U.S. ENVIRONMENTAL PROTECTION AGENCY

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1995

ENVIRONMENTAL SERVICES DIVISION
REGION 2
EDISON, NEW JERSEY 08837

NEW YORK BIGHT WATER QUALITY

SUMMER OF 1995

Prepared By: United States Environmental Protection Agency
Region 2 - Surveillance and Monitoring Branch
Edison, New Jersey 08837

8/23/96

Helen Grebe, Environmental Scientist

ABSTRACT

The purpose of this report is to disseminate technical information gathered by the Environmental Services Division of the U.S. Environmental Protection Agency (EPA), Region 2, during the 1995 New York Bight Water Quality Monitoring Program. The monitoring program was conducted via a contract helicopter for sample collection and floatable surveillance. The monitoring period was from May 15 to September 6 of 1995. The program consisted of four separate parts, as follows:

1. Beach network - 26 Long Island beach stations and 44 New Jersey beach stations sampled for bacteriological analysis once a week,

2. Phytoplankton network - phytoplankton samples along the New Jersey coast and in Raritan Bay, Sandy Hook Bay, Barnegat Bay, Great Egg Harbor, and Delaware Bay collected semimonthly,

3. Perpendicular network - ten transects (one New York Bight and nine New Jersey coast transects) extending nine nautical miles east from the New Jersey coast sampled five to seven times during the sampling season for dissolved oxygen and temperature, and

4. Floatable surveillance network - helicopter flights around the New York/New Jersey Harbor Complex conducted six days a week during the summer months.

Bacteriological data indicated that fecal coliform densities at the Long Island and New Jersey beach stations were well within the acceptable Federal guidelines and State limits for primary contact recreation (a geometric mean of 200 fecal coliforms/100ml). A total of 317 samples along the Long Island coast, and 524 samples along the New Jersey coast, were collected for fecal coliform and enterococcus analyses. Only One individual fecal coliform density along the Long Island coast and one individual density along the New Jersey coast, exceeded the States' bathing water quality standard of 200 fecal coliforms/100ml. The recommended EPA criterion for enterococci in marine waters is a geometric mean of 35

enterococci/100ml. On only four occasions, individual enterococcus densities exceeded 35 enterococci/100ml, twice along the Long Island coast and twice along the New Jersey coast. Based on fecal coliform and enterococcus data, Long Island and New Jersey coastal waters are of excellent quality.

Dissolved oxygen levels were generally good along the New Jersey and New York Bight perpendiculars. Semimonthly average dissolved oxygen concentrations remained above 5.5 mg/l. Most individual dissolved oxygen values remained above the "lethal if prolonged" guideline of 2 - 3 mg/l. Dissolved oxygen values have remained higher than those of 1985 when, in mid to late summer, approximately 1600 square miles of ocean bottom off New Jersey were plagued with dissolved oxygen concentrations considered stressful for aquatic life, for extended periods of time.

During the summer of 1995, phytoplankton blooms and chlorophyll a levels were highest in the intercoastal bays of New Jersey. Red algal blooms were predominant in Raritan and Sandy Hook Bays from May through August. The minute brown alga, Aureococcus anophagefferens was documented in bloom proportions for the first time in Little Egg Harbor adjacent to lower Barnegat Bay, New Jersey, in 1995. This brown alga was associated with damage to shellfish crops in the eastern embayments of Long Island, NY. Most coastal beaches along New Jersey were affected by blooms of short duration, however extensive phytoplankton blooms did not occur.

There were no beach closures due to wash-ups of floatable debris in 1995. This was largely due to the initiation of a Short-Term Action Plan aimed at addressing floatable debris in the New York/New Jersey Harbor Complex. The action plan is a cooperative monitoring and response effort on the part of various federal, state and local government agencies.

TABLE OF CONTENTS

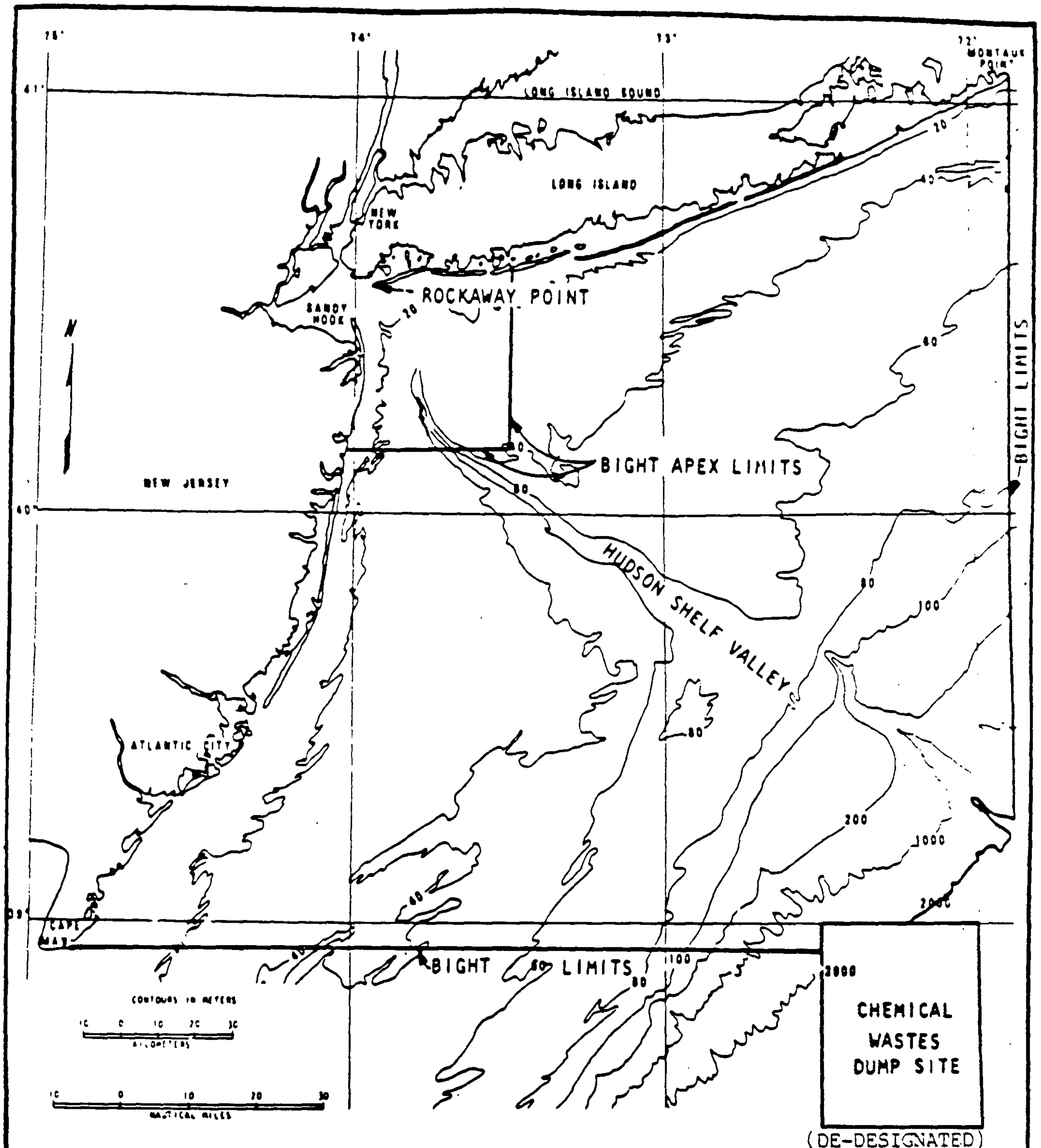
LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

The Division of Environmental Science and Assessment of the U.S. Environmental Protection Agency has prepared this report to disseminate environmental data for the New York Bight Apex, the New York/New Jersey Harbor Complex, 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 de-designated sewage sludge, acid waste, and cellar dirt disposal sites, and the active dredged material disposal site, is shown in Figure 2. The New York/New Jersey Harbor Complex, for purposes of this report, is defined as the Arthur Kill, Newark Bay, Kill Van Kull, southern portions of the East and Hudson Rivers, Verrazano Narrows, Gravesend Bay, the Coney Island coastline to the mouth of Jamaica Bay, and Upper and Lower New York Harbors. The New York/New Jersey Harbor Complex is shown in Figure 3.

This report is the twenty-first in a series and reflects the monitoring period from May 15 to September 6 of 1995. The New York Bight Water Quality Monitoring Program is EPA's response to its mandated responsibilities as defined under the Marine Protection, Research and Sanctuaries Act of 1972, the Water Pollution Control Act Amendments of 1972 and 1977, and the Water Quality Act of 1987.



THE NEW YORK BIGHT

Figure 1

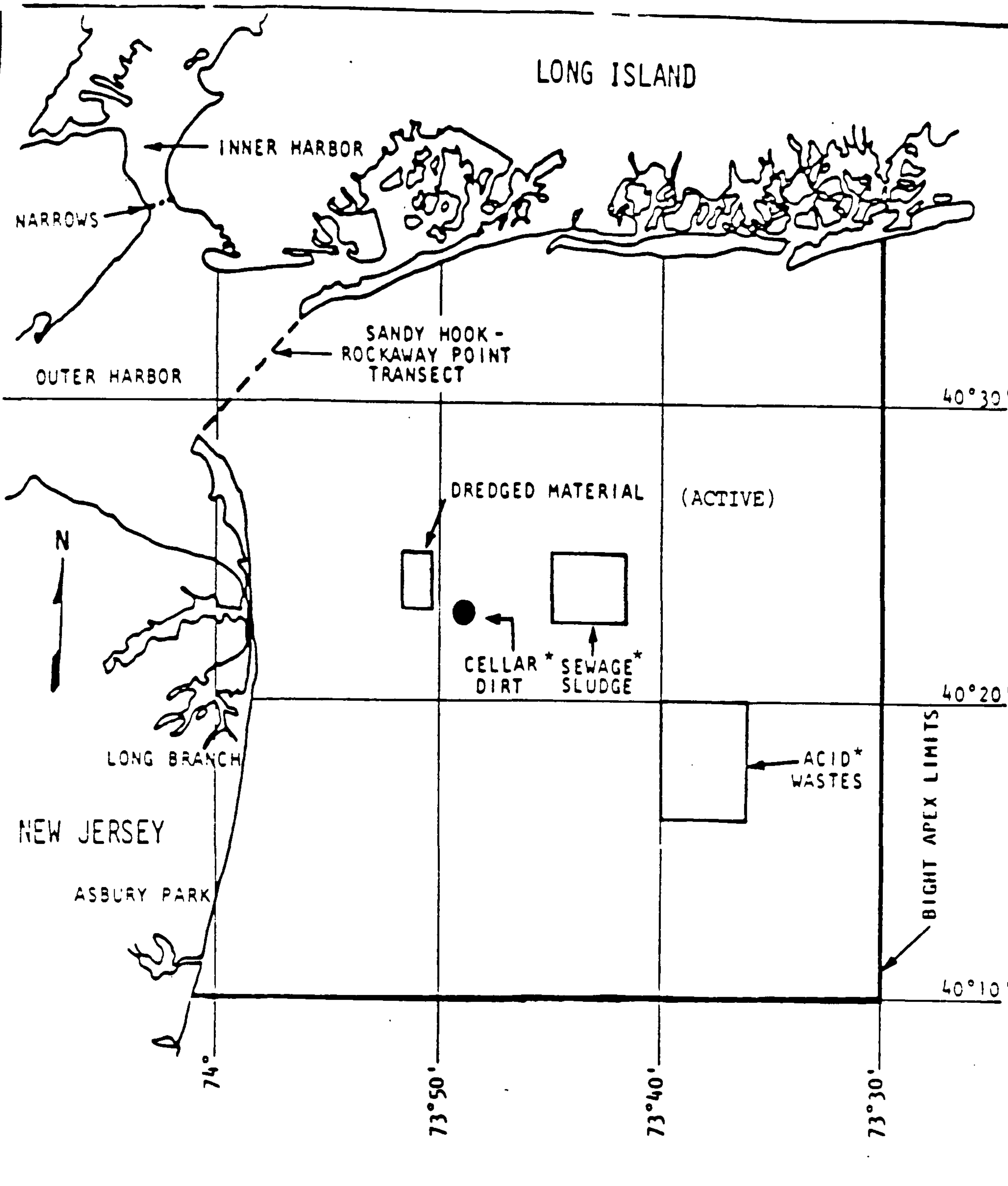
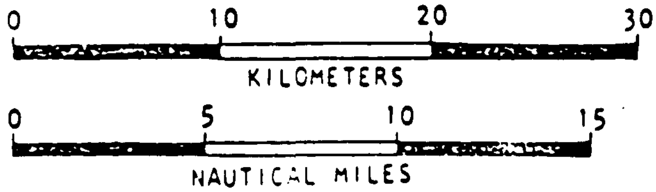


Figure 2

BIGHT APEX AND EXISTING DUMP SITES

* = DE-DESIGNATED



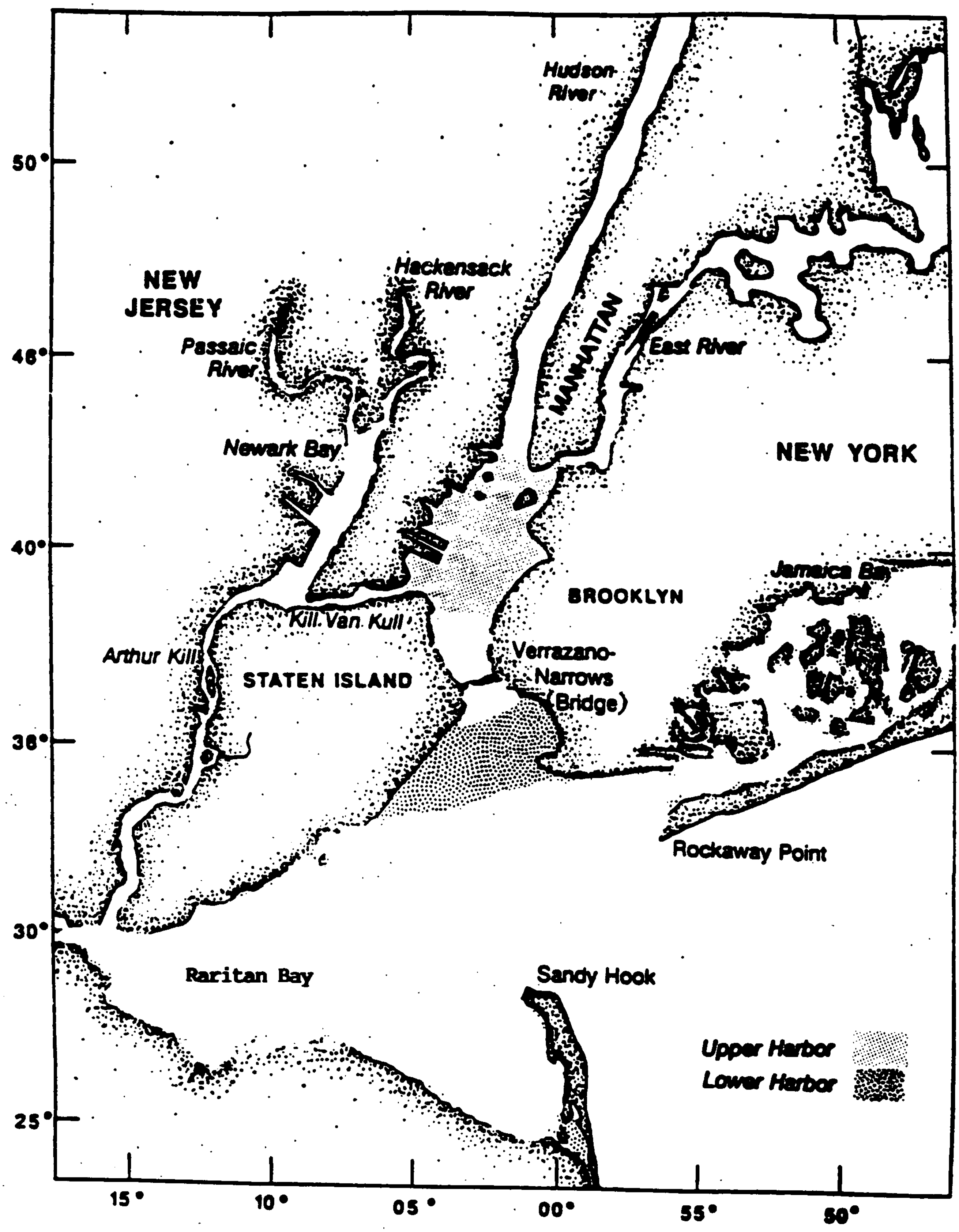


Figure 3 Map of New York/New Jersey Harbor Complex

II. HISTORY OF THE NEW YORK BIGHT MONITORING PROGRAM

Since its initiation in 1974, the New York Bight Water Quality Monitoring Program has been modified several times to be more responsive to the needs of the general public, the states, the counties, and EPA; and to concentrate on specific areas of concern during the critical summer period. Many changes occurred after the summer of 1976, when anoxic conditions caused a fishkill in the Bight and an unusually heavy wash-up of debris occurred on Long Island beaches. It was clear that summer conditions in the Bight called for more intensive monitoring in order to predict environmental crises, investigate the origins of these crises, and direct any decisions regarding protection of the Bight's water quality.

In 1986, the monitoring program was modified to intensify sampling activities along the southern New Jersey beaches. During mid to late summer in 1985, beaches along the southern New Jersey coast were affected by algal blooms, which caused "green tide," and high bacterial counts that resulted in beach closings. To improve monitoring coverage, four additional beach stations between Long Beach Island and Wildwood were sampled weekly for phytoplankton. In addition, bacteria samples were collected weekly rather than bimonthly along the southern New Jersey beaches. However, since 1985, extensive phytoplankton blooms of long duration have not occurred along the New Jersey coast. As a result, beginning in 1993 and continuing through 1995, the frequency of phytoplankton monitoring decreased from once a week to semimonthly. Weekly bacteriological samples continue to be collected.

In August 1987, a 50-mile slick of garbage washed ashore along mid to southern New Jersey. In 1988, several miles of Long Island beaches were plagued with garbage wash-ups, including medical debris. This precipitated the need to develop a response network to prevent future beach closures due to floatables. As a result, EPA along with the New York State

Department of Environmental Conservation, New York City Department of Environmental Protection, New York City Department of Sanitation, U.S. Army Corps of Engineers, New Jersey Department of Environmental Protection, and the U.S. Coast Guard developed the "Short Term Action Plan for Addressing Floatables Debris in the New York Bight" (USEPA, 1989). The Short Term Action Plan establishes a monitoring and response network to locate and coordinate cleanup operations for slicks found in the New York/New Jersey Harbor Complex. The intent was to prevent slick materials from escaping the harbor and potentially stranding on regional beaches. The nucleus of the plan consists of daily helicopter floatable observation flights of the New York/New Jersey Harbor Complex, a command/communication center, and the cleanup of floatable debris by the U.S. Army Corps of Engineers or the New York City Department of Environmental Protection.

In 1992, in response to a changing environment, i.e., the cessation of sewage sludge dumping, monitoring for dissolved oxygen in the New York Bight Apex was modified. The following stations were not sampled in 1992, 1993 or 1994: the Long Island perpendiculars, the Manasquan Inlet perpendicular, most New York Bight Apex stations, and New Jersey perpendicular stations 3 and 7 nautical miles off the coast. Four New York Bight Apex stations were retained, and four new ones added. The New York Bight Apex stations extended east off the New Jersey Coast, approximately 4, 8, 12, and 16 nautical miles offshore. New Jersey perpendicular stations were sampled at 1, 5, 9, 12, and 16 nautical miles off the coast, in 1992, 1993 and 1994. The new sampling scheme was developed to document the extent of low dissolved oxygen concentrations off the New Jersey coast.

Monitoring for dissolved oxygen was again modified in 1995. Stations 12 and 16 nautical miles off the coast did not show low dissolved oxygen, and were therefore not sampled in 1995. The 1995 dissolved oxygen monitoring network better reflects the historical data base, i.e., pre 1992. New Jersey perpendicular stations were sampled 1, 3, 5, 7, and 9 nautical miles off the coast. The New York Bight stations are sampled approximately 2, 4, 6, 7 and 8 nautical miles offshore, centering around the dredged material dump site.

Frequency of dissolved oxygen monitoring has also been changed. In past years, monitoring for dissolved oxygen occurred every week throughout the summer. In 1992, 1993 and 1994, dissolved oxygen monitoring occurred three to four times during the summer season, focusing around historically low periods. In 1995, dissolved oxygen monitoring occurred eight times.

III. SAMPLING AND SURVEILLANCE PROCEDURES

During the period of May 15 through September 6, 1995, water quality monitoring and surveillance activities were carried out using a contract helicopter. The monitoring program is composed of three separate sampling networks and one floatable surveillance network. Table 1 outlines the 1995 monitoring program, including station groups, frequency of sampling, parameters analyzed, and sample depth.

