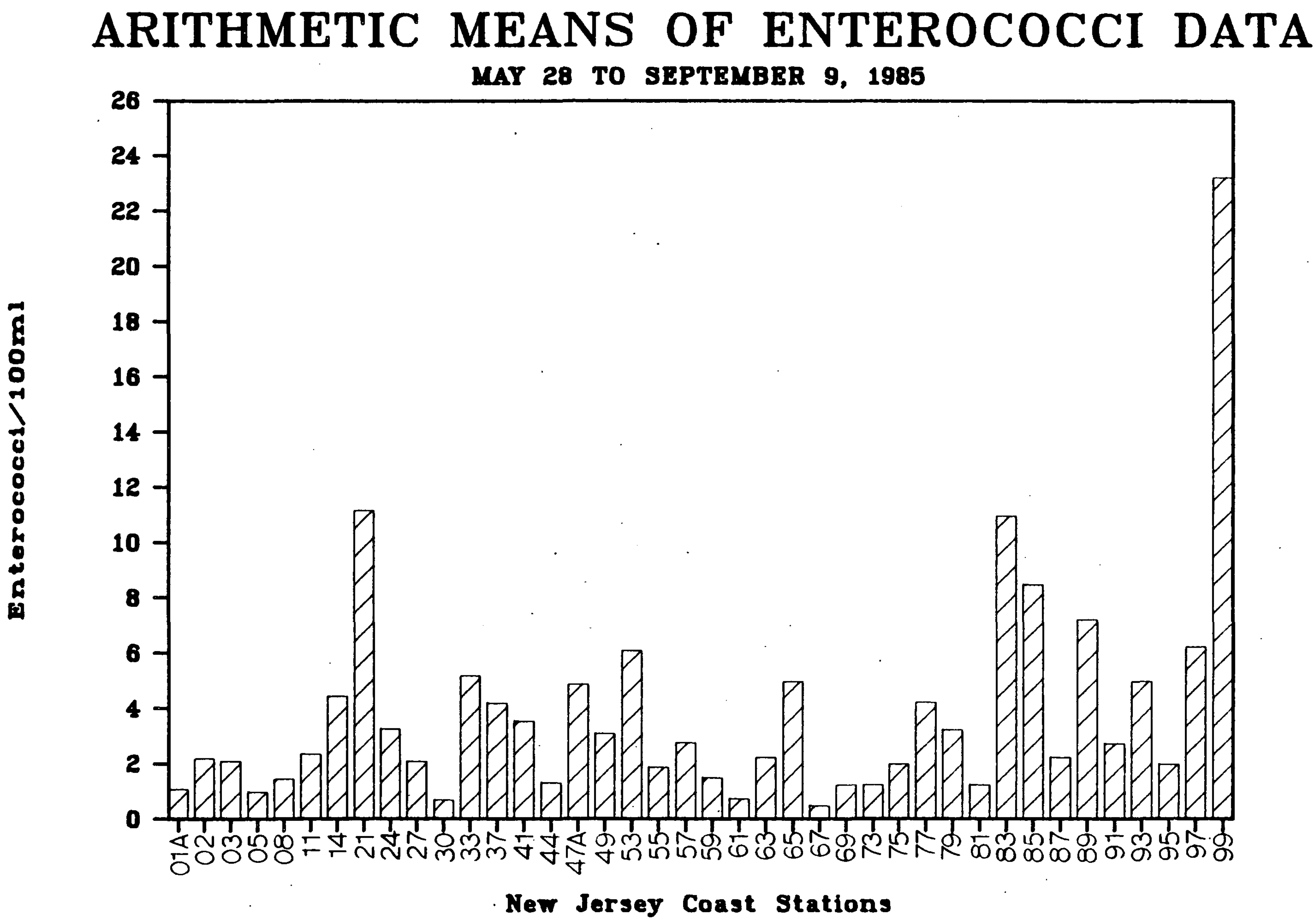

ARITHMETIC MEANS OF ENTEROCOCCI DATA
MAY 28 TO SEPTEMBER 9, 1985
Enterococci/100ml
0
2
4
6
8
10
12
14
16
18
20
22
24
26
01A 02 03 05 08 11 14 21 24 27 30 33 37 41 44 47A 49 53 55 57 59 61 63 65 67 69 73 75 77 79 81 83 85 87 89 91 93 95 97 99
New Jersey Coast Stations

FIGURE 33

were:

Station	Date Sampled	Enterococci/100ml
JC 21	8/9/85	92
JC 83	8/9/85	36
JC 99	6/6/85	84

The high density at JC 21 was probably caused by poorly treated sewage from the Asbury Park Sewage Treatment Plant. The high density at JC99 was probably due to poorly treated sewage from Delaware Bay. The probable cause of the elevated density at JC 83 is unknown.

Long Island

Table 12 presents a summary of the enterococci data collected along the Long Island coast from May 16, 1985 to August 27, 1985. The arithmetic mean for each station is plotted in Figure 34. Figure 34 shows the highest arithmetic mean, 5 enterococci/100ml, occurred at station LIC 04 at Rockaway, off B92 Road. Two stations, LIC 26 at Tiana Beach and LIC 28 east of Shinnecock Inlet, had no detectable enterococci densities throughout the summer.

A total of 198 enterococci samples were collected along the coast of Long Island during the summer. None of the samples exceeded EPA's criterion of 35 enterococci/100ml. The highest density, 32 enterococci/100ml, occurred at station LIC 04. This count was probably due to poorly treated sewage from the Hudson River estuary complex. Based on the enterococci densities, the water quality of the Long Island coast is excellent.

New York Bight Apex

During the summer of 1985 a total of 390 samples were collected in the

Table 12

Summary of enterococci data
collected along the Long Island coast
May 16, 1985 through August 27, 1985

Station	Number of Samples Collected	Maximum Value Enterococci/100ml	Arithmetic Mean Enterococci/100ml
LIC 01	9	10	1.3
LIC 02	9	18	2.4
LIC 03	9	6	2.1
LIC 04	9	32	5.0
LIC 05	9	3	1.1
LIC 07	9	4	0.9
LIC 08	9	5	1.7
LIC 09	9	4	1.6
LIC 10	9	8	2.0
LIC 12	9	2	0.8
LIC 13	9	2	0.4
LIC 14	9	7	1.1
LIC 15	9	2	0.6
LIC 16	9	11	2.3
LIC 17	6	2	0.3
LIC 18	6	4	1.0
LIC 19	6	3	0.7
LIC 20	6	6	1.2
LIC 21	6	2	0.5
LIC 22	6	2	0.5
LIC 23	6	1	0.2
LIC 24	6	1	0.2
LIC 25	6	4	0.8
LIC 26	6	0	0.0
LIC 27	6	3	1.5
LIC 28	6	0	0.0

ARITHMETIC MEANS OF ENTEROCOCCI DATA

MAY 16 TO AUGUST 27, 1985

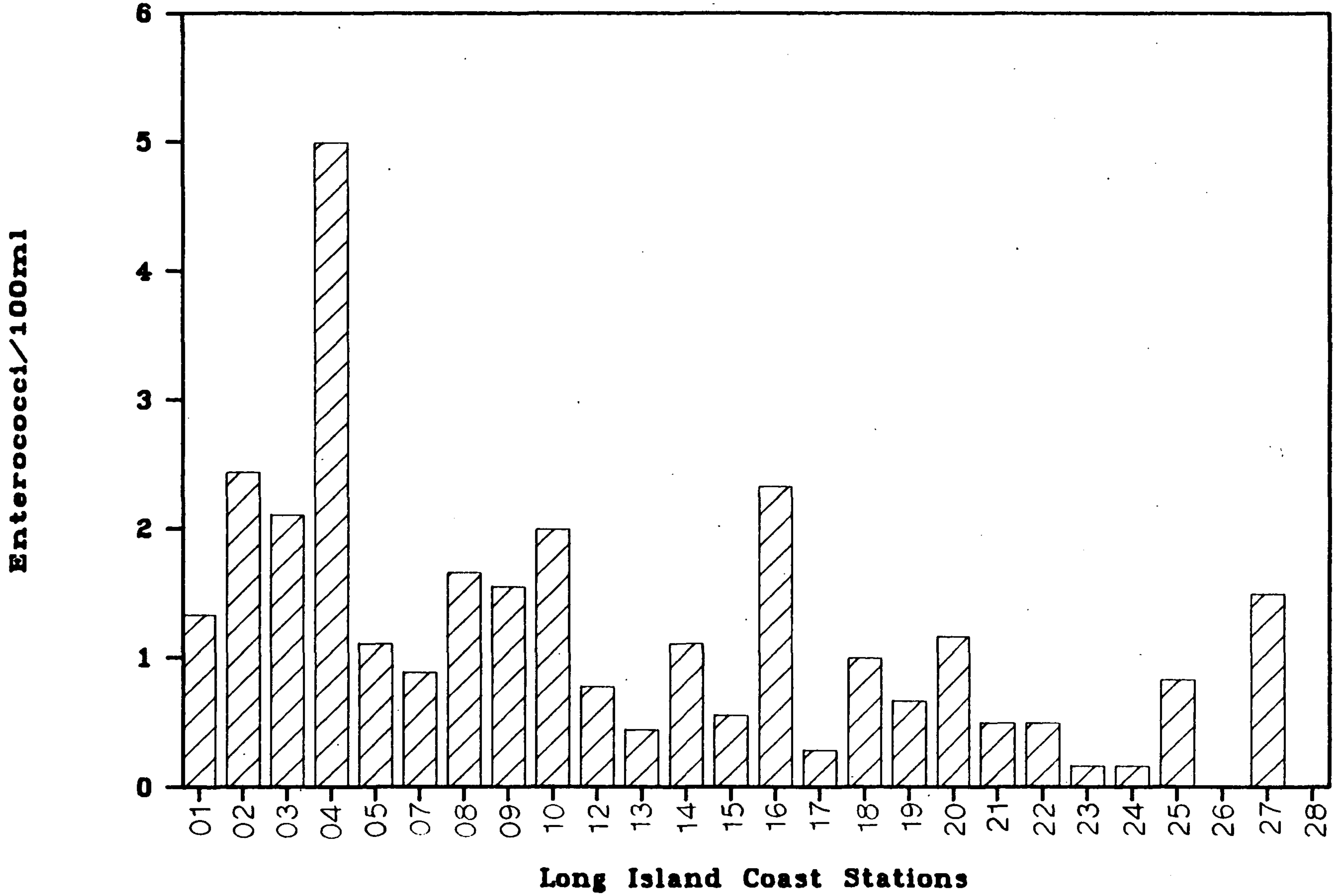


FIGURE 34

inner New York Bight for enterococci analysis. The stations sampled were the same as those sampled for fecal coliforms. Of the 390 samples, three or 0.8 percent were above the proposed criteria of 35 enterococci/100ml. The three samples were:

Station	Date Sampled	Depth (feet)	Enterococci/100ml
NYB 25	7/15/85	76	460
NYB 25	8/6/85	76	112
NYB 45	7/15/85	88	204

The cause of these elevated densities was recent sewage sludge dumping at the sewage sludge dump site.

