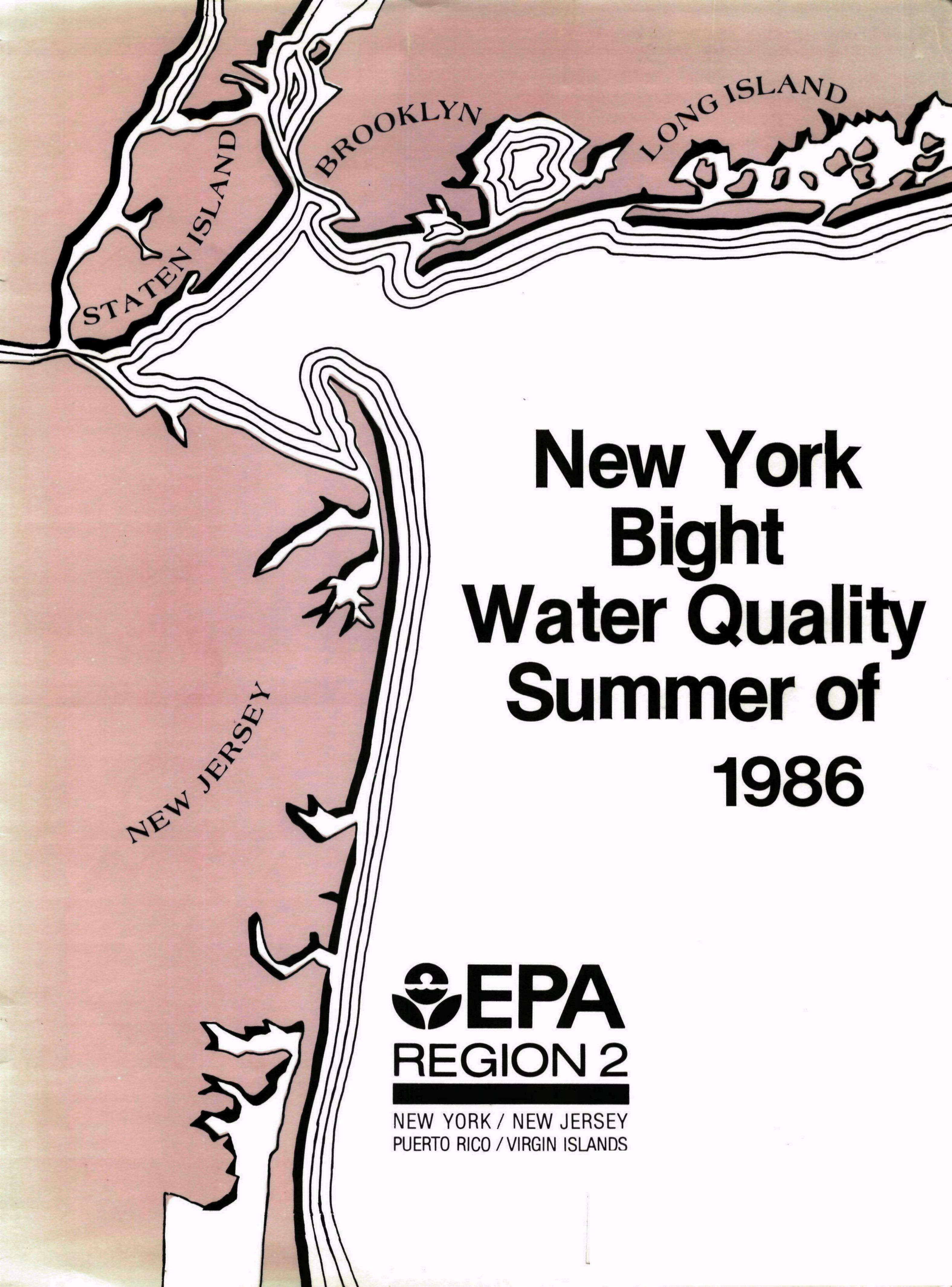

New York Bight Water Quality Summer of 1986

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

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1986

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ABSTRACT

The purpose of this report is to disseminate technical information gathered by the U.S. Environmental Protection Agency (EPA), Region 2, during the 1986 New York Bight Water Quality Monitoring Program. The monitoring program was conducted using the EPA helicopter for water quality sample collection. During the period from May 6 to October 30, 1986, approximately 140 stations were sampled each week, weather permitting. The Bight sampling program consisted of five separate sampling networks. Sampling was conducted 5 days a week and extended to 6 days a week in July and August.

Bacteriological data indicated that fecal coliform densities at the beaches along both the New Jersey and Long Island coasts were well within the acceptable Federal limits for primary contact recreation (200 fecal coliforms/ 100ml). Except for two occasions, fecal coliform densities along the New Jersey coast were all below the New Jersey water quality standard of 50 fecal coliforms/100ml. Enterococcus densities exceeded EPA's criterion of 35 enterococci/100 ml only once during the summer along the Long Island coast, and not at all along the New Jersey coast.

Dissolved oxygen concentrations were generally good along the New Jersey perpendiculars, the Long Island perpendiculars and in the New York Bight Apex. Dissolved oxygen levels in 1986 were higher than in 1985. In 1986 some depressed bottom dissolved oxygen levels occurred in isolated areas of the Bight Apex and off the New Jersey coast, but only persisted a short time. In mid to late summer 1985 approximately 1600 square miles of ocean bottom off New Jersey were plagued with low dissolved oxygen concentrations for extended periods of time. The improvement in

dissolved oxygen concentrations in 1986 is attributed to meteorological conditions. Higher than normal winds and numerous local storms promoted mixing of the water column. The low dissolved oxygen levels which occurred in certain areas of the Bight are attributed to the combined effects of: the respiration of organisms in organic-rich sediments; the decomposition of dead algal blooms and other organic material, which occur in the nutrient-rich areas of the Bight; and thermal stratification of the water column.

During the summer, phytoplankton blooms were observed over extensive areas. At some point during the summer, most beaches along New Jersey were affected by blooms of short duration. Algal blooms of longer duration occurred in the intercoastal bays of New Jersey and Long Island. A major bloom caused by a brown algae, Aureococcus anorexefferens, persisted throughout most of the summer in many of the bays of western Long Island (Flanders Bay, Great Peconic Bay, Shinnecock Bay, Moriches Bay, and the western portion of Great South Bay). Red and green algal blooms occurred to a lesser degree in many of the bays and coastal beaches in New Jersey. Red blooms were predominant in Raritan and Sandy Hook Bays. Along the southern New Jersey coast, a green bloom. caused by Nannochloris sp., developed in mid-August. This bloom was much smaller than the green blooms (green tides) which occurred in this area in 1984 and 1985, which were caused by the organism Gyrodiniun aureolum.

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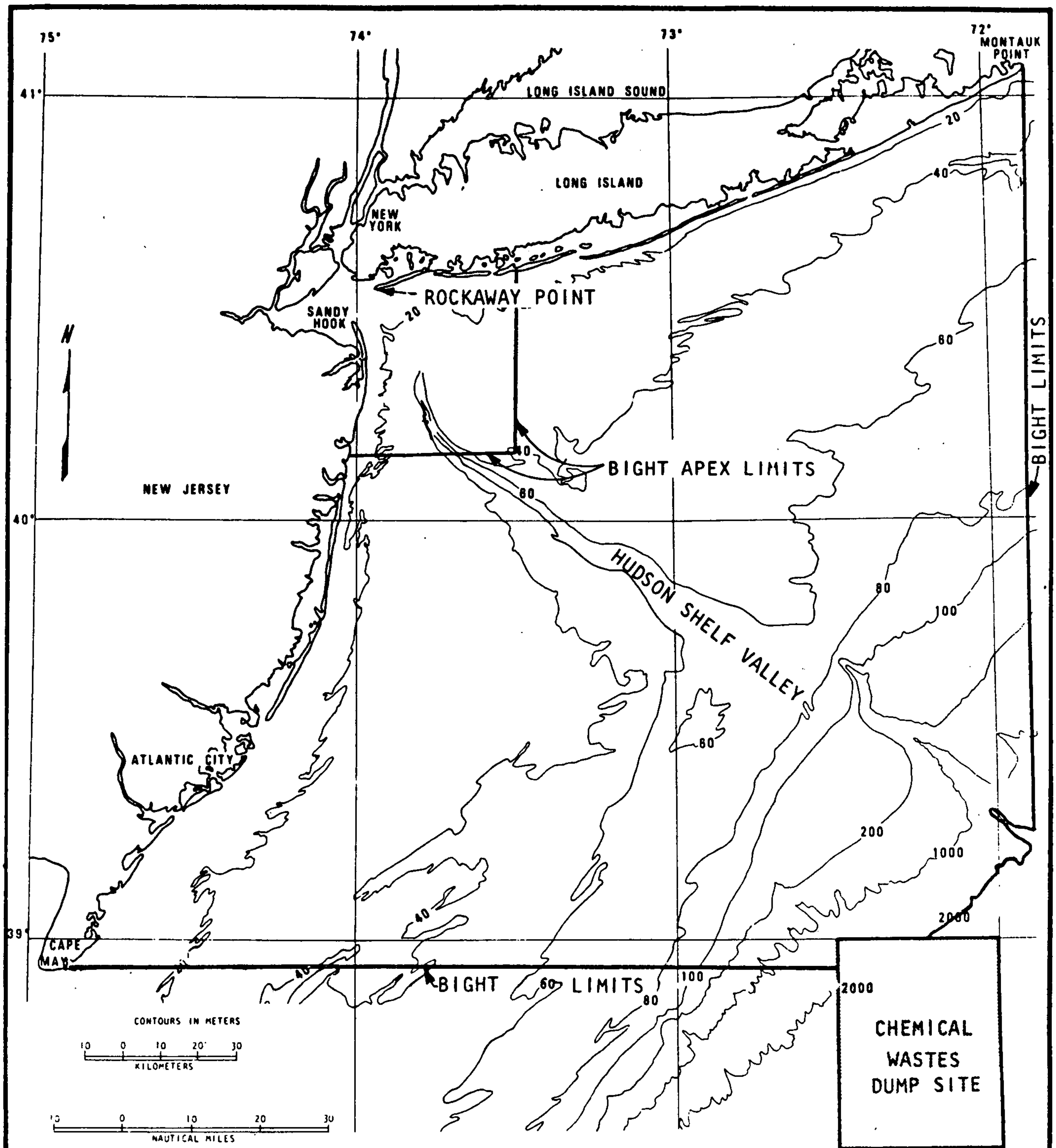
I. INTRODUCTION

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 disposal sites, is shown in Figure 2.

This report is the thirteenth in a series and reflects the monitoring period between May 6, 1986 and October 30, 1986. 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.



THE NEW YORK BIGHT

Figure 1

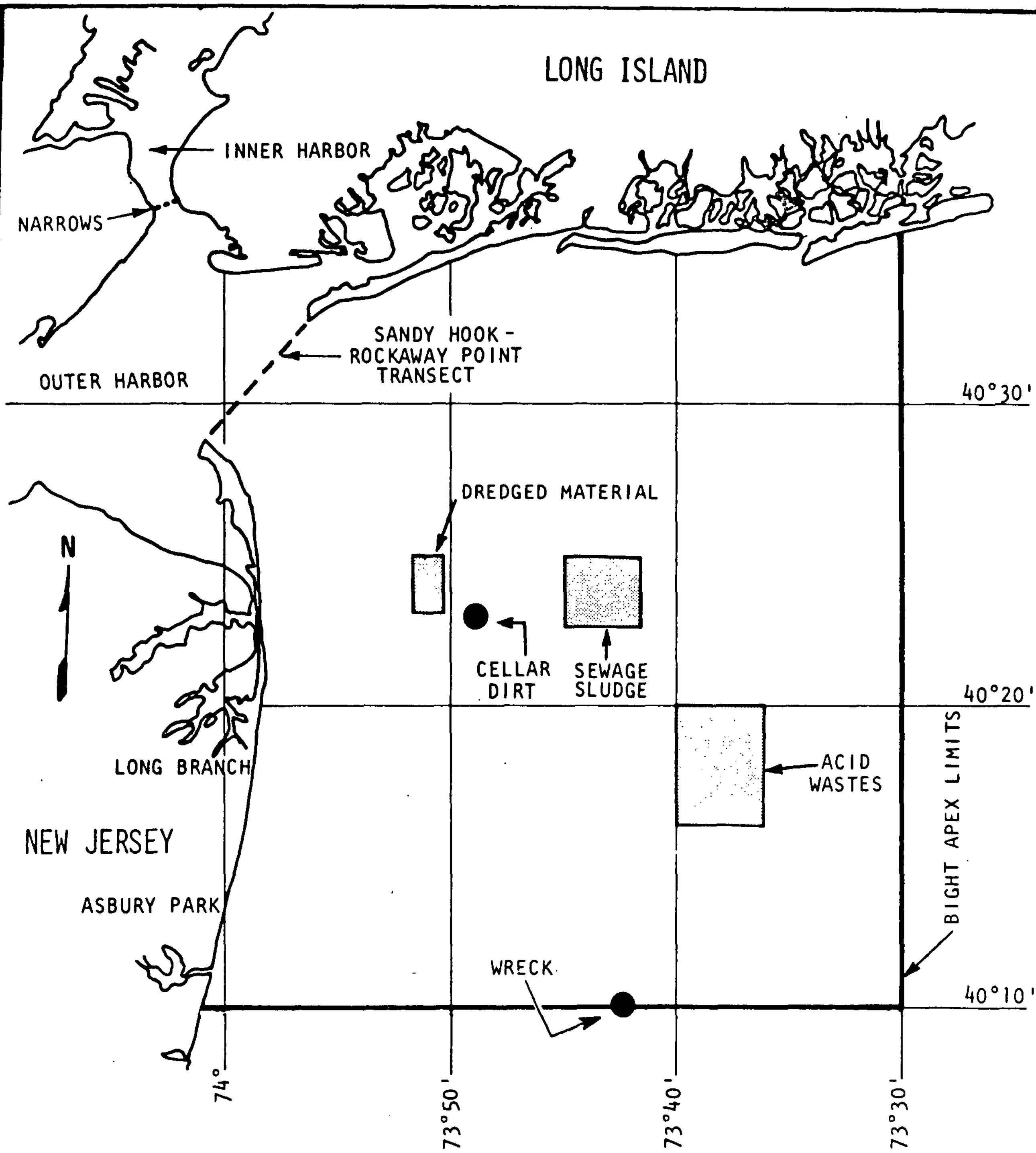
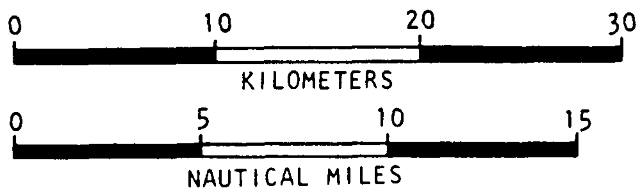


Figure 2

BIGHT APEX AND EXISTING DUMP SITES



In recent years, monitoring has been expanded to include analyses of Bight sediments for heavy metals and toxics; collection of benthic organisms for species diversity and number; and analyses of water in the sewage sludge disposal site area for viruses and pathogens. The sediment and benthic organism samplings were conducted from EPA's ocean survey vessels "Anderson" and "Clean Waters". These 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.

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

II. SAMPLE COLLECTION PROGRAM

During the period of May 1986 through October 1986, water quality monitoring was carried out primarily using the EPA Huey helicopter. Major repair work on the EPA Huey helicopter in the middle of August 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 made it inherently difficult to adhere to the weekly sampling frequency and protocol (only bottom samples were collected in September)

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. The New York Bight Contingency Network consisted of 24 stations which were sampled for dissolved oxygen, and fecal coliform and entercoccus densities. Samples for phytoplankton identification and nutrient analysis were collected

Table 1

Outline of 1986 sampling program

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

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

Table 2

Parameters evaluated for each station group

Parameters	L.I. & N.J. Beaches*	L.I. & N.J. Perpendiculars**	N.Y. Bight**	Bight Contingency**	Phytoplankton*
Fecal Coliform	X		X	X	
Enterococcus	X		X	X	
Salinity Chlorinity		X			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.

along the New Jersey coast and in Raritan Bay at 12 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 enterococcus bacteria densities. This portion of the sampling program totaled 66 stations per week. At the beach stations, samples were collected just offshore in the surf zone while the helicopter hovered approximately 3 meters from the surface. Sampling was accomplished by lowering a 1-liter Kemmerer sampler approximately 1 meter below the water surface. The sample was transferred to a sterile plastic container, iced and subsequently transported (within 6 hours) to the Edison Laboratory for fecal coliform and enterococcus analyses.

The twenty stations in the Bight Apex were sampled once a week. Depending upon sea conditions, the EPA helicopter hovered or landed at the designated station and a 1-liter Kemmerer sampler was used to obtain water samples 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 entercoccus 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. Therefore, a 24-station network was developed and sampled twice a week for dissolved oxygen and once a week for fecal coliform and entercoccus densities. Part of the sampling requirements for the New York Bight contingency plan was satisfied by the regularly scheduled Bight and perpendicular sampling runs. Bacteriological samples for 18 of the stations were collected during the perpendicular sampling runs for dissolved oxygen. The bacteriological requirements for 6 of the stations were met by the regular Bight sampling since bacteriological assays were performed for all Bight stations. An 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. Phytoplankton were identified and quantified by the New Jersey Department of Environmental Protection (NJDEP) and the nutrient analyses were 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. Station JC 44, Mantoloking, was inadvertertly omitted from Figure 4.

New York Bight Stations

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

Table 3

Long Island coast station locations

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

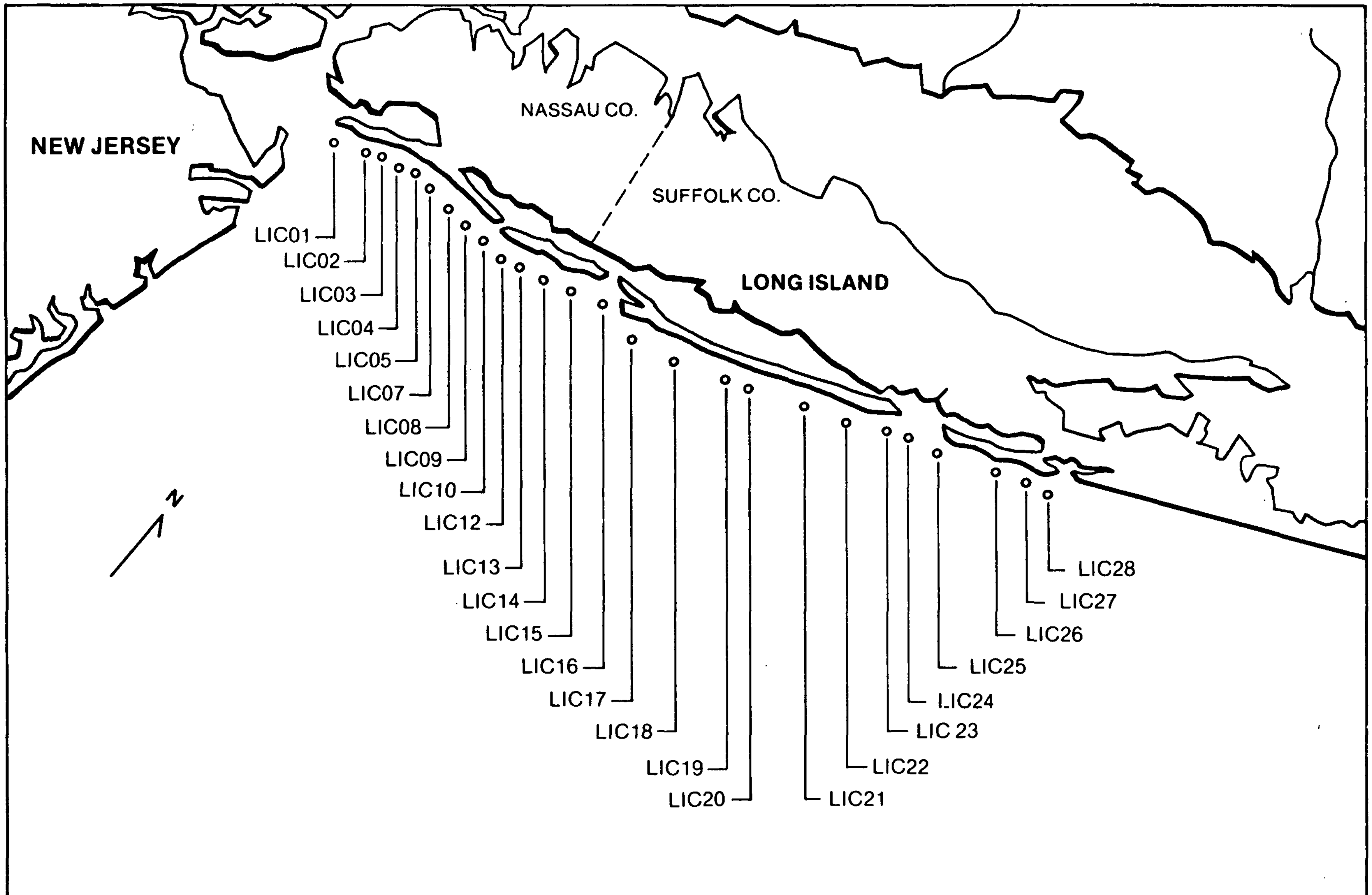


FIGURE 3
LONG ISLAND COAST STATION LOCATIONS

Table 4

New Jersey coast station locations

Station No.	Location
JC 01A	Sandy Hook, 1.2 km south of tip
JC 02	Sandy Hook, off large radome
JC 03	Sandy Hook, off Nature Center building (tower)
JC 05	Sandy Hook, just north of Park entrance
JC 08	Sea Bright, at public beach
JC 11	Monmouth Beach Bath & Tennis Club
JC 14	Long Branch, off foot of S. Bath Avenue
JC 21	Asbury Park, off building north of Convention Hall
JC 24	Bradley Beach, off foot of Cliff Avenue
JC 27	Belmar, off the "White House" near fishing club pier
JC 30	Spring Lake, south of yellow brick building on beach
JC 33	Sea Girt, off foot of Chicago Avenue
JC 37	Point Pleasant, south of Manasquan Inlet
JC 41	Bay Head, off foot of Johnson Street
JC 44	Mantoloking, off foot of Albertson Street
JC 47A	Silver Beach, off foot of Colony Road
JC 49	Lavallette, off foot of Washington Avenue
JC 53	Seaside 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	Harvey Cedars, opposite Harvey Cedars standpipe
JC 65	Ship Bottom, opposite Ship Bottom water tower
JC 67	Beach Haven Terrace, opposite standpipe
JC 69	Beach Haven Heights, opposite the most southern water tower on Long Beach Island
JC 73	Brigantine, off large hotel on beach
JC 75	Atlantic City, off the Convention Center
JC 77	Ventnor City, just north of fishing pier
JC 79	Longport, off water tower
JC 81	Ocean City, opposite large apartment building
JC 83	Peck Beach, opposite large blue water tower
JC 85	Strathmere, off blue standpipe
JC 87	Sea Isle City, opposite blue water tower with bridge in the background
JC 89	Avalon, off beige building on the beach
JC 91	Stone Harbor, off large blue water tower
JC 93	Wildwood, off northern amusement pier
JC 95	Two mile beach, opposite radio tower
JC 97	Cape May, off white house with red roof on the beach
JC 99	Cape May Point, opposite lighthouse

