1986/1987 INTENSIVE WATER QUALITY SURVEYS WITHIN THE NEW YORK/NEW JERSEY METROPOLITAN AREA

PREPARED BY:

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CONTENTS

ABSTRACT

In 1985, several waterbodies within the Interstate Sanitation District were upgraded by the Interstate Sanitation Commission, New York State, and New Jersey. The Commission's year-round disinfection requirement also went into effect on July 1, 1986. To assess the results of these actions and plan for the future, the Commission, in cooperation with the environmental departments of the States of New York and New Jersey, conducted special ambient water quality sampling surveys.

Sampling surveys were conducted in August and November 1986 and in February and April 1987. Stations were chosen in the Hudson River, Upper New York Bay, Lower New York Bay, Raritan Bay, Sandy Hook Bay, and the Atlantic Ocean, including several stations located in or adjacent to shellfishing areas.

The water quality with respect to coliforms contamination has shown improvement since the Commission's year-round disinfection requirement went into effect. Heavy metals concentrations were low throughout the study area, except for copper. It is likely that the copper concentrations exceed the ambient water quality standard promulgated by the New York State Department of Environmental Conservation.

Dissolved oxygen values in the study area met the Commission's criteria most of the time. A severe condition (D.O. $<$ 1.0 mg/l) was found in the bottom waters at two stations -- one in the Hudson River and one in Upper New York Bay -- in November 1986.

The study showed that combined sewer overflow discharges, which are triggered by wet weather conditions, are an influential pollutant source contributing to the degradation of ambient waters in the area.

The Commission has scheduled follow-up sampling surveys for areas of Raritan Bay and the Atlantic Ocean off the Rockaways to begin late this fall. Sufficient data will be collected so the States can make decisions on extending the season for shellfish areas that are only seasonally opened and opening shellfishing areas that are presently closed.

INTRODUCTION

In 1985, as a result of Use Attainability Analyses (UAAs), several waterbodies within the Interstate Sanitation District were upgraded by the Interstate Sanitation Commission (ISC), New York State, and New Jersey. The Commission's year-round disinfection requirement also went into effect on July 1, 1986.

As a follow-up to the two aforementioned actions, the Commission, in cooperation with the environmental departments of the States of New York and New Jersey, conducted special ambient water quality sampling surveys to assess the results of those actions and to plan for the future. To reduce the cost of chartering commercial boats to conduct the sampling, whenever possible, the State environmental departments supplied their boats. Commission personnel did the sampling and the analyses were performed by the ISC laboratory.

Sampling surveys, each lasting from three to ten days, were conducted in August and November 1986 and in February and April 1987. Seventeen stations were chosen in the Hudson River, Upper New York Bay, Lower New York Bay, Raritan Bay, Sandy Hook Bay, and the Atlantic Ocean. A map and listing of the station locations are included (see Figure 1 and Table 1). Several of the Raritan/Sandy Hook Bay stations are located in shellfishing areas and the station off the Rockaways is located near the New York State Department of Environmental Conservation (NYS DEC) summer closure boundary for shellfishing.

On all four surveys, top (approximately 5 feet below the surface) and bottom (approximately 1 to 2 feet above the bottom) samples were taken for dissolved oxygen, temperature and conductivity. Top samples for fecal and total coliforms were taken on all four surveys and bottom samples for these parameters were taken at one station. Additionally, on the August 1986 and February 1987 surveys, top samples were taken for metals, nutrients, and chlorophylls.

DATA INTEGRATION AND METHOD OF ANALYSIS

The data were input to the US EPA STORET database at the National Computer Center (NCC). Various types of analyses were performed by utilizing the Statistical Analysis System (SAS). NOAA's 1986 and 1987 Tide Tables and local climatological data were also entered into the database to reflect the impact resulting from rainfall and tidal variation. After the initial review of the database, it was decided to use the following major guidelines to help interpret the data:

(a) NOAA's daily climatological data at Central Park in New York City was used as the reference to determine the weather conditions for the area. It was assumed that for each sampling date, the cumulative precipitation within the previous 24 hours must exceed 0.05 inches in order to be classified as a "wet" condition.

(b) The tidal stage for each sampling station at each sampling time was determined by using NOAA's Tide Tables. The tidal difference constants were applied relevant to the reference point (New York - Battery). The "outgoing" tide was defined as the period from one hour after the occurrence of high tide to low tide.

(c) The National Shellfish Sanitation Program (NSSP) Manual and ISC ambient water quality standards were used as the criteria for coliform and dissolved oxygen (D.O.) assessments, respectively.

(d) The definition of Geometric Mean (G.M.) is:

$$G.M. = \text{antilog} \left(\frac{\sum_{i=1}^{N} \text{Log}\,(X_i)}{N} \right)$$

Where: X_i = any measured value
N = total number of measured values

RESULTS AND DISCUSSION

Coliforms

Weather Effect

The geometric means of fecal and total coliforms were plotted for each sampling station under different weather conditions (see Figures 2 and 3). The data showed that the adverse effect resulting from rainfall is consistent throughout the area except at Stations 1 and 2, which are the points in the Hudson River near Yonkers and the George Washington Bridge. Generally speaking, the coliform values have positive correlation relationships with the amount of precipitation. The coliform levels in the study area during the four sampling periods were elevated to an order of 2-3 times higher during wet weather conditions over those measured under dry weather conditions.

Seasonal Variation

The coliform data were further divided into four monthly groups to show the seasonal variation (see Figures 4 to 7). The data showed little, if any, seasonal variation, except in Raritan Bay, Lower Bay, and Sandy Hook Bay. The coliform levels in those areas showed a slightly noticeable seasonal pattern that appeared to be the lowest in February and the highest in April. This may be a consequence of the rainfall pattern. From NOAA's daily climatological data, it was found that the monthly cumulative precipitation within the previous 48 hours prior to the start of each sampling period was 0.5 inches in February, 0.83 inches in November, 1.57 inches in August, and 2.75 inches in April. A comparison was made of the coliform levels measured in November 1986 and February 1987 (when year-round disinfection was practiced) and of winter data prior to 1986 (when year-round disinfection was not practiced). The coliform values were substantially lower with year-round disinfection in effect (see Table 2). Since the Commission's year-round disinfection regulation went into effect on July 1, 1986, the water quality with respect to coliforms has generally shown encouraging results on a year-round basis.

The combined sewer overflow (CSO) discharges, which result from rainfall, should be considered as a primary factor for elevated coliform concentrations in the waters within the study area. Another important source loading from upstream was from the Red Hook sewage treatment plant service area in Brooklyn, which discharged approximately 60 MGD of untreated sewage during the sampling period. In late Spring 1987, the Red Hook sewage treatment plant became operational and is now providing primary treatment and disinfection. It will provide secondary treatment in 1989.

Tidal Effect

The database was divided into two groups based on the tidal information and criteria previously discussed. Figures 8 and 9 show the geometric means of coliforms, plotted for each sampling station with "tide" as the key variable. The data showed very little variation in the area south of Coney Island. Stations 1, 2, and 3 (which are north of Midtown Manhattan in the Hudson River) showed higher coliform values during the outgoing tide and the degree of differentiation tended to dissipate when traveling toward north. No pattern could be seen in the waters of the Hudson River south of Midtown Manhattan or in Upper New York Bay.

Dissolved Oxygen

Dissolved oxygen (D.O.) data were analyzed and are shown on Figures 10 through 17. In general, lower D.O.'s were found in the bottom waters throughout the entire study area. Although the D.O. values were lowest in August, the data showed that the D.O. criteria were met most of the time during that period. The D.O. fell below the 4 mg/l requirement at Stations 2, 3, 4 and 6 (between the George Washington Bridge and the Narrows) in August. One severe condition (D.O. $<$ 1.0 mg/l) was found in the bottom waters at Stations 4 and 5 (the Hudson River at the Battery and Upper New York Bay) in November.

It should be noted that the Red Hook and North River sewage treatment plants in New York City, which came on-line providing primary treatment in the spring of 1987 and 1986, respectively, are expected to provide secondary treatment in 1989. The Hudson County, New Jersey communities providing primary treatment are expected to go to secondary treatment in the near future. These upgradings will further improve the D.O. levels.

Heavy Metals Contamination

Heavy metals concentrations are summarized on Table 3. Shown are the maximum, minimum, and mean values for 10 metals at 17 stations. For each metal, the concentration appeared to be in the same order of magnitude throughout the study area. In general, the metals concentrations were low except for copper. The high copper concentrations within the study area continue to be a problem. The measured values for copper are much higher than the ambient water quality standard (2.0 μg/l) promulgated by the New York State Department of Environmental Conservation in 1986. It must be noted that the NYS DEC standard is for "acid-soluble" copper, whereas the measurements taken are for "total" copper. In spite of this difference, it is likely that the NYS DEC standard for copper is being exceeded.

CONCLUSIONS AND RECOMMENDATIONS

Surveys were conducted in the New York Bight during four different time periods from August 1986 through April 1987 for a total of twenty-three sampling runs. There are a total of 635 observations, of which 317 observations are for surface water data and the remaining are for bottom data.

The data were encouraging with respect to improved coliform values. Year-round disinfection is a major factor in this improvement. The improved dissolved oxygen values can be attributed to better treatment practices and treatment of sewage that was previously discharged raw, although several plants still need to be upgraded.

Combined sewer overflow discharges, which are caused by wet weather conditions, are a primary driving force contributing to the degradation of the ambient waters in the area.

The data collected during these surveys are limited in nature and require further verification. The Commission has scheduled follow-up sampling surveys for areas of Raritan Bay and the Atlantic Ocean off the Rockaways. This sampling program is scheduled to begin late in the fall of 1987. Sufficient data will be collected so the States of New York and New Jersey can make a determination on extending the season for those shellfish areas that are only seasonally opened and for opening areas that are presently closed.

Station 9 is right on the border of the area approved by New York State for direct harvesting of shellfish during the summer. The data showed that the geometric mean for total coliform was 52/100 ml and 16 percent of the samples exceeded 230/100 ml (see Figure 18). The total coliform criteria for direct harvesting is 70/100 ml with no more than 10% of the values greater than 230/100 ml. More data are needed to determine the period when these criteria are being met.

A basic objective of any water quality monitoring program is to document the conditions of the waterbody with sufficient resolution to support environmental management decision-making goals. The database was broken up to characterize the tidal and rainfall effects on a monthly basis for further analysis; however, more data must be collected to draw more definitive conclusions. There are several recommendations presented below for future monitoring work.

(a) The monitoring program should be carefully scheduled to capture the "worst case" scenario. The period during and/or immediately after wet weather occurs is the ideal time for sampling with respect to coliform concentrations. Based on shellfishing certification practices, each sampling should be done during an outgoing tidal cycle.

(b) Bottom and mid-depth waters, if possible, should be monitored along with surface water to insure the proper characterization of the water quality, especially for dissolved oxygen. This type of information is necessary for determining stratification conditions.

(c) Under normal circumstances, conservative pollutants like heavy metals may require less sampling frequency than nonconservative pollutants.

(d) Regional combined sewer overflow (CSO) data is necessary to enhance the understanding of pollution due to storm water runoff. Proper data must be collected to make a first estimation of pollution magnitude. Additional field sampling will be required to verify and refine estimates.