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 B. When Appendix B was written, the proposed enterococci criteria was 3/100ml. The discussion presented in Appendix B is based on this proposed criteria rather than 35 enterococci/100ml used throughout this report.

VI. BEACH CLOSINGS

During the summer of 1985, a number of beaches were closed for short periods of time due to the washup of sewage-related materials. Some of the beaches experiencing these closings were Sea Girt, Belmar, Bradley Beach and Ocean City. Only two water quality problems, due to high fecal coliform densities, forced health officials to close swimming beaches along the New Jersey coast. These closings occurred in Asbury Park, Monmouth County and Wildwood, North Wildwood and Wildwood Crest, Cape May County. Both incidences occurred in late August and are attributed to heavy rains, which caused sewage treatment plant by-passing, resulting in high fecal coliform counts at the beaches. Dredging conducted by the New Jersey Department of Environmental Protection (NJDEP) in Herford Inlet may also have contributed to the elevated densities at the Wildwoods in Cape May County. EPA, NJDEP, and the county health departments monitored the fecal coliform densities at the affected beaches.

Monmouth County beaches sampled by the EPA on August 26 indicated elevated fecal coliform counts; the highest density, 104/100ml, occurred at station JC 21 (Asbury Park). The Monmouth County Health Department also obtained high densities at this time. The beaches in Asbury Park were closed on August 30. They were reopened the following day based on low densities found in samples collected on August 29.

The Cape May County Department of Health banned swimming at Wildwood, North Wildwood and Wildwood Crest Beaches on August 22 due to high fecal coliform densities in samples collected from August 18 to August 20. As a result, EPA established twenty-five special stations which were sampled, using the EPA helicopter, on August 22, 23, and 26. Initial sampling on

August 22 showed some elevated fecal coliform densities. The highest were 60/100ml and 21/100ml. The densities were much lower on August 23, with the highest being 13/100ml. The August 26 sampling showed no detectable fecal coliform densities. On August 28 the Wildwood Beaches were reopened for bathing.

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APPENDIX A

SUMMARY OF PHYTOPLANKTON BLOOMS and RELATED EVENTS in NEW JERSEY COASTAL WATERS SUMMER OF 1985

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

INTRODUCTION

Each year from May to September, the NJDEP monitors marine algal blooms responsible for the recurrence of "red tides" and other instances of discoloration in our coastal waters. Phytoplankton sampling and analysis is coordinated by the DWR Bureau of Monitoring and Data Management (M&DM) primarily in conjunction with the EPA Region II helicoptor surveillance unit as part of their New York Bight Water Quality Monitoring Program. Helicopter monitoring is also conducted for bottom dissolved oxygen on transects perpendicular to the shore and for bacteriological water quality in the surf. Additional analyses are performed for the shore county environmental health agencies in response to localized blooms, while the counties conduct routine bacteriological monitoring as part of the Coastal Cooperative Program. Assistance is also provided by the DWR Bureau of Shellfish Control, DEP Bureau of Marine Fisheries, and the National Marine Fisheries Service at Sandy Hook.

Red tides have occurred annually, usually beginning in mid-June, in the Lower New York Bay estuarine system, and subsequently extending to adjacent New Jersey coastal waters. Thus, our original survey and monitoring efforts were concentrated in the northern shore area. The blooms have been documented for over 20 years; several phytoflagellate species, principally *Olisthodiscus luteus* and *Prorocentrum* spp. were responsible. Blooms elsewhere in New Jersey were inconspicuous, or they were localized and of short duration. For the past few summers, however, algal blooms have been responsible for extensive areas of greenish colored water off the central to southern N.J. coast. Fortunately for us, these red and green tides were not the acutely toxic varieties such as those which contaminate shellfish, causing paralytic shellfish poisoning (PSP) in the New England region or wide-spread fishkills in Florida. However, they have been known to produce respiratory discomfort and minor irritation in bathers. Of note here was the bloom of *Prorocentrum micans* which covered the Monmouth county shore in 1968 and, to a lesser degree, in other years. In addition, the blooms imparted an unaesthetic quality especially upon decomposition.

1985 HIGHLIGHTS

DATE	
	Phytoytoplankton species succession is summarized in Table 1; nutrient data, in Tables 2 and 3; major events are presented below.
May 21,28	When sampling commenced on May 28, a late spring diatom flowering was in progress with highest cell densities in Sandy Hook Bay. The dominant species was *Cerataulina pelagica,* with *Asterionella* and *Thalassiosira sp.* abundant, and various phytoflagellates present. Also during May, dissolved oxygen readings as low as 2.0 ppm were found on the bottom of Sandy Hook Bay by personnel of the National Marine Fisheries Service.
June 12 20,25	In mid-June, phytoflagellates gained dominace with blooms occurring primarily in Raritan and Sandy Hook Bay; dominant species included *Olisthodiscus luteus*, *Katodinium rotundatum* and *Euglena (Eutreptia)* sp. During the latter part of June, a bloom of *Prorocentrum redfieldi,* with various other species present, occurred in Sandy Hook Bay, while diatoms were abundant in ocean samples taken south of Spring Lake.
July 2	This condition persisted into early July with the *P. redfieldi* bloom extending southward in patches along the Monmouth ocean front at least to Spring Lake.
4	On July 4, special samples taken by the Monmouth Co. Health Department in the Long Branch to Asbury Park sector contained many diatoms which were apparently associated with masses of decomposing cells of *P. redfieldi*.
9	Also in July, yellowish brown water was reported in portions of Barnegat Bay. Examination of samples taken on July 9 in the bay at Surf City revealed substantial blooms of a minute chlorophyte, likely *Nannochloris atomus*, which is normally dominant in the Sandy Hook vicinity in late summer. Extensive mats of decomposing eelgrass *(Zostera* sp.)

Date

July — were also noted along the bay shore at Surf City. Through July, the murky water, sometimes greenish in color, was also reported in ocean waters at Island Beach and Long Beach Island. Later in
18 — the month, various phytoflagellates, particularly *K. rotundatum*, were also abundant in Raritan Bay and in ocean stations southward to Island Beach.

Because of critically low dissolved oxygen levels($\leq$2.0ppm), the EPA helicopter was diverted from the beach run to sampling perpendicular transects. Therefore, gaps are present in phytoplankton data for our northern stations beginning in late July and continuing through August. A D.O. sag usually occurs in late summer in a contained cell off northern Ocean County, but now the condition extended significantly farther south (to Beach Haven) and farther offshore than usual. Dissolved oxygen results are discussed in the EPA report.

30 — Supplementary data collected July 30 through August 7 aboard the DEP shellfisheries boat, the R.J. Sullivan, revealed D.O. levels generally higher than 2.0ppm from surf to five miles offshore south of Beach Haven to Atlantic City. Possible association of algal blooms with low bottom D.O. levels was investigated by concurrent phytoplankton sample collections. A substantial bloom of *Nannochloris* sp. (to 300,000 cells/ml) within three miles of shore from Beach Haven to Brigantine was observed. Simultaneously, a conspicuous abundance of jellyfish, primarily *Cyanea* sp. (roughly one individual per square yard of ocean surface), was noted to a minimum of ten miles off Beach Haven.

<u>Date</u>

<u>July</u> The third week of July bright green water was
reported along the beaches of sourthern New
21 Jersey, first in the vicinity of Hereford
Inlet and, subsequently, at Ocean City. At
24 this time, water temperatures up to 75°F
were reported within the latter area. To the
27 north, an onwelling of cooler water brought
temperatures of 58-60°F into the surf of
29-31 Ocean County as reported from Island Beach
By the fourth week of July, the brilliant
green water was reportedly most apparent in
Ocean City from 20th Street to the south
end while it was also seen at points southward to Hereford Inlet.

<u>August</u> The first week in August, samples were taken
by Ocean City lifeguards at 47th and 55th
7 Streets; examination of these revealed the
same causative organism as in last year's
"green tide", an unarmored dinoflagellate
with bright green chromatophores. Since the
cells preserved poorly, identification
remained tentative as <u>Gymnodinum</u> sp. Sample
counts taken were as high as 30,000 cells/ml.
During this week, some of the lifeguards experienced various symptoms including nausea,
sore throat and sinuses, eye irritation,
fatigue, dizziness, fever and lung
congestion. The lifeguards were possibly
affected by aerosols of the material from the
surf as well as by immersion. Most persons
on the beach were apparently unaffected.