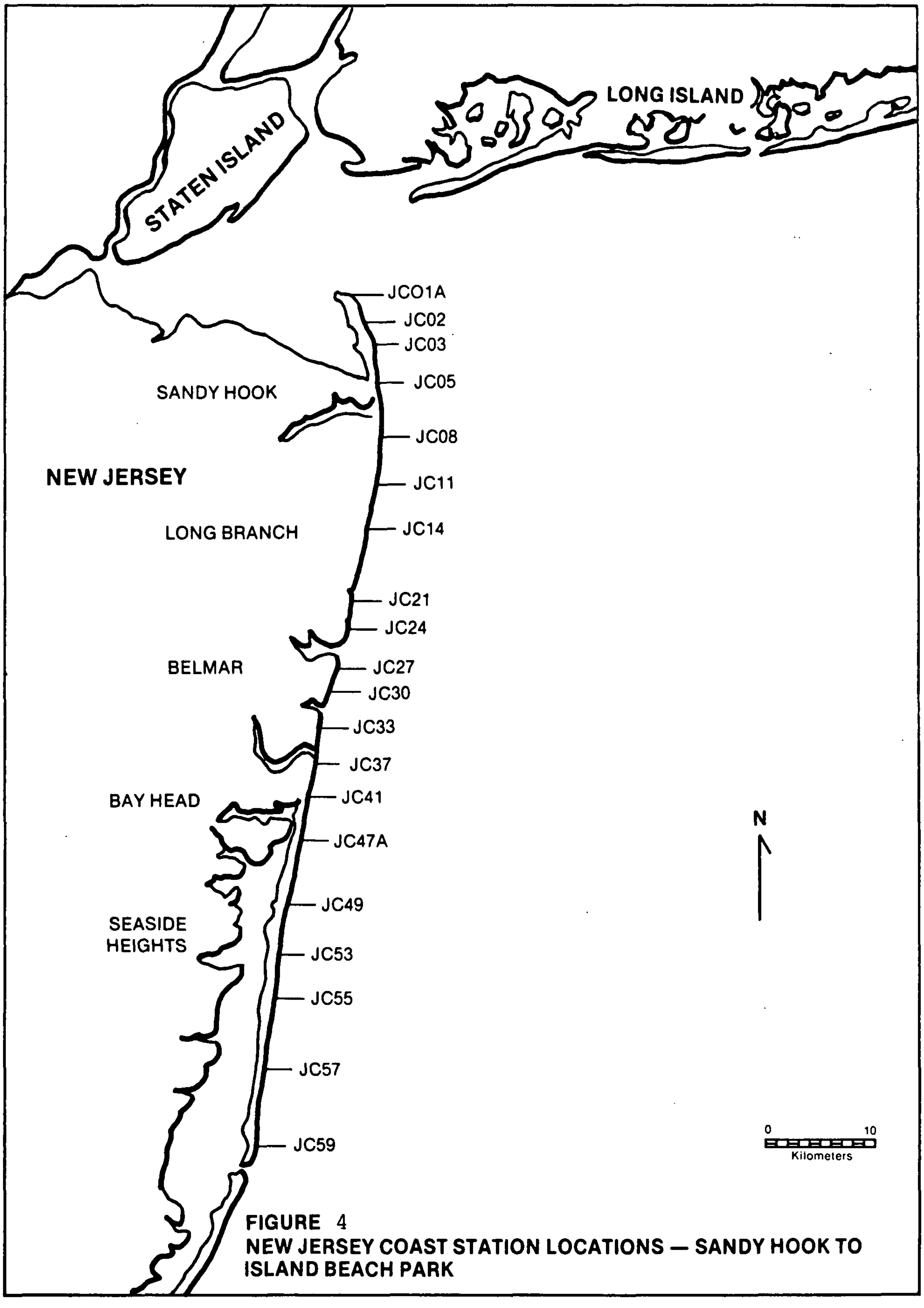


FIGURE 4
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

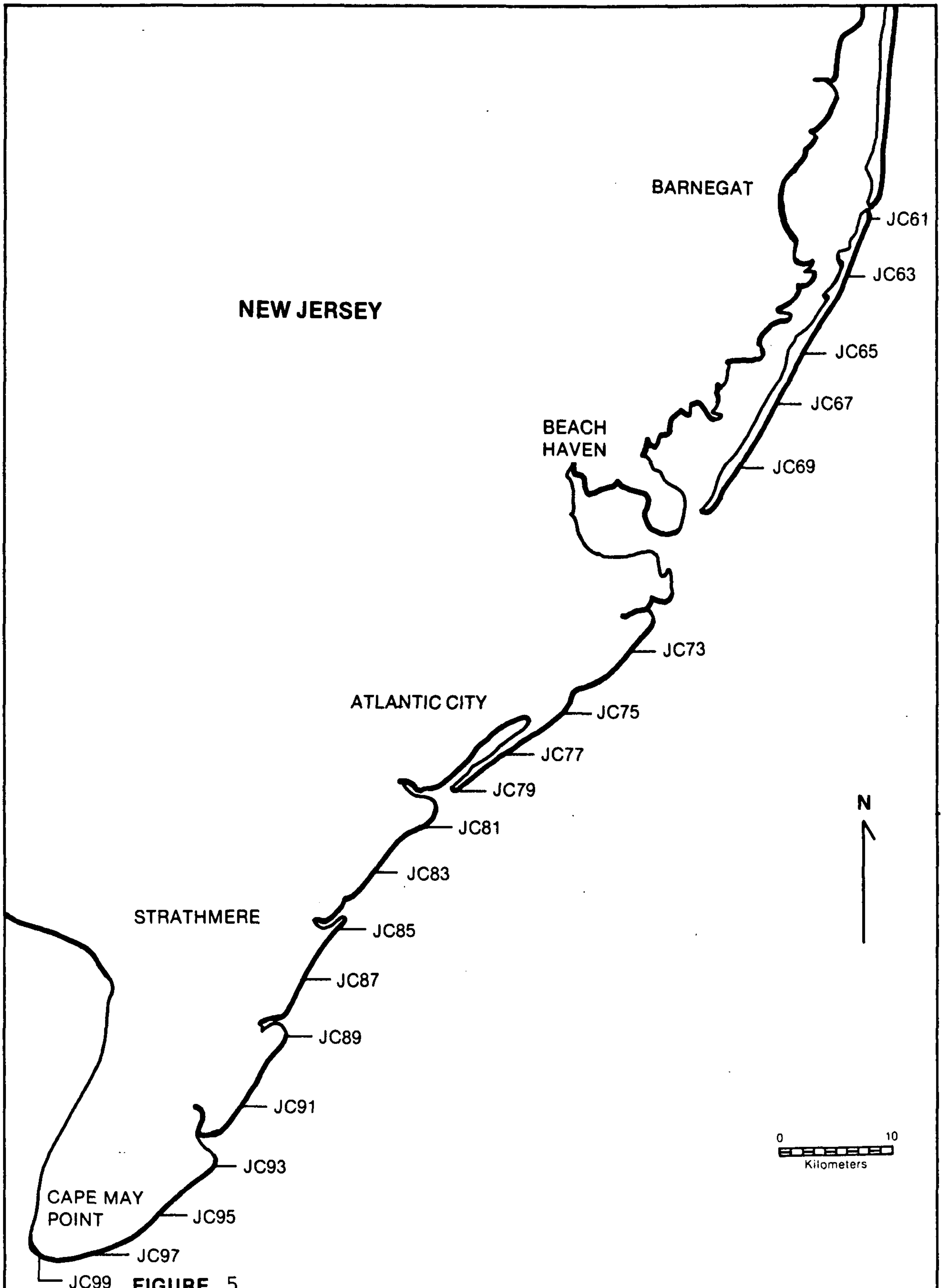


FIGURE 5
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

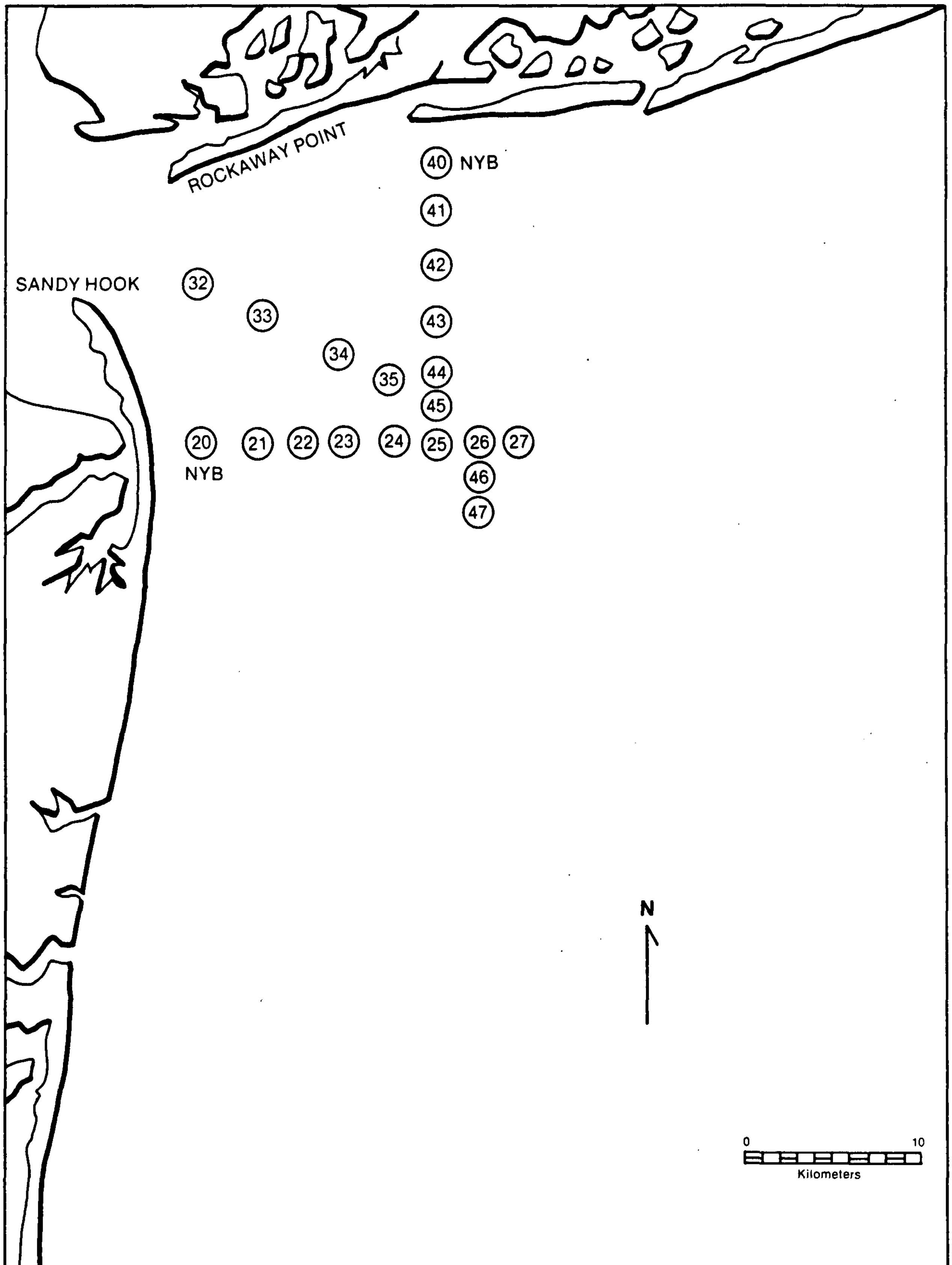


FIGURE 6
NEW YORK BIGHT STATION LOCATIONS

Perpendicular Stations

Sampling stations perpendicular to the Long Island coastline are 5.4 kilometers (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 the National Oceanic and Atmospheric Administration (NOAA) to provide dissolved oxygen profiles from stations further out in the Bight in conjunction with their Northeast Monitoring Program (NEMP) 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.

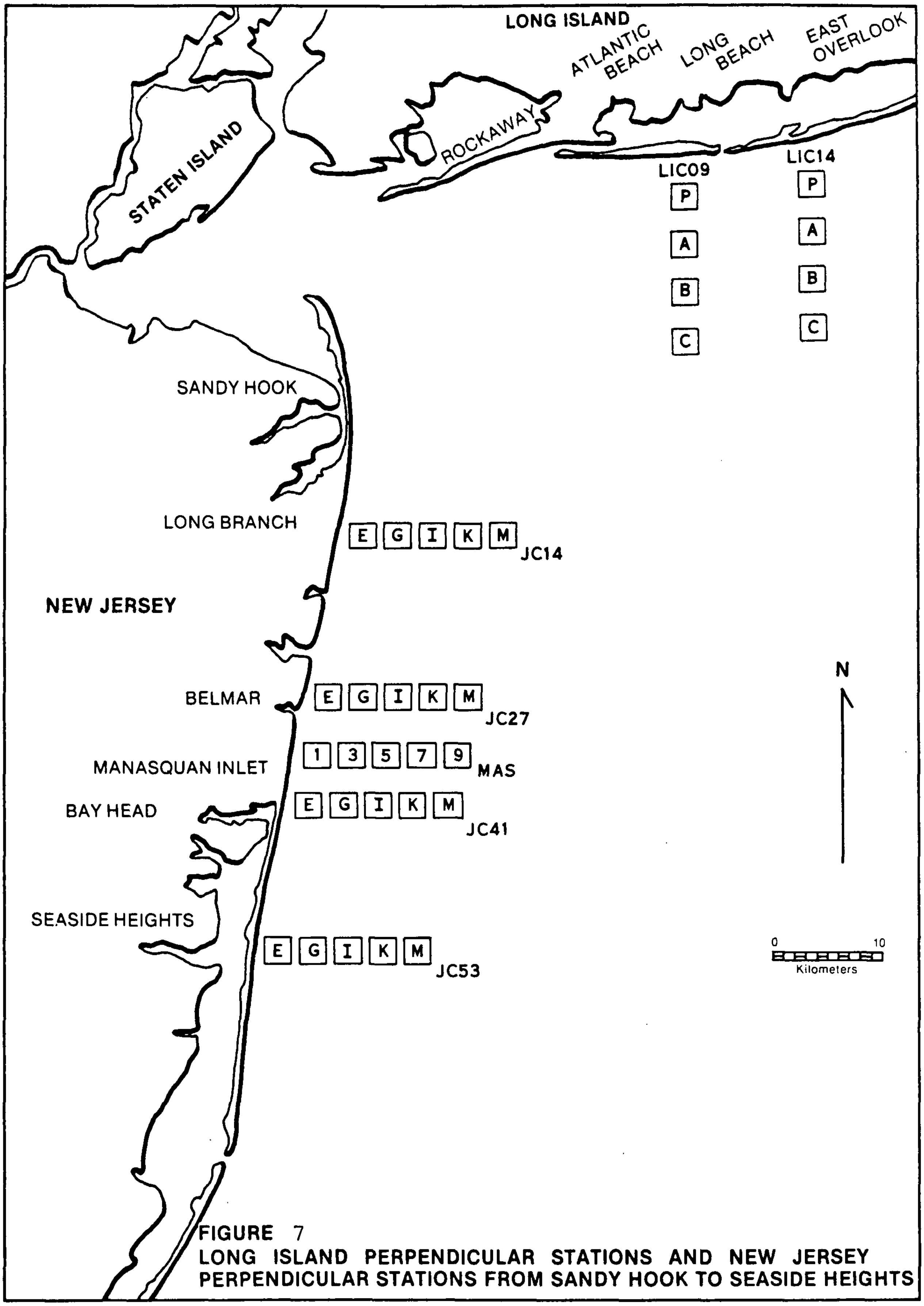


FIGURE 7
LONG ISLAND PERPENDICULAR STATIONS AND NEW JERSEY PERPENDICULAR STATIONS FROM SANDY HOOK TO SEASIDE HEIGHTS

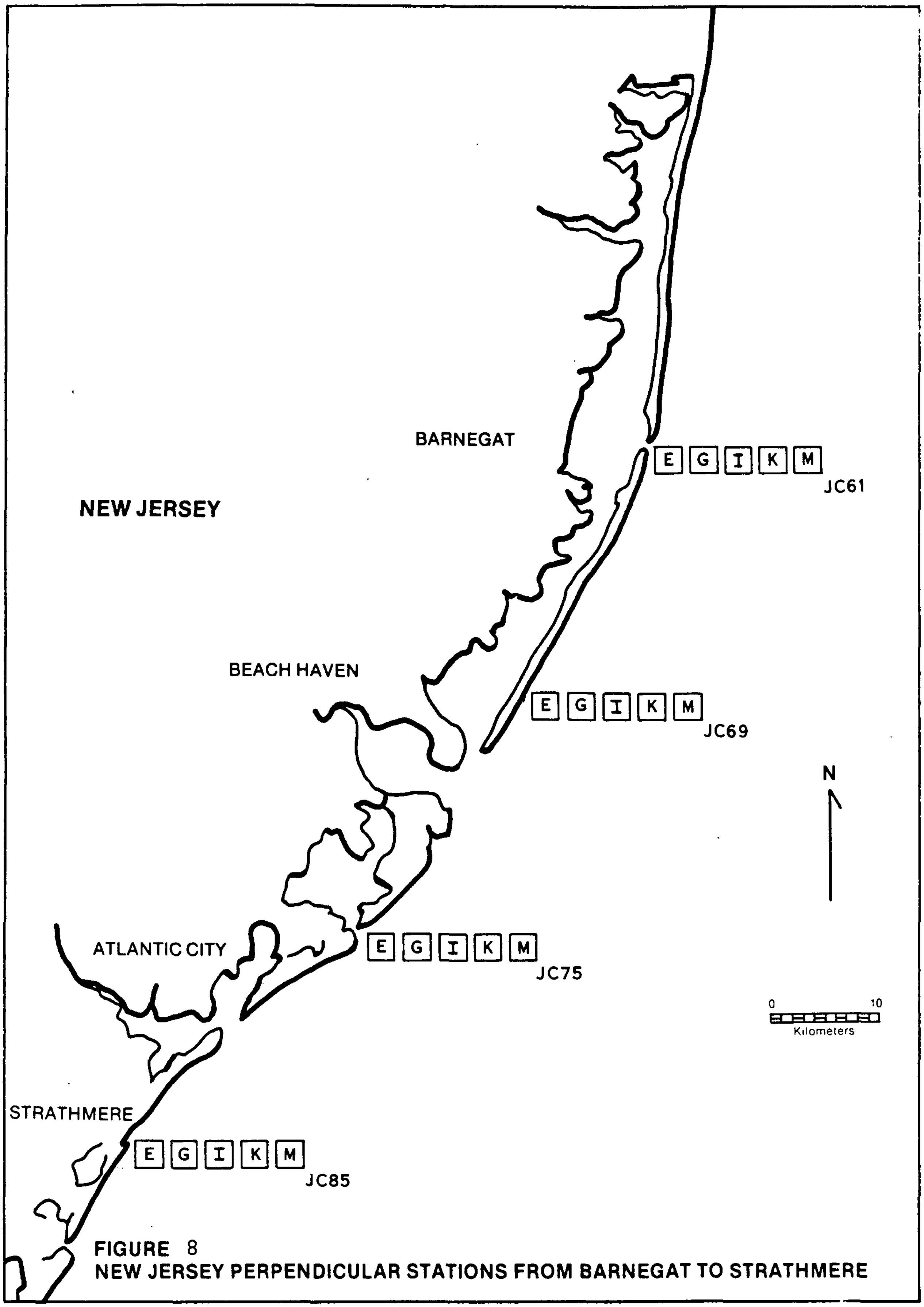


FIGURE 8
NEW JERSEY PERPENDICULAR STATIONS FROM BARNEGAT TO STRATHMERE

Phytoplankton Stations

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

JC 05	JC 49	JC 65
JC 11	JC 57	JC 75
JC 21	RB 32	JC 83
JC 30	RB 15	JC 93

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.

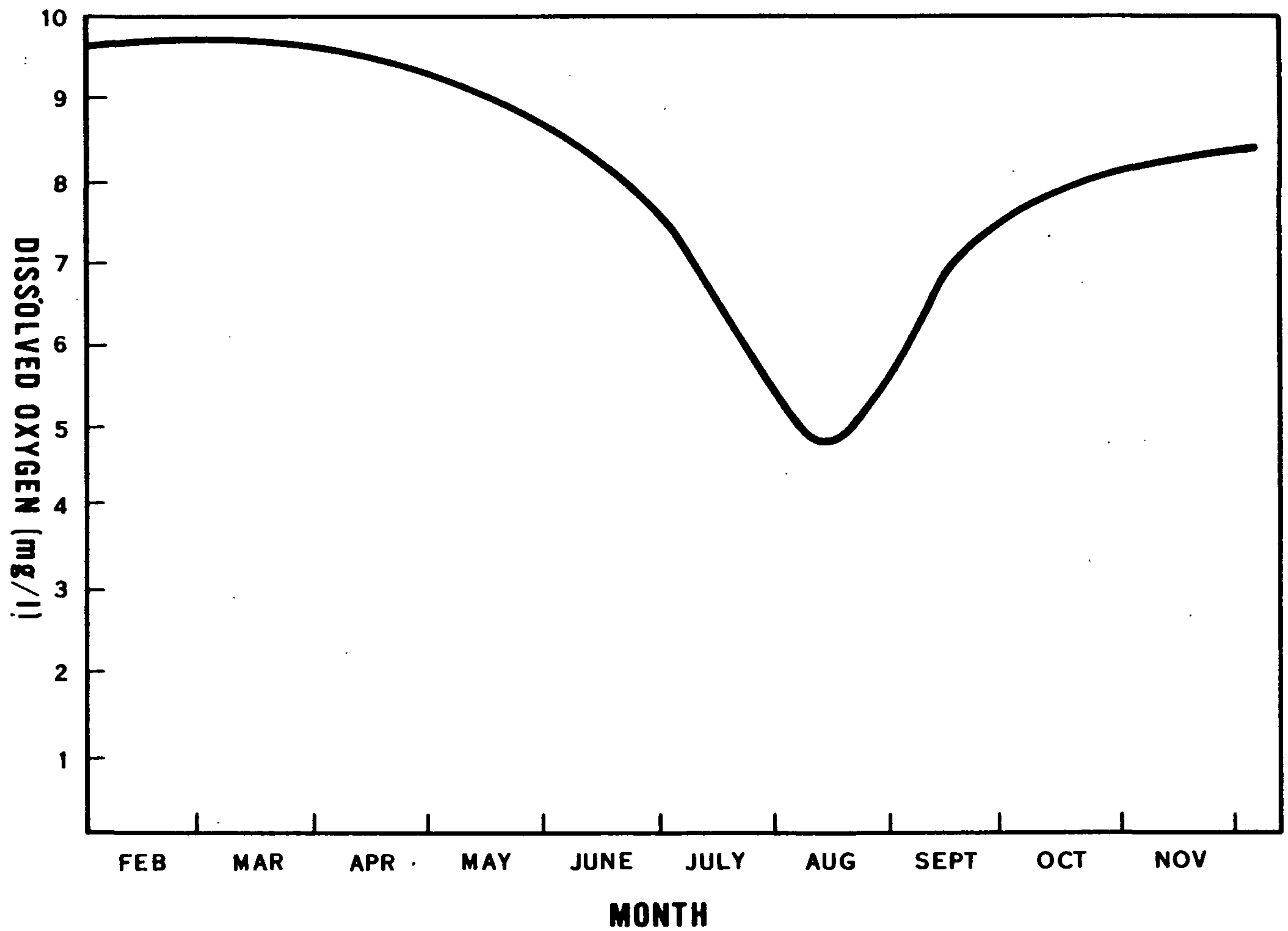


FIGURE 9
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

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

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

Surface Dissolved Oxygen - 1986

The completely mixed upper water layer had dissolved oxygen levels at or near saturation during the entire sampling period, May 6, 1986 through October 30, 1986, therefore no further discussion of surface dissolved oxygen will be presented in this report.

Bottom Dissolved Oxygen - 1986

Long Island Coast

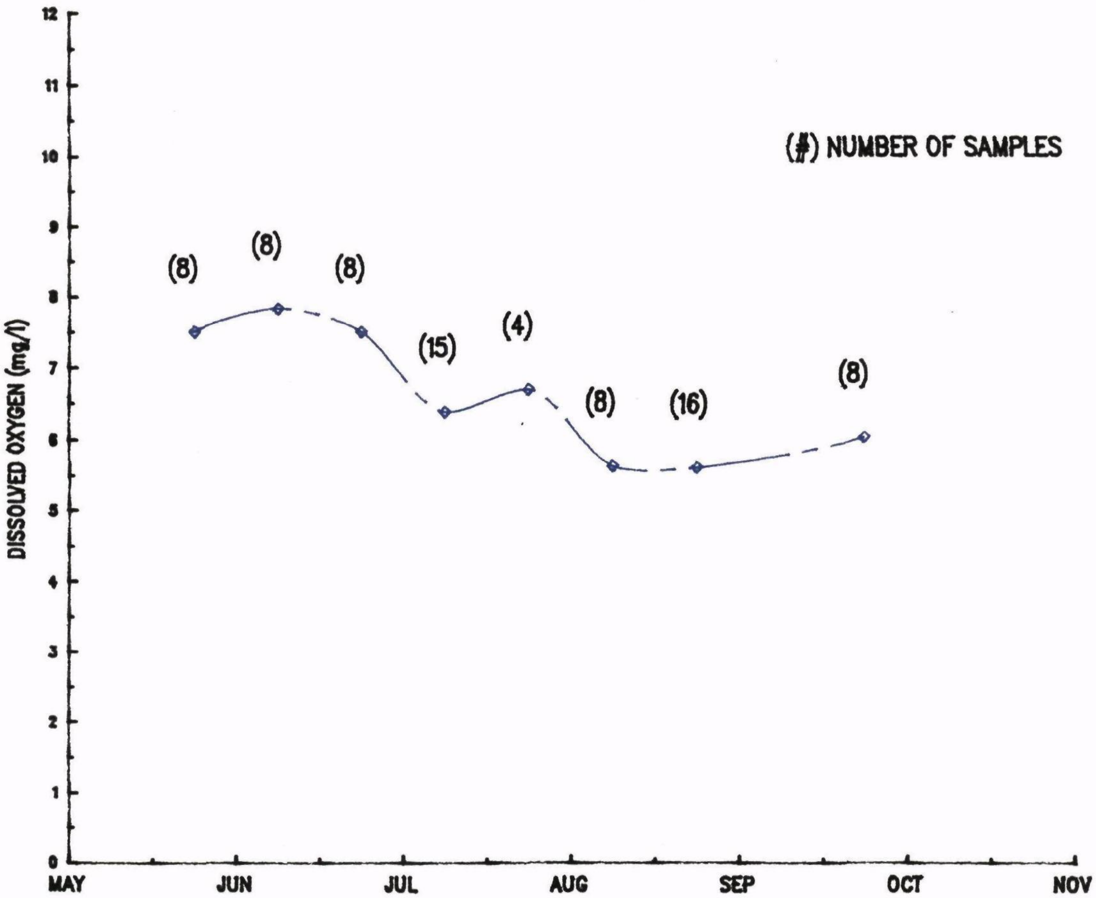
Figure 10 illustrates the semi-monthly averages of dissolved oxygen values from May through September along the Long Island perpendiculars. As in previous years, the dissolved oxygen averages during 1986 remained well above concentrations considered stressful to aquatic life. The dissolved oxygen average from May through July remained in the 6-8 mg/l range. The lowest dissolved oxygen average, 5.5 mg/l, occurred in mid-August with a subsequent dissolved oxygen increase occurring in mid-September.

During the sampling period, 103 bottom samples were collected for dissolved oxygen along the Long Island perpendiculars. Of the 103 samples, only one was below the 4 mg/l "borderline to healthy" guideline. On August 12, station LIC 09B, 11 miles off Long Beach, had a dissolved oxygen concentration of 2.9 mg/l.

New York Bight Apex

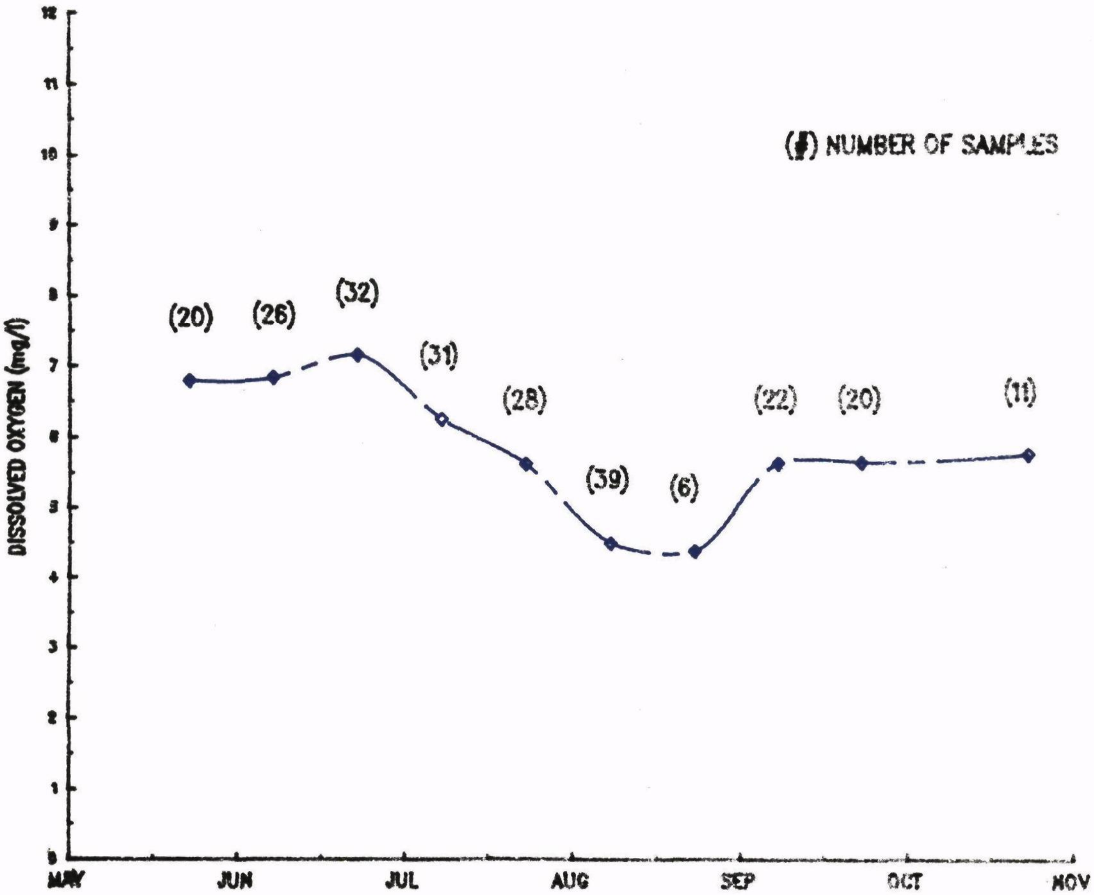
Figure 11 illustrates the semi-monthly dissolved oxygen averages at the New York Bight Apex stations from May through October, 1986. The dissolved oxygen average increased slightly from 6.9 mg/l in May to 7.2 mg/l in late June. During July and August, the dissolved oxygen average steadily decreased, reaching a low of 4.2 mg/l in late August. From late August to early September, the dissolved oxygen average increased 1.3 mg/l to 5.5 mg/l, and remained at this level into late October.

FIGURE 10



LONG ISLAND COAST BOTTOM DISSOLVED OXYGEN, 1986
SEMIMONTHLY AVERAGE OF ALL LONG ISLAND PERPENDICULAR STATIONS.

Figure 11



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1986
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

Out of 241 samples collected in the New York Bight Apex from May 16 to October 29 and measured for dissolved oxygen, 9 samples, or 3.7 percent, were between the 3-4 mg/l level considered "stressful if prolonged" for aquatic life, and 4 samples, or 1.7 percent, were between the 2-3 mg/l level considered "lethal if prolonged".

Table 5 summarizes the dissolved oxygen values less than 4 mg/l in the New York Bight Apex during the summer of 1986.

