U.S. ENVIRONMENTAL PROTECTION AGENCY

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1982

ENVIRONMENTAL SERVICES DIVISION
REGION 2
NEW YORK, NEW YORK 10278

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ABSTRACT

The purpose of this report is to disseminate technical information gathered by the U.S. Environmental Protection Agency, Region II, during the 1982 New York Bight Water Quality Monitoring Program. The monitoring program was conducted using an EPA helicopter for water quality sample collection. During the summer period of May 26 to November 8, 1982, 149 stations were sampled each week, weather permitting. The Bight sampling program was conducted 5 days a week, 6 days a week in July and August, and consisted of four separate sampling networks.

The beach station network gathered bacteriological water quality information at 26 Long Island coast stations and 40 New Jersey coast stations. The New York Bight station network gathered 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, along 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 twice weekly for dissolved oxygen and once a week for fecal coliform densities. Samples for phytoplankton identification and nutrient analysis were collected at 9 stations along the New Jersey coast and in Raritan Bay.

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I. INTRODUCTION

The U.S. Environmental Protection Agency has prepared this report in an effort to disseminate environmental data for the New York Bight Apex and the shorelines of New York and New Jersey. This report is the ninth in a series and reflects the monitoring period between May 26, 1982 and November 8, 1982. The New York Bight monitoring program is EPA's response to its mandated responsibilities as defined under the Marine Protection, Research and Sanctuaries Act of 1972 and the Water Pollution Control Act Amendments of 1972 and 1977.

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

In recent years, monitoring has been expanded to include analyses of Bight sediments for heavy metals and toxics, and analyses of water in the sewage sludge dumping area for virus and pathogens. The sediment sampling was conducted from EPA's ocean survey vessel "Antelope" and the data will be presented in a separate report. 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.

Results indicate that New York Bight water quality was generally good during the summer sampling period. Some stressful dissolved oxygen conditions were found at the New Jersey perpendicular stations and New York Bight Apex stations from mid to late summer during periods of low wind and storm activity. These depressed levels occurred in specific isolated areas and did not remain low for extended periods of time. The low DO in certain areas of the Bight is attributed to the combined effects of the respiration of organisms in organic-rich sediments, the decomposition of the alga blooms which occur in the nutrient-rich areas of the Bight, thermal water column stratification, and no circulation due to a lack of storm activity.

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

II. SAMPLE COLLECTION PROGRAM

During the period of May 1982 through November 1982, ambient water quality monitoring was carried out using the EPA Huey helicopter 5 days a week, except for July and August when sampling occurred 6 days a week.

Table 1 is an outline of the 1982 sampling program. Table 2 lists the parameters analyzed for each group of stations.

Table 1

Outline of 1982 sampling program

Station Group	Frequency per Week	Parameter	Sample Depth
Long Island Beaches & (Rockaway Pt. to Fire Island Inlet)	1	Bacteriological	Top[1]
North Jersey Beaches (Sandy Hook to Barnegat)	1	Bacteriological	Top[1]
Long Island Beaches (Fire Island Inlet to Shinnecock Inlet)	Bimonthly	Bacteriological	Top[1]
South Jersey Beaches (Barnegat to Cape May)	Bimonthly	Bacteriological	Top[1]
Long Island Perpendiculars	1	Dissolved Oxygen	Top[1], Bottom[2]
North Jersey Perpendiculars (Long Branch to Barnegat)	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 Metals	Top[1], Bottom[2]

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

Table 2

Parameters evaluated for each station group

Parameters	L.I. & N.J. Beaches*	L.I. & N.J. Perpendiculars**	N.Y. Bight**	Bight Contingency**	Phytoplankton*
Fecal Coliform	X		X	X	
Salinity Chlorinity					X
Temperature		X	X	X	
Dissolved Oxygen (DO)		X	X	X	
Metals			X		
Total Phosphorus (TP)					X
Phosphate Phosphorus (PO_4-P)					X
Ammonia Nitrogen (NH_3-N)					X
Nitrite Nitrogen (NO_2-N)					X
Nitrate Nitrogen (NO_3-N)					X
Silica (SiO_2)					X
Plankton					X

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

The weekly sampling program averaged approximately 150 stations. Beach stations along New York and New Jersey were sampled once a week. These stations were sampled for fecal coliform bacteria densities. This portion of the sampling program totaled 66 stations one week and 34 stations the following week. At the beach stations, samples were collected just off shore in the surf zone while the helicopter hovered approximately 3 meters from the surface. Sampling was accomplished by dropping a 1-liter Kemmerer sampler through a cut-out in the mid-section of the helicopter to approximately 1 meter below the water surface. The sample was transferred to a sterile plastic container and subsequently transported (within 6 hours) to the Edison Laboratory for fecal coliform analysis.

Twenty stations in the apex of the Bight were sampled once a week. Depending upon sea condition, the EPA helicopter hovered or landed at the designated station and two, 3-liter Kemmerer samplers were used to obtain water samples at 1 meter below the surface and 1 meter above the ocean bottom. After collection, portions of the sample water were transferred to a BOD bottle for dissolved oxygen analysis, a sterile plastic cubitainer for heavy metal analysis, and a sterile plastic bottle for fecal coliform analysis. The dissolved oxygen sample was immediately fixed at the station by the addition of 2 ml of manganous sulfate followed by 2 ml of alkaliiodide-azide reagent. The sample was shaken to facilitate floc formation and then placed in a metal rack and returned to the laboratory for analysis. The samples were held for less than 6 hours before returning to the laboratory for analysis. At the laboratory the heavy metal samples were preserved with HNO_3.

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

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

III. DESCRIPTION OF SAMPLING STATIONS

Beach Stations

A total of 66 bathing beach areas were sampled routinely for bacteriological water quality along the Long Island and New Jersey coastlines. The Long Island sampling stations extend from the western tip of Rockaway Point to Shinnecock Inlet some 130 km eastward with a total of 26 stations (LIC 01-LIC 28). Sample station location, nomenclature, and description are given in Table 3 and Figure 1. 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 2 and 3.

New York Bight Stations

The New York Bight stations established as part of the original ocean monitoring program cover the inner Bight area in 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 4.

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	Fire Island
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

Table 4

New Jersey coast station locations

Station No.	Location
JC 01A	Sandy Hook, 1.2 km south of tip
JC 02	Sandy Hook, off large radome
JC 03	Sandy Hook, off Nature Center building (tower)
JC 05	Sandy Hook, just north of Park entrance
JC 08	Sea Bright, at public beach
JC 11	Monmouth Beach Bath & Tennis Club
JC 14	Long Branch, off foot of S. Bath Avenue
JC 21	Asbury Park, off building north of Convention Hall
JC 24	Bradley Beach, off foot of Cliff Avenue
JC 27	Belmar, off the "White House" near fishing club pier
JC 30	Spring Lake, south of yellow brick building on beach
JC 33	Sea Girt, off foot of Chicago Avenue
JC 37	Point Pleasant, south of Manasquan Inlet
JC 41	Bay Head, off foot of Johnson Street
JC 44	Mantoloking, off foot of Albertson Street
JC 47A	Silver Beach, off foot of Colony Road
JC 49	Lavallette, off foot of Washington Avenue
JC 53	Seaside Park, off foot of 5th Avenue
JC 55	Island Beach State Park, off white building north of Park Hq.
JC 57	Island Beach State Park, between two main parking lots in center of park
JC 59	Island Beach State Park, off white house next to the lookout tower

Table 4 (Continued)

Station No.	Location
JC 61	Barnegat, first rock jetty south of Barnegat Inlet
JC 63	Harvey Cedars, opposite Harvey Cedars standpipe
JC 65	Ship Bottom, opposite Ship Bottom water tower
JC 67	Beach Haven Terrace, opposite standpipe
JC 69	Beach Haven Heights, opposite the most southern water tower on Long Beach Island
JC 73	Brigantine, off large hotel on beach
JC 75	Atlantic City, off the Convention Center
JC 77	Ventnor City, just north of fishing pier
JC 79	Longport, off water tower
JC 81	Ocean City, opposite large apartment building
JC 83	Peck Beach, opposite large blue water tower
JC 85	Strathmere, off blue standpipe
JC 87	Sea Isle City, opposite blue water tower with bridge in the background
JC 89	Avalon, off beige building on the beach
JC 91	Stone Harbor, off large blue water tower
JC 93	Wildwood, off northern amusement pier
JC 95	Two mile beach, opposite radio tower
JC 97	Cape May, off white house with red roof on the beach
JC 99	Cape May Point, opposite lighthouse