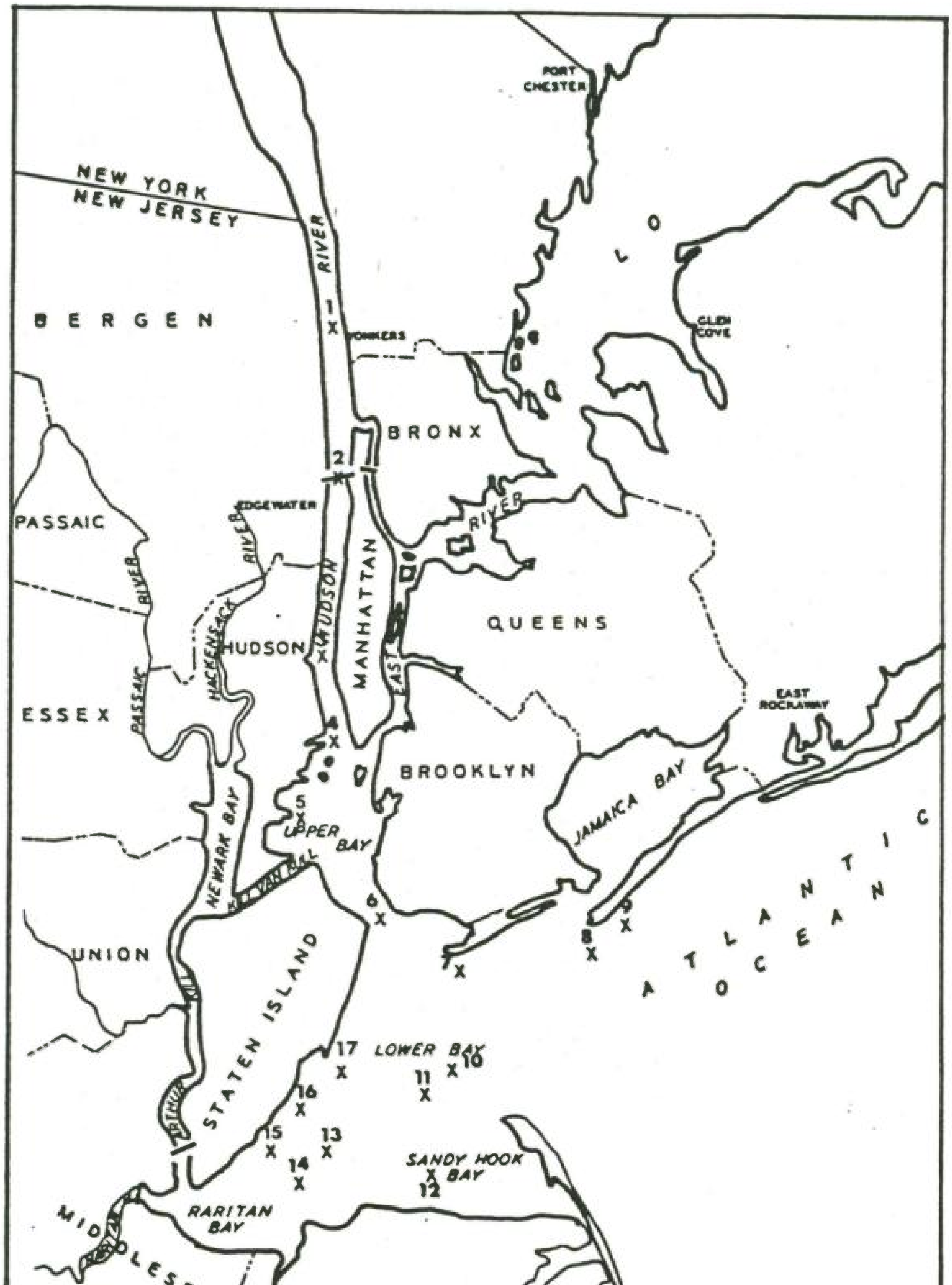


Fig 1: Interstate Sanitation Commission 1986-1987 Special Intensive Survey Sampling Stations

Figure 2

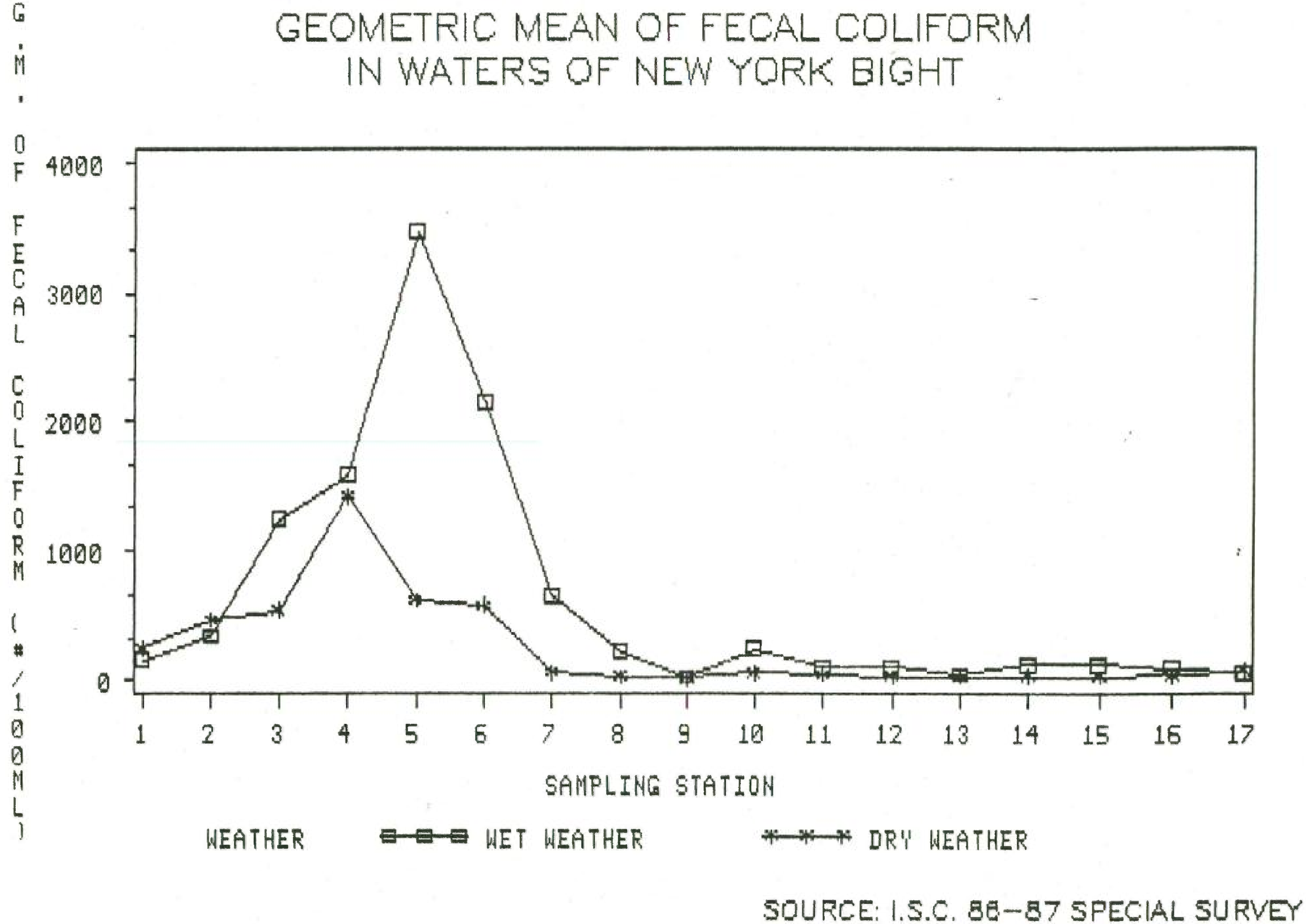
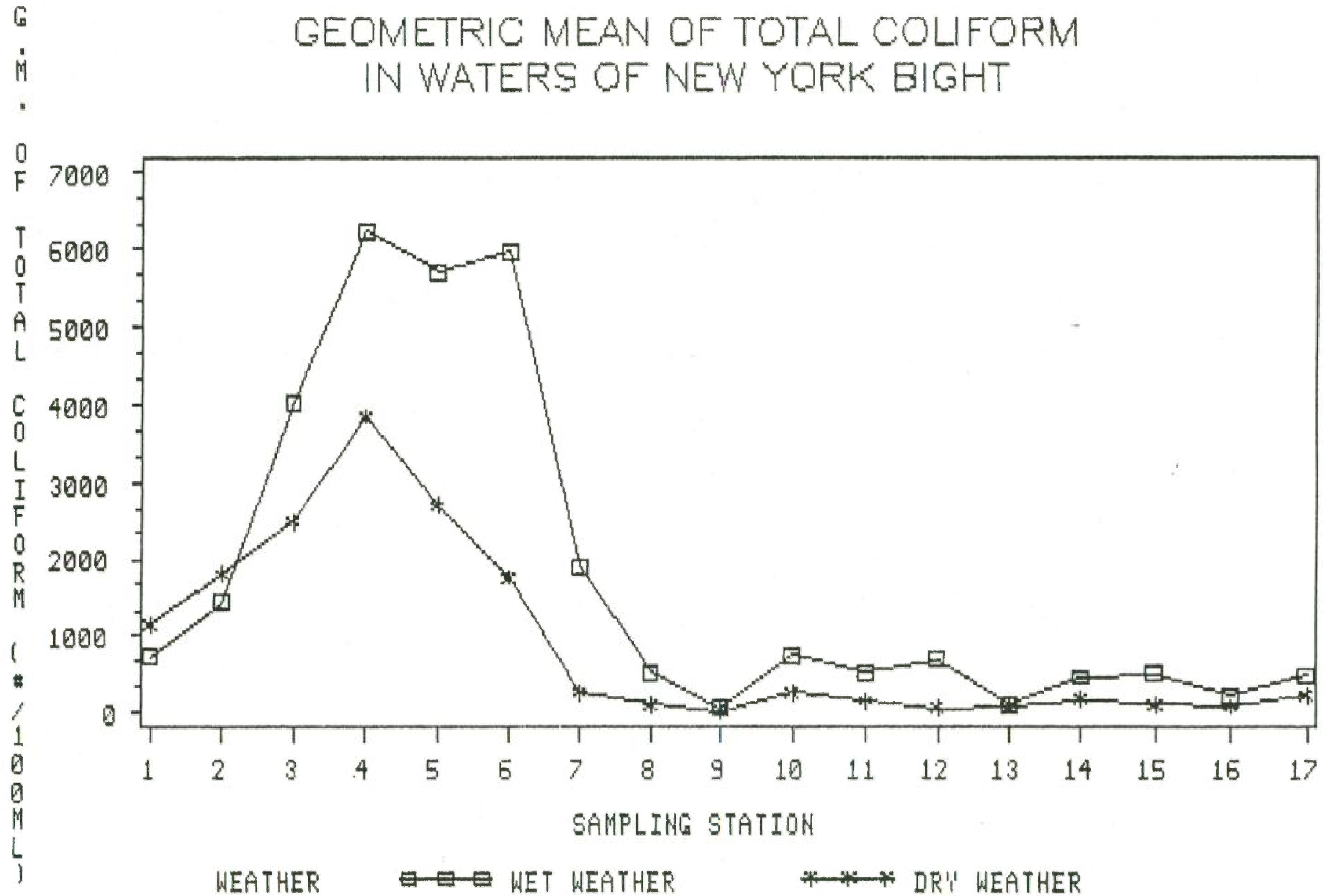

GEOMETRIC MEAN OF FECAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF FECAL COLIFORM (#/100ML)
4000
3000
2000
1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
SAMPLING STATION
WEATHER
WET WEATHER
DRY WEATHER
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 3