Table 5 - Dissolved oxygen (D.O.) concentrations less than 4 mg/l in the New York Bight Apex, summer 1986

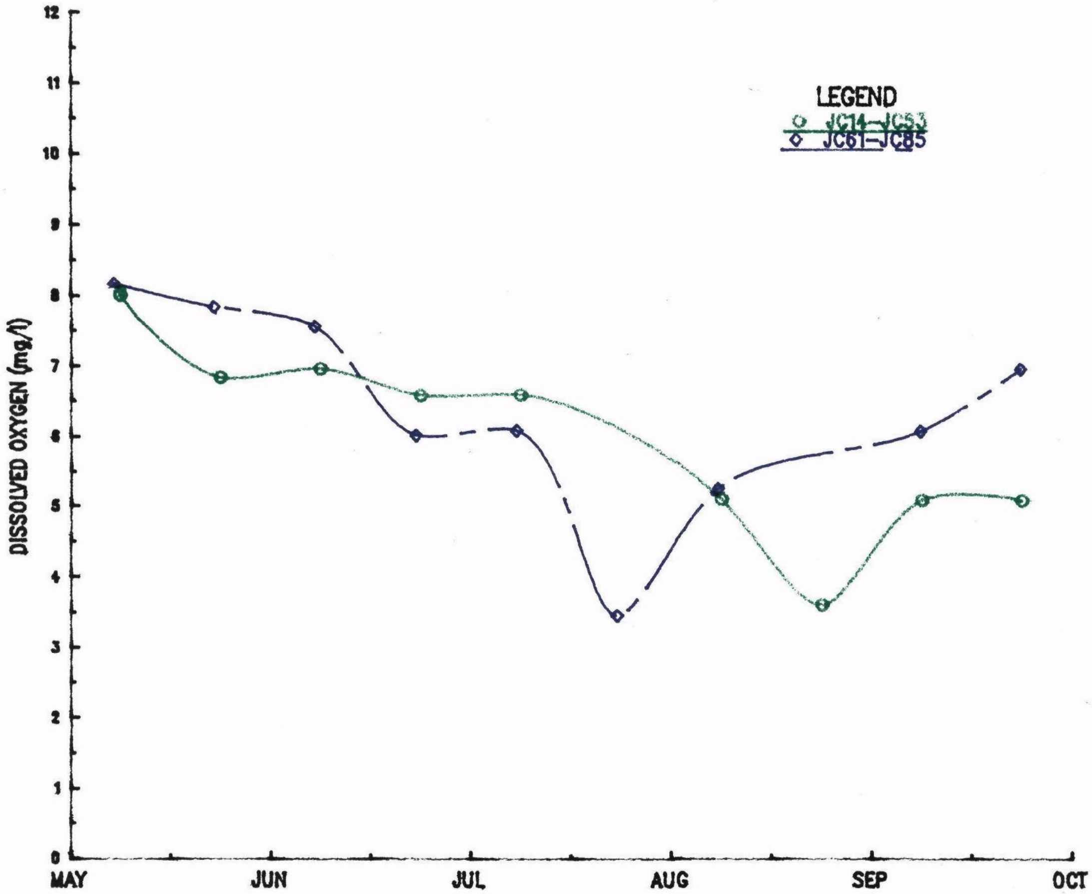
DATE	STATION	D.O. (mg/l)
8/7	NYB 34	3.5
8/7	NYB 35	3.8
8/7	NYB 42	3.8
8/7	NYB 43	2.5
8/7	NYB 44	2.6
8/14	NYB 26	3.8
8/14	NYB 27	3.6
8/14	NYB 41	3.8
8/14	NYB 42	3.7
8/14	NYB 43	2.3
8/16	NYB 42	3.8
8/16	NYB 44	2.6
9/9	NYB 22	3.9

New Jersey Coast

Figure 12 illustrates the semi-monthly dissolved oxygen average off the New Jersey coast during the summer of 1986, with separate lines for the northern (JC 14-JC 53) perpendiculars and the southern (JC 61-JC 85) perpendiculars. The average dissolved oxygen value along the northern perpendiculars was 8 mg/l in early May, declined approximately 1 mg/l during May and remained at this level into early July. The dissolved oxygen average gradually decreased from 6.7 mg/l in early July to a low of 3.6 mg/l in late August, and increased 1.4 mg/l in early September. Along the southern New Jersey perpendiculars, the dissolved oxygen average was 8.2 mg/l in early May and decreased slightly to 7.7 mg/l in early June. The dissolved oxygen declined to 6 mg/l in late June, remained at this level into early July, then decreased substantially to a low of 3.5 mg/l in late July. This was followed by a dissolved oxygen recovery in August and September.

Table 6 summarizes the bottom dissolved oxygen values for the New Jersey coast perpendiculars. There were 598 samples collected along the New Jersey perpendiculars between May 6 and October 30, 1986 and analyzed for dissolved oxygen. Of these samples, 161 values (26.9 percent) were below 5 mg/l. Of the 161 samples, 105 values (17.6 percent of all samples collected) were between 4-5 mg/l, 54 values (9.0 percent) were between 2-4 mg/l and 2 values (0.3 percent) were between 0-2 mg/l. In comparison, during the summer of 1985, 635 samples were collected. Of these, 107 values (16.9 percent) were between 4-5 mg/l, 244 values (38.4 percent) were between 2-4 mg/l, and 40 values (6.3 percent) were between 0-2 mg/l. Dissolved oxygen values in 1986 were considerably higher than those encountered in 1985.

Figure 12



NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1986. SEMIMONTHLY AVERAGES OF ALL NORTHERN (JC14–JC53) AND SOUTHERN (JC61–JC85) PERPENDICULAR STATIONS.

Table 6 - 1986 NJ DO Distribution (Bottom Values)

	May 6	May 13	May 19	May 27	May 30	Jun 9	Jun 13	Jun 23	Jun 26	Jun 27	Jun 30	Jul 7	Jul 10	Jul 11	Jul 26	Aug 1	Aug 2	Aug 4	Aug 9	Aug 11	Aug 15	Aug 16	Sep 3	Sep 5	Sep 10	Sep 11	Sep 15	Sep 17	Sep 25	Oct 30
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	◆		◆			◆		◆			◆	◆	◆			●		▲		▲			▲		●		▲		◆	
MAS5	◆		◆			◆		◆			◆	◆	◆			◆		◆		◆			◆		◆		◆		▲	
MAS4	◆		◆			◆		◆			◆	◆	◆			◆		▲		◆			◆		▲		◆		▲	
MAS3	◆		◆			◆		◆			◆	◆	◆			◆		▲		◆			◆		●		◆		▲	
MAS2	◆		●			◆		◆			◆	◆	◆			◆		●		◆			◆		▲		▲		▲	
MAS1	◆		◆			◆		◆			◆	◆	◆			◆		●		▲			◆		▲		◆		▲	
JC27M	◆		◆	◆		◆		◆	◆		◆	◆	◆			◆		▲		◆		▲	◆		▲		◆		▲	●
JC27K	◆		◆			◆		◆	◆		◆	◆	◆			◆		▲		▲		▲	◆		◆		◆		◆	▲
JC27I	◆		◆	◆		◆		◆	◆		◆	◆	◆			●		▲		●		●	◆		●		◆		◆	◆
JC27G	◆		◆	◆		◆		◆	▲		◆	◆	◆			◆		▲		●		●	▲		●		◆		◆	◆
JC27E	◆		◆	●		◆		▲	●		◆	◆	◆			◆		▲		●		●	●		▲		◆		◆	◆
JC14M	◆		◆	◆		◆		◆	◆		◆	◆	◆			◆		▲		◆		●	◆		◆		◆		▲	
JC14K	◆		◆	◆		◆		◆	◆		◆	◆	◆			◆		▲		▲		▲	◆		▲		◆		▲	
JC14I	◆			◆		◆		◆	◆		◆	◆	◆			◆		◆		●		▲	◆		●		◆		▲	
JC14G	◆		◆	◆		◆		◆	▲		◆	◆	◆			◆		◆		▲		●	▲		●		◆		◆	
JC14E	◆		◆	◆		◆		●	▲		▲	▲	◆			◆		▲		●		●	▲		▲		◆		◆	

◆ = > 5 mg/l ▲ = 4–5 mg/l ● = 2–4 mg/l ■ = 0–2 mg/l

Figures 13, 14, 15, 16, and 17 display dissolved oxygen profiles along the New Jersey coast from May through September. Figures 13 and 14 show that the dissolved oxygen concentrations in May and June were high. With the exception in May of perpendicular JC 53, Seaside Heights, the dissolved oxygen levels increased with distance from shore. Figure 15 shows that in July the dissolved oxygen levels decreased considerably along the southern New Jersey perpendiculars. The dissolved oxygen levels again increased with distance from shore with the exceptions of the Beach Haven, JC 69, and Atlantic City, JC 75, perpendiculars. During August, Figure 16, the dissolved oxygen concentrations along the northern New Jersey perpendiculars were slightly lower than in July and increased with distance offshore. All dissolved oxygen concentrations improved in September, Figure 17, with the northern 5 New Jersey perpendiculars again exhibiting an increase of dissolved oxygen with distance offshore.

Figure 18 compares the shore to seaward distribution of dissolved oxygen along the northern New Jersey perpendiculars. As shown in Figures 13-17, generally the dissolved oxygen values increase with distance offshore. During late June through late August, the dissolved oxygen concentrations 1 and 3 miles offshore were approximately 1 to 2 mg/l less than the values 5, 7, and 9 miles offshore. The low dissolved oxygen values found at the nearshore stations were attributed to the influence of river discharges, treatment plant effluents, stormwater runoff, benthic oxygen demand from inlet dredged material disposal sites, and the Hudson-Raritan River Estuary system.

Figure 19 compares the shore to seaward distribution of dissolved

Figure 13

Dissolved Oxygen Concentration Profiles

New Jersey Coast

May 1986

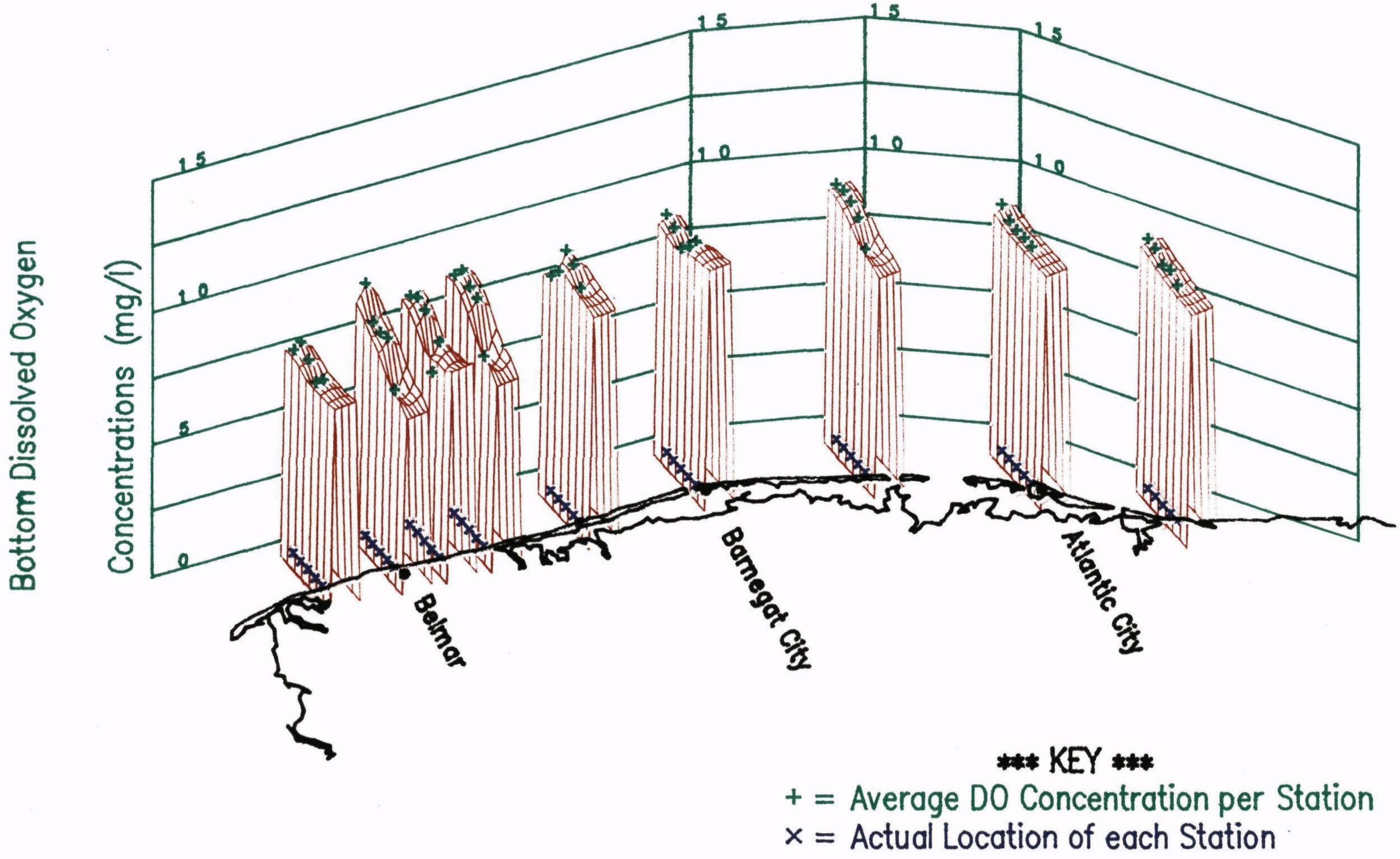


Figure 14

Dissolved Oxygen Concentration Profiles

New Jersey Coast

June 1986

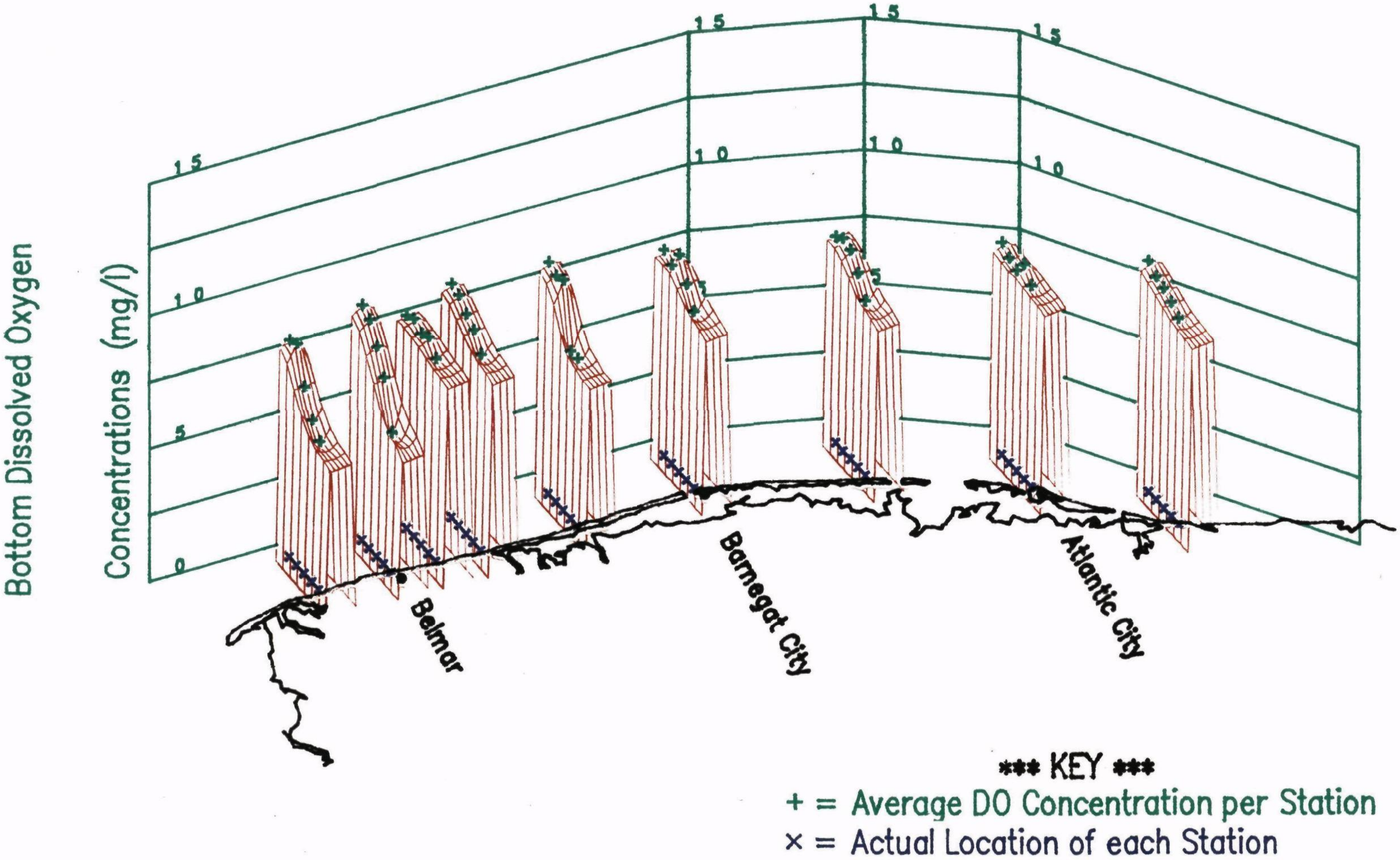
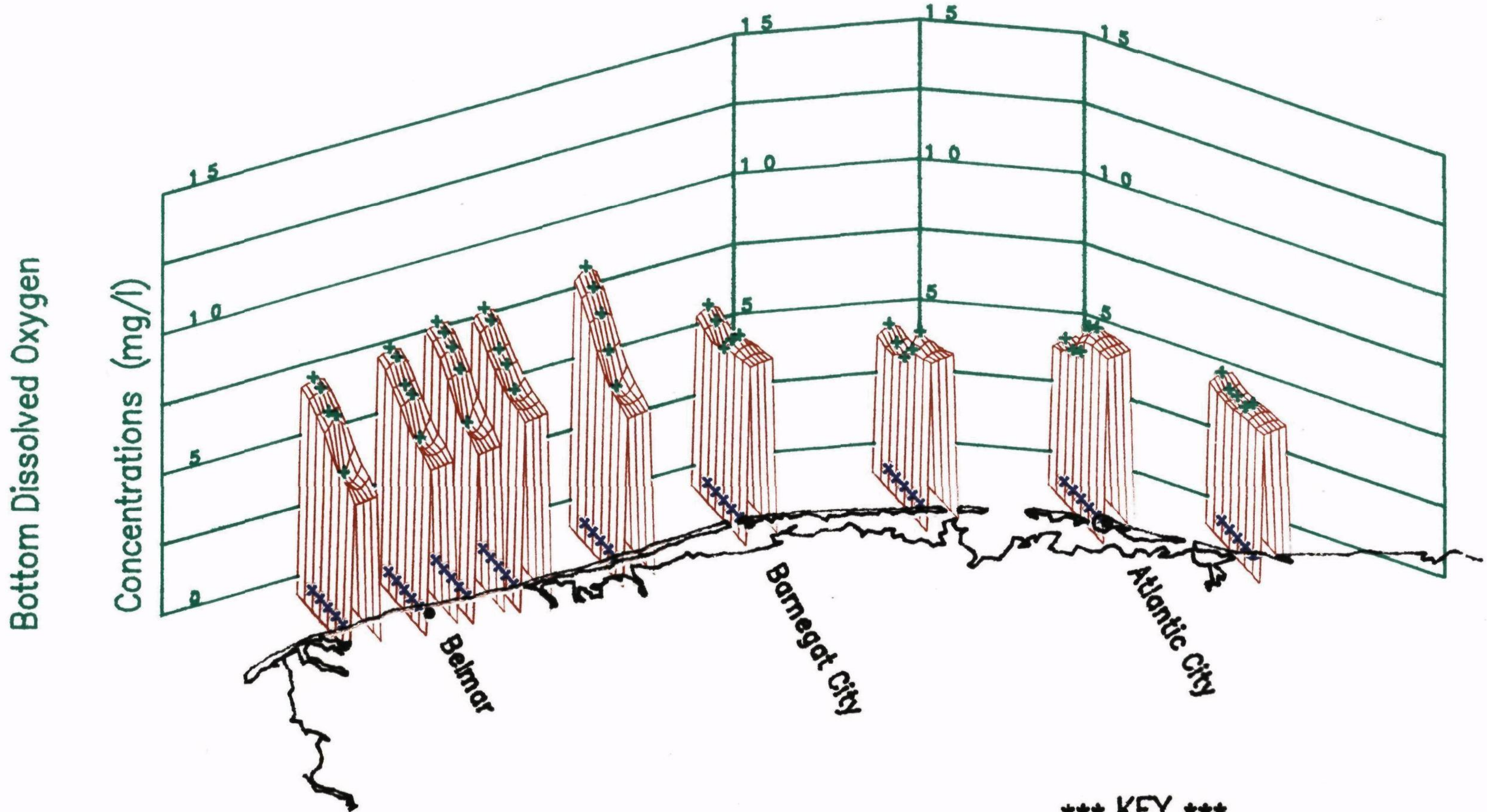


Figure 15

Dissolved Oxygen Concentration Profiles

New Jersey Coast

July 1986



*** KEY ***

+ = Average DO Concentration per Station

× = Actual Location of each Station

Figure 16

Dissolved Oxygen Concentration Profiles

New Jersey Coast

August 1986

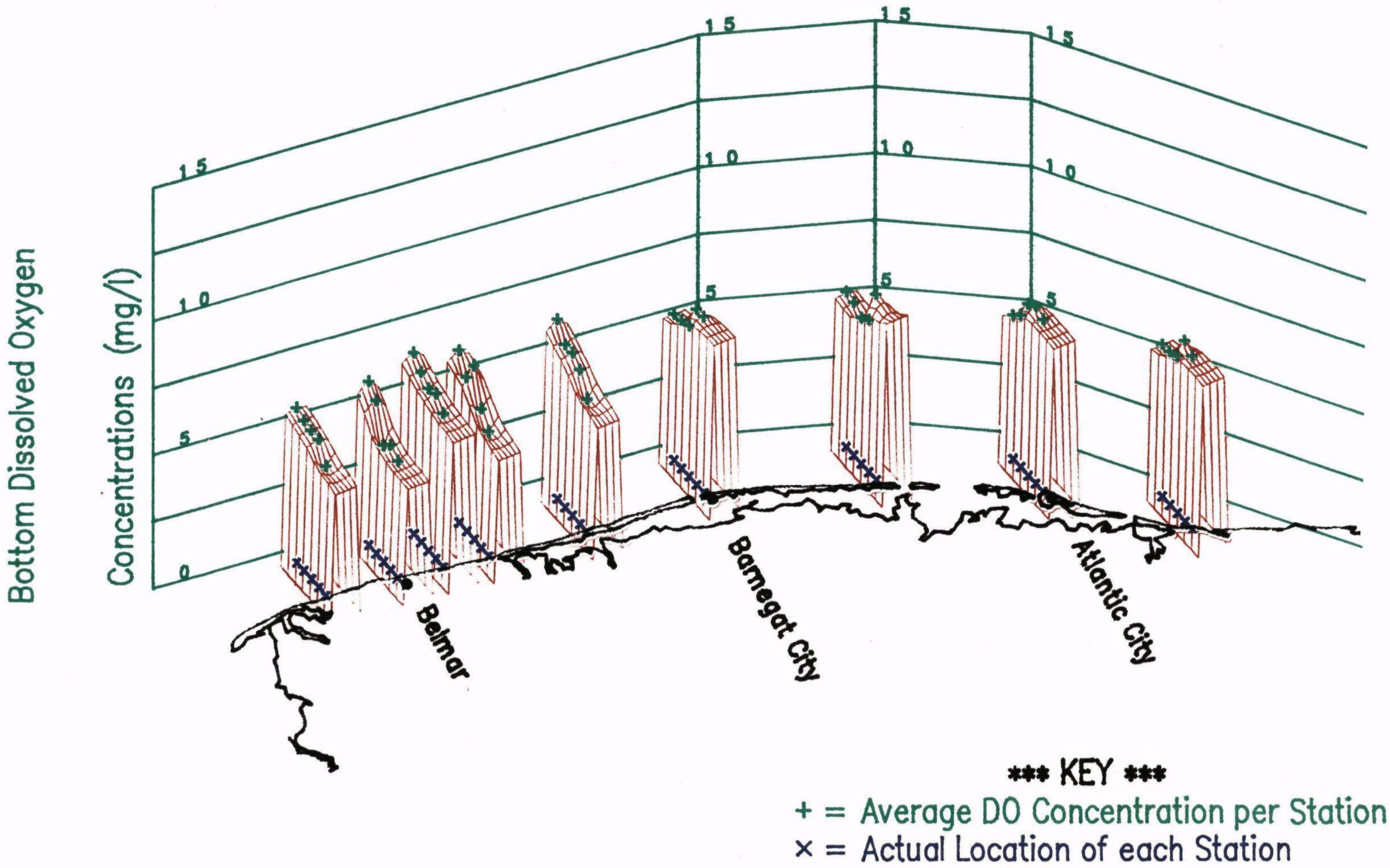
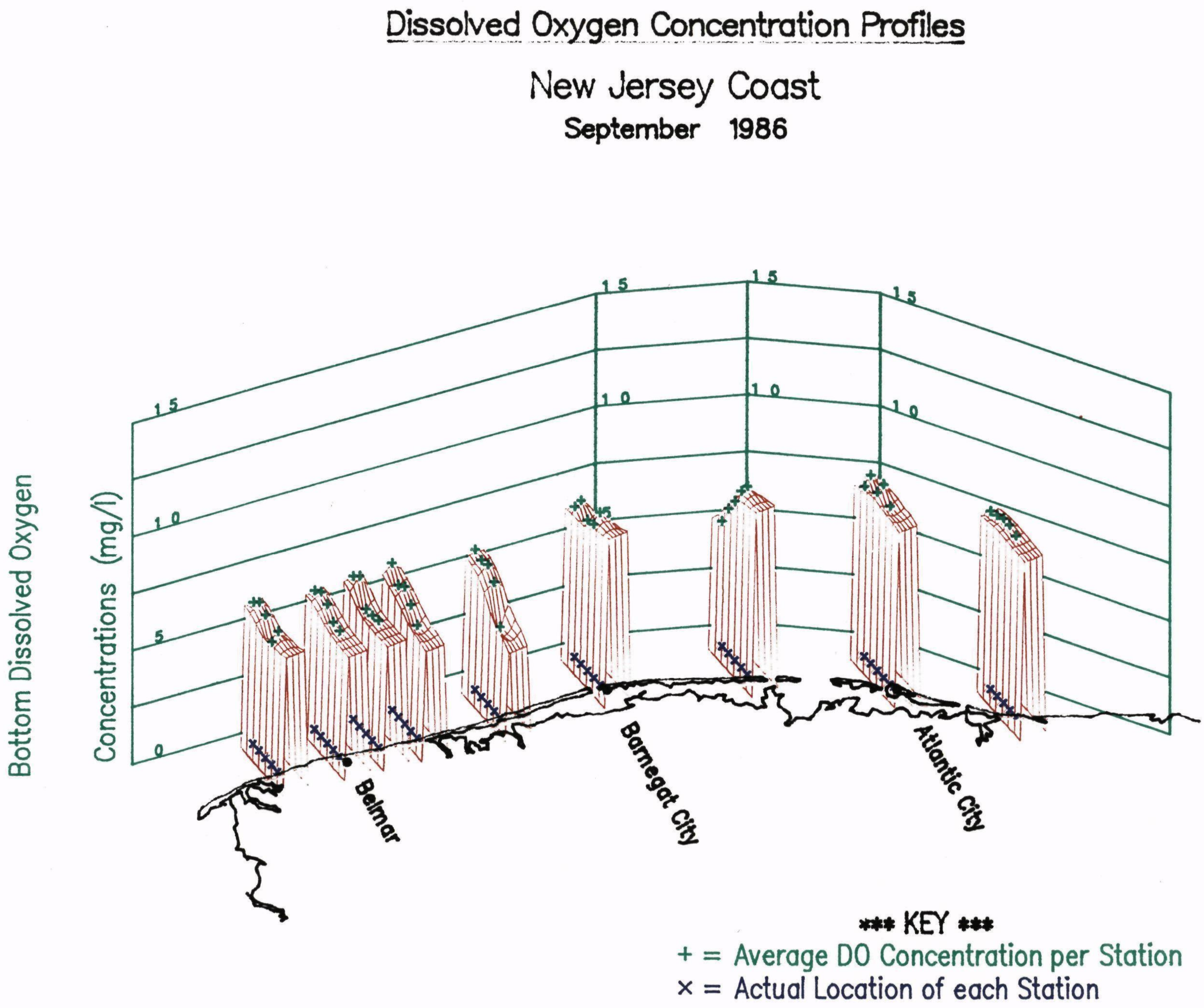
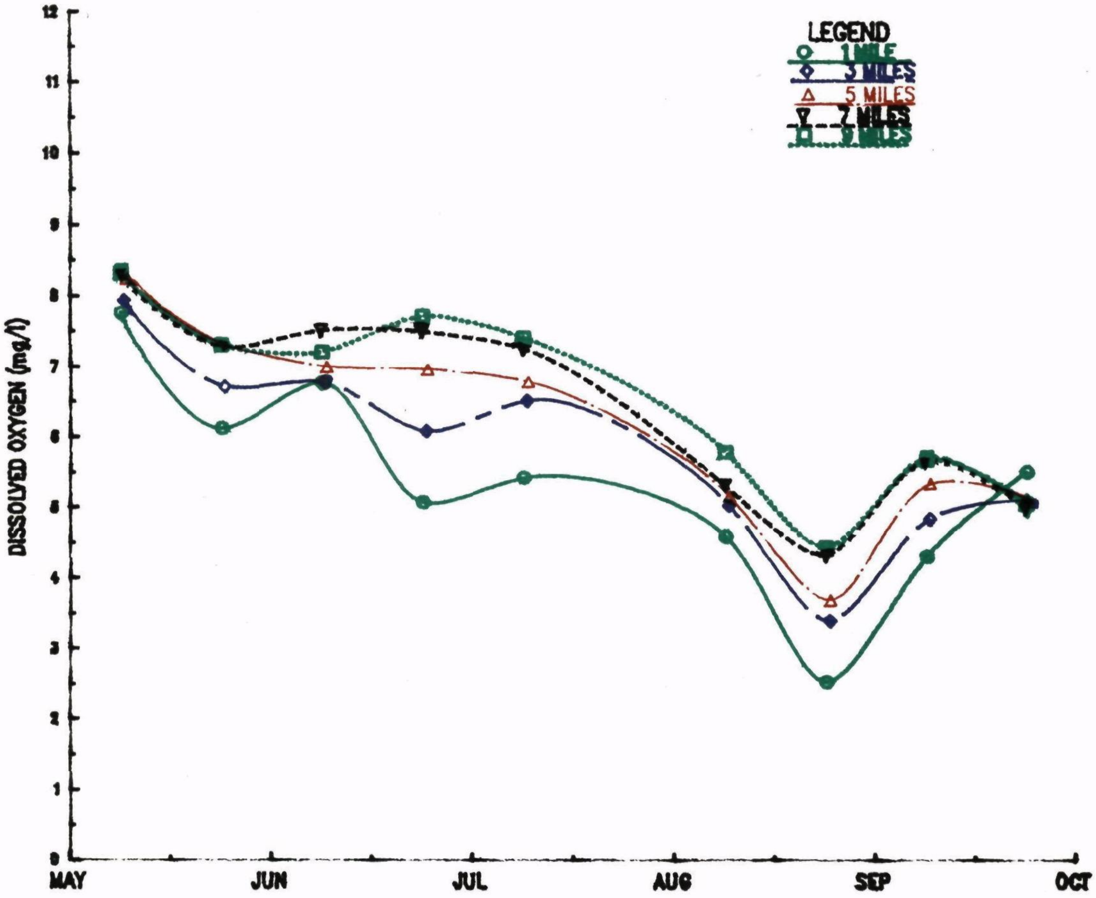