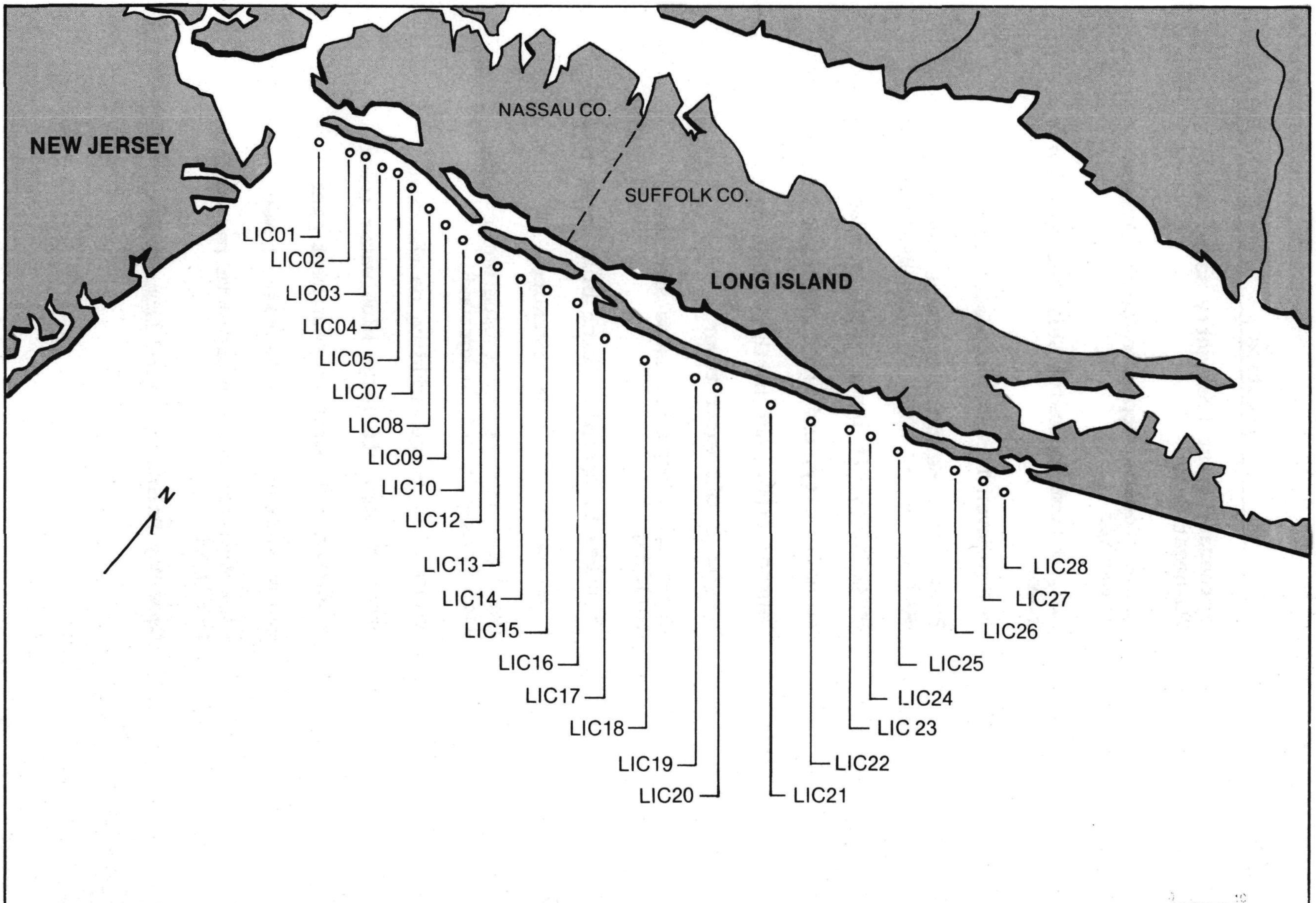


FIGURE 1
LONG ISLAND COAST STATION LOCATIONS

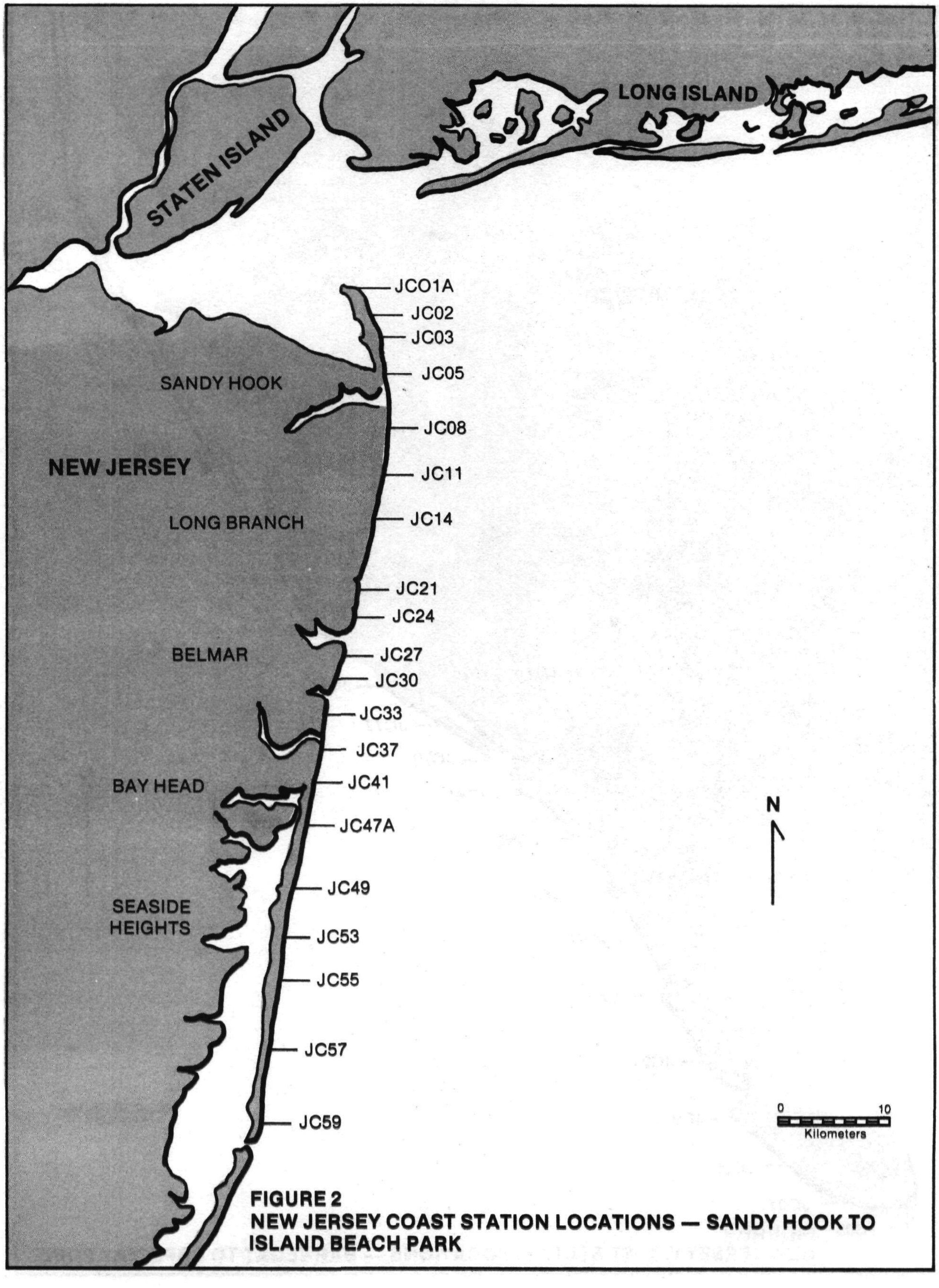


FIGURE 2
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

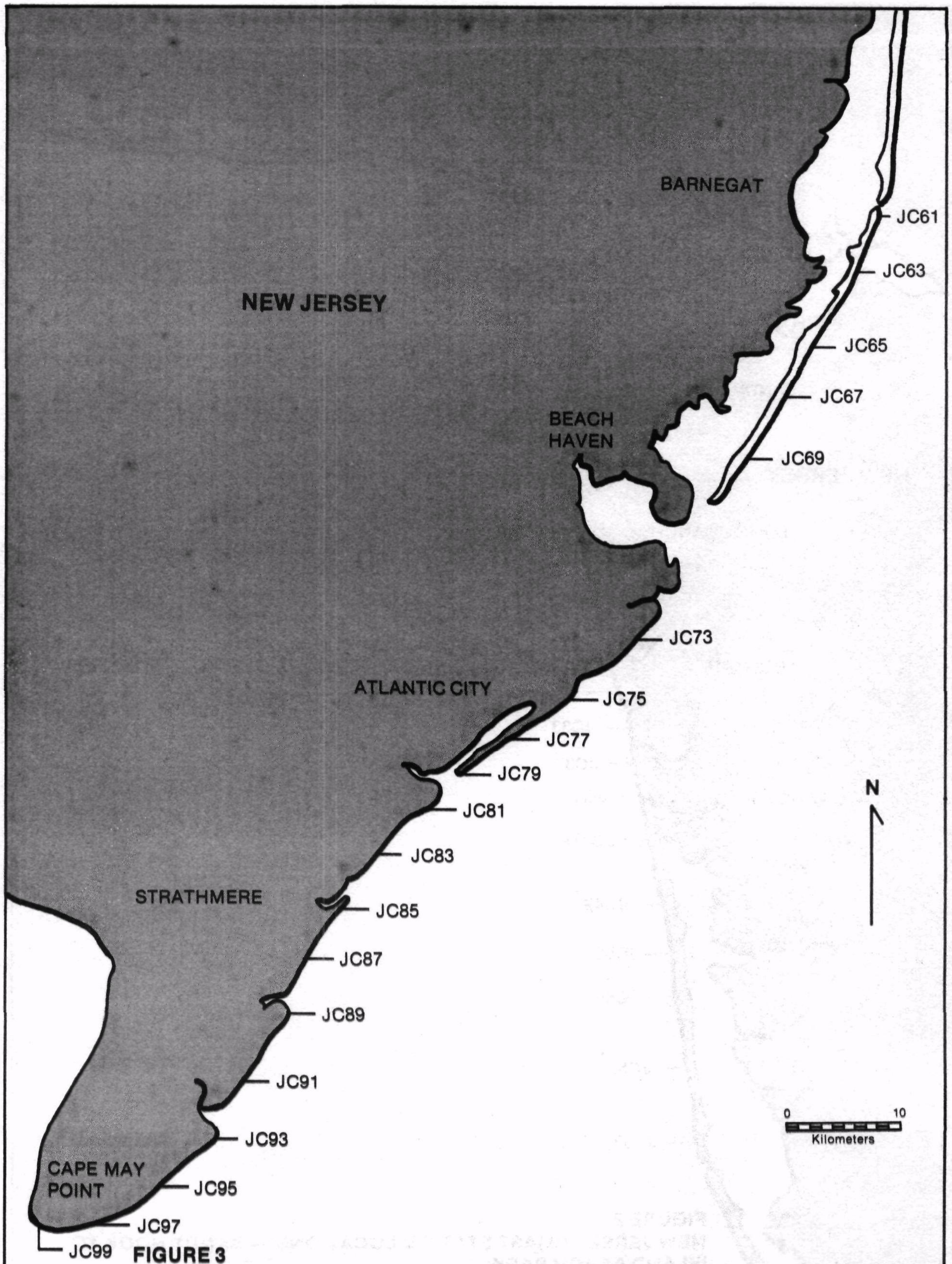


FIGURE 3
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

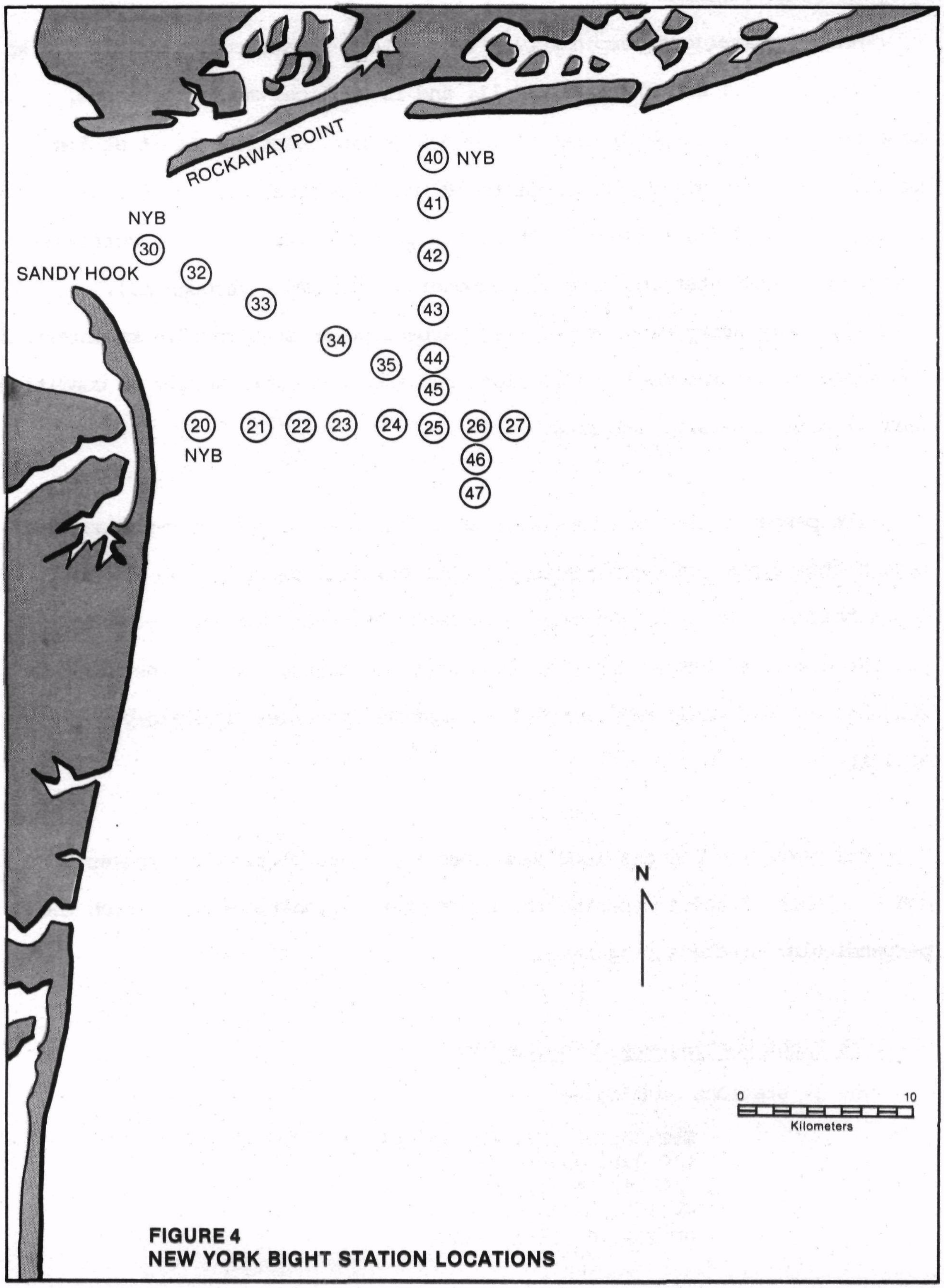


FIGURE 4
NEW YORK BIGHT STATION LOCATIONS

Perpendicular Stations

Sampling stations perpendicular to the Long Island coastline are 5.4 km, 12.6 km, 19.8 km, and 27 km (3, 7, 11, and 15 nautical miles) offshore. Sampling stations perpendicular to the New Jersey coastline start at 1.8 km and are spaced every 1.8 km out to 18 km (1 nautical mile with 1 nm increments to 10 nm) offshore. These stations are identified by suffixes E through N (MAS stations have corresponding suffixed 1 through 10). Normally, only every other New Jersey perpendicular station (3.6 km intervals) was sampled; the intermediate stations remained available should DO conditions warrant more intensive sampling.

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

The perpendicular stations described above are plotted in Figures 5 and 6. 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 were:

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

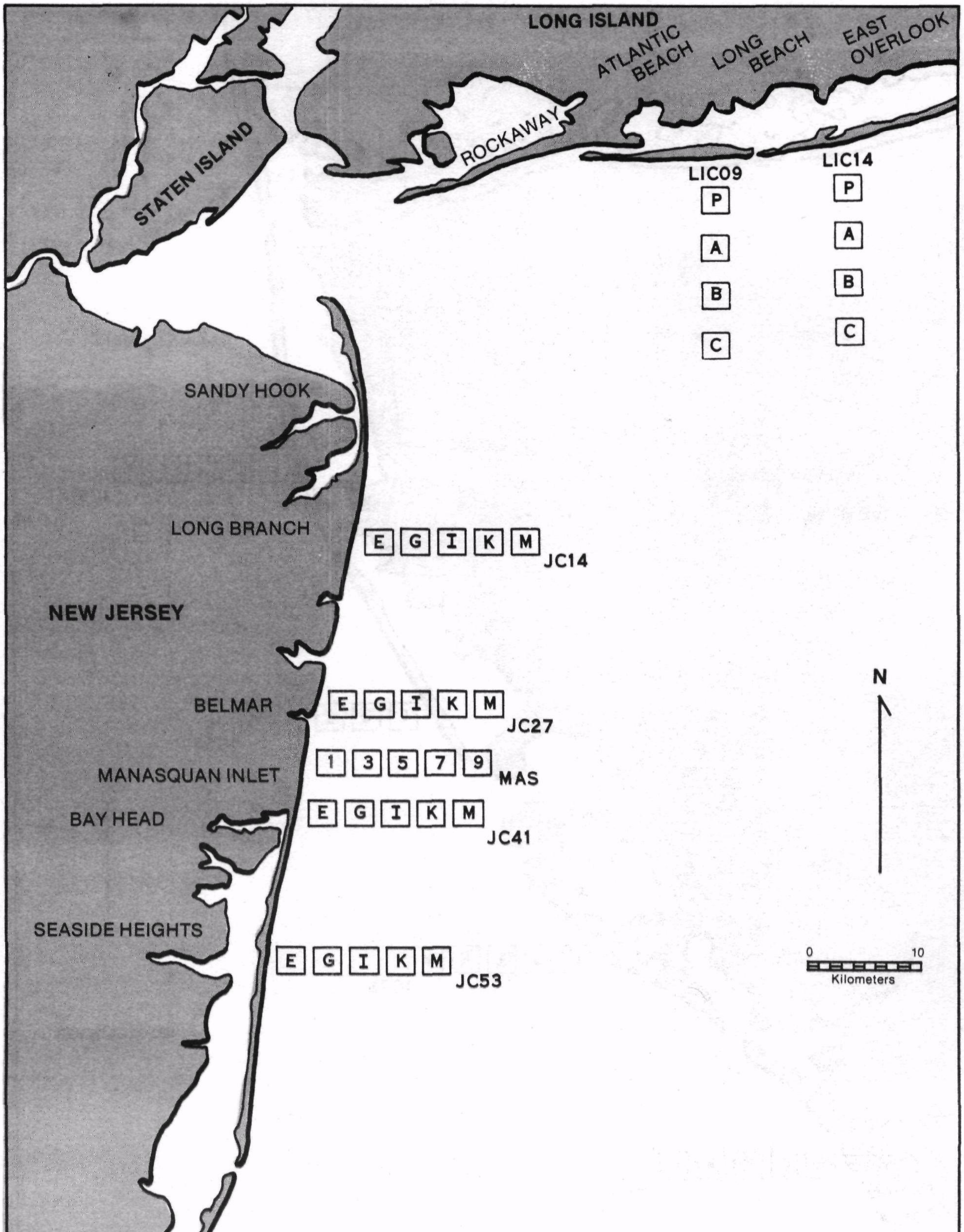


FIGURE 5
LONG ISLAND PERPENDICULAR STATIONS AND NEW JERSEY PERPENDICULAR STATIONS FROM SANDY HOOK TO SEASIDE HEIGHTS

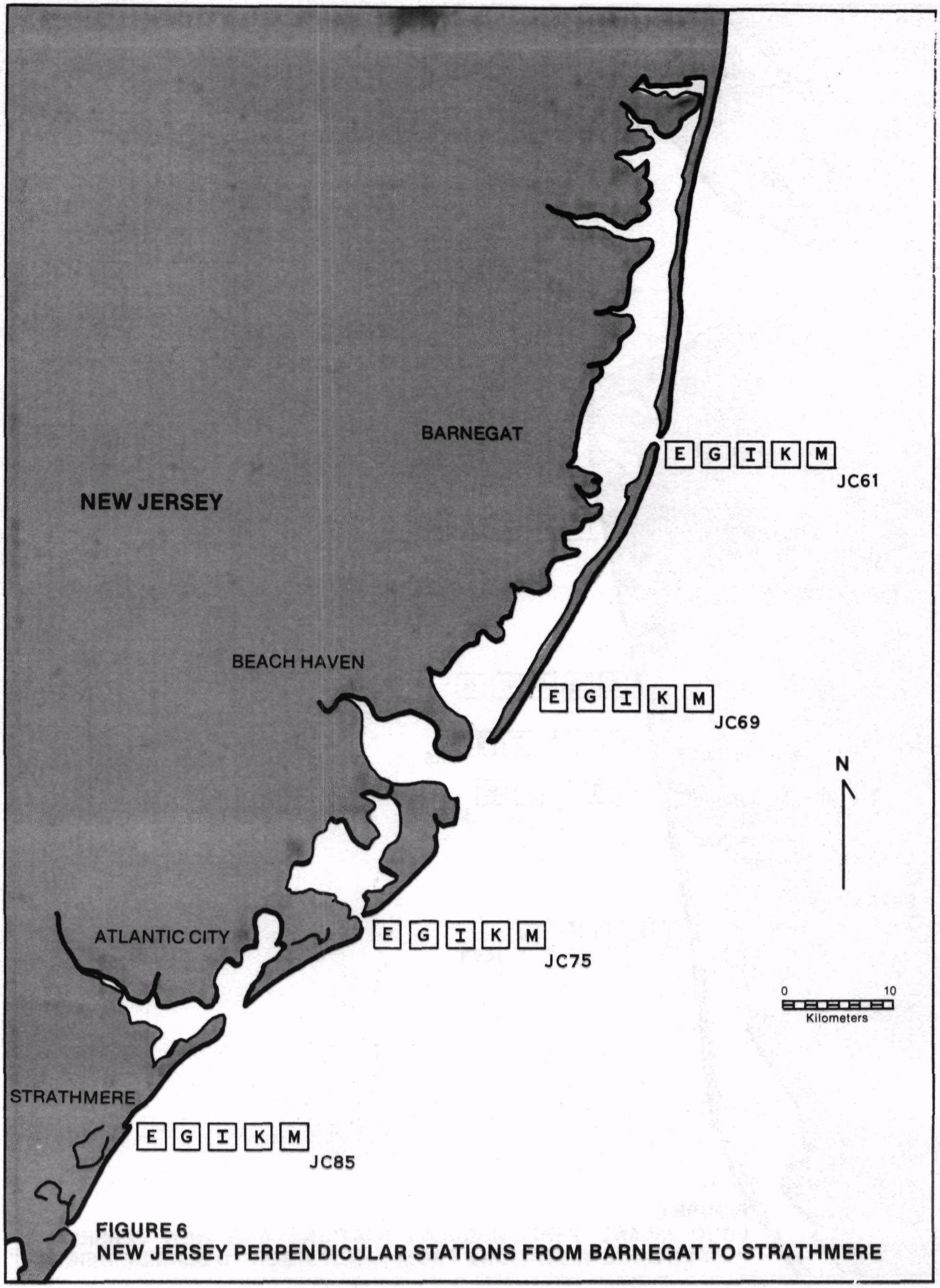


FIGURE 6
NEW JERSEY PERPENDICULAR STATIONS FROM BARNEGAT TO STRATHMERE

Their locations are described in the preceding tables and figures.

Phytoplankton Stations

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

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

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

IV. DISSOLVED OXYGEN RESULTS AND DISCUSSION

Normal Trends in the Ocean

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

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

> In early January the waters of the Bight are completely mixed throughout the water column with temperatures ranging from 4°C to 10°C while dissolved oxygen values are between 8 and 10 mg/l with slightly depressed values at the sediment-water interface. The warm spring air temperatures and solar heating increase the temperature of the upper water layer and, in the absence of high energy input from local storms or tropical hurricanes, a thermally stratified water column develops. This stratification effectively blocks the free transport of the oxygen-rich upper layer into the cool oxygen-poor bottom waters.

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

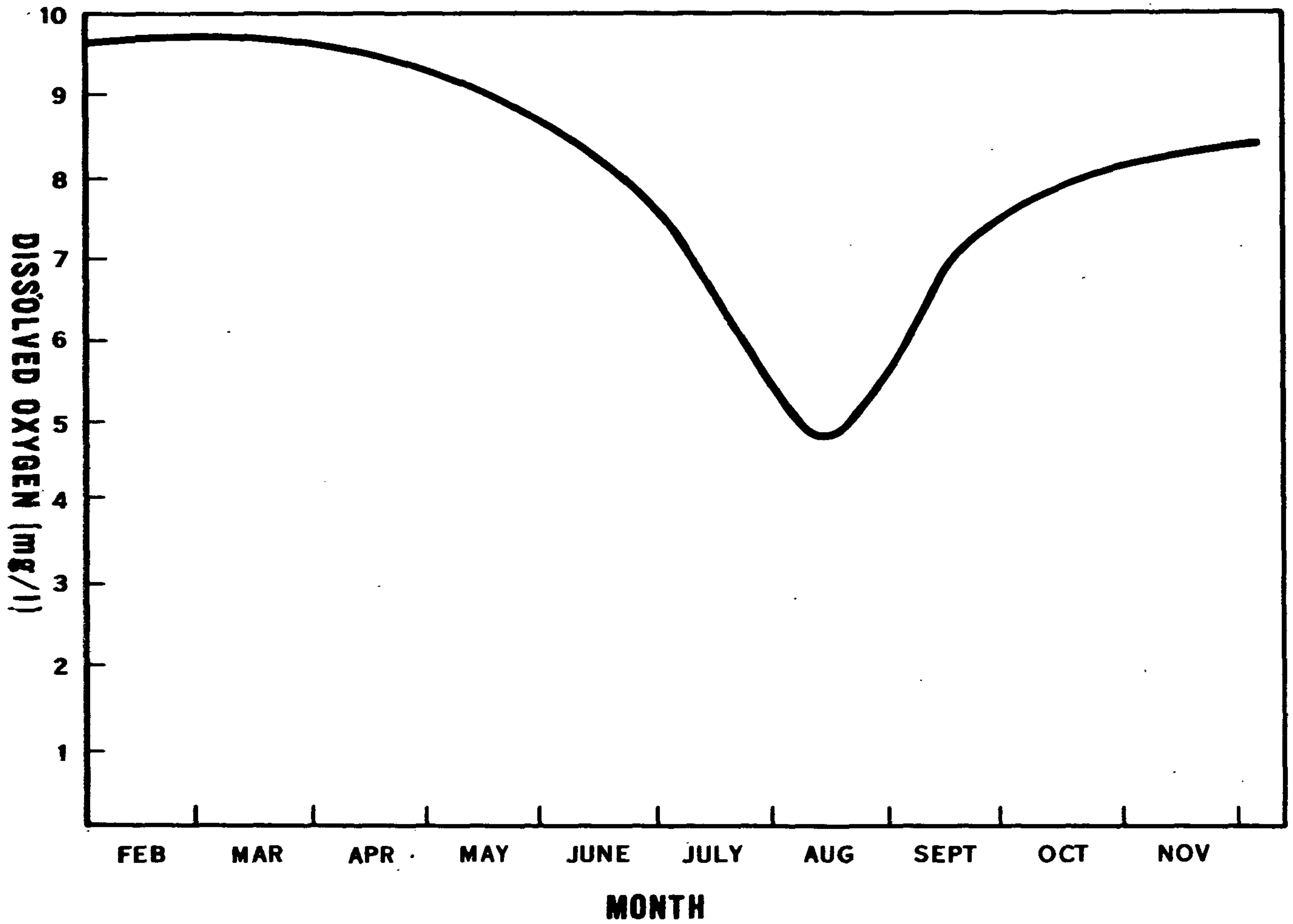


FIGURE 7
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

Dissolved Oxygen Criteria

The dissolved oxygen levels necessary for survival and/or reproduction vary among biological species. Insufficient data have been accumulated to assign definitive limits or lower levels of tolerance for each species at various growth states. Rough guidelines are available for aquatic species for purposes of surveillance and monitoring. These are as follows:

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

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

Surface Dissolved Oxygen - 1982

The completely mixed upper water layer had dissolved oxygen levels at or near saturation during the entire sampling period, June 1, 1982 through November 8, 1982, therefore no further discussion of surface dissolved oxygen will be presented in this report.

