2-1977

Environmental effects of James River sewage treatment plant outfall construction

Dexter S. Haven
Virginia Institute of Marine Science

Paul C. Kendall
Virginia Institute of Marine Science

Robert J. Diaz
Virginia Institute of Marine Science

Donald F. Boesch
Virginia Institute of Marine Science

Michael E. Bender
Virginia Institute of Marine Science

ENVIRONMENTAL EFFECTS OF JAMES RIVER SEWAGE TREATMENT PLANT OUTFALL CONSTRUCTION

by

Virginia Institute of Marine Science

Gloucester Point, Virginia

D. S. Haven
P. C. Kendall
R. J. Diaz
D. F. Boesch
M. E. Bender

Final Report to

Hampton Roads Sanitation District

Virginia Beach, Virginia

February 1977

VIMS Contract #187

TABLE OF CONTENTS

General Introduction

In the spring of 1975 the Institute began a program to determine whether significant environmental changes would occur in the area of the new James River Plant outfall that might be related to its construction and/or initial operation. Parameters measured in the study were benthic animal and oyster populations, coliform levels and chlorine residuals. The primary emphasis of the study centered on the estimation of the impact of the construction activity on shellfish beds in the area.

The results of the investigation are presented in three segments, the first dealing with shellfish populations, the second with other benthic animals and the third with coliforms and chlorine.

Section I.

ENVIRONMENTAL EFFECTS OF JAMES RIVER SEWAGE TREATMENT PLANT OUTFALL CONSTRUCTION ON OYSTER BEDS IN THE JAMES RIVER.

By

Dexter S. Haven and Paul C. Kendall

Virginia Institute of Marine Science

Gloucester Point, Virginia 23062

September, 1976

INTRODUCTION

A study was made by the Virginia Institute of Marine Science at the request of the Hampton Roads Sanitation District to determine the possible impact on the surrounding bottom of constructing a new sewage pipeline parallel to the existing one from the James River Sewage Treatment Plant.

The area surveyed is located in the James River at the mouth of the Warwick River about one-half mile inshore from the highly productive Wreck Shoals seed area. This section of the James is almost entirely free of the oyster pathogens MSX and *Dermocystidium* which cause extensive mortalities to oysters in regions of higher salinities. Also, the oyster drill *Urosalpinx cinerea* is absent.

The pipeline and the area covered by this study lie within shellfish condemnation area No. 55. Oysters from such regions may not be harvested for direct consumption, but must be relaid prior to sale in a state approved area for 15 days with temperatures over 50°F.

The pipeline crosses portions of five leases and a short portion of Baylor Grounds at the terminal end (Figure 1). A summary of lease size, ownership, etc., from the files of the Virginia Marine Resources Commission (VMRC) follows:

Plot 17 (11.73 acres) leased by Seacrest Corp.

Plot 29 (60.65 acres) leased by W. H. Morgan & Sons

Plot 34 (24.98 acres) leased by W. D. Melzer

Plot 39 (12.67 acres) leased by W. D. Melzer

Plot 37 (3.80 acres) leased by Nelson Firth, Sr.

Water depths (MLW) at the offshore end of the pipeline ranged from 7 to 8 feet and gradually shelved to 3 to 4 feet at the inshore end at plot 37. The bottom is largely soft mud in which are embedded occasional oyster shells, but patches of hard bottom composed of sand and/or shells and oysters occurred in several locations.

METHODS

Station Locations

Prior to the study, the bounds of the leases were delineated with stakes by personnel of the VMRC. Sampling stations were located every 200 feet on transects located at 200 feet intervals parallel to the pipeline; this outlined a grid with squares 200 feet on each side. In the field, locations were established with the aid of stakes whose positions were established with the aid of a sextant.

The first study was conducted in April 1975, prior to construction activity; the second took place in April 1976 after construction was ended. Most of the reference stakes utilized during the first study were still in place when the second phase began. Those which were missing, if they marked leased areas, were replaced by the VMRC.

Permission was obtained from the lease holders to obtain bottom samples from leases 17, 29 and 37. Permission was not granted to sample bottoms on leases 34 and 39.