SOURCE: I.S.C. 86–87 SPECIAL SURVEY

Figure 4

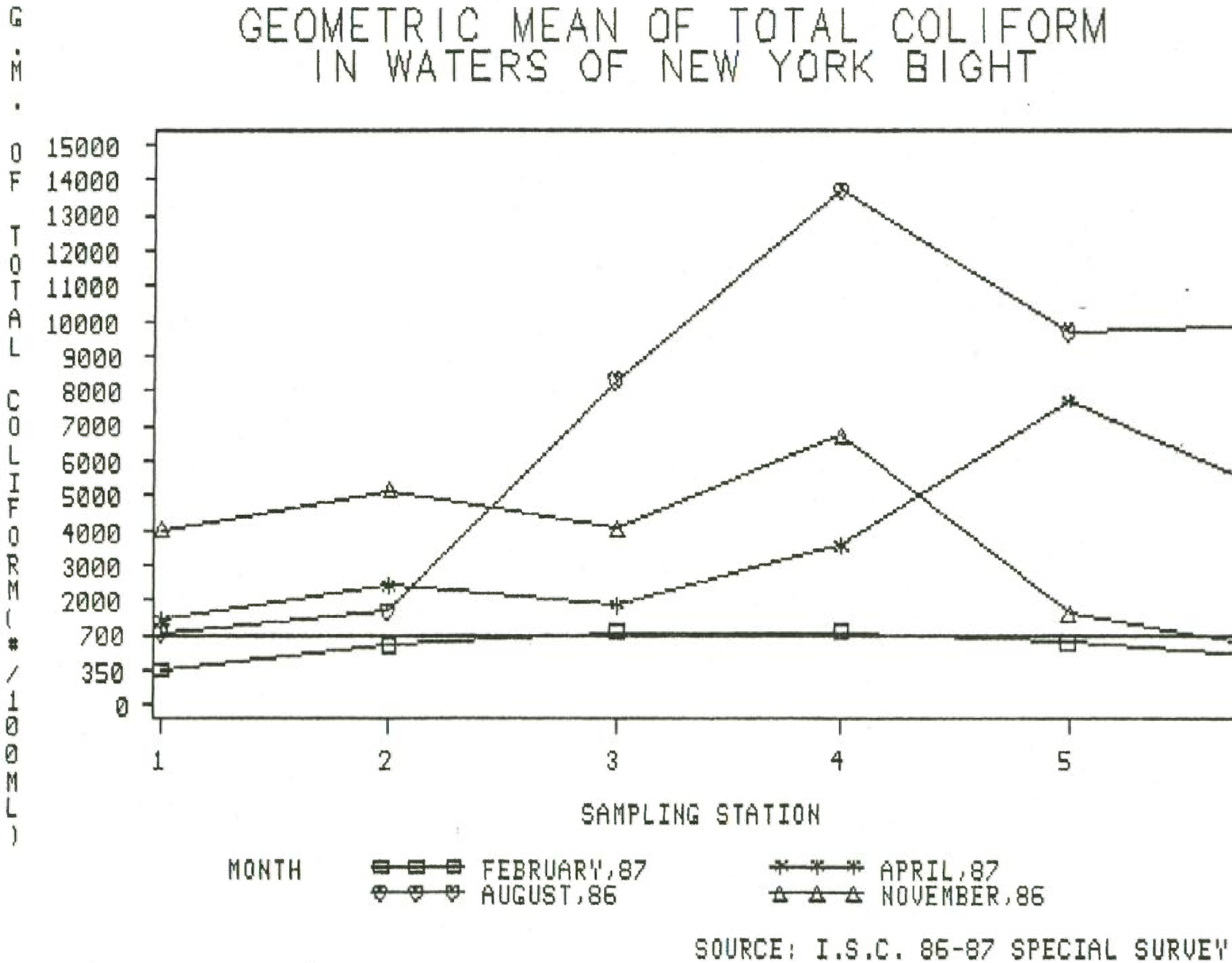

GEOMETRIC MEAN OF TOTAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF TOTAL COLIFORM (#/100ML)
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
700
350
0
1
2
3
4
5
6
SAMPLING STATION
MONTH
FEBRUARY,87
APRIL,87
AUGUST,86
NOVEMBER,86
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 5

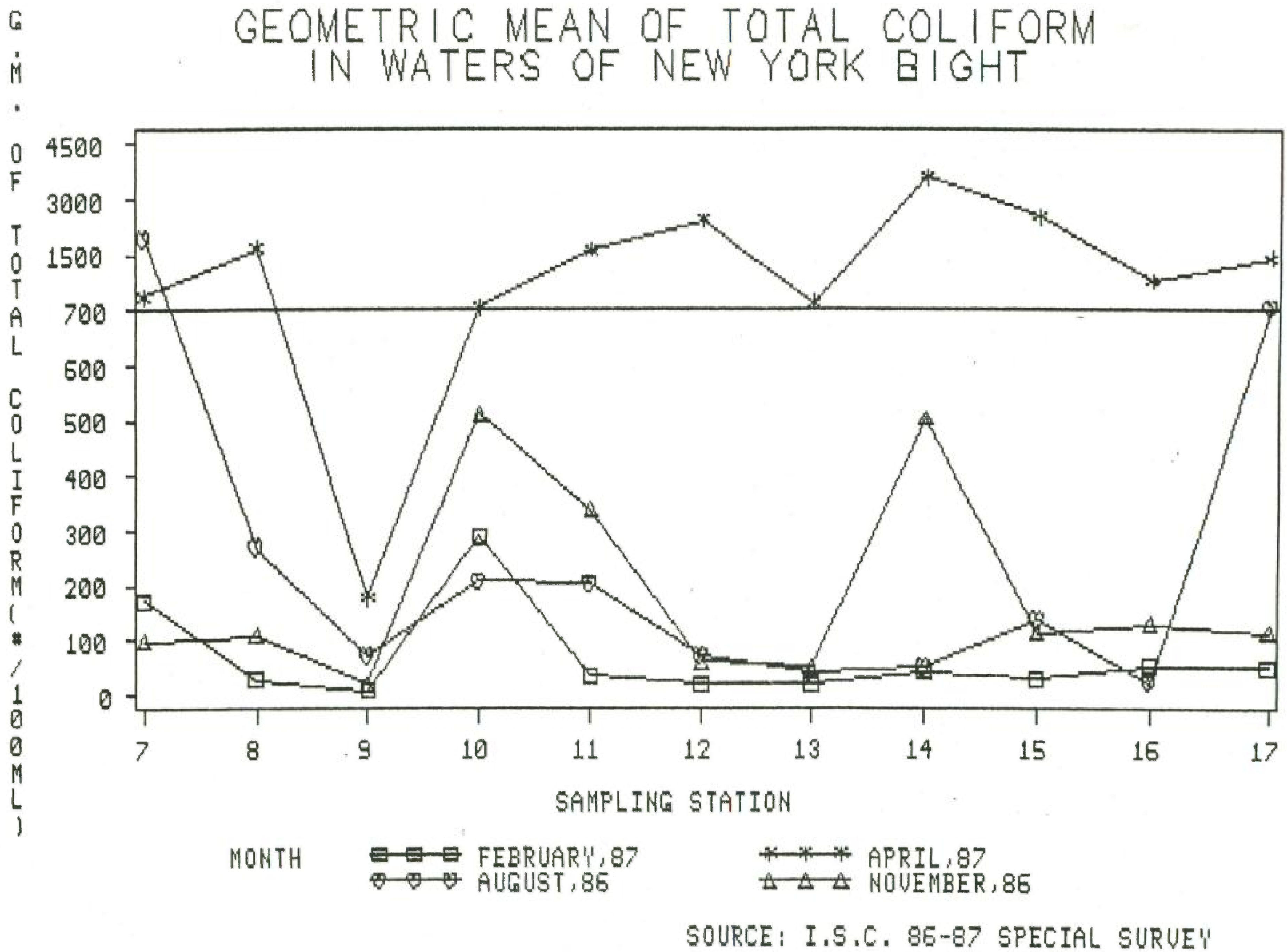

GEOMETRIC MEAN OF TOTAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF TOTAL COLIFORM(#/100ML)
4500
3000
1500
700
600
500
400
300
200
100
0
7
8
9
10
11
12
13
14
15
16
17
SAMPLING STATION
MONTH
FEBRUARY,87
AUGUST,86
APRIL,87
NOVEMBER,86
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 6

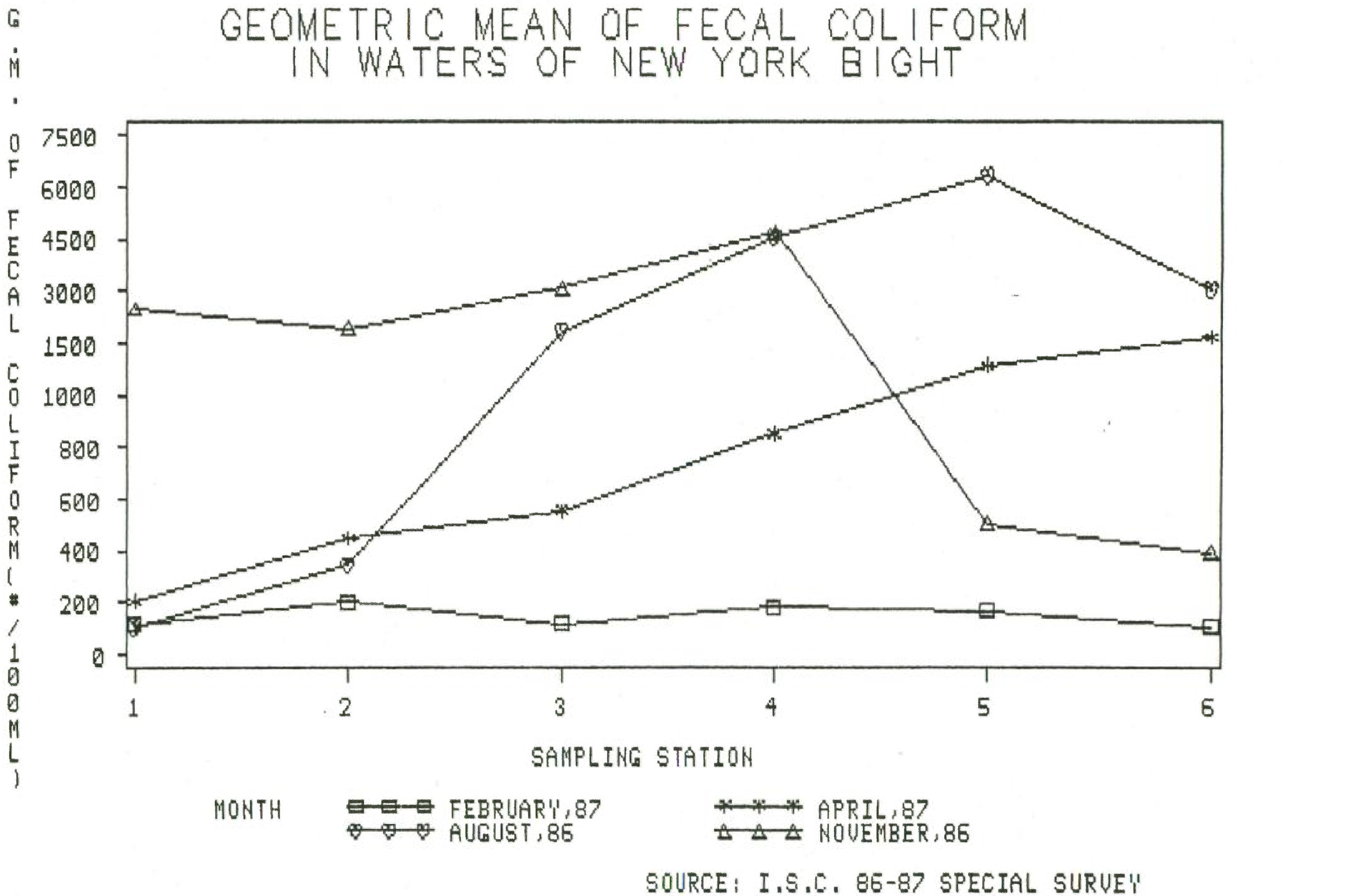

GEOMETRIC MEAN OF FECAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF FECAL COLIFORM(#/100ML)
7500
6000
4500
3000
1500
1000
800
600
400
200
0
1
2
3
4
5
6
SAMPLING STATION
MONTH
FEBRUARY,87
APRIL,87
AUGUST,86
NOVEMBER,86
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 7