Bottom Dissolved Oxygen - 1982

Long Island Coast

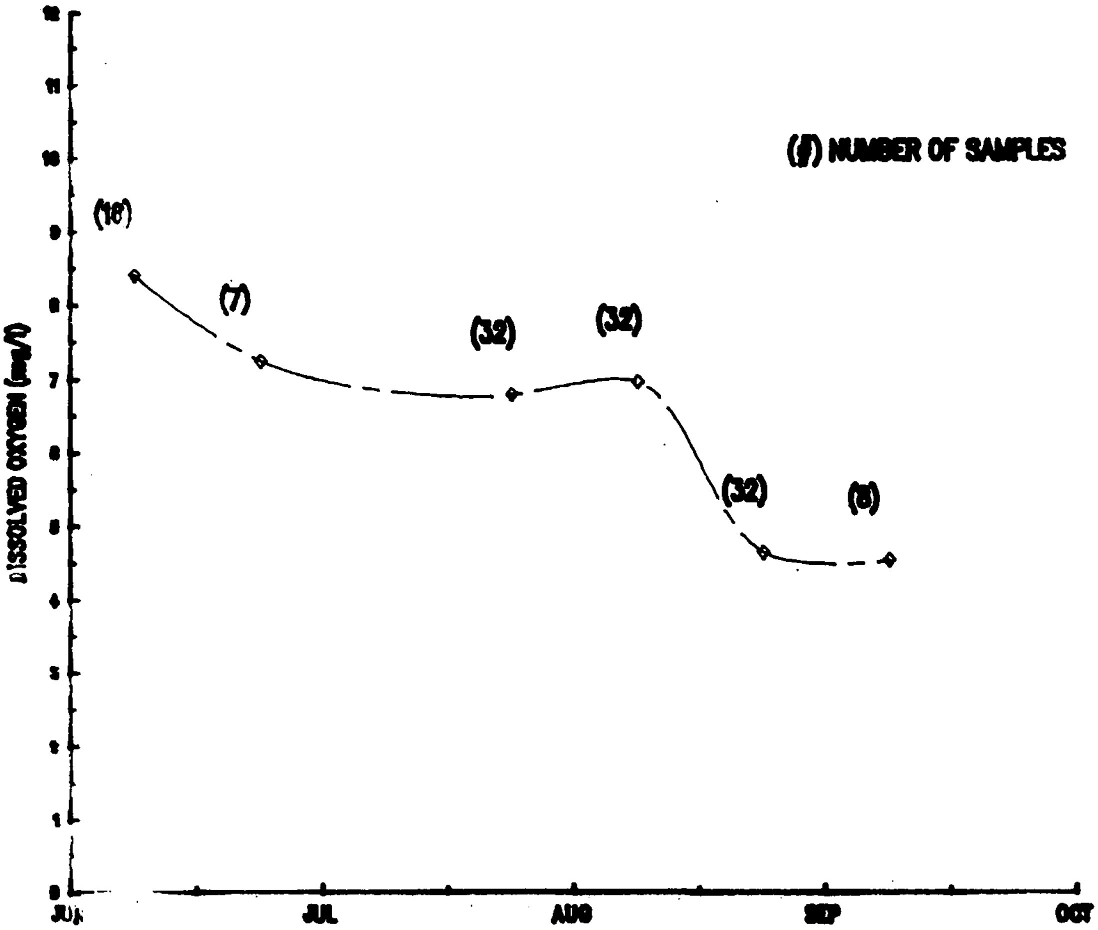
As in previous years, the dissolved oxygen levels off the coast of Long Island were, for the most part, well above the 4 mg/l "borderline to healthy" guideline for the entire sampling period. Figure 8 shows semi-monthly averages of dissolved oxygen values found from June through October, 1982. Out of 119 samples taken throughout the summer, only 7, or slightly less than 6 percent, were below the 4 mg/l guideline. These values were only slightly below the guideline with only one value below 3.0 mg/l, and are consistent with temporarily depressed values observed in this area in other years during the summer. Table 5 summarizes the dissolved oxygen values below 4 mg/l off the Long Island Coast during the Summer 1982.

Table 5

Dissolved oxygen concentrations less than 4 mg/l found off the Long Island coast, summer 1982.

Date	Station	D.O. (mg/l)
8/26	LIC 09P	3.4
8/28	LIC 09P	2.8
8/31	LIC 09P	3.8
9/5	LIC 09P	3.4
9/5	LIC 14P	3.6
8/28	LIC 14A	3.0
8/28	LIC 14B	3.9

FIGURE 08



LONG ISLAND COAST BOTTOM DISSOLVED OXYGEN, 1982
SEMIMONTHLY AVERAGE OF ALL LONG ISLAND PERPENDICULAR STATIONS.

New York Bight Apex

Figure 9 illustrates the semi-monthly dissolved oxygen values found in the New York Bight stations from June through September, 1982. The double minima which has been observed in the New York Bight during the summer months in other years were not observed during 1982. The low point was observed in late August. In early September the dissolved oxygen was beginning its seasonal recovery.

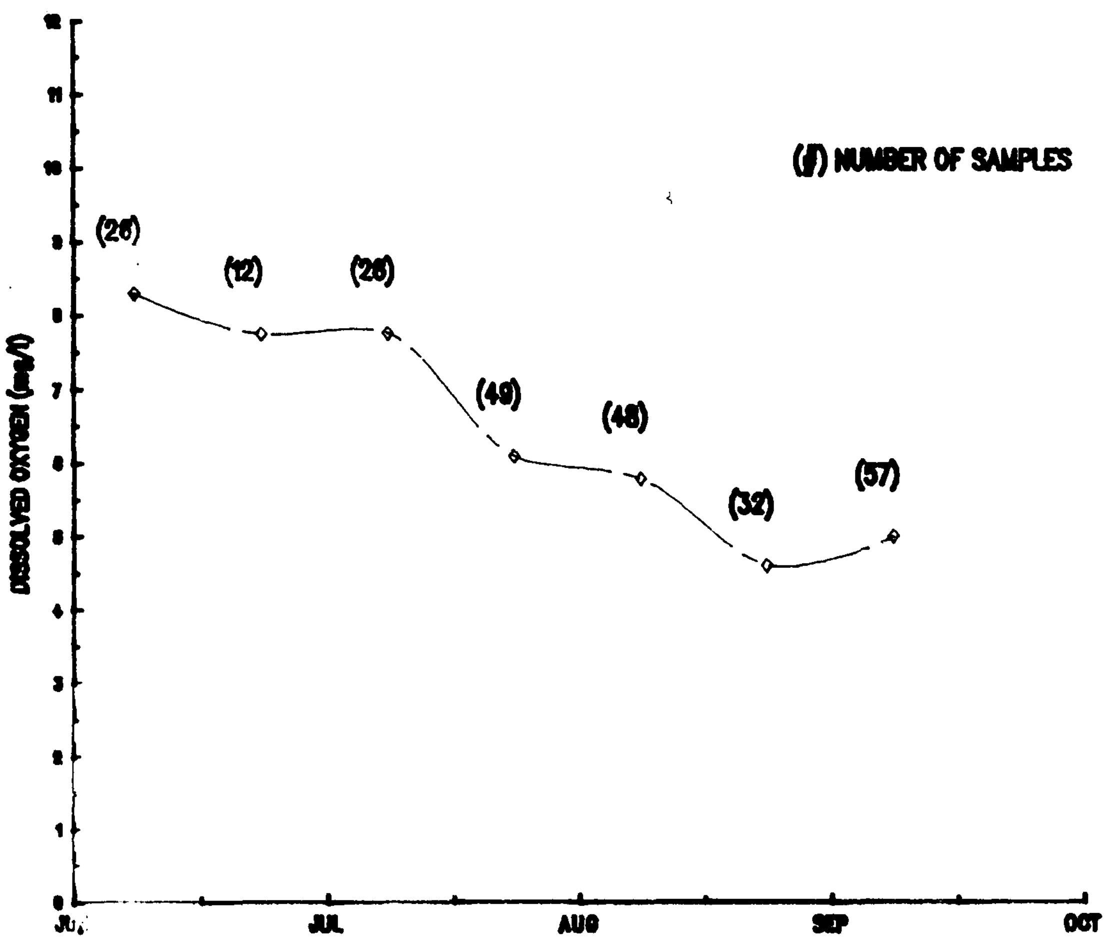
Out of 193 samples collected in the New York Bight from June 4-September 8 and measured for dissolved oxygen, 18 samples, or 9.3 percent, were below the 4 mg/l level considered "borderline to healthy" for aquatic life.

Table 6 summarizes the dissolved oxygen values below 4 mg/l in the New York Bight during the Summer 1982.

Table 6 - Dissolved oxygen concentration less than 4 mg/l in the New York Bight Apex, summer 1982

DATE	STATION	D.O. (mg/l)
8/04	NYB 45	3.9
8/04	NYB 25	3.0
8/14	NYB 24	3.8
8/18	NYB 34	3.8
8/18	NYB 25	3.9
8/18	NYB 26	3.9
8/21	NYB 22	3.9
8/28	NYB 22	3.0
8/28	NYB 24	3.8
8/28	NYB 40	3.5
8/28	NYB 42	3.6
8/28	NYB 44	3.9
9/03	NYB 27	3.3
9/03	NYB 20	3.8
9/03	NYB 40	3.8
9/08	NYB 25	1.9
9/08	NYB 41	3.3
9/08	NYB 45	3.7

FIGURE 09



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

New Jersey Coast

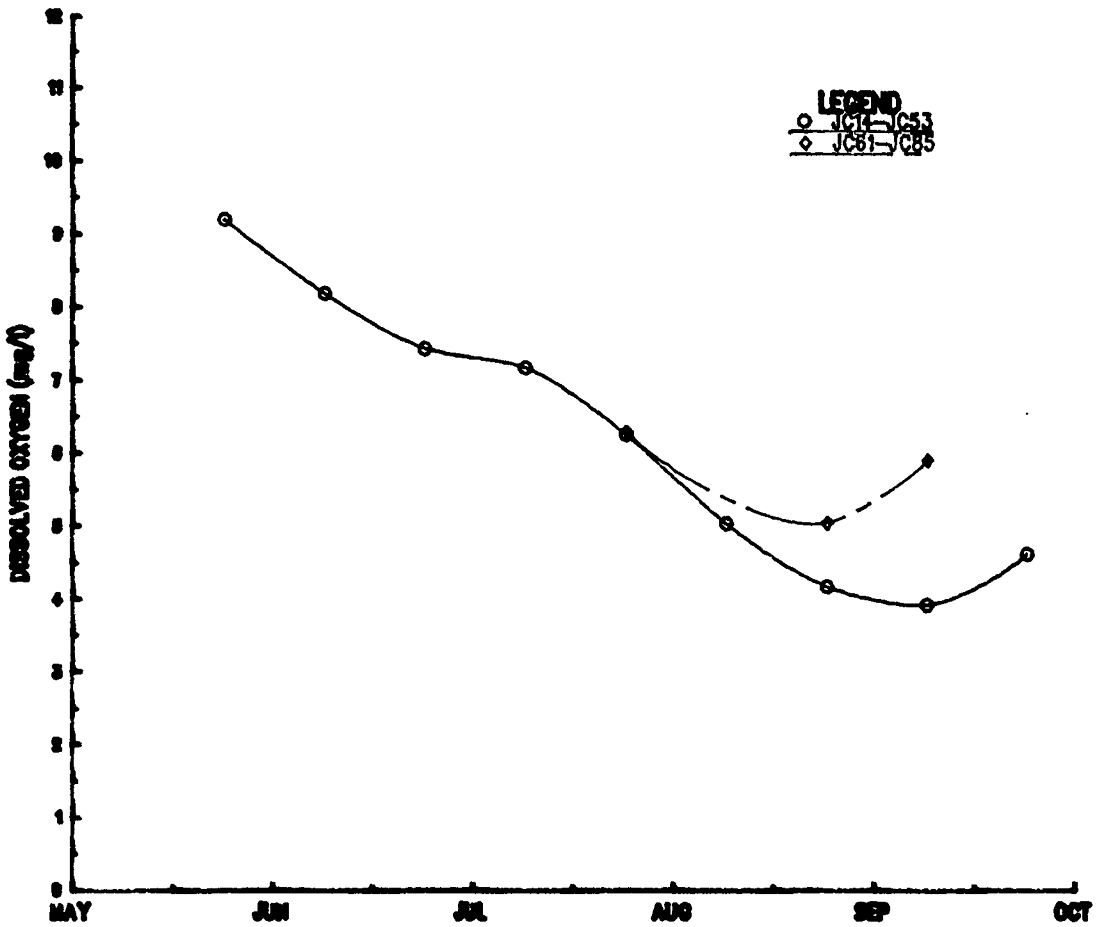
Figure 10 illustrates the semi-monthly dissolved oxygen values off the New Jersey coast during the summer of 1982, with separate lines for the northern (JC 14-JC 53) perpendiculars and the southern (JC 61-JC 85) perpendiculars. The dissolved oxygen values show an average downward trend throughout the summer.

Table 7 summarizes the dissolved oxygen values for all the New Jersey coast perpendiculars. During August and September there were 60 values between 4-5 mg/l, 54 values between 2-4 mg/l and 0 values between 0-2 mg/l. This compares with only 12 values between 4-5 mg/l and 0 values below 4 mg/l during June and July. Dissolved oxygen at the bottom reaches a minimum in late August/September due to a lack of reaeration and sediment oxygen demand. Values usually improve later in the season when storms and/or increased winds aid reaeration.

Figures 11 and 12 show dissolved oxygen profiles along the coast for July and August. The profiles show that, generally, DO increases with distance offshore and that August values show a decrease from July values.

Table 8 is a summary of dissolved oxygen values below 4 mg/l for the period between June 10 and November 2, 1982. There were 414 samples collected off the New Jersey coast and analyzed for dissolved oxygen. Of these, 54 samples, or 13 percent, were below 4 mg/l. During the month of August there were several values between 2-3 mg/l. There were no readings below 2 mg/l, contrary to previous years when August had several values below 2 mg/l.

FIGURE 10



NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1982. SEMIMONTHLY AVERAGES OF ALL NORTHERN (JC14–JC53) AND SOUTHERN (JC61–JC85) PERPENDICULAR STATIONS.

TABLE 07

Dissolved Oxygen Distribution (Bottom Values)

New Jersey Coast Perpendiculars

1982

	May 26	Jun 4	Jun 9	Jun 10	Jun 23	Jun 25	Jul 2	Jul 8	Jul 17	Jul 19	Jul 22	Jul 24	Jul 26	Jul 31	Aug 2	Aug 7	Aug 12	Aug 13	Aug 14	Aug 16	Aug 21	Aug 26	Aug 27	Aug 28	Aug 31	Sep 6	Sep 9	Sep 13	Sep 16	Nov 2
JC85M											◆												◆				◆			
JC85K											◆												◆				◆			
JC85I											◆												◆				◆			
JC85G											◆												◆				◆			
JC85E											◆												◆				◆			
JC75M											◆												◆				◆			
JC75K											◆												◆				◆			
JC75I											◆												◆				◆			
JC75G											◆												◆							
JC75E											◆																◆			
JC69M																							▲				▲			
JC69K											◆												▲				▲			
JC69I											▲												●				▲			
JC69G											◆												●				◆			
JC69E											◆												●				◆			
JC61M											◆												◆				◆			
JC61K											◆												◆				▲			
JC61I											◆												◆				▲			
JC61G											◆												●				▲			
JC61E											◆												●				◆			
JC53M				◆	◆				◆						◆			▲		▲										◆
JC53K				◆	◆				◆						◆			▲		▲										◆
JC53I				◆	◆			◆	◆						◆			◆		▲										◆
JC53G				◆	◆			◆	◆						◆			●		●										◆
JC53E				◆	◆			◆	◆	◆					◆			◆		●										◆
JC41M				◆	◆			◆		◆					◆			▲		▲					▲					◆
JC41K				◆	◆			◆		◆					◆			●		●					▲					◆
JC41I				◆	◆			◆		◆					◆			●		▲					▲					◆
JC41G				◆	◆			◆		◆					◆			●		●					▲					◆
JC41E				◆	▲			◆	▲	▲					●			●		●					●					◆
JC27M	◆		◆		◆	◆	◆	◆		◆			◆	◆	◆		◆		▲	▲	●	●			●			●	▲	◆
JC27K	◆		◆		◆	◆	◆	◆		◆		◆	◆	◆	◆		▲		●	◆	●	▲		●	●			▲	▲	◆
JC27I	◆	◆	◆		◆	◆	◆	◆		◆		◆	◆	◆	◆	◆	▲		●	▲	▲	▲		●	●			▲	▲	◆
JC27G	◆	◆	◆		◆	◆	◆	◆		◆		◆	◆	▲	◆	▲			●	●	●	◆		▲	●	●		▲	▲	◆
JC27E	◆	◆	◆		◆	▲	◆	◆		▲		▲	▲	◆	●	◆	◆		●	●	●	▲		●	●	●		●	▲	◆
JC14M	◆	◆	◆		◆	◆	◆	◆		◆		◆	◆	◆	▲		▲		●	▲	▲	●			▲			▲	▲	
JC14K	◆	◆	◆		◆	◆	◆	◆		◆			◆	◆	◆	◆	●		▲	▲	▲	●		●				●	▲	
JC14I	◆	◆	◆		◆	◆	◆	◆		◆			◆	◆	▲	◆	●		▲	▲	●	●		●	▲			◆	◆	
JC14G	◆	◆	◆		◆	◆	◆	◆		◆			◆	◆	▲	◆	▲		◆	▲	◆	◆	●		▲			▲	◆	
JC14E	◆	◆	◆		◆	◆	▲	◆		▲			◆	▲	▲	◆	◆		◆	▲	◆	◆		●	●			▲	◆	