Sampling Methods

Three methods were used to evaluate the impact of construction activities on oyster populations and on the bottom: 1) surveys of oysters (number per unit area of bottom) using patent tongs: 2) studies of the bottom by divers; and 3) studies of bottom topography with a fathometer.

The patent tongs used in the first and second studies obtained samples from 12 and 10.6 ft^2, respectively, and were operated from a patent tong boat by an experienced waterman. About 172 stations were occupied in 1975, and about 89 in 1976. In one instance, on lease 37, where water depths were too shoal for patent tongs, hand tongs were used to collect samples.

Samples were not taken on Baylor Bottoms in 1976 to the SW of the outfall since extensive harvesting was observed after 1975.

The samples were collected at 200 foot intervals along the route of the pipeline, and at 200 foot intervals on each side. Along the pipeline route and along each transect immediately adjacent, four grabs were made at each station; at other locations, two grabs were made.

Materials collected by the tongs were examined in the field and the following data recorded: numbers of market oysters (3 inches or larger); small and yearling oysters (about 3/4 to 3 inches); and spat (the current year class). Also recorded, as an index of mortality, were the number of boxes (hinged valves). The quantity of shell collected in each grab was measured to the nearest quart. The results of successive samples taken at the same station were averaged and the following calculations made: acreage sampled, area from which samples were taken, number of oysters collected by the tongs in an area, bushels of oysters and shell per acre, and total bushels of oysters and shell on each leased plot.

Diver Survey

Divers were employed to observe the bottom before and after construction. They swam along transects parallel to and at right angles to the pipeline and noted the character of the bottom, concentrations of oysters or shell, and the occurrence of holes or other unusual features. In 1975, the diver reported to a recorder after each dive; in 1976 the diver was in direct communication via a telephone "hook up" with personnel in the boat and a tape recorder. Observations of the divers were summarized for this report.

Fathometer Study

A recording fathometer was operated along transects parallel to and at right angles to the pipeline prior to and after construction and the topography of the bottom recorded. Later, the 1975 and 1976 traces were placed adjacent to each other for comparison.

RESULTS

The results of the fathometer and diver study are discussed first without reference to leases or numbers of oysters/acre to give an overview of the entire area. Later, oyster density (bu/acre) are discussed in reference to individual leases.

Diver and Fathometer Study

Construction activity had a measurable impact on bottom topography in the immediate vicinity of the pipeline, but it seemed to be confined to a distance of 100 feet or less on either side of the new pipeline.

A diver on 11 and 12 April 1975, covered three transects: 2) over the pipeline; and 1 & 3) 200 feet on either side (Figure 2). He observed that the bottom 200 feet to the west of the pipeline was largely soft mud. Over the pipeline it was soft mud with an occasional live oyster. Two hundred feet to the east of the pipeline, areas of live oysters and shell were common (Appendix I, Transects 1, 2, 3 and 6-1/2).

Eight fathometer traces were made in 1975 in the vicinity of the pipeline. Three were parallel to and west of the pipeline at 200 foot intervals. Four were parallel to and east at 200 foot intervals. One was over the pipeline (Figure 3). In most locations, the bottom was smooth with few depressions or hills. Over the old pipeline a few peaks about one foot high were noted (Appendix II, Transects A-B (1975) and A_1 through A_7).

In 1976 after the pipeline was completed, the diver observed a major change in the character of the bottom over and adjacent to the site of the new pipeline. On this date, the diver swam over the pipeline and 200 feet on either side; also five additional transects were covered at right angles to the pipeline (Figure 4). The diver reported a trench or a series of partially filled holes over the pipeline which ranged down to 8 or 10 feet below the surrounding bottom. Balls or lumps of clay up to 2 feet in diameter lay along the side of the trench. Occasional lumps of clay one or two feet in diameter were observed 200-400 feet to the west of the pipeline (Appendix II, Transects A-B (1976) and A_1 through A_8).