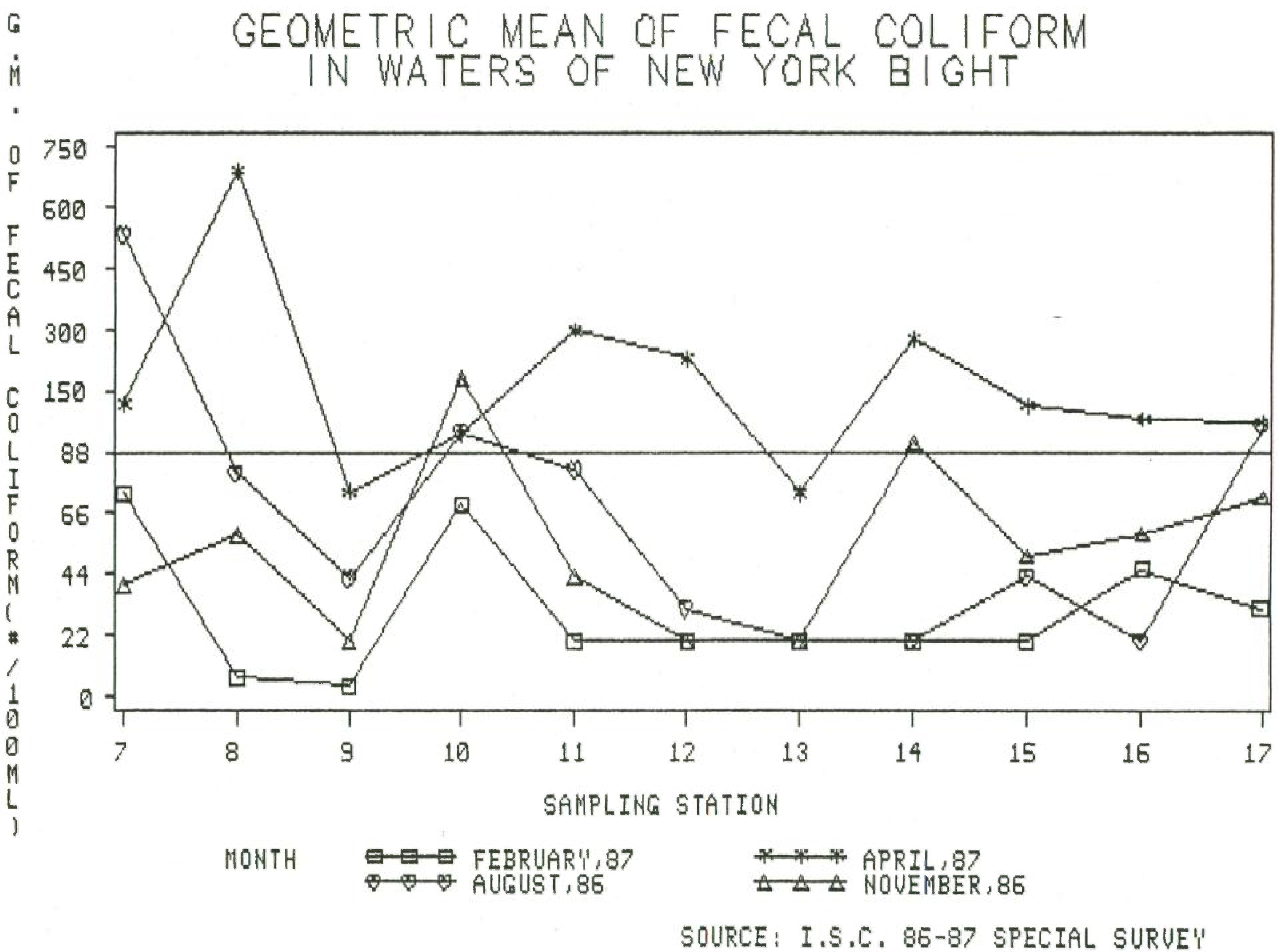

GEOMETRIC MEAN OF FECAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF FECAL COLIFORM(#/100ML)
750
600
450
300
150
88
66
44
22
0
7
8
9
10
11
12
13
14
15
16
17
SAMPLING STATION
MONTH
FEBRUARY,87
AUGUST,86
APRIL,87
NOVEMBER,86
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 8

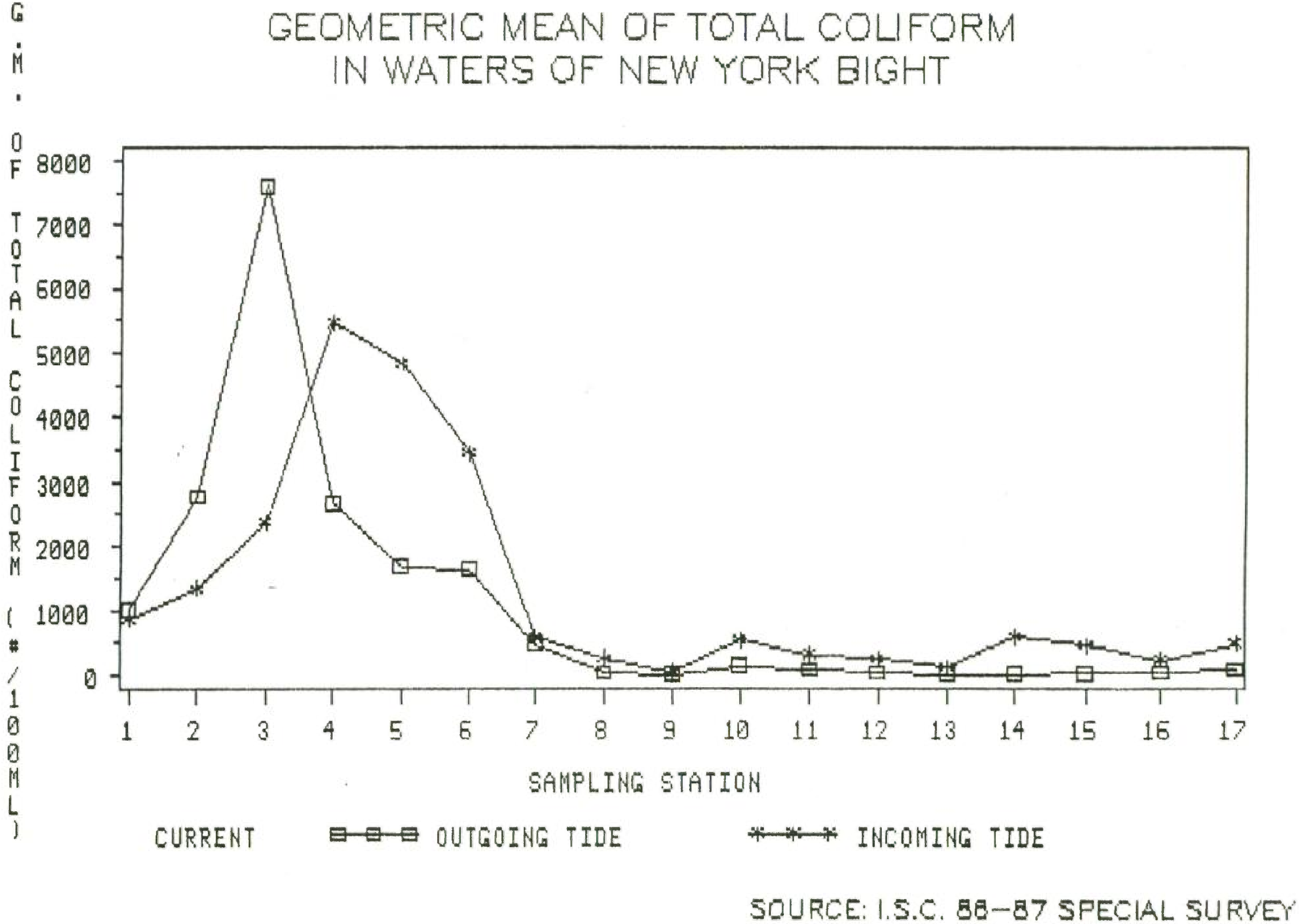
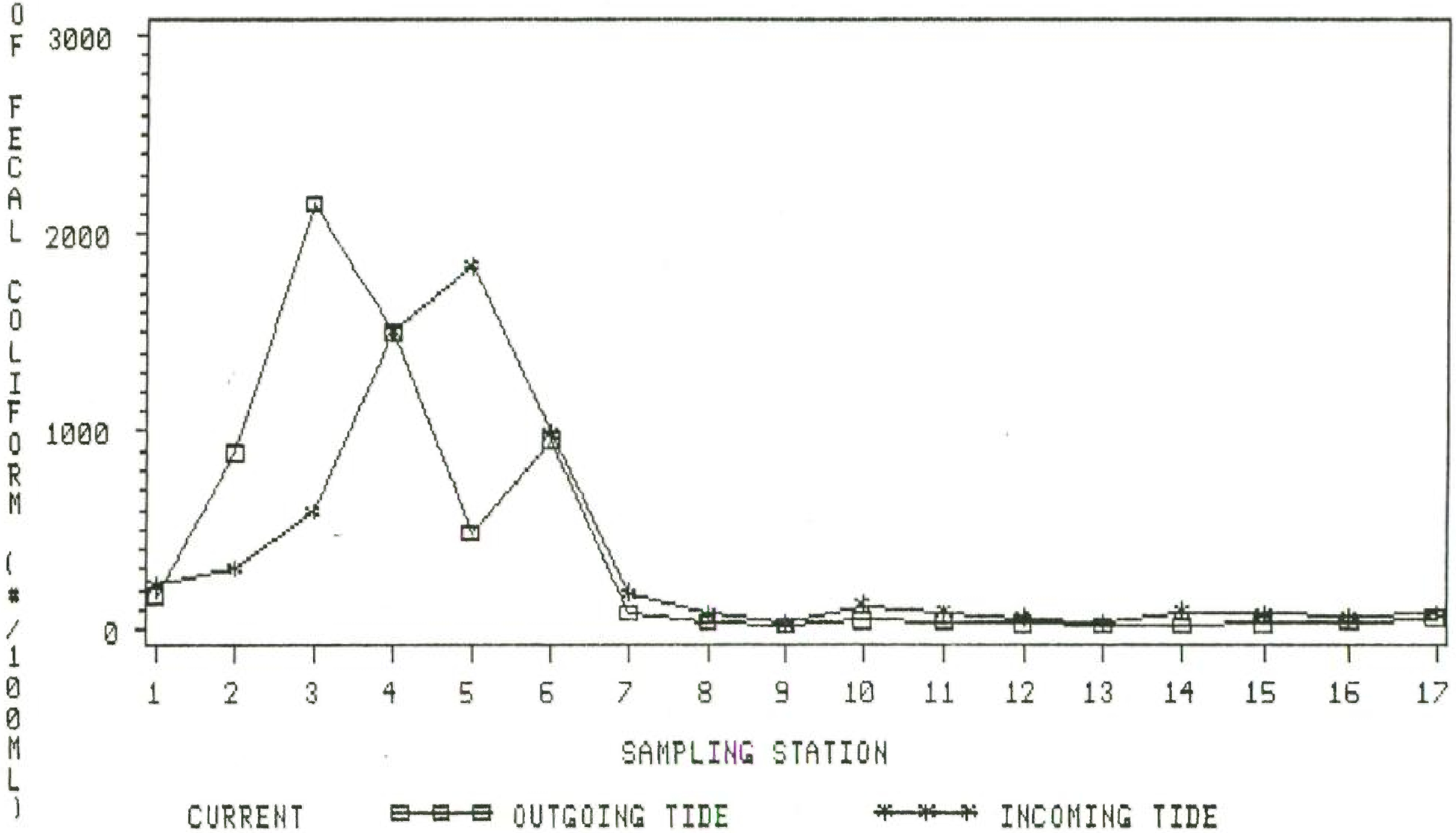