10 The second week of August, a northward drift
by the green tide was evident after it had
been most concentrated toward the south end
of Ocean City. On the 10th (Sunday) beaches
12 from 29th to 37th Streets were closed, due to
the presence and odor of the algae. Several
13 complaints arose from the Atlantic City area,
but no beach restrictions were imposed. On
the 13th, observations and samples taken
aboard the R.J. Sullivan showed the algae
14 much more concentrated from the north end of
Ocean City near 9th Street, around Great Egg
Inlet, and all along Absecon Island to
Absecon Inlet. It was generally concentrated
in patches within a half-mile of the surf
zone but extended out one to two miles in the
estuarine plume. The yellow-green color was

Date

August

most vivid around mid-day after waters appeared greenish brown in early morning.

9 to 29 The bloom of *Gymnodinium* sp. apparently peaked about this time. North of Atlantic City, the green tide was not as evident as in 1984.

While abundance of *Gymnodinium* sp. peaked in mid-August, the murky greenish coloration, which was earlier evident north of Atlantic City, expanded throughout our coastal waters in shades varying from light green to yellowish-brown. Formerly, this condition had occurred commonly only in Raritan Bay and adjacent areas. It became apparent every where from Sandy Hook to Cape May County, with a similar condition pervading the intracoastal area from Great Bay to upper Barnegat Bay. *Nannochloris* sp. was ubiquitous and clearly dominant almost everywhere, while warm water temperatures prevailed. In late summer, several potential red-tide species including *Katodinium rotundatum* and *Prorocentrum redfieldi*, as well as *Gymnodinium* sp., were also abundant in our northern coastal waters.

28 The offshore extent of this condition was confirmed by fishermen who reported turbid green water instead of the normally clear blue water as far out as the Hudson Canyon. Fishing for some species was apparently affected by the murky surface layer. Bottom dissolved oxygen levels remained low between Manasquan and Beach Haven transects; however, only a few minor fishkills of demersal species were reported, primarily in the area one to two miles off Manasquan Inlet.

Parallel situations that developed in late August compromised sanitary quality along bathing beaches when sewage overflows occurred at Wildwood and, subsequently, at Asbury Park. Material resembling sewage washed ashore at Sea Girt and adjacent sec-

29 tions of Monmouth County. A few scattered reports were received of bathers becoming ill, but no direct associations could be made with surf conditions.

Date

September

5 The murky greenish water remained through most of September. Samples taken on transects by the EPA helicopter just before and after Labor Day showed *Nannochloris* in heavy blooms quantities up to ten miles off Manasquan Inlet (cell counts to 400,000/ml)
9 and only slightly lower off Atlantic City. Densities were moderately heavy on other transects between Barnegat and Strathmere. Counts of *Nannochloris* remained moderately high while diatoms, particularly *Phaeodactylum tricornutum*, increased in abundance in samples taken the second week of September; this included both northern shore stations and lower Cape May County stations.

11 The second week of September a strong northeast storm resulted in an abrupt increase in bottom dissolved oxygen levels to 6.0ppm or better at all stations sampled. With this overturn effected, waters still remained somewhat murky as numbers of *Nannochloris* gradually diminished and diatoms gained in
27 prominence. Hurricane Gloria, in late September, forcefully stirred the water column, resulting in a heavy suspension of organic matter and even a few scattered red tide blooms (likely *Prorocentrum* sp.) off Ocean County. Waters remained somewhat turbid until late October.

DISCUSSION

Phytoplankton productivity, reflected in both species composition and cell densities, is high in our coastal waters, especially in the northern region (see table 1). Certain differences in bloom incidence, however, have been apparent the past few summers. Red tides around Sandy Hook which were dominated by Olisthodiscus luteus, have been less intense than in former years; similarly, blooms of Prorocentrum spp.and Katodinium rotundatum have been sporadic in Monmouth County waters. The green tide events caused by Gymnodinium sp., which occurred in southern New Jersey the past two summers, were not previously experienced to such an extent. Additionally, in 1985, the greenish-brown water caused by Nannochloris sp. had not previously been observed over such a large area. Though less conspicuous, its extent was similar to the Ceratium tripos bloom of 1976; however, hypoxic conditions 1985 were not as uniformly widespread as in 1976.

While nutrient sources are substantial, especially in our northern waters, phytoplankton production is usually governed by other factors such as temperature and light intensity. Additionally, bloom development and dissipation is physically influenced by tides and weather conditions as well as by zooplankton grazing. Flagellate blooms remain an annual occurrence in Sandy Hook Bay, where hydrographic conditions are optimal for phytoplankton accumulation. Outside the estuary, within the New York Bight "apex", phytoplankton activity may be more limited by currents and turbulence. Oceanographic and meteorological conditions may serve in transporting potential bloom species from offshore; this is a possibility in the case of the green tide, which also occurred in adjacent regions such as Long Island. Chemical as well as physical factors may be responsible for the lack of green tides in our northern waters as well as for the reduced intensity of certain other phytoflagellates. With increasing anthropogenic nutrient sources, including sewage and dredge spoils, combined with high urban and agricultural runoff and nutrient inputs from adjacent areas, growth suppression within the apex would influence phytoplankton productivity over a larger area. This appears to be true of the 1985 Nannochloris bloom being ubiquitous over much of our Continental Shelf.

It is well-documented that our northern coastal waters are largely influenced by the Hudson/Raritan estuary throughout the Bight apex, e.g. at least as far south as Manasquan Inlet. This is enhanced by the Coriolis effect which, in this hemisphere, causes effluents to curve to the right in the course of their trajectories. To compound this, a general onshore drift (the Gulf Stream counter-current) and the predominance of southerly winds in summer may combine to cause a net counter-clockwise gyre off the Monmouth and Ocean County shore. It is within this area, particularly in southern Monmouth County, that wash-ins of unaesthetic material occur from time to time. A substantial benthic oxygen demand would be generated by phytoplankton, zooplankton grazing, plus jellyfish and other pelagic forms, combined with organic loading from runoff and other anthropogenic sources settling within this gyre.

A different system, less influenced by the Hudson/Raritan estuary, is apparent in southern New Jersey. Several smaller inlets bring nutrients to the ocean from marshes and estuaries such as the Great Bay-Mullica River and Great Egg Harbor systems. With the southerly winds of summer, this may create a swirling action similar to that in our northern waters. However, the coastline from Atlantic City to Ocean City curves inshore to the southwest forming a large, relatively sheltered cove. This geographical feature, associated with onshore winds, may serve to hold warm water along the shore resulting in stimulation of phyto-flagellate growth.

Wind, or lack of it, significantly effects vertical mixing as well as phytoplankton accumulation. As with effluent plumes, wind-induced currents in this region also progress at angles to the right. Sustained westerly or southerly winds have the effect, along much of New Jersey, of pushing surface water offshore, allowing onwelling of cooler bottom water inshore. This can result in an abundance of cool-water planktonic forms, such as diatoms, even in summer. The upwelling occasionally carries in dark-colored flocculent material remnant of previous phytoplankton blooms. The net force of southerly winds is seen along the N.J. shore in littoral drift effects most evident north of Island Beach, while the effects of northeasterly winds along shore are more apparent southward of Barnegat Inlet. A strong northeasterly wind, while holding warmer water inshore, has a positive effect against stratification through the downwelling of seas forced directly onshore. A lack of northeast storms along our coast in summer tends to result in pronounced vertical stratification and bottom hypoxia. During the 1985 summer season, vertical stratification of the water column was not evident shallower than 10M or about the 30ft. depth contour. Critically low bottom dissolved oxygen levels were found off Beach Haven and northward where the 30ft. contour comes within one mile of the beach. From Beach Haven south, inshore waters are shoaled to the extent that the 30ft. contour extends beyond three miles off Brigantine and Atlantic City, and to approximately two miles off Ocean City. Critically low bottom dissolved oxygen readings were not found in these areas.

Table 1. Succession of major phytoplankton species found in the 1985 survey. Dominance (+) was attained when cell densities of a species at some point exceeded 10^3/ml (10^4 for *Nannochloris* sp.); sub-dominance was noted when cell counts approached but did not exceed 10^3/ml. Blooms (*) became apparent when counts greater than 10^4/ml (10^5 for *Nannochloris*) produced visible water coloration. Sampling periods are as follows: a. May 28; b. June 6,12; c. June 20-July 9; d. July 18-August 14; e. August 29-September 12. Sampling locations are designated as: 1. Raritan-Sandy Hook Bay; 2. Sandy Hook-Monmouth Beach; 3. Long Branch-Sea Girt; 4. Manasquan-Island Beach; 5. Long Beach Island-Brigantine; 6. Atlantic City-Ocean City; 7. Strathmere-Cape May.