The beach station network was sampled to gather bacteriological water quality information for the protection of human health. Samples were collected weekly starting one week before Memorial Day until Labor Day. Twenty-six Long Island coast stations and forty-four New Jersey coast stations were sampled once a week for fecal coliform and enterococcus bacteria densities. At beach stations, samples were collected just offshore in the surf zone, while the helicopter hovered over 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)

Table 1

Outline of the 1995 Monitoring Program

Station Group	Frequency	Parameter	Sample Depth
Long Island Beaches (Rockaway Pt. to Shinnecock Inlet)	26 stations/week	Fecal Coliform Enterococcus	one meter below the surface
New Jersey Beaches (Sandy Hook to Cape May)	44 stations/week	Fecal Coliform Enterococcus	one meter below the surface
New Jersey Phytoplankton Station Network	8 - 12 samples semimonthly	Phytoplankton Chlorophyll a	one meter below the surface
New Jersey and New York Bight Apex Perpendicular Station Network (Sandy Hook to Hereford Inlet)	50 stations 10 transects	Dissolved Oxygen	one meter below the surface, one meter above the ocean floor
NY/NJ Harbor Overflight	6 days/ week	observations	surface water

to the Edison Laboratory for fecal coliform and enterococcus analyses. The results of the bacteriological data for 1995 are contained in Appendix A.

The phytoplankton sampling network was sampled to monitor phytoplankton assemblages and red tide blooms in New Jersey coastal waters and bays. Water samples for phytoplankton identification and quantification, and chlorophyll analysis, were collected eight times during the summer season. Sample analyses were completed by the New Jersey Department of Environmental Protection (NJDEP). The samples were collected as close to the surface as possible, using a 1-liter Kemmerer sampler. A 500 ml dark brown plastic bottle was filled for phytoplankton and chlorophyll a analyses, and preserved by cooling to 4°C. The NJDEP picked up the phytoplankton samples at our Edison laboratory within 24 hours of collection. At the laboratory, the NJDEP removed an aliquot of sample for chlorophyll analysis. The results of the NJDEP's analyses are contained in Appendix B.

The perpendicular station network was established to gather surface and bottom dissolved oxygen values during the critical summer period. The perpendicular station network consists of ten transects extending east from the New Jersey coast. One transect extended east from Northern New Jersey in the New York Bight Apex, with 5 stations; and 9 transects extended east from the remainder of the New Jersey coast, with 5 stations in each transect. The transects cover the inner Bight from Sandy Hook to Hereford Inlet, New Jersey. Samples were collected for dissolved oxygen and temperature. Depending upon sea conditions, the contract helicopter hovered or landed at the designated station and a 1-liter Kemmerer sampler was used to obtain water samples. Samples were taken at 1 meter below the surface and 1 meter above the ocean floor. After collection, the water sample was transferred to a biochemical oxygen demand bottle for dissolved oxygen analysis. The dissolved oxygen sample was immediately fixed at the station by the addition of 2 ml of manganous sulfate followed by 2 ml of alkali-iodide-azide reagent. The sample was shaken to facilitate floc formation and then placed in a metal rack. The samples were held for less than 6 hours before returning to the laboratory, where 2 ml of sulfuric acid were added, and the samples were titrated with 0.0375N sodium thiosulfate.

The floatable surveillance network encompassed overflights of the New York/New Jersey Harbor Complex. The networks' objective is to improve water quality by sighting slicks and determining the most efficient coordinated cleanup effort possible. The removal of floatable debris from the water column in the Harbor Complex, prevents the debris from stranding on regional beaches or shore lines. The overflights consisted of flying a helicopter 50 to 300 feet above the water, 6 days/week from May 15 to September 6. Approximate size or dimension, contents, relative density, location, possible sources and time of sighting of significant floatable debris were recorded. The information was reported to a central communication response network, specifically established to coordinate cleanup efforts. Cleanup efforts were conducted by the Corps of Engineers or the New York City Department of Environmental Protection as necessary.

IV. LOCATION OF SAMPLING STATIONS AND OBSERVATION POINTS

Beach Stations

A total of 70 bathing beach areas was 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 2 and Figure 4. There are 44 New Jersey coast stations, beginning at Sandy Hook extending south to Cape May Point (JC 01A-JC 99). These stations are described and identified in Table 3 and in Figures 5 and 6.

The results of the bacteriological data are contained in Appendix A.

Phytoplankton Stations

Phytoplankton samples were collected eight times during the summer season along the New Jersey coast and in Raritan Bay, Sandy Hook Bay, and Barnegat Bay. The stations were as follows:

RB 05	JC 30	JC 65	JC 91
RB 15	JC 33	JC 75	BB 02
RB 51	JC 57	JC 83	DB 1
JC 11	JC 63	JC 87	

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

Table 2

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

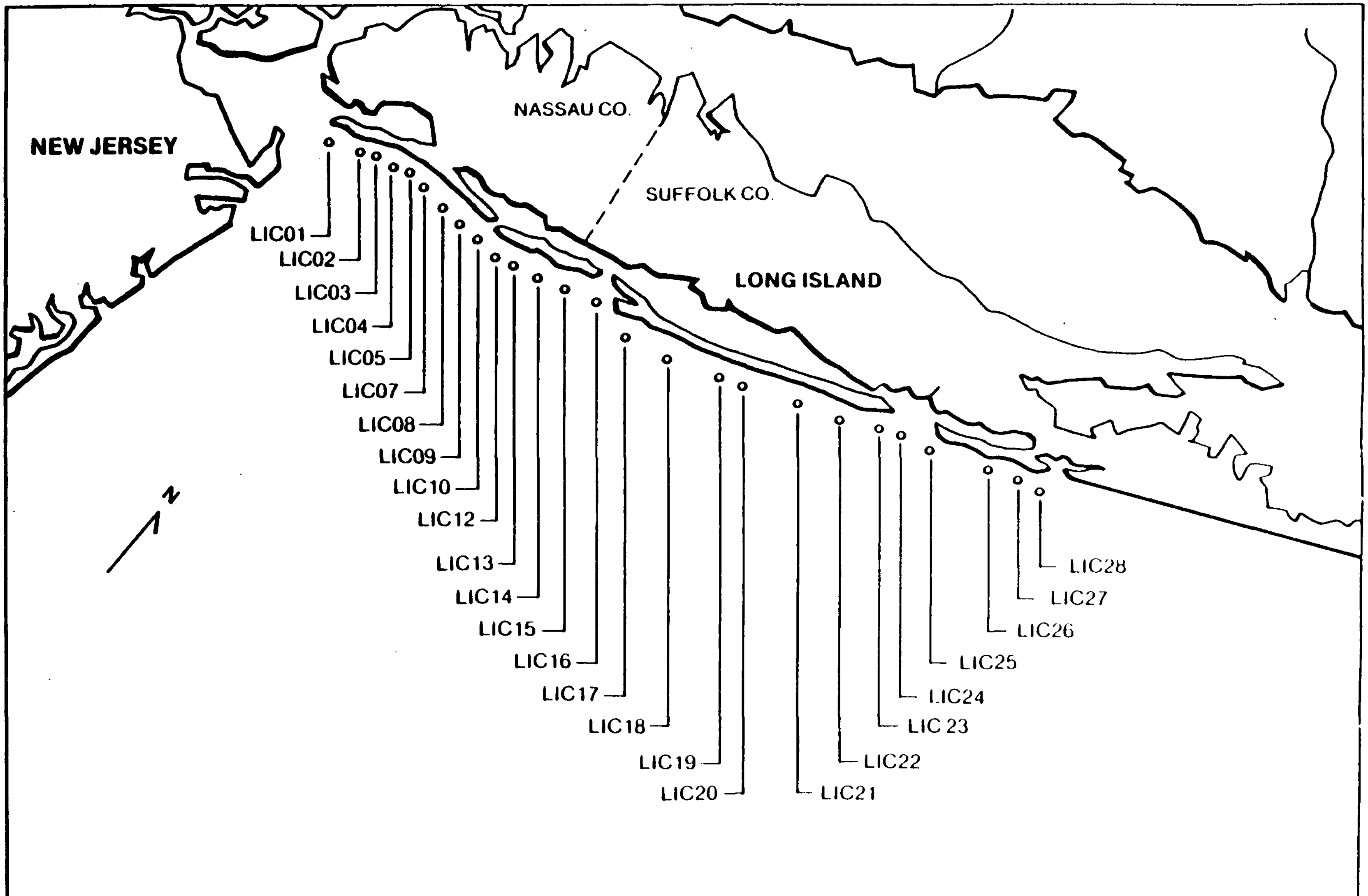


FIGURE 4
LONG ISLAND COAST STATION LOCATIONS

Table 3

New Jersey Coast Station Locations

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

Table 3 (continued)

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

Table 3 (continued)

Station No.	Location
JC 89	Avalon, off beige building on the beach
JC 92	Hereford Inlet
JC 93	Wildwood, off northern amusement pier
JC 95	Two mile beach, opposite radio tower
JC 96	Cape May Inlet
JC 97	Cape May, off white house with red roof on the beach
JC 99	Cape May Point, opposite lighthouse

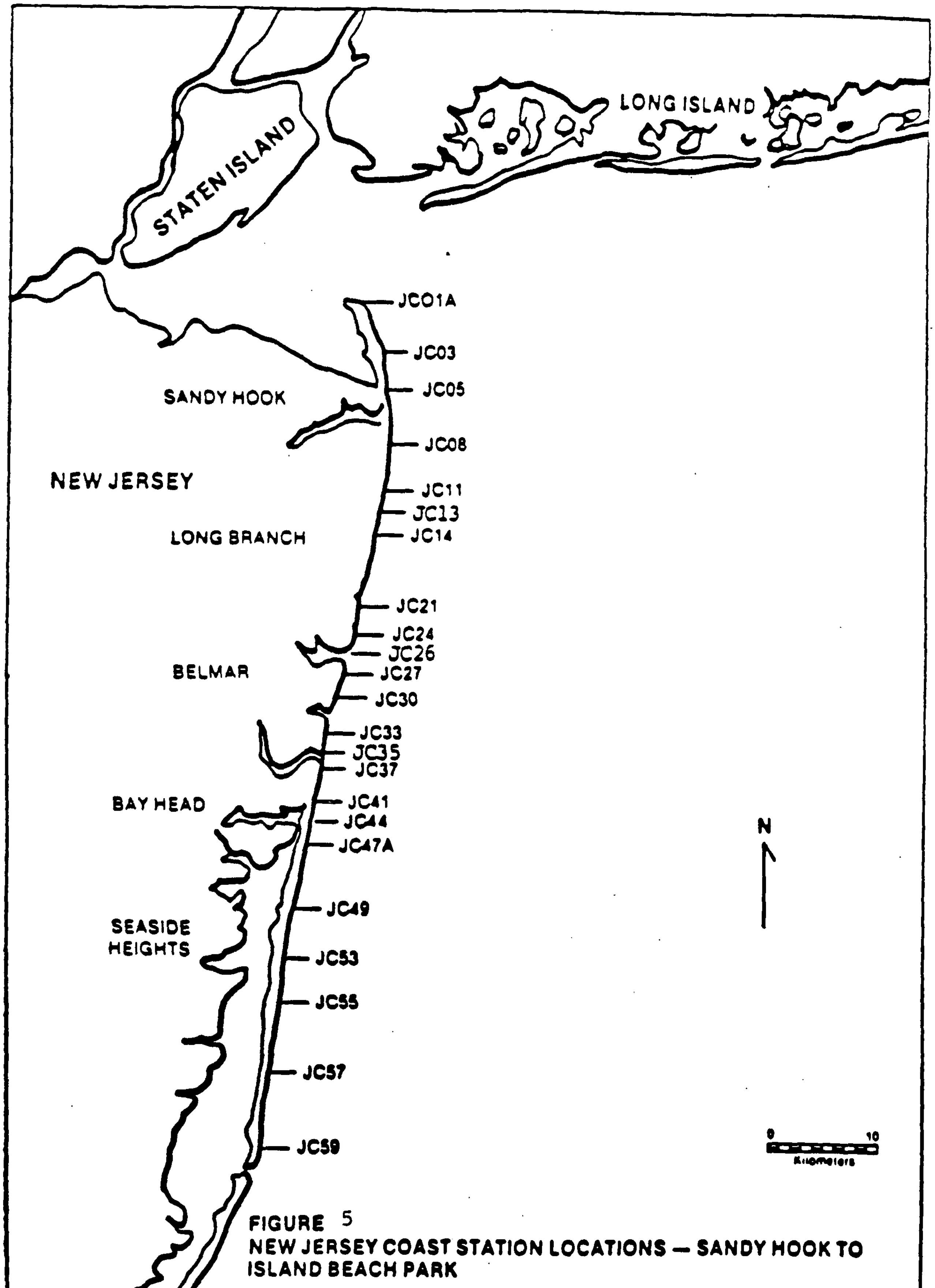


FIGURE 5
NEW JERSEY COAST STATION LOCATIONS — SANDY HOOK TO ISLAND BEACH PARK

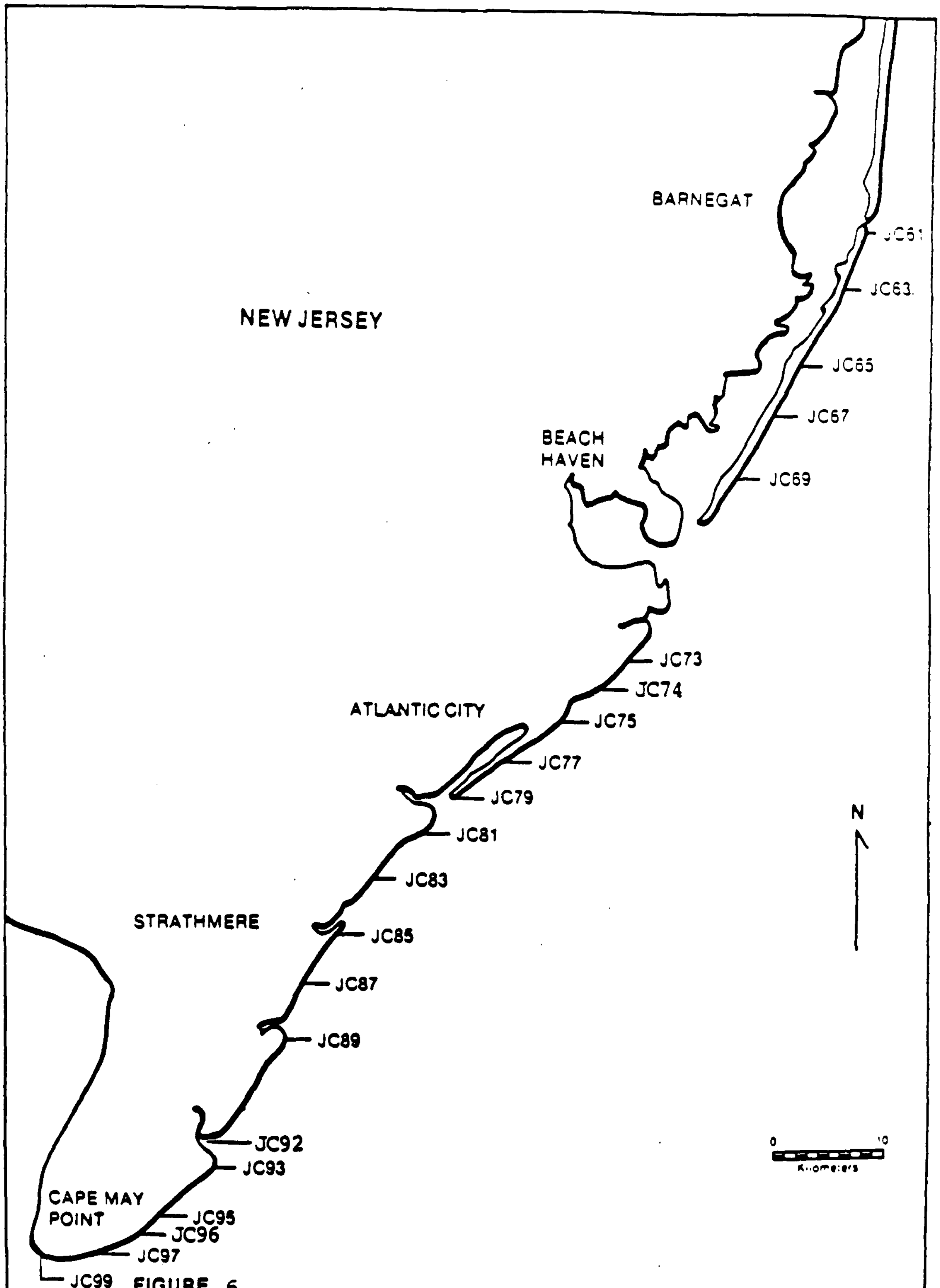


FIGURE 6
NEW JERSEY COAST STATION LOCATIONS — BARNEGAT TO CAPE MAY POINT

Perpendicular Stations

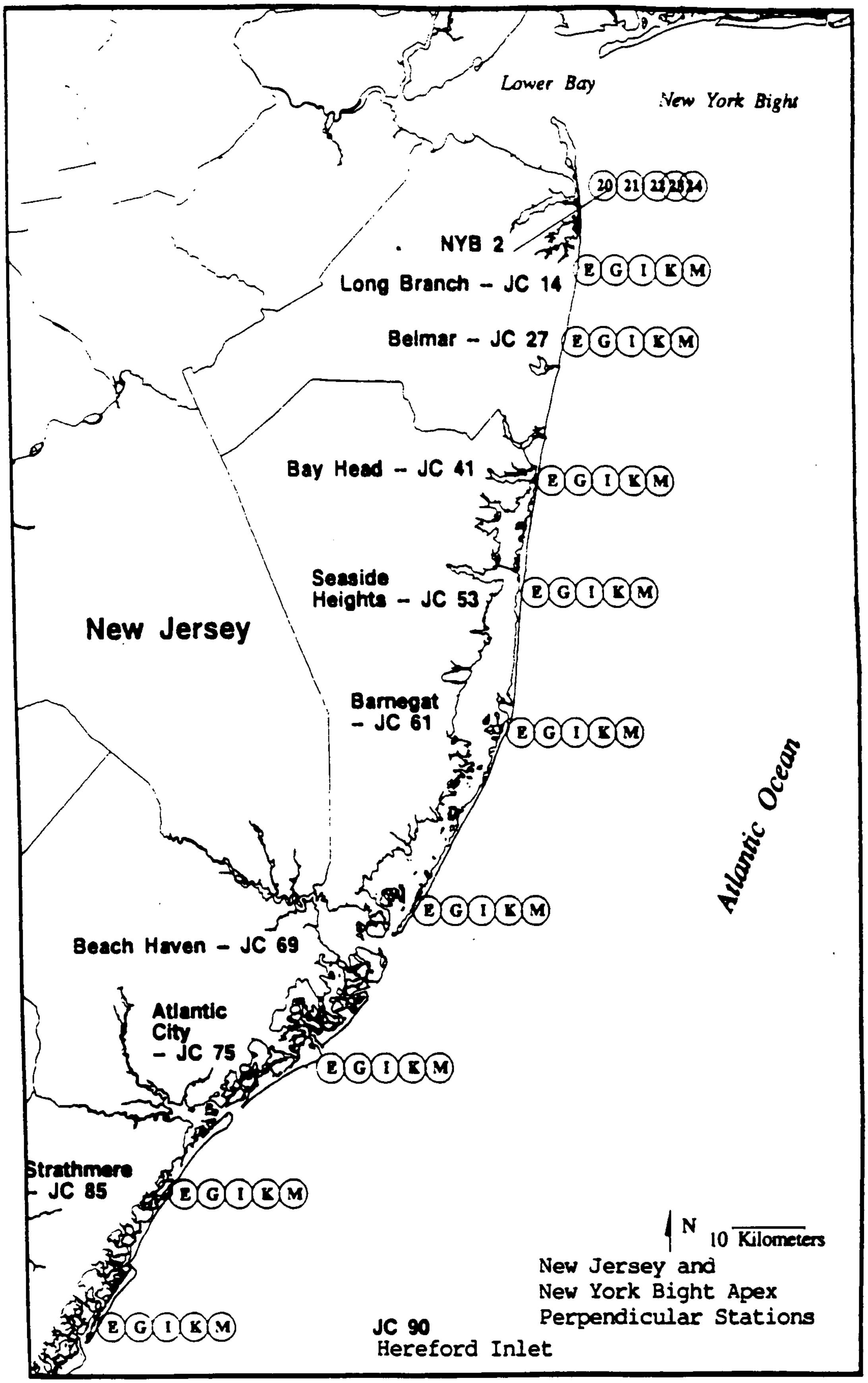
The perpendicular station network consists of ten transects extending east from the New Jersey coast. Nine New Jersey coast (JC) perpendicular transects extend east from Long Branch to Hereford Inlet, and one New York Bight (NYB) Apex perpendicular transect extends east from the southern end of Sandy Hook. New Jersey coast perpendicular stations start at 1 nautical mile (nm) and extend east, to nine nm offshore. In 1995, perpendicular transects from Long Branch to Hereford Inlet were sampled at 1, 3, 5, 7, and 9 nm offshore. The Hereford Inlet (JC90) perpendicular transect was established in 1992. Historical New York Bight Apex stations, NYB 20, 21, 22, 23 and 24 were sampled in 1995. The New York Bight stations are approximately 2, 4, 6, 7, and 8 nm off the southern end of Sandy Hook.

The perpendicular station locations are plotted in Figure 7.

New York/New Jersey Harbor Complex

A complete overflight of the New York/New Jersey Harbor Complex included the following waterways: the Arthur Kill; Newark Bay, as far north as the New Jersey Turnpike Bridge; the Kill Van Kull; the Upper New York Harbor; the Hudson and East Rivers as far north as Central Park, New York; the Verrazano Narrows; Gravesend Bay; the shoreline of Coney Island as far east as the Marine Parkway Bridge; and the Lower New York Harbor, see Figure 3.