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

FIGURE 11 - **Dissolved Oxygen Concentration Profiles**

New Jersey Coast

July 1982

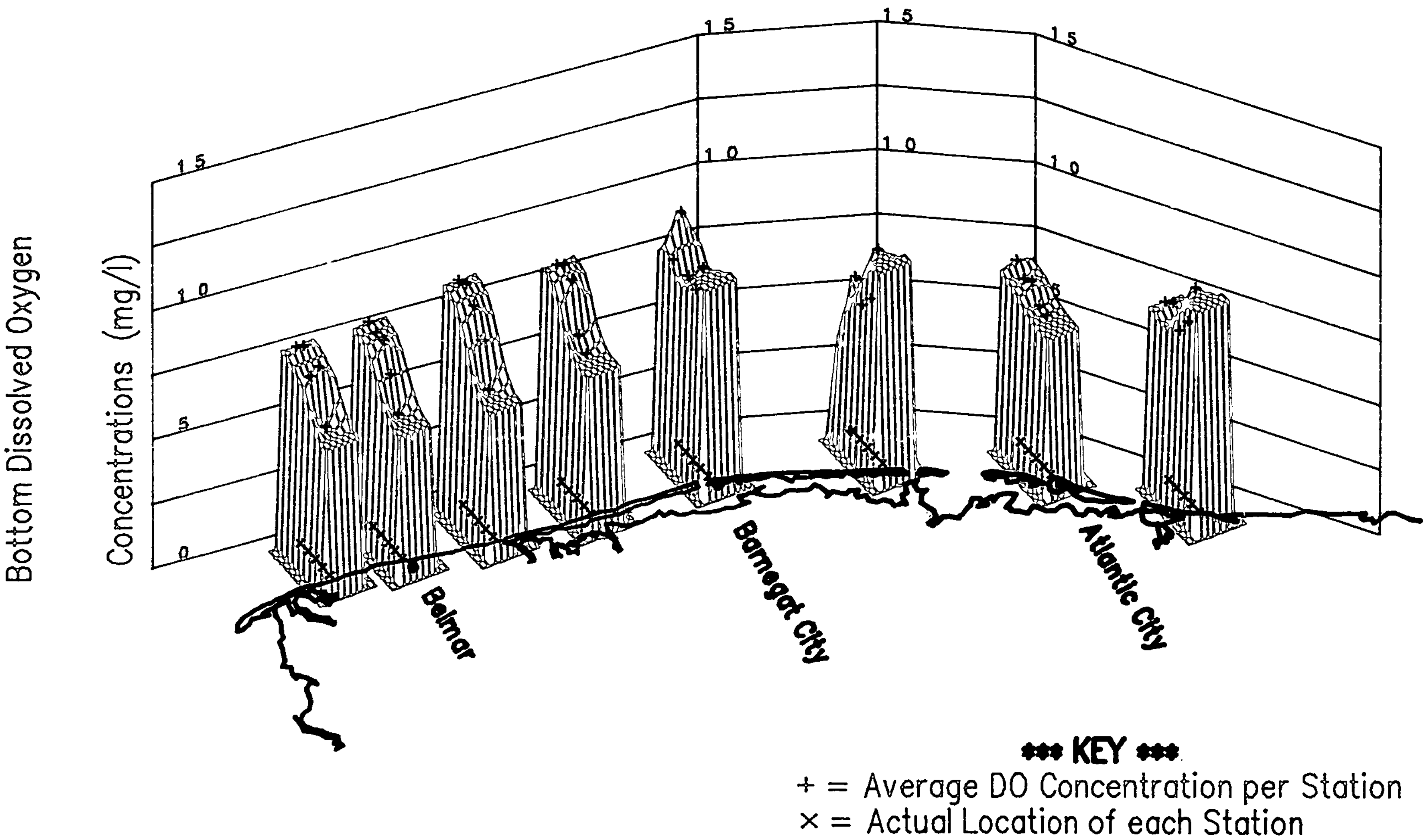


FIGURE 12 - **Dissolved Oxygen Concentration Profiles**

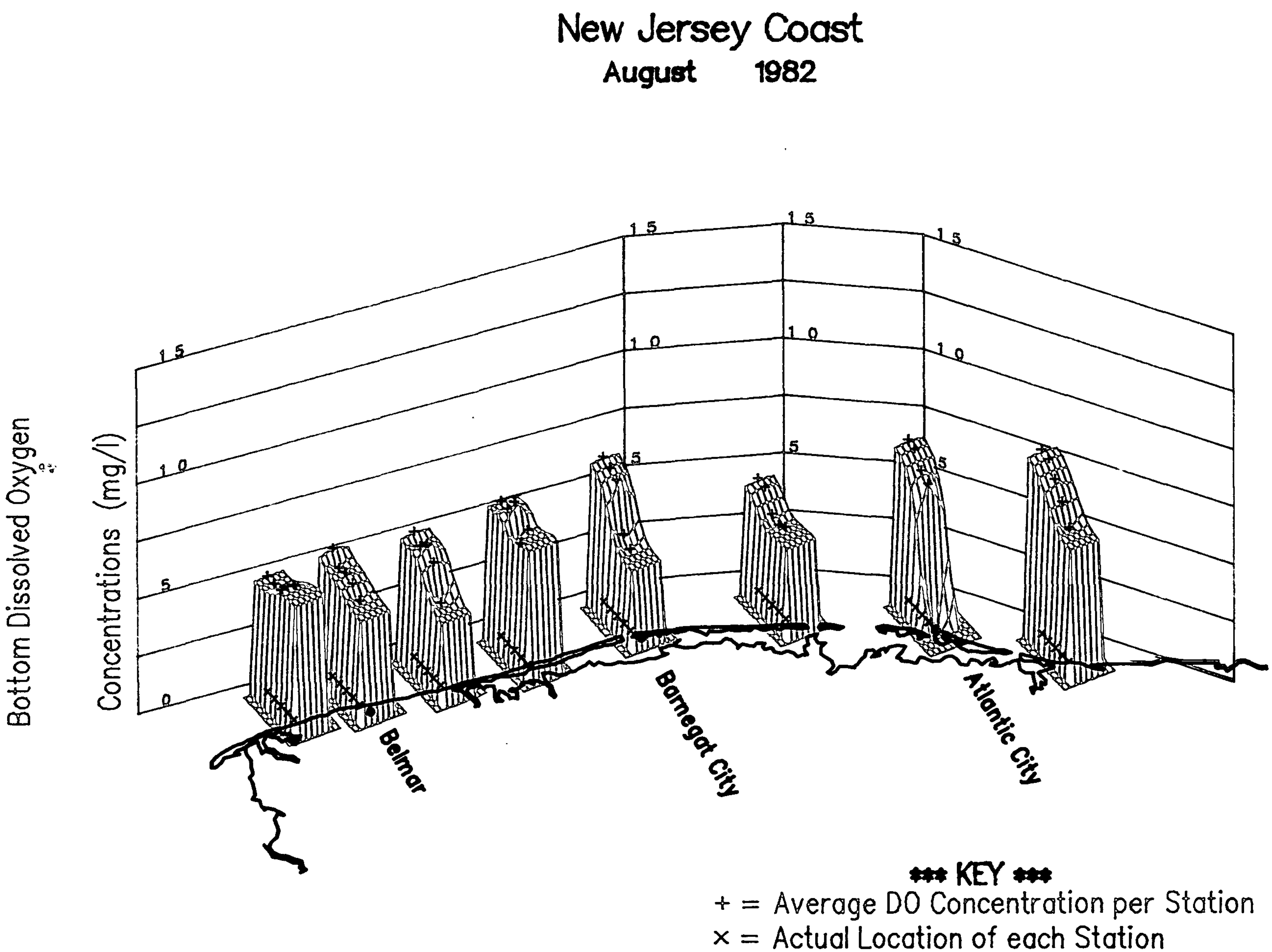


TABLE 8

Dissolved oxygen concentrations less than 4 mg/l found off the New Jersey coast, summer 1982

DATE	STATION	D.O. (mg/l)
8/02	JC 27E	3.1
8/02	JC 41E	3.2
8/12	JC 14K	3.5
8/12	JC 14I	3.4
8/13	MAS 4	3.1
8/13	JC 41E	3.3
8/13	MAS 5	3.6
8/13	JC 41G	3.8
8/13	JC 41K	3.8
8/13	JC 53G	3.4
8/14	JC 27K	3.7
8/14	JC 27E	2.9
8/14	JC 27G	3.8
8/14	JC 14M	3.7
8/16	JC 27E	2.2
8/16	JC 53G	3.8
8/16	MAS 2	2.8
8/16	JC 41G	3.9
8/16	MAS 1	3.8
8/16	JC 41E	3.3
8/16	MAS 4	2.8
8/16	MAS 3	3.5
8/16	MAS 5	3.8
8/16	JC 53E	3.4
8/16	JC 41K	3.7
8/21	JC 14I	3.3
8/21	JC 27E	3.1
8/21	JC 27G	3.1
8/26	JC 14K	3.6
8/27	JC 14G	3.5
8/27	JC 61E	3.1
8/27	JC 61G	3.4
8/27	JC 69E	3.5
8/27	JC 69I	3.4
8/27	JC 69G	3.3
8/28	JC 14E	3.6
8/28	JC 14I	3.8
8/28	JC 27E	3.3
8/28	JC 27I	3.8
8/28	JC 27K	3.5
8/31	JC 14E	3.5
8/31	JC 27E	3.8
8/31	JC 27G	3.8
8/31	JC 27K	3.8
8/31	JC 41E	2.7
9/06	JC 27E	3.2
9/13	JC 14K	3.7
9/13	JC 27E	3.3
9/13	JC 27M	3.4
9/13	MAS 1	2.6
9/13	MAS 2	3.6
9/13	MAS 3	2.7
9/13	MAS 4	2.9
9/13	MAS 5	2.7

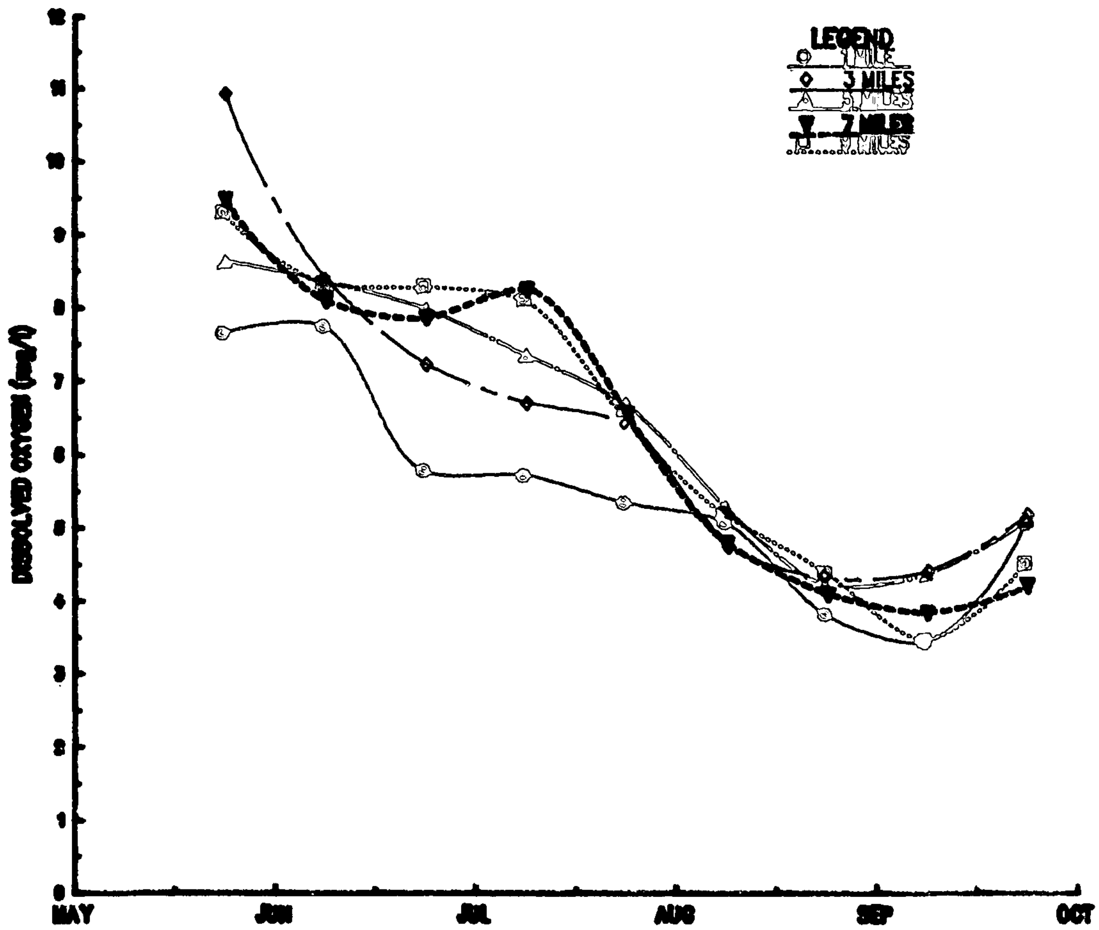
Figure 13 compares the shore to seaward distribution of dissolved oxygen values along the northern New Jersey perpendiculars. These graph shows the following:

- In previous years a "double minima" occurred along the New Jersey coast. Dissolved oxygen lows were recorded in early to mid July followed by an improvement with a subsequent lower minima than in July occurring in early September. This year the "double minima" was only observed 7 miles off the coast.
- Throughout June and July the northern New Jersey perpendicular stations that are 1 and 3 miles offshore had average dissolved oxygen values 1-3 mg/l less than the stations 5, 7 and 9 miles offshore. In general, the lower DO values found at the nearshore stations may be attributed to the influence of river runoff, treatment plant effluent, inlet dredged material disposal sites, and the Hudson Estuary system on the water along the New Jersey coast.

Figure 14 compares the shore to seaward distribution of dissolved oxygen values along the southern New Jersey perpendiculars. The stations 1, 3, and 5 miles off the coast exhibited the lowest dissolved oxygen in late August followed by a recovery in early September. The stations 7 and 9 miles offshore showed a gradual decline in dissolved oxygen levels from late July through early September with no evidence of commencement of the recovery.

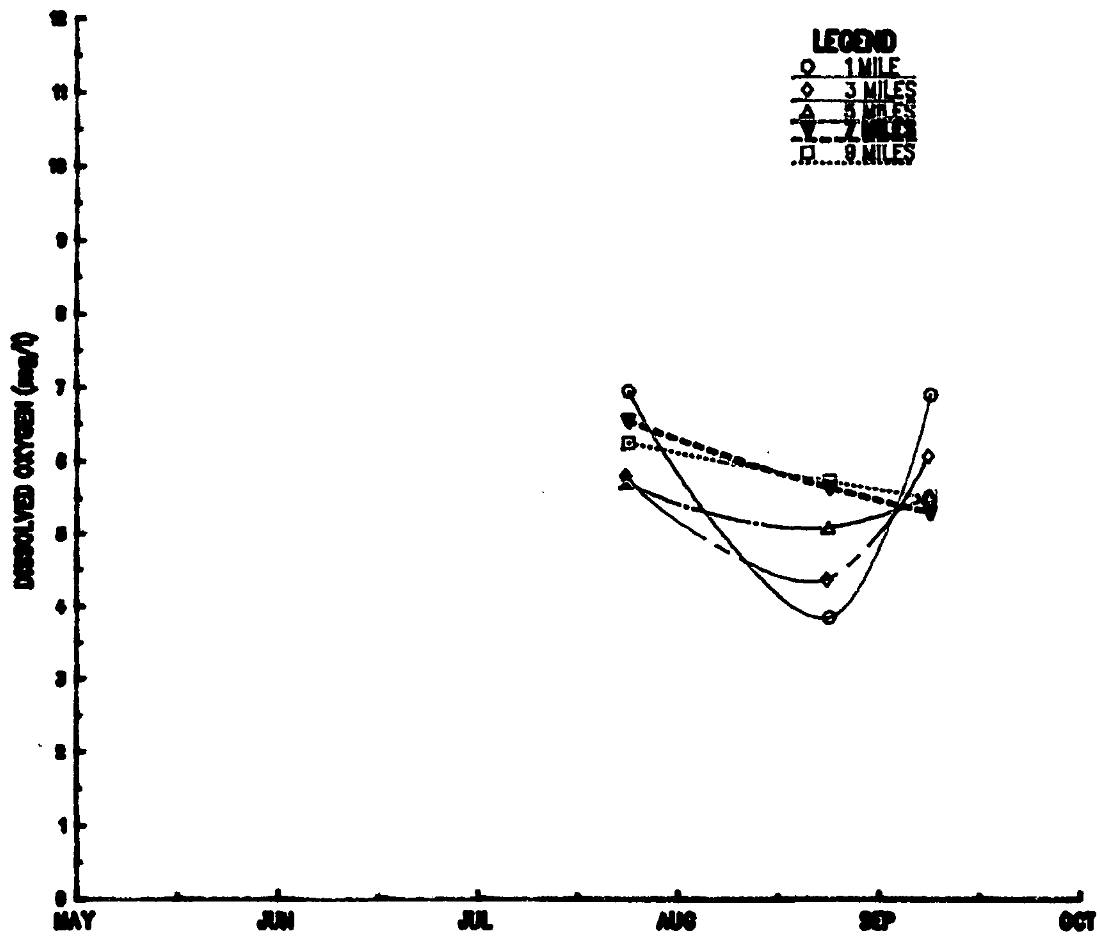
Figure 15 illustrates the DO values for the northern perpendiculars in 1982 as compared to an overall average. JC 41 and JC 53 clearly show the "double minima" effect, however they occur two weeks apart, while JC 14, JC 27 and MAS show a DO decline in June that continues until late August.

FIGURE 13



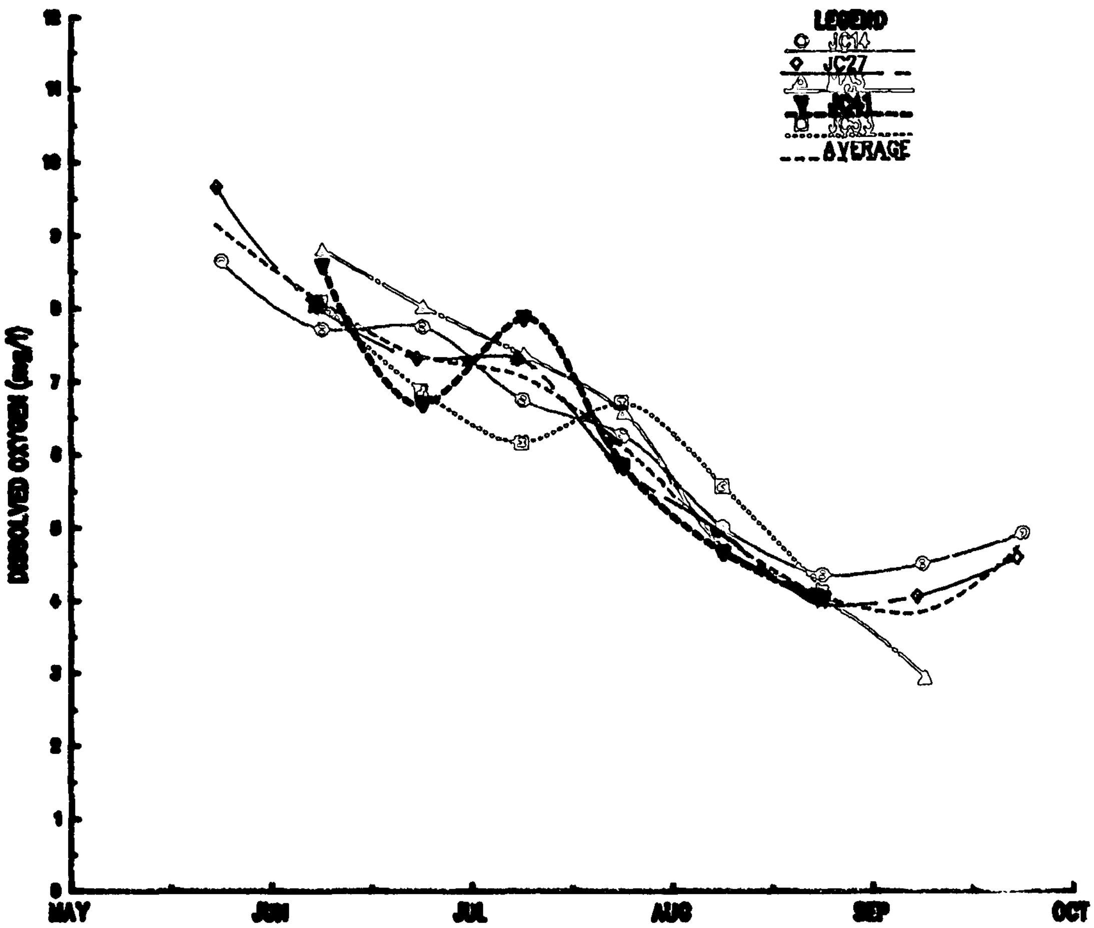
SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1982
SEMIMONTHLY AVERAGES OF ALL NORTHERN PERPENDICULAR STATIONS
(JC14-JC53), AT FIXED DISTANCES FROM SHORE.

FIGURE 14



SHORE-TO-SEAWARD DISTRIBUTION OF BOTTOM DISSOLVED OXYGEN, 1982
SEMIMONTHLY AVERAGES OF ALL SOUTHERN PERPENDICULAR STATIONS
(JC81-JC85), AT FIXED DISTANCES FROM SHORE.

FIGURE 15



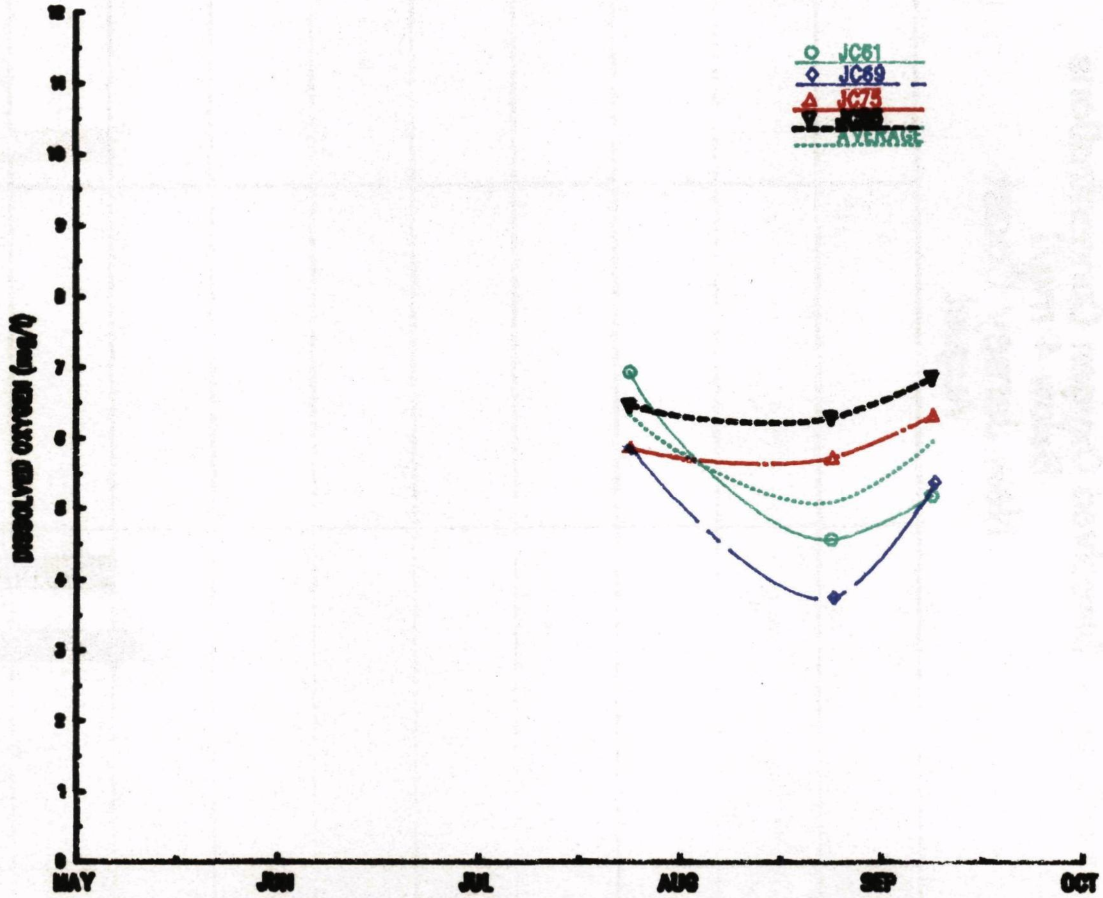
NORTH–SOUTH BOTTOM DISSOLVED OXYGEN DISTRIBUTION FOR NORTHERN NEW JERSEY, 1982.
SEMIMONTHLY AVERAGES ALONG PERPENDICULARS JC14–JC53, COMPARED TO OVERALL AVERAGE.