On the west side of the pipeline, on leases 17, 29, 34 and 39, the bottom was predominantly soft mud with buried shell and an occasional patch of live oysters. On the eastern side, on plots 34 and 37, the bottom was either sand or soft mud. However, on plots 29 and 17, from one quarter to one third of the bottom had oysters, with the remainder showing mud and scattered shells.

The fathometer study made during April 1976 covered nine transects parallel to the pipeline, and four at right angles to the pipeline (Figure 5). Over the site of the new pipeline, the trench was not completely filled and consisted of a series of peaks and depressions; some of the peaks extended within 5 feet of water's surface. Many holes were 8 to 10 feet below the existing bottom level. The trench varied from about 10 to 40 feet wide. Often sediments occurred in piles along the side of the trench, so the total modified area varied from about 40 to 60 feet (Appendix II, Transects A-B, A_1 through A_8 and 4, 5, 6 and 7).

When fathometer traces made in 1976 (200 feet or more away from the pipeline)are compared with those made over the same areas in 1975 no extensive changes are noted at the same locations (Appendix II, Transects A_1-A_7).

Number of Oysters on Leased Bottoms Before and After Construction of the Pipeline

Size of Oysters - Occurrence of Spat

The 1975 study showed a predominance of market-sized oysters on plots 17 and 29. On plot 29, 75% of all the oysters collected by the patent tongs (exclusive of spat) were 3 inches long or longer. On plot 17, 98% were over 3 inches in length. Both of the leased areas had a moderate level of setting in 1974 (attachment of oyster larvae to substrate). In April 1975, spat ranged from about 1/2 to 3/4 inch long. It was estimated that a bushel of bottom material (shells and oysters) contained from 93 to 144 spat/bu. Number of oysters per bushel, exclusive of spat, was 307 on plot 29, and 218 on plot 17 (Table 1).

By April 1976 when the second study took place, many of the spat had increased in size and were counted with the larger oysters. This was shown by a decrease in percentage of market-sized oysters per bushel over the preceding year. That is, on plot 29, only 58% were market-size; on plot 17, 53% were in this size class. Accompanying this was an increase in numbers of oysters per bushel; counts were 377 per bushel on plot 29, and 339 per bushel on plot 17 (Table 1).

Plot #37 - Firth - Oyster Distribution

This was a very narrow strip of leased bottom 3.80 acres in size. In 1975, 25 to 30 grabs with oyster tongs were made to determine oyster distribution. From the western end to just off the outfall, the bottom was sandy or soft mud with no oysters. From the outfall to the eastern end, the bottom changed gradually from sand to rocks 4-10 inches in diameter. Oysters occurred between and on the rocks. Density over the extreme end of the lease at two sampling stations on an area estimated to be about 0.8 acre, was 200 and 240 bu/acre in 1975; in 1976 it was slightly less; 150 and 171 bu/acre (Figure 6 and 7).

Plot #17 - Seacrest Corp.

This is a narrow lease of 11.73 acres lying obliquely across the pipelines (Figure 1). In 1975, the bottom, as determined by a diver, was predominantly soft mud, or mud in which was embedded an occasional oyster shell; scattered areas of surface shells and oysters also occurred. The diver study in 1976 indicated an extensive modification of the bottom on this lease along the pipeline and as previously discussed the trench and area of deposition ranged from 40 to 60 feet wide, with holes up to 8-10 feet deep. Neither the diver study or that made by the fathometer indicated bottom modification further than 100 feet from the pipeline (Appendices I, II & III).

Oyster density in 1975 was low over most of plot #17, and, with one exception, it ranged from 0 to 30 bu/acre with a mean of 19 bu/acre. The exception was at the western end of the lease where one station showed 175 bu/acre (Table 2 and Figure 6). The total quantity of shell on the plot was low and was estimated at 147 bu/acre, or 1911 bushels for the entire plot (Table 4).

The 1976 study showed essentially the same distribution. Oyster density ranged from 0 to 76 bu/acre with a mean of 21 bu/acre (Table 2 and Figure 7).