GEOMETRIC MEAN OF TOTAL COLIFORM
IN WATERS OF NEW YORK BIGHT
G.M. OF TOTAL COLIFORM (#/100ML)
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
SAMPLING STATION
CURRENT
OUTGOING TIDE
INCOMING TIDE
SOURCE: I.S.C. 86-87 SPECIAL SURVEY

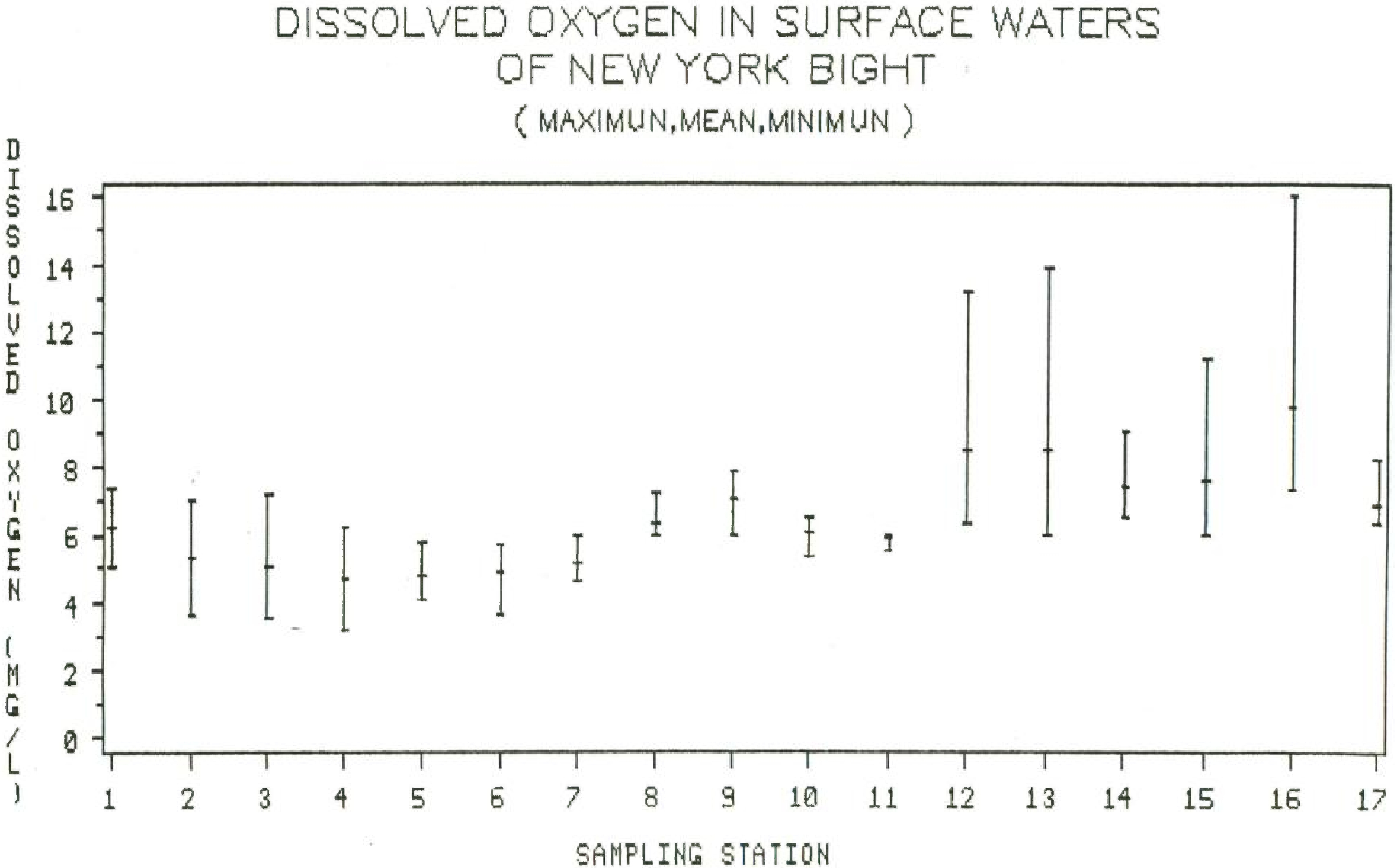
Figure 9

GEOMETRIC MEAN OF FECAL COLIFORM
IN WATERS OF NEW YORK BIGHT



SOURCE: I.S.C. 86-87 SPECIAL SURVEY

Figure 10

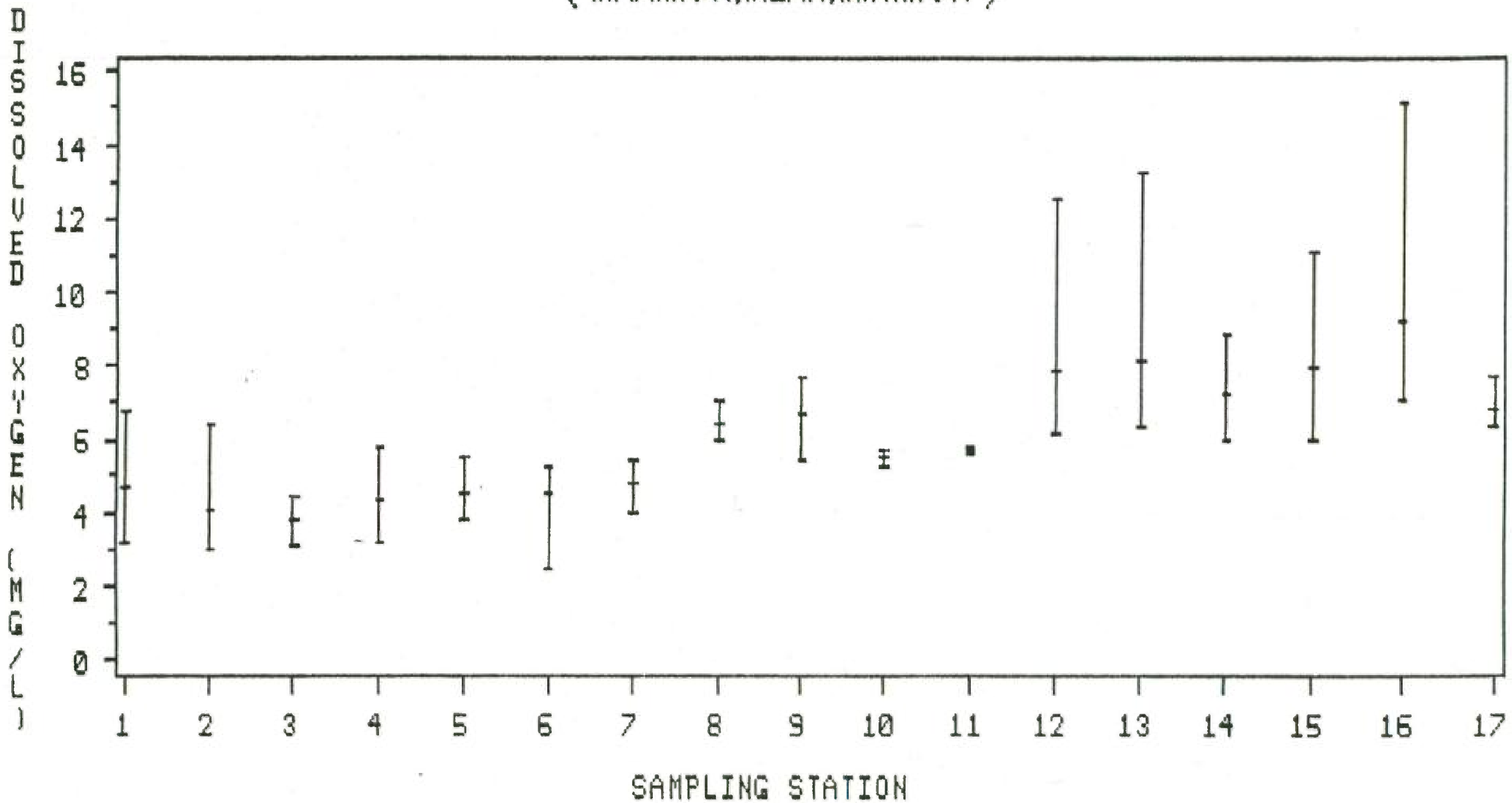


SOURCE: I.S.C. 86–87 SPECIAL SURVEY
AUGUST, 1986

Figure 11

DISSOLVED OXYGEN IN BOTTOM WATERS OF NEW YORK BIGHT

(MAXIMUN, MEAN, MINIMUN)