JC 14 and JC 27 show a recovery in September, while MAS continued to drop.

Figure 16 gives the same plot for the southern perpendiculars. JC 61 and JC 69 reached a low in late August and began a recovery in early Setpember. JC 75 and JC 85 remained fairly constant in late July and August and rose slightly in early Septmeber.

Figures 17 and 18 show the number of dissolved oxygen observations on each perpendicular which, during August and September, were below a level of 4 mg/l. The Manasquan perpendicular (MAS) is not represented in the graphs. In August, 1982 all of the perpendiculars had at least one value less than 4 mg/l, while in September only 3 out of the 8 perpendiculars had values less than 4 mg/l. This shows the DO recovery in September. The low DO values in August of 1982 were similar to those recorded in 1979 and 1981 but substantially lower than 1978 and 1980. In September of 1982 the DO values were significantly higher than in 1978 and 1979, slightly higher than 1981, and similar to 1980.

FIGURE 16



NORTH-SOUTH BOTTOM DISSOLVED OXYGEN DISTRIBUTION FOR SOUTHERN NEW JERSEY, 1982.
SEMIMONTHLY AVERAGES ALONG PERPENDICULARS JC61-JC85, COMPARED TO OVERALL AVERAGE.

FIGURE 17 - Dissolved Oxygen Concentrations Below 4 mg/l New Jersey Coast August

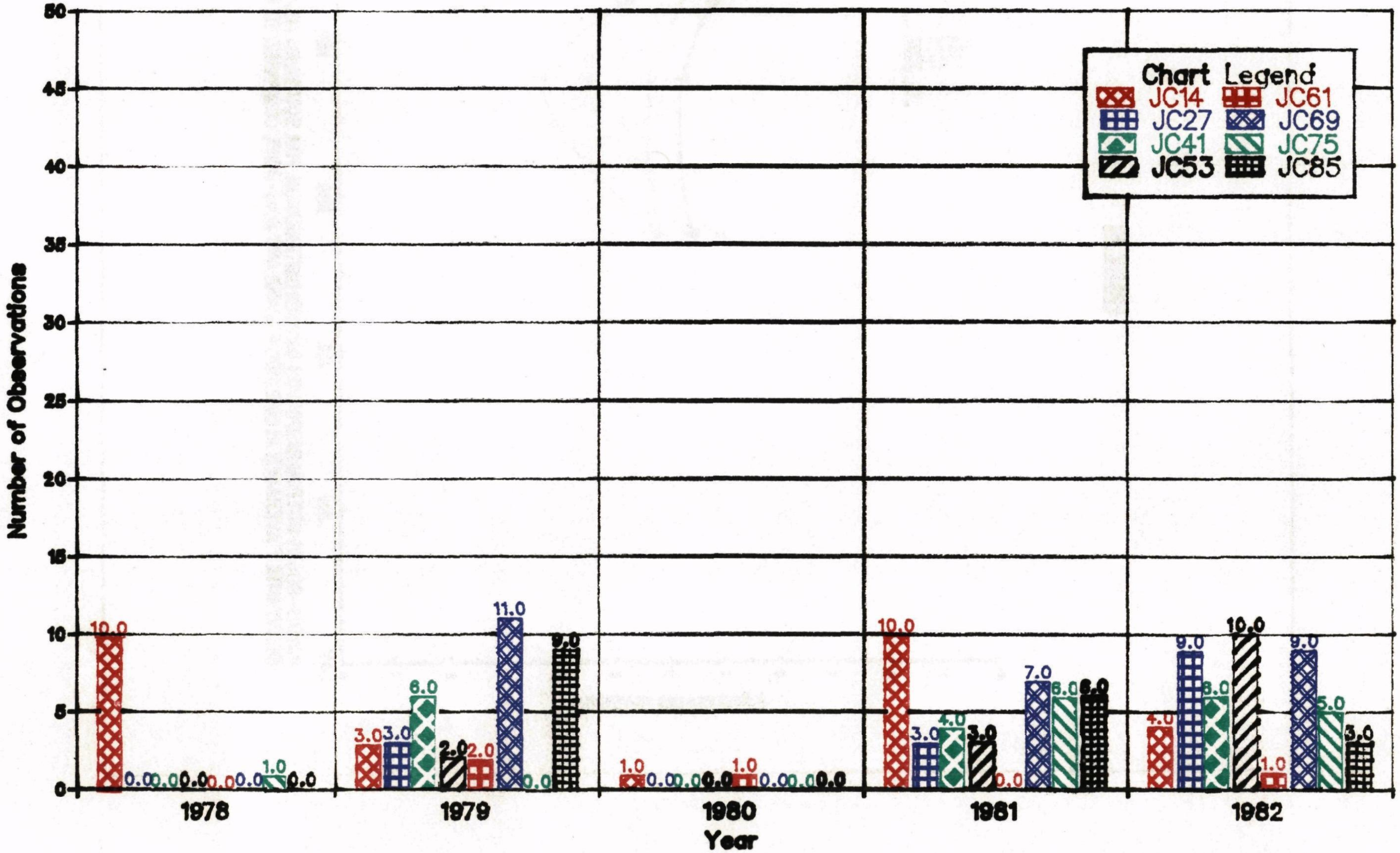
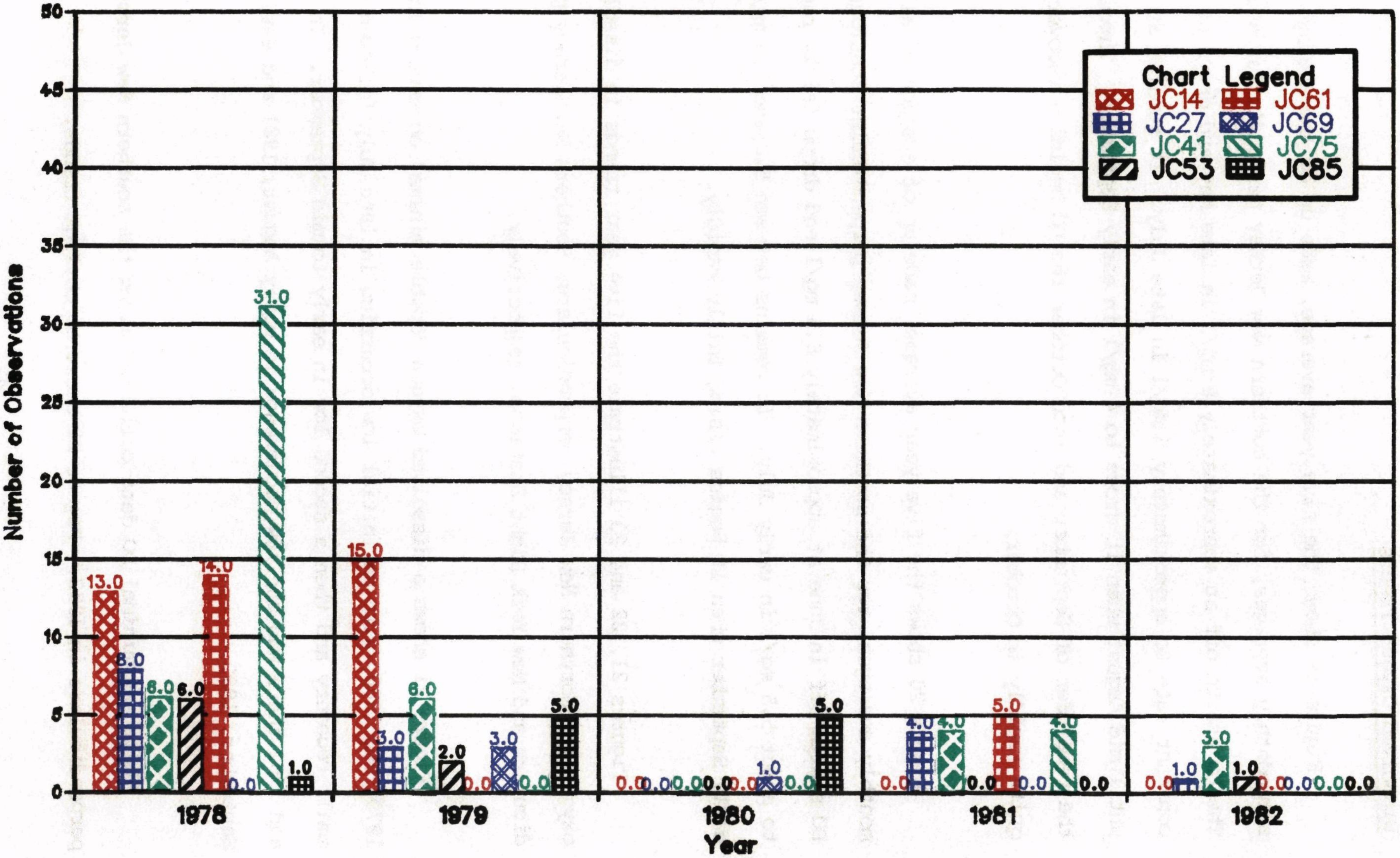


FIGURE 18 - **Dissolved Oxygen Concentrations**
Below 4 mg/l
New Jersey Coast
September



Dissolved Oxygen Trends

Figure 19 shows the five year average, made up of the average of all semimonthly averages, for the northern New Jersey perpendicular stations. The DO starts off at approximately 8 mg/l in late May and drops at a fairly constant rate to approximately 5 mg/l in late July. It remains at 5 mg/l until mid August when it drops to 4 mg/l in early September. Throughout the remainder of September and into October the DO begins a recovery, rising quite rapidly in October.

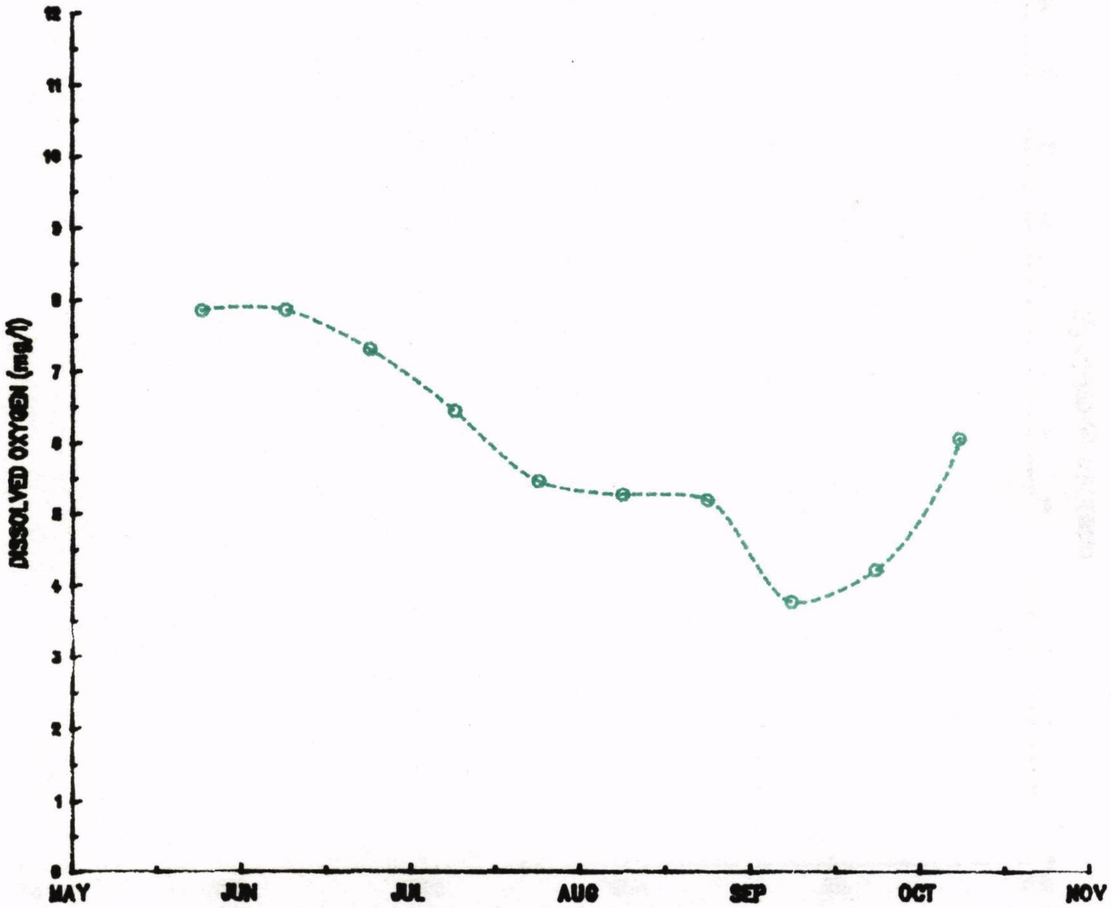
Figure 20 shows the five year average, made up of average of all semimonthly averages, for the southern New Jersey perpendicular stations. The DO starts off in June at approximately 8.5 mg/l and drops fairly rapidly to about 5.5 mg/l in early July. It remains between 5.0 and 5.5 mg/l until early September when it begins rising fairly rapidly.

Figures 21, 22 and 23 illustrate the five year trends in dissolved oxygen for Northern New Jersey perpendiculars, Southern New Jersey perpendiculars and New York Bight Stations, respectively.

Figure 21 shows a dissolved oxygen "double minima" occurring in 1978, 1979, and 1980, with an initial low occurring in late July followed by a small recovery and then a second low in early to mid September. In 1981 and 1982 there was one low occurrence in early August, 1981 and early September, 1982.

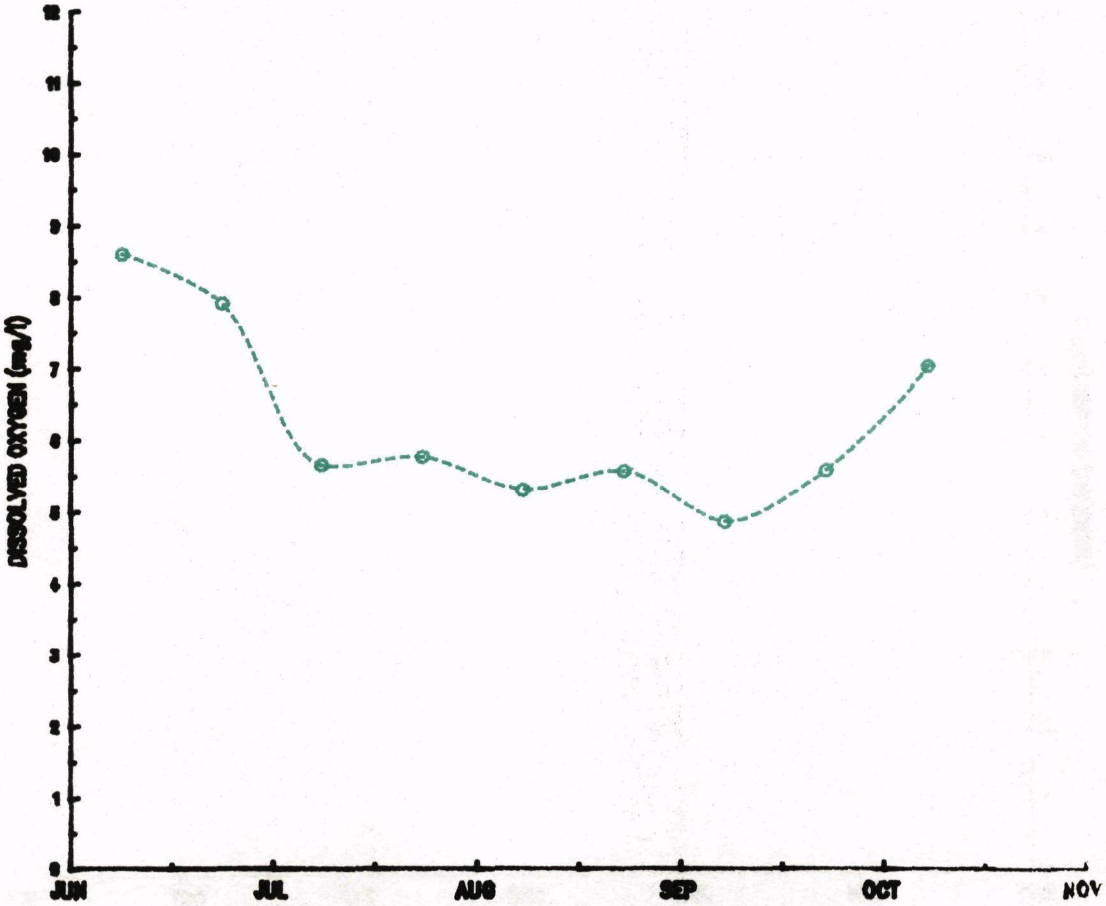
There was minimal DO data collected along the southern New Jersey perpendiculars in 1982. Figure 22 shows no obvious trends.