Figure 17



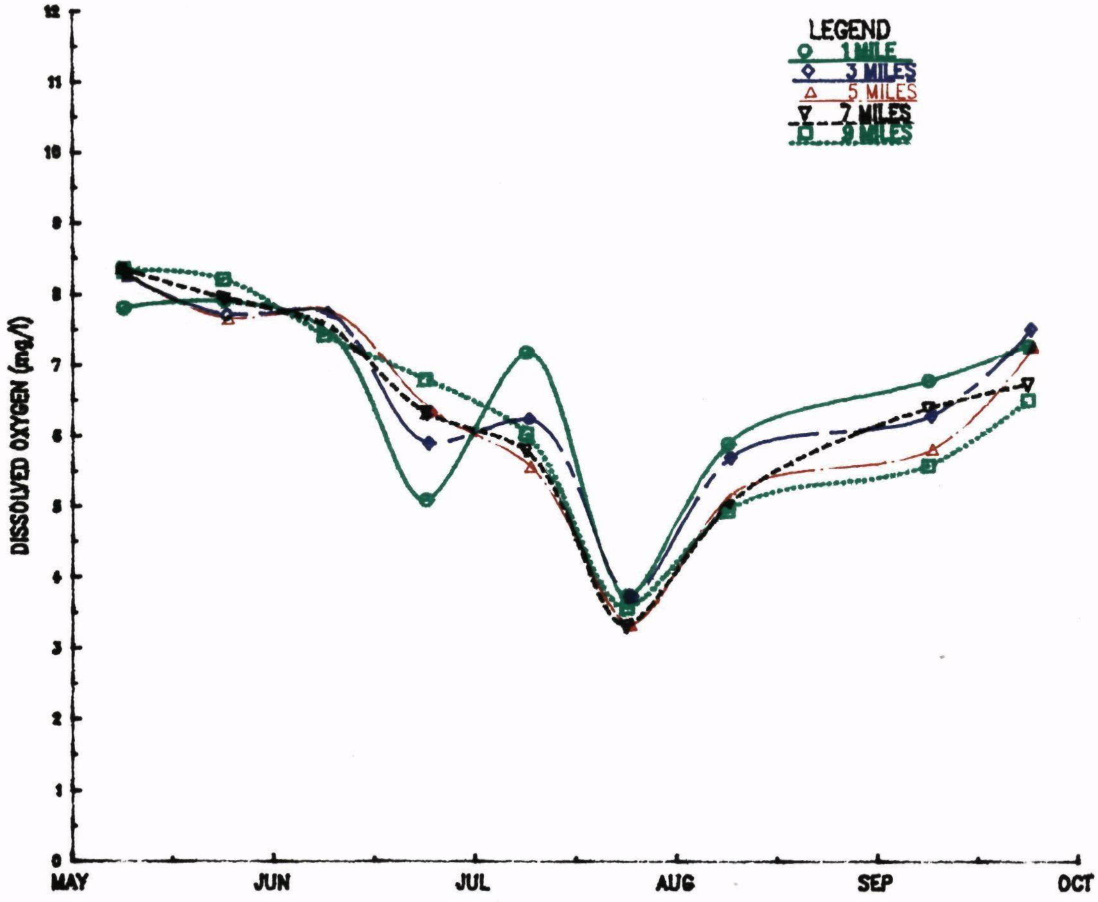
Dissolved Oxygen Concentration Profiles
New Jersey Coast
September 1986
Bottom Dissolved Oxygen
Concentrations (mg/l)
15
10
5
0
Belmar
Barnegat City
Atlantic City
*** KEY ***
+ = Average DO Concentration per Station
× = Actual Location of each Station

FIGURE 18



SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1986
SEMIMONTHLY AVERAGES OF ALL NORTHERN PERPENDICULAR STATIONS
(JC14-JC53), AT FIXED DISTANCES FROM SHORE.

Figure 19



SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1986
SEMIMONTHLY AVERAGES OF ALL SOUTHERN PERPENDICULAR STATIONS
(JC61-JC85), AT FIXED DISTANCES FROM SHORE.

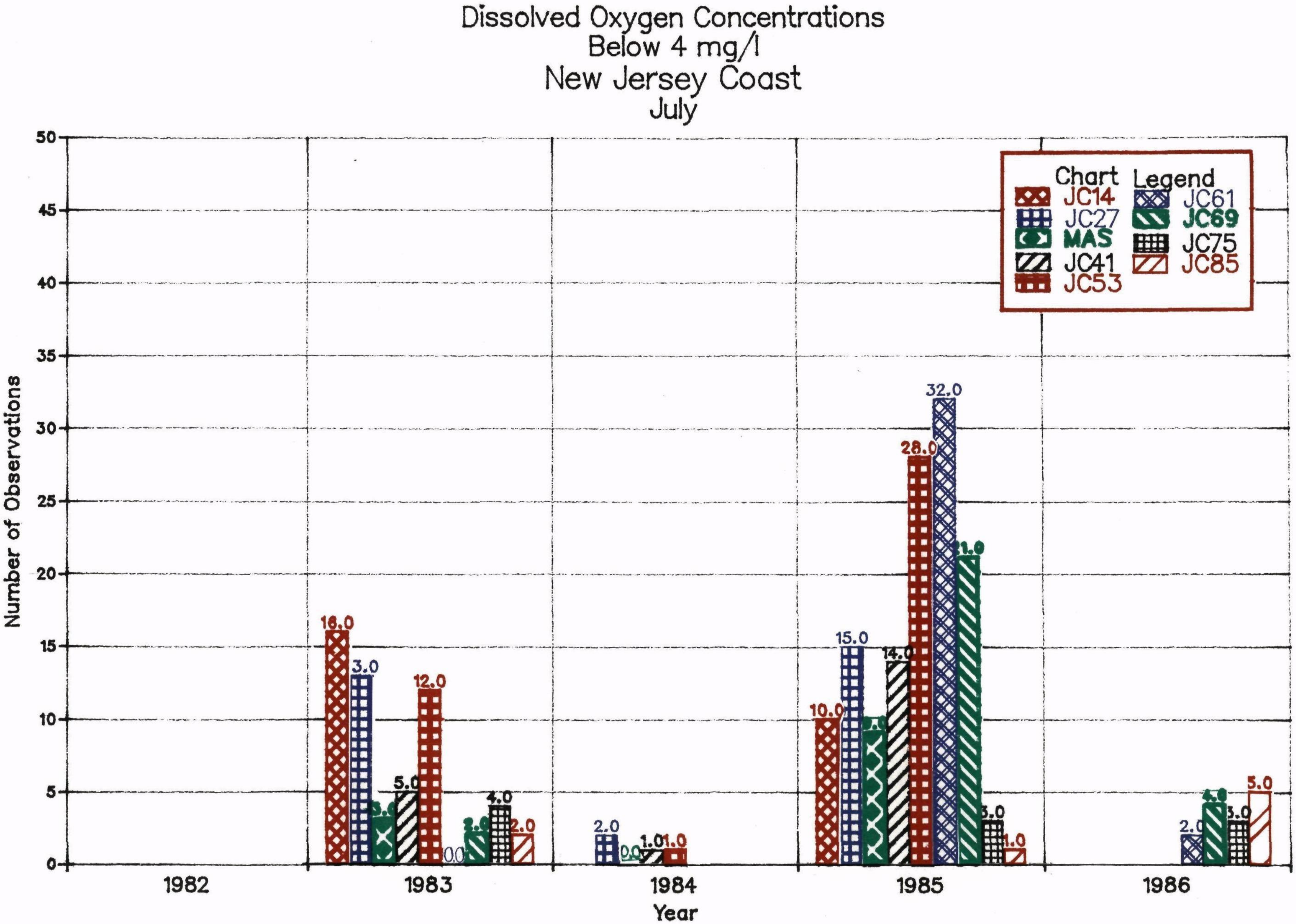
oxygen along the southern New Jersey perpendiculars. The stations 1 mile offshore exhibited a "double minima", with low points of 5 mg/l in late June and 3.7 mg/l in late July. The stations 3, 5, 7 and 9 miles offshore followed the general dissolved oxygen cycle, Figure 9, reaching a low in late July. The dissolved oxygen values increased considerably at all distances from shore in August and September.

Dissolved Oxygen Trends

Figures 20, 21 and 22 display the number of dissolved oxygen observations below 4 mg/l during July, August and September 1982-1986, for each perpendicular. The graphs indicate that, similar to 1982 and 1984, the dissolved oxygen concentrations from July to September 1986 were generally good with few values below 4 mg/l, as contrasted with 1983 and 1985 which had numerous dissolved oxygen values below 4 mg/l. In July 1986, 14 dissolved oxygen values below 4 mg/l were observed along the New Jersey perpendiculars, Figure 20, as compared with 132 during the same period in 1985. In 1986, the largest number of dissolved oxygen values below 4 mg/l, 24 observations, occurred in August, as shown in Figure 21. This is contrasted with 108 dissolved oxygen values below 4 mg/l during August in 1985. In September 1986, 7 dissolved oxygen values were below 4 mg/l, and in 1985 there were 81 values below 4 mg/l, Figure 22.

Figure 23 displays the five year dissolved oxygen arithmetic mean of all semi-monthly averages for the northern New Jersey perpendicular stations. The average dissolved oxygen in early May was 8 mg/l. From May through late July the dissolved oxygen gradually decreased to approx-

Figure 20



Dissolved Oxygen Concentrations
Below 4 mg/l
New Jersey Coast
July
Chart Legend
JC14
JC27
MAS
JC41
JC53
JC61
JC69
JC75
JC85
Number of Observations
Year
1982
1983
1984
1985
1986

Figure 21

Dissolved Oxygen Concentrations
Below 4 mg/l
New Jersey Coast
August

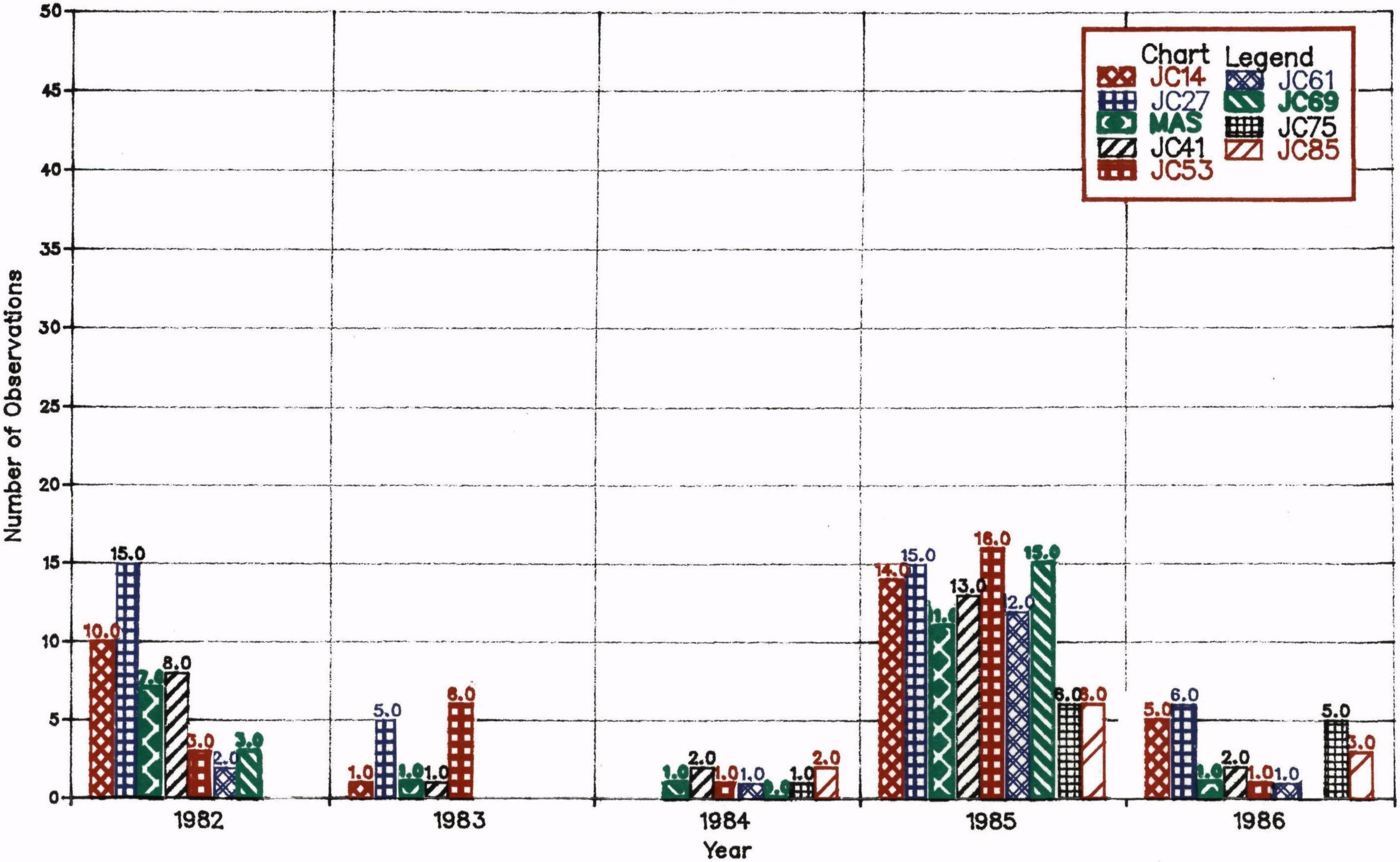


Figure 22

Dissolved Oxygen Concentrations Below 4 mg/l New Jersey Coast September

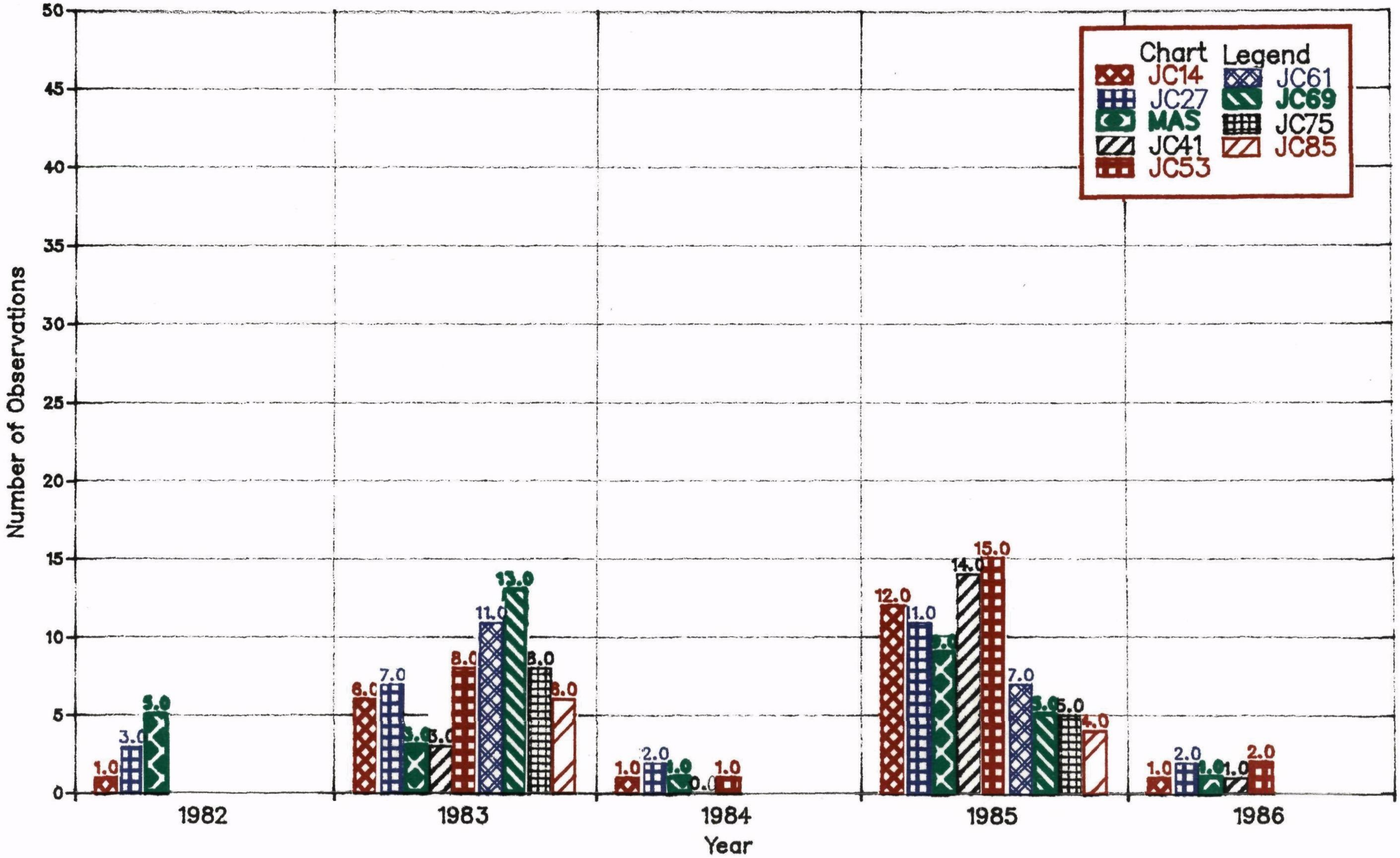
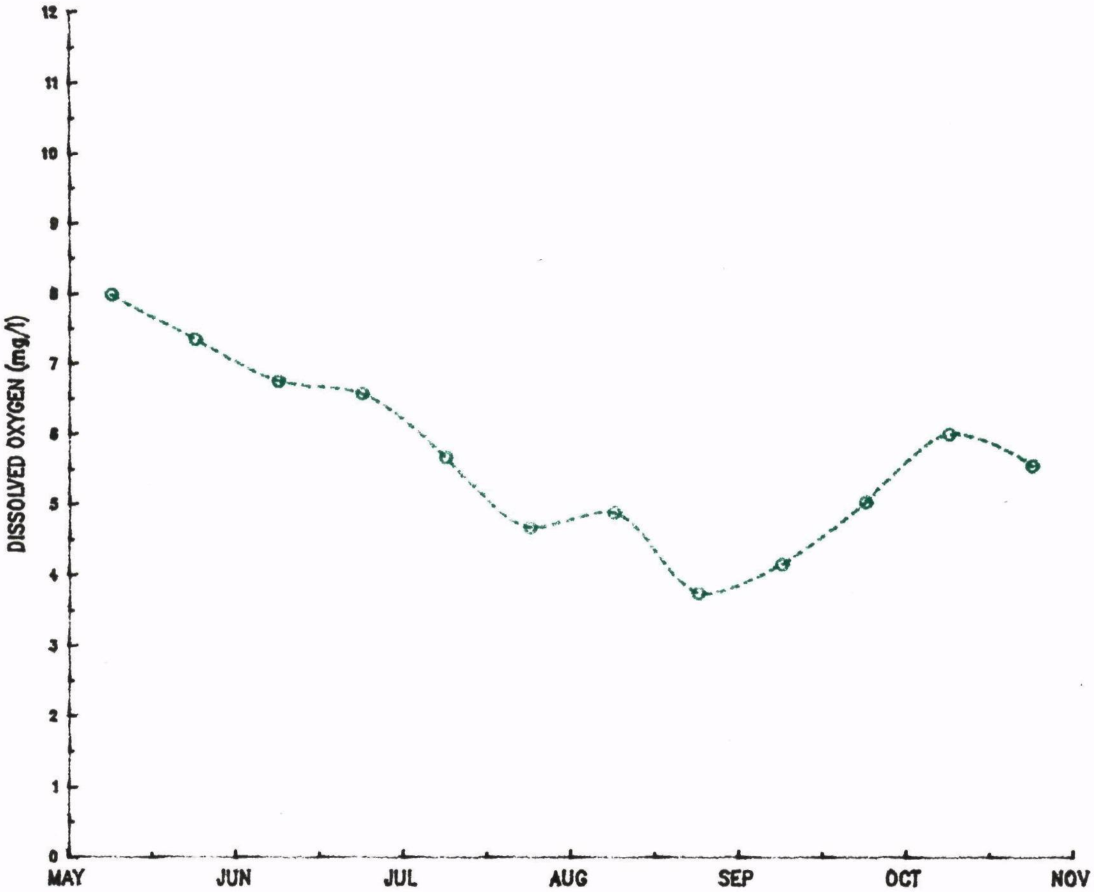


Figure 23

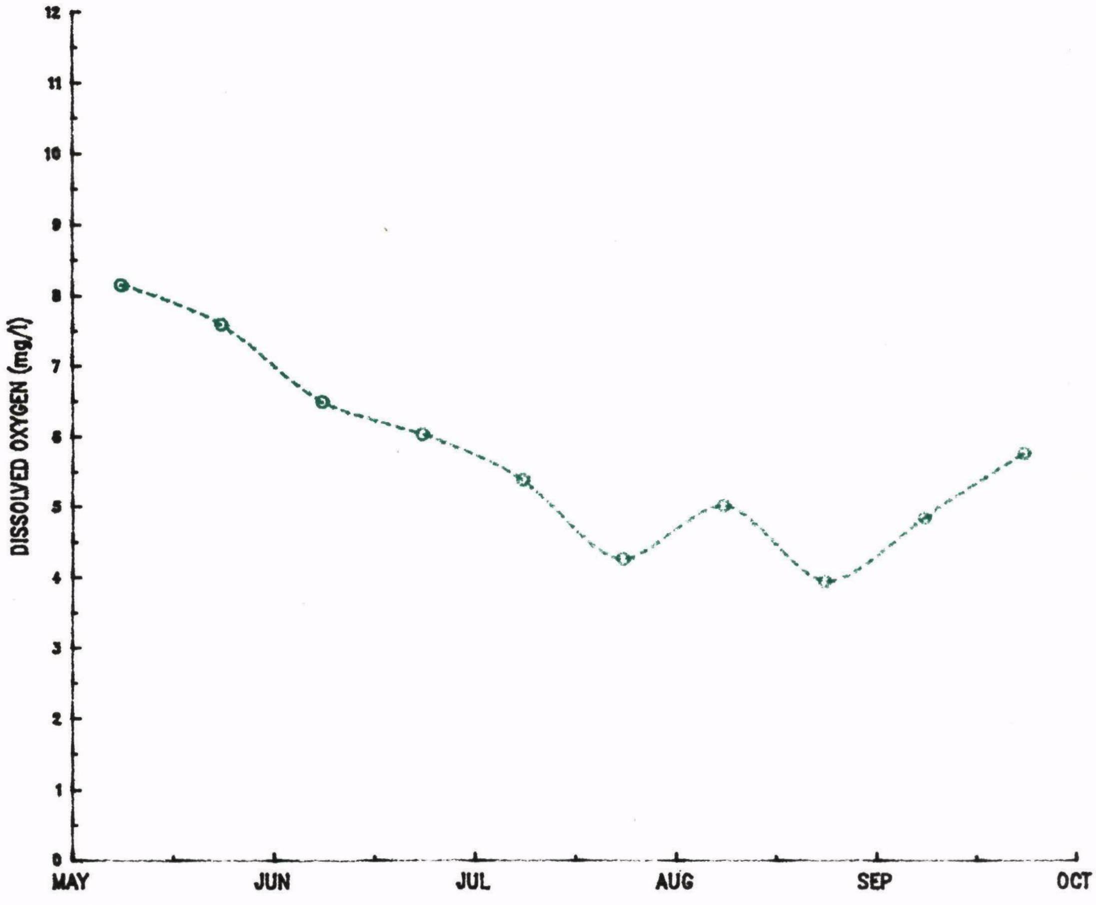


NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1982 TO 1986 imately 4.8 mg/l. The dissolved oxygen increased slightly in early August and then decreased to a low of approximately 4 mg/l in late August. During September and October, there was a rapid dissolved oxygen recovery.

Figure 24 displays the five year dissolved oxygen arithmetic mean of all semi-monthly averages for the southern New Jersey perpendicular stations. In early May, the dissolved oxygen average was 8.2 mg/l. From May through July, the dissolved oxygen gradually decreased to 4.3 mg/l. The dissolved oxygen recovered slightly in early August, then decreased to a low of 4 mg/l in late August. During September, the dissolved oxygen increased substantially.