An inspection of oyster numbers at varying distances from the pipeline (Table 2) indicates that there were no oysters in the pipeline to 100 foot zone in 1976, but a few were observed there in 1975. This indicates that, as shown by the diver and fathometer study, oysters were probably destroyed in a narrow zone varying from 40 to 60 feet wide from the site of the new pipeline.

The density of shell was determined again in 1976 and it ranged from 139 to 168 bu/acre or about 1784 bushels for the entire lease. This was about the same as in 1975 (Table 4).

Box counts for lease 17 averaged 12% in 1975 and 5% in 1976 which is in the normal range for that area of the James. This stable condition suggests that on the average, there were no abnormal mortalities during the 1975-76 period. There is one reservation to this generalization. During construction, oysters in the narrow 40 to 60 foot wide zone over the pipeline were absent in 1976; the oysters seen there in 1975 had been dredged up and deposited elsewhere or they had been covered by the spoil material too deep for us to recover boxes. The area over the pipeline was so small in relation to the whole plot that mortality there had little effect on the overall mortality.

Plot #29 - Morgan

In 1975, to the west of the pipeline the bottom, as shown by the patent tong survey was largely devoid of oysters (Figure 6); observations by a diver confirmed this and indicated a soft mud bottom with occasional patches of shell or oysters (Appendix I - Transects 1-3). Three concentrations of oysters were noted: 1) on the extreme western part of the lease; 2) in the central part over the pipeline; and 3) on the eastern edge where lease 29 adjoins lease 17. All contained harvestable densities (46-145 bu/acre) or high densities (over 145 bu/acre). Actual densities ranged from 0 to 316 bushels/acre.

The average for all stations was 28 bu/acre and it was estimated that the 60.65 acre tract contained 1748 bushels (Table 3).

Shell was scarce; densities ranged from 102 to 150 bu/acre with a total for the plot of 7500 bushels (Table 5).

The April 1976 patent tong study showed essentially the same distribution of oysters as was observed in 1975 (Figure 7). To the west of the pipeline, the bottom was almost completely barren with the bottom largely mud or mud with a few shells (Appendix III). Most of the oysters found were concentrated on either side of the trench (with an absence of oysters in the trenched area) and extended toward the east to lease 17, in the same locations as were noted in 1975. In these regions, oysters occurred at rates ranging from 0 to 279 bu/acre. Average density for lease 29 was 41 bu/acre; this was an increase in average number over the 28 bu/acre noted in 1975. This increase was caused by the spat noted in 1975 being included in the 1976 population estimates (Table 3).

Box counts for lease 29 averaged 8% in 1975 and 10% in 1976 which is normal for the area and was about the same as noted on plot 17. The absence of an increase in box counts indicates no abnormal mortalities for most of the plot. However, as just outlined for plot 29, we observed that destruction of the oyster population was complete for the 40-60 foot zone area over the pipeline.

Shell ranged from 133 bu/acre on the western side of the pipeline to 217 bu/acre on the eastern side; total for the lease was 9870 bushel. This was slightly more than was observed in 1975 (Table 5).

Plots #34 and 39

While bottom surveys were not made on these two plots, diver and fathometer studies were carried out. These studies indicated modifications of the bottom in the vicinity of the pipeline as was observed on plots 17 and 29, and no modification elsewhere except occasional lumps of clay deposited on the bottom.

CONCLUSIONS

When the new sewage outfall was constructed, it caused modification to the bottom in the immediate vicinity of the pipeline. A trench still exists with holes up to 8-10 feet deep. On either side of this trench are clumps or piles of bottom material which extend about 2 feet above the surrounding bottom. It is estimated that the area of disrupted bottom extends, on the average, about 20-30 feet on either side of the pipeline. No evidence of bottom modification was seen by the divers or shown by fathometer traces 100 feet or more from the pipeline.

The study of oyster numbers by patent tongs on the leased bottoms indicates, on the average, more oysters on the plots in 1976 than in 1975. This increase was due to the fact that the 1975 spat survived and grew and were counted in 1976 as oysters (Figure 7).