Figure 7



New Jersey and
New York Bight Apex
Perpendicular Stations

V. DISSOLVED OXYGEN RESULTS AND DISCUSSION

Normal Trends in the Ocean

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

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

> In early January, the waters of the Bight are completely mixed throughout the water column with temperatures ranging from $4^{\circ}C$ to $10^{\circ}C$ 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 $10^{\circ}C$

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 8 depicts a representative history of dissolved oxygen concentration in the general ocean area off of New Jersey, New York, and New England.

Dissolved Oxygen Criteria

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

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

These criteria are consistent with biological information recorded in the New York Bight over the past 15-20 years. Most

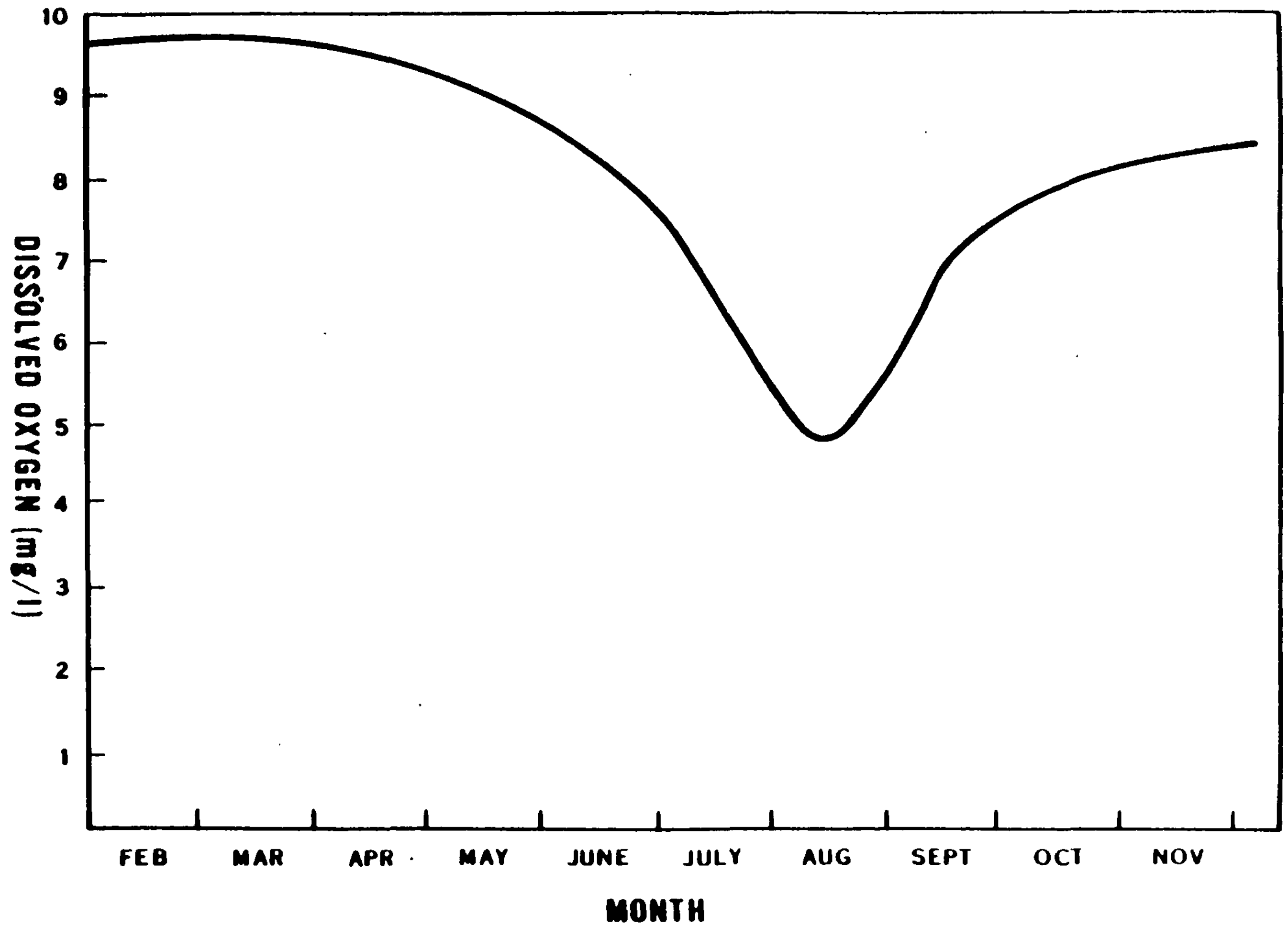


FIGURE 8
GENERALIZED ANNUAL MARINE DISSOLVED OXYGEN CYCLE OFF THE NORTHEAST U.S. (FROM NOAA)

data concerning the lower tolerance levels were recorded during the summer of 1976. In 1976, widespread and persistent dissolved oxygen levels between 0.0 and 2.0 mg/l occurred over a large area of the Bight. This resulted in extensive fishkills and benthic organism mortality.

Surface Dissolved Oxygen - 1995

During the 1995 dissolved oxygen sampling period, July 7 through September 5, a total of 369 surface samples was collected for dissolved oxygen analysis. The upper water column, as in past years, appeared to be completely mixed with dissolved oxygen levels at or near saturation. Therefore, no further discussion on surface dissolved oxygen will be presented in this report.

Bottom Dissolved Oxygen - 1995

New York Bight Apex Perpendiculars

New York Bight Apex perpendicular stations, (NYB20, 21, 22, 23 and 24) were sampled eight times during the 1995 sampling period. A total of 44 bottom samples was collected for dissolved oxygen, see Table 4. Six samples were below the "borderline to healthy" guideline of 4.0 mg/l. These six values were:

Station	Date	Dissolved Oxygen
NYB21	8/21/95	2.1 mg/l
NYB23	8/21/95	2.5 mg/l
NYB24	8/21/95	2.5 mg/l
NYB21	8/26/95	3.7 mg/l
NYB21	9/01/95	3.8 mg/l
NYB24	9/01/95	3.9 mg/l

Based on these data, dissolved oxygen remained well above the guidelines considered stressful to aquatic life.

Table 4

1995 New Jersey and New York Bight Dissolved Oxygen Distribution (Bottom Values)

	July 7	July 13	July 17	July 20	July 21	July 25	July 27	July 28	July 31	Aug 3	Aug 4	Aug 7	Aug 10	Aug 11	Aug 14	Aug 21	Aug 25	Aug 26	Sept 1	Sept 5
NYB20	*	X			*			*		*		*		*		*		X	*	
NYB21	*				*			*		*		*		▼		■		*	X	
NYB22	*				*			*		*		*		▼				▼	▼	
NYB23	*				*			*		*		*		▼		■		*	▼	
NYB24	*				*			*		*		▼		*		■		*	X	
JC14E	X				▼			*		▼		*		▼		*			X	
JC14G	*				*			*		*		*		X		*			■	
JC14I	*				*			*		*		*		▼		▼			X	
JC14K	*				*			*		*		*		*		▼			▼	
JC14M	*				*			*		*		*		*		X			*	
JC27E	*				*			*		*		*		*		*			▼	
JC27G	*				*			*		*		*		X		▼			▼	
JC27I	*				*			*		*		*		▼		*			X	
JC27K	*				*			*		*		*		▼		*			X	
JC27M	*				*			*		*		*		*		X			▼	
JC41E	*				*			*		*		*		X		*			*	
JC41G	▼	*			*			*		▼		*		▼		▼		■	X	
JC41I	*				*			*		*		*		▼		O		X	X	
JC41K	*				*			*		*		*		▼		*		X	▼	
JC41M	*				*			*		*		*		▼		*		X	*	
JC53E	*	▼			▼			▼		*		*		▼		*			*	
JC53G	▼	*			*			▼		*		*		*		*			X	
JC53I	*	*			▼			*		*		*		▼		*			*	
JC53K	*	*			*			*		*		*		*		▼			*	
JC53M	*	*			*			*		▼		*		▼		X			*	
JC61E		*				X			*		*		*		*		*			*
JC61G		*				X			▼		▼		*		*		*			X
JC61I		*				*			*		▼		*		X		▼			X
JC61K						▼			*		▼		*		X		■			*
JC61M		*				*			*		X		*		*		▼			*
JC69E		X		*			▼		*		▼		*		▼		*			*
JC69G		▼		*			▼		*		▼		*		*		*			*
JC69I		▼		▼			*		*		*		*		▼		*			*
JC69K		▼		*			▼		*		*		*		▼		*			
JC69M		*		*			▼		*		*		*		*					X
JC75E			*				*		X		X		*		*		*			*
JC75G			*				X		■		■		*		*		*			*
JC75I			▼				*		X		X		*		*		*			*
JC75K			*				▼		X		X		*		▼		*			*
JC75M			▼				▼		▼		▼		*		*		*			*
JC85E				▼			*		*		*		*		*		*			*
JC85G				▼			*		*		*		*		▼		*			*
JC85I				*			*		*		*		*		▼		*			*
JC85K				*			*		*		*		*		▼		*			*
JC85M				*			*		*		*		*		▼		*			*
JC90E				▼			■		▼		*		*		X		*			*
JC90G				*			X		*		*		*		*		*			*
JC90I				▼			X		*		*		*		*		*			*
JC90K				*			*		*		*		*		▼		*			*
JC90M				*			*		*		*		*		*		*			*

KEY: *=≥ 5mg/l ▼=5-4mg/l X=4-3mg/l ■=3-2mg/l O=< 2mg/l

New Jersey Coast Perpendiculars

Figure 9 illustrates the 1995 semimonthly average of bottom dissolved oxygen concentrations for the New Jersey coast and New York Bight perpendiculars. The dissolved oxygen averages remained above 5.5 mg/l, from July to early September.

Table 4 summarizes the bottom dissolved oxygen values for the New York Bight and New Jersey coast perpendiculars. Of the 369 New Jersey perpendicular samples collected, 113 values (30.6 percent) were below 5 mg/l. Of the 113 values, 69 values (18.7 percent of all New Jersey samples collected) were between 4-5 mg/l, 37 values (10.0 percent) were between 3-4, 6 values (1.6 percent) were between 2-3 mg/l, and only one value (0.3 percent) was below 2 mg/l.

Figure 10 compares the shore to seaward distribution, (or distance off the coast) of average dissolved oxygen concentrations along the New Jersey coast perpendicular transects. The dissolved oxygen values increased with distance offshore, through July. Average dissolved oxygen concentrations are within 0.6 mg/l of each other in August, and decrease with increasing distance offshore in late August. Average dissolved oxygen concentrations one nautical mile off the coast show an increase in late August. This increase is probably due to prevailing winds and heavy surf oxygenating the inner coast. With the exception of stations one nautical mile off the coast, dissolved oxygen averages return to increasing values with distance offshore, in September.

Figure 9

New Jersey and NYB Perpendiculars, 1995

Semi-Monthly Average of Bottom Dissolved Oxygen Concentrations

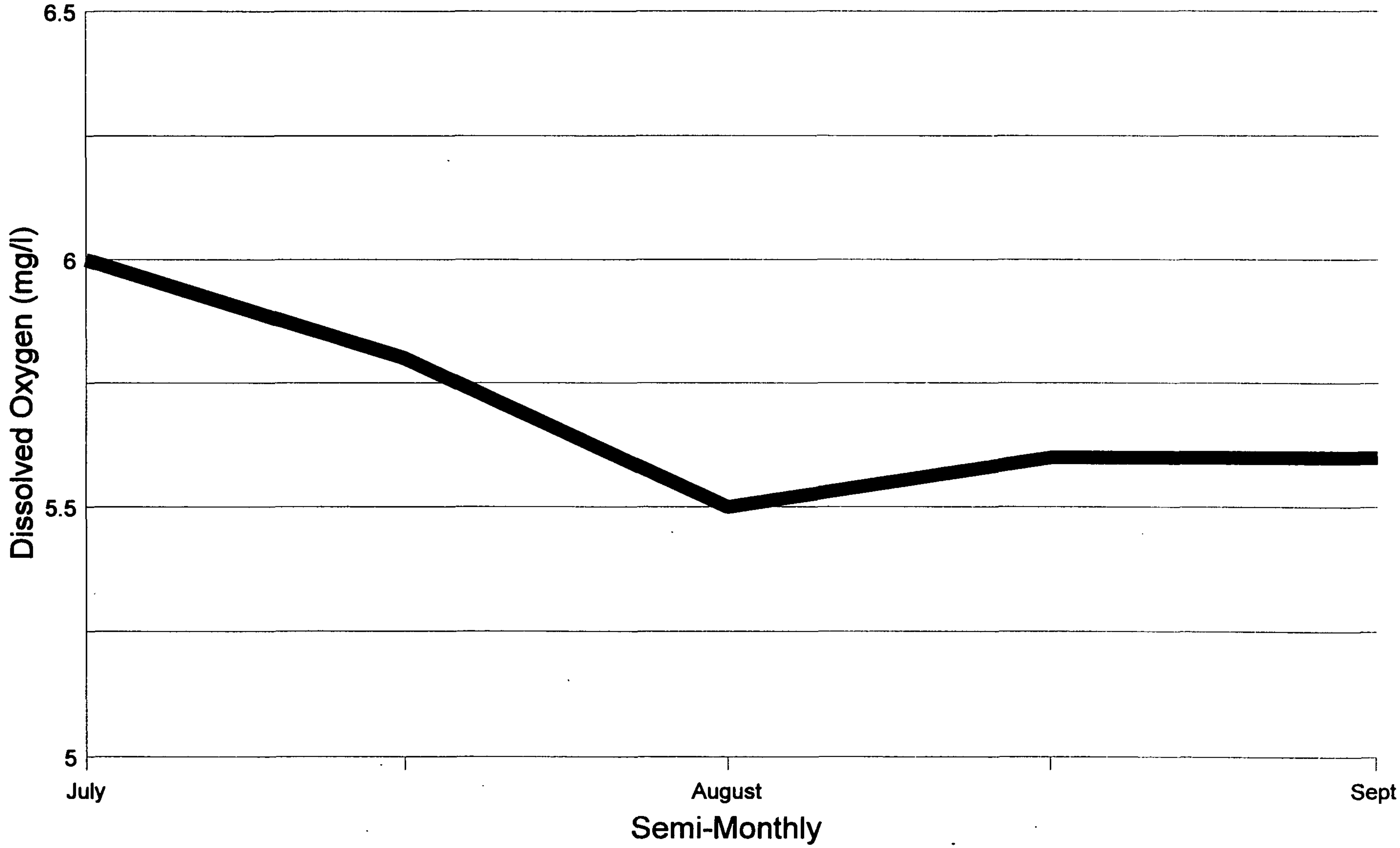
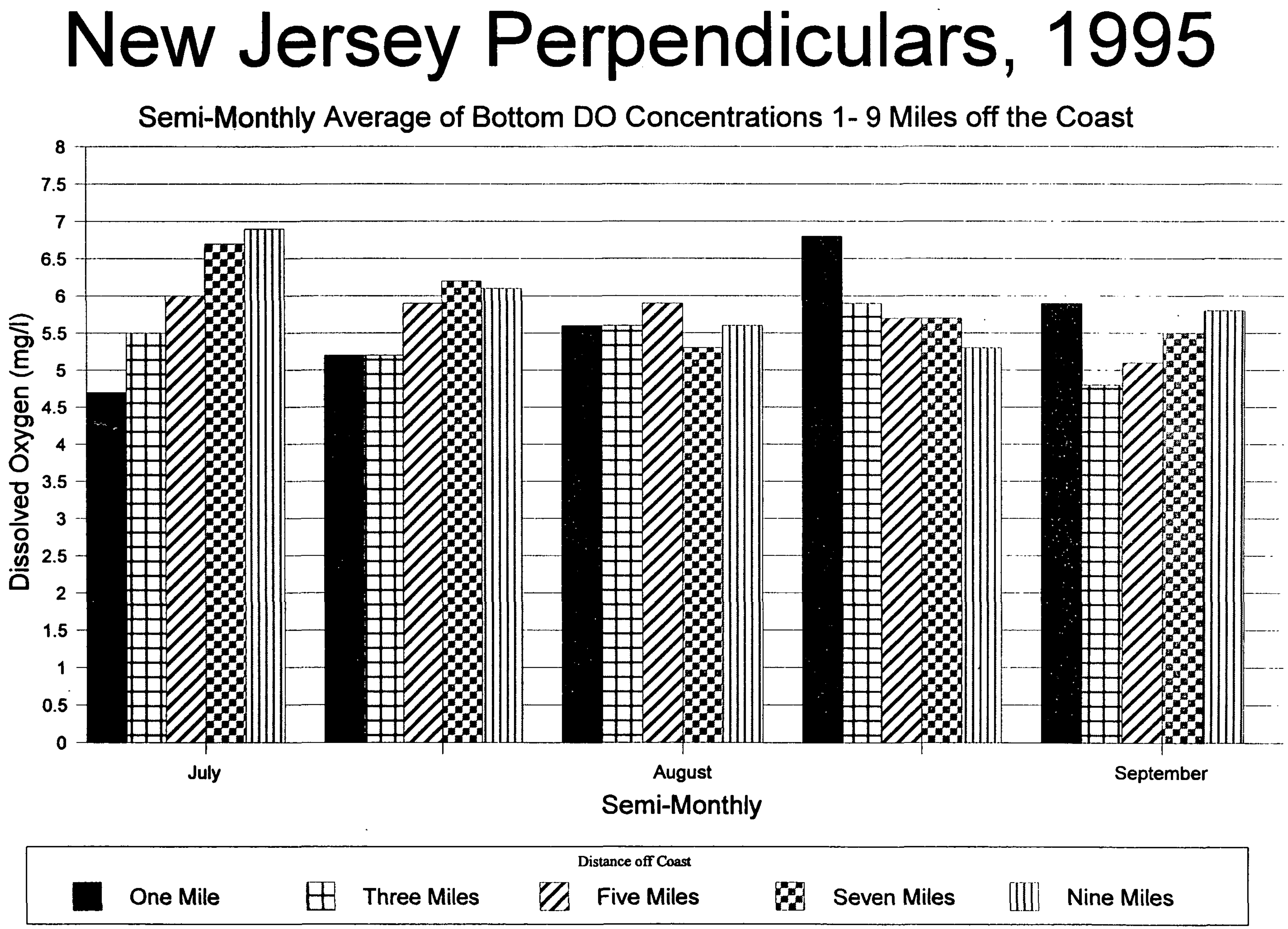


Figure 10


New Jersey Perpendiculars, 1995
Semi-Monthly Average of Bottom DO Concentrations 1- 9 Miles off the Coast
Dissolved Oxygen (mg/l)
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
July
August
September
Semi-Monthly
Distance off Coast
One Mile
Three Miles
Five Miles
Seven Miles
Nine Miles

Dissolved Oxygen Trends

Figure 11 compares the semimonthly average of bottom dissolved oxygen concentrations of the New Jersey and New York Bight perpendiculars, for 1992, 1993, 1994, and 1995. All average values are above 5.0 mg/l, with the lowest value, 5.3 mg/l, occurring in late August of 1992. No samples were collected in early July 1992 and 1994, late July 1992, early August 1993, late August 1993, and early September 1994. Generally, the 1995 values are 1.0 mg/l lower than the 1992, 1993 or 1994 values. A possible reason for this is the change in sampling locations, from a maximum of sixteen nm to nine nm off the coast in 1995. Dissolved oxygen concentrations are generally lower closer to shore.

Figure 12 displays the average dissolved oxygen concentrations along the New Jersey perpendiculars one, five and nine nautical miles off the coast, for 1992, 1993, 1994, and 1995. With the exception of 1992, the dissolved oxygen values increased with distance offshore. Dissolved oxygen averages at stations one, five and nine miles off the coast are within 0.6, 1.0 and 1.8 mg/l of each other, respectively.

The percent of New Jersey bottom dissolved oxygen values below 4 mg/l, from 1981 - 1995, is illustrated in Figure 13. Depressed levels fluctuated greatly, year to year, from 1981 through 1986. From 1986 to 1995, fluctuation from year to year has been less severe. The year 1985 was the most hypoxic. The percentage of low values increased from 1987 to 1990, decreased from 1990 to 1994, and increased again in 1995.

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. The low dissolved oxygen levels in 1990 were not as widespread or persistent as those encountered in 1985.