Table 1. Routine Sampling Locations[1] | Non - Routine Locations

Species	1 abcde	2 abcde	3 abcde	4 abcde	5 cde[3,4]	6 de[4]	7 de
diatoms							
Leptocylindrus sp.		-	- +	- -			
Skeletonema costatum	+ -*	---++	- - +	+-	-	-	--
Cyclotella sp.	+- +	+- +	-	- +			
Thalassiosira gravida	----	+	-++	+-		-	
T. nordenskioldii	+	-+-	-				-
Cerataulina pelagica	*	* +	+ +	+ +-	-	--	--
Chaetoceros sp.	-	- -		- -		+	
Asterionella glacialis	+ +	+++	-++	- +			
Phaeodactylum tricornutum	+ *	-*	--*	-+	-	--	+
Nitzschia seriata	+		+				-
Cylindrotheca closterium		-	+-				-
dinoflagellates							
Prorocentrum micans		-			-		
P. minimum	+ -	- -		-			
P. redfieldi	+*-	--	+ +	-+			
Gymnodinium sp.[2]	- --	--	- -	- +	-	*	-
G.danicans	++ +						
Katodinium rotundatum	* *-	-+ +-	+ ++	++	-+	-	-
Heterocapsa triquetra	+						
Peridinium trochoideum	--+		- -			-	-
other phytoflagellates							
Olisthodiscus luteus	+*++	+- +	- +		-	-	-
Calycomonas sp.	+-++-	+-+--	-+	-+-		-	-
Pyramimonas sp.	+--	- -+*	- -+-	-++			-
Tetraselmis sp.	+	+ -	- -	+ -			
Euglena/Eutreptia sp.	-*++	----	--	- --			--
Chroomonas sp.	-+*+	--+	-+	+		-	-
Cryptomonas sp.							
Rhodomonas sp.	++++	+-+ -	-+ +	-- -+			
chlorophytes							
Chlorella sp.	+++	--	--+		-		-
Nannochloris sp.	+++*+	+++**	--++*	++ +-+**[5]	***	+*	+*

Footnotes:

1. Routine sampling locations correspond with EPA stations RB32, RB15, NYB20, JC05, JC11, JC21, JC30, JC37, JC57.

2. This species responsible for green tides.

3. Sample taken in intra-coastal waters.

4. Includes samples taken on transects to five miles out.

5. Includes samples taken on transect to ten miles out.

TABLE 3.
NUTRIENT DATA CONTINUED
P:Total/Ortho (mg/l)
SAMPLING LOCATION

DATE	1	2	3	4	5	6	7	8	9
May 28	.060/.120	.120/.130	.070/.080	.130/.080	.070/.100	.090/.060	.060/.080	.060/.060	.060/.060
June 12	.100/.080	.090/.070		.080/.060	.060/.070	.060/.050	.080/.070	.050K/.060	.060/.070
27	.150/.420	.200/.400	.100/.280	.120/.290	.170/.290	.090/.290	.130/.260	.150/.250	.170/.230
July 2	.280/.280	.230/.330	.130/.160	.150/.160	.220/.290	.180/.300	.100/.170	.100/.090	.110/.170
August 9	.120/ -	.120/ -	.500/ -	.830/ -	.950/ -	.050/ -	.560/ -	.490/ -	.530/ -
Sept. 9	.200/.170	.190/.150	.120/.080	.120/.080	.120/.080	.320/.040	.040/.030	.090/.040	.040/.040
11	.240/.200	.200/.190	.120/.090	.100/.070	.130/.070	.070/.040	.060/.030	.050/.030	.050/.030

TABLE 2.
NUTRIENT DATA FOR THE 1984 RED TIDE SURVEY
NH_3 + NH_4 /NO_2 + NO_3 (mg/l)

SAMPLING LOCATION [1]

DATE	1	2	3	4	5	6	7	8	9
May 28	.310/.28	.020K/.02K	.020K/.02	.020K/.06	.020/.02K	.020K/.02	.020K/.02K	.020K/.02K	.020K/.02
June 6	.490/.32	.160/.32	.060/.07	.070/.09	.060/.04	.050/.05	.040/.04	.020K/.03	.020/.02
12	.050K/.30	.260/.32		.060/.10	.050K/.05K	.050K/.05K	.050K/.05K	.050K/.05K	.050K/.05K
27	.170/.14	.650/.28	.080/.05	.120/.07	.070/.04	.130/.08	.060/.03	.020/.01	.000/.04
July 2	.620/.37	.190/.17	.170/.12	.120/.12	.320/.23	.070/.08	.010K/.05K	.050/.5	.020/.05K
August 9	.280/.12	.120/.01K	.200/.01K	.130/.01K	.480/.68	.270/.01K	.870/.01K	.670/.01K	.020/.01K
Sept. 9	.270/.30	.110/.11	.050/.18	.050/.20	.080/.03	.020K/.02K	.020K/.02K	.020K/.02K	.020K/.02K
11	.140/.30	.310/.14	.190/.14	.110/.11	.130/.14	.080/.02	.070/.10	.530/.01	.050/.01

Footnote:

1. Sampling locations correspond with EPA routine stations given in Table 1.

APPENDIX B

MICROBIOLOGICAL WATER QUALITY NEW YORK BIGHT

SUMMER OF 1985

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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 infected individuals, and are thus potentially present in their sewage and its receiving waters. Epidemiological studies have been used to assess incidence of illness with bathing waters containing fecal contamination. Evidence exists showing 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 culturing procedures are usually required for the isolation of most pathogens in mixed populations making them undesirable as a routine monitoring tool. The ideal indicator should be present in large numbers in healthy humans and animals that harbor human pathogens. They should persist longer in the environment than pathogens, and should be easy to detect on a routine basis from samples containing a mixed flora of organisms. When an indicator organism is present, it is assumed that pathogens may be present and the water may be potentially harmful. No ideal indicator is known, but two bacterial groups, coliforms and fecal streptococci, satisfy the requirements to a high degree (Finstein, 1972).

In 1976, the U.S. EPA recommended a fecal coliform bacterial guideline for primary contact recreational waters which was subsequently adopted by most states. Their recommendation states that fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreational waters. The recommended criterion is as follows: 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 200/100 ml nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml (Quality Criteria for Water, 1976).

The criterion was derived from data collected by the National Technical Advisory Committee (NTAC). NTAC conducted studies on the Great Lakes (Michigan) and the Ohio River that showed an epidemiological health effect at levels of 2300-2400 total 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 400 FC/100 ml 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 uses 50 FC/100 ml as a coastal water quality standard.

Fecal coliforms are defined as gram-negative, nonspore-forming rods that ferment lactose in 24 ± 2 hours at 44.5 ± 0.2 °C with the production of gas in the multiple-tube procedure (MPN) or produce acidity with blue colonies in the membrane filtration procedure (MF). 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 then the choice over other coliform groups.

EPA has recently published the results of two research projects which compared the relationship between illnesses associated with bathing waters and ambient densities of several indicator organisms (Cabelli, 1980 and DuFour, 1984). One study was performed on marine water beaches and one on freshwater beaches. The results have caused EPA to reevaluate the current use of fecal coliforms as indicator organisms. The studies indicated that enterococci have a far better correlation with swimming associated illnesses both in marine and freshwater than do fecal coliforms. New methodology has made it easier to detect the organism (Levin, *et al*, 1975 and Miescier & Cabelli, 1982). The studies also demonstrated that *E. coli*, a specific species in the fecal coliform group, has a correlation equal to enterococcus in freshwater, but not in marine waters.

Enterococci are members of the fecal streptococci group. This group is used to describe the streptococci which indicate the sanitary quality of water and wastewater. The occurrence of fecal streptococci in water indicates fecal contamination from warm-blooded animals. One is able to pinpoint the source of fecal contamination by the biochemical identification of the fecal streptococci group. The enterococcus group includes the following species: *S. faecalis*; *S. faecalis, subsp. liquefaciens*; *S. faecalis, subsp. zymogenes*; and *S. faecium*.

More information about both fecal coliforms and enterococci can be found in the following references:

1. *Standard Methods*, 16 edition, Section 909 and 910. (1985).
2. *Microbiological Methods for Montioring the Environment, Water and Wastewater.* EPA-600/8-78-017. Part III, Section C & D. (1978).
3. *Bergey's Manual of Systemic Bacteriology,* Volume I. (1984).

EPA has proposed regulations recommending enterococci and *E. coli* for inclusion into state water quality standards for the protection of primary contact recreational uses in the lieu of fecal coliforms. The proposed criterion for enterococci for marine waters is 3/100 ml. This information was published in the Federal Register on May 24, 1984, and is in the process of a round robin study evaluating the precision of the new methodology for detecting these indicator organisms.

As part of the annual monitoring of the coastal waters off the shores of Long Island and New Jersey, a study of the densities of both fecal coliforms and enterococci was conducted in 1985. Monitoring at selected sites in the New York Bight was also conducted.

MATERIALS AND METHODS

Marine water samples were collected by helicopter and boat on a biweekly basis (weather permitting) from May to October 1985. The samples were collected using a Kemmerer sampler and transferred to 500 ml sterile, wide-mouth plastic containers. They were transported on ice to the Region II Edison laboratory for analysis.

Fecal coliform determinations were conducted according to the membrane filtration (MF) procedures described in Standard Methods, 16 edition, 1985 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, et al. (1975) using the modified mE media. Confirmation of enterococci colonies was conducted following procedures outlined in Microbiological Methods for Monitoring the Environment, Water and Waste-Water, EPA-600/8-78-017, 1978.

RESULTS AND DISCUSSION

During the survey time period, only two samples collected along the New Jersey coast demonstrated fecal coliform (FC) densities greater than 50/100 ml (Table 1). JC-21 (Asbury Park, off building north of Convention Hall) had a FC count of 104/100 ml and JC-47A (Silver Beach, off foot of Colony Road) had a count of 70 FC/100 ml. The geometric means of FC densities for all the New Jersey stations were all less than 7.8 (Table 2). This is well below the 50 FC/100 ml standard set by the State of New Jersey. Figure 1 depicts graphically the geometric means of FC densities for New Jersey.

There were no FC densities greater than 50/100 ml observed during the survey time period along the Long Island coast. The geometric means were all less than 1.8 (Table 3). This is also well below New York State's standard of 200 FC/100 ml. Figure 2 depicts graphically the geometric means of FC densities for Long Island.