There was no evidence on the basis of box counts of an excessive mortality over the plots. There is one reservation relative to this point. That is, destruction of oysters was complete in the narrow 40 to 60 foot wide path over the pipeline and oysters from this area were buried or transported from the area, and, therefore, few if any boxes were collected by the patent tongs.

We conclude that damage to the bottom and oyster populations was confined to a 40-60 foot wide zone over the site of the new pipeline. There appeared to be total destruction of the oyster population here.

Table 1

Number of oysters per bushel of bottom cultch and percentage by size class in area adjacent to sewage outfall.

	1975	
Size Class	Plot 29 % of Total	Plot 17 % of Total
Market	75	98
Small & Yearling	25	2
No./Bu.	(307)	(218)
No. Spat/Bu.	93	144

	1976	
Size Class	Plot 29 % of Total	Plot 17 % of Total
Market	58	53
Small & Yearling	42	47
No./Bu.	(377)	(339)
No. Spat/Bu.	0	0

Table 3

Leased Plot 29

Estimates of Quantities of Live Oysters (Less Spat) At Various Distances from the Existing Pipeline

April 1975 and April 1976

Distance and Direction From the Old Pipeline	LIVE OYSTERS Area Sampled (ft^2)		Area Sampled (Acres)		Actual Number Found (Total No.)		Average Density (Bu/Acre)		Estimated Quantity (bu)		OYSTER BOXES Actual Number Found (Total No.)		% BOXES Boxes / Boxes + Live	
	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Northwest														
Pipeline to 100'	168	148	3.5	3.5	45	41.5	38.0	32.4	133	113	5	9.5	10	20
100 - 300'	384	339	8	8	3	6	1.1	2.0	9	16	6	0	66	0
300 - 500'	216	191	9	9	28	10	18.4	6.0	166	54	3	0	10	0
500 - 700'	240	212	10	10	4	2	2.4	1.1	24	11	1	0	20	0
700 - 900'	120	106	5	5	7	0	8.3	0	42	0	0	0	0	--
900 -1100'	48	42	2	2	0	0	0	0	0	0	0	0	--	--
Summary for subarea	1,176	1,038	37.5	37.5	87	59.5	10.5	6.6	394	248	15	9.5	15	14
Southeast														
Pipeline to 100'	168	148	3.5	3.5	45	41.5	38.0	32.4	133	113	5	9.5	9	20
100 - 300'	336	297	7	7	201	317	84.9	123.3	594	863	6	21	21	6
300 - 500'	120	106	5	5	16	69	18.9	75.2	94	376	1	9	9	12
500 - 700'	96	85	4	4	15	118	22.2	160.4	89	642	1	12	12	9
700 - 900'	72	42	3	2	22	5	43.4	13.8	130	28	3	0	0	0
900 -1100'	24	0	1	0	11	--	65.0	--	65	--	2	--	--	--
1100 -1300'	24	21	1	1	3	5	17.7	27.5	18	28	3	0	0	0
Summary for subarea	840	699	24.5	22.5	313	555.5	52.9	91.8	1,296	2,066	21	51.5	10	8
Summary for Total Area	2,016	1,737	62.0	60.0	400	615.0	28.2	40.9	1,748	2,454	36	61.0	8	10

1 Based on 377 oysters/bu for 1976; 307 oysters/bu in 1975.

Table 4

Leased Plot 17
Estimates of Quantities of Shell

SHELL

	Average Density (bu/ac)		Sample Area (acres)		Estimated Quantity (bu)	
	1975	1976	1975	1976	1975	1976
Northwest of pipeline						
Summary for subarea	147	168	5	4	735	672
Southeast of pipeline						
Summary for Subarea	147	139	8	8	1,176	1,112
Summary for Total Area	--	--			1,911	1,784

Table 5

Leased Plot 29
Estimated Quantities of Shell

	SHELL					
	Average Density (bu/ac)		Sample Area (acres)		Estimated Quantity (bu)	
	1975	1976	1975	1976	1975	1976
Northwest of pipeline						
Summary for subarea	102	133	37.5	37.5	3,825	4,988
Southeast of pipeline						
Summary for subarea	150	217	24.5	22.5	3,675	4,882
Summary for Total Area	--	--			7,500	9,870