FIGURE 19



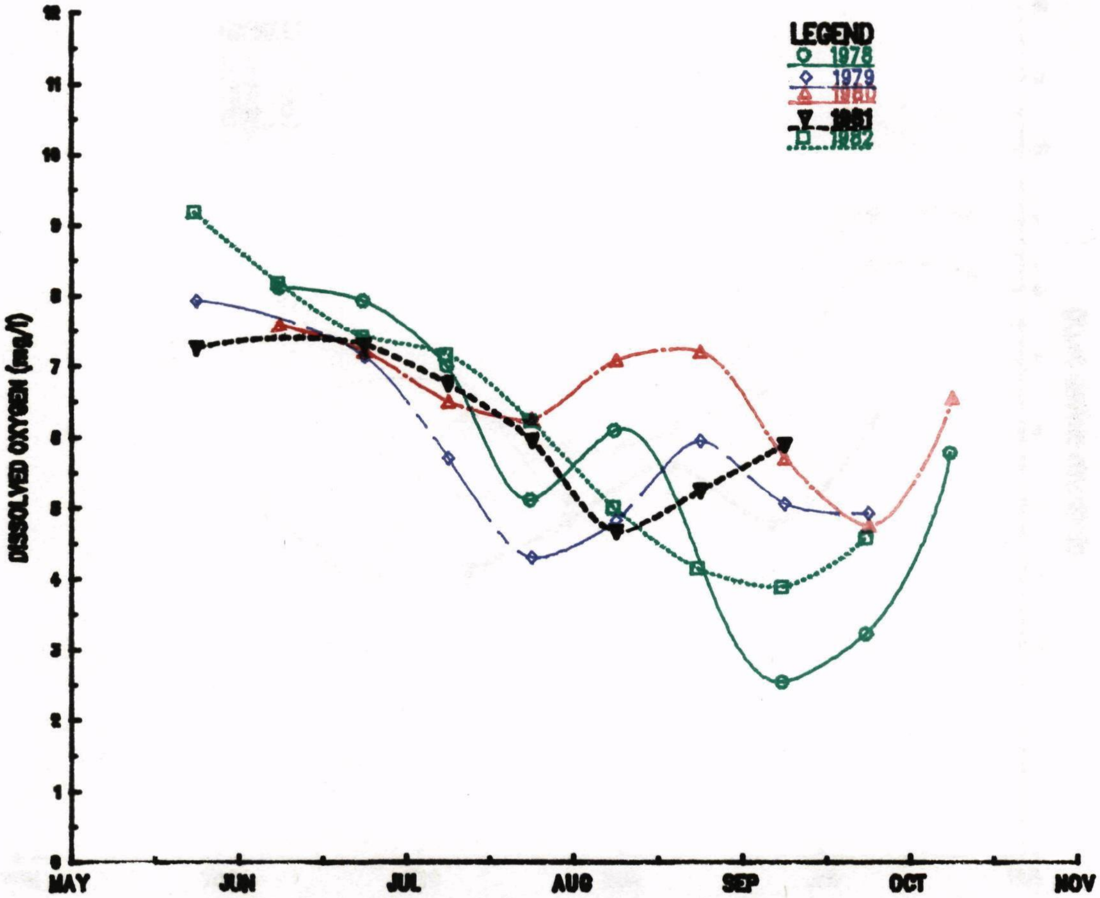
NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1978 TO 1982

FIGURE 20



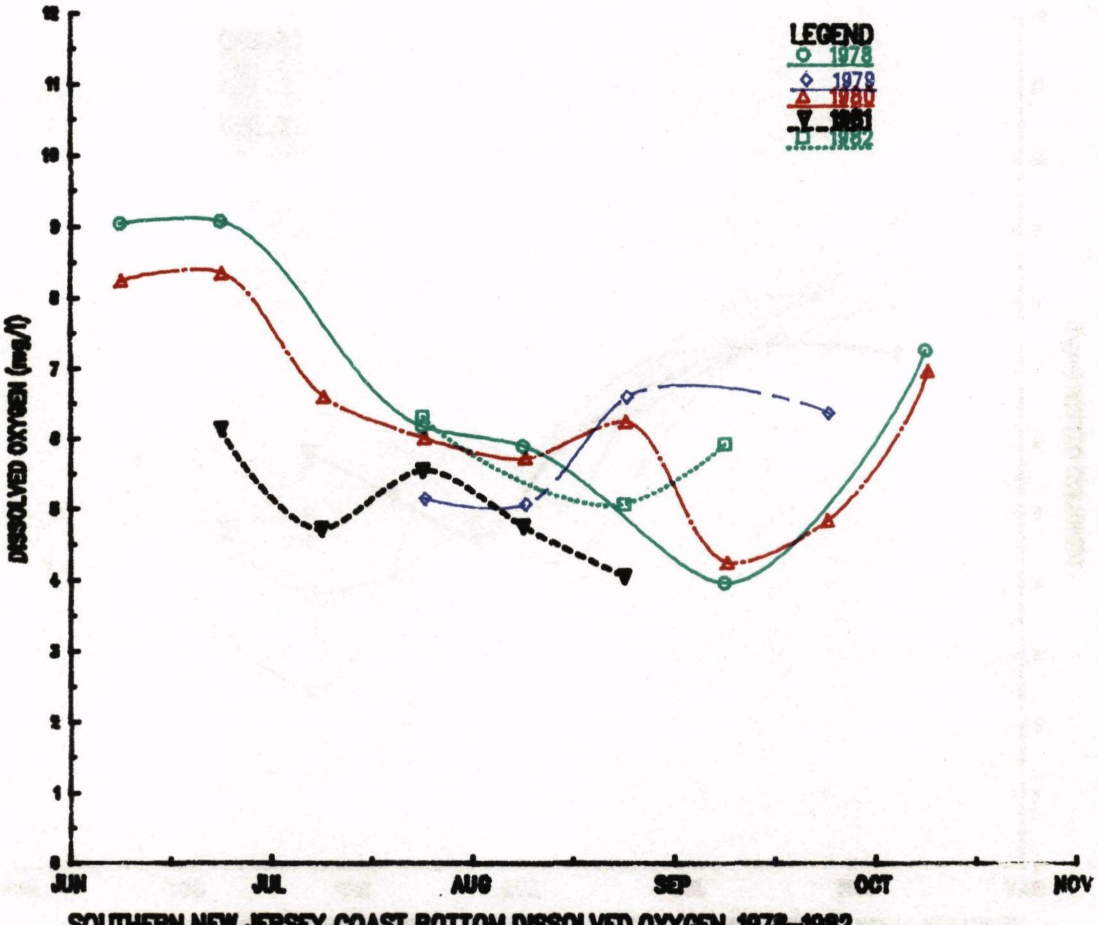
SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, FIVE YEAR AVERAGE OF THE INDIVIDUAL SEMIMONTHLY AVERAGES, 1978 TO 1982

FIGURE 21



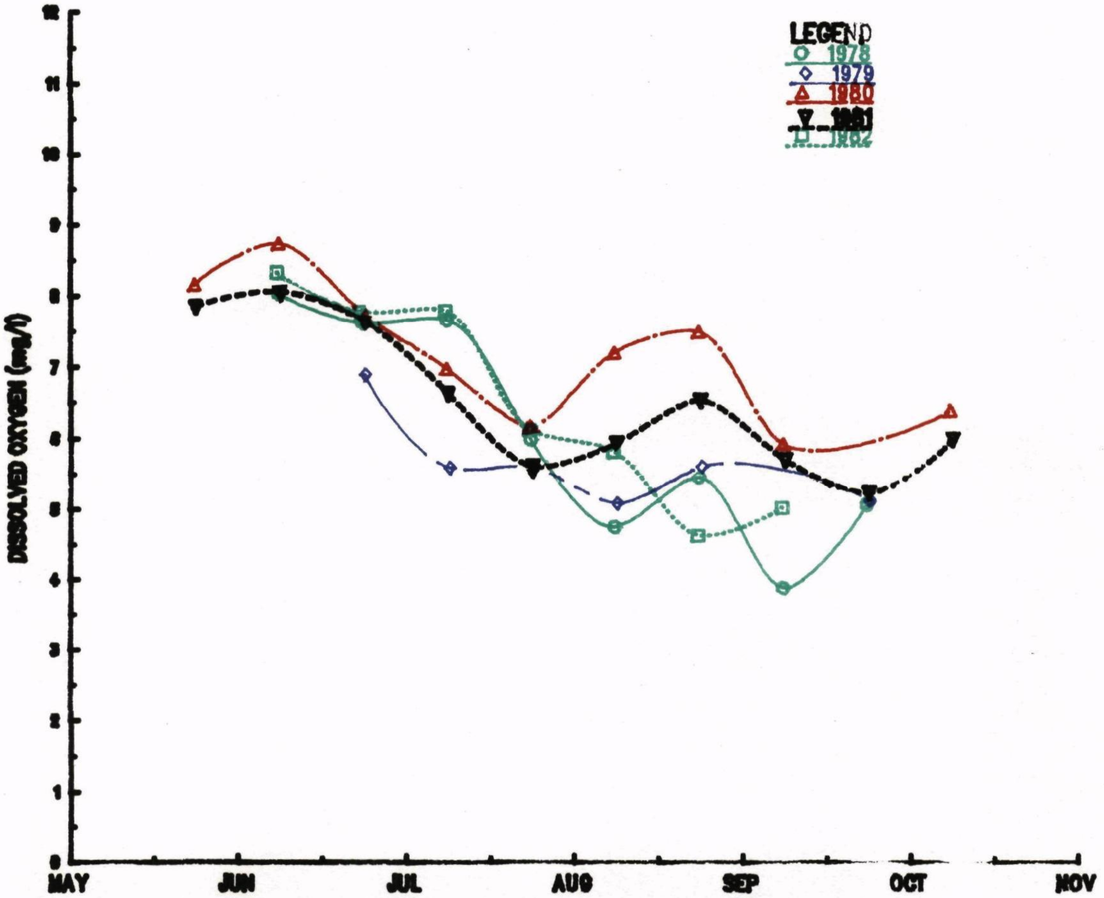
NORTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1978-1982 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC14-JC53 PERPENDICULAR STATIONS.

FIGURE 22



SOUTHERN NEW JERSEY COAST BOTTOM DISSOLVED OXYGEN, 1978–1982 COMPARISON. SEMIMONTHLY AVERAGES OF ALL JC61–JC85 PERPENDICULAR STATIONS.

FIGURE 23



NEW YORK BIGHT BOTTOM DISSOLVED OXYGEN, 1978–1982 COMPARISON.
SEMIMONTHLY AVERAGE OF ALL NEW YORK BIGHT STATIONS.

In Figure 23 a comparison of all New York Bight stations is shown for the years 1978-1982. The 1982 average dissolved oxygen values were lower in the second half of August than they had been for any August in the previous four years. The early September average was the second lowest September average for the five year period. The usual fall decline and recovery of dissolved oxygen values appears to have started earlier in 1982 than in previous years.

V. BACTERIOLOGICAL RESULTS

New Jersey

Table 9 presents a summary of the fecal coliform data collected along the coast of New Jersey between June 3, 1982 and November 8, 1982. The geometric mean for each station is plotted in Figure 24. The state standard for primary contact recreation along the New Jersey Coast is a geometric mean of 50 fecal coliforms/100 ml based on five or more samples analyzed within a 30 day period. Due to the low values found and the relatively small number of samples collected, only one geometric mean was calculated for each station over the entire summer. The highest geometric mean, 8.5, is at station JC 75. JC 93 and 95 had geometric means of 6.9. JC 93 had the highest geometric mean during the last three years. JC 75 is located at Atlantic City and near a sewage treatment effluent which may account for the elevated geometric mean. Figure 24 clearly shows that the New Jersey coastal stations are well below the bacteriological standard. Based on this limited fecal coliform data, New Jersey coastal waters have excellent water quality.

Throughout the summer sampling period, a total of 260 samples were collected for fecal coliform analyses along the New Jersey Coast. Of the 320 samples, six or approximately two percent were above 50 fecal coliforms/ 100 ml. These samples were:

Station	Date Sampled	Fecal Coliform/100ml
JC 11	8/03/82	1,200
JC 21	6/03/82	68
JC 37	6/30/82	56
JC 57	8/17/82	73
JC 75	11/05/82	51
JC 93	11/05/82	54

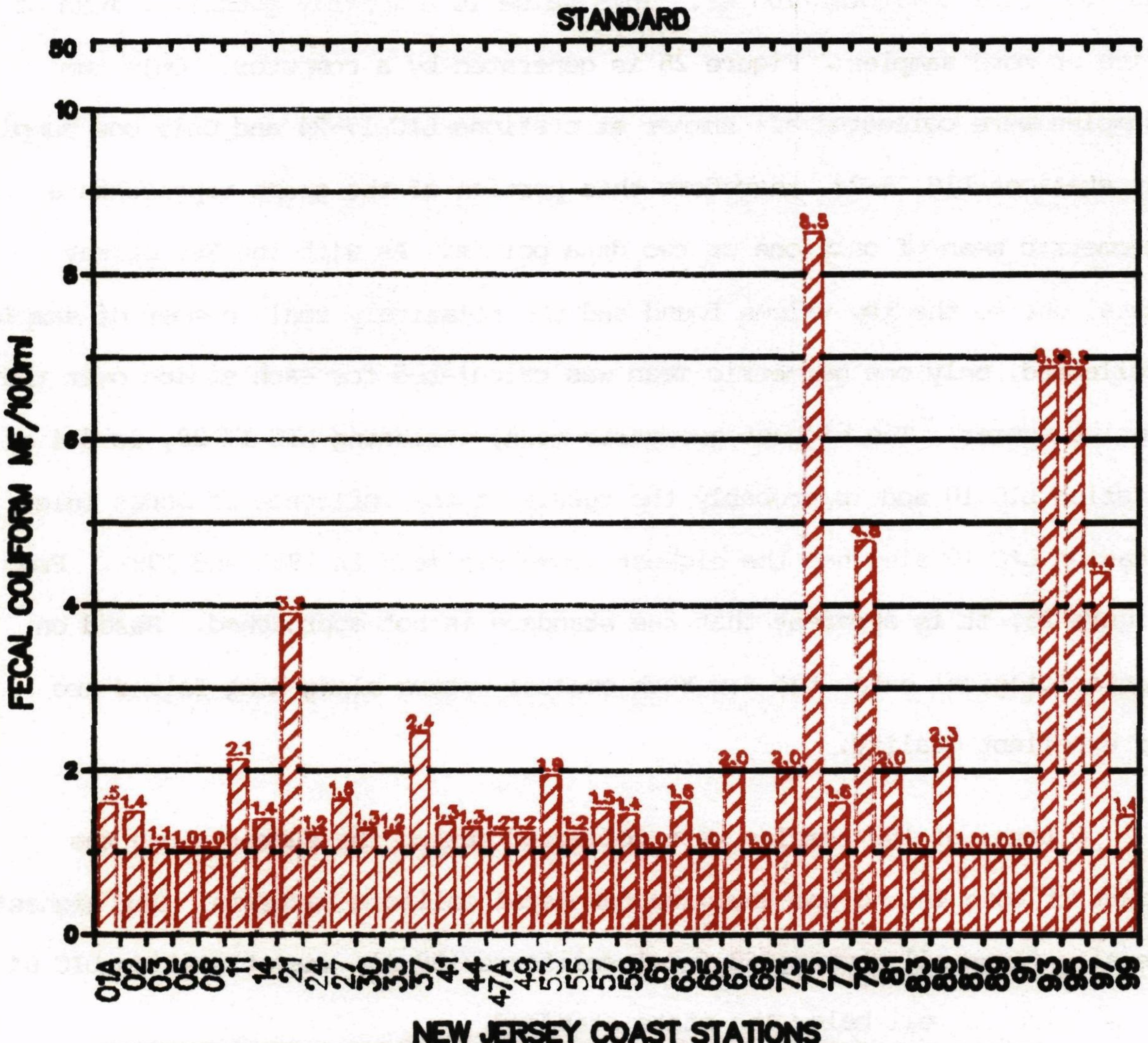
The causes for the elevated densities at stations JC 11, JC 21, JC 37 and JC 57 are unknown. The cause of the high value at JC 75 is probably poorly treated sewage from the Atlantic City Sewage Treatment Plant. The cause of the elevated value at JC 93 is probably storm sewer discharge.

TABLE 9

Summary of bacteriological data collected along the New Jersey coast June 3, 1982 through November 8, 1982

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean Fecal Coliform/100 ml
JC01A	14	11	1.5
JC02	14	27	1.4
JC03	14	2	1.1
JC05	13	1	1.0
JC08	13	1	1.0
JC11	13	1,200	2.1
JC14	13	14	1.4
JC21	13	68	3.9
JC24	13	11	1.2
JC27	13	12	1.6
JC30	13	20	1.3
JC33	13	14	1.2
JC37	13	56	2.4
JC41	13	11	1.3
JC44	13	12	1.3
JC47A	13	6	1.2
JC49	13	6	1.2
JC53	13	18	1.9
JC55	12	9	1.2
JC57	13	73	1.5
JC59	3	3	1.4
JC61	3	1	1.0
JC63	3	4	1.6
JC65	3	1	1.0
JC67	3	8	2.0
JC69	3	0	1.0
JC73	2	4	2.0
JC75	3	51	8.5
JC77	3	4	1.6
JC79	3	27	4.8
JC81	3	8	2.0
JC83	3	1	1.0
JC85	3	12	2.3
JC87	3	1	1.0
JC89	2	1	1.0
JC91	3	0	1.0
JC93	3	54	6.9
JC95	3	36	6.9
JC97	3	14	4.4
JC99	3	3	1.4

FIGURE 24



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF NEW JERSEY, JUN 3, 1982 TO NOV 8, 1982.
(ACTUAL VALUES PRINTED ABOVE BARS)

Long Island

Table 10 presents a summary of the fecal coliform data collected along the coast of Long Island from June 3, 1982 through September 14, 1982. The geometric mean for each station is plotted in Figure 25. The 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. Figure 25 is generated by a computor. Only two samples were collected all summer at stations LIC 17-24 and only one sample at stations LIC 25-28, therefore this portion of the graph represents a geometric mean of only one or two data points. 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 staion over the entire summer. The highest geometric mean, excluding LIC 17-28, is 3.4 at station LIC 10 and is probably the result of the influence of Jones Inlet. Station LIC 10 also had the highest geometric mean in 1980 and 1981. From Figure 25, it is apparent that the standard is not approached. Based on bacteriological data, the New York coastal waters along Long Island are of excellent quality.

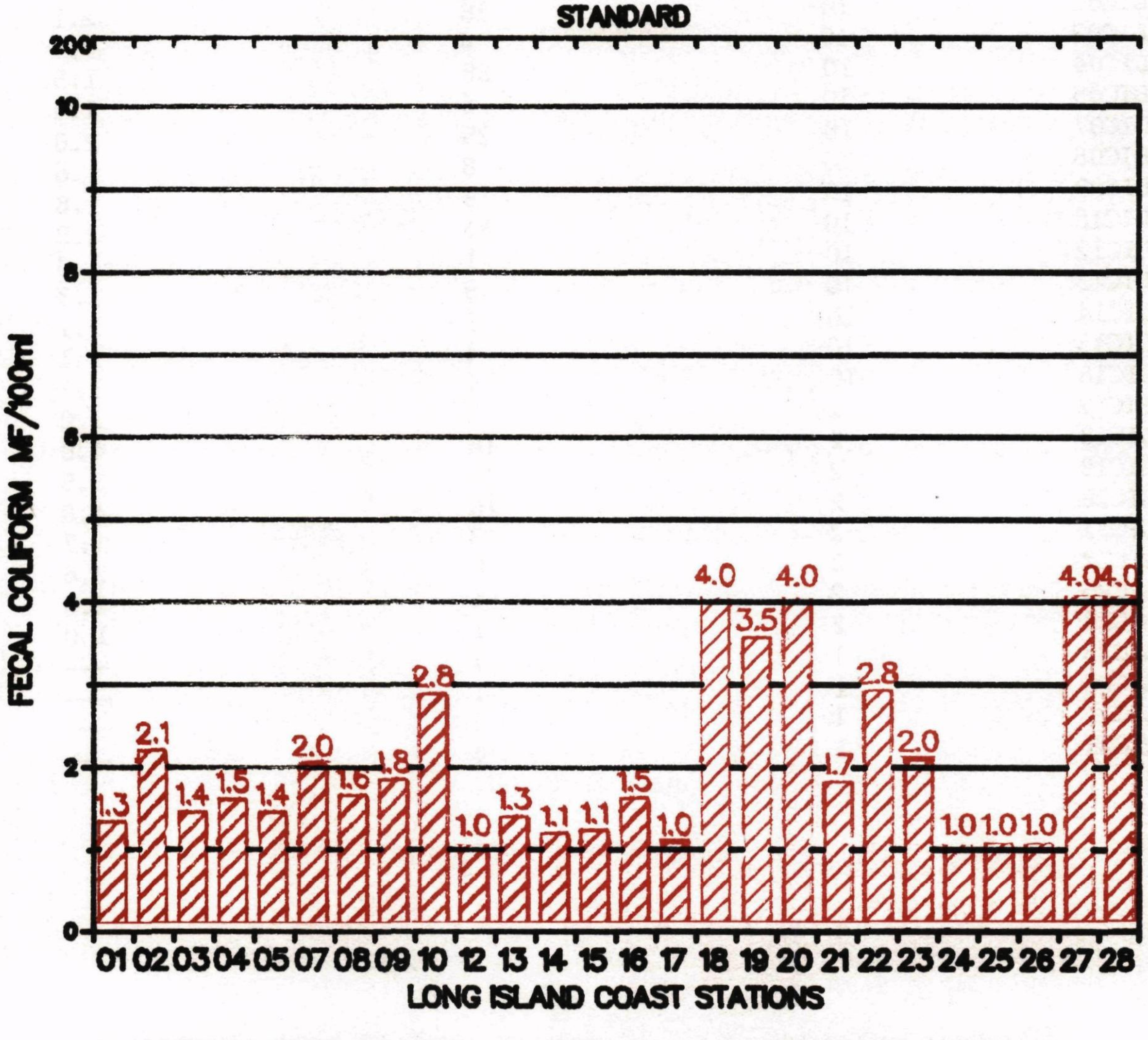
A total of 160 samples were collected during the summer along the coast of Long Island and analyzed for fecal coliform bacteria. The highest density found all summer, 68 fecal coliforms/100 ml, was at station LIC 04. This value is well below the state standard.