SOURCE: I.S.C. 86–87 SPECIAL SURVEY
AUGUST, 1988

Figure 12

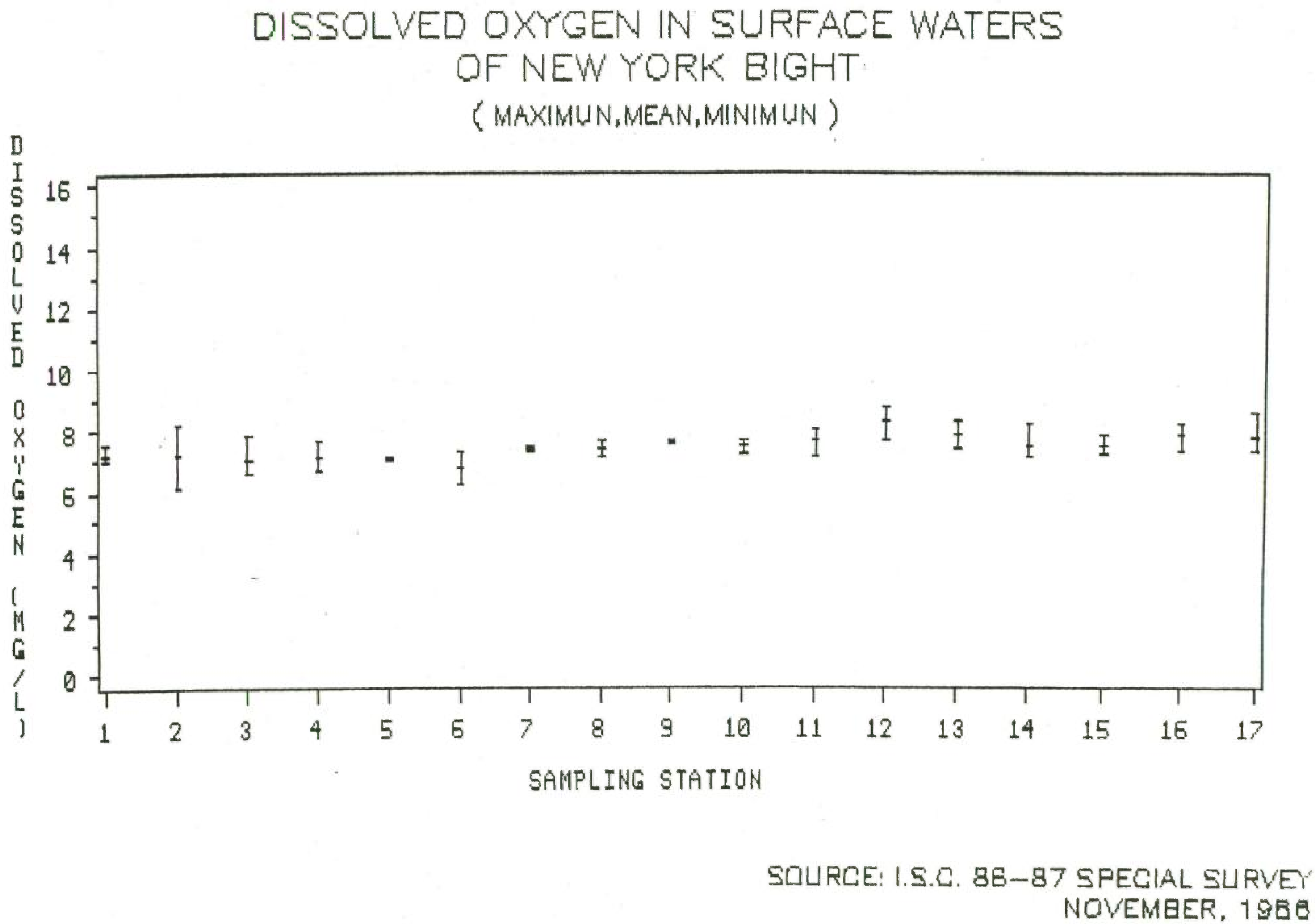

DISSOLVED OXYGEN IN SURFACE WATERS
OF NEW YORK BIGHT
(MAXIMUN,MEAN,MINIMUN)
DISSOLVED OXYGEN (MG/L)
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
SAMPLING STATION
SOURCE: I.S.C. 86-87 SPECIAL SURVEY
NOVEMBER, 1986

Figure 13

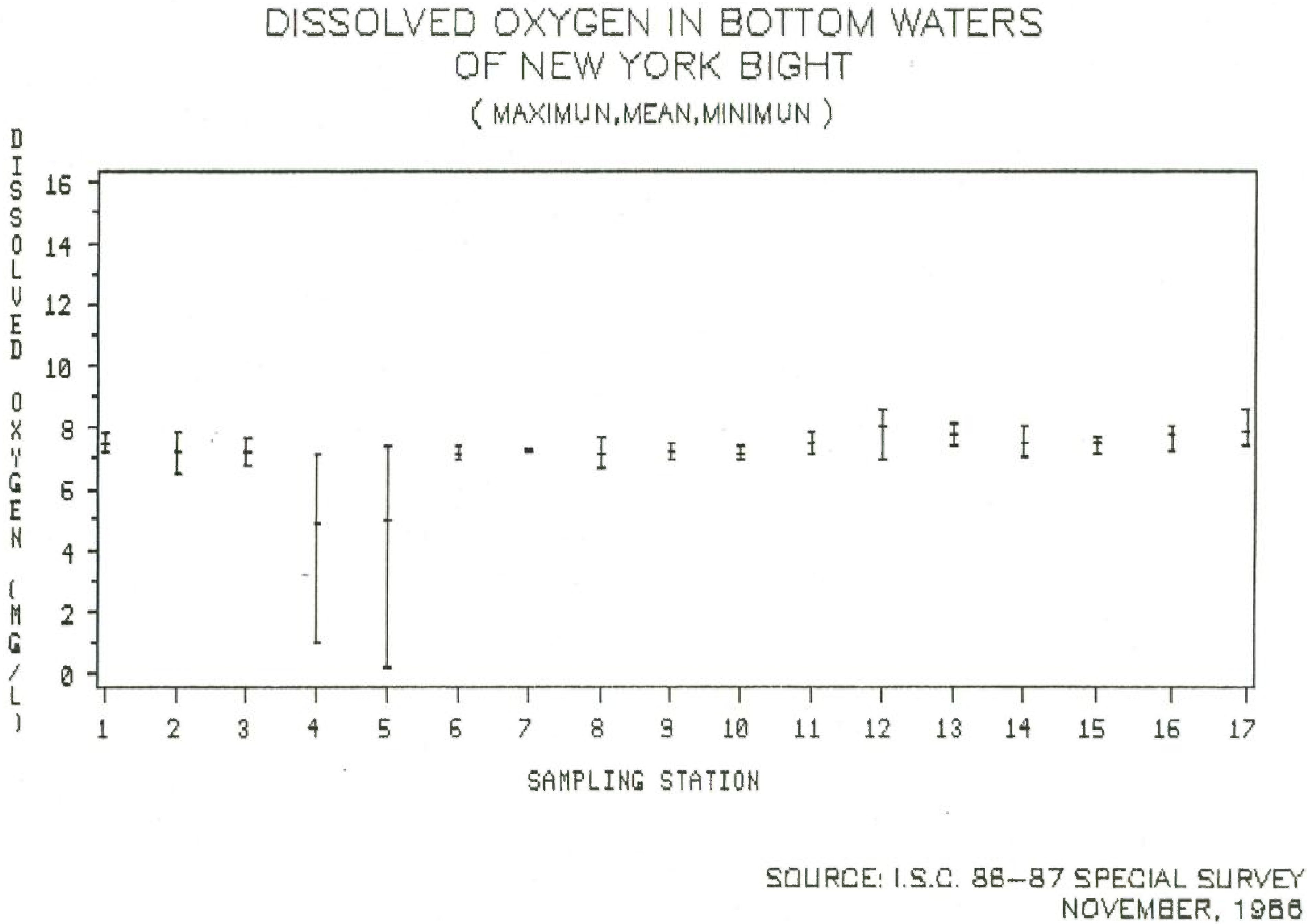
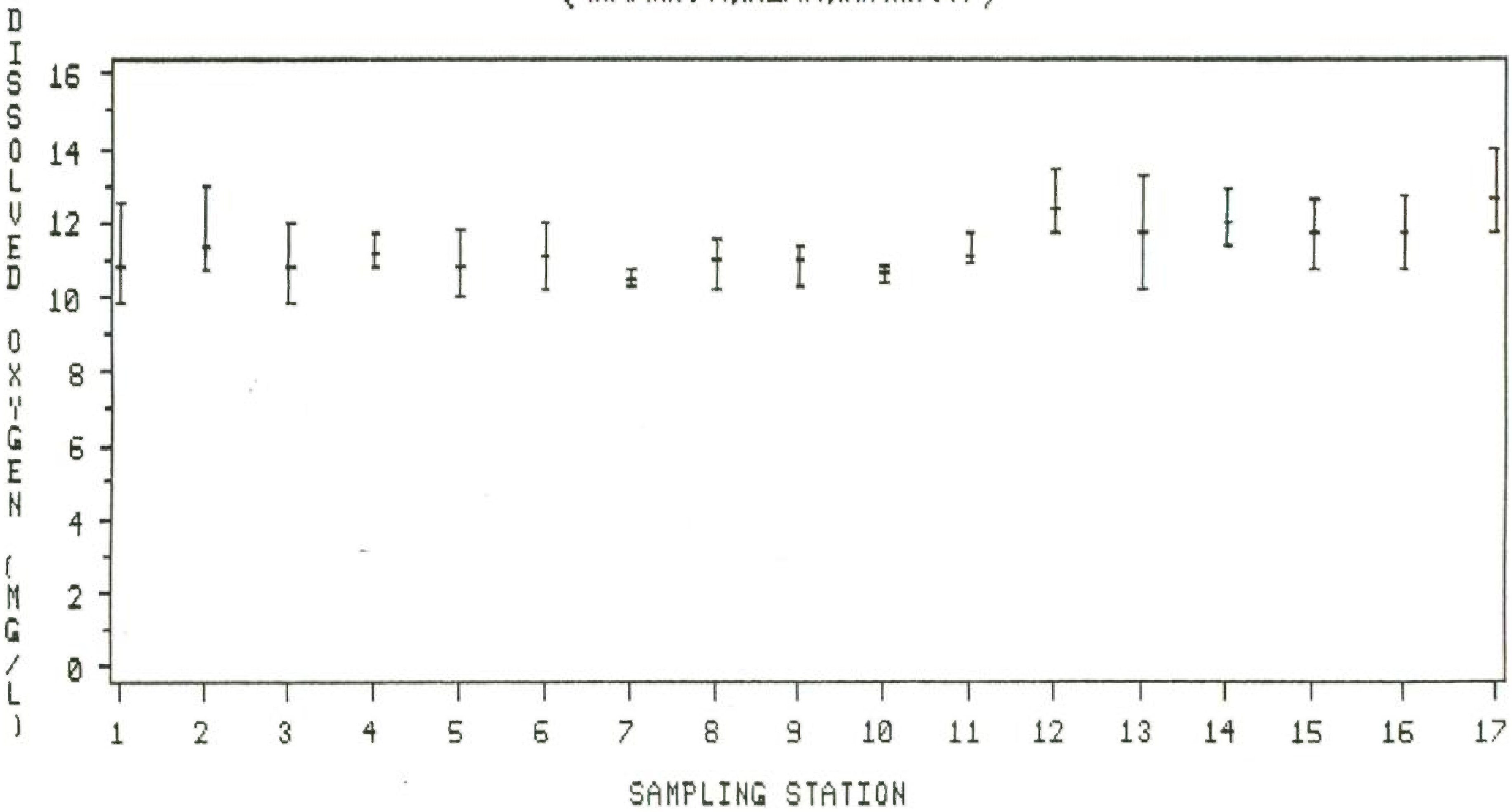

DISSOLVED OXYGEN IN BOTTOM WATERS
OF NEW YORK BIGHT
(MAXIMUN,MEAN,MINIMUN)
DISSOLVED OXYGEN (MG/L)
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
SAMPLING STATION
SOURCE: I.S.C. 86–87 SPECIAL SURVEY
NOVEMBER, 1986