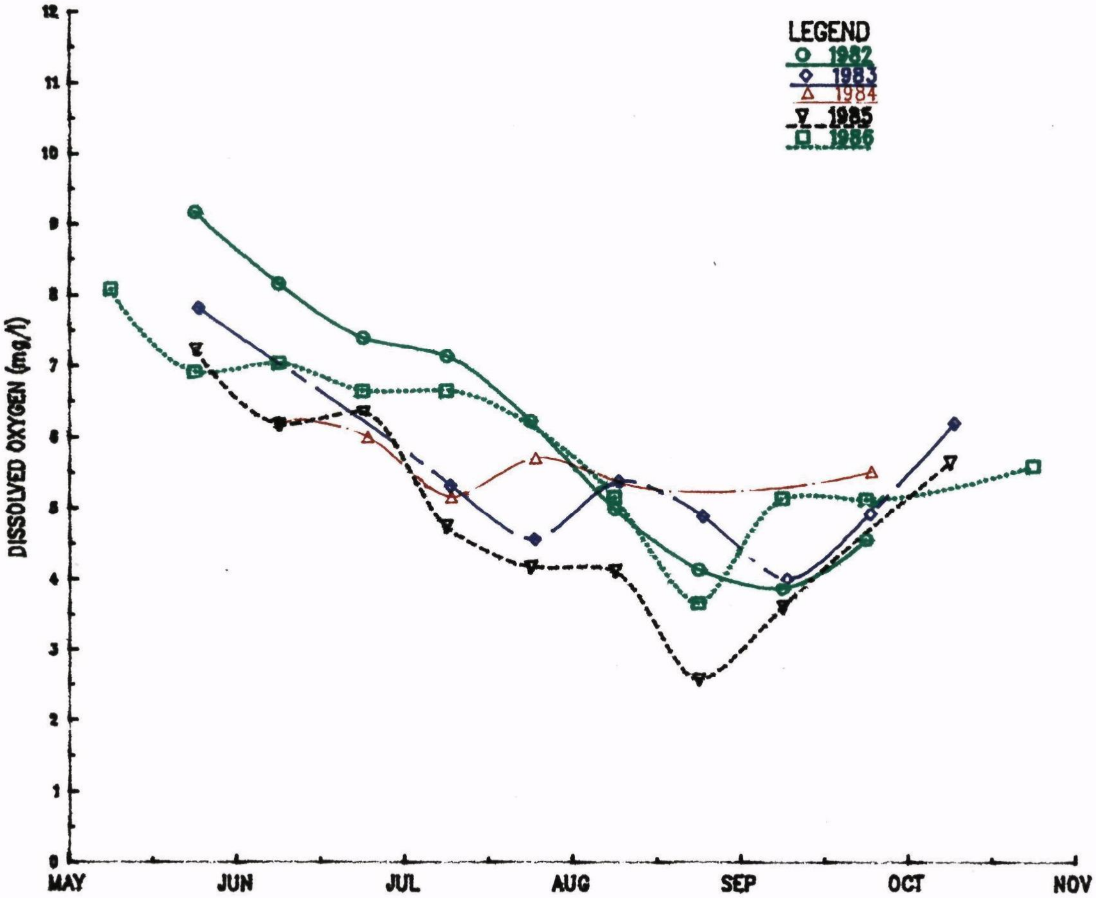
Figures 25 and 26 illustrate the five year dissolved oxygen trends for the northern New Jersey perpendicular stations and the southern New Jersey perpendicular stations, respectively. Figure 25 shows that in 1982 along the northern New Jersey coast, the average dissolved oxygen low was 4 mg/l in early September. A dissolved oxygen "double minima" occurred in 1983 and 1984. During 1983, the first low occurred in late July, followed by a second low in early September. The "double minima" in 1984 was not as prominent as in 1983, with the first low occurring in early July and the second in early August. During the last five years, the dissolved oxygen values were lowest from July through September 1985. In late August 1985, the average dissolved oxygen concentration dropped to a low of 2.5 mg/l. During June through September of 1986, the dissolved oxygen levels were approximately 1-2 mg/l greater than the same time period in 1985.

Figure 24



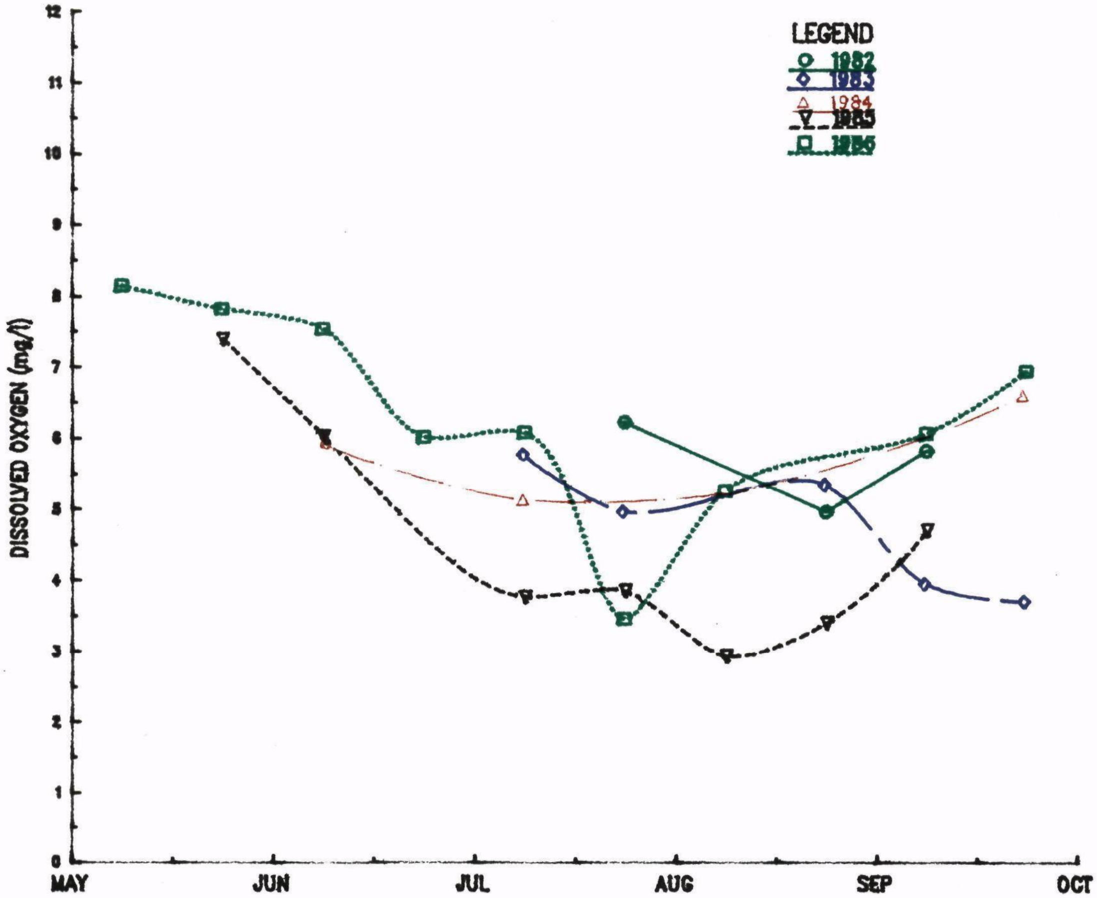
SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1982 TO 1986

Figure 25



NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1982–1986 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC14–JC53 PERPENDICULAR STATIONS.

Figure 26



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1982–1986 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC61–JC85 PERPENDICULAR STATIONS.

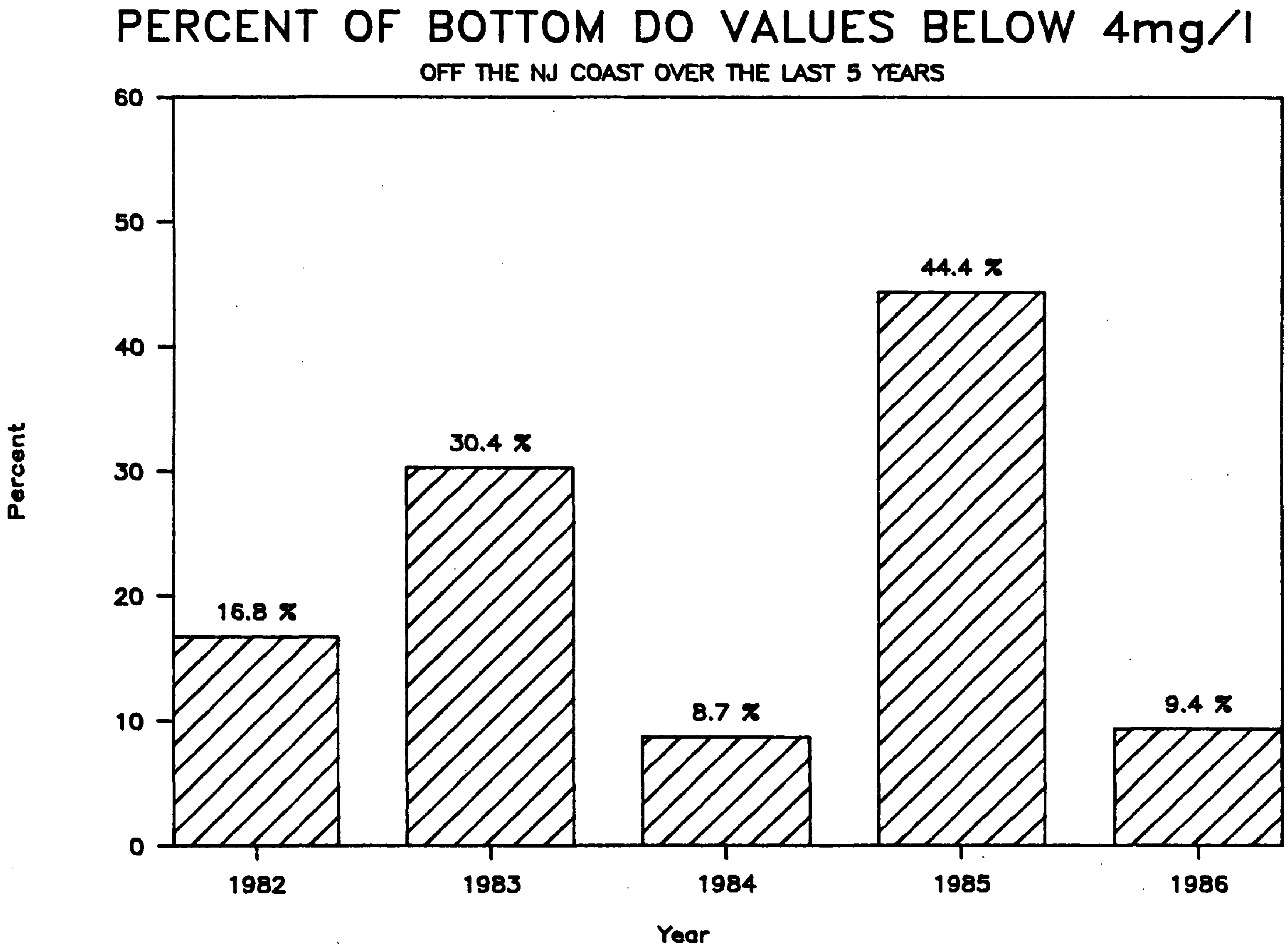
Figure 26 illustrates that, for the most part, the lowest dissolved oxygen levels along the southern New Jersey perpendicular stations during the last five years occurred in 1985. With the exception of late July, the dissolved oxygen levels along the southern New Jersey perpendiculars in 1986 were higher than the previous four years. The dissolved oxygen concentrations in late July 1986 were even slightly lower than in 1985.

Figure 27 displays the percentages of bottom dissolved oxygen samples with concentrations below 4 mg/l along the New Jersey perpediculars over the last five years. The highest percentage of low dissolved oxygen values, 44.4 percent, occurred in 1985. In 1986, the percentage dropped considerably to below ten percent. The graph indicates that the percentage of dissolved oxygen values below 4 mg/l fluctuates considerably from year to year. In 1983 and 1985, the percentage of dissolved oxygen concentrations below 4 mg/l was significantly greater than in the other three years.

Figure 28 shows a five year comparison of the semi-monthly averages for the New York Bight Apex stations for the years 1982-1986. The average dissolved oxygen concentrations remained above 4 mg/l from 1982 to 1986. In 1982, 1985 and 1986 the lowest dissolved oxygen concentrations occurred in August followed by a dissolved oxygen recovery in September. A dissolved oxygen "double minima" was observed in 1983 and 1985. In general, the New York Bight Apex dissolved oxygen levels improved from 1985 to 1986.

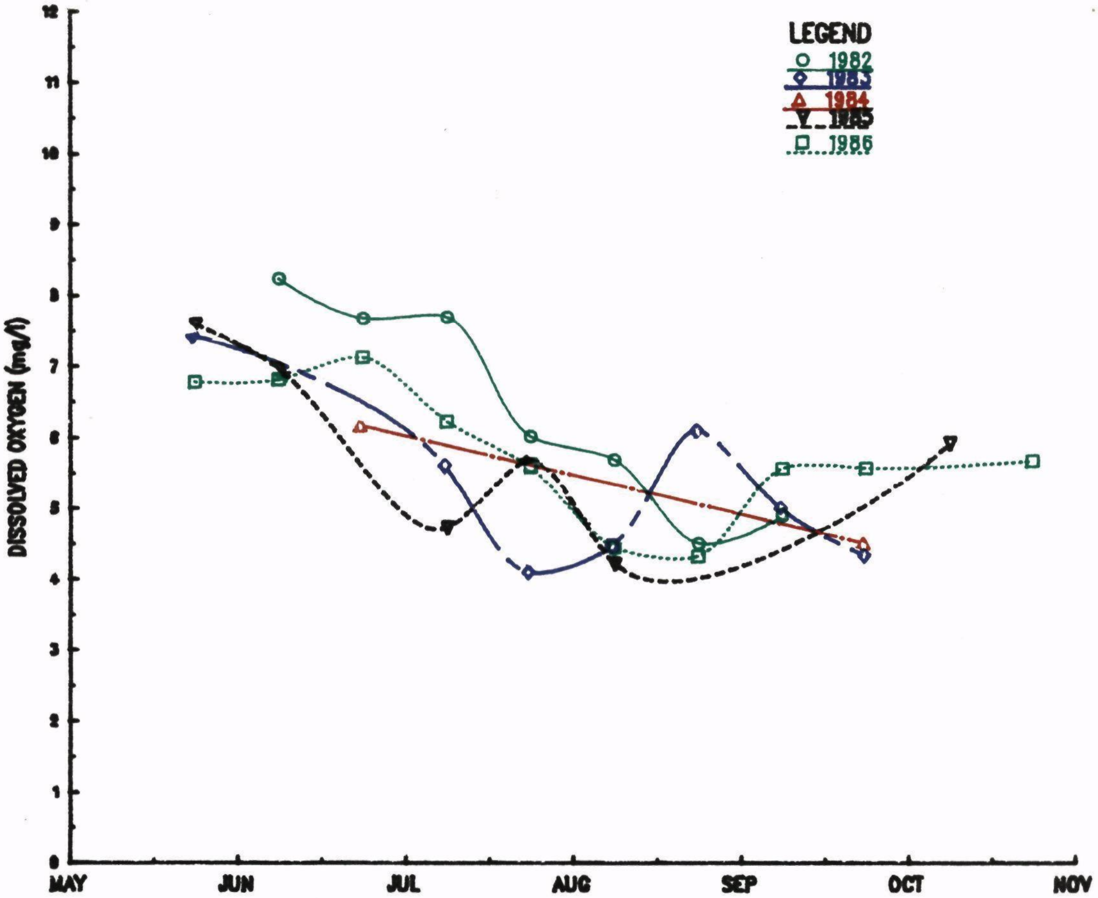
All of the dissolved oxygen trend graphs presented of the New Jersey perpendicular stations show that after an unusually large number of low dissolved oxygen concentrations in 1985, there was considerable improve-

Figure 27



PERCENT OF BOTTOM DO VALUES BELOW 4mg/l
OFF THE NJ COAST OVER THE LAST 5 YEARS
Percent
60
50
40
30
20
10
0
16.8 %
30.4 %
8.7 %
44.4 %
9.4 %
1982
1983
1984
1985
1986
Year

Figure 28



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1982-1986 COMPARISON.
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

ment in 1986. The prolonged depressed dissolved oxygen levels in 1985 were attributed to the decomposition of the organisms responsible for the numerous algal blooms that occurred, the lack of meteorological events favoring reaeration, such as substantial winds and storm activity, and the presence of a strong thermocline. During the summer of 1986, fewer algal blooms were observed, higher winds occurred, and there were numerous storms promoting reaeration.

V. BACTERIOLOGICAL RESULTS

FECAL COLIFORMS

New Jersey

Table 7 presents a summary of the fecal coliform data collected along the coast of New Jersey between May 7, 1986 and August 13, 1986. The geometric mean for each station is plotted in Figure 29. The overall State 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, 3.2, was at station JC 93 at Wildwood. Station JC 75 at Atlantic City had a geometric mean of 3.1. All of the geometric means are very low. Figure 29 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 465 samples were collected for fecal coliform analysis along the New Jersey Coast. Of the 465 samples, two or 0.4 percent were above 50 fecal coliforms/100ml. These samples were:

Station	Date Sampled	Fecal Coliforms/100ml
JC 75	6/25/86	51
JC 93	7/23/86	100

The cause of the elevated value at JC 93 was probably poorly treated sewage from the Wildwood Sewage Treatment Plant.

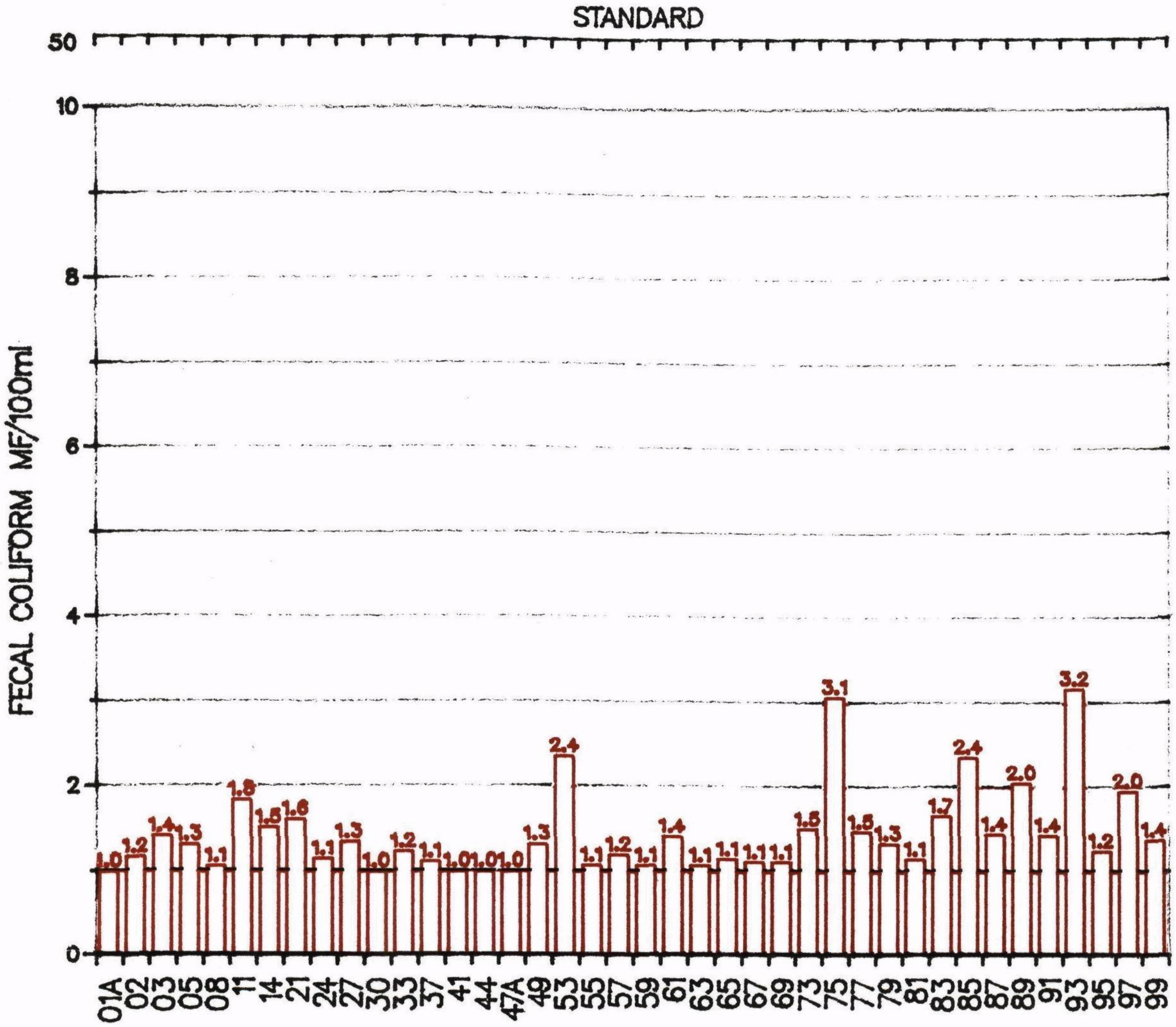
Table 7

Summary of fecal coliform data
collected along the New Jersey coast
May 7, 1986 through August 13, 1986

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100ml	Geometric Mean* Fecal Coliform/100ml
JC 01A	12	7	1.0
JC 02	13	3	1.2
JC 03	13	4	1.4
JC 05	13	7	1.3
JC 08	13	2	1.1
JC 11	13	15	1.8
JC 14	12	8	1.5
JC 21	12	15	1.6
JC 24	12	2	1.1
JC 27	12	10	1.3
JC 30	12	10	1.0
JC 33	12	8	1.2
JC 37	12	3	1.1
JC 41	12	1	1.0
JC 44	12	0	1.0
JC 47A	12	0	1.0
JC 49	12	4	1.3
JC 53	12	12	2.4
JC 55	12	2	1.1
JC 57	12	6	1.2
JC 59	11	0	1.1
JC 61	11	4	1.4
JC 63	11	0	1.1
JC 65	11	2	1.1
JC 67	11	3	1.1
JC 69	11	3	1.1
JC 73	11	5	1.5
JC 75	11	51	3.1
JC 77	11	6	1.5
JC 79	11	6	1.3
JC 81	11	2	1.1
JC 83	11	16	1.7
JC 85	11	6	2.4
JC 87	11	5	1.4
JC 89	11	18	2.0
JC 91	11	4	1.4
JC 93	11	100	3.2
JC 95	11	3	1.2
JC 97	11	10	2.0
JC 99	11	4	1.4

* Geometric means were calculated using the natural log

Figure 29



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF NEW JERSEY, MAY 7, 1986 TO AUG 13, 1986.
(ACTUAL VALUES PRINTED ABOVE BARS)

Long Island

Table 8 presents a summary of the fecal coliform data collected along the coast of Long Island from May 12, 1986 through September 8, 1986. The geometric mean for each station is plotted in Figure 30. The New York State standard for primary contact recreation along the Long Island coast is 200 fecal coliforms/100 ml. This value is a monthly geometric mean of five or more samples. As with the New Jersey data, due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The highest geometric mean was 2.1, which occurred at station LIC 16, Cedar Island Beach. From Figure 30, it is apparent that the standard was not approached. Based on fecal coliform data, the New York coastal waters along Long Island are of excellent quality.

A total of 263 samples were collected during the summer along the coast of Long Island and analyzed for fecal coliform bacteria. The highest density found all summer, 30 fecal coliforms/100 ml, was at station LIC 16. This value is well below the New York State standard.

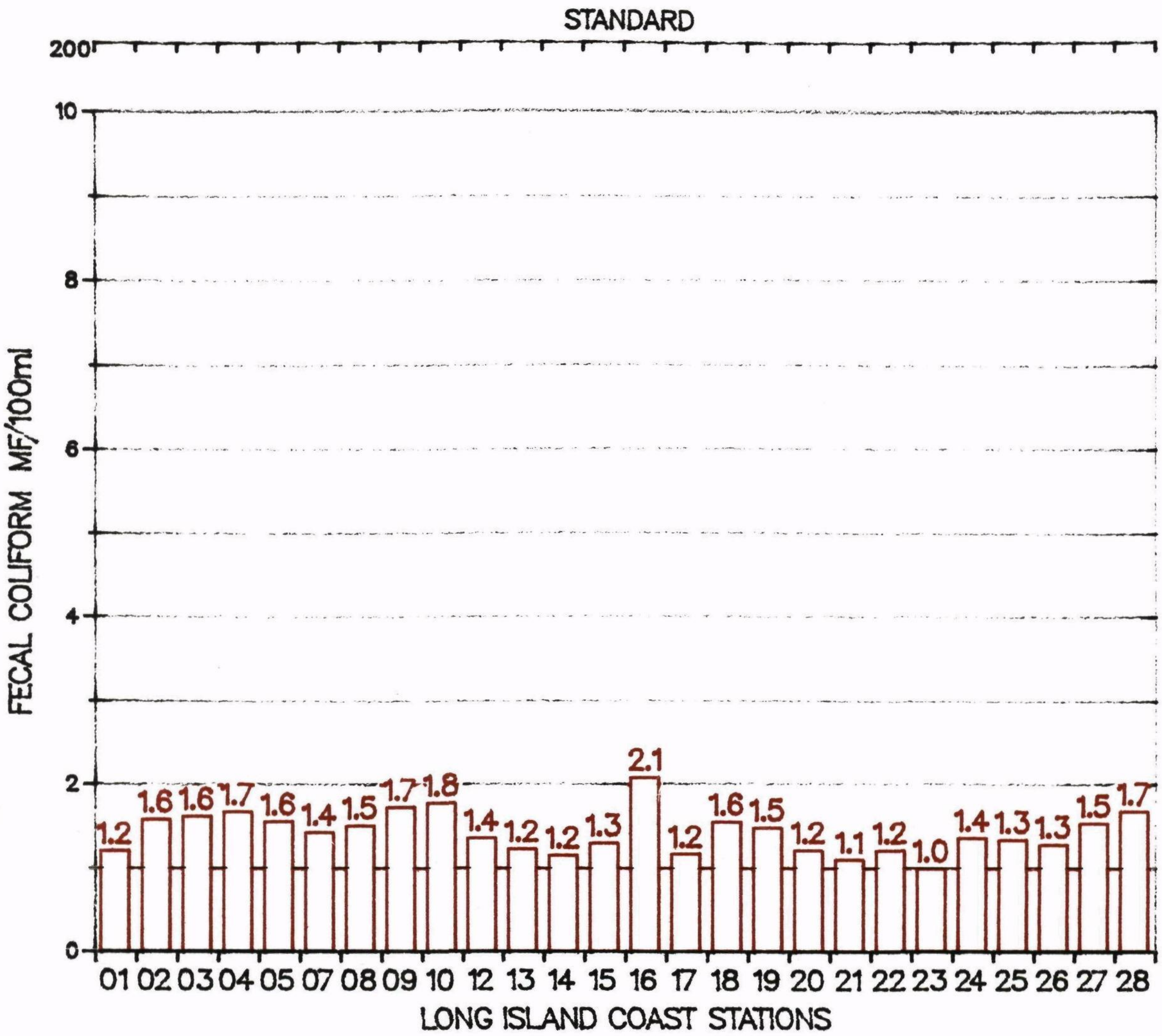
Table 8

Summary of fecal coliform data
collected along the Long Island coast
May 12, 1986 through September 8, 1986

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100ml	Geometric Mean* Fecal Coliform/100ml
LIC 01	12	4	1.2
LIC 02	12	27	1.6
LIC 03	12	17	1.6
LIC 04	12	10	1.7
LIC 05	12	15	1.6
LIC 07	12	9	1.4
LIC 08	12	8	1.5
LIC 09	11	16	1.7
LIC 10	12	8	1.8
LIC 12	12	5	1.4
LIC 13	12	5	1.2
LIC 14	12	5	1.2
LIC 15	12	18	1.3
LIC 16	12	30	2.1
LIC 17	8	3	1.2
LIC 18	8	11	1.6
LIC 19	8	16	1.5
LIC 20	8	4	1.2
LIC 21	8	2	1.1
LIC 22	8	4	1.2
LIC 23	8	1	1.0
LIC 24	8	9	1.4
LIC 25	8	8	1.3
LIC 26	8	6	1.3
LIC 27	8	7	1.5
LIC 28	8	13	1.7

* Geometric means were calculated using the natural log

Figure 30



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF LONG ISLAND, MAY 12, 1986 TO SEP 8, 1986.
(ACTUAL VALUES PRINTED ABOVE BARS)

New York Bight Apex

During the summer of 1986, a total of 528 samples were collected in the inner New York Bight (NYB) 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. None of the fecal coliform densities exceeded 50 fecal coliforms/100ml. The highest fecal coliform count, 16/100ml, occurred at station NYB 25 on July 15. 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 1981, 1982, 1983, 1984 and 1985, the percentage of samples having densities above 50/100 ml was 0.7, 2.1, 0.9, 0.4 and 1.3 respectively.