The Federal Register dated May 24, 1984 has proposed a recommended criterion of 3 enterococci/100 ml standard for marine waters. Table 4 lists all the enterococci densities that exceeded this criterion during the survey time period for the New Jersey coast. Seventy (70) single observations were detected above the recommended limit. Stations JC-37, JC-53, JC-65, JC-83 and JC-89 exceeded the criterion 40-50% of the time. Stations JC-03, JC-11, JC-21, JC-33, JC-41, JC-47A, JC-57, JC-85 and JC-97 exceeded the criterion 25-35% of the time. However, when evaluating the geometric means for all the stations, only six had values above 3 enterococci/100 ml (Table 5). The highest geometric mean, 5.3, was observed at Station JC-99 (Cape May Point, opposite the light-house). Stations JC-65 (Ship Bottom), JC-83 (Peck Beach), JC-85 (Strathmere), JC-89 (Avalon) and JC-97 (Cape May, off white house with the red roof off the beach) had geometric means of 3.4, 4.5, 3.4, 3.6, and 3.4 respectively. Figure 3 graphically depicts the geometric means of the enterococci densities for the New Jersey coast. If the recommended criterion is adopted, the above results suggest questionable water quality for these 6 stations. This is contrary to the FC data. The FC data indicates excellent water quality with the highest geometric mean only being 7.7. However, only 4 samples were collected at the southern New Jersey stations. More extensive sampling would be necessary to make more conclusive statements.

There were 17 observations detected above the recommended criterion for enterococci for the Long Island coast (Table 6). The geometric means were all below 3 (Table 7). The highest geometric mean, 1.8, was observed at station LIC-04 (Rockaway, off foot of B92 Road). Figure 4 graphically depicts the geometric means of the enterococci densities for the Long Island coast. The enterococci data falls below the recommended criterion and this coincides with the FC data. Both suggest the water quality of the Long Island coast to be acceptable for primary contact recreational use.

Five (5) samples collected from the New York Bight detected FC densities greater than 50/100 ml (Table 8). Station NYB-32 (at the mouth of the Raritan Bay - Figure 5) had two separate counts of 216 and 176 FC/100 ml. This station also exceeded 50 FC/100 ml in 1984. Station NYB-33 (also at the mouth of the Raritan Bay) had a count of 100 FC/100 ml. Station NYB-45 (one mile northwest of sewage sludge dump site) had two separate counts of 60 and 160 FC/100 ml. The geometric means of FC densities for all the stations are presented in Table 9. The highest geometric mean, 13.1, was observed at Station NYB-45.

Thirteen (13) samples collected from the New York Bight detected enterococci densities greater than 3/100 ml (Table 10). These included the same stations that showed high FC densities. The geometric means of enterococci densities for all the stations are presented in Table 11. The highest geometric mean was 26.5 at Station NYB-25 (the center of the sewage sludge dump site), with the next highest at Station NYB-45 of 8.3.

Since the membrane filtration procedure used for determining the enterococci densities was a new method, confirmation of a selected number of colonies from the modified mE plates was conducted throughout the extent of the survey. Colonies of various sizes, shapes and colors were picked and subjected to a series of biochemical tests. The results indicated that a colony having the following characteristics and biochemical reactions confirmed as a member of the enterococci group:

Colony Characteristics

Color: dark blue or gray blue with dark blue halo.
Size: medium to large, 2.0 - 2.5 mm.
Shape: round, flat colony with raised center and a smooth, entire edge.

Biochemical Reactions

Test	Reaction
Catalase	negative
Growth at 10°C	positive
Growth at 45°C	positive
Growth with 6.5% NaCl	positive
Growth with 40% Bile	positive
0.1% Methylene Blue Reduction	positive
Litmus Milk Reduction	coagulation or peptonization

It is recommended that confirmation be conducted when using the modified mE method until the analyst feels confident about the method. The original paper has been updated by the author and the description of the colonies changed (Cabelli, personal communication). Other environmental stresses can also alter the appearance of the colonies.

CONCLUSIONS AND RECOMMENDATIONS

The majority of the stations showing elevated enterococci geometric means were located along the southern coast of New Jersey. These stations were only sampled four times during the survey time period. The geometric means were calculated based on the results of only four samples. A true geometric mean is calculated based on at least 5 samples during a 30 day period. It is recommended that samples be collected from these stations on a more frequent basis next year. This should give a larger data base to further evaluate the utility of using enterococci as an indicator of fecal contamination.

The elevated bacterial counts observed during the survey may be related to stormwater runoff or bypass by sewage treatment plants. It is therefore recommended that the amount of rainfall during the survey time period be recorded so that this relationship may be investigated.

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Table 1

FECAL COLIFORM DENSITIES >50 PER 100 ML
NEW JERSEY COAST STATIONS
SUMMER 1985

OBS	STATION	DATE	FECCOLI
1	JC21	850826	104
2	JC47A	850826	70

Table 2

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1985

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	0.68084	0	4	10
2	JC02	0.23114	0	1	10
3	JC03	0.76894	0	19	10
4	JC05	1.57356	0	40	11
5	JC08	0.84908	0	17	11
6	JC11	1.42790	0	19	11
7	JC14	3.02268	0	41	11
8	JC21	1.42169	0	104	11
9	JC24	1.21625	0	10	11
10	JC27	1.02370	0	7	10
11	JC30	1.01068	0	4	10
12	JC33	1.06936	0	29	10
13	JC37	1.27903	0	34	10
14	JC41	0.90855	0	6	9
15	JC44	0.94152	0	6	9
16	JC47A	0.92025	0	70	9
17	JC49	1.05654	0	46	9
18	JC53	4.28768	0	16	9
19	JC55	0.61562	0	14	9
20	JC57	0.80952	0	25	9
21	JC59	0.89883	0	12	4
22	JC61	1.11474	0	4	4
23	JC63	1.54573	0	6	4
24	JC65	0.62658	0	6	4
25	JC67	1.21336	0	3	4
26	JC69	0.00000	0	0	4
27	JC73	2.73688	0	12	4
28	JC75	4.38356	2	9	4
29	JC77	1.35961	0	30	4
30	JC79	2.70779	0	8	4
31	JC81	1.91295	0	5	4
32	JC83	0.56508	0	2	4
33	JC85	0.62658	0	6	4
34	JC87	2.99609	0	16	4
35	JC89	2.66284	0	9	4
36	JC91	1.63215	0	7	4
37	JC93	7.67982	0	42	4
38	JC95	0.41421	0	3	4
39	JC97	3.36793	0	25	4
40	JC99	4.02973	0	31	4

Table 3

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1985

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	0.50597	0	14	10
2	LIC02	0.82056	0	7	10
3	LIC03	0.59264	0	6	10
4	LIC04	0.84213	0	5	10
5	LIC05	0.58489	0	4	10
6	LIC07	0.53367	0	2	10
7	LIC08	0.70532	0	12	10
8	LIC09	1.06936	0	5	10
9	LIC10	1.72624	0	8	10
10	LIC12	0.33514	0	2	10
11	LIC13	0.00000	0	0	10
12	LIC14	0.19623	0	2	10
13	LIC15	0.14870	0	1	10
14	LIC16	0.97697	0	18	10
15	LIC17	0.00000	0	0	7
16	LIC18	0.10409	0	1	7
17	LIC19	0.00000	0	0	7
18	LIC20	0.10409	0	1	7
19	LIC21	0.10409	0	1	7
20	LIC22	0.16993	0	2	7
21	LIC23	0.51121	0	8	7
22	LIC24	0.00000	0	0	7
23	LIC25	0.10409	0	1	7
24	LIC26	0.16993	0	2	7
25	LIC27	0.10409	0	1	7
26	LIC28	0.34590	0	1	7

Table 4

ENTEROCOCCI DENSITIES >3 PER 100 ML
NEW JERSEY COAST STATIONS
SUMMER 1985

OBS	STATION	DATE	ENTERO
1	JC01A	850528	4
2	JC01A	850718	4
3	JC02	850528	15
4	JC02	850905	4
5	JC03	850528	11
6	JC03	850718	5
7	JC03	850826	4
8	JC05	850528	6
9	JC08	850612	4
10	JC11	850612	8
11	JC11	850627	5
12	JC11	850809	8
13	JC14	850627	12
14	JC14	850826	30
15	JC21	850528	4
16	JC21	850809	92
17	JC21	850826	19
18	JC24	850528	18
19	JC24	850829	8
20	JC27	850528	6
21	JC27	850809	4
22	JC33	850528	12
23	JC33	850809	32
24	JC33	850826	4
25	JC37	850528	20
26	JC37	850606	4
27	JC37	850702	4
28	JC37	850826	9
29	JC41	850528	17
30	JC41	850702	4
31	JC41	850826	9
32	JC44	850528	9
33	JC47A	850528	11
34	JC47A	850627	4
35	JC47A	850809	28
36	JC49	850627	20
37	JC49	850826	7
38	JC53	850528	32
39	JC53	850627	8
40	JC53	850826	6

Table 4 (cont.)