Figure 11

New Jersey and NYB Perpendiculars, 1992 - 1995

Semi-Monthly Averages of Bottom DO Concentrations

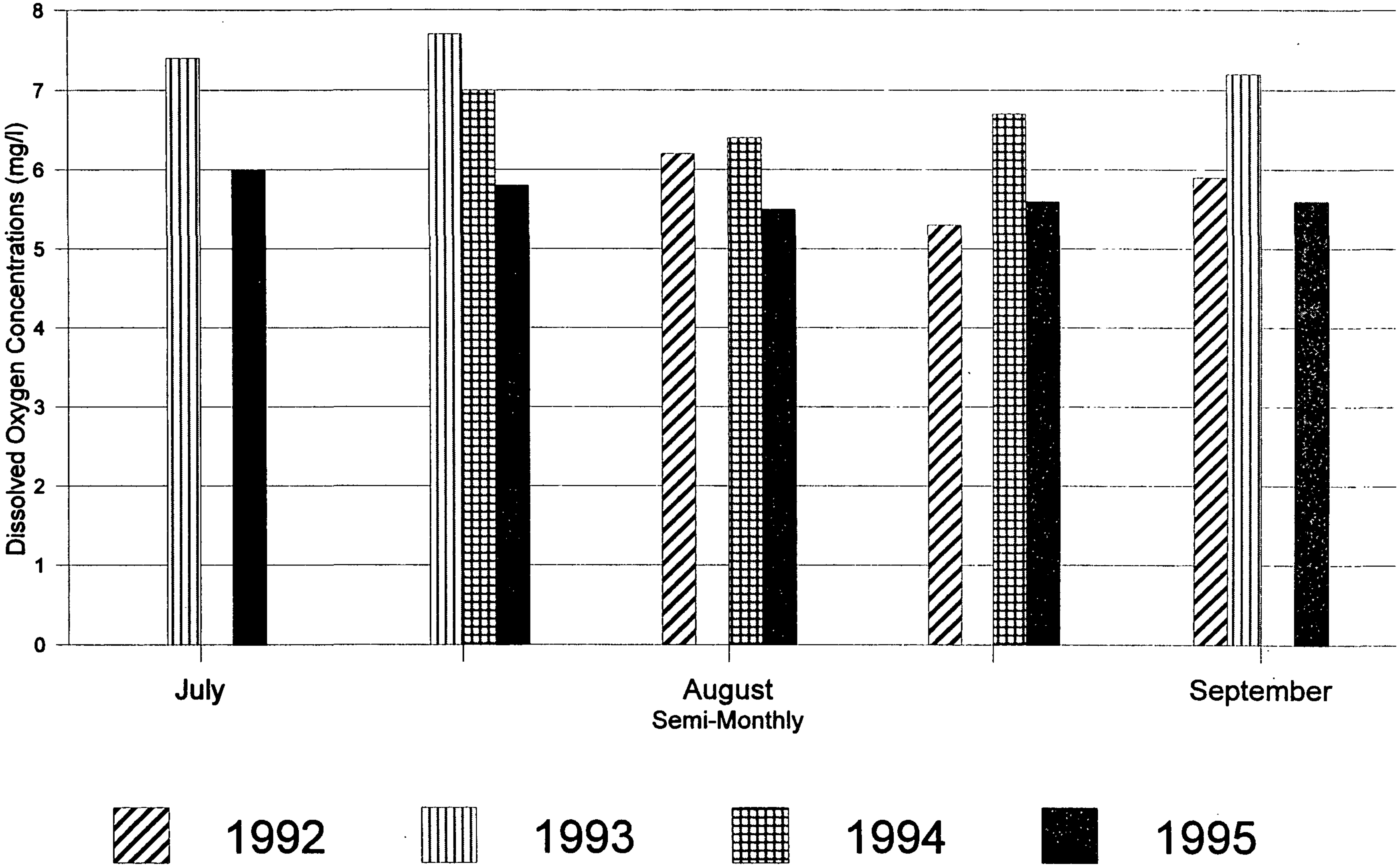


Figure 12

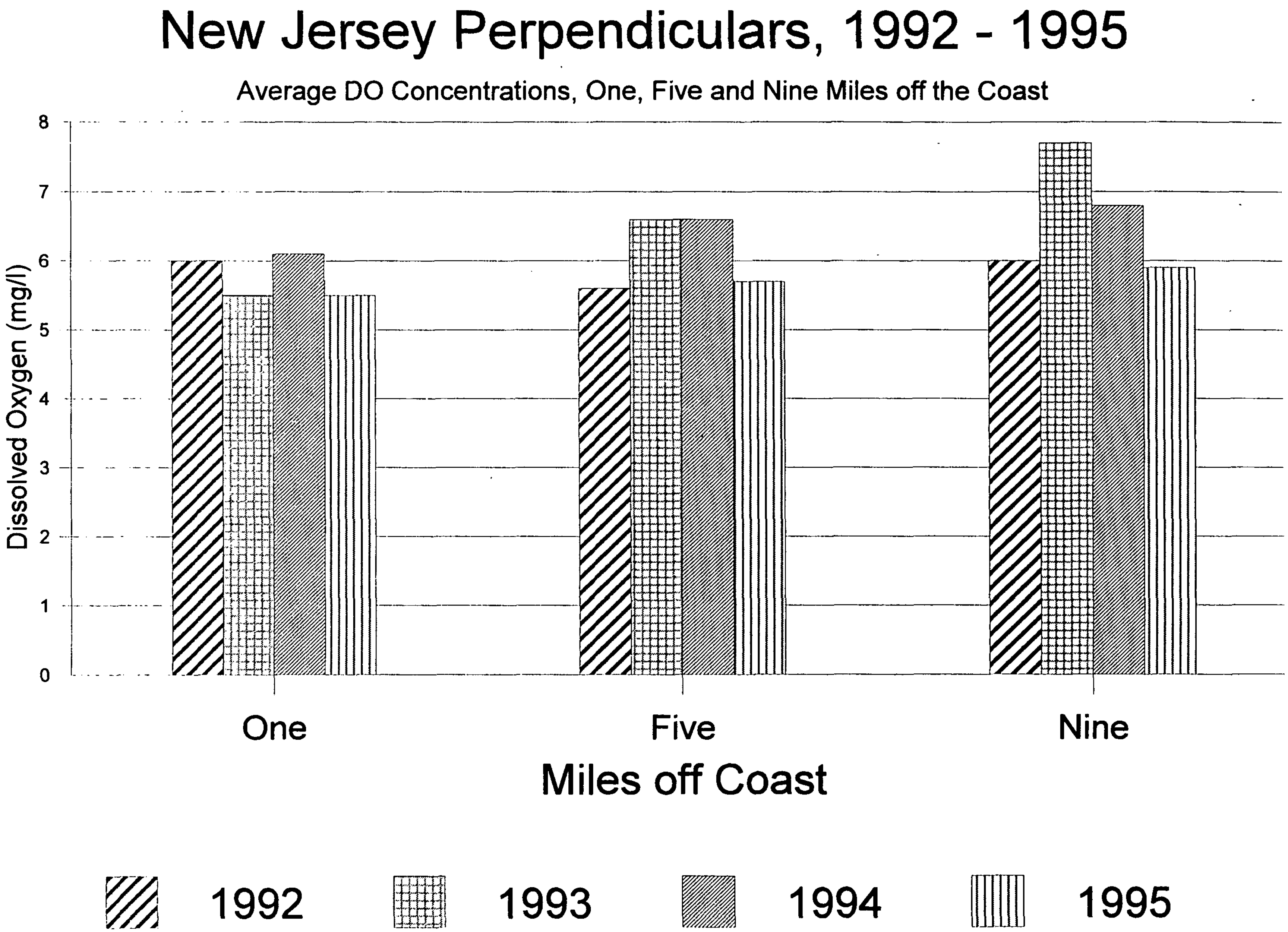
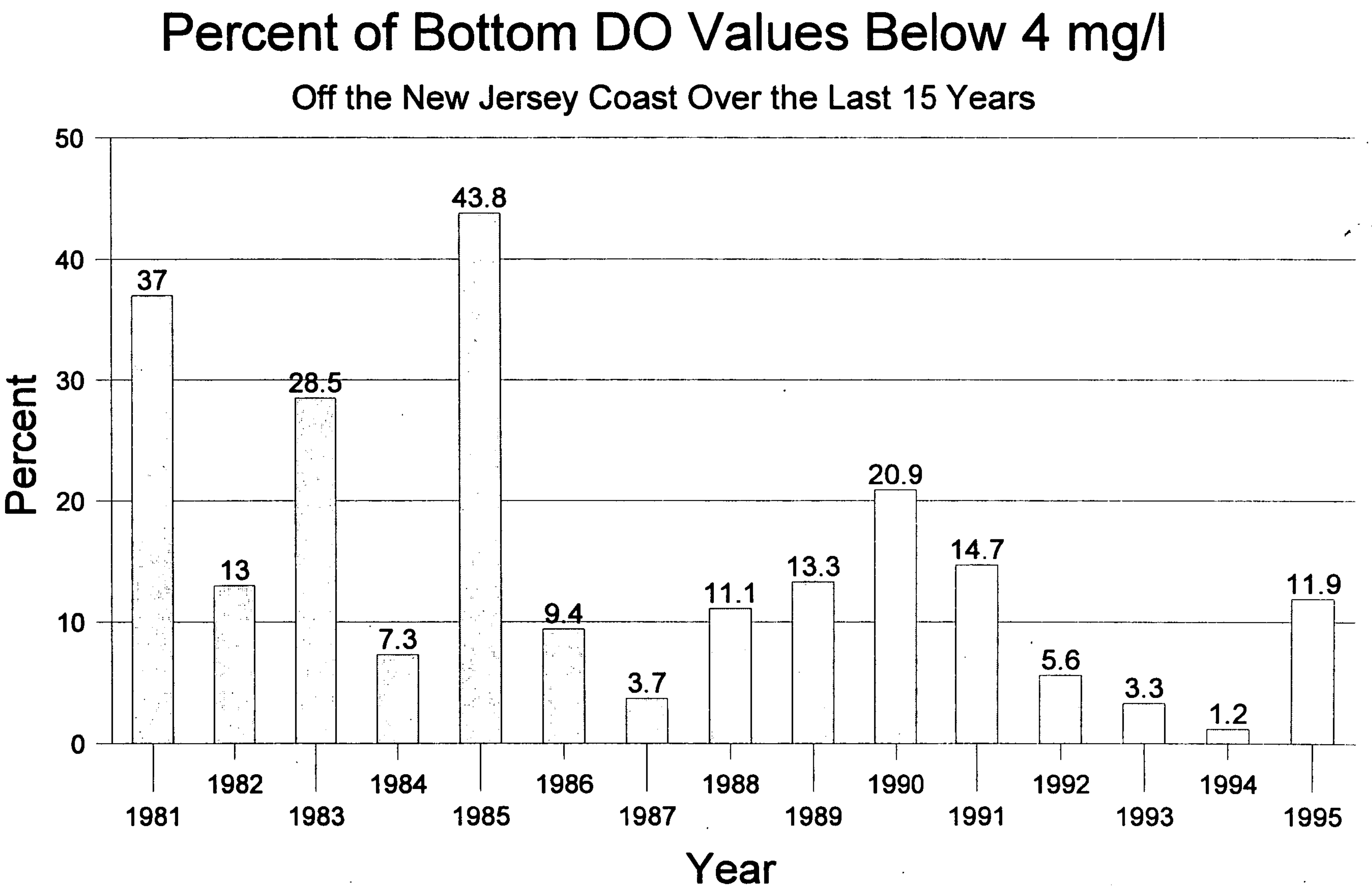

New Jersey Perpendiculars, 1992 - 1995
Average DO Concentrations, One, Five and Nine Miles off the Coast
Dissolved Oxygen (mg/l)
8
7
6
5
4
3
2
1
0
One
Five
Nine
Miles off Coast
1992
1993
1994
1995

Figure 13


Percent of Bottom DO Values Below 4 mg/l
Off the New Jersey Coast Over the Last 15 Years
Percent
0
10
20
30
40
50
37
13
28.5
7.3
43.8
9.4
3.7
11.1
13.3
20.9
14.7
5.6
3.3
1.2
11.9
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year

Since 1985, dissolved oxygen values have fluctuated with few values below 4 mg/l, and never approached the widespread hypoxia of 1985. This improvement is partially attributed to the increased storm activity in subsequent years, promoting reaeration; and the absence of a significant green tide event.

During the summer of 1995, few algal blooms were observed, strong winds prevailed, water temperature remained low, and there were numerous storms promoting reaeration. Based on these facts and the data collected, New Jersey coastal waters were of excellent quality in 1995.

VI. FLOATABLES OBSERVATIONS AND DISCUSSION

Purpose

During the summer of 1989, the USEPA initiated surveillance overflights of the New York/New Jersey Harbor Complex in response to the Short Term Action Plan for Addressing Floatable Debris. This Action Plan, which is part of the New York Bight Restoration Plan, was developed by an Interagency Floatable Task Force in an effort to prevent the occurrence of beach closures due to floatable debris, as occurred in previous years. Overflights of the New York/New Jersey Harbor Complex for floatable surveillance continued through 1995. All floatable observations were reported to either the Army Corps of Engineers, or the New York City Department of Environmental Protection. Cleanups were conducted as necessary.

In 1994, a joint effort by the Interagency Floatable Task Force, resulted in the acquisition of a new vessel to be owned and operated by New York City Department of Environmental Protection for collection of floatables debris in designated New York waterways. As a result, surveillance of the New York/New Jersey Harbor increased to include the following New York waterways (or expanded coverage sites): the southern portions of the Hudson and East Rivers, Gravesend Bay, the coastline of Coney Island, and the mouth of Jamaica Bay. This surveillance continued in 1995.

From mid May to mid September, 1989 - 1995, the New York/New Jersey Harbor Complex was surveyed for floatables, six days a week, weather permitting. For comparison, data from 1989, 1992, 1993, 1994 and 1995 will be presented.

Criteria for Reportable Floatables

For cleanup purposes, the Short Term Action Plan defined a "slick" as an aggregation of floating debris of indefinite width and a minimum length of approximately 400 meters. Using this as a guideline, all slicks have been divided into the following five categories (from largest to smallest):

Major: any slick more than 1600 meters in length;

Heavy: 800 meters to 1600 meters

Moderate: 400 meters to 800 meters;

Light: any slick less than 400 meters;

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

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

The categories of slicks are subjective. All floatable observations have been placed in one of the five categories according to the slick's estimated dimensions, relative density and other recorded observations. Any slick not meeting the length requirements that has a relatively heavy density or extensive width can be moved up a category; as any slick with a relative light density or broken pattern can be moved down a category.

Trends

Figure 14 displays the total number of slicks observed in the New York/New Jersey Harbor Complex divided into two categories: 1) slicks meeting cleanup requirements - major, heavy, and moderate, and 2) slicks not meeting cleanup requirements - minor and dispersed slicks. The sighting of slicks meeting cleanup requirements decreased steadily from 1989 to 1994, and increased significantly 1995. In 1989, 63 slicks were observed which met the cleanup requirements; in 1992, 38 slicks required cleanup; in 1993, 21 slicks required cleanup; in 1994, 19 slicks required cleanup and in 1995, 46

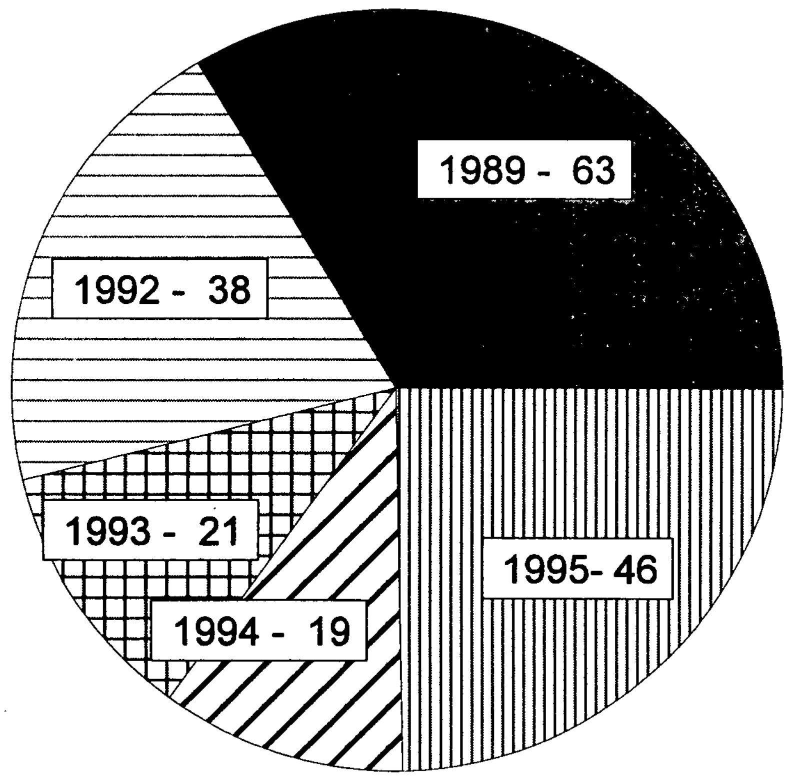
Figure 14

Total Number of Slicks Observed in the NY/NJ Harbor Comlpex

Mid May - Mid September, 1989, 1992, 1993, 1994 and 1995

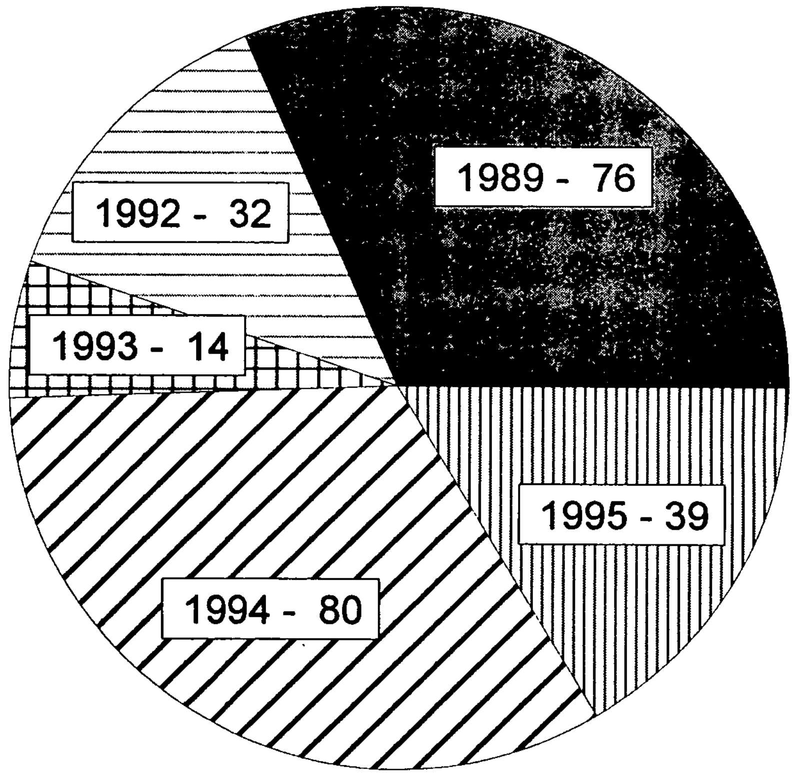
Pie 1

Slicks Meeting Cleanup Requirements



Pie 2

Minor and Dispersed Slicks



slicks required cleanup, see Pie Chart 1, Figure 14. The sightings of minor and dispersed slicks decreased from 1989 to 1993, and increased in 1994, see Pie Chart 2, Figure 14. The increase of minor and dispersed slicks in 1994, and the increase of slicks requiring cleanup in 1995, is partially due to the expanded coverage of the monitoring area, which began in 1994.

Figure 15 presents the total number of slicks observed by each size category for each year. As in Figure 14, slicks meeting cleanup requirements steadily decreased from 1989 to 1994, however, in 1995 slicks meeting cleanup requirements substantially increased in each category, moderate, heavy and major.

Figure 16 shows the total number of slicks reported corresponding to one of six locational divisions of the New York/New Jersey Harbor Complex, and the total number of slicks observed at the expanded coverage sites. The sighting of slicks generally decreased in the Verrazano Narrows, the Kill Van Kull, and the Lower New York Harbor. The sighting of slicks in the Upper New York Harbor and the Arthur Kill decreased from 1989 to 1993, but increased in 1994 and again in 1995. Slick sightings decreased from 1994 to 1995 at the expanded coverage sites.

Figure 17 displays the total number of slicks observed at the expanded coverage sites divided by the size categories. Gravesend Bay had the greatest number of slicks observed, ten slicks in 1994 and six slicks in 1995. The greatest number of slicks observed meeting the cleanup requirements, three slicks, occurred at Coney Island, in 1995.