TABLE 10

Summary of bacteriological data collected along the coast of Long Island June 3, 1982 through September 14, 1982

Station	Number of Samples Collected	Maximum Value Fecal Coliform/100 ml	Geometric Mean Fecal Coliform/100 ml
LIC01	10	5	1.3
LIC02	10	18	2.1
LIC03	10	4	1.4
LIC04	10	68	1.5
LIC05	10	6	1.4
LIC07	10	25	2.0
LIC08	10	8	1.6
LIC09	10	8	1.8
LIC10	10	46	2.8
LIC12	10	1	1.0
LIC13	10	8	1.3
LIC14	10	3	1.1
LIC15	10	4	1.1
LIC16	10	4	1.5
LIC17	2	1	1.0
LIC18	2	16	4.0
LIC19	2	12	3.5
LIC20	2	16	4.0
LIC21	2	3	1.7
LIC22	2	8	2.8
LIC23	2	4	2.0
LIC24	2	1	1.0
LIC25	1	1	---
LIC26	1	1	---
LIC27	1	4	---
LIC28	1	4	---

FIGURE 25



GEOMETRIC MEANS OF FECAL COLIFORM DATA COLLECTION ALONG THE COAST OF LONG ISLAND, JUN 3, 1982 TO SEP 14, 1982.
(ACTUAL VALUES PRINTED ABOVE BARS)

New York Bight Apex

During the summer of 1982 a total of 190 samples were collected in the inner New York Bight for fecal coliform analysis. The stations sampled were the 20 inner NYB series stations, the LIC 09 and LIC 14 perpendicular stations, and the JC 14 and JC 27 perpendicular stations. Of the 190 samples collected, four had fecal coliform densities in excess of 50 fecal coliforms/100 ml. This represents 2.1 percent of the samples. There is no fecal coliform standard for the New York Bight Apex waters. The value of 50 fecal coliforms/100 ml was chosen for use in comparison with previous years. In 1978, 1979, 1980 and 1981 the percentage of samples having counts above 50/100 ml was 3.3, 2.3, 0.4 and 0.7 respectively. The four high values found this past summer were:

Station	Date Collected	Sample Depth (feet)	Fecal Coliform 100ml of sample
NYB 26	7/21/82	076	75
NYB 32	7/21/82	002	88
NYB 32	7/21/82	043	59
NYB 45	8/04/82	088	56

The elevated values at stations NYB 26 and NYB 45 maybe due to recent disposal of sewage sludge in the sewage sludge dump site. Station NYB-32 is under the direct influence of flow from the N.Y. Harbor and Raritan Bay estuary, both of which frequently exhibit elevated fecal coliform densities.

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

VI. NEW YORK BIGHT HEAVY METALS

Heavy metals data for the New York Bight Apex stations sampled during the summer of 1982 are summarized in Table 11. The two values listed for each station are the maximum and minimum values obtained from deep samples of the water column. The samples were collected from the EPA helicopter during the Sample Collection Program for New York Bight Apex stations. The sampling method is described in that section.

Results of heavy metal analysis showed small variations of concentrations within perpendiculars. However, statistical analysis (ANOVA) showed no significant patterns of variations between perpendiculars and specific locations such as dump sites.

TABLE 11 - Heavy metal concentrations in the water column at the New York Bight Apex stations, all samples were collected 1 meter from the bottom

New York Bight Stations

Parameter	20	21	22	23	24	25	26	27	32	33
Arsenic	33-1K	47-2K	59-0.9K	24-0.9K	23-0.9K	25-0.9K	28-1K	26-0.9K	36-0.9K	39-0.9K
Beryllium	3K-0.4K	3K-0.4K	4K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	4K-0.4K	6-0.4K
Cadmium	13-2K	3K-1K	3K-1K	3K-1K	3K-2K	8-1K	3K-1K	3K-1K	3K-1K	3K-1K
Chromium	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	42-3K	10K-3K	10K-4K	10K-3K	10K-3K
Copper	56-22	52-19	45-21	40-17	49-13	164-18	51-16	65-16	46-16	29-11
Lead	475-10K	500-10K	110-10K	110-10K	110-10K	130-10K	110-10K	110-10K	480-10K	510-10K
Thallium	98-3.2K	20-2K	18-3.3	21-3.4	23-4.3	23-4.0	22-3.8	28-4.2	66-1K	52-0.4K
Nickel	10K-8K	20-8K	10K-7K	10K-7K	10K-7K	10K-8K	10K-8K	10K-8K	10K-8K	10K-8K
Silver	3K-2K	4K-2K	4K-2K	4K-2K	4K-2K	4K-2K	4K-2K	4K-2K	3K-2K	3K-2K
Zinc	200-38	145-38	120-40	120-33	94-36	350-37	70-37	95-25	68-45	58-40
Antimony	20-10K	11-10K	10-6.9	10-4.0	10-10	10-6.0	10-9.6	10-5.6	20-7.0	20-9.7
Selenium	28-0.7K	57-1K	29-1K	32-0.9K	18-1K	51-1K	47-0.7K	52-0.7K	51-3.7	54-3.3
Mercury	0.73-0.35	0.82 0.2K	0.35-0.2K	0.52-0.2K	0.30-0.2K	0.73-0.2K	0.59-0.2K	0.51-0.2K	0.47-0.2K	0.59-0.2K

K = less than

TABLE 11 - Heavy metal concentrations in the water column at the New York Bight Apex stations, all samples were collected 1 meter from the bottom

Parameter	New York Bight Stations									
	34	35	40	41	42	43	44	45	46	47
Arsenic	51-0.9K	34-0.9K	2-0.9K	3-0.9K	5-0.9K	2-0.9K	5.4-0.9K	6.3-0.9K	7.3-0.9K	15-0.9K
Beryllium	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K	3K-0.4K
Cadmium	3K-1K	3K-1K	3K-1K	3K-1K	3K-1K	3K-2K	3K-1K	3K-1K	8-2K	3K-1K
Chromium	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K	10K-3K
Copper	16-12	16-14	53-14	26-7.9	27-2	28-12	24-5.8	23-7.9	27-5.8	23-7.9
Lead	490-10K	520-10K	82-10K	97-10K	94-10K	92-10K	88-10K	92-10K	96-10K	99-10K
Thallium	40-0.4K	51-1K	31-0.4K	24-0.4K	34-0.4K	15-0.4K	33-0.4K	43-0.4K	46-0.4K	31-0.8K
Nickel	10K-8K	10K-8K	10K-7K	10K-7K	10K-7K	10K-9K	10K-8K	10K-7K	10K-7K	10K-7K
Silver	3K-2K	3K-2K	4K-2K	4K-2K	4K-2K	4K-2K	4K-2K	5.0-2K	26-2K	4K-2K
Zinc	52-20	70-32	270-29	95-26	160-21	150-25	95-34	82-20	100-37	88-44
Antimony	10-5.2	20-6.3	12-10.0	20-6.4	10-3.0	10-0.9	10-0.8	10-2.0	150-1.0	10-3.0
Selenium	68-0.7K	28-0.7K	24-0.7K	23-0.7K	29-1K	16-1K	11-1K	19-1K	16-1K	19-1K
Mercury	0.59-0.30	0.34-0.2K	1.30-0.2K	0.57-0.2K	0.64-0.2K	0.90-0.2K	0.90-0.2K	0.62-0.2K	2.00-0.2K	0.45-0.2K

K = less than

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APPENDIX A

Summary of Phytoplankton Dynamics and Bloom Incidence In New Jersey Coastal Waters 1982

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

Introduction

This report summarizes the results of the red tide monitoring program for the summer of 1982. This program is conducted in cooperation with the USEPA, Region II, Surveillance and Analysis Division as part of the New York Bight Water Quality Monitoring program. We monitor the development of blooms and similar events, with the common goal to assess the effects on our valuable fishery and recreational resources. Weekly news releases regarding beach conditions are given to the DEP press office.

The history of this program is given in detail in previous reports. The National Marine Fisheries Service (Sandy Hook unit), formerly in an active role, presently cooperates in an advisory capacity. An Interagency Committee on Phytoplankton Blooms in New York/New Jersey Waters maintains a protocol of communication in the event of serious blooms. This includes the Long Island and New Jersey county health departments as well as the State and Federal agencies. Although our red tides are not the poisonous varieties such as in New England or Florida, they are occasionally toxic to humans or lethal to fish.

Field collections are made by members of the E&S Division helicopter unit as part of their routine monitoring. Weekly phytoplankton aliquot samples are taken along the New Jersey northern estuarine and coastal sector, where red tides tend to recur. Sampling locations correspond with the nine EPA stations marked with an asterisk in Figure 1. Supplemental samples may be taken wherever blooms are sighted. No routine sampling is done south of Island Beach, since major blooms rarely occur in this sector of the N.J. coast. During periods when the helicopter is in maintenance, we continue surveillance in critical areas with the help of the other cooperating agencies. Phytoplankton analysis is performed in the DEP lab. Methods are based on those used in the original DEP/NMFS study. Nutrient analysis is done by the EPA (Edison, N.J.) laboratory.

Results

Phytoplankton species succession and relative abundance (Table 1) display a pattern typical of that seen in recent years. Certain differences are noted over the previous year.

The diatom, Asterionella glacialis, is not seen in the same levels of abundance it attained in 1981. It is possible that spring diatom flowerings were missed, since sampling did not commence until June in 1982.

Abundance of Olisthodiscus luteus, the phytoflagellate responsible for most of our recent red tides, peaked in July where it had peaked in June the previous year. An exception here is the Raritan Bay station (RB32) where blooms occurred in June and in August of 1982 (see Table 1). Excessive phytoplankton activity was observed in the vicinity of the Monmouth Beach station (JC11), possibly enhanced by a broken sewerage outfall there. These blooms occurred in July and included other sub-dominant species such as Prorocentrum spp. and Katodinium rotundatum (both responsible for some red tides) as well as O. luteus.

The minute but ubiquitous chlorophytes bloomed somewhat earlier than in previous years, occurring simultaneously with the phytoflagellate blooms in the estuary and at JC11. Diatoms regained prominence earlier than in previous years; a late summer bloom including Chaetoceros sp. and Skeletonema costatum occurred in August simultaneously with a secondary peak of Nannochloris atomus (Table 1).

Cell densities as well as numbers of species generally decreased south from JC11. This is the normal situation, as proximity to the New York Bight apex decreases.

Nutrient parameters include dissolved inorganic forms of nitrogen (Table II) which is generally considered limiting for algal growth in marine environments. Values for 1982 are highest in June in Raritan Bay, with some secondary peaks in the general Sandy Hook vicinity (bay and ocean stations). Other secondary peaks are seen in July, while bay stations had substantial concentrations through summer. Decomposition in the samples prior to analysis may have elevated the NH_3+NH_4 levels over the respective values at the times of sampling.

Discussion

Background information and references on methodologies, species abundance and succession are given in previous reports.

Following spring diatom flowerings, phytoflagellate abundance usually peaks initially (in June) in the Raritan/ Sandy Hook estuary. This also follows spring nutrient maxima from the Raritan River effluent. In conformance with area hydrography, blooms which originate in the bay wash out to a mile or three off Sandy Hook; then, due to Coriolis forces, curl to the right, inward toward the beach between Sea Bright and Long Branch.

The Hudson River normally attains peak discharge somewhat later in the spring than the Raritan, its plume extending southward along the New Jersey shore to about northern Ocean County. This enhances bloom development in the ocean following that in Raritan/Sandy Hook Bay. Red tides tend to concentrate in patches near the beach, especially in northern Monmouth County. Localized outfalls such as from inlets, storm drains and sewage treatment plants probably serve to sustain the blooms in this section.

Previous studies have shown that algae can utilize nutrient concentrations as low as 0.05ppm NO_3 and 0.01ppm NH_3, therefore, our results show substantial amounts, especially NH_3, in Raritan Bay.

In 1982, the initial bloom was sighted in early June in Raritan Bay and southward one-quarter mile off the beach to Seaside Park. Our analysis confirmed O. luteus as the dominant species. In mid-July, another red tide was sighted in Raritan Bay and simultaneously in the vicinity of Monmouth Beach. Our analysis confirmed several species prevalent in this case (see Table 1) with O.luteus again dominant in moderate bloom densities. A late summer outbreak was reported in Raritan Bay in August, consisting of two patches of different colors. Our results indicated Peridinium trochoideum (a potential red tide species) in one and Chaetoceros sp. and Skeletonema costatum (diatoms) in the other. A few sporadic outbreaks in various locales (not all confirmed) were reported independently of the routine monitoring.

Events other than red tides were reported as far south as Cape May. Dirty water containing decomposing organic material or algae (possibly an upwelling effect of spring tides) was reported during early summer at Sandy Hook to Raritan Bay, Avon to Lavallette, Little Egg Harbor bay, Longport and Cape May. Around the same time localized fishkills occurred in Sandy Hook Bay and at Toms River, and oil-like slicks(possibly from bunker)

Discussion (cont.)

were observed at Sea Bright and in Little Egg and Great Egg Harbor Inlets. Isolated algae blooms were reported in late summer in Shark River, Barnegat Bay, and the Atlantic City and Ocean City surf. The latter, coloring the water green, appeared to be a dinoflagellate (*Gymnodinium splendens*)previously recorded from the area. Earlier, at North Long Branch, three lifeguards were reportedly on antibiotics because of sewage washing onto the beach from a nearby outfall.

We are fortunate in that our red tides, *per se*, are not the toxic variety such as found in New England waters. Although *Gonyaulax tamarensis* (causative agent of paralytic shellfish poisoning) has been found as close as western Long Island, PSP is thus far not significant in Long Island or New Jersey waters. In the course of our red tide study (since 1975) *G. tamarensis* has not been detected, even in low numbers, in New Jersey waters. We are conducting a separate ongoing survey, however, to detect its possible presence in N.J. estuarine waters, either as vegetative cells or benthic cysts, with negative results to date.

Conclusion and Recommendations

Red tides have continued to occur in New Jersey northern estuarine and coastal waters, where nutrients for their development are in ample supply. Although there have been no extensive blooms such as affected the Monmouth County shore in 1968-72, or the New York Bight in 1976, several more sporadic events have taken place in recent summers. In 1982, while the main bloom pattern normally conformed to the hydrography of the area, more phytoplankton activity than in recent years occurred in certain segments of the northern Monmouth County coastline. Sewerage outfalls in those vicinities appeared to have a sustaining effect on the blooms. Other events, which occurred at several locales between Cape May and Sandy Hook, appeared to be more closely related to phenomena other than red tides.

Continuation of the ongoing monitoring efforts is needed with more sampling in early season to monitor nutrients and bloom development. More intensive sampling in the vicinity of certain outfalls, especially in Monmouth County, may emphasize that these discharges should not be in such close proximity to public beach bathing areas.

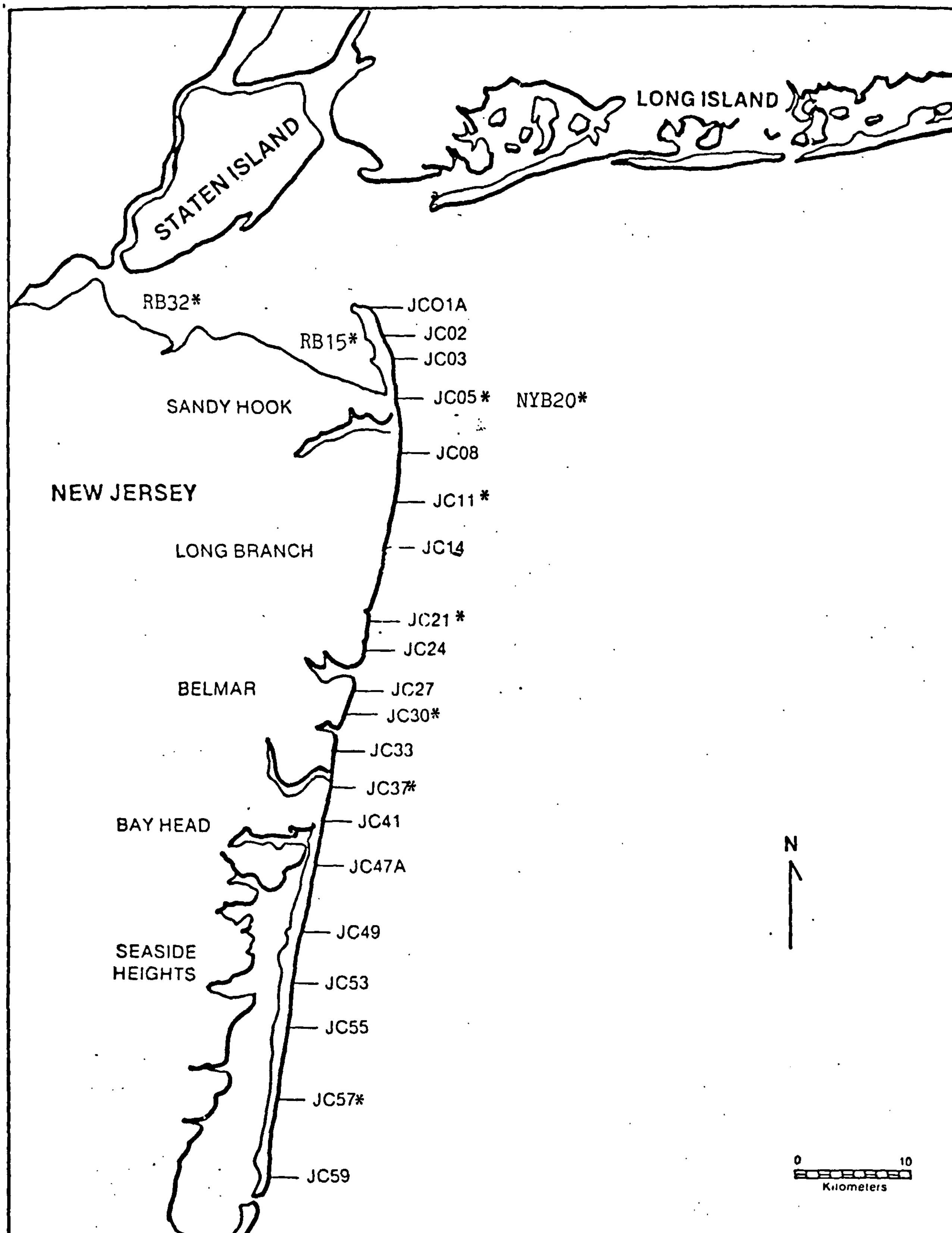

FIGURE 1
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

Asterisks (*) designate the stations where phytoplankton samples are collected.