ENTEROCOCCI DENSITIES >3 PER 100 ML
NEW JERSEY COAST STATIONS
SUMMER 1985

OBS	STATION	DATE	ENTERO
41	JC53	850909	4
42	JC55	850627	16
43	JC57	850528	10
44	JC57	850606	7
45	JC57	850627	7
46	JC59	850627	5
47	JC63	850809	4
48	JC65	850627	8
49	JC65	850826	9
50	JC69	850627	5
51	JC73	850606	4
52	JC75	850606	5
53	JC77	850826	17
54	JC79	850627	8
55	JC81	850606	4
56	JC83	850606	4
57	JC83	850627	4
58	JC83	850809	36
59	JC85	850826	29
60	JC87	850809	9
61	JC89	850606	16
62	JC89	850809	12
63	JC91	850606	5
64	JC91	850809	6
65	JC93	850606	5
66	JC93	850627	15
67	JC95	850606	5
68	JC97	850606	20
69	JC99	850606	84
70	JC99	850809	8

Table 5

GEOMETRIC MEANS OF ENTEROCOCCI DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1985

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	0.69865	0	4	10
2	JC02	0.85406	0	15	10
3	JC03	0.93078	0	11	10
4	JC05	0.53565	0	6	11
5	JC08	1.06296	0	4	11
6	JC11	1.28221	0	8	11
7	JC14	1.51793	0	30	11
8	JC21	2.38547	0	92	11
9	JC24	1.67043	0	18	11
10	JC27	1.41400	0	6	10
11	JC30	0.51572	0	3	10
12	JC33	1.76096	0	32	10
13	JC37	2.01949	0	20	10
14	JC41	1.48396	0	17	9
15	JC44	0.57606	0	9	9
16	JC47A	1.47462	0	28	9
17	JC49	0.90855	0	20	9
18	JC53	2.97805	0	32	9
19	JC55	0.47967	0	16	9
20	JC57	1.23792	0	10	9
21	JC59	0.86121	0	5	4
22	JC61	0.56508	0	2	4
23	JC63	1.78316	0	4	4
24	JC65	3.35588	0	9	4
25	JC67	0.31607	0	2	4
26	JC69	0.56508	0	5	4
27	JC73	0.77828	0	4	4
28	JC75	1.44949	0	5	4
29	JC77	1.05977	0	17	4
30	JC79	2.22371	0	8	4
31	JC81	0.77828	0	4	4
32	JC83	4.51487	0	36	4
33	JC85	3.35588	0	29	4
34	JC87	0.77828	0	9	4
35	JC89	3.58517	0	16	4
36	JC91	1.54573	0	6	4
37	JC93	2.13017	0	15	4
38	JC95	1.44949	0	5	4
39	JC97	3.40933	1	20	4
40	JC99	5.25422	0	84	4

Table 6

ENTEROCOCCI DENSITIES >3 PER 100 ML
LONG ISLAND COAST STATIONS
SUMMER 1985

OBS	STATION	DATE	ENTERO
1	LIC01	850702	10
2	LIC02	850702	18
3	LIC03	850702	6
4	LIC03	850717	5
5	LIC04	850613	32
6	LIC04	850717	7
7	LIC07	850702	4
8	LIC08	850702	5
9	LIC09	850516	4
10	LIC09	850702	4
11	LIC09	850827	4
12	LIC10	850613	8
13	LIC14	850717	7
14	LIC16	850613	11
15	LIC18	850604	4
16	LIC20	850827	6
17	LIC25	850717	4

Table 7

GEOMETRIC MEANS OF ENTEROCOCCI DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1985

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	0.52267	0	10	9
2	LIC02	0.77056	0	18	9
3	LIC03	1.43630	0	6	9
4	LIC04	1.76688	0	32	9
5	LIC05	0.79349	0	3	9
6	LIC07	0.57606	0	4	9
7	LIC08	1.18857	0	5	9
8	LIC09	0.99474	0	4	9
9	LIC10	1.50529	0	8	9
10	LIC12	0.60831	0	2	9
11	LIC13	0.31798	0	2	9
12	LIC14	0.58740	0	7	9
13	LIC15	0.42350	0	2	9
14	LIC16	1.36379	0	11	9
15	LIC17	0.20094	0	2	6
16	LIC18	0.64755	0	4	6
17	LIC19	0.41421	0	3	6
18	LIC20	0.55246	0	6	6
19	LIC21	0.34801	0	2	6
20	LIC22	0.34801	0	2	6
21	LIC23	0.12246	0	1	6
22	LIC24	0.12246	0	1	6
23	LIC25	0.46780	0	4	6
24	LIC26	0.00000	0	0	6
25	LIC27	1.13983	0	3	6
26	LIC28	0.00000	0	0	6

Table 8

FECAL COLIFORM DENSITIES >50 PER 100 ML
NEW YORK BIGHT STATIONS
SUMMER 1985

OBS	STATION	DATE	FECCOLI	DEPTH
1	NYB32	851009	216	S
2	NYB32	851009	176	B
3	NYB33	851009	100	S
4	NYB45	850715	60	B
5	NYB45	851009	160	B

Table 9

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW YORK BIGHT STATIONS
SUMMER 1985

OBS	DEPTH	STATION	MEAN	MINIMUM	MAXIMUM	N
1	B	NYB20	0.5651	0	2	4
2	B	NYB21	0.0000	0	0	4
3	B	NYB22	0.0000	0	0	4
4	B	NYB23	0.0000	0	0	4
5	B	NYB24	0.0000	0	0	4
6	B	NYB25	8.7444	0	48	4
7	B	NYB26	1.5755	0	21	4
8	B	NYB27	0.4142	0	3	4
9	B	NYB32	2.6475	0	176	4
10	B	NYB33	0.5651	0	2	4
11	B	NYB34	0.0000	0	0	4
12	B	NYB35	0.0000	0	0	4
13	B	NYB40	0.0000	0	0	4
14	B	NYB41	0.0000	0	0	4
15	B	NYB42	0.0000	0	0	4
16	B	NYB43	0.0000	0	0	4
17	B	NYB44	1.9428	0	14	4
18	B	NYB45	13.0784	0	160	4
19	B	NYB46	0.1892	0	1	4
20	B	NYB47	0.0000	0	0	4
21	S	NYB20	0.4953	0	4	4
22	S	NYB21	0.0000	0	0	4
23	S	NYB22	0.0000	0	0	4
24	S	NYB23	0.0000	0	0	4
25	S	NYB24	0.0000	0	0	4
26	S	NYB25	0.0000	0	0	4
27	S	NYB26	0.0000	0	0	4
28	S	NYB27	0.0000	0	0	4
29	S	NYB32	3.5643	0	216	4
30	S	NYB33	3.1722	0	100	4
31	S	NYB34	0.1892	0	1	4
32	S	NYB35	0.3161	0	2	4
33	S	NYB40	1.0305	0	16	4
34	S	NYB41	0.3161	0	2	4
35	S	NYB42	0.0000	0	0	4
36	S	NYB43	0.7321	0	8	4
37	S	NYB44	0.0000	0	0	4
38	S	NYB45	0.0000	0	0	4
39	S	NYB46	0.0000	0	0	4
40	S	NYB47	0.0000	0	0	4

Table 10

ENTEROCOCCI DENSITIES >3 PER 100 ML
NEW YORK BIGHT STATIONS
SUMMER 1985

OBS	STATION	DATE	ENTERO	DEPTH
1	NYB24	850715	7	B
2	NYB25	850715	460	B
3	NYB25	850806	112	B
4	NYB25	850814	10	B
5	NYB26	850806	5	B
6	NYB26	850814	8	B
7	NYB32	851009	5	B
8	NYB33	851009	9	S
9	NYB43	850715	20	B
10	NYB44	850715	32	B
11	NYB45	850715	204	B
12	NYB45	850802	5	B
13	NYB46	850715	9	B