From 1989 to 1994, there has been a significant reduction of floatable slicks requiring cleanups. However, an increase in slicks requiring cleanup did occur in 1995, subsequently, programs directly attributed to reducing slicks are still needed. A reduction of slicks can be directly attributed to the initiation of beach and litter cleanup activities, such as

Figure 15

Total Number of Slicks Observed in the New York/New Jersey Harbor Complex

By Size Category in 1989, 1992, 1993, 1994 and 1995

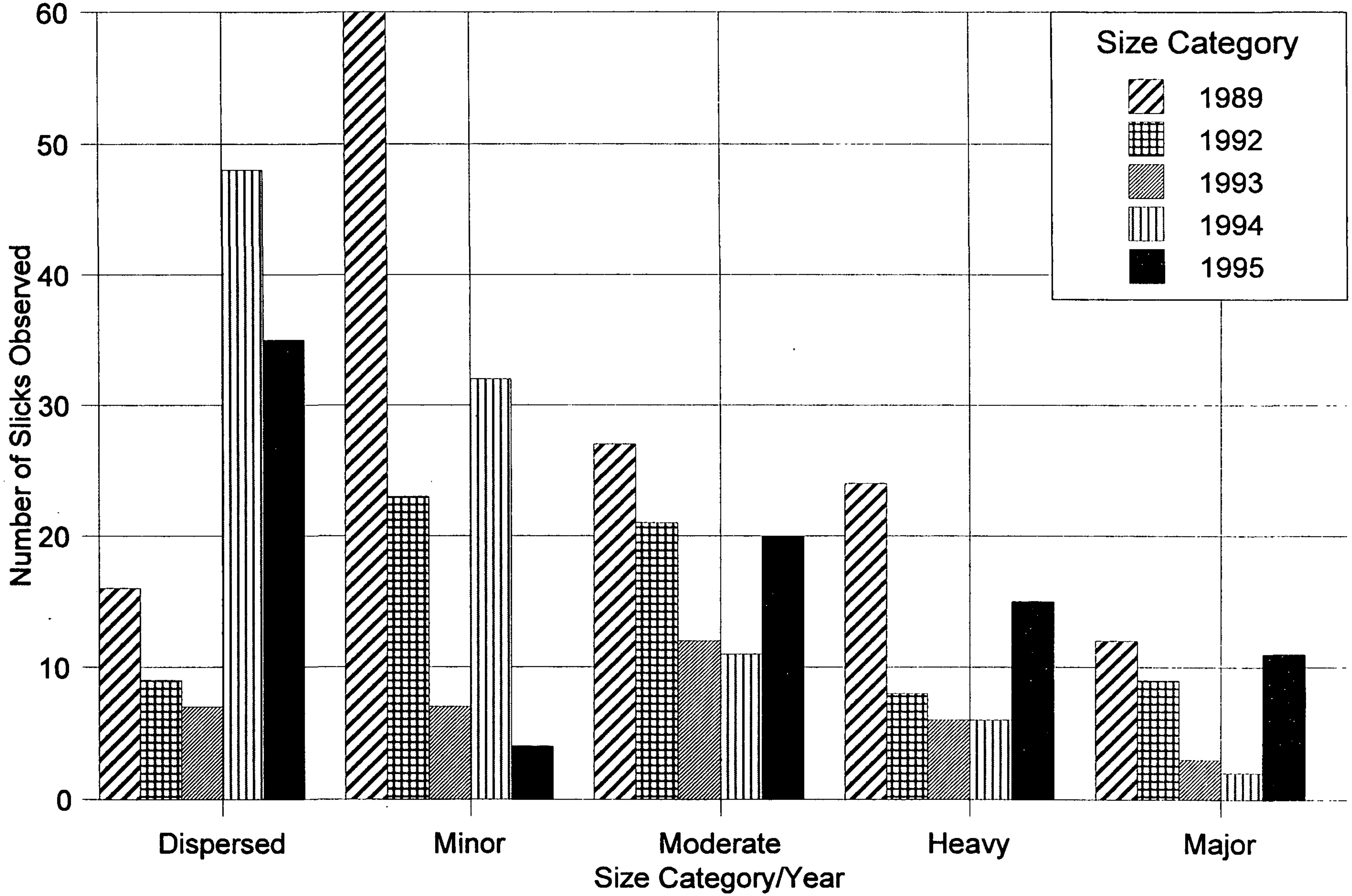


Figure 16

Total Number of Slicks Observed in the New York/New Jersey Harbor Complex

By Locational Subdivision in 1989, 1992, 1993, 1994 and 1995

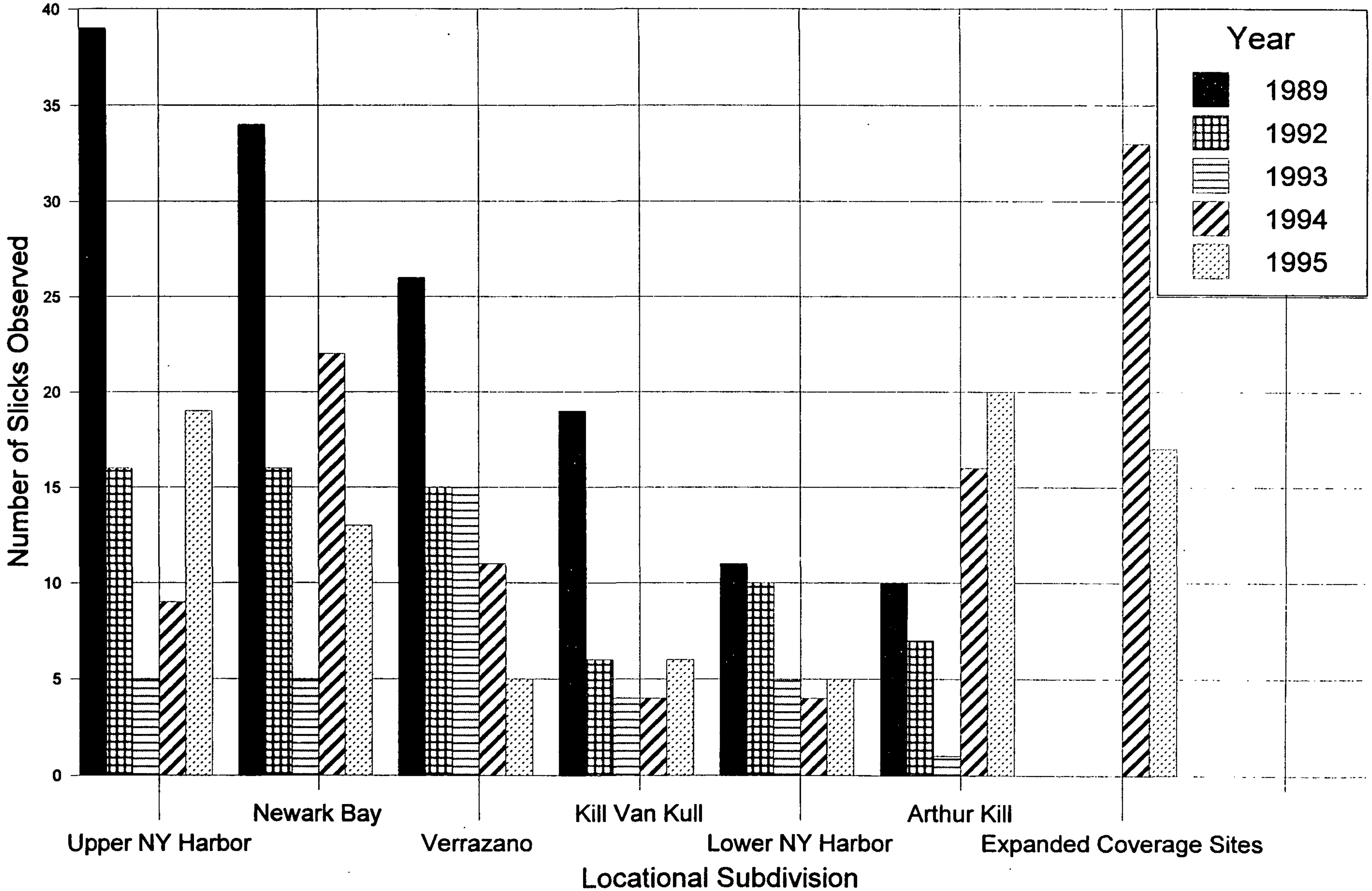
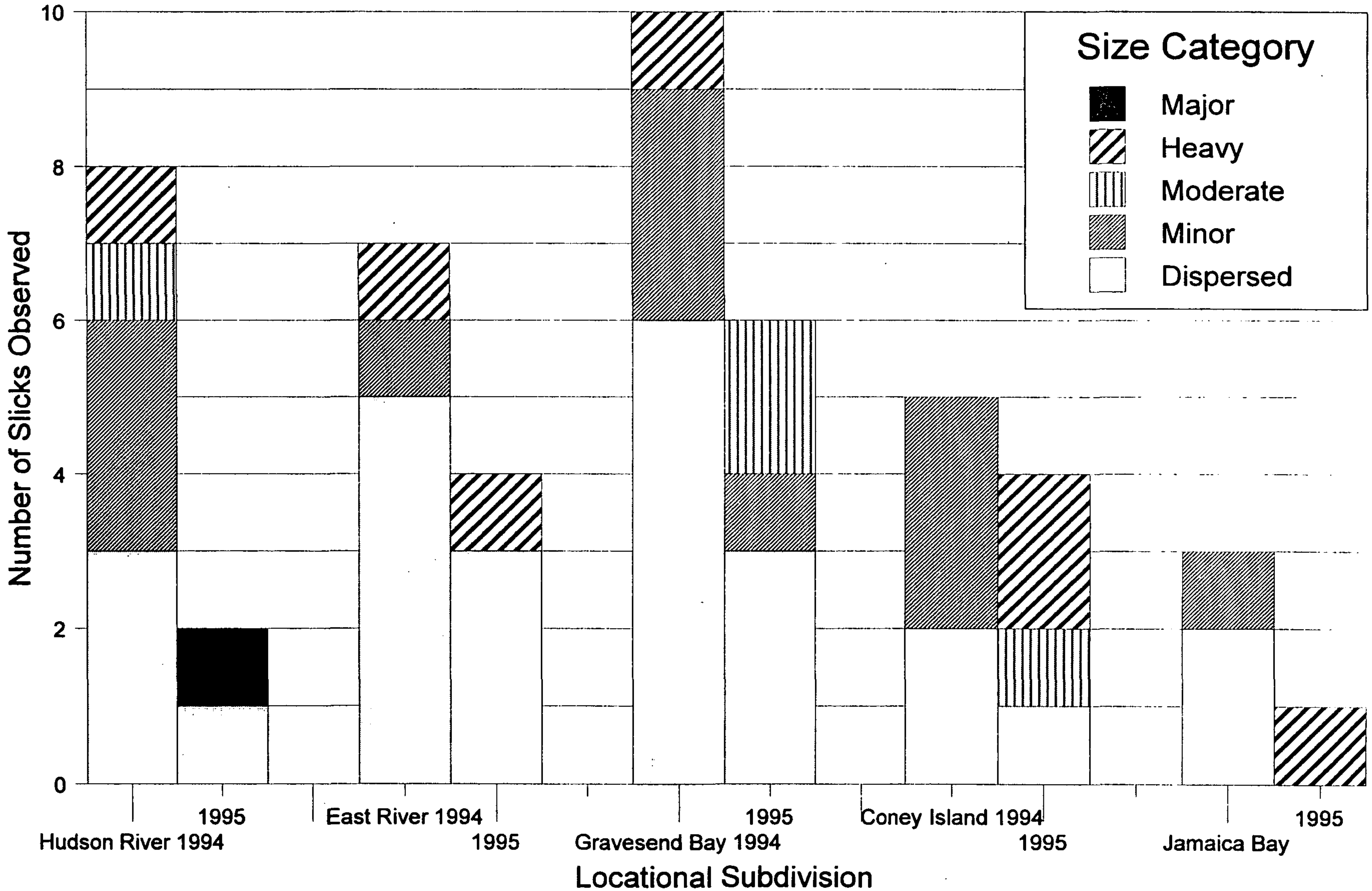


Figure 17

Total Number of Slicks Observed at Expanded Coverage Sites, 1994 and 1995

Divided by Size Categories



the Short Term Action Plan, the Clean Streets/Clean Beaches campaign, and Operation Clean Shores. The Clean Streets/Clean Beaches campaign commenced in 1992 by a coalition of metropolitan-area public and private groups. The campaign stresses public education on the link between street and beach litter. Operation Clean Shores, a program utilizing prisoners, was initiated by the New Jersey Department of Environmental Protection in 1989 to remove floatable debris from impacted shorelines. Increasing the program from seasonal to year-round, and with the cooperation from participating municipalities, 11.6 million pounds of floatables were removed in 1992, 11.5 million pounds in 1993, 7.4 million pounds in 1994, and 4.1 million pounds in 1995. Although the amount of debris has lessened, the miles of shoreline coverage have fluctuated as follows: 72 miles of shoreline were cleaned in 1992, 62 miles in 1993 and 1994, and 80 miles in 1995 (Rosenblat). More programs such as these would help reduce the amount of floatable debris. Removal of floatables from impacted shorelines prevents the material from resuspending into the water column and washing up on other shorelines or bathing beaches.

BIBLIOGRAPHY

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

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

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

4. Rosenblat, David, New Jersey Departmant of Environmental Protection, personal communication, 4 June 1995.

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

6. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1979", Environmental Services Division, Region 2, Edison, New Jersey, 1979.

7. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1980", Environmental Services Division, Region 2, Edison, New Jersey, 1981.

8. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1981", Environmental Services Division, Region 2, Edison, New Jersey, 1982.

9. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1982", Environmental Services Division, Region 2, Edison, New Jersey, 1983.

10. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1983", Environmental Services Division, Region 2, Edison, New Jersey, 1984.

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

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

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

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

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

16. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1988", Environmental Services Division, Region 2, Edison, New Jersey, July 1989.

17. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1989", Environmental Services Division, Region 2, Edison, New Jersey, August 1990.

18. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1990", Environmental Services Division, Region 2, Edison, New Jersey, July 1991.

19. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1991", Environmental Services Division, Region 2, Edison, New Jersey, September 1992.

20. U.S. Environmental Protection Agency; "New York Bight Water Quality Summers of 1992 and 1993", Environmental Services Division, Region 2, Edison, New Jersey, April 1994.

21. U.S. Environmental Protection Agency; "New York Bight Water Quality Summer of 1994", Environmental Services Division, Region 2, Edison, New Jersey, December 1995.

APPENDIX A

Microbiological Water Quality

New York Bight Summer 1995

MICROBIOLOGICAL WATER QUALITY

NEW YORK BIGHT

SUMMER 1995

Introduction

A study of the density* of fecal coliform and enterococcus organisms was conducted in 1995 as part of the continuing annual monitoring of the nearshore waters off the Long Island and New Jersey coasts.

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

Investigations have shown that agents of bacterial disease, enteropathogenic/toxigenic Escherichia coli, Pseudomonas aeruginosa, Klebsiella, Salmonella, and Shigella are excreted in large numbers in the feces of infected individuals, and are thus potentially present in sewage. Members of the genera Salmonella & Shigella are not indicator but legitimate intestinal pathogens. Clostridium perfringens, a pathogen, which are present as normal flora in man, and warm-blooded animals, are also excreted in large numbers (2). It is common practice to use an indicator organism to detect fecal contamination because of the ease of isolating and quantitating certain microorganisms on membrane filters. Elaborate procedures are usually required for the detection of most pathogens in mixed populations. When numerous indicator organisms are present, the likelihood of pathogens being found is far greater.

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

---

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

the total coliforms. This would indicate that detectable health effects may occur at a fecal coliform level above approximately 400/100 ml. A limit of 200 fecal coliforms per 100 ml would therefore provide a quality of water which should exceed that which would cause a detectable health effect (3).

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

Fecal Coliform Indicator Bacteria

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

Enterococcus Group: Indicator Bacteria

Enterococci are a subgroup of the fecal streptococci. The occurrence of fecal streptococci in water indicates fecal contamination from warm-blooded animals. One is able to pinpoint the source of fecal contamination (such as human, equine, bovine, avian) by identifying the species utilizing biochemical tests. The enterococcus group includes the following species: *Enterococcus faecalis*; *Enterococcus faecalis*, subspecies *liquefaciens*; *Enterococcus faecalis*, subspecies *zymogenes*; and *Enterococcus faecium*. *Enterococcus faecalis*, one of the group D streptoccal species, grows in broth containing 6.5% NaCl, hydrolyzes arginine and utilizes pyruvate (4-6). *Enterococcus faecium* grows in 6.5% NaCL broth, hydrolyzes arginine, but does not utilize pyruvate. *Streptococcus bovis* does not grow in 6.5% NaCl broth, does not hydrolyze arginine, and does not utilize pyruvate. These are the three most common species of group D streptococci found as pathogens in human infection. *Enterococcus durans* is isolated occasionally, and *Streptococcus equinus* is found rarely (7).

The taxonomy and nomenclature of the streptococci have undergone major changes over the past few years. Primarily on the basis of the results of DNA-DNA hybridization studies two new genera, *Enterococcus* and *Lactococcus* have been proposed to accommodate the fecal group D and lactic group N streptococci respectively (8).

EPA has recently published the results of two research projects which compared the relationship between illnesses associated with bathing in recreational waters and ambient densities of several indicator organisms (9). One study was performed on marine bathing beaches and one on freshwater beaches. Studies at marine and fresh water bathing beaches indicated that gastroenteritis is directly related to the quality of the bathing water and that enterococci is a better indicator of water quality than fecal coliforms (1,3).

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

Materials and Methods

Marine water samples were collected by helicopter from May to September 1995. The samples were collected using a Kemmerer sampler and transferred to 500 ml sterile, wide-mouthed plastic containers, and then transported in an ice chest, with ice cubes, to the Region 2 Edison laboratory for bacteriological analysis.

Fecal coliform determinations were conducted according to the membrane filtration (MF) procedures described in Standard Methods, 18th edition, 1992 (4) and Microbiological Methods for Monitoring the Environment, Water and Wastewater, (5) Enterococci determinations were conducted according to the MF procedure described by Levin (10), and DuFour (11), using the modified mE media. Confirmation of enterococci colonies were conducted following procedures outlined in Microbiological Methods for Monitoring the Environment, Water and Wastewater, (5).

Results and Discussion

Fecal Coliform - New Jersey

Along the New Jersey Coast, fecal coliform densities equal to or greater than 50/100 ml occurred on five occasions at station JC-26 (Shark River Inlet), JC-49 (Lavallette, off the foot of Washington Avenue), JC-96 (Cape May Inlet). It was noted that at station JC-26 fecal coliform densities equal to or greater than 50/100 ml occurred on 3 occasions two weeks apart. (Tables 1 & 2 and Figure 1).

Fecal Coliform - Long Island

Fecal coliform densities greater than 50/100 ml occurred on three occasions at station LIC-05 (Far Rockaway, off the foot of B41 Road), LIC-08 (Long Beach, off the foot of Grand Avenue), LIC-16 (Cedar Island Beach). (Tables 3 & 4 and Figure 2).

Enterococci - New Jersey

Enterococci densities exceeding the standard of 35/100 ml occurred on two occasions at station JC-14 (Long Branch, off the foot of South Bath Avenue)., and JC-96 (Cape May Inlet). (Tables 5 & 6 and Figure 3).

Enterococci - Long Island

Enterococci densities exceeding the standard of 35/100 ml occurred at station LIC-09 (Long Beach, off of the foot of Pacific Boulevard) and at LIC-10 (Point Lookout, off of Hempstead public beach). (Tables 7 & 8 and Figure 4).

For the majority of New Jersey and Long Island Coastal Station low fecal coliform geometric mean densities per 100 ml were observed.

New Jersey had high maximum peaks on specific dates similar to prior years. Long Island had higher maximum peaks on specific dates than in prior year. This profile is visually presented in the geometric mean value of fecal coliform densities in Figures 1 and 2.

Geometric mean densities for enterococci along the New Jersey and Long Island Coastal Stations were somewhat higher than in prior years. These profiles are visually evident in Figures 3 and 4.

Numerous studies addressing the disappearance of fecal coliform and enterococci in marine waters show extremely varied results. Bacterial survival is affected by numerous physical and biological parameters (12).

REFERENCES

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

2. O'Reilly, J.E., I.J. Katz, & A.F.J. Draxler. 1995. Changes in the aboundance and distribution of Clostridium perfringens, a microbial indicator, related to cessation of sewage sludge dumping in the New York Bight. In A. Studholme, J. O'Reilly, and M. Ingham (eds.). Effects of the cessation of sewage sludge dumping at the 12-mile site. Proceedings of the 12-mile dumpsite symposium. P. 113-132. NOAA Technical Report NMFS 124.

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

4. Standard Methods for the Examination of Water and Wastewater. 1992. 18th ed., American Public Health Association. Washington, DC.

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

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

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

8. Schleifer, K.H. 1984. Transfer of Streptococcus faecalis and Streptococcus faecium to the genus Enterococcus nom. rev. as Enterococcus faecalis comb. nov. and Enterococcis faecium. Comb. nov. Int. J. Syst. Bacteriolog 34:31-34

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

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

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

12. Bonnefont, Y.P. et al. 1990. Experimental Studies on the Survival of Fecal Bacteria from Urban Sewage in Seawater Wat. Res. 24:267-273.