ENTEROCOCCI

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

New Jersey

Table 9 presents a summary of the enterococcus data collected along the New Jersey coast from May 7 to August 13, 1986. The State of New Jersey does not have a water quality standard for enterococcus bacteria. The EPA criterion for enterococci in marine waters is 35 bacteria/100ml. This criterion is based on a geometric mean of a statistically sufficient number of samples, generally not less than five samples equally spaced over a thirty day period. Due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The geometric mean for each station is plotted in Figure 31. Figure 31 shows that the geometric mean of enterococcus densities at each station is well below the EPA criterion. All the geometric means are low. The highest mean, 2.4, occurred at station JC 75, Atlantic City.

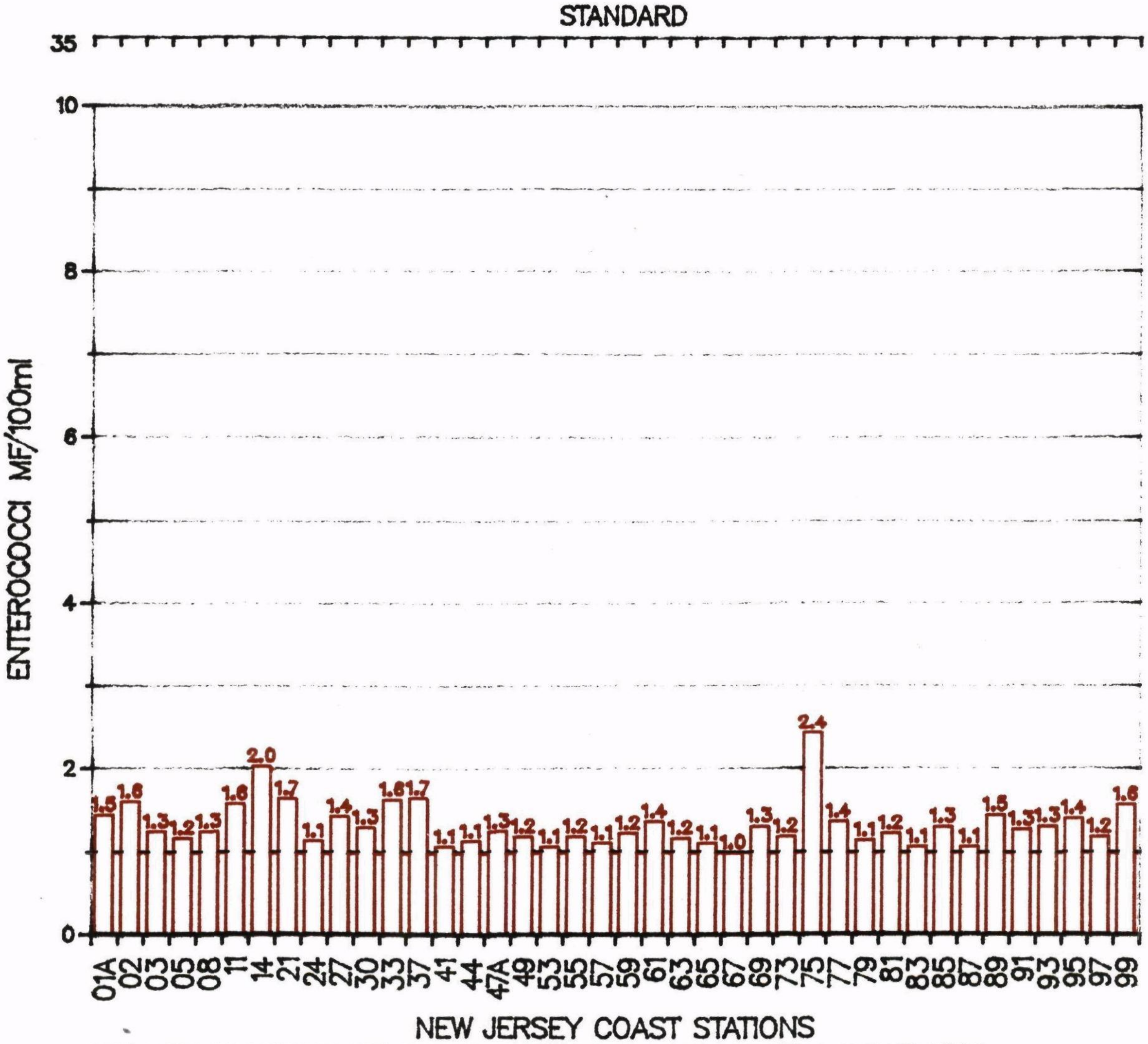
Table 9

Summary of enterococci data
collected along the New Jersey coast
May 7, 1986 through August 13, 1986

Station	Number of Samples Collected	Maximum Value Enterococci/100ml	Geometric Mean* Enterococci/100ml
JC 01A	12	7	1.5
JC 02	13	16	1.6
JC 03	13	3	1.3
JC 05	13	4	1.2
JC 08	13	3	1.3
JC 11	13	5	1.6
JC 14	12	22	2.0
JC 21	12	15	1.7
JC 24	12	2	1.1
JC 27	12	5	1.4
JC 30	12	5	1.3
JC 33	12	24	1.6
JC 37	12	8	1.7
JC 41	12	2	1.1
JC 44	12	4	1.1
JC 47A	12	5	1.3
JC 49	12	3	1.2
JC 53	12	2	1.1
JC 55	12	3	1.2
JC 57	12	3	1.1
JC 59	11	4	1.2
JC 61	11	6	1.4
JC 63	11	5	1.2
JC 65	11	3	1.1
JC 67	11	1	1.0
JC 69	11	4	1.3
JC 73	11	3	1.2
JC 75	11	29	2.4
JC 77	11	4	1.4
JC 79	11	4	1.1
JC 81	11	4	1.2
JC 83	11	1	1.1
JC 85	11	15	1.3
JC 87	11	8	1.1
JC 89	11	7	1.5
JC 91	11	4	1.3
JC 93	11	4	1.3
JC 95	11	4	1.4
JC 97	11	3	1.2
JC 99	11	4	1.6

* Geometric means were calculated using the natural log

Figure 31



GEOMETRIC MEANS OF ENTEROCOCCI DATA COLLECTION ALONG THE COAST OF NEW JERSEY, MAY 7, 1986 TO AUG 13, 1986.
(ACTUAL VALUES PRINTED ABOVE BARS)

A total of 465 samples were analyzed for enterococcus bacteria along the New Jersey coast. No enterococcus densities were above the criterion of 35/100ml. The highest enterococcus density detected during the summer was 29/100ml at Atlantic City, station JC 75, on June 25.

Based on enterococcus data, the quality of New Jersey coastal waters is excellent.

Long Island

Table 10 presents a summary of the enterococcus data collected along the Long Island coast from May 12, 1986 to September 8, 1986. The geometric mean for each station is plotted in Figure 32. New York State does not have a water quality standard for enterococcus bacteria. As with the New Jersey data, the enterococcus data along the Long Island coast are compared to the EPA criterion of 35 enterococci/100ml. Due to the low values found and the relatively small number of samples collected per station, only one geometric mean was calculated for each station over the summer. The highest geometric mean, 2.3, occurred at station LIC 25, West Hampton Beach. Figure 32 shows that all of the geometric means are well below the EPA criterion.

A total of 263 enterococcus samples were collected along the coast of Long Island during the summer. Only one sample exceeded the enterococcus criterion. On August 19, a count of 48 enterococci/100ml occurred at Rockaway, station LIC 02. A majority of the maximum densities detected at each station were detected on August 19. This was attributed to storm water runoff from a heavy storm which passed through area on August 18.

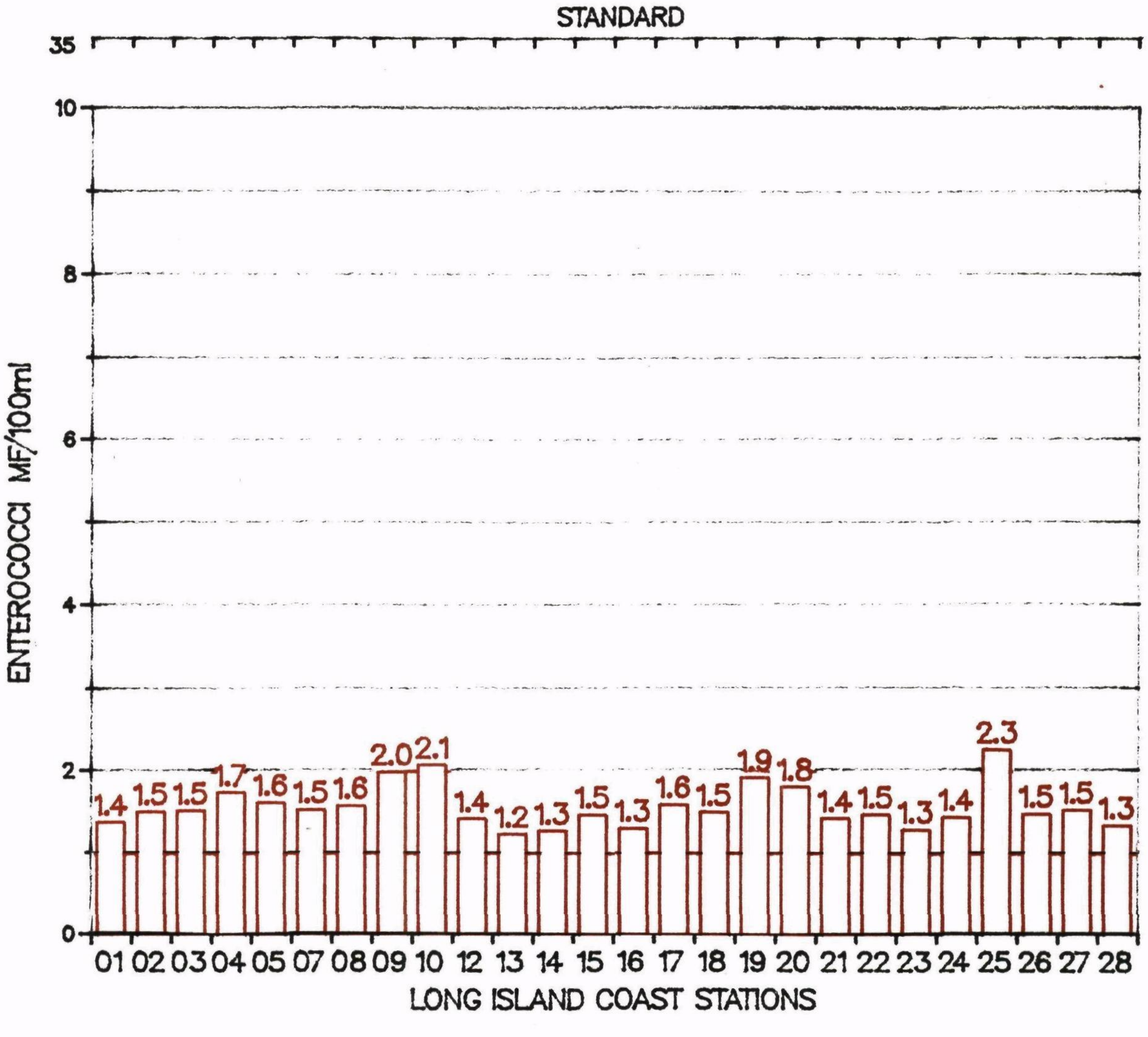
Table 10

Summary of enterococci data
collected along the Long Island coast
May 12, 1986 through September 8, 1986

Station	Number of Samples Collected	Maximum Value Enterococci/100ml	Geometric Mean* Enterococci/100ml
LIC 01	12	12	1.4
LIC 02	12	48	1.5
LIC 03	12	34	1.5
LIC 04	12	19	1.7
LIC 05	12	30	1.6
LIC 07	12	6	1.5
LIC 08	12	26	1.6
LIC 09	11	20	2.0
LIC 10	12	8	2.1
LIC 12	12	12	1.4
LIC 13	12	10	1.2
LIC 14	12	7	1.3
LIC 15	12	23	1.5
LIC 16	12	18	1.3
LIC 17	8	26	1.6
LIC 18	8	17	1.5
LIC 19	8	24	1.9
LIC 20	8	21	1.8
LIC 21	8	12	1.4
LIC 22	8	5	1.5
LIC 23	8	3	1.3
LIC 24	8	13	1.4
LIC 25	8	25	2.3
LIC 26	8	16	1.5
LIC 27	8	10	1.5
LIC 28	8	8	1.3

* Geometric means were calculated using the natural log

Figure 32



GEOMETRIC MEANS OF ENTEROCOCCI DATA COLLECTION ALONG THE COAST OF LONG ISLAND, MAY 12, 1986 TO SEP 8, 1986. (ACTUAL VALUES PRINTED ABOVE BARS)

Based on the enterococcus densities, the water quality of the Long Island coast is excellent.

New York Bight Apex

During the summer of 1986 a total of 528 samples were collected in the inner New York Bight for enterococci analysis. The stations sampled were the same as those sampled for fecal coliforms. None of the samples had enterococcus densities above the EPA criterion of 35/100ml. The highest density recorded during the summer was 32 enterococci/100ml at station NYB 45 on July 15. The cause of this elevated value was a recent sewage sludge dump at the sewage sludge disposal 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.

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APPENDIX "A"

SUMMARY OF PHYTOPLANKTON BLOOMS AND RELATED EVENTS IN NEW JERSEY COASTAL WATERS SUMMER OF 1986

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

Synopsis

Red tides caused by several phytoflagellate species, notably *Prorocentrum* spp. and *Olisthodiscus luteus*, have occurred annually in Lower New York Bay and adjacent New Jersey coastal waters for at least 25 years (Mahoney and McLaughlin, 1977). Although the blooms were not of the acutely toxic varieties, they were sometimes associated with irritation to bathers or fish kills via anoxia when the blooms collapsed. The New Jersey Department of Environmental Protection (NJDEP), Division of Water Resources, the U.S. Environmental Protection Agency, Region II (Edison, N.J.) and the(NMFS) National Marine Fisheries Service (Sandy Hook Laboratory) cooperatively have monitored phytoplankton species composition and bloom development in the N.J. northern shore (Raritan Bay to Island Beach) since 1974 (USEPA, 1978-85; Olsen and Cohn, 1979). Standard methodologies were developed jointly by the NMFS, Sandy Hook Laboratory and the Division of Water Resources (DWR) Bureau of Monitoring Management, Biological Services Unit. These are incorporated by the DWR (NJDEP DWR, 1983) and also recorded by the Biological Services Unit as Standard Operating Procedures.

Within the past few summers (especially in 1984-85) "green tides" caused by a dinoflagellate, *Gyrodinium aureolum*, occurred along the central to southern N.J. shore, while the red tides to the north were less conspicuous than in previous years. In 1986, in response to the green tide events, routine monitoring for phytoplankton and related parameters was expanded to include the New Jersey coast between Island Beach and Cape May. Four locations were added in the southern half of the coastline (Figure 2) while, in the northern half, two (NYB20 and JC37) were deleted and one (JC49) added (Figure 1). This raised the total number of sampling stations from nine to twelve. Also in 1986, the Interagency Green Tide Strategy Committee was formed consisting primarily of representatives of the USEPA, NMFS, NJDEP, Rutgers University and the N.J. Sea Grant Extension Service. In conjunction with this an "Environmental Inventory for Green Tide" (USEPA, 1986), summarizing information for the N.Y. Bight, was prepared under direction of the USEPA, Region II. Additionally, the NJDEP Bureau of Monitoring Management undertook a baseline intensive survey in 1986 of waters in the Atlantic City/Ocean City vicinity.

In 1986, while no extensive red or green tides were observed, the minute chlorophyte previously identified as *Nannochloris atomus* was ubiquitous in bloom concentrations, resulting in muddy green colored water along the entire coast of New Jersey. This condition was also present in 1985, overlapping the area of the "green tides" and extending offshore in the area of the Hudson Shelf Valley. In both 1985 and '86, blooms became conspicuous in the intracoastal system progressing from Barnegat Bay southward; this parallelled the "brown tide" that occurred almost simultaneously in eastern Long Island embayments (Table 1). In early to mid-June of 1986, a red tide of *Katodinium rotundatum* occurred from Raritan Bay to the upper Monmouth County coast; as in previous years it was apparently densest and most persistent in Sandy Hook Bay. In an event remote from our routine sampling pattern, a red tide (species unconfirmed) was observed in early July along the cape shore of Delaware Bay. Throughout New Jersey reports of ill effects to bathers, or fish kills, due to algae blooms were minimal in 1986.

1986 Highlights

The brilliant "Green Tide" which had been prominent the previous two summers was conspicuous in its absence in 1986. It had occurred in the south-central New Jersey shore where such phenomena, including red tides, had previously been uncommon. The green tide species, identified as *Gyrodinium aureolum*, was found in low concentrations (to 500 cells/ml) in our samples off south Ocean City from July 17-22 and off Atlantic City during August 6-7, 1986; it was found again, with several other species more abundant, in non-routine samples taken in a lagoon (Clam Creek) off Absecon Inlet and in the surf of northern Ocean County between September 1 and 11 (Table 2). Development of green tide blooms this summer may have been precluded by adverse weather conditions (Table 1) during the period when the species was present.

The minute chlorophyte previously identified as *Nannochloris atomus* was present again in dense concentrations to 500,000 cells/ml (Table 2). It caused muddy green colored water along much of the coast between Sandy Hook and Cape May, overlapping the area where the "green tide" had occurred. This was reflected in high chlorophyll-a levels from mid-July to mid-September in our 1986 Atlantic City/Ocean City survey (data unpublished). Similarly, the yellowish-brown water which became conspicuous in Barnegat Bay the past few summers, in 1986 was seen in dense concentrations (>1,000,000 cells/ml) throughout much of the intracoastal system at least as far south as Great Egg Harbor. This bloom parallelled the "brown tide" that was present in eastern Long Island but without the serious environmental effects of the latter. In the vicinity of tidal inlets between Barnegat and Great Egg Harbor, N.J., and at Fire Island, L.I., a distinct demarcation at times was noted between the intracoastal brown water and the coastal greenish water; this was possibly due to differences in species composition of the blooms as well as differences in background water quality (Table 1). Periods of abundance of several diatom and phytoflagellate species occurred before and after the *Nannochloris* peak in August (Table 2). Offshore water which, in 1985, had been reported somewhat discolored as far as the Hudson Canyon were generally clear in 1986; several species normally found in mid-shelf waters were present (Table 1). Greenish water was reported the second week of August in the mid-shelf area southward of the Hudson Shelf Valley, but this condition apparently did not persist.

In earlier events this season, fishermen on a party boat in the Asbury Park-Deal vicinity, in late May experienced "brown slime" on their lines (Table 1). This is likely the result of heavy spring diatom blooms (Mahoney and Steimle, 1979). Of late this has been an annual recurrence, especially within the Bight Apex; subsequent phytoflagellate blooms have had similar effects in these waters. Also in late May - early June, "fingers" or streaks of brown to green water were observed from the beach to a few miles out between Long Branch and Long Beach Island; farther south, waters adjacent to the beach were generally discolored. These were likely wind-driven suspensions consisting of detritus and diatom bloom remnants, with a greater proportion of particulate matter from estuarine drainage off southern New Jersey.

As in previous years, local red tides occured initially in late spring-early summer in the Raritan/Sandy Hook estuary and spread to adjacent N.J. coastal areas. One of the few usually dominant species, Katodinium rotundatum, was primarily responsible in 1986. Also during this period, at New Jersey's southern extreme, a red tide of an unconfirmed species was reported in Delaware Bay (Table 1). This was associated with westerly winds which apparently concentrated the organisms along the northwestern portion of the cape shore. Red tides are known to occur in Delaware Bay (Martin and Nelson, 1929; Pomeroy et al, 1956) but have not been routinely reported. Very few incidents of fish kills or bathers complaints due to red tides in New Jersey were reported in 1986.

Discussion

In the vicinity of the Hudson/Raritan estuary, phytoplankton blooms recur in a generally hypertrophic environment (Mahoney and McLaughlin, 1977). Macro-nutrients are normally at high levels within the estuary (Draxler et al, 1982) and its coastal plume (Malone et al, 1985), while concentratious ample for algal growth at times are present along much of the New Jersey coast (Tables 3 and 4). Nitrogen is generally more critical than phosphorus (Ryther and Dunstan, 1971); regeneration, reflected in higher ammonia levels, accounts for a greater proportion of the available N in summer. Given sufficient nutrient concentrations, phytoplankton production is thus governed by physical factors, e.g. temperature, light intensity, etc. Production may be high over a relatively wide area, especially around the Bight apex (Marshall and Cohn, 1982; Malone et al, 1985); however, most red or green tides southward off New Jersey occur in waters adjacent to the coastline (NJDEP, 1978-85).

The estuaries and embayments form natural retention areas promoting phytoplankton blooms, which may extend into adjacent nearshore locales. Red tides in the open sea, however, are often dependent on other physical processes to concentrate the organisms or bring them in contact with nutrient-rich water. This is seen in various regions of the globe, such as in European waters where blooms of G. aureolum have resulted through vertical movements of the dinoflagellates, wind-driven upwelling or convergence of different water masses (Tangen, 1977); similar effects have been observed in major estuaries such as Delaware Bay on the U.S. east coast (Pomeroy et al, 1956). In the New York Bight, where oceanic and meteorological forces also exert major influence, wind is seen to be a dominant factor (USEPA, 1986). On the mid-Atlantic Bight inner shelf, prevailing flow from a northeasterly direction is often reversed in summer by predominant winds from a west to south quadrant (Bumpus, 1973); this could result in greater residence time of waters within the N.Y. Bight. In the New Jersey nearshore zone, sustained winds from a southwesterly direction may also force upwelling (Ingham and Eberwine, 1984); while this influx of deeper water may contribute to subsequent blooms, the corresponding decrease in surface temperature along with turbulent conditions may temporarily inhibit phytoflagellate activity. This possibly happened in 1986 when the green tide failed to materialize, although concentrations of Nannochloris were quite substantial through the period. This summer, strong southwesterly winds prevailed and several days of strong easterly winds, highlighted by Hurricane Charley, were noted in August (NOAA data); consequently, hypoxic conditions were not extensive in 1986 (USEPA data). In 1985, however, pronounced stratification and hypoxia were present in areas adjacent to the northeast of those where green tides occurred. Without forcing upwelling, moderate winds from an easterly quadrant could favor bloom development by increasing retention of water alongshore in proximity to various external nutrient sources. In the south-central New Jersey shore, tidal mixing with estuarine and intracoastal waters may contribute significantly to this, since there are five inlets within a 25-mile stretch from Long Beach Island through Ocean City. Due to the change in alignment of the coastline in this region (Figure 2), sustained winds from a southerly direction could increase retention in the southern portion while inducing upwelling in the northernmost portion. This apparently happened in July of 1985 when green tides of G. aureolum were not observed north of Atlantic City, but Nannochloris sp. bloomed in both northern and southern areas (NJDEP, 1985); surf temperatures at that time were reported at 75° F in Cape May County while, in Ocean County a sudden drop to 58° - 60° F was reported.

The green tide species, identified as Gyrodinium aureolum, was first described from Cape Cod by Hulburt in 1957. It is an unarmored dinoflagellate with some variation in size and shape; cells are essentially globular, but somewhat ellipsoidal to broadly conical, with length less than 20um to about 35um and girdle displacement 15-20%. Our specimens were in good agreement with Hulburt's description. Most accounts of the species describe the chloroplasts as yellow-brown, but Taylor (1985) describes them as pale green. Blooms of it were first recorded in 1966 from Norway; it has since become the most common red tide dinoflagellate in European waters, with evidence that it can be toxic to marine fauna (Tangen, 1977). Some mortality of crabs and mussels, possible avoidance by fish, and ill effects to bathers were noted during the New Jersey blooms. G. aureolum has also been observed in the South Atlantic off Brazil and, possibly, in the Pacific off Japan (Taylor, 1985). In our region, the first documented blooms were localized in a Long Island estuary in 1982 (Chang and Carpenter, 1985). The presence of the species in the New York Bight was first documented in a 1974-78 estuarine and coastal survey (Olsen and Cohn, 1979), and subsequently in a 1978-81 ocean survey (Marshall and Cohn, 1982) at several locations, most within 20 miles of the southern N.J. coast. This may represent a seed source for the coastal blooms, since G. aureolum is apparently a normal inhabitant of inner shelf waters. Several other observations of green tide blooms were made both in New Jersey and Long Island between 1979 and 1984, but these were relatively transient and localized. Competition from red tide species may be a factor in why major green tides in N.J. did not occur in the northern shore; trace metal concentrations (Mahoney, 1982) or hyperchlorination of effluents in area waters are other factors possibly suppressing blooms. Problems in identification of G. aureolum arise from the fact that, in order to keep the cells intact, samples must be maintained live under in-situ conditions. Because of its low incidence in 1986, we were not able to isolate specimens for culturing and eventual toxicity and growth testing.

Regarding the possible "brown tide" bloom in our intracoastal system, the organism closely resembled that recently identified as a chrysophyte, Aureococcus anorexefferens, by Sieburth et al (unpublished) from Rhode Island and eastern Long Island embayments (Table 1). Using light microscopy, however, the coccoid cells of about 2um could not be distinguished from Nannochloris atomus Butcher, which has been ubiquitous in our region. In 1986, apparently spreading southward from Barnegat Bay, it persisted from July through September with peak cell concentrations in August exceeding 1.5×10^6/ml and corresponding Secchi readings less than 0.5m. While shading may have had some effect on the eelgrass and local sportfishing, depletion of our shellfisheries was apparently minimal; our primary resource, the hard clam, was not adversely affected as were the bay scallop of Long Island and the blue mussel of Rhode Island. Future determinations employing electron or epifluorescent microscopy and pigment analysis are needed for positive identification of the brown tide species in New Jersey.

The paralytic shellfish poisoning (PSP) toxin in Flanders Bay, L.I. (Table 1) was detected in shellfish collected there; apparently, no humans were affected since the area was subsequently closed to shellfish harvesting. In the northeastern U.S., incidence of PSP in humans has been associated with the occurrence of the causative species, Gonyaulax tamarensis, primarily in the Gulf of Maine (Hurst, 1979). The dinoflagellate has more recently been found in southern New England (Anderson et al., 1982) and Long Island embayments as close to New Jersey as the southern shore of Nassau County (Freudenthal, 1983). It has been found in low concentrations at several locations in the ocean within 20 mi. of the N.J. coast (Marshall and Cohn, 1982). A recent survey of New Jersey coastal waters (Cohn et al., unpublished), concurrent with our red tide monitoring, has also detected low concentrations of G. tamarensis in a few southern N.J. embayments.

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Table 1. Sequence of events reported during the 1986 season.