TABLE I.

Major phytoplankton species found in the 1982 survey. Those seasonally dominant (+) often attained cell densities of 1000/ml (10,000 for chlorophytes) or greater. Those abundant (-) appeared frequently but in lower numbers. Visibility of a bloom is related to cell size and density. Blooms (*) occurred where concentrations at some observed point approached 10,000 cells/ml (100,000 for chlorophytes).

SEASON	SPECIES	Sampling Location							
		RB 15	RB 32	JC 05	NYB 20	JC 11	JC 21	JC 30	JC 37
	diatoms								
Winter	Asterionella glacialis	+	+	+		+			
Spring	Skeletonema costatum	—	—						
Spring	A. glacialis		—	+	+				
Summer	S. costatum					—			
	Thalassiosira sp.	+		—	—	—			—
	dinoflagellates								
	Prorocentrum minimum	—		—		+	+		
	Peridinium trochoideum				—				
	Katodinium rotundatum	+	—	+	—	+	—		
	other phytoflagellates								
	Calycomonas sp.	—	—	+	+	—	—	—	—
	Olisthodiscus luteus	+	*	+	+	*	+	—	—
	Pyramimonas sp.	+	—	—	—	+	—		—
	Euglena/Eutreptia sp.	—	—	+	+	+	—	—	—
	Chroomonas sp.	+	+	+	+	—			
	chlorophytes								
	Nannochloris atomus	*	*	+	—	*	+	+	+
	Chlorella sp.					—	—		—
Summer	N. atomus	+	*	*	+	+			—
	dinoflagellates						—	—	
	Prorocentrum micans			—	—	+	—		
	P. minimum			—		—	—	—	
	Peridinium trochoideum		+	—		—			
	Gymnodinium sp.						+	—	
	other phytoflagellates								
	Calycomonas sp.	—	—	+	—	+			
	Olisthodiscus luteus		*	+	—	—			
	Pyramimonas sp.	—					—		
	Euglena/Eutreptia sp.	—	—			—			
	Cryptomonas acuta		+		—				
	Chrysochromulina sp.			—		—			
	diatoms								
	Asterionella glacialis								
	Leptocylindrus sp.								
Summer	A. glacialis	—	+	—	+	—			
Autumn	Leptocylindrus sp.			—				+	
	Thalassiosira sp.	+	—	+	—	—	—		—
	Chaetoceros sp.	*	*	*	+	*			
	S. costatum	*	*	*	—	*	—	—	—

TABLE II.

Nutrient Data for the 1982 Phytoplankton Survey.

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

Date		Sampling Location								
		RB32	RB15	NYB20	JC05	JC11	JC21	JC30	JC37	JC57
June	3	.77/.62	.23/.08	.10/.14	.10/.19	.15/.14	.08/.14	<.02/<.02	<.02/.03	.02/.03
	7	.64/.63	.27/.17	-	.24/.26	.25/.22	.17/.17	.14/.16	.13/.15	.06/.[illegible]
	17	-	.31/.16	.06/.02	.08/.04	.07/.03	.08/.02	.07/.03	.06/.04	.08/.05
	22	.47/.43	.09/.18	.11/.03	.10/.13	.14/.03	.12/<.02	.14/<.02	.11/.03	.12/.[illegible]
	30	.65/.35	.15/.11	.09/.10	.08/.11	.10/.11	.08/.05	/06/.06	.10/.08	.07/.06
July	8	.33/.30	.07/.16	.06/.05	.06/.13	.04/.12	.09/.08	.09/.06	.07/.04	.06/.[illegible]
	15	.46/.39	.66/.19	.64/.15	.79/.23	.80/.19	.77/.17	.91/.18	.85/.18	.91/.19
	17	.16/.05	.85/.32	.76/.16	.74/.18	.67/.17	.80/.17	.71/.15	.49/.10	.52/.[illegible]
	21	.62/.28	.16/.20	.71/.20	.65/.19	.92/.18	.70/.14	.82/.19	.87/.19	.76/.21
	27	.75/.31	.80/.28	.73/.26	.68/.16	.59/.14	.88/.17	.71/.17	.75/.17	.74/.[illegible]
August	10	-	.20/.23	.62/.16	.68/.19	.75/.17	.71/.16	.78/.19	.65/.16	.75/.19
	24	.62/.47	.20/.27	.08/.07	1.8/.14	.07/.08	.23/.11	.05/.07	.11/.11	.12/.[illegible]

APPENDIX B

Bacteriological Report - 1982
Beach Monitoring - N.Y. Bight
1/12/83

Introduction

A study of the density* of fecal coliform (FC) organisms was conducted in 1982 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.

By using specific fecal indicators in water, one can make risk assessments related to swimming. Epidemiological studies have investigated 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, 1980).

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 indicators 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. Later work done 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 approx. 400/100 ml. A safety factor was included which established the 200/100 ml limit, providing for a quality of water which should be better than 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 200/100 ml or thereabout.

Fecal Coliform Indicator Bacteria

Fecal coliforms comprise all of the coliform bacteria that ferment lactose at 44.5 $\pm$ 2°C. This group according to traditional thinking, more accurately reflects the presence of fecal discharges from warm-blooded animals. As indicators, the bacteria have the advantage of being less subject to regrowth in polluted waters. Their increased specificity to fecal sources made them the choice over other coliform organisms.

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

1. Standard Methods 15th ed., 909C (F.C.)
2. Microbiological Methods Manual EPA-600/8-78-017, Sect. C. p. 124.
3. Bergey's Manual of Determinative Bacteriology, 8th Ed., 1974, p. 290, members of the Enterobacteriaceae, p. 295 Escherichia coli.

Materials and Methods

Marine water samples were collected by helicopter on a weekly sampling schedule from June to September 1982. Samples were collected using a Kemmerer sampler, transferred to a 500 ml sterile wide-mouth plastic container, and then returned to the Region II Edison laboratory for analysis.

Fecal coliform determinations were conducted according to membrane filter (MF) methodology in Standard Methods, 15th edition, 1980 and Microbiological Methods for Monitoring the Environment, EPA 600/8-78-017.

Results and Discussion

Along the New Jersey Coast, fecal coliform (FC) densities greater than 50/100 ml were only observed at four stations (Table 1). The observations were made at JC-11 (Monmouth Beach), JC-21 (Asbury Park), JC-37 (Point Pleasant) and JC-57 (Island Beach State Park). For the majority of New Jersey control stations, low FC geometric means (GM) were observed (see Table 2). This profile is visually presented in the geometric mean values of FC densities in Figure 1. Fecal coliform densities along the Long Island coast were even more dilute. Fecal coliform densities greater than 50/100 ml occurred only once at station LIC-04 (Rockaway, B92 Road) (Table 3). Geometric mean F.C. densities were all less than five. (See Table 4 and Figure 2).

*Bacterial density in this study is referred to as the number of bacteria belonging to a specific indicator group per 100/ml of water.

The New York State standard for primary contact recreation waters states that the monthly geometric mean of 5 or more samples shall not exceed 200 fecal coliform/100 ml. Geometric mean values for all stations were two orders of magnitude less than this standard.

New York Bight

The distribution of fecal coliform densities >50/100 ml in the New York Bight is shown in (Table 5). The geometric mean densities of fecal coliforms found in the Bight are presented in (Table 6) Station NYB-26 is located in the center of the sewage sludge disposal site. Samples at this site were taken at a depth of 76 feet and had a fecal coliform count of 75. Station NYB-45 which is approximately 1 mile northwest from the sewage sludge site had a fecal coliform count of 56. Samples at this site were taken at a depth of 74 feet (Tables 5 & 6). The fecal coliform counts obtained at these stations are a likely result of deposition of sewage sludge at the sewage sludge dump site. Fecal coliform indicator organisms are sometimes more numerous in the sediments and off the bottom suggesting greater survival after sedimentation. (Van Donsel, et al, 1971.; Rittenburg et al, 1958). The high counts observed at Station NYD-45, outside the dump site proper, may be attributed to movement of sewage sludge into the Christiensen Basin. Such movement has been suggested by Cabelli (1980) to explain the distribution of Clostridial species in the New York Bight apex.

NYB-32, which is close to the Ambrose Channel in the lower bay portion of N.Y. Harbor had fecal coliform counts of 88 and 59 at the shallow and deep depths, respectively (Table 5). The high density of coliforms in the sample taken at a shallow depth, two feet from the surface, further supports previous fecal coliform data collected along Coney Island and Staten Island which indicates patterns of sewage coming from the Upper N.Y. Harbor flowing in a southeasterly direction.

Data presented in this report affirms what we have consistently pointed out regarding flow patterns and fecal wastes coming from the Upper New York Harbor. Previous studies by the FWPCA also support these flow patterns (FWPCA, 1967).

<u>References</u>

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Table 1

BACTERIAL DENSITIES > 50/100ML
NEW JERSEY BEACHES
SUMMER 1982

OBS	STATION	BACTERIA	DATE	DENSITY
1	JC-11	FECAL COLI(M-FC)	08/03	1200
2	JC-21	FECAL COLI(M-FC)	06/03	68
3	JC-37	FECAL COLI(M-FC)	06/30	56
4	JC-57	FECAL COLI(M-FC)	08/17	73

Table 2

GEOMETRIC MEAN OF BACTERIAL DENSITIES
NEW JERSEY BEACHES
SUMMER 1982

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC-01	0.45497	0	9	12
2	JC-02	0.32007	0	6	12
3	JC-03	0.09587	0	2	12
4	JC-05	0.05946	0	1	12
5	JC-08	0.18921	0	1	12
6	JC-11	1.29739	0	1200	12
7	JC-14	0.34801	0	2	12
8	JC-21	3.32556	0	68	12
9	JC-24	0.30322	0	11	12
10	JC-27	0.91913	0	12	12
11	JC-30	0.36543	0	20	12
12	JC-33	0.25316	0	14	12
13	JC-37	2.23492	0	56	12
14	JC-41	0.75675	0	11	12
15	JC-44	0.35703	0	12	12
16	JC-47A	0.44663	0	6	12
17	JC-49	0.28880	0	6	12
18	JC-53	1.24002	0	18	12
19	JC-55	0.21153	0	9	12
20	JC-57	0.60672	0	73	12
21	JC-61	0.00000	0	0	2
22	JC-63	1.23607	0	4	2
23	JC-65	0.00000	0	0	2
24	JC-67	0.00000	0	0	2
25	JC-69	0.00000	0	0	2
26	JC-73	0.00000	0	0	2
27	JC-75	2.60555	0	12	2
28	JC-77	2.16228	1	4	2
29	JC-79	1.23607	0	4	2
30	JC-81	2.00000	0	8	2
31	JC-83	0.41421	0	1	2
32	JC-85	2.60555	0	12	2
33	JC-87	0.41421	0	1	2
34	JC-89	0.41421	0	1	2
35	JC-91	0.00000	0	0	2
36	JC-93	1.64575	0	6	2
37	JC-95	5.08276	0	36	2
38	JC-97	2.74166	1	6	2
39	JC-99	0.00000	0	0	2

Table 3

BACTERIAL DENSITIES > 50/100ML
LONG ISLAND BEACHES
SUMMER 1982

OBS	STATION	BACTERIA	DATE	DENSITY
1	LIC-04	FECAL COLI(M-FC)	07/20	68

Table 4

GEOMETRIC MEANS OF BACTERIAL DENSITIES
LONG ISLAND BEACHES
SUMMER 1982

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC-01	0.74261	0	24	11
2	LIC-02	1.90240	0	18	11
3	LIC-03	0.75287	0	4	11
4	LIC-04	0.77528	0	68	11
5	LIC-05	0.77761	0	6	11
6	LIC-07	0.90075	0	25	11
7	LIC-08	0.93697	0	8	11
8	LIC-09	0.93697	0	8	11
9	LIC-10	2.70900	0	46	11
10	LIC-12	0.28666	0	1	11
11	LIC-13	0.43711	0	8	11
12	LIC-14	0.13431	0	3	11
13	LIC-15	0.45094	0	4	11
14	LIC-16	1.11762	0	4	11
15	LIC-17	0.00000	0	0	2
16	LIC-18	3.12311	0	16	2
17	LIC-19	2.60555	0	12	2
18	LIC-20	3.12311	0	16	2
19	LIC-21	1.00000	0	3	2
20	LIC-22	2.00000	0	8	2
21	LIC-23	1.23607	0	4	2
22	LIC-24	0.00000	0	0	2
23	LIC-25	0.00000	0	0	1
24	LIC-26	1.00000	1	1	1
25	LIC-27	4.00000	4	4	1
26	LIC-28	4.00000	4	4	1

Table 5

BACTERIAL DENSITIES > 50/100ML
NEW YORK BIGHT STATIONS
SUMMER 1982

OBS	STATION	DEPTH	BACTERIA	DATE	DENSITY
1	NYB-26	D	FECAL COLI(M-FC)	07/21	75
2	NYB-32	S	FECAL COLI(M-FC)	07/21	88
3	NYB-32	D	FECAL COLI(M-FC)	07/21	59
4	NYB-45	D	FECAL COLI(M-FC)	08/04	56

Table 6

GEOMETRIC MEAN OF BACTERIAL DENSITIES
NEW YORK BIGHT STATIONS
SUMMER 1982

OBS	STATION	DEPTH	MEAN	MINIMUM	MAXIMUM	N
1	NYB-20	D	0.00000	0	0	6
2	NYB-20	S	0.66100	0	20	6
3	NYB-21	D	0.12246	0	1	6
4	NYB-21	S	0.12246	0	1	6
5	NYB-22	D	0.20094	0	2	6
6	NYB-22	S	0.30766	0	4	6
7	NYB-23	D	0.20094	0	2	6
8	NYB-23	S	0.12246	0	1	6
9	NYB-24	D	0.46780	0	4	6
10	NYB-24	S	0.12246	0	1	6
11	NYB-25	D	0.46780	0	4	6
12	NYB-25	S	0.00000	0	0	6
13	NYB-26	D	5.35900	0	75	6
14	NYB-26	S	0.00000	0	0	6
15	NYB-27	D	0.20094	0	2	6
16	NYB-27	S	0.00000	0	0	6
17	NYB-32	D	1.60517	0	59	5
18	NYB-32	S	1.81893	0	88	5
19	NYB-33	D	0.31951	0	1	5
20	NYB-33	S	0.14870	0	1	5
21	NYB-34	D	0.14870	0	1	5
22	NYB-34	S	0.00000	0	0	5
23	NYB-35	D	0.47577	0	6	5
24	NYB-35	S	0.00000	0	0	5
25	NYB-40	D	0.00000	0	0	6
26	NYB-40	S	0.00000	0	0	6
27	NYB-41	D	0.00000	0	0	6
28	NYB-41	S	0.00000	0	0	6
29	NYB-42	D	0.12246	0	1	6
30	NYB-42	S	0.00000	0	0	6
31	NYB-43	D	0.25992	0	1	6
32	NYB-43	S	0.00000	0	0	6
33	NYB-44	D	0.51309	0	5	6
34	NYB-44	S	0.00000	0	0	6
35	NYB-45	D	1.87947	0	56	6
36	NYB-45	S	0.00000	0	0	6
37	NYB-46	D	0.25992	0	3	6
38	NYB-46	S	0.00000	0	0	6
39	NYB-47	D	0.00000	0	0	6
40	NYB-47	S	0.00000	0	0	6

Figure 1

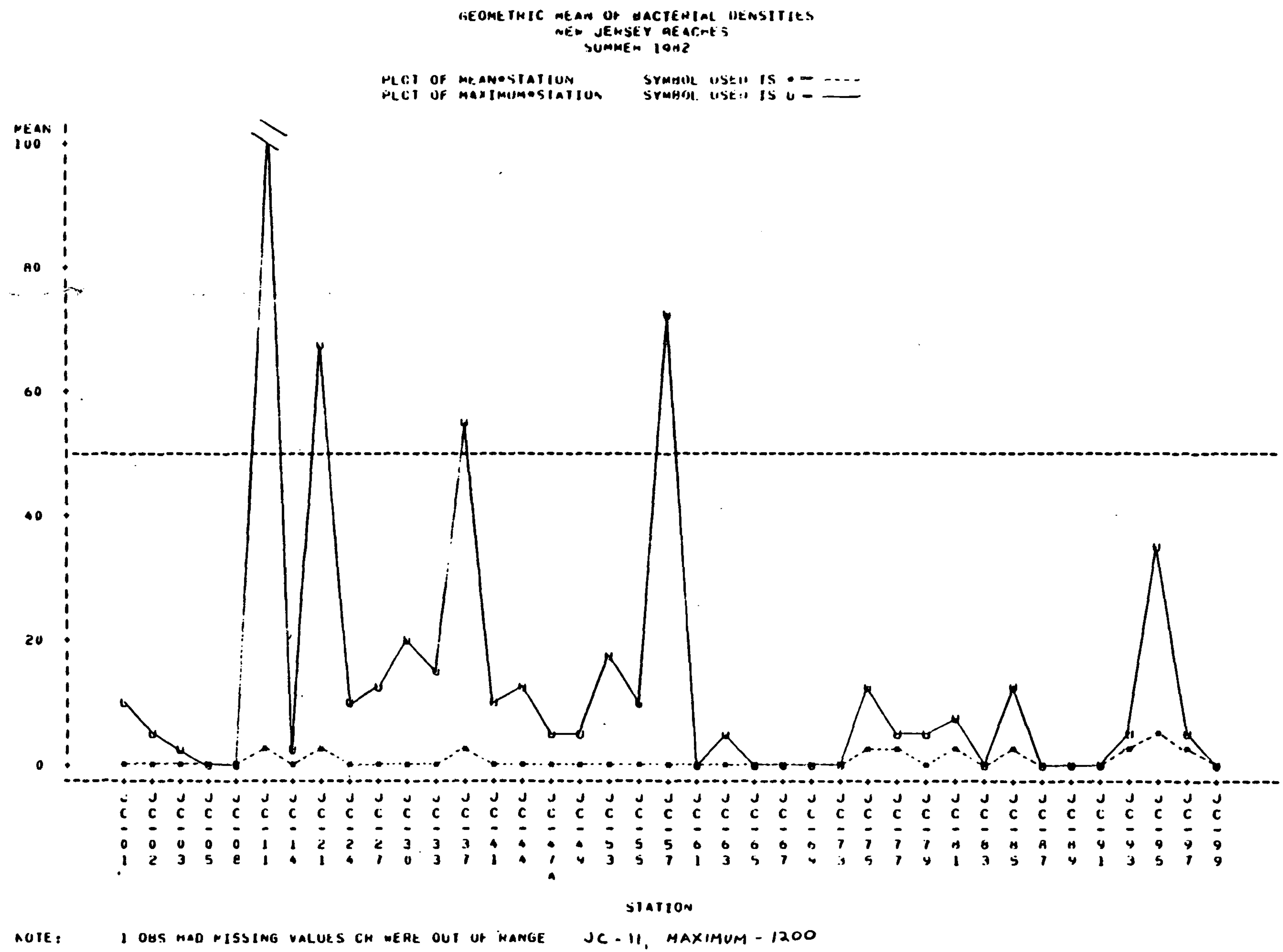
GEOMETRIC MEAN OF BACTERIAL DENSITIES
NEW JERSEY BEACHES
SUMMER 1982
PLOT OF MEAN*STATION SYMBOL USED IS *
PLOT OF MAXIMUM*STATION SYMBOL USED IS 0
MEAN
100
80
60
40
20
0
STATION
NOTE: 1 OBS HAD MISSING VALUES OR WERE OUT OF RANGE
JC-11, MAXIMUM - 1200

Figure 2

GEOMETRIC MEANS OF BACTERIAL DENSITIES
LONG ISLAND BEACHES
SUMMER 1982

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