Figure 14

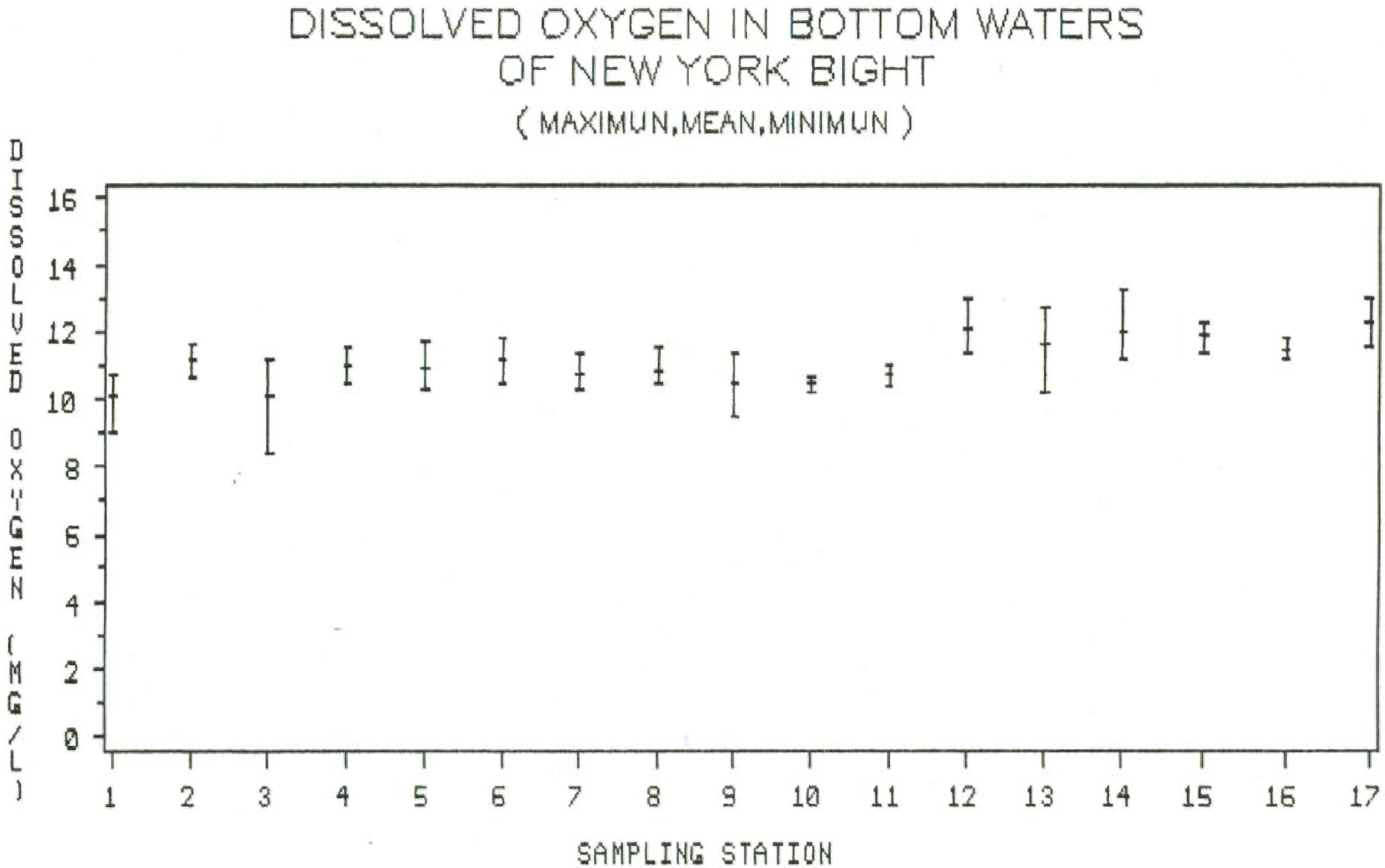
DISSOLVED OXYGEN IN SURFACE WATERS OF NEW YORK BIGHT

(MAXIMUN,MEAN,MINIMUN)



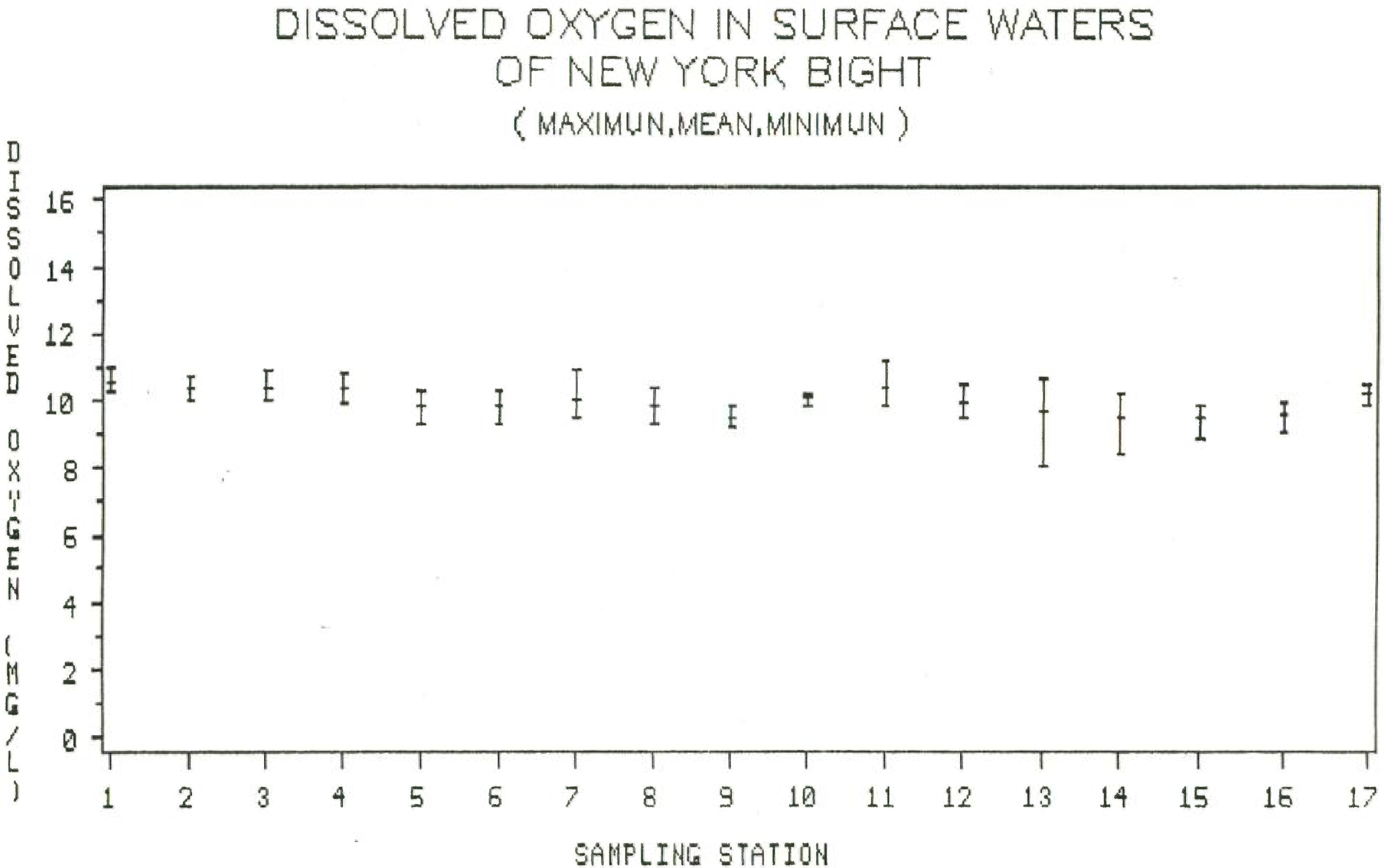
SOURCE: I.S.C. 86–87 SPECIAL SURVEY
FEBRUARY, 1987

Figure 15



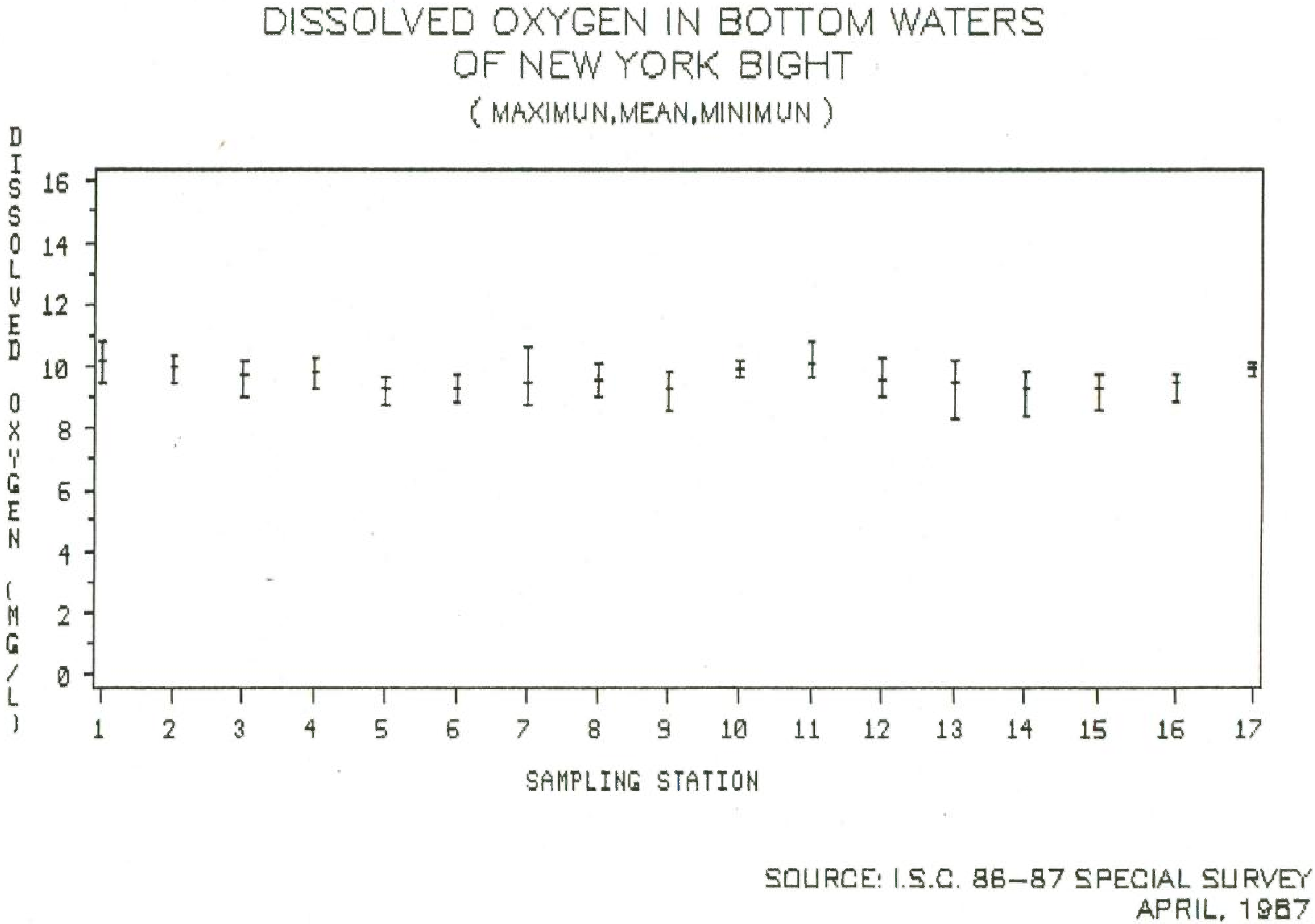
SOURCE: I.S.C. 86—87 SPECIAL SURVEY
FEBRUARY, 1987