DATE	LOCATION	OBSERVATION	CONDITION/NOTE
May 27	Asbury Park to Deal	"brown slime" on lines (party boat)	probable algal bloom remnants
30	Long Branch to south Jersey	"fingers" of brown to green water from beach out a few miles (EPA helicopter)	probable wind-driven suspensions; samples full of stringy material, diatoms abundant
June 2	Sandy Hook	red tide off beach (L. Jargowsky, Monmouth Co. Health Dept.)	dense bloom of *Katodinium rotundatum*
4	Raritan-Sandy Hook Bay; Sandy Hook to Deal	heavy red tide in bay extending halfway down Sandy Hook on ocean side; patchy from there to Deal;	dense bloom of *Katodinium rotundatum*
	New York bight apex	dissolved oxygen levels high (EPA helicopter)	D.O. 10 - 11 ppm, probable result of red tide bloom
	Island Beach to Long Beach Island; Little Egg Inlet to Wildwood	"fingers" again out from beach; general brown discoloration south of Long Beach Island (EPA helicopter)	probable wind-driven suspensions; diatoms and particulate matter plentiful in samples; more tidal mixing in southern area
June 11	Raritan-Sandy Hook Bay	red tide in bay - ocean clear (EPA helicopter);	heavy bloom of *K. rotundatum* continued in bay; dead fish likely from pound nets
15	Sandy Hook Bay at Highlands	red tide heavy, dead bunker in bay (K. Sass, NJDEP)	
24	Long Island, Peconic system into Flanders Bay	massive bloom of "brown tide"; PSP toxin also detected in Flanders Bay (R. Nuzzi, Suffolk Co. Health Dept.)	very dense bloom of *Aureococcus anorexefferans*, $2x10^6$ cells/ml to 40ft. depth (see Discussion); PSP due to *Gonyaulax tamarensis*

DATE	LOCATION	OBSERVATION	CONDITION/NOTE
June 27	Barnegat Bay at Harvey Cedars	brown water (EPA helicopter)	resembling "brown tide"
July 8 9	Ocean City Atlantic City	upwelling in surf; air warm, water cool (D. Rosenblatt, NJDEP)	bottom cooler than surface ($5^{o}F$ difference) within one mile of beach; wind from west
	Delaware Bay, (north) west cape shore	red tide (H. Haskin Rutgers U. Shellfish Research Lab.)	species unconfirmed; wind from west
11	Barnegat Bay	brown water, heaviest behind Long Beach Island but extending all across bay and north to Toms River (EPA)	apparent bloom of Nannochloris atomus (10^{6} cells/ml), water color yellowish-brown
14	New York, Jamaica Bay at Hook Creek	reddish-brown water (R. Austin, NYDEC)	annual blooms of various species (brown to green water) normal in this region
17	Spring Lake	objectionable floating material on beach (Monmouth Co. Health Dept.)	not unusual in this vicinity
21-28	Sandy Hook to Wildwood	greenish water becoming apparent along much of N.J. coast	dense bloom(s) of N. atomus ($\mp$500,000 cells/ml)
29	Long Island, vicinity of Fire Is. Inlet	greenish water in ocean adjacent to inlet; brown water in Great South Bay (L. Cosper, State U. of N.Y. Stony Brook)	marked contrast in the inlet between green and brown water; brown tide still in Peconic Bay
30	Ocean Beach	patch of red water in surf (Ocean Co. Health Dept.)	K. rotundatum dominant, several species abundant, copepods numerous in sample

DATE	LOCATION	OBSERVATION	CONDITION/NOTE
July 12– August 17 August 6-27	N.J. offshore and inshore off Long Beach Island	water generally clear, "conditions normal" (J. Tiedemann, N.J. Sea Grant Extension Service)	usual species dominant: diatoms - Leptocylindrus, Rhizosolenia sp.; dinoflagellates - Prorocentrum (inshore), Peridinium sp.; concentrations, including nannoplanktonic forms, low to moderate
August 2-5	Ocean City - Atlantic City	surf light green, water warm (>70°F) calm	continued N. atomus bloom; generally good weather, breezes onshore.
6-8	Ocean City - Atlantic City	surf turbid, water cool (<65°F) south to north current	sustained winds from southwest (prevalent this summer) with frequent frontal systems & thunderstorms
10	offshore, mid shelf easterly of Long Beach Island	greenish water over a considerable area (fishermen) water warm (75°)	inshore water moved offsnore, apparently a transient condition
15-21	mid-Atlantic region	Hurricane Charley off Carolinas, turned eastward off Cape May	sustained winds from easterly, strong off N.J. (gale force on 8/18)
25	Atlantic City-Ocean City	algal concentrations diminished in coastal waters	result of turbulent conditions
September 2-3	Atlantic City-Ocean City, Monmouth/Ocean Co.	greenish water again present (NJDEP)	reflected in cell counts and chlorophyll level higher than last week
4	Mud Dump, N.Y. Bight apex	apparent red tide bloom (EPA Helicopter)	species unconfirmed
12	Harvey Cedars-Barnegat Inlet, Barnegat Bay	light green water in ocean near beach, marked contrast in inlet with brown water from bay	partially due to differences in depth and background water quality
18	Atlantic City - Ocean City	greenish water persisting in ocean; brown water, in bay	last NJDEP sampling in 1986

Table 2.

Succession of major phytoplankton species found in the 1986 survey. Terms for relative abundance are defined as follows: sub-dominant (1) = cell counts or densities approaching 10^3/ml; dominant (2) = densities exceeding 10^3/ml (10^4 for Nannochloris); bloom (3) = counts exceeding 10^4 (10^5 for Nannochloris) often producing visible water coloration. No designation indicates that the species was either present in very low densities or was not observed. All species are included under one of four taxonomic groups designated as (a) diatoms = Bacillariophyceae; (b) dinoflagellates = Dinophyceae; (c) other phytoflagellates = Chrysophyceae, Prasinophyceae, Euglenophyceae, Cryptophyceae; etc. (d) non-motile coccoids = Chlorophyceae.

Table 2.

		Sampling						Location					
		RB32	RB15	JC05	JC11	JC21	JC30	JC49	JC57	JC65	JC75	JC83	JC93
Late Spring (May 22 - June 11)													
(a)	Leptocylindrus sp.	1	2	3				2	1	2	3	2	2
	Skeletonema costatum	1		2	2	1					1	2	1
	Cyclotella sp.	2	3	2					1				
	Talassiosira gravida	3	2	2	2		1	2			2	2	
	T. nordenskioldii			2	2					1	2	2	1
	Cerataulina pelagica	2	3	2	2		1				2	2	1
	Chaetoceros sp.	1	2								1		
	Asterionella glacialis	2							2		2	2	1
	Nitzschia seriata										2		2
(b)	Prorocentrum minimum		1		1							1	
	P. redfieldi	1	2		1								
	Katodinium rotundatum	3	2	2	2		1			1			
(c)	Olisthodiscus luteus	2	2		1		1						
(d)	Nannochloris atomus	2	1	1	1	1	1	1	1	1	2	2	1
Early Summer (June 18 - July 9)													
(a)	Leptocylindrus sp.										3	3	1
	S. costatum			1									
	Cyclotella sp.	2	2	2									2
	T. gravida	2	2	2									
	T. nordenskioldii	2		1					1		2		
	C. pelagica		3				2					2	
	Chaetoceros sp.										3	2	
	Phaeodactylum tricornutum												2
(b)	Prorocentrum micans							1			2	2	
	P. minimum		2		1			1					
	P. redfieldi	1		2	1			1					
	Amphidinium fusiforme		1				1			1	2	2	1
	K. rotundatum	2	3	2	1		1			2	1	2	
(d)	N. atomus	2	2	1	2	1	1			1	2	2	1
Mid-Summer (July 16 - August 6)													
(a)	P. tricornutum	2	2	1	1	1					2	1	1
	Rhizoslenia delicatula									1	2	2	1
(b)	Prorocentrum triangulatum									1	3	2	
	P. micans		2										
	K. rotundatum	1		2							1	1	
(d)	N. atomus	3	3	2	3	2	1	2	1	3	3	3	3
Late Summer (August 13 - September 18)													
(a)	S. costatum	1	1	1	1					1	1	2	1
	A. glacialis											3	
	P. tricornutum	2	2	1	2					1	1	1	2
(b)	P. redfieldi										2	2	
	K. rotundatum	1	1				2	2		1	1	1	1
(d)	N.atomus	3	3	3	3	1	3	3	2	2	3	3	3

TABLE 3.
Nutrient Data For The Red Tide
Survey: $NH_3 + NH_4$ (mg/l)
$NO_2 + NO_3$ (mg/l)
K = below detectable limits

DATE	SAMPLING LOCATION										
	RB32	RB15	JC05	JC11	JC21	JC30	JC49	JC57	JC65	JC75	JC83	JC93
22 May	.390 .18	.010K .06	.010K .03	.010K .02								
28 May	.470 .22	.060 .01K	.050 .01K	.070 .01	.030 .01	.040 .01K	.040 .01	.050 .01K	.040 .01	.090 .01K	.040 .01K	.050 .01K
4 June	.630 .25	.020 .02	.030 .03	.030 .04	.030 .04	.030 .03	.030 .03	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K
11 June	.470 .10	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K	.010K .01K
18 June	.560 .20	.060 .01	.010K .01	.010K .01	.010K .02	.010K .01	.010K .01	.010K .02	.010K .01	.010K .01	.010K .02	.010K .02
25 June	.460 .23	.010K .01K	.010K .06	.010K .01	.010K .02	.010K .01K	.010K .02	.010K .03	.010K .02	.010K .02	.010K .01K	.010K .01K
9 July	.290 .26	.040 .01K	.040 .01K	.440 .01K	.020 .01K	.030 .01K	.010 .01K	.030 .01K	.030 .01K	.030 .01K	.040 .01K	.040 .01
16 July	.550 .26	.100 .01K	.130 .04	.100 .01K	.100 .02	.060 .01K	.050 .01K	.070 .01K	.060 .01K	.060 .02	.070 .01	.040 .01
23 July	.480 .27	.070 .18	.020 .08	.080 .03	.010K .04	.010K .02	.010K .01	.010K .02	.060 .01	.010K .01	.010K .02	.010K .02
30 July	.570 .37	.210 .22	.190 .12	.650 .03	.120 .02	.070 .01	.110 .02	.060 .01				
6 Aug.	.280 .43	.100 .12	.070 .05	.110 .02	.110 .01K	.090 .01K	.020 .01	.030 .01K	.020 .01K	.020 .01K	.020 .01K	.010 .01K
13 Aug.	.860 .43	.110 .29	.110 .11	.090 .09	.120 .08	.070 .01K	.050 .01K	.030 .01K	.020 .01K	.080 .01	.070 .01K	.050 .01K

TABLE 4.
Nutrient Data For The Red Tide
Survey: PO_4 Total (mg/l)
PO_4 Ortho (mg/l)

K = below detectable limits

DATE	SAMPLING LOCATION RB32	RB15	JC5	JC11	JC21	JC30	JC49	JC57	JC65	JC75	JC83	JC93
22 May	.120 .050	.080 .020	.060 .020	.060 .020								
28 May	.120 .060	.100 .020	.040 .020	.040 .020	.030 .020	.040 .020	.030 .010	.030 .020	.040 .020	.100 .030	.070 .020	.050 .010
4 June	.130 .090	.120 .020	.020 .020	.030 .030	.030 .030	.020 .020	.020 .020	.010K .020	.020 .020	.080 .050	.020 .020	.020 .020
11 June	.130 .030	.090 .020	.050 .030	.090 .040	.050 .030	.090 .030	.080 .020	.050 .020	.050 .020	.050 .020	.090 .020	.030 .010
18 June	.160 .090	.120 .040	.050 .030	.060 .030	.040 .030	.030 .020	.030 .030	.040 .030	.050 .030	.040 .030	.050 .030	.060 .030
25 June	.120 .120	.100 .070	.050 .040	.030 .030	.030 .030	.050 .030	.020 .020	.020 .020	.030 .020	.070 .030	.040 .030	.040 .030
9 July	.160 .100	.160 .060	.050 .020	.050 .060	.040 .020	.030 .010	.010 .010	.030 .010	.040 .020	.040 .030	.040 .030	.030 .020
16 July	.170 .150	.110 .060	.050 .050	.050 .030	.050 .030	.030 .020	.030 .020	.020 .010	.020 .020	.040 .030	.040 .030	.030 .020
23 July	.190 .160	.210 .170	.080 .050	.070 .040	.070 .030	.070 .040	.050 .020	.060 .030	.050 .020	.070 .040	.070 .040	.060 .030
30 July	.210 .140	.230 .200	.100 .070	.120 .070	.060 .030	.040 .020	.030 .020	.030 .020				
6 Aug.	.190 .170	.150 .080	.060 .040	.060 .040	.070 .030	.060 .020	.020 .010K	.020 .010	.030 .010	.050 .030	.050 .030	.030 .010
13 Aug.	.220 .200	.170 .170	.080 .030	.070 .070	.060 .050	.040 .030	.040 .020	.030 .020	.020 .010	.060 .040	.040 .040	.040 .030

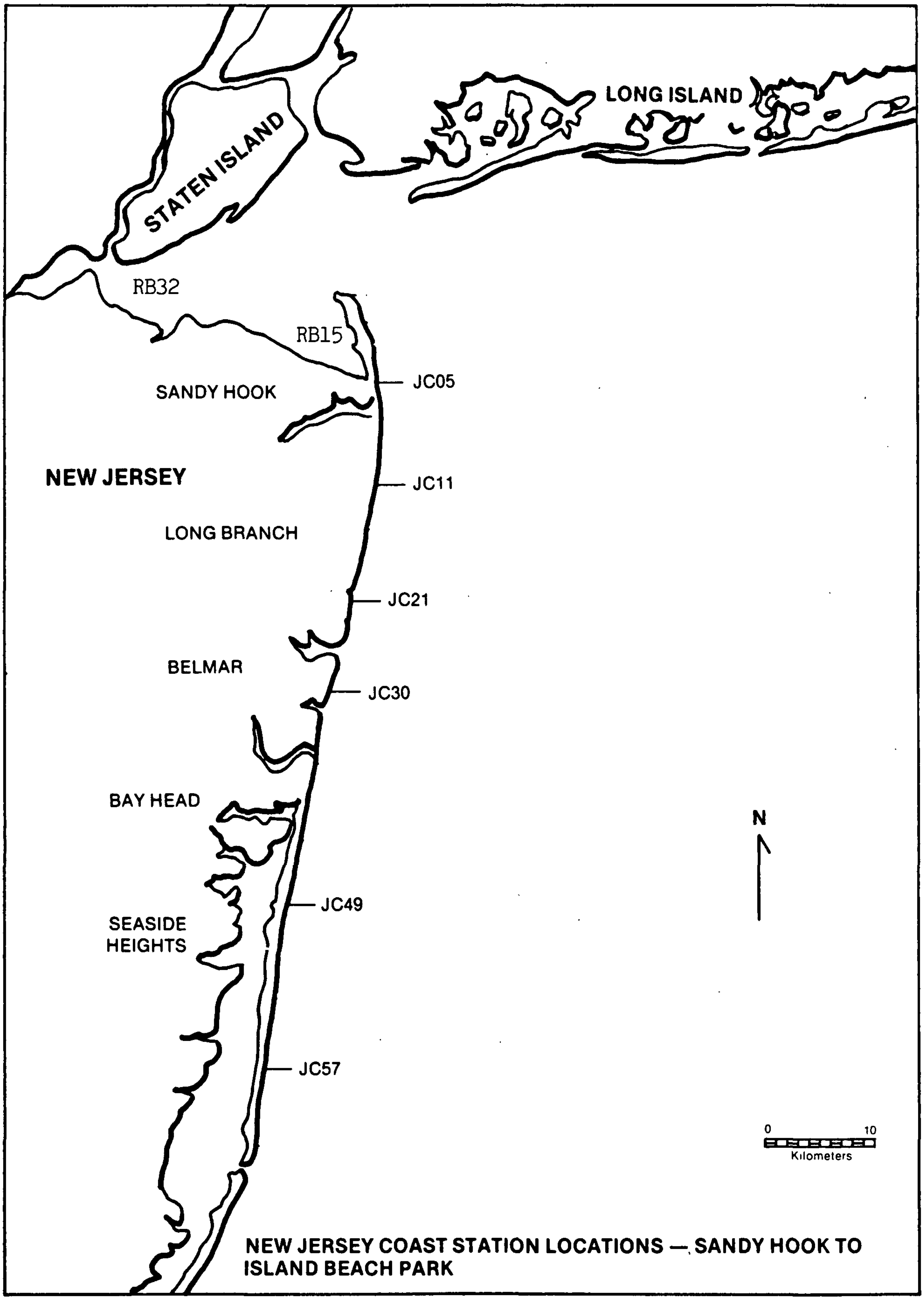


Figure 1. New Jersey northern shore locations where phytoplankton and nutrient samples are collected by the EPA helicopter.

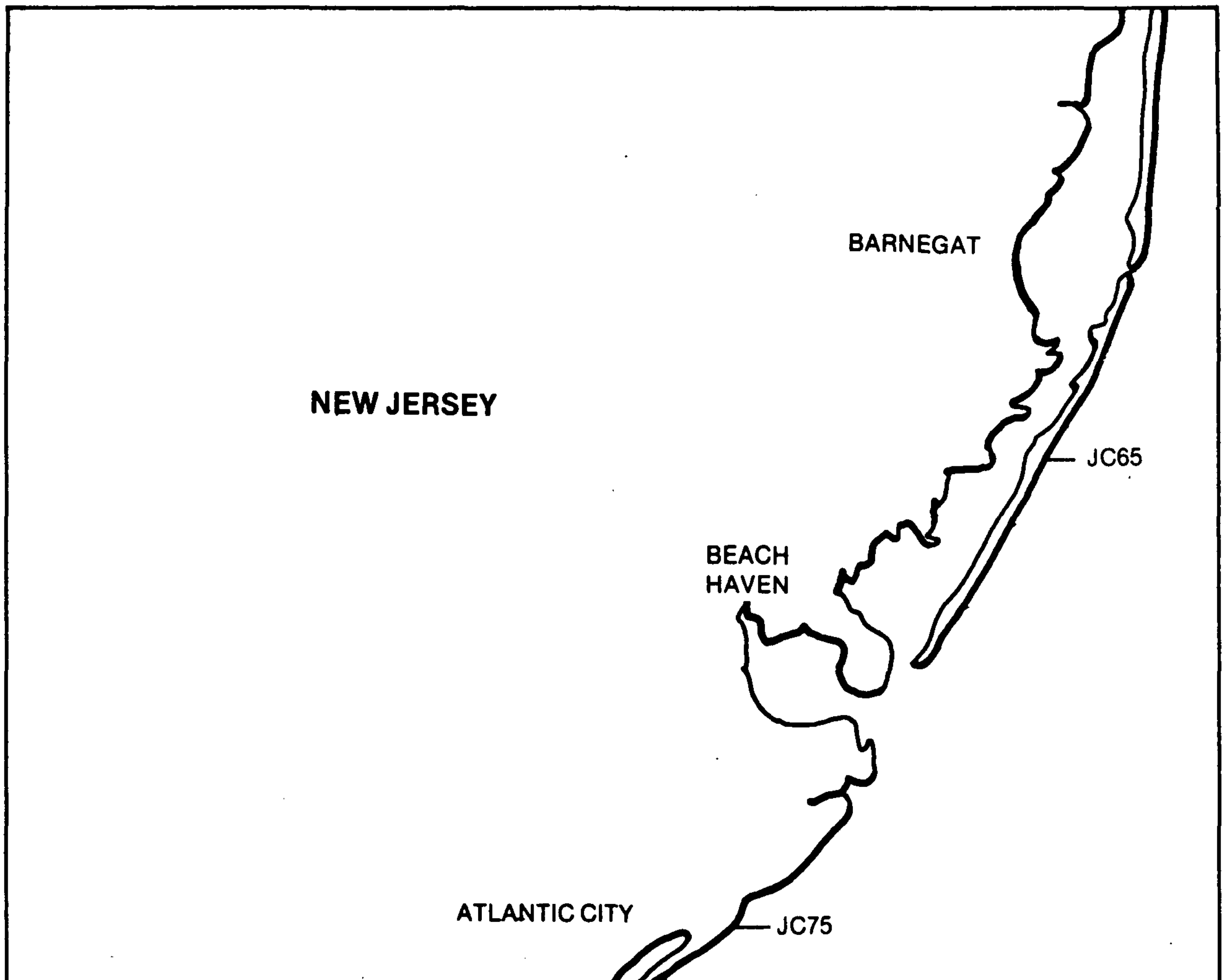


Figure 2. New Jersey southern shore locations where phytoplankton and nutrient samples are collected by the EPA helicopter.

APPENDIX "B"

MICROBIOLOGICAL WATER QUALITY

NEW YORK BIGHT

SUMMER 1986

Introduction

A study of the density* of fecal coliform (FC) and enterococcus organisms was conducted in 1986 as part of the continuing annual monitoring of the nearshore waters off the Long Island and New Jersey Coast. Monitoring at selected stations in the New York Bight was also conducted together with perpendicular stations off the New Jersey and Long Island coast.

By determining the bacteriological water quality, one can estimate potential health risks associated with the presence of sewage pollution. Epidemiological studies have attempted to assess the incidence of illness with bathing in water containing fecal contamination. Evidence exists that there is a relationship between bacterial water quality and transmission of certain infectious diseases (Cabelli, V.J., et al, 1979, 1980).

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

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

New York State, for its primary contact recreational coastal waters, has adopted the log mean of 200 fecal coliforms/100 ml. New Jersey, however, chose to adopt more stringent limits. For their coastal primary contact recreational waters, a log mean of 50 fecal coliforms/100 ml was established. By 1978, most of the states adopted the fecal coliform indicator with geometric mean limits at 200 fecal coliforms/100 ml.

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

Fecal Coliform Indicator Bacteria

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

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 bathing 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 also made it easier to detect enterococci (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 enterococci in freshwater, but not in marine waters.

Enterococci are members of the fecal streptococci group. This group is used to describe the streptococci which are indicative of 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 identifying the species utilizing biochemical tests. The enterococcus group includes the following species: *S. faecalis*; *S. faecalis*, *subsp. liquefaciens*; *S. faecalis*, *subsp. zymogenes*; and *S. faecium*. *S. faecalis*, one of the group D streptococcal species, grows in broth containing 6.5% NaCl, hydrolyzes arginine, and utilizes pyruvate. *S. faecium* grows in 6.5% NaCl broth, hydrolyzes arginine, but does not utilize pyruvate. *S. bovis* does not grow in 6.5% NaCl broth, does not hydrolyze arginine, and does not utilize pyruvate. These are the three most common species of group D streptococci found as pathogens in human infection. *S. durans* is isolated occasionally, and *S equinus* is found rarely (Facklam, 1980).

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 Monitoring the Environment, Water and Wastewater.* EPA-600/8-78-017. Part III, Section C & D. (1978).
3. *Bergey's Manual of Systematic 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 lieu of fecal coliforms. The proposed criterion for enterococci for marine waters is 35/100 ml. This information was published in the Federal Register on March 7, 1986.

MATERIALS AND METHODS

Marine water samples were collected by helicopter from May to September 1986. The samples were collected using a Kemmerer sampler and transferred to 500 ml sterile, wide-mouth plastic containers, and then transported in an ice chest to the Region II Edison laboratory for analysis.

Fecal coliform determinations were conducted according to the membrane filtration (MF) procedures described in Standard Methods, 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

Along the New Jersey Coast, FC densities greater than 50/100 ml occurred only twice at two different stations (Tables 1 & 2). The observations were made at JC-75 (Atlantic City, off the Convention Center) and JC-93 (Wildwood, off Northern amusement pier). All enterococci densities were below the standard of 35/100 ml (Table 3 & Figure 2). The highest value of 29 was observed at station JC-75 (Atlantic City).

The FC and enterococci densities observed at the New Jersey Coast perpendicular stations were all low (Tables 4 & 5).

Along the Long Island Coast, FC densities were never above 50/100 ml (Table 6 and Figure 3). The enterococci densities along the Long Island Coast were higher (Table 7), however, none exceeded 35/100 ml.

Both bacterial indicators were often non-detectable at the Long Island Coast perpendicular stations (Tables 8 & 9). Enterococci were detected more frequently than FC and were more common in bottom samples.

New York Bight

The densities of FC and enterococci found in the New York Bight are presented in Tables 10 and 11. Elevated FC and enterococci densities were occasionally observed at or near the 12-mile sewage sludge dumpsite (Stations NYB-25 and NYB-26). Enterococci densities at stations NYB-26 (Center of the sewage sludge disposal site), NYB-27 (one mile east of the sewage sludge site) and NYB-45 (one mile northwest of the sewage sludge site) were 15, 10 and 32 respectively.

Elevated counts were all observed in samples collected near the ocean bottom (Tables 10 & 11).

The FC and enterococci counts obtained at these stations may be attributed to recently dumped sewage sludge or resuspension of contaminated sediments at the dump site. FC and enterococci indicator organisms are often found in sediments. The enterococci are known to be facultative with respect to oxygen and the FC can also remain viable at reduced oxygen levels. This data supports the suggestion that there is survival after sedimentation (Van Donsel, et al, 1971. Rittenburg et al, 1958). Elevated bacterial densities outside the dump site proper may be attributable to movement of contaminated sludge and sediments by tidal and ocean currents into the Christiansen Basin.

A comparative media study was also undertaken to determine if FC A-1 media showed any better recoveries than FC on MF media and enterococci on m-E media. Table 12 compares the values determined using the three media at selected New Jersey and Long Island coast stations. The data shows that there was no consistent difference between m-FC and A-1 media. In several cases, the values for the A-1 media were substantially higher, such as the observations at JC-03 (Sandy Hook), JC-21 (Asbury Park) and JC-61 (Barnegat). A possible explanation for this observation is that some FC bacteria become stressed or injured when exposed to marine waters for any length of time. Such stressed organisms may then fail to grow on selected media (m-FC) which has many inhibitors. The bacteria are even stressed further by immediately incubating the MF plates at 44.5 ± 0.2°C for 24 hours. The A-1 method includes a three hour resuscitation at 35°C in an air incubator followed by placement in a water bath at 44.5 ± 0.2°C for 24 hours. This is a much less stressful procedure.

As a result of this comparative study, the following conclusions have been drawn:

1. No consistent difference was found between the m-FC, and A-1 media in recovering and enumerating FC from the New Jersey Coast stations.

2. Some FC, particularly E. coli, may require a resuscitation period in order to overcome a sublethal condition caused by exposure to ocean waters.

3. The m-E procedure and m-FC procedures gave similar indications of bacterial contamination in this study.

Due to the small number of total observations and the large proportion of relatively uncontaminated samples, this study needs to be repeated at a site with frequent bacterial contamination episodes and with a larger number of samples. The results of this study do not support the use of the A-1 procedure in preference to the m-FC procedures.