TABLE 1
FECAL COLIFORM DENSITIES > 50 PER 100ML
NEW JERSEY COAST STATIONS
SUMMER 1995

OBS	STATION	DATE	VALUE
1	JC26	071295	50
2	JC26	072695	116
3	JC26	080995	172
4	JC49	072695	57
5	JC96	080995	400

TABLE 2
GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STARIONS
SUMMER 1995

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	1.46807	0	9	14
2	JC03	1.33312	0	28	14
3	JC05	1.51514	0	12	14
4	JC08	1.38545	0	12	14
5	JC11	1.35727	0	6	14
6	JC13	1.85104	0	11	14
7	JC14	1.79223	0	7	14
8	JC21	1.51121	0	6	14
9	JC24	2.02051	0	12	14
10	JC26	7.04521	0	172	13
11	JC27	2.26301	0	18	13
12	JC30	1.24899	0	3	13
13	JC33	1.56983	0	8	12
14	JC35	1.13431	0	4	11
15	JC37	1.78972	0	10	12
16	JC41	1.33484	0	8	12
17	JC44	1.33827	0	11	12
18	JC47A	1.49831	0	8	12
19	JC49	2.19210	0	57	12
20	JC53	2.37592	0	21	12
21	JC55	1.12246	0	4	12
22	JC57	1.05946	0	2	12
23	JC59	1.05946	0	2	12
24	JC61	1.39856	0	8	12
25	JC63	1.09587	0	3	12
26	JC65	1.33484	0	8	12
27	JC67	1.17690	0	6	11
28	JC69	1.22109	0	3	11
29	JC73	1.31303	0	5	11
30	JC74	1.58261	0	13	11
31	JC75	2.85560	0	22	11
32	JC77	1.83619	0	5	11
33	JC79	1.61277	0	12	11
34	JC81	1.87719	0	17	11
35	JC83	2.21479	0	37	11
36	JC85	1.47519	0	12	11
37	JC87	1.44187	0	7	11
38	JC89	1.69134	0	9	11
39	JC92	2.33875	0	17	10
40	JC93	1.66929	0	14	10
41	JC95	1.28209	0	6	10
42	JC96	1.82056	0	400	10
43	JC97	1.41421	0	8	10
44	JC99	2.10744	0	24	10

Figure 1

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1995

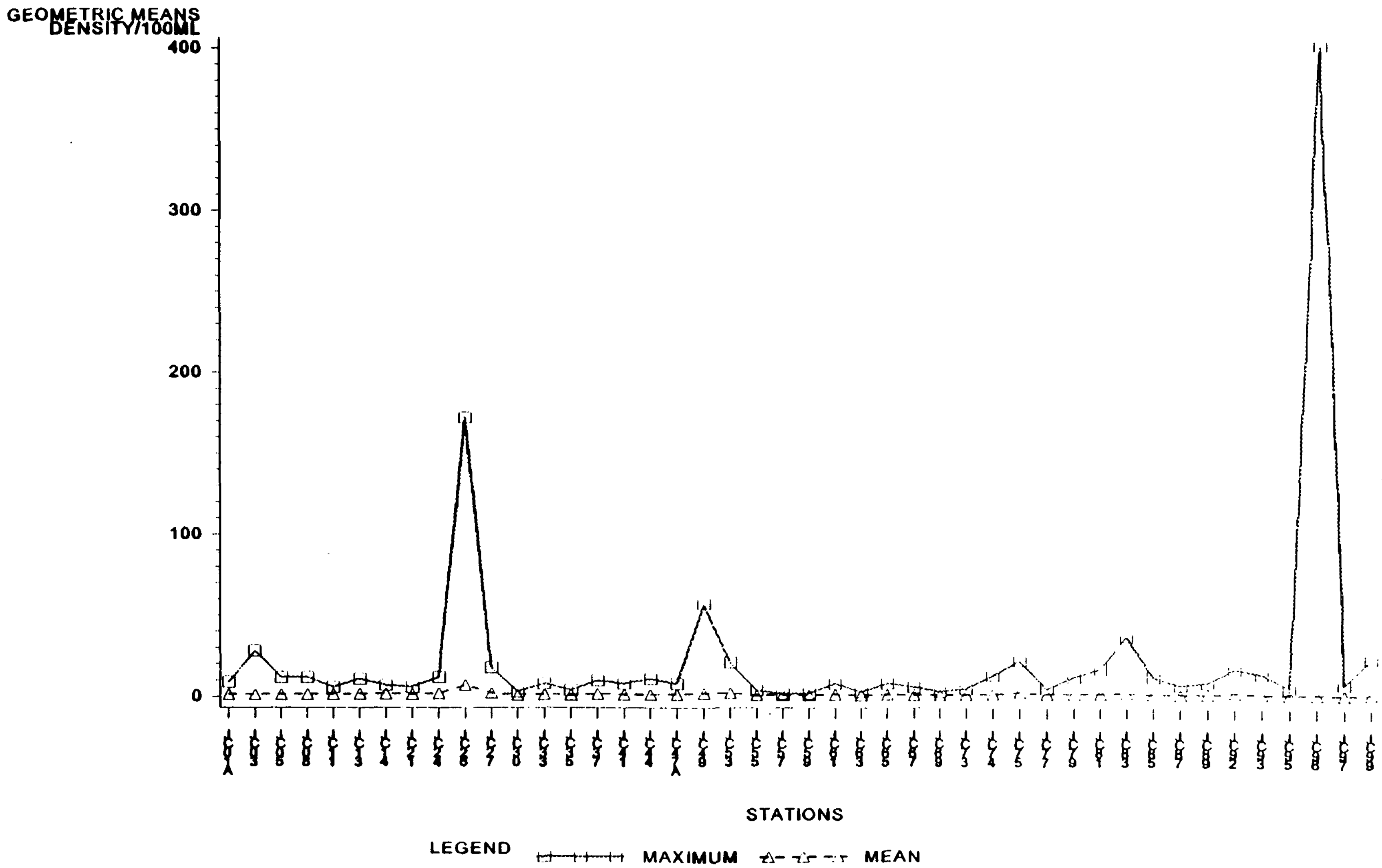


TABLE 3
FECAL COLIFORM DENSITIES > 50 PER 100ML
LONG ISLAND COAST STATIONS
SUMMER 1995

OBS	STATION	DATE	VALUE
1	LIC05	071895	200
2	LIC08	072595	86
3	LIC16	080895	67

TABLE 4
GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1995

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	1.69592	0	40	13
2	LIC02	1.50315	0	10	13
3	LIC03	2.15412	0	12	13
4	LIC04	2.40512	0	16	13
5	LIC05	2.52865	0	200	13
6	LIC07	1.84767	0	39	13
7	LIC08	2.19112	0	86	13
8	LIC09	1.41360	0	6	13
9	LIC10	2.03216	0	15	13
10	LIC12	1.18921	0	4	12
11	LIC13	1.45225	0	22	12
12	LIC14	1.05946	0	2	12
13	LIC15	1.33484	0	8	12
14	LIC16	2.88874	0	67	12
15	LIC17	1.21153	0	10	12
16	LIC18	1.55954	0	23	12
17	LIC19	1.52957	0	41	12
18	LIC20	1.34160	0	17	12
19	LIC21	1.28880	0	21	12
20	LIC22	1.00000	0	1	12
21	LIC23	1.27235	0	6	12
22	LIC24	1.12246	0	4	12
23	LIC25	1.10503	0	3	11
24	LIC26	1.13431	0	4	11
25	LIC27	1.25345	0	6	11
26	LIC28	1.22109	0	9	11

Figure 2

GEOMETRIC MEANS OF FECAL COLIFORM DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1995

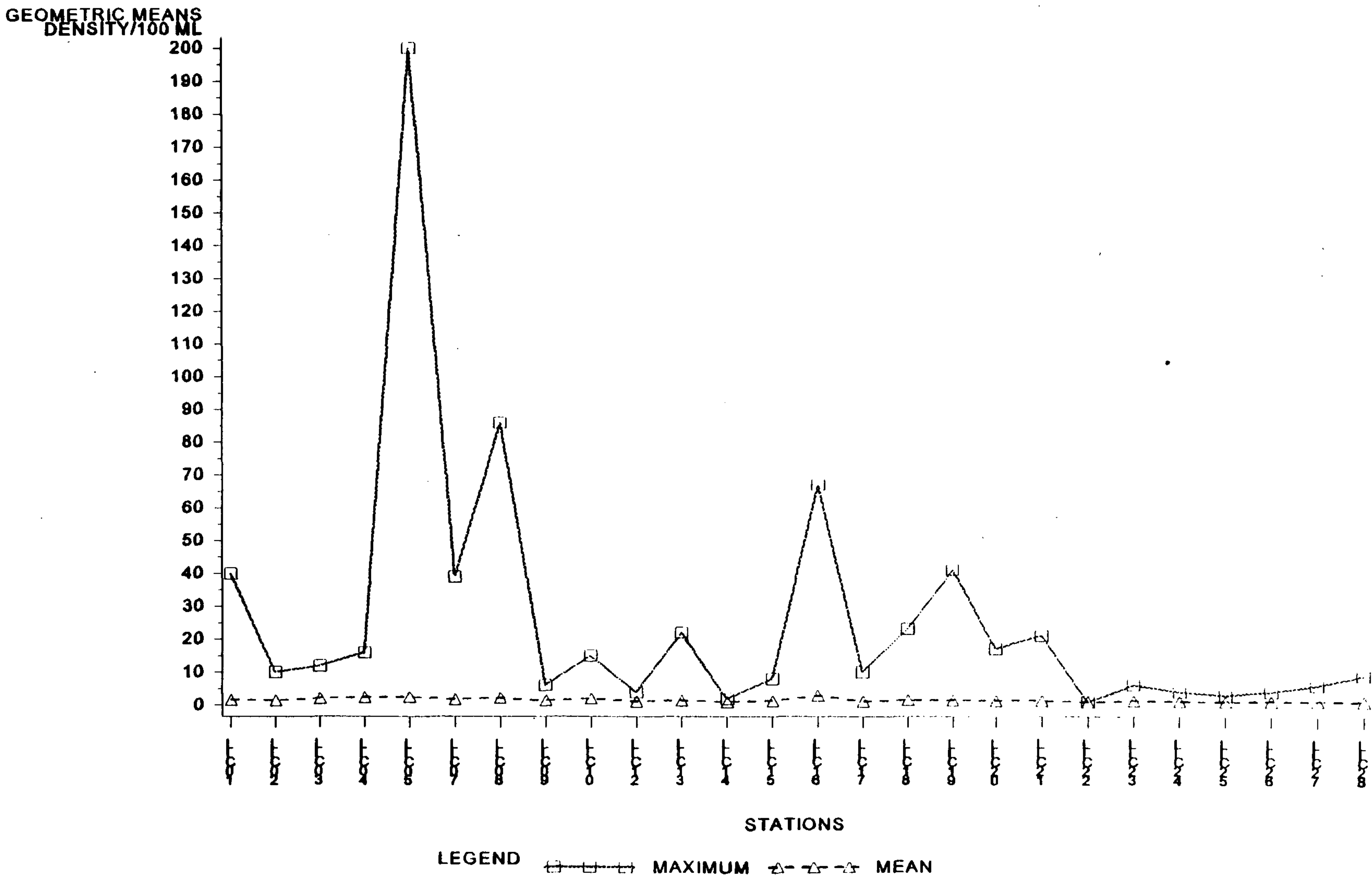


TABLE 5

ENTEROCOCCUS DENSITIES > 35 PER 100ML
NEW JERSEY COAST STATIONS
SUMMER 1995

OBS	STATION	DATE	VALUE
1	JC14	061495	45
2	JC96	080995	1040

TABLE 6
GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1995

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	JC01A	1.11253	0	2	13
2	JC03	1.11253	0	4	13
3	JC05	1.34687	0	8	13
4	JC08	1.00000	0	1	13
5	JC11	1.38345	0	17	13
6	JC13	1.21064	0	6	13
7	JC14	1.51683	0	45	13
8	JC21	1.40612	0	28	13
9	JC24	1.21064	0	12	13
10	JC26	1.95671	0	21	12
11	JC27	1.33484	0	8	12
12	JC30	1.33484	0	16	12
13	JC33	1.06504	0	2	11
14	JC35	1.00000	0	0	10
15	JC37	1.57114	0	12	11
16	JC41	1.28666	0	4	11
17	JC44	1.10503	0	3	11
18	JC47A	1.28666	0	8	11
19	JC49	1.43711	0	18	11
20	JC53	1.17690	0	3	11
21	JC55	1.20809	0	8	11
22	JC57	1.13431	0	4	11
23	JC59	1.25345	0	4	11
24	JC61	1.28666	0	16	11
25	JC63	1.17690	0	6	11
26	JC65	1.17690	0	3	11
27	JC67	1.07177	0	2	10
28	JC69	1.19623	0	3	10
29	JC73	1.14870	0	4	10
30	JC74	1.00000	0	1	10
31	JC75	1.37411	0	6	10
32	JC77	1.46326	0	9	10
33	JC79	1.94023	0	18	10
34	JC81	1.25893	0	5	10
35	JC83	1.07177	0	2	10
36	JC85	1.47273	0	24	10
37	JC87	1.44613	0	20	10
38	JC89	1.23114	0	8	10
39	JC92	1.84851	0	7	9
40	JC93	1.12983	0	3	9
41	JC95	1.39495	0	20	9
42	JC96	2.64051	0	1040	9
43	JC97	1.08006	0	2	9
44	JC99	1.56402	0	7	9

Figure 3

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
NEW JERSEY COAST STATIONS
SUMMER 1995

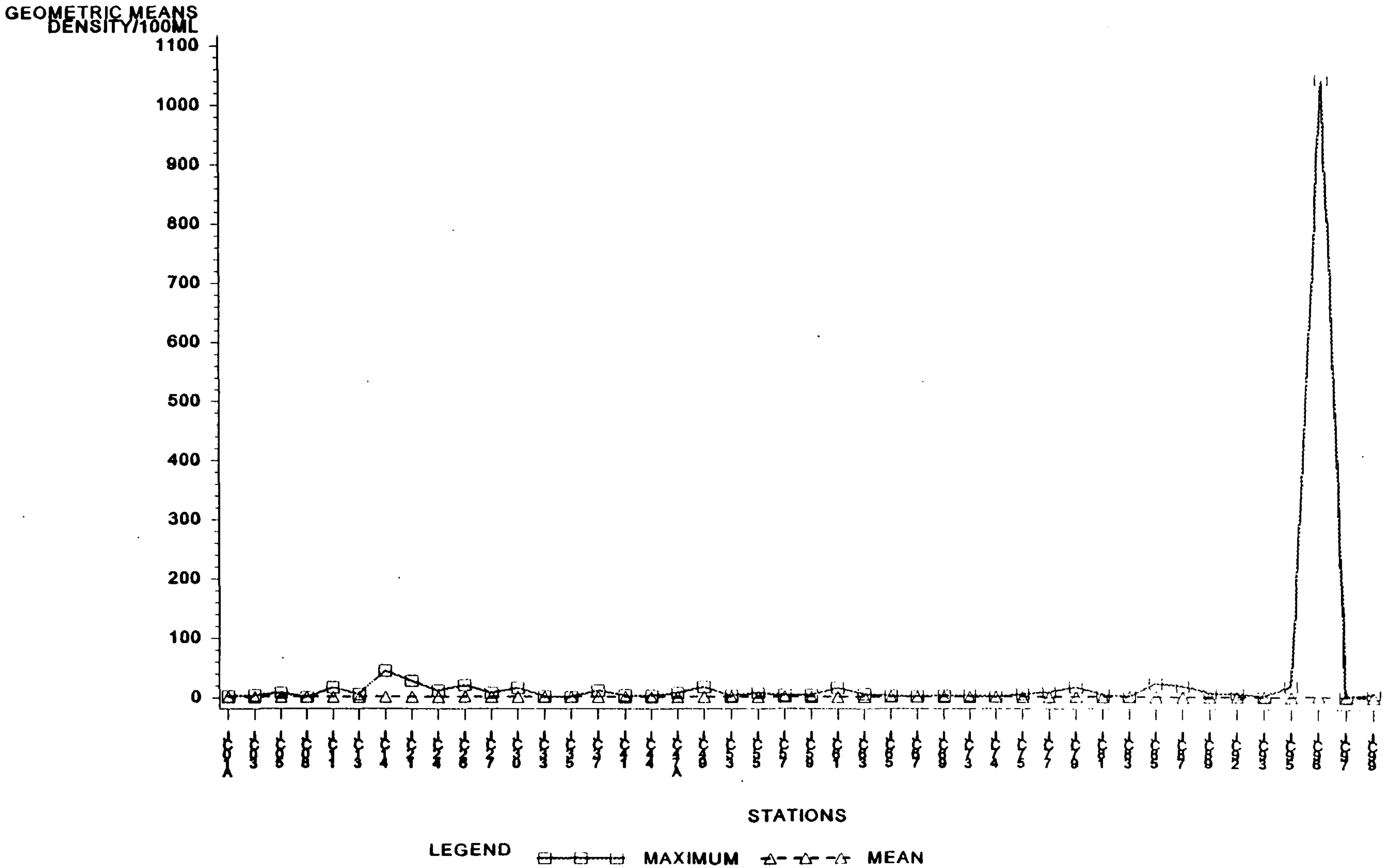


TABLE 7

ENTEROCOCCUS DENSITIES > 35 PER 100ML
LONG ISLAND COAST STATIONS
SUMMER 1995

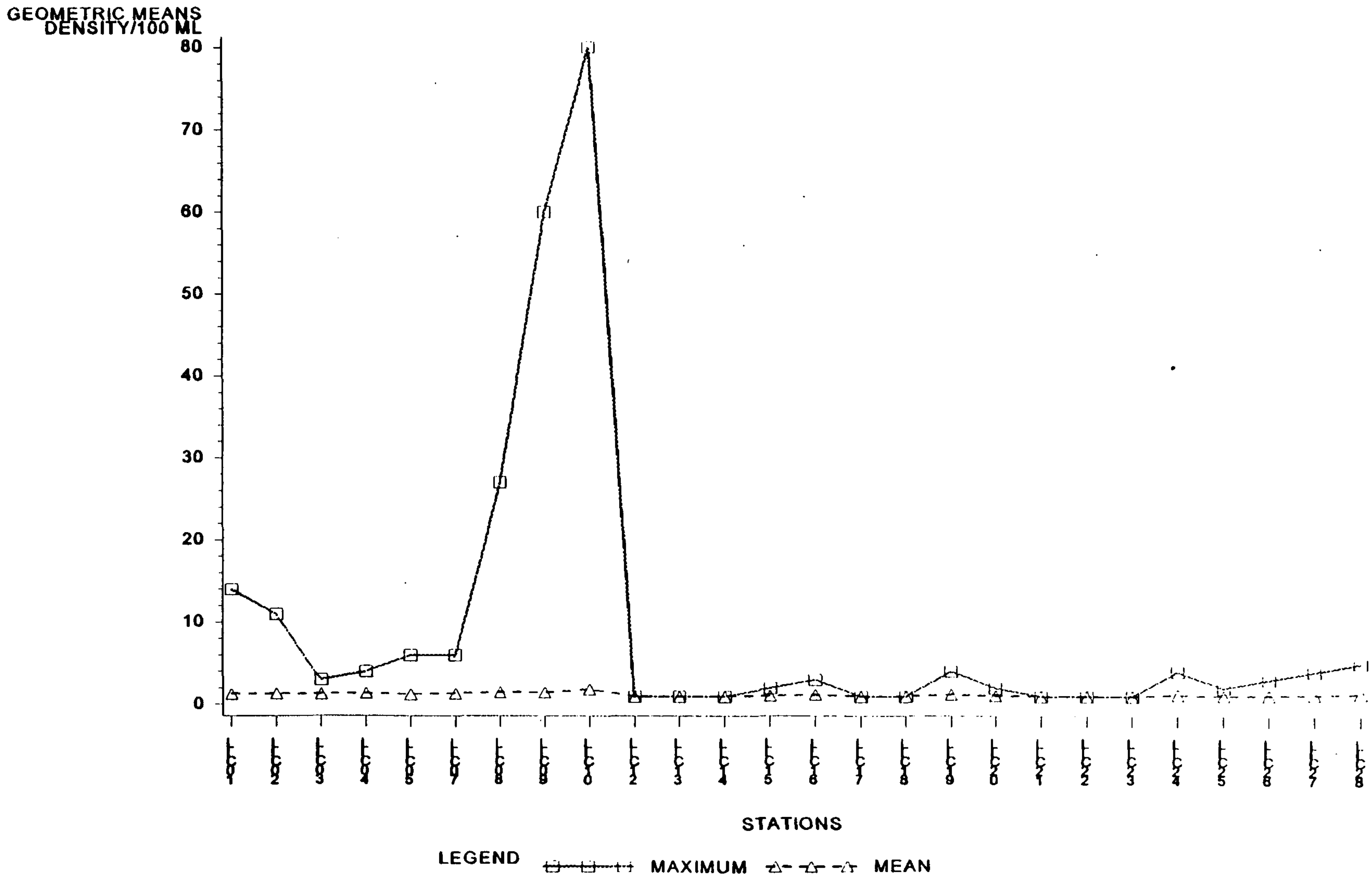
OBS	STATION	DATE	VALUE
1	LIC09	072595	60
2	LIC10	072595	80

TABLE 8
GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1995

OBS	STATION	MEAN	MINIMUM	MAXIMUM	N
1	LIC01	1.27114	0	14	11
2	LIC02	1.32446	0	11	11
3	LIC03	1.30052	0	3	11
4	LIC04	1.38510	0	4	11
5	LIC05	1.25345	0	6	11
6	LIC07	1.33498	0	6	11
7	LIC08	1.49107	0	27	11
8	LIC09	1.45094	0	60	11
9	LIC10	1.86688	0	80	11
10	LIC12	1.00000	0	0	10
11	LIC13	1.00000	0	1	10
12	LIC14	1.00000	0	0	10
13	LIC15	1.07177	0	2	10
14	LIC16	1.19623	0	3	10
15	LIC17	1.00000	0	1	10
16	LIC18	1.00000	0	1	10
17	LIC19	1.23114	0	4	10
18	LIC20	1.07177	0	2	10
19	LIC21	1.00000	0	1	10
20	LIC22	1.00000	0	0	10
21	LIC23	1.00000	0	0	10
22	LIC24	1.23114	0	4	10
23	LIC25	1.07177	0	2	10
24	LIC26	1.11612	0	3	10
25	LIC27	1.23114	0	4	10
26	LIC28	1.34928	0	5	10

Figure 4

GEOMETRIC MEANS OF ENTEROCOCCUS DENSITIES
LONG ISLAND COAST STATIONS
SUMMER 1995



APPENDIX B

Summary of Phytoplankton Blooms and

Related Conditions in New Jersey

Coastal Waters

Summer of 1995

NJ Department of Environmental Protection
Division of Science and Research
CN 422, Trenton, NJ 08625-0422

WATER MONITORING MANAGEMENT
James Mumman, Administrator

April, 1996

ANNUAL SUMMARY OF PHYTOPLANKTON BLOOMS AND RELATED CONDITIONS IN NEW JERSEY COASTAL WATERS SUMMER OF 1995

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF SCIENCE AND RESEARCH
OFFICE OF WATER MONITORING MANAGEMENT
BUREAU OF WATER MONITORING
BIOMONITORING UNIT

Paul Olsen, project manager
John Kurtz
Barbara Kurtz

ANNUAL SUMMARY OF PHYTOPLANKTON BLOOM AND RELATED CONDITIONS IN NEW JERSEY COASTAL WATERS SUMMER OF 1995

INTRODUCTION

The New Jersey Department of Environmental Protection (DEP) each summer monitors phytoplankton assemblages and red tide blooms in its coastal waters and major estuaries with regard to water quality conditions. This information, obtained cooperatively with the US Environmental Protection Agency (EPA) Region II, is summarized for the 1995 season. These results complement the dissolved oxygen and sanitary bacteriological data also gathered during their annual New York Bight Water Quality Survey [1] and the Coastal Cooperative Monitoring Program (CCMP) involving DEP and the shore county health agencies [2].