Figure 16



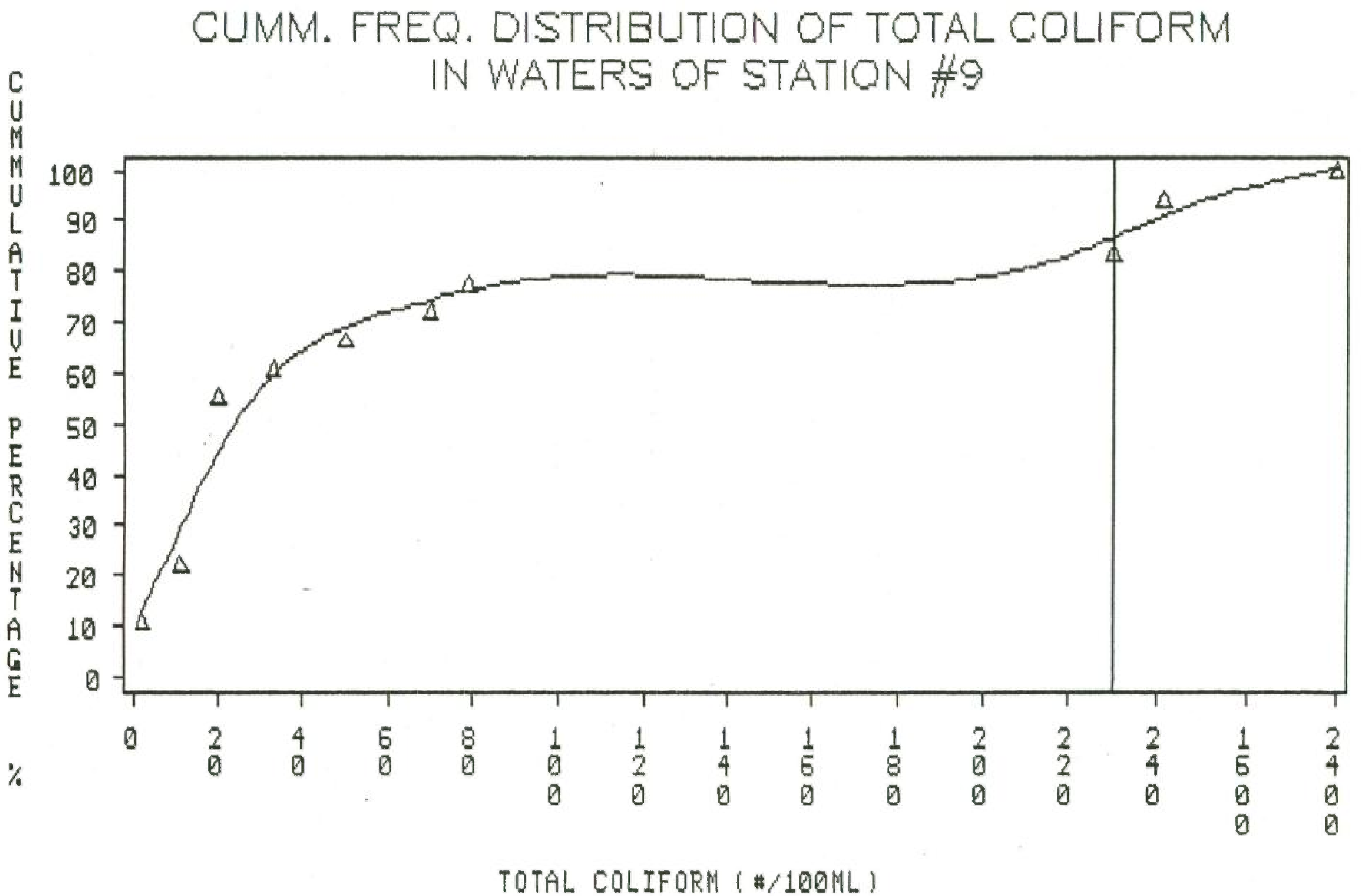
SOURCE: I.S.C. 86—87 SPECIAL SURVEY
APRIL, 1987

Figure 17



DISSOLVED OXYGEN IN BOTTOM WATERS
OF NEW YORK BIGHT
(MAXIMUN,MEAN,MINIMUN)
DISSOLVED OXYGEN (MG/L)
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
SAMPLING STATION
SOURCE: I.S.C. 86-87 SPECIAL SURVEY
APRIL, 1987

Figure 18



SOURCE: I.S.C. 86—87 SPECIAL SURVEY

Table 1: I.S.C. 1986-1987 Special Sampling Survey Station Description

ISC SURVEY STATION NUMBER	LATITUDE NORTH D M S	LONGITUDE WEST D M S	DESCRIPTION	MAP REFERENCE NUMBER
AO-01	40-31-47	73-56-37	Flashing Red R "2" Gong (4 sec.)	8
HR-01	40-42-20	74-01-36	Mid-channel of Hudson River N-S: Line of black buoys E-W: Fire Boat Pier (NY) and railroad pier (NJ)	4
HR-02	40-45-17	74-00-58	Mid-channel of Hudson River E-W: Heliport (NY) and Seatrain pier (NJ)	3
HR-04	40-51-04	73-57-04	Mid-channel of Hudson River under George Washington Bridge	2
HR-07	40-56-51	73-54-27	Mid-channel of Hudson River E-W: Opposite Phelps Dodge (Yonkers)	1
LB-01	40-30-44	74-06-03	500 feet from Old Orchard Light in line with the beacon at Old Orchard Shore	17
LB-03	40-34-03	73-59-00	200 feet south of Steeplechase Pier at Coney Island - N "2S"	7
LB-05	40-29-01	74-07-35	Buoy "1" Fl 4 sec; off Point Comfort	13
LB-07	40-29-40	74-02-53	Buoy Fl G 4 sec; Southern end of Chapel Hill South Channel	11
LB-08	40-31-28	74-02-07	Buoy R "10S" Gong Fl R 4 sec; Northwest end of Swash Channel	10
RB-16	40-30-16	74-09-46	North side of Fl 4 sec 8M "20" Buoy located on northern boundary of Raritan Bay West Reach; off Huguenot Beach on Staten Island	16
RB-19	40-28-26	74-11-02	Buoy "1" Fl G 2.5 sec; off Conaskonk Point	14
RB-20	40-27-27	74-04-20	Buoy "1" Fl G 4 sec Bell; off Port Monmouth	12
RB-21	40-29-25	74-11-40	Midway between Fl 4 sec Buoy and Fl 4 sec 8M "20" Buoy and 2300 yards south of Seguine Point on Staten Island	15
UH-03	40-39-14	74-03-35	Passaic Valley Outfalls E-W: Robbins Reef Light and forward water tower on Naval Dock N-S: Statue of Liberty and Black Bell Buoy 1-G	5
UH-13	40-36-26	74-02-45	Middle of channel in Narrows under Verrazano Bridge	6
W-06	40-32-36	73-51-54	South of main building with twin towers at Riis Park and approximately 1 1/2 miles from shore	9

Table 2

Comparison of Geometric Means of Coliform Concentrations
in Cold Weather Before and After ISC Year-Round Disinfection Requirement*

Fecal Coliform (count/100ml)

Station	Seasonal Disinfection**	Year-Round Disinfection***
1	920	430
2	700	470
3	4400	390
4	3300	620
5	2200	250
6	4700	190
7	970	61
8	1100	15
10	2000	98
16	83	50
17	43	43

Total Coliform (count/100ml)

Station	Seasonal Disinfection**	Year-Round Disinfection***
1	1700	980
2	2700	1300
3	11000	1500
4	7600	1800
5	15000	900
6	18000	490
7	5400	150
8	11000	46
10	5500	360
16	180	75
17	290	69

* ISC's year-round disinfection requirement went into effect on July 1, 1986.
** March 1984, March 1985 and March 1986 which seasonal disinfection was practiced
*** November 1986 and February 1987 which year-round disinfection was practiced

Table 3

Summary of Heavy Metal Concentration in Study Area *(Unit: μg/l) in total

PARAMETER		STATION 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Silver	Max.	10	6	5	5	4	5	5	5	6	5	6	4	4	5	7	4	4
	Min.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean(N)**	3.2 (4)	2.5(6)	2.1(6)	2(6)	1.8(6)	2.5(4)	2(5)	2(6)	2.5(5)	2.4(5)	2(5)	2(5)	2.2(5)	2.6(5)	1.8(5)	2.4(5)	2.2(5)
Arsenic	Max.	2	3	7	8	5	4	4	3	3	3	4	4	4	5	4	5	3
	Min.	1	1	1	1	2	1	1	1	1	2	2	1	2	2	2	2	1
	Mean (N)	1.3 (4)	2(6)	2.5(6)	2.8(6)	2.5(6)	2.5(4)	2.4(5)	2.1(6)	2.3(6)	2.2(5)	2.6(5)	3.2(5)	3.0(5)	3.5(4)	2.8(5)	2.8(5)	2.2(5)
Cadmium	Max.	0.5	1.7	0.9	0.6	0.8	1.2	0.9	1.4	1.5	0.5	1.0	0.7	0.6	1.0	1.7	0.6	1
	Min.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Mean (N)	0.5 (4)	0.7(6)	0.6(6)	0.5(6)	0.6(6)	0.7(4)	0.6(5)	0.7(6)	0.7(6)	0.5(5)	0.6(5)	0.5(5)	0.5(50	0.6(5)	0.7(5)	0.5(5)	0.6(5)
Chromium	Max.	3.8	7.7	5.8	3.8	2.5	3.8	1.5	2.3	2.3	5.8	1.8	2.3	2.3	3.8	3.8	3	3
	Min.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1	1
	Mean (N)	2.4 (4)	2.9(6)	2.6(6)	2.0(6)	1.6(6)	2.5(5)	1.1(5)	1.2(6)	1.2(6)	2.7(4)	1.3(5)	1.2(5)	1.3(5)	1.6(5)	1.9(5)	1.4(5)	1.4(5)
Copper	Max.	62	44	55	69	77	44	63	125	51	72	113	50	89	74	61	32	41
	Min.	7	4	2	7	4	4	4	2	4	3	4	5	5	5	2	2	4
	Mean (N)	30(4)	24(6)	27(6)	31(6)	38(6)	20(4)	24(5)	29(6)	17(6)	25(5)	36(5)	24(5)	31(5)	26(5)	22(5)	17(5)	15(5)
Iron	Max.	365	625	629	315	306	162	211	98	104	110	116	119	121	148	189	513	186
	Min.	197	265	181	68	108	46	63	35	37	44	45	32	32	50	44	96	53
	Mean (N)	299(4)	425(6)	348(6)	187(6)	182(6)	121(4)	101(5)	72(6)	58(6)	67(5)	73(5)	74(5)	87(4)	90(5)	114(5)	199(5)	103(5)
Mercury	Max.	0.3	0.4	0.3	0.2	0.2	0.2	0.8	0.9	0.9	0.3	0.7	0.5	0.3	0.6	0.5	0.1	0.3
	Min.	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Mean (N)	0.15(4)	0.18(6	0.18(6	0.1(6)	0.1(6)	0.1(4)	0.3(5)	0.3(5)	0.4(6)	0.1(5)	0.2(5)	0.2(5)	0.2(5)	0.2(5)	0.2(5)	0.1(5)	0.1(5)
Nickel	Max.	5	14	11	7	13	9	9	9	7	6	10	8	9	16	13	10	11
	Min.	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Mean (N)	5 (4)	7.8(6)	6.3(6)	5.5(6)	6.8(6)	6.2(4)	6.2(5)	6.1(6)	5.5(6)	5.4(5)	6.6(5)	6.6(5)	6.7(4)	9.4(5)	8(5)	6(5)	7(5)
Lead	Max.	38	38	58	40	63	33	30	18	16	25	13	18	25	16	18	27	16
	Min.	5	5	8	5	6	10	8	5	5	7	5	17	5	5	5	6	8
	Mean (N)	16(4)	17(6)	23(6)	17(6)	25(6)	18(4)	15(5)	10(6)	10(6)	12(5)	8(5)	11(5)	13(4)	10(5)	11(5)	17(5)	11(5)
Zinc	Max.	28	48	36	71	85	168	35	87	64	57	81	56	89	92	57	63	35
	Min.	14	8	10	11	15	11	17	1	3	2	5	12	13	32	9	8	11
	Mean (N)	22(4)	24(6)	23(6)	28(6)	37(6)	60(4)	24(5)	33(6)	31(6)	32(5)	41(5)	33(5)	45(5)	50(5)	29(5)	38(5)	24(5)

Note: * : source of data - I.S.C. 86-87 special survey
** : (N) denote the total number of data