Table 11

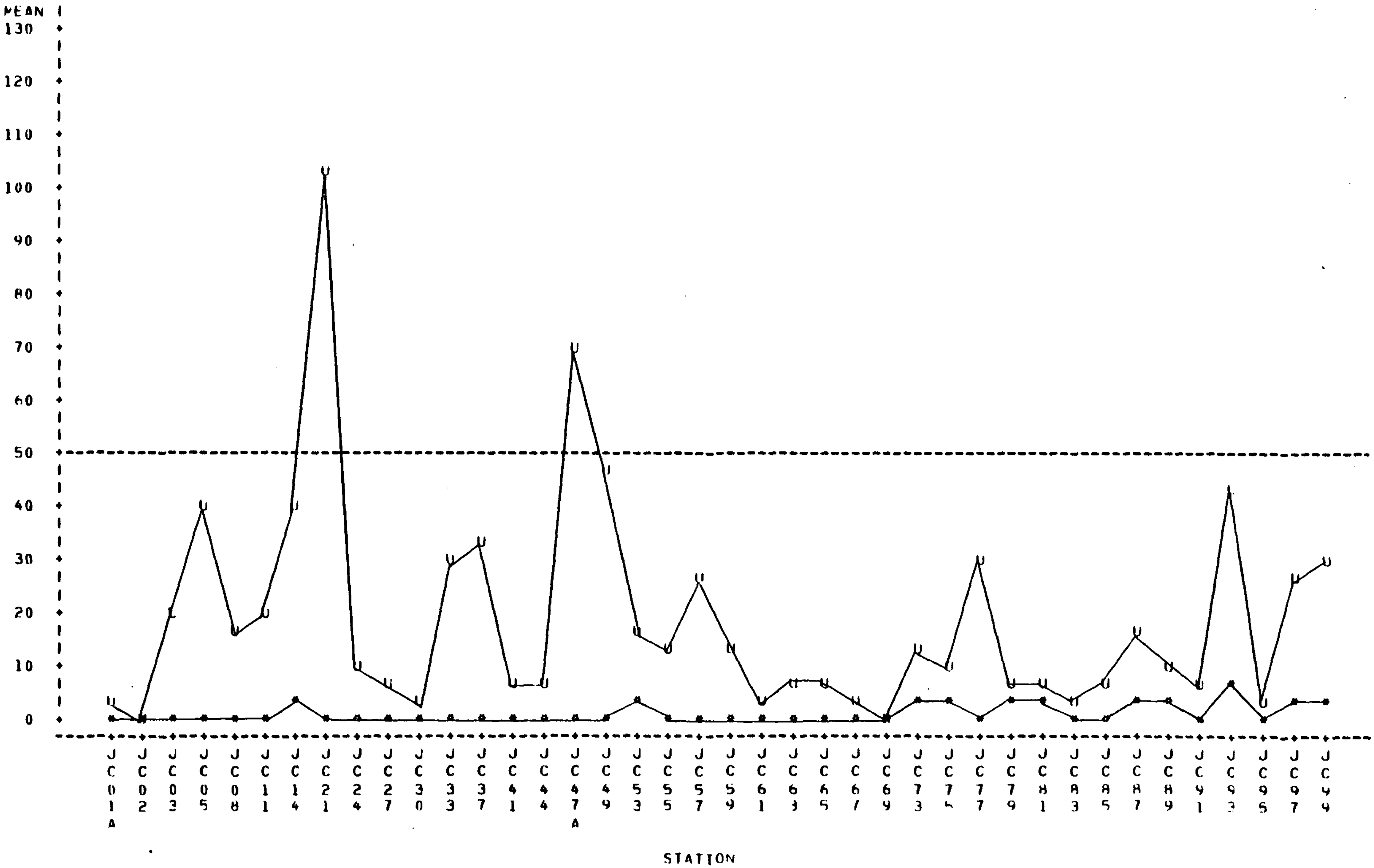
GEOMETRIC MEANS OF ENTEROCOCCI DENSITIES
NEW YORK BIGHT STATIONS
SUMMER 1985

OBS	DEPTH	STATION	MEAN	MINIMUM	MAXIMUM	N
1	B	NYB20	0.3161	0	2	4
2	B	NYB21	0.1892	0	1	4
3	B	NYB22	0.1892	0	1	4
4	B	NYB23	0.3161	0	2	4
5	B	NYB24	1.0000	0	7	4
6	B	NYB25	26.5133	0	460	4
7	B	NYB26	2.2237	0	8	4
8	B	NYB27	0.3161	0	2	4
9	B	NYB32	0.8612	0	5	4
10	B	NYB33	0.5651	0	2	4
11	B	NYB34	0.0000	0	0	4
12	B	NYB35	1.2134	0	3	4
13	B	NYB40	0.0000	0	0	4
14	B	NYB41	0.1892	0	1	4
15	B	NYB42	0.1892	0	1	4
16	B	NYB43	2.9843	0	20	4
17	B	NYB44	2.7512	0	32	4
18	B	NYB45	8.2686	0	204	4
19	B	NYB46	1.1147	0	9	4
20	B	NYB47	0.0000	0	0	4
21	S	NYB20	0.0000	0	0	4
22	S	NYB21	0.0000	0	0	4
23	S	NYB22	0.0000	0	0	4
24	S	NYB23	0.0000	0	0	4
25	S	NYB24	0.0000	0	0	4
26	S	NYB25	0.0000	0	0	4
27	S	NYB26	0.0000	0	0	4
28	S	NYB27	0.0000	0	0	4
29	S	NYB32	0.6818	0	3	4
30	S	NYB33	0.7783	0	9	4
31	S	NYB34	0.4142	0	3	4
32	S	NYB35	0.4142	0	1	4
33	S	NYB40	0.0000	0	0	4
34	S	NYB41	0.0000	0	0	4
35	S	NYB42	0.1892	0	1	4
36	S	NYB43	0.1892	0	1	4
37	S	NYB44	0.1892	0	1	4
38	S	NYB45	0.0000	0	0	4
39	S	NYB46	0.1892	0	1	4
40	S	NYB47	0.0000	0	0	4

Figure 1

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1985

PLOT OF MEAN*STATION SYMBOL USED IS *
PLOT OF MAXIMUM*STATION SYMBOL USED IS U



ure

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1985

PLOT OF MEAN*STATION SYMBOL USED IS *
PLOT OF MAXIMUM*STATION SYMBOL USED IS O

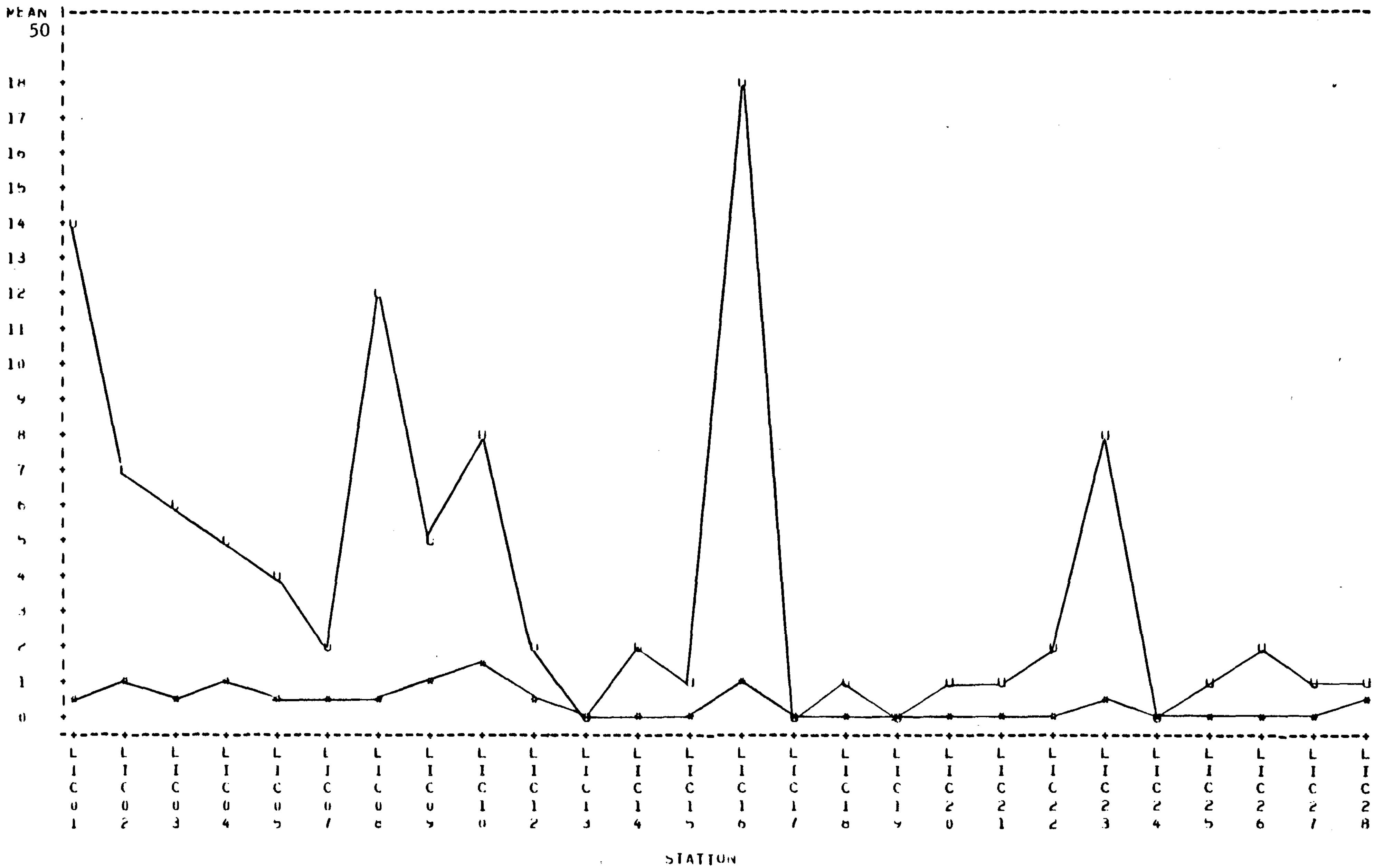


Figure 5

GEOMETRIC MEANS OF ENTEROCOCCI DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1985