TABLE 1 - FECAL COLIFORM DENSITIES >50 PER 100ML
NEW JERSEY COAST STATIONS
SUMMER 1986

OBS	STATION	DATE	FECCOLI
1	JC75	860625	51
2	JC93	860723	100

TABLE 2 - GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1986

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	0.41421	0	7	12
2	JC02	0.49844	0	3	13
3	JC03	0.65880	0	4	13
4	JC05	0.37701	0	7	13
5	JC08	0.49844	0	2	13
6	JC11	1.11819	0	15	13
7	JC14	0.68927	0	8	12
8	JC21	0.67277	0	15	12
9	JC24	0.27235	0	2	12
10	JC27	0.59148	0	10	12
11	JC30	0.29380	0	10	12
12	JC33	0.27235	0	8	12
13	JC37	0.25992	0	3	12
14	JC41	0.06504	0	1	11
15	JC44	0.00000	0	0	12
16	JC47A	0.00000	0	0	12
17	JC49	0.38542	0	4	12
18	JC53	1.34064	0	12	12
19	JC55	0.16104	0	2	12
20	JC57	0.17605	0	6	12
21	JC59	0.00000	0	0	11
22	JC61	0.56195	0	4	11
23	JC63	0.00000	0	0	11
24	JC65	0.22109	0	2	11
25	JC67	0.20809	0	3	11
26	JC69	0.13431	0	3	11
27	JC73	0.45094	0	5	11
28	JC75	2.06548	0	51	11
29	JC77	0.73172	0	6	11
30	JC79	0.69694	0	6	11
31	JC81	0.10503	0	2	11
32	JC83	0.89353	0	16	11
33	JC85	1.42624	0	6	11
34	JC87	0.51428	0	5	11
35	JC89	1.26903	0	18	11
36	JC91	0.58626	0	4	11
37	JC93	2.63774	0	100	11
38	JC95	0.13431	0	3	11
39	JC97	1.34659	0	10	11
40	JC99	0.54531	0	4	11

TABLE 3 -GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1986

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	0.69838	0	7	12
2	JC02	0.65153	0	16	13
3	JC03	0.38954	0	3	13
4	JC05	0.52438	0	4	13
5	JC08	0.38954	0	3	13
6	JC11	0.68752	0	5	13
7	JC14	1.07058	0	22	12
8	JC21	0.93852	0	15	12
9	JC24	0.47724	0	2	12
10	JC27	0.73026	0	5	12
11	JC30	0.46281	0	5	12
12	JC33	0.60852	0	24	12
13	JC37	0.89614	0	8	12
14	JC41	0.25345	0	2	11
15	JC44	0.14353	0	4	12
16	JC47A	0.34801	0	5	12
17	JC49	0.30322	0	3	12
18	JC53	0.38071	0	2	12
19	JC55	0.23008	0	3	12
20	JC57	0.25992	0	3	12
21	JC59	0.41349	0	4	11
22	JC61	0.56712	0	6	11
23	JC63	0.38510	0	5	11
24	JC65	0.20809	0	3	11
25	JC67	0.06504	0	1	11
26	JC69	0.33994	0	4	11
27	JC73	0.61277	0	3	11
28	JC75	1.99323	0	29	11
29	JC77	0.64582	0	4	11
30	JC79	0.48939	0	4	11
31	JC81	0.60334	0	4	11
32	JC83	0.13431	0	1	11
33	JC85	0.74191	0	15	11
34	JC87	0.73616	0	8	11
35	JC89	0.71767	0	7	11
36	JC91	0.48939	0	4	11
37	JC93	0.60334	0	4	11
38	JC95	0.67955	0	4	11
39	JC97	0.57114	0	3	11
40	JC99	1.00970	0	4	11

TABLE 4 - GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY PERPENDICULAR STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	JC14E	B	0.000000	0	0	7
2	JC14E	S	0.291708	0	2	7
3	JC14G	B	0.000000	0	0	7
4	JC14G	S	0.169931	0	2	7
5	JC14I	B	0.000000	0	0	7
6	JC14I	S	0.000000	0	0	7
7	JC14K	B	0.000000	0	0	7
8	JC14K	S	0.104090	0	1	7
9	JC14M	B	0.000000	0	0	7
10	JC14M	S	0.000000	0	0	7
11	JC27E	B	0.000000	0	0	7
12	JC27E	S	0.000000	0	0	7
13	JC27G	B	0.104090	0	1	7
14	JC27G	S	0.000000	0	0	7
15	JC27I	B	0.000000	0	0	7
16	JC27I	S	0.000000	0	0	7
17	JC27K	B	0.000000	0	0	7
18	JC27K	S	0.000000	0	0	7
19	JC27M	B	0.104090	0	1	7
20	JC27M	S	0.000000	0	0	7

TABLE 5 - GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY PERPENDICULAR STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	JC14E	B	0.169931	0	2	7
2	JC14E	S	0.104090	0	1	7
3	JC14G	B	0.291708	0	2	7
4	JC14G	S	0.668510	0	17	7
5	JC14I	B	0.000000	0	0	7
6	JC14I	S	0.000000	0	0	7
7	JC14K	B	0.219014	0	3	7
8	JC14K	S	0.104090	0	1	7
9	JC14M	B	0.219014	0	1	7
10	JC14M	S	0.000000	0	0	7
11	JC27E	B	0.219014	0	1	7
12	JC27E	S	0.219014	0	1	7
13	JC27G	B	0.000000	0	0	7
14	JC27G	S	0.345900	0	3	7
15	JC27I	B	0.000000	0	0	7
16	JC27I	S	0.169931	0	2	7
17	JC27K	B	0.000000	0	0	7
18	JC27K	S	0.000000	0	0	7
19	JC27M	B	0.000000	0	0	7
20	JC27M	S	0.000000	0	0	7

TABLE 6 -GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1986

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	0.25316	0	4	12
2	LIC02	0.82264	0	27	12
3	LIC03	0.92517	0	17	12
4	LIC04	0.76660	0	10	12
5	LIC05	0.78180	0	15	12
6	LIC07	0.57889	0	9	12
7	LIC08	0.71513	0	8	12
8	LIC09	0.72716	0	16	11
9	LIC10	0.92848	0	8	12
10	LIC12	0.51309	0	5	12
11	LIC13	0.27235	0	5	12
12	LIC14	0.23008	0	5	12
13	LIC15	0.35409	0	18	12
14	LIC16	1.57079	0	30	12
15	LIC17	0.18921	0	3	8
16	LIC18	0.70674	0	11	8
17	LIC19	0.55394	0	16	8
18	LIC20	0.22284	0	4	8
19	LIC21	0.36426	0	2	8
20	LIC22	0.45422	0	4	8
21	LIC23	0.29684	0	1	8
22	LIC24	0.45422	0	9	8
23	LIC25	0.43519	0	8	8
24	LIC26	0.39080	0	6	8
25	LIC27	0.83401	0	7	8
26	LIC28	0.80365	0	13	8

TABLE 7 - GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1986

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	0.47260	0	12	12
2	LIC02	0.70130	0	48	12
3	LIC03	0.59930	0	34	12
4	LIC04	1.03487	0	19	12
5	LIC05	1.57079	0	30	12
6	LIC07	0.93102	0	6	12
7	LIC08	1.33240	0	26	12
8	LIC09	1.59067	0	20	11
9	LIC10	1.12556	0	8	12
10	LIC12	0.57556	0	12	12
11	LIC13	0.37074	0	10	12
12	LIC14	0.46281	0	7	12
13	LIC15	0.64195	0	23	12
14	LIC16	0.61030	0	18	12
15	LIC17	0.64645	0	26	8
16	LIC18	0.43519	0	17	8
17	LIC19	1.14611	0	24	8
18	LIC20	1.33378	0	21	8
19	LIC21	0.50270	0	12	8
20	LIC22	0.76923	0	5	8
21	LIC23	0.48774	0	3	8
22	LIC24	0.51668	0	13	8
23	LIC25	1.25810	0	25	8
24	LIC26	0.55394	0	16	8
25	LIC27	0.68827	0	10	8
26	LIC28	0.43519	0	8	8

TABLE 8 - GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND PERPENDICULAR STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	LIC09A	B	0.000000	0	0	4
2	LIC09A	S	0.000000	0	0	4
3	LIC09B	B	0.000000	0	0	4
4	LIC09B	S	0.000000	0	0	4
5	LIC09C	B	0.000000	0	0	4
6	LIC09C	S	0.000000	0	0	4
7	LIC09P	B	0.000000	0	0	4
8	LIC09P	S	0.414214	0	1	4
9	LIC14A	B	0.000000	0	0	4
10	LIC14A	S	0.000000	0	0	4
11	LIC14B	B	0.000000	0	0	4
12	LIC14B	S	0.000000	0	0	4
13	LIC14C	B	0.000000	0	0	4
14	LIC14C	S	0.000000	0	0	4
15	LIC14P	B	0.000000	0	0	4
16	LIC14P	S	0.000000	0	0	4

TABLE 9 -GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND PERPENDICULAR STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	LIC09A	B	0.18921	0	1	4
2	LIC09A	S	0.00000	0	0	4
3	LIC09B	B	0.00000	0	0	4
4	LIC09B	S	0.00000	0	0	4
5	LIC09C	B	0.00000	0	0	4
6	LIC09C	S	0.00000	0	0	4
7	LIC09P	B	1.44949	0	5	4
8	LIC09P	S	0.18921	0	1	4
9	LIC14A	B	0.00000	0	0	4
10	LIC14A	S	0.00000	0	0	4
11	LIC14B	B	0.00000	0	0	4
12	LIC14B	S	0.00000	0	0	4
13	LIC14C	B	1.05977	0	5	4
14	LIC14C	S	0.18921	0	1	4
15	LIC14P	B	0.18921	0	1	4
16	LIC14P	S	0.18921	0	1	4

TABLE 10 - GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW YORK BIGHT STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	NYB20	B	0.00000	0	0	4
2	NYB20	S	0.00000	0	0	4
3	NYB21	B	0.18921	0	1	4
4	NYB21	S	0.18921	0	1	4
5	NYB22	B	0.00000	0	0	4
6	NYB22	S	0.18921	0	1	4
7	NYB23	B	0.18921	0	1	4
8	NYB23	S	0.41421	0	3	4
9	NYB24	B	0.00000	0	0	4
10	NYB24	S	0.18921	0	1	4
11	NYB25	B	2.41495	0	16	4
12	NYB25	S	0.18921	0	1	4
13	NYB26	B	1.11474	0	4	4
14	NYB26	S	0.00000	0	0	4
15	NYB27	B	0.18921	0	1	4
16	NYB27	S	0.00000	0	0	4
17	NYB32	B	0.81712	0	2	3
18	NYB32	S	2.10723	0	14	3
19	NYB33	B	0.25992	0	1	3
20	NYB33	S	0.70998	0	4	3
21	NYB34	B	0.00000	0	0	3
22	NYB34	S	0.25992	0	1	3
23	NYB35	B	0.41421	0	1	4
24	NYB35	S	0.18921	0	1	4
25	NYB40	B	0.00000	0	0	3
26	NYB40	S	0.00000	0	0	3
27	NYB41	B	0.00000	0	0	3
28	NYB41	S	0.00000	0	0	3
29	NYB42	B	0.25992	0	1	3
30	NYB42	S	0.00000	0	0	3
31	NYB43	B	0.00000	0	0	3
32	NYB43	S	0.00000	0	0	3
33	NYB44	B	0.00000	0	0	3
34	NYB44	S	0.00000	0	0	3
35	NYB45	B	1.11474	0	4	4
36	NYB45	S	0.00000	0	0	4
37	NYB46	B	0.00000	0	0	4
38	NYB46	S	0.00000	0	0	4
39	NYB47	B	0.00000	0	0	4
40	NYB47	S	0.00000	0	0	4

TABLE 11 - GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW YORK BIGHT STATIONS
SUMMER 1986

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	NYB20	B	0.18921	0	1	4
2	NYB20	S	0.00000	0	0	4
3	NYB21	B	0.41421	0	1	4
4	NYB21	S	0.00000	0	0	4
5	NYB22	B	0.31607	0	2	4
6	NYB22	S	0.18921	0	1	4
7	NYB23	B	0.18921	0	1	4
8	NYB23	S	0.18921	0	1	4
9	NYB24	B	0.86121	0	2	4
10	NYB24	S	0.00000	0	0	4
11	NYB25	B	2.08007	0	5	4
12	NYB25	S	0.00000	0	0	4
13	NYB26	B	1.63215	0	15	4
14	NYB26	S	0.00000	0	0	4
15	NYB27	B	1.85027	0	10	4
16	NYB27	S	0.00000	0	0	4
17	NYB32	B	0.44225	0	2	3
18	NYB32	S	0.25992	0	1	3
19	NYB33	B	0.00000	0	0	3
20	NYB33	S	0.00000	0	0	3
21	NYB34	B	0.00000	0	0	3
22	NYB34	S	0.00000	0	0	3
23	NYB35	B	0.56508	0	2	4
24	NYB35	S	0.00000	0	0	4
25	NYB40	B	0.00000	0	0	3
26	NYB40	S	0.00000	0	0	3
27	NYB41	B	0.00000	0	0	3
28	NYB41	S	0.00000	0	0	3
29	NYB42	B	0.25992	0	1	3
30	NYB42	S	0.00000	0	0	3
31	NYB43	B	0.81712	0	2	3
32	NYB43	S	0.25992	0	1	3
33	NYB44	B	1.41014	0	6	3
34	NYB44	S	0.00000	0	0	3
35	NYB45	B	6.16805	0	32	4
36	NYB45	S	0.00000	0	0	4
37	NYB46	B	0.86121	0	5	4
38	NYB46	S	0.18921	0	1	4
39	NYB47	B	0.77828	0	4	4
40	NYB47	S	0.18921	0	1	4

TABLE 12 - COMPARISON OF FECAL COLIFORM MF, FECAL COLIFORM A-1 MPN AND ENTEROCOCCUS MF RESULTS NEW JERSEY AND LONG ISLAND COAST STATIONS SUMMER 1986

OBS	STATION	DATE	FECCOLI	ENTERO	FCAONE
1	JC01	860730	4	2	2
2	JC01A	860507	7	0	5
3	JC02	860507	0	2	5
4	JC02	860730	0	0	14
5	JC03	860730	0	0	33
6	JC05	860611	0	16	2
7	JC05	860730	0	0	0
8	JC08	860611	1	0	4
9	JC08	860806	0	0	0
10	JC11	860611	0	0	0
11	JC14	860611	0	0	0
12	JC14	860716	3	0	5
13	JC14	860723	0	0	4
14	JC21	860611	0	2	0
15	JC21	860716	3	0	2
16	JC21	860723	0	0	49
17	JC21	860806	2	3	0
18	JC24	860611	1	7	0
19	JC27	860611	1	1	0
20	JC30	860611	0	0	0
21	JC59	860723	0	0	0
22	JC61	860723	0	1	11
23	JC61	860813	0	2	49
24	JC63	860813	0	0	0
25	JC73	860813	0	0	13
26	JC75	860813	1	4	8
27	JC77	860508	0	3	0
28	JC85	860508	0	0	5
29	JC89	860716	2	0	2
30	JC91	860618	1	0	0
31	JC91	860716	1	3	5
32	JC93	860716	0	1	2
33	JC95	860618	0	0	0
34	JC95	860716	0	0	5
35	JC97	860618	0	4	0
36	JC97	860716	0	0	0
37	JC97	860806	3	2	2
38	JC99	860618	1	0	2
39	JC99	860716	0	0	0
40	JC99	860806	2	0	5
41	LIC01	860512	0	0	2
42	LIC02	860512	1	0	0

FIGURE 1 - GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1986

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

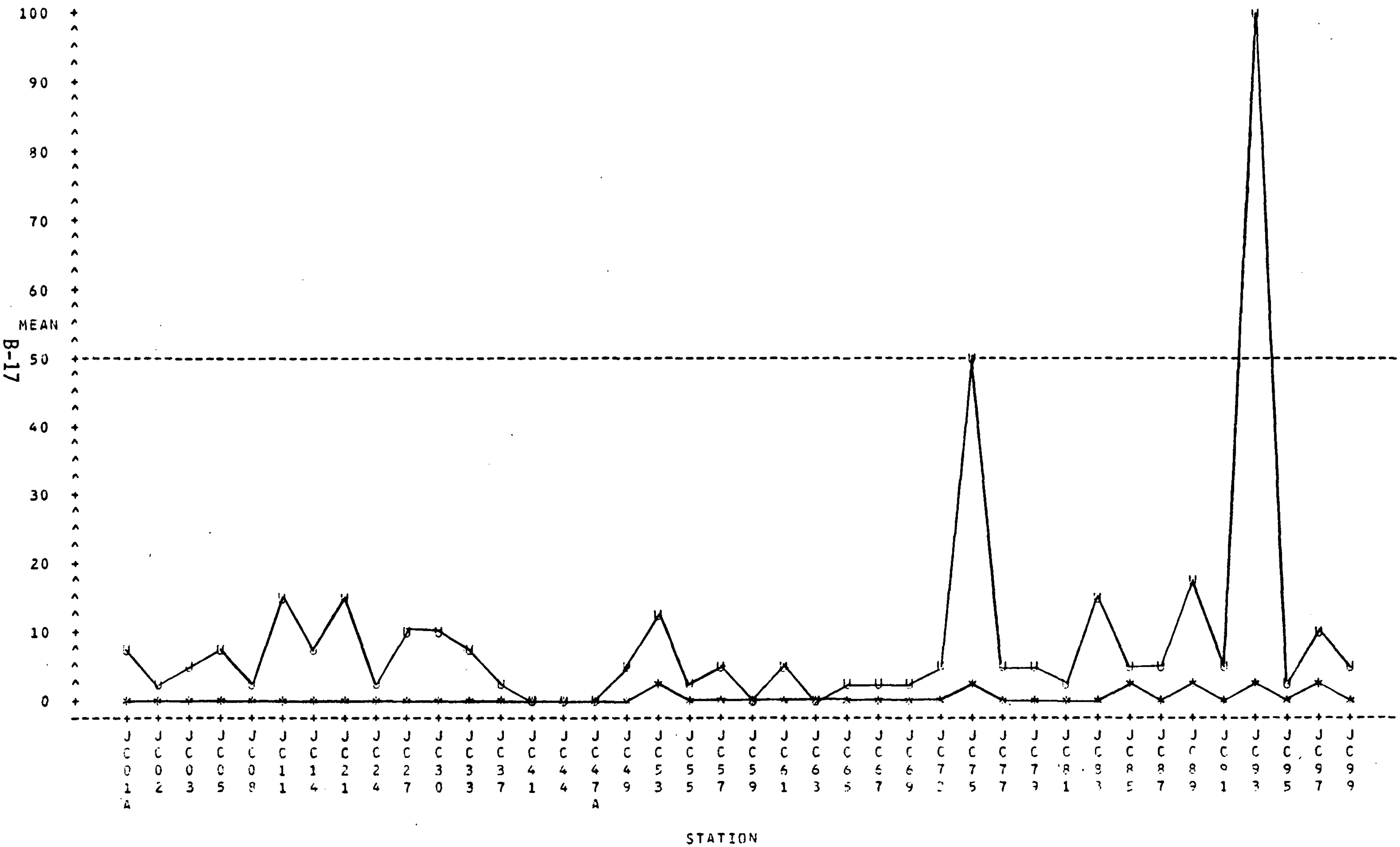


FIGURE 2 - GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1985

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

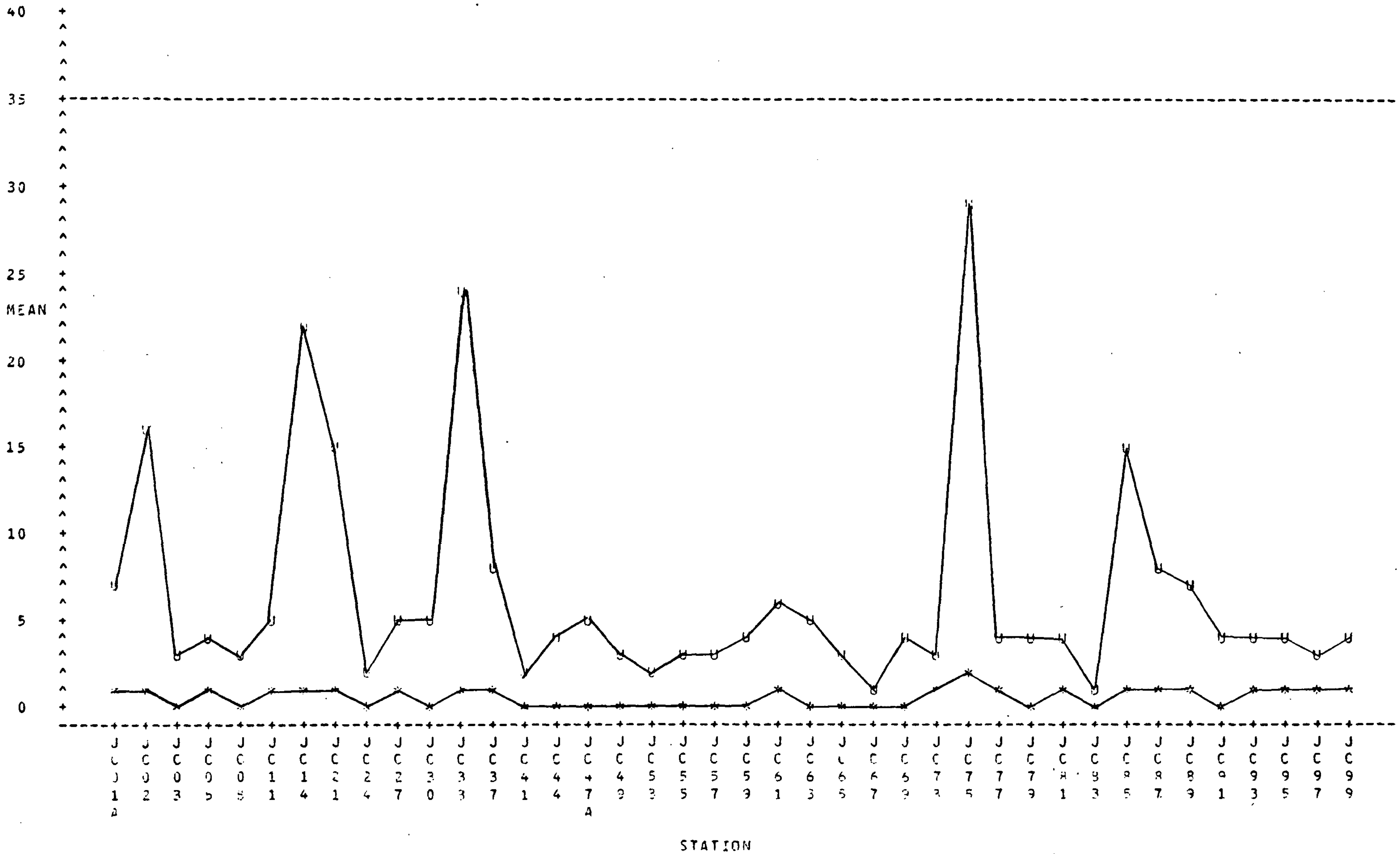


FIGURE 3 GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1986

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

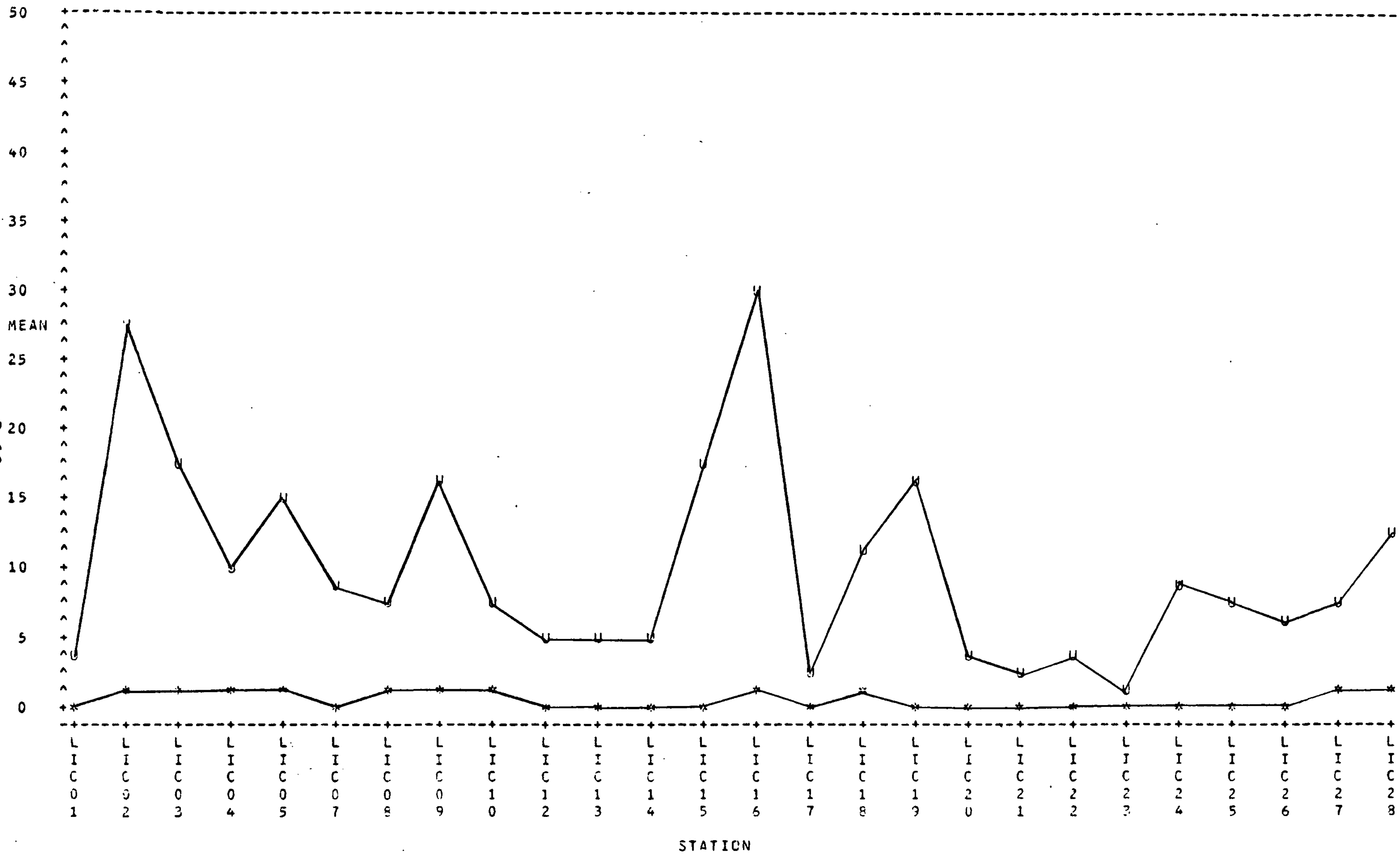
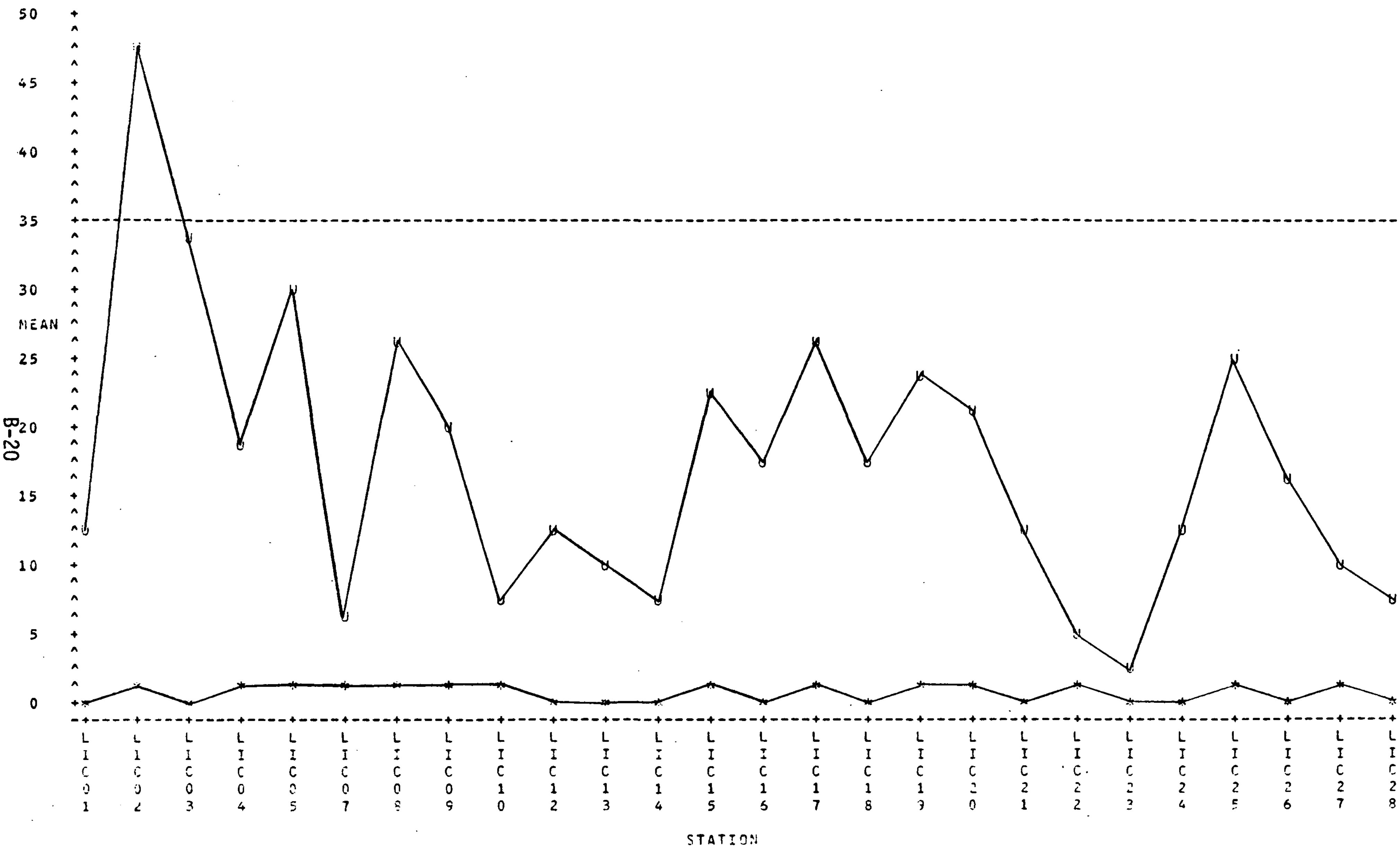


FIGURE 4 GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1986

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



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