Routine helicopter surveillance and sample collections in coastal waters of the New York Bight commenced in 1977 following the massive offshore *Ceratium tripos* bloom, which was associated with oxygen depletion and consequent widespread fish mortalities [3]. Prior to this, beginning in 1973, the NJDEP and the national Marine Fisheries Service (NMFS) Sandy Hook Laboratory conducted an intensive phytoplankton survey of the New Jersey northern estuarine and coastal area [4]. Red tides caused by a few species of phytoflagellates, including *Olisthodiscus luteus*, *Prorocentrum* spp and *Katodinium rotundatum*, have been recurrent in this region since the early 1960's. The blooms often extended from the Hudson-Raritan estuary southward along the NJ coast, sometimes as far as Shark River or beyond. The blooms have been associated with hypertrophication in the region [5]. Adverse effects were usually only aesthetic in nature, albeit occasional fish kills via hypoxia, or complaints by bathers of minor irritation, did result. *Gonyaulax tamarensis*, causative species of paralytic shellfish poisoning within the northwestern Atlantic region, has been found in New Jersey, but only in very low concentrations [6]. A history of bloom events in New Jersey waters, and the phytoplankton species involved is given in previous reports [1].

The dinoflagellate green tides of 1984-85, caused by *Gyrodinium cf aureolum* [7], were the first serious blooms along the southern New Jersey coast. Also in 1985, yellowish - brown water caused by the minute chlorophyte, *Nannochloris atomus*, became conspicuous in the Barnegat Bay system and has recurred each subsequent summer [8]. Following these events, routine surveillance was expanded southward from Island Beach to Cape May. In more recent years, major phytoflagellate red tides have been confined primarily to the Hudson-Raritan estuary; *K. rotundatum* has been the most dominant species, while several others such as *Eutreptia lanowii* have become more abundant. These have usually occurred in early summer followed by blooms of several diatom species, especially *Skeletonema costatum* and *Thalassiosira* spp., both in the major estuaries (with the exception of Barnegat Bay) and, to a lesser degree, along the New Jersey coast [1]. In 1995, the minute "brown tide" alga, *Aureococcus anophagefferens*, associated with damage to shellfish crops in eastern Long Island (NY) embayments, was documented in bloom proportions for the first time in New Jersey, in Little Egg Harbor adjacent to lower Barnegat Bay.

METHODS

The current survey encompasses the entire New Jersey coastal region including the major estuaries at the northern and southern extremes. A total of fourteen stations were sampled routinely for phytoplankton. These included seven of those from the USEPA New York Bight NJ Beach network (Fig. 1) concurrently with bacteriological sampling, five sites from the Hudson/Raritan estuary network, and one each in Barnegat and Delaware Bays. In 1995, due to personnel limitations, routine sampling was scheduled only eight times in the following sequence: late May (pre-Memorial Day) - eight sites including all of those in Raritan/Sandy Hook Bay and the NJ coast south to Island Beach; mid June (about the equinox) - same as late May; early July (pre July 4th) - twelve estuarine and coastal locations, complementing the full sampling range to Cape May, including RB56A, 51A and 15 in Raritan/Sandy Hook Bay, all coastal locations in Figure 1, Barnegat Bay (BB2) and Delaware Bay (DB1); mid July - eight or nine sites, including three in Raritan/Sandy Hook Bay (RB56A, 51A and 15) and coastal locations south to Cape May County (JC11, 35, 57, 65, 75, 83, 89A); end of July/start of August - same as mid July; mid August and late August - same as mid July; early September (pre Labor Day) - same as pre-July 4th. Supplemental sampling was done on a few occasions when red tide blooms were sighted along the coast, and to monitor the newly discovered brown tide bloom, especially in Little Egg Harbor (BB3).

Field collections via helicopter were made as in previous years by members of the USEPA, Region II Monitoring and Surveillance Branch (Edison NJ). Samples were taken at a one meter depth using a Kemmerer sampler. Coastal stations were sampled just outside the surf zone. Water aliquots for phytoplankton species composition/chlorophyll a remained iced, to be analyzed within 48 hours of collection. All procedures were in accordance with DEP standard field methods [9]. Phytoplankton identification, cell counts, and chlorophyll a analysis were performed according to Standard Operating Procedures (SOP) of the DEP Aquatic Biomonitoring Laboratory.

RESULTS AND DISCUSSION

1995 Highlights

May 24 - 31: Raritan Sandy Hook Bay to northern Ocean County coast	Spring diatom flowerings ongoing; *Skeletonema costatum* dominant in the estuary; *Cerataulina pelagica* dominant along the coast; *Leptocylindrus*, *Thalassiosira* sp and minute chlorophyte *Nannochloris atomus* abundant; several flagellate species present, with *Tetraselmis* sp abundant in coastal areas; brown water sighted 1/4 mile off beach from Sandy Hook to Bay Head, with some brown foam along the surf line
June 14 Raritan Bay- Ocean County coast	Late spring bloom of the diatom *Rhizosolenia delicatula*; as in the *S. costatum* bloom, maximum cell counts approach $3x10^4$ ml^{-1} ; other diatom species remnant of the previous blooms present; chlorophytes *N. atomus* still abundant in the estuary, and *Chlorella* sp there and along the coast; the dinoflagellate, *Oblea rotunda* present throughout this area (Raritan Bay to Island Beach)
Little Egg Harbor	An apparent bloom of the minute "brown tide" species *Aureococcus anophagefferens* associated with cessation of growth of juvenile hard clams at the Biosphere nursery on the southwestern shore at Tuckerton; cell concentrations approaching 10^6 ml^{-1}; algal identification and count by the Suffolk County (NY) Health Department; this constitutes the first documented occurrence of *A. anophagefferens* in bloom proportions in New Jersey
July 5 - 12 Raritan Bay - Ocean County coast	phytoflagellates of several species abundant throughout the sampling area, with red water reported at Pt. Pleasant in the vicinity of Manasquan Inlet (southern Monmouth - northern Ocean County); dominant species include dinoflagellates *Katodinium rotundatum* and *Prorocentrum minimum*, and the euglenoid *Eutreptia lanowii*; total cell count $>2.4x10^4$ ml^{-1}; chlorophytes still present, *N. atomus* abundant in Raritan Bay
lower Barnegat Bay- Little Egg Harbor	*A. anophagefferens* apparently spreading northward to Barnegat Bay; still a bloom but counts lower than previously; another minute species, *N. atomus* gaining dominance in this area as total counts of both species combined exceed 10^6 ml^{-1} (to $2x10^6$ in Little Egg Harbor)
Ocean County- Cape May County coast	the flagellate, *Euglena* sp abundant; several other species present

Delaware Bay	several diatom species and chlorophytes (N. atomus) abundant
July 18 - 26 Raritan Bay- Monmouth County coast	flagellate red tides persisting, dominated by *Olisthodiscus luteus* and dinoflagellates *Prorocentrum* and *Gymno (Gyro) dinium* spp; chlorophytes *N. atomus* and *Chlorella* sp and diatoms, especially minute *Phaeodactylum* sp also abundant, with blooms in the estuary; sampling and observations this period contributed in part by the Monmouth County Health Department.
Raritan Bay (Cliffwood Beach - Keyport Harbor - Union Beach)	fish kills occur, attributed to dissolved oxygen depletion due to decomposition of dense algae concentrations from recent blooms in the area; up to 10,000 dead fish (mostly juvenile winter flounder, but also pipefish, silversides, summer flounder and blue claw crabs) found on shore by members of the National Marine Fisheries Service, Sandy Hook Laboratory; following this, bottom d.o. levels, from samples taken by the USEPA helicopter crew off Keyport Harbor - Union Beach, found hypoxic between 3.0 and 0.44 ppm.
lower Cape May County coast (Seven Mile Beach)	several flagellates including *O. luteus*, *Euglena* sp and a few dinoflagellates, plus diatoms and chlorophytes, abundant
August 9 - 14 Raritan - Sandy Hook Bay and New Jersey coast	diatoms regaining prominence, with blooms of *S. costatum*, throughout the estuary and *T. gravida* in Sandy Hook Bay; *Chaetoceros* sp also abundant; these three species present to a lesser extent along the coast; red water in the surf at Pt. Pleasant (just south of Manasquan Inlet) caused by accumulation(s) of jellyfish or ctenophores; diatoms, a few flagellates and chlorophytes abundant in lower Cape May County
Monmouth- Ocean County, and Cape May County coast	bottom d.o. levels borderline hypoxic; slight hypoxia (3.9-3.3ppm) one to three miles off Long Branch, Belmar, Bay Head and Wildwood, also seven miles off Barnegat Light; samples taken from EPA helicopter perpendicular transects
Barnegat Bay - Little Egg Harbor	blooms of picoplankton (*N. atomus* and *A. anophagefferens*) still ongoing, with combined cell densities $>10^6$ ml^{-1}; a few small flagellates, especially *Chrysochromulina* sp becoming abundant

August 23 - 29 Raritan - Sandy Hook Bay	blooms of *S. costatum* and *Thalassiosira* sp persisting, especially in vicinity of Sandy Hook Bay; several other diatom and a few flagellate species present; *N. atomus* abundant
New Jersey coast	diatoms *T. gravida*, *S. costatum* and *Chaetoceros* sp abundant at most sites; several flagellates present; *N. atomus* blooming along Ocean County; the presence of *Aureococcus* in small numbers determined at various sites from Raritan Bay to Delaware Bay
Sandy Hook- Ocean County coast	low bottom d.o., from EPA helicopter samples, found four to eight miles off Sandy Hook (2.0-2.5ppm) and five miles off Bay Head (1.3ppm); significant numbers of dead fish (menhaden?) reported, seen inshore off Mantoloking just south of Bay Head, and off Holgate just north of Little Egg Inlet; this kill apparently unrelated to hypoxic conditions; fish probably discarded from fishing boats
Barnegat Bay - Little Egg Harbor	*Nannochloris* blooms persisting with cell counts as high as $2x10^6$ ml^{-1}; Aureococcus now present only in low concentrations; several flagellate species, primarily *Calycomonas ovalis* and *Chroomonas minuta*, abundant
Delaware Bay	many diatom species present, *Nitzschia* spp in bloom proportions; a few flagellates present; *N. atomus* abundant

Phytoplankton Species Composition

A list of major phytoplankton species for the 1995 season, with notes on occurrence and distribution, is presented in Table 1, spatial and temporal succession of dominant species is included. Species considered dominant occurred often in cell concentrations greater than 10^3 ml^{-1}. Blooms occurred when densities of one or more dominants approached or exceeded 10^4 cells ml^{-1}, as concentrations in this range tend to impart visible coloration to the water, i.e. cause "red tide". Red tides in the Hudson/Raritan estuary and adjacent New Jersey Coastal waters historically have been attributed to blooms of phytoflagellates, especially *Olisthodiscus luteus, Katodinium rotundatum* and *Prorocentrum* spp. In recent years, however, diatoms, normally dominant during the cool months, have undergone summer blooms (most notably *Skeletonema costatum* and *Thalassiosira* spp), with resultant brownish water discoloration, and accumulations of brown floc following bloom collapse. Additionally, the euglenoid *Eutreptia lanowii* has also attained dominant status, while several other flagellate species have become more abundant. The most intense red tides in recent years have been in Raritan-Sandy Hook Bay, especially stations RB51A and 56A and, in 1995, RB15. In 1995 these occurred during May-June and August sampling dates; dominant species included diatoms *S. costatum, Chaetoceros* spp, *Thalassiosira* spp (max. 3.0 x 10^4 cells ml^{-1}) and, in June, *Rhizosolenia delicatula.* The chlorophyte *Nannochloris atomus* bloomed at various times during the sampling period. For *Nannochloris*, because of its minute size (<5um), the criterion for blooms (10^5 ml^{-1}) is an order of magnitude higher than for the other species. Cells of this size range (mostly 1.5-3.5um) are collectively termed picoplankton. Although *N. atomus* has been abundant throughout the region, especially in Raritan-Sandy Hook Bay, in recent years its densities in Barnegat Bay (to >10^6 ml^{-1}) have well exceeded those in the other areas. In 1995, another picoplankter, *Aureococcus anophagefferens*, was discovered in bloom concentrations in the lower Barnegat Bay system. Several other small (nanoplanktonic) species including flagellates *Calycomonas ovalis, Chrysochromulina* sp, *Pyramiminas micron* and *Chroomonas minuta,* and *Nitzschia* sp (a diatom), have been associated with these summer picoplankton blooms.

Concerning the appearance of the brown tide alga in New Jersey, the presence of *A. anophagefferens* in Barnegat Bay, albeit in small proportions, has been known since 1987. In 1995, however, it was detected in major bloom proportions in Little Egg Harbor and, to a lesser degree, in Barnegat Bay adjacent to the north of Little Egg Harbor. Maximum cell concentrations approached 10^6 ml^{-1} in early June, well exceeding the minimum level of $2x10^5$ associated with damage to shellfish crops, as happened to the bay scallop fishery in eastern Long Island, NY. Little Egg Harbor is a prime hard clam harvesting area for New Jersey. Temporary cessation of growth in juvenile hard clams (*Mercenaria* sp) was experienced at the Biosphere nursery on the southwestern shore at Tuckerton; concomitantly, an unusual golden-brown coloration of the bay water was observed. As concentrations of *Aureococcus* diminished in midsummer, growth of the clams resumed. The chronic summer-long blooms of *N. atomus*, responsible for murky yellowish-or greenish-brown water in the Barnegat Bay system, may well have masked the rising abundance of *A. anophagefferens*. From late June through August, total picoplankton concentrations at times approached $2x10^6$ ml^{-1}. By mid August, levels of *Aureococcus* had substantially diminished, so that *Nannochloris* had become the predominant species. Confirmed identification of *A. anophagefferens* (and other coccoid forms such as *N. atomus*) is facilitated by the use of immunoflourescence microscopy, a capability we are developing.

Biomass Measurements

As opposed to species differential cell counts, chlorophyll a measurements are reflective of total phytoplankton biomass. An extreme high value of >255mg/m^3 at site JC37 (just south of Manasquan Inlet) reflected a single sample taken of a dense flagellate red tide on July 5. Otherwise, in 1995, seasonal variation, as well as highest levels, again were greatest in the major estuaries at northern and southern ends of the New Jersey coast (Table 2, Figures 2 and 3). Raritan Bay had a higher single value of >144 at site RB51A, while Delaware Bay had a slightly higher mean value of almost 64 mg/m^3. This is attributed in part to tidal fluctuations, but more so to the intense bloom pulses in these estuaries. Delaware Bay normally exhibits a high diversity of diatoms, chlorophytes and flagellates. Barnegat Bay (BB2) again sustained moderately high chlorophyll a levels, with a mean of about 15 mg/m^3, in summer due to the persistence of *N. atomus*. A somewhat higher mean value of >26mg/m^3 for Little Egg Harbor reflects the added contribution of *Aureococcus*. Although cell densities have been considerably greater here than in the other estuaries, the minute size of the dominant species (<*5um*) represents considerably less biomass than the dominant species in other areas. Mean chlorophyll a levels for the entire season are shown for each station in Figure 3. Overall, values for 1995 were slightly higher than those for 1994. In the coastal region certain sites (especially in Monmouth and Cape May Counties) reflected estuarine influence, having somewhat higher chlorophyll values than the others.

Environmental Factors

Given the ample nutrient supply of the inner New York Bight (5,10), it is surprising that major phytoflagellate blooms have not been more frequent in recent years, particularly in coastal areas (the last being in 1985). For the past few summers, major red tides have been confined principally to the Hudson - Raritan estuary; these have occurred primarily in early summer, preceded and often followed by blooms of diatom species (1). In view of the fact that diatoms are normally dominant during the cooler months, the midsummer shift from flagellate to diatom dominance (as occurred in recent years) may have been weather-induced. This is supported by the fact that the same diatom species were abundant simultaneously in both the estuary and adjacent coastal waters. Most of the phytoflagellate species encountered are indigenous to the estuarine areas. The abundance of diatoms in the bays, however, may reflect a contribution from ocean waters via wind and tidal currents. The nearshore waters of the New York Bight are subject to considerably greater turbulence and slower warming than the sheltered estuaries and embayments. Sustained southwesterly or northeasterly winds can promote upwelling or downwelling (respectively), and thus water column mixing, along the New Jersey coast (10). National Weather Service regional data indicates that conditions such as these have persisted in varying degrees during the past several summers. Conversely, flagellate blooms, or red tides, in the coastal waters have typically developed under conditions of quiescence and warmth, which promote water column stratification; likewise, the same conditions have prolonged the blooms in the estuaries and bays (1,7,10). The persistent brownish water in the Barnegat bay system is reflective partially of its hydrography. It is well sheltered from the New York Bight by barrier islands; however, due to its shallowness, it is also well-mixed, thus precluding hypoxia in most cases. Except near the inlets, it is not well flushed by tidal currents, although tidal exchange with ocean waters may be somewhat greater in Little Egg Harbor than in Barnegat Bay proper. Hydrographic patterns also likely influence the annual recurrence of bottom hypoxia in certain areas (e.g. portions of Raritan Bay, and coastal waters one to three miles off southern Monmouth to northern Ocean County) by allowing accumulation, deposition and decomposition of phytoplankton within those areas, especially during periods of quiescent summer weather. Diligent monitoring of current meteorological and oceanographic data (wind direction and velocity, precipitation and sunlight, water column temperature and salinity, etc.) thus could aid considerably in prediction of red tide blooms and hypoxic conditions in areas where they have historically occurred.

REFERENCES

1. U.S. Environmental Protection (EPA). 1978-1992 (inclusive). New York Bight water quality, annual reports, Summers of 1977-1990 (inc.). Region II, Surveillance and Monitoring Branch, Edison, NJ.

2. New Jersey Department of Environmental Protection 1988-1991 (inc.). The Cooperative Coastal Monitoring Program, 1987-1990 (inc.) annual reports. Division of Water Resources, Bureau of Water Monitoring, Trenton.

3. Swanson, R.L. and C.J. Sindermann (eds). 1979. Oxygen depletion and Associated Mortalities in the New York Bight, 1976. NOAA Prof. Paper No. 11. Rockville, MD, 345 pp.

4. Olsen, P and M.S. Cohn. 1979. Phytoplankton in Lower New York Bay and Adjacent New Jersey Estuarine and Coastal Areas. Bull. N.J. Acad. Sci. 24:59-70.

5. Mahoney, J.B. and J.J.A. McLaughlіln, 1977. The Association of Phytoflagellate Blooms in Lower New York Bay with Hypertrophication. J. Exp Mar. Biol. Ecol. 28:53-65.

6. Cohn, M.S., P Olsen, J.B. Mahoney and E. Feerst. 1988. Occurrence of the Dinoflagellate, *Gonyaulax tamarensis*, in New Jersey. Bull N.J. Acad. Sci. 33:43-49.

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

8. Olsen, P.S. 1989. Development and distribution of a brown-water algal bloom in Barnegat Bay, New Jersey, with perspective on resources and other red tides in the region. In: Novel phytoplankton blooms: causes and impacts of recurrent brown tides and other unusual blooms, pp 189-211. E.M. Cosper, E.J. Carpenter and V.M. Bricelj eds. Coastal and Estuarine Studies. Springer-Verlag Berlin.

9. New Jersey Department of Environmental Protection (NJDEP) 1992. Field Sampling Procedures Manual. NJDEP, Trenton, 360 pp with Appendices.

10. U.S. Environmental Protection Agency (EPA). 1986. An Environmental Inventory of the New Jersey Coast/New York Bight Relevant to Green Tide Occurrence. Prepared by Science Applications International Corp of USEPA, Region II, New York, New York, 156 pp.