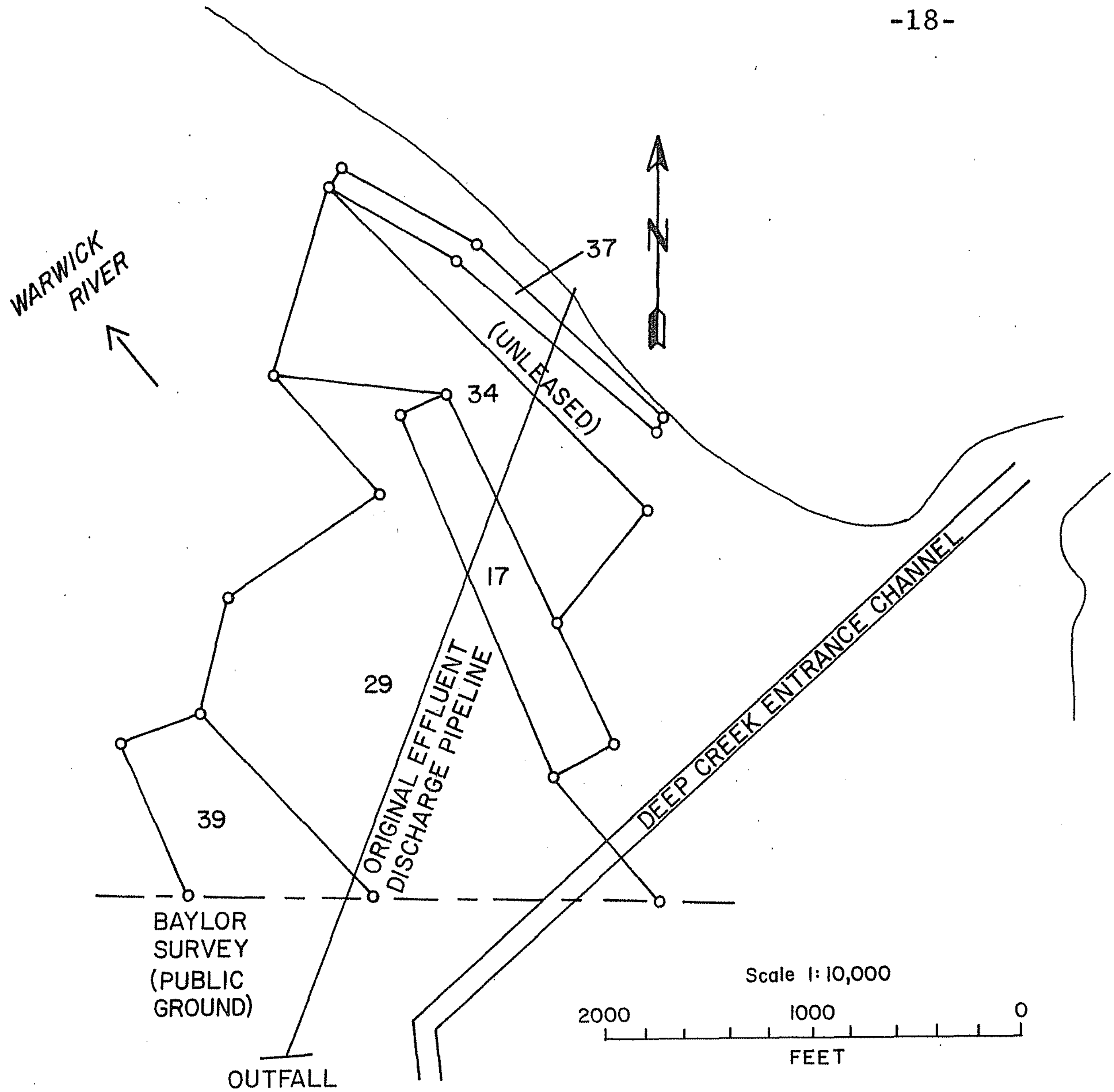