PLOT OF MEAN*STATION SYMBOL USED IS *
PLOT OF MAXIMUM*STATION SYMBOL USED IS U

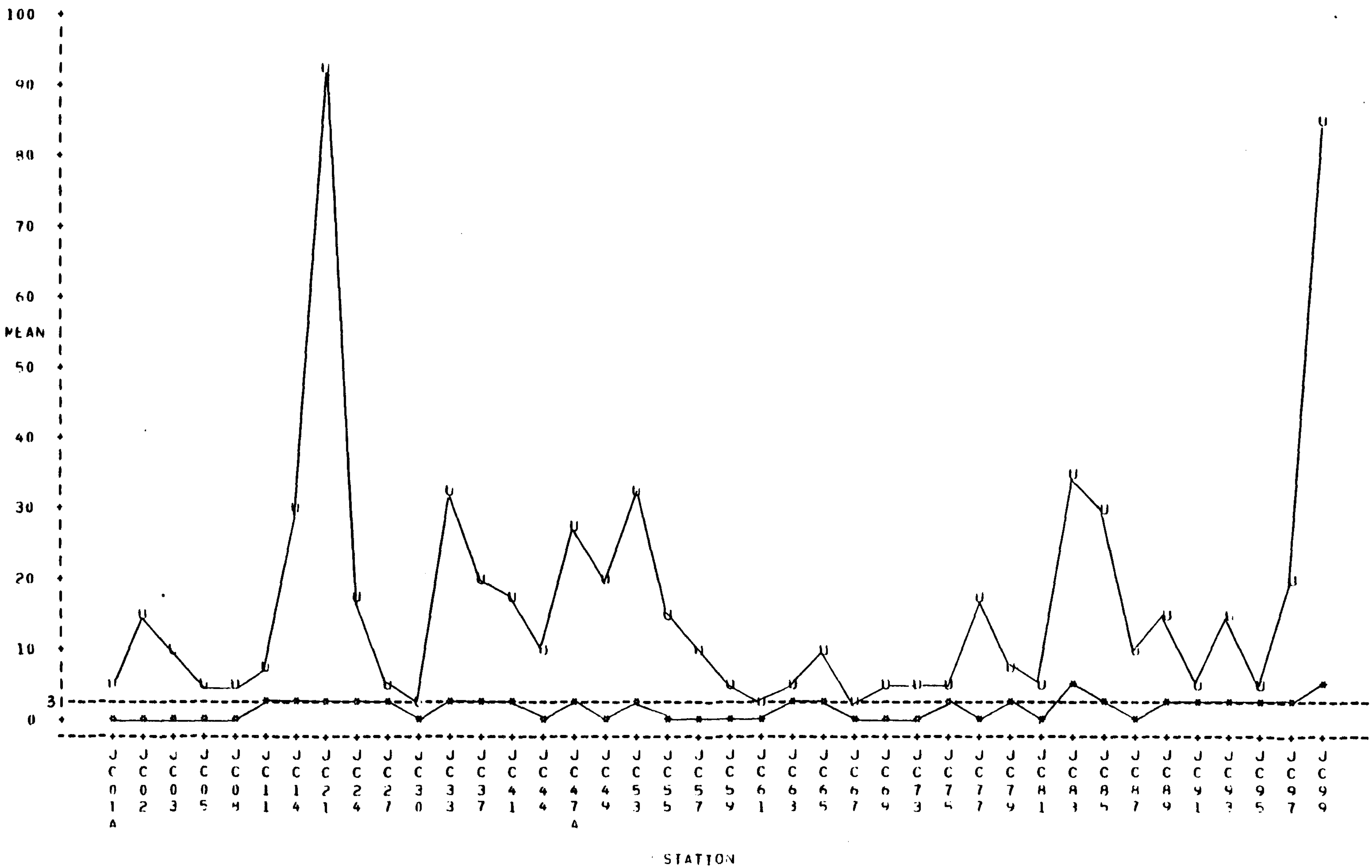
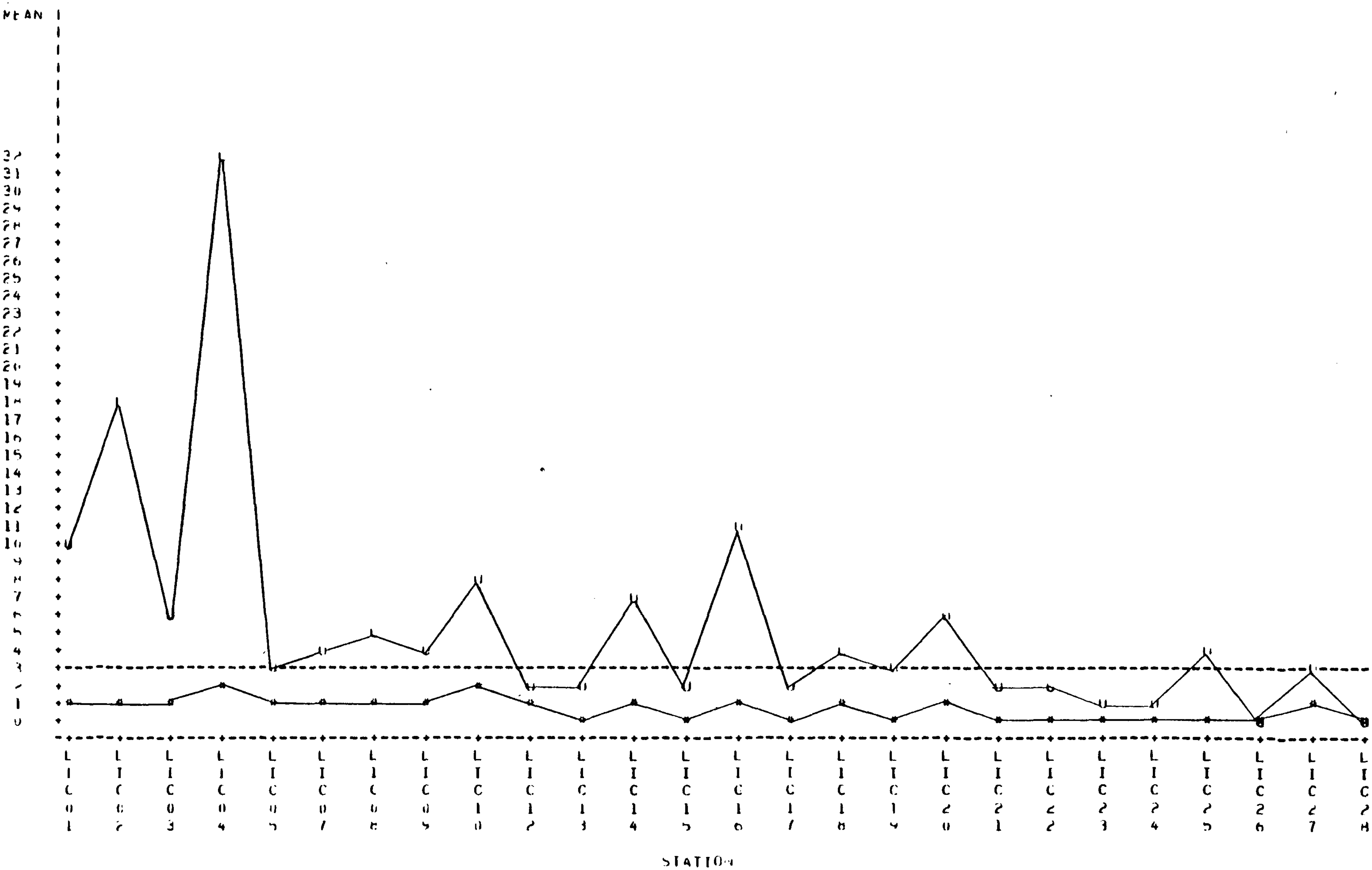


Figure 4
GEOMETRIC MEANS OF ENTEROCOCCI DENSITIES

LONG ISLAND COAST STATIONS
SUMMER 1985

PLOT OF MEAN*STATION   SYMBOL USED IS *
PLOT OF MAXIMUM*STATION   SYMBOL USED IS 0



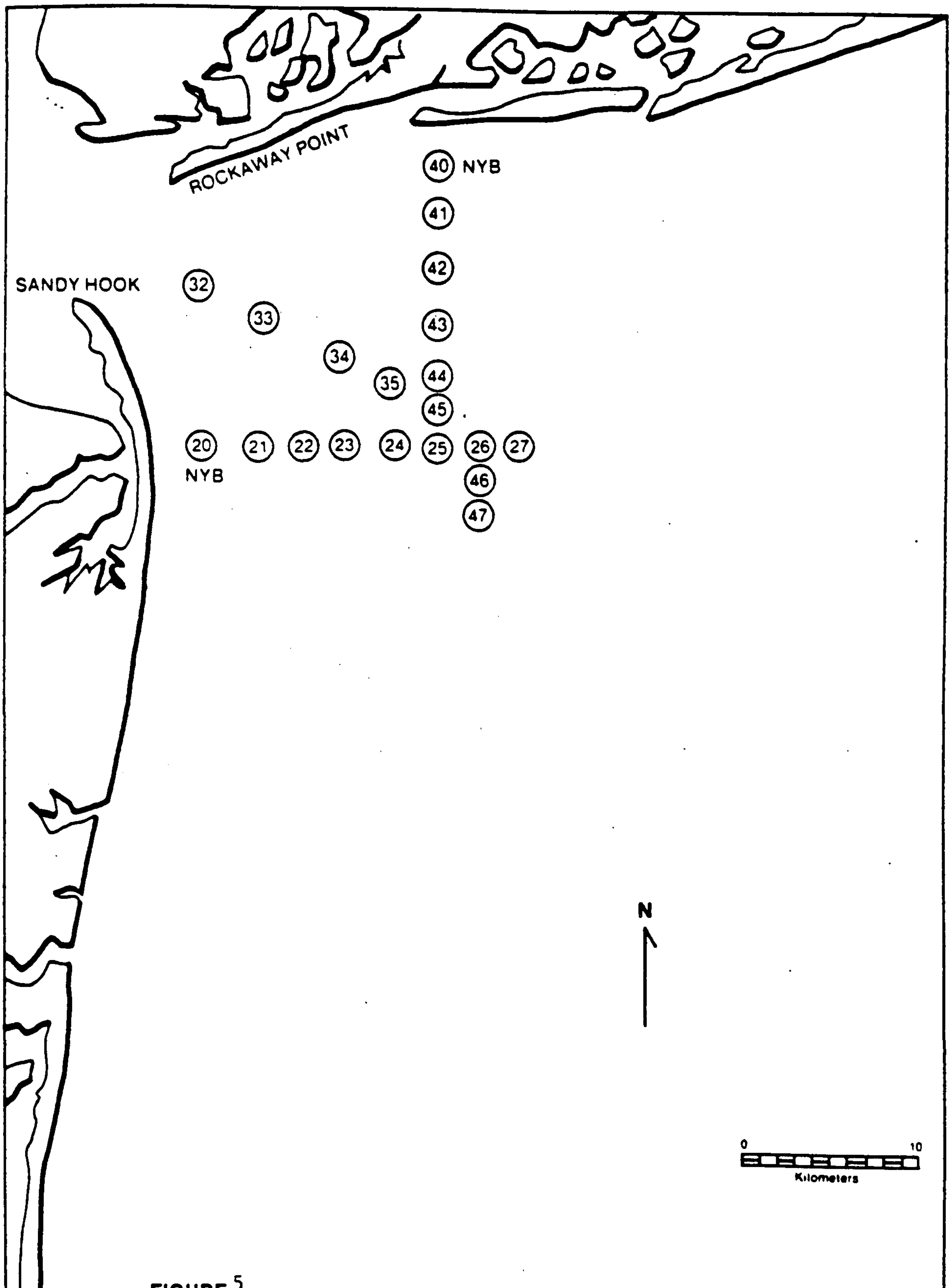


FIGURE 5
NEW YORK BIGHT STATION LOCATIONS