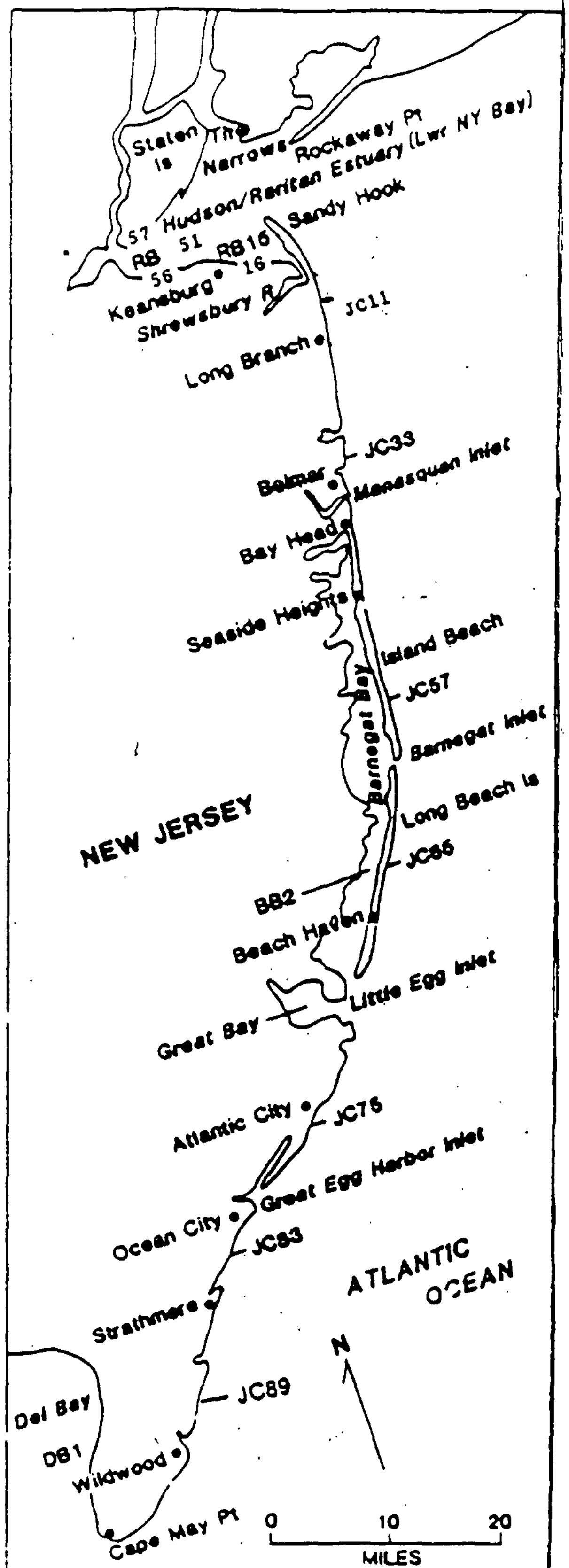


Figure 1. New Jersey coast station locations, Sandy Hook to Cape May.

Table 1. Major phytoplankton species found in the 1995 New Jersey coastal and estuarine survey, with notes on occurrence and distribution. An asterisk (*) denotes species which were dominant or abundant, exceeding cell concentrations of 10^3 ml^{-1} at some time during the sampling period. Two asterisks (**) denote species which bloomed, approaching or exceeding 10^4 cells ml^{-1}. For Nannochloris and Aureococcus, because of their minute size (1.5-3.0 µm), these criteria are increased by a factor of ten. Other species listed occurred commonly, although not usually in abundance. Spatial and temporal distribution of dominants is included; for genera with more than one species on the list, a capital letter following the name indicates the species which attained dominance.

Diatoms

Leptocylindrus danicus[3](A)
L. minimus[3](B)*
Skeletonema costatum**5
Cyclotella sp.*[2,5]
Thalassiosira sp.[5]
T. gravida**[5](A)
T. nordenskioldii**[2](B)
Eucampia zoodiacus
Cerataulina pelagica*[3]
Chaetoceraos spp.**[3]
Rizosolenia sp.[3]
R. delicatula (A)**
Asterionella glacialis*[5]
Navicula sp.
Nitzschia sp.*
Phaeodactylum tricornutum*[2]
Cylindrotheca closterium[2]

Dinoflagellates

Prorocentrum minimum[1,5]
P. triestinum (redfieldi)[1,5]
P. micans[1,5]
Dinophysis acuta[3]
Gymnodinium spp.[2]
Gyrodinium spp.[2,5]
G. aureolum*[1]
Katodinium rotundatum*[1,5]
Heterocapsa triquetra[2,5]
Oblea rotunda
Protoperidinium sp.[3]
P. trochoideum

Other Phytoflagellates

Olisthodiscus luteus*[1,5]
Calycomonas ovalis*[4]
Chrysochromulina*sp.[2]
Pyramimonas spp.[2]
Tetraselmis sp.[2]
T. gracilis (A)*
Bipedinomonas sp.
Euglena sp.(proxima)*[2]
Eutreptia lanowii**[5](A)
E. viridis[2](B)
Cryptomonas sp.[5]
Chroomonas amphioxiea[5](A)
C. minuta*[2](B)
C. vectensis[2](C)

Nonmotile Coccoids

Aureococcus anophagefferens**[6]
Chlorella spp.*[2]
Nannochloris atomus**[2,4]

Footnotes:

1 - historically responsible for red tides in the region
2 - primarily estuarine
3 - primarily coastal
4 - most predominate in Barnegat Bay
5 - most abundant in Raritan/Sandy Hook Bay and adjacent NJ coastal waters
6 - has been responsible for brown tide blooms in eastern Long Island embayments, with damage to shellfish crops; in 1995, found in New Jersey for the first time in bloom proportions

TABLE 1(cont.). Dominant species distribution.

S A M P L I N G   D A T E S

LOCATION North	mid spring May 24,31	late spring June 14	early summer July 5,12	midsummer July 26	midsummer August 9	late summer August 23,29
Raritan Bay						
RB56A (57)	Skeletonema* Leptocylindrus B* Thalassiosira B* Chroomonas A* Nannochloris* Chlorella	Rhizosolenia** Nitzschia sp* Oblea Nannochloris*	X	Phaeodactylum* Prorocentrum* C Gyrodinium* A Olisthodiscus* Calycommonas* Nannochloris**	Skeletonema* Thalassiosira A* Chaetoceros** Calycomonas* Nannochloris*	Skeletonema Thalassiosira Nannochloris* Chlorella
RB51A	X	Rhizosolenia** Leptocylindrus B* Nitzschia Oblea Nannochloris* Chlorella*	Skeletonema Phaeodactylum* Katodinium* Olisthodiscus* Calycomonas Eutreptia A* Nannochloris** Chlorella*	Skeletonema* Phaeodactylum** Calycomonas* Nannochloris** Chlorella*	Skeletonoma* Thalassiosira A** Nannochloris Chlorella	Skeletonema** ThalassiosiraA** Chaetoceros* Euglena Nannochloris Chlorella
Sandy Hook Bay						
RB15 16A	Skeletonema** Leptocylindrus B* Thalassiosira B* Cerataulina* Prorocentrum A* Nannochloris*	Rhizosolenia** Thalassiosira B Oblea* Bipedinomonas Nannochloris* Chlorella*	Skeletonema Phaeodactylum Calycomonas Chlorella*	Skeletonema* Phaeodactylum** Chroomonas* Nannochloris** Chlorella*	Skeletonema** Thalassiosira A* Chaetoceros* Calycomonas Nannochloris	Skeletonema** Leptocylindrus B Thalassiosira A* Chaetoceros* Chrysochromulina Nannochloris
Monmouth County coast						
JC11	Skeletonema* Thalassiosira A* Cerataulina** Tetraselmis A	Rhizosolenia** Cyclotella* Oblea	X	Phaeodactylum* Gymnodinium Katodinium* Olisthodiscus Chroomonas Nannochloris* Chlorella*	Skeletonema* Chroomonas Nannochloris	Skeletonema* Protoperidinium A Gymnodinium Nannochloris* Chlorella
JC35	Eutreptia* Chroomonas	Rhizosolenia* Leptocylindrus B Bipedinomonas Chroomonas C Chlorella*	Prorocentrum A* Katodinium * Eutreptia A* Nannochloris Chlorella*	Skeletonema* Phaeodactylum Nannochloris* Chlorella*	Skeletonema Thalassiosira A	Skeletonema A Chaetoceros Protoperidinium A Nannochloris* Chlorella
Ocean County coast						
JC57	X	Rhizosolenia** Leptocylindrus B Cyclotella* Oblea Chlorella*	Prorocentrum A Eutreptia A* Nannochloris* Chlorella*	X	Nannochloris	Skeletonema Thalassiosira A* Chaetoceros* Pyramimonas* Tetraselmis Chroomonas
JC65	X	X	Phaeodactylum* Euglena Nannochloris Chlorella	X	X	Nannochloris**
Barnegat Bay						
BB1-2	X	X	Aureococcus Nannochloris**	Aureococcus* Nannochloris**	Aureococcus Nannochloris** Calycomonas Chrysochromulina* Chlorella	Nannochloris*** Nitzschia* Gymnodinium Calycomonas* Pyramimonas Chroomonas B
Little Egg Harbor						
BB3	Aureococcus*	Aureococcus** Nannochloris	Aureococcus** Nannochloris** Calycomonas	Aureococcus* Nannochloris**	Aureococcus Nannochloris** Chrysochromulina*	Nannochloris*** Nitzschia* Gymnodinium Calycomonas* Pyramimonas Chroomonas B
Atlantic County coast						
JC75	X	X	Phaeodactylum Euglena*	Chaetoceros* Navicula Nannochloris Chlorella	Skeletonema Thalassiosira Navicula Nannochloris	Skeletonema* Thalassiosira A Leptocylindrus B Nitzschia Calycomonas Nannochloris*
Cape May County coast						
JC83	X	X	Phaeodactylum Euglena* Chlorella	X	X	Skeletonema* Thalassiosira Chaetoceros Nitzschia Nannochloris
JC89A			Euglena Chlorella	Skeletonema* Chaetoceros* Navicula Euglena Gyrodinium Olisthodiscus Nannochloris Chlorella	Skeletonema* Chaetoceros Nitzschia Prorocentrum Katodinium omonas Nannochloris* Chlorella	Thalassiosira A* Leptocylindrus B* Chaetoceros* Nannochloris
Delaware Bay capeshore						
DB1	X	X	Skeletonema* Thalassiosira* Phaeodactylum Nannochloris*	X	X	Nitzschia** Phaeodactylum Gymnodinium Nannochloris** Chlorella

Table 2. Chlorophyll 'a' (mg/m3) for the 1995 NJ coastal and estuarine phytoplankton survey

	24 May	14 Jun	5 Jul	12 Jul	26 Jul	9 Aug	23 Aug	Mean
H/RE	**28.91**	**112.38**	**47.87**	**23.48**	**65.27**	**21.38**	**23.84**	**46.18**
RB57	24.27	95.00						59.64
RB56A	12.83	141.01			87.71	12.04		63.40
RB51A	12.67	144.42	87.32	˙35.20	56.19	11.62	40.43	55.41
RB16A	39.65	106.87					17.81	54.78
RB15	55.11	74.62	8.42	11.76	51.90	40.48	13.58	36.55
MCC	**2.69**	**18.40**	**140.30**	**7.37**	**7.47**	**9.76**	**5.75**	**27.39**
JC11	4.31	25.06			8.51	13.56		12.86
JC35	1.06	11.74	24.67	7.37	6.42	5.96	5.75	9.00
JC37			255.92					255.92
OCC	**2.84**	**9.14**	**20.97**	**3.12**		**4.09**	**8.52**	**8.11**
JC57	2.84	9.14	35.97	3.12		4.09	8.52	10.61
JC65			5.97					5.97
BB			**21.53**	**16.33**	**34.12**	**18.58**	**9.20**	**19.58**
BB01							8.46	8.46
BB02			16.15	16.33	18.02	20.56	8.41	15.89
BB03			26.90		50.22	16.59	10.73	26.11
A/CMC			**2.70**		**17.81**	**6.42**	**7.78**	**8.68**
JC75			2.02		15.71	7.50	6.59	7.96
JC83			3.73					3.73
JC89A					19.91	5.34	8.96	11.40
JC91A			2.34					2.34
DB			**35.84**				**55.30**	**45.57**
DB01			35.84				91.62	63.73
DB02							18.98	18.98

H/RE - Hudson/Raritan Estuary (RB57,56A,51A,16A,15)
MCC - Monmouth County coast (JC11,35,37)
OCC - Ocean County coast (JC57,65)
BB - Barnegat Bay (BB01,02,03)
A/CMCC - Atlantic/Cape May Counties coast (JC75,83,89A,91A)
DB - Delaware Bay (DB01,02)

APPENDIX C

Daily Floatables Observations

for the Summers of 1995

Daily Floatable Observations, 1995

May 15 - 26, 1995

The New York/New Jersey Harbor Complex was monitored for floatables a total of eleven times during the period of May 15 - 26, 1995.

The Harbor Complex was clear of significant floatables on May 22, 23, and 24.

On May 16 and 17, light to moderately dense slicks, approximately 500 to 1500 yards long, were reported in the Arthur Kill, Newark Bay and Kill Van Kull. On May 18, moderate to heavy slicks, approximately one half to one mile long, were reported in the Arthur Kill, Kill Van Kull, Upper New York Harbor, and the East River. On May 19, scattered debris was reported throughout the Harbor Complex. Two slicks, approximately one half mile by 10 - 20 feet were reported in the Arthur Kill and Jamaica Bay, on May 20. On May 25, a moderately dense slick, approximately 400 yards by 10 feet was reported in the Verrazano Narrows. On May 26, a small slick was reported in the Verrazano Narrows. All slicks consisted of plastic, paper, household debris, and wood.

May 27 - June 2, 1995

The New York/New Jersey Harbor Complex was monitored for floatables every day during the period of May 27 - June 2, 1995.

The Harbor Complex was clear of significant floatables on May 27, 29, 30 and June 2.

On May 28, a light density slick, approximately 300 feet by 50 feet, was reported in Newark Bay. Two smaller slicks were reported in the Upper NY Harbor. On May 31, two moderately dense slicks, each approximately 300 yards by 5 feet, were reported in Newark Bay and Gravesend Bay. A moderately dense slick, approximately one to one and a half miles long by 5 feet, was reported northeast of the Verrazano Bridge. Light scattered debris was reported in the Arthur Kill, Newark Bay and Upper NY Harbor, on June 1. All slicks consisted of plastic, paper, household debris, and wood.

On June 2, an oil sheen, approximately 2 miles by 5 feet, was reported south of Pralls Island in the Arthur Kill. This sheen was reported to the US Coast Guard.

June 3 - 9, 1995

The New York/New Jersey Harbor Complex was monitored for floatables four times during the period of June 3 - 9, 1995. The Harbor Complex was clear of significant floatables on June 9.

On June 5, scattered debris was reported in the Arthur Kill, Newark Bay, and the East River. One June 6, a light density slick, approximately 1000 yards by 5 feet, was reported off Coney Island. All slicks consisted of plastic, paper, household debris, and wood.

June 10 - 16, 1995

The New York/New Jersey Harbor Complex was monitored for floatables six times during the period of June 10 - 16, 1995.

On June 10, scattered debris was reported in Newark Bay and the East River, and a light density slick, approximately one half mile by 5 feet, was reported in the Upper New York Harbor. Two small slicks, approximately 100 yards by 5 ft, were reported in the Arthur Kill and Lower New York Harbor, on June 12. On June 13, a moderately dense slick, approximately one half mile by 5 feet was reported in the Lower New York Harbor.

On June 14, an oily sheen, approximately one mile by 20 feet with 500 yards of scattered debris mixed in, was reported in the Arthur Kill. A heavy dense slick, approximately one and a half miles long by 10 - 20 feet wide, was reported in Newark Bay. Light to moderately dense slicks were reported in the following locations: the Kill Van Kull, a half mile by 2 feet slick; the Upper New York Harbor, a 200 yards by 5 feet slick; the Verrazano Narrows, a 600 yard by 10 feet slick; and in Gravesend Bay, a 500 yard by 10 feet slick was reported.

On June 15, a small oily sheen was reported in the Arthur Kill. A moderately dense slick, approximately 800 yards by 20 feet, was reported off Coney Island.

On June 16, scattered debris was reported in the Kill Van Kull, the Upper New York Harbor and Gravesend Bay. Oily sheens ranging from 100 to 500 yards were observed in the Kill Van Kull and Gravesend Bay.

All slicks consisted of plastic, paper, reeds, street litter, household debris, and wood.

June 17 - 23, 1995

The New York/New Jersey Harbor Complex was monitored for floatables six times during the period of June 17 - 23, 1995.

The Harbor Complex was clear of significant floatable on June 17, 19, 21, and 23.

On June 20, an oily sheen, approximately 500 yards by 30 feet, was reported in the Upper New York Harbor.

On June 22, an oily sheen, approximately 1.5 miles long by 150 yards was reported in the Kill Van Kull, but the source was not found.

June 24 - 30, 1995

The New York/New Jersey Harbor Complex was monitored for floatables five times during the period of June 24 - 30, 1995.

The Harbor Complex was clear of significant floatable on June 27, and 28.

On June 24, a floatable slick, approximately 200 yards by 20 feet, was reported in Newark Bay.

On June 26, a floatable slick, approximately 3/4 mile long was reported in the Arthur Kill. A floatable slick, approximately 50 yards by 4 yards, was reported in the Upper New York Harbor. On June 30, two slicks, approximately 45 yards by 20 feet, were reported in the Arthur Kill and the Newark Bay. A floatable slick, approximately one and a half miles by 30 feet, was reported in the Upper New York Harbor.

All floatable slicks consisted of wood and plastic.

July 1 - 7, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted every day this week, July 1 - 7, except Sunday. Light scattered debris was reported in the Arthur Kill on July 4, 5, 6 and 7. Light scattered debris was reported in the Lower New York Harbor on July 6. No significant slicks were reported.

On July 7, an oily sheen approximately one mile by 30 feet, was reported in the East River.

Oil sheens were reported to the U.S. Coast Guard.

July 8 - 14, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week, July 8 - 14.

A floatable patch was reported in the Upper New York Harbor, approximately 100 yards radius, on July 8.

An oil sheen, approximately 3/4 mile by 15 feet was reported in the East River, on July 8 and 10.

A floatable slick, approximately 1 1/2 miles by 20 feet, was reported in the Hudson River, on July 10.

A floatable slick, approximately 1 1/2 miles by 15 feet, was reported in the Arthur Kill, on July 11. Timbers, approximately 100 feet long, were reported in the Hudson River, on July 11.

A floatable slick, approximately 1/2 mile by 10 feet, was reported in the Arthur Kill, on July 12.

A floatable slick was reported in the Newark Bay, approximately 1 1/2 miles by 10 feet, on July 13.

A floatable slick was reported in the Upper New York Harbor, approximately 1 mile long, on July 14.

July 15 - 21, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week.

Two low density slicks were reported on July 18, one just south of Pralls Island, approximately 1 mile long by 20 feet wide. The other slick was 2 miles long by 10 feet wide, north of the Goethals Bridge.

Two slicks were reported on July 19, one, moderately dense slick, approximately 1 mile long by 10 feet wide, south of Pralls Island. The second, a low density slick approximately 2 miles long by 10 feet wide just southwest of Governor's Island

An oil slick approximately 2 miles long and 50 feet wide under the Bayonne Bridge, and a 1.5 mile by 10 feet moderate density slick south the Verrazano Bridge were reported on July 20.

An oil slick approximately 2.5 miles long by 50 feet wide south of Queensboro Bridge, and a moderately dense slick approximately 0.5 mile by 10 feet southwest of Governors Island, were reported on July 21.

July 22 - 28, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week, July 22 - 28.

A floatable slick, approximately 300 yards by 10 feet, was reported in the Upper New York Harbor, on July 24.

A floatable slick, approximately 1/2 mile by 7 feet, was reported in the Upper New York Harbor, on July 26.

A floatable slick, approximately 2 miles by 10 feet, was reported in the Upper New York Harbor, on July 28.

All floatables slicks consisted of wood, plastic and paper.

July 29 - August 4, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted five days this week, July 29 - August 4.

The Harbor was clear of significant floatables on July 29, August 2 and 4.

A floatable slick, approximately 3/4 mile by 10 feet, was reported in the Lower New York Harbor, on July 31.

Oil slicks, approximately 300 yards by 20 feet and 600 yards by 10 feet, were reported in the Arthur Kill, on August 3. A floatable slick of light density, approximately 1/2 mile by 5 feet, was reported in the Lower New York Harbor, on August 3.

August 5 - 11, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week, August 5 - 11.

The Harbor was clear of significant floatables on August 5, 7, and 8.

A floatable slick, approximately 100 yards by 30 feet, was reported in the Lower New York Harbor, on August 9. An oil sheen was reported 300 yards off the coast of Sea Bright, on August 9.

On August 10, four oil and floatable slicks, approximately 1/2 to one mile long, were reported in the Arthur Kill, Newark Bay, Kill Van Kull, and Coney Island.

Oil and floatable slicks, approximately 1/2 to two miles, were reported in the Arthur Kill, Upper New York Harbor, and Gravesend Bay, on August 11.

August 12 - 18, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week, August 12 - 18.

The Harbor was clear of significant floatables on August 14, 15, 16, 17, and 18.

A floatable slick, approximately 1/2 mile by 2 feet, was reported in the Gravesend Bay, on August 12.

August 19 - 25, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted six days this week, August 19 - 25.

The Harbor was clear of significant floatables on all six days, August 19, 21, 22, 23, 24 and 25.

August 25 - September 6, 1995

Floatable overflights of the NY/NJ Harbor Complex were conducted a total of eleven times between August 25 - September 6.

The Harbor was clear of significant floatables on all days.

All floatables were reported to the Army Corps of Engineers or the New York City Department of Environmental Protection. Cleanups were conducted as necessary.

All oil sheens were reported to the US Coast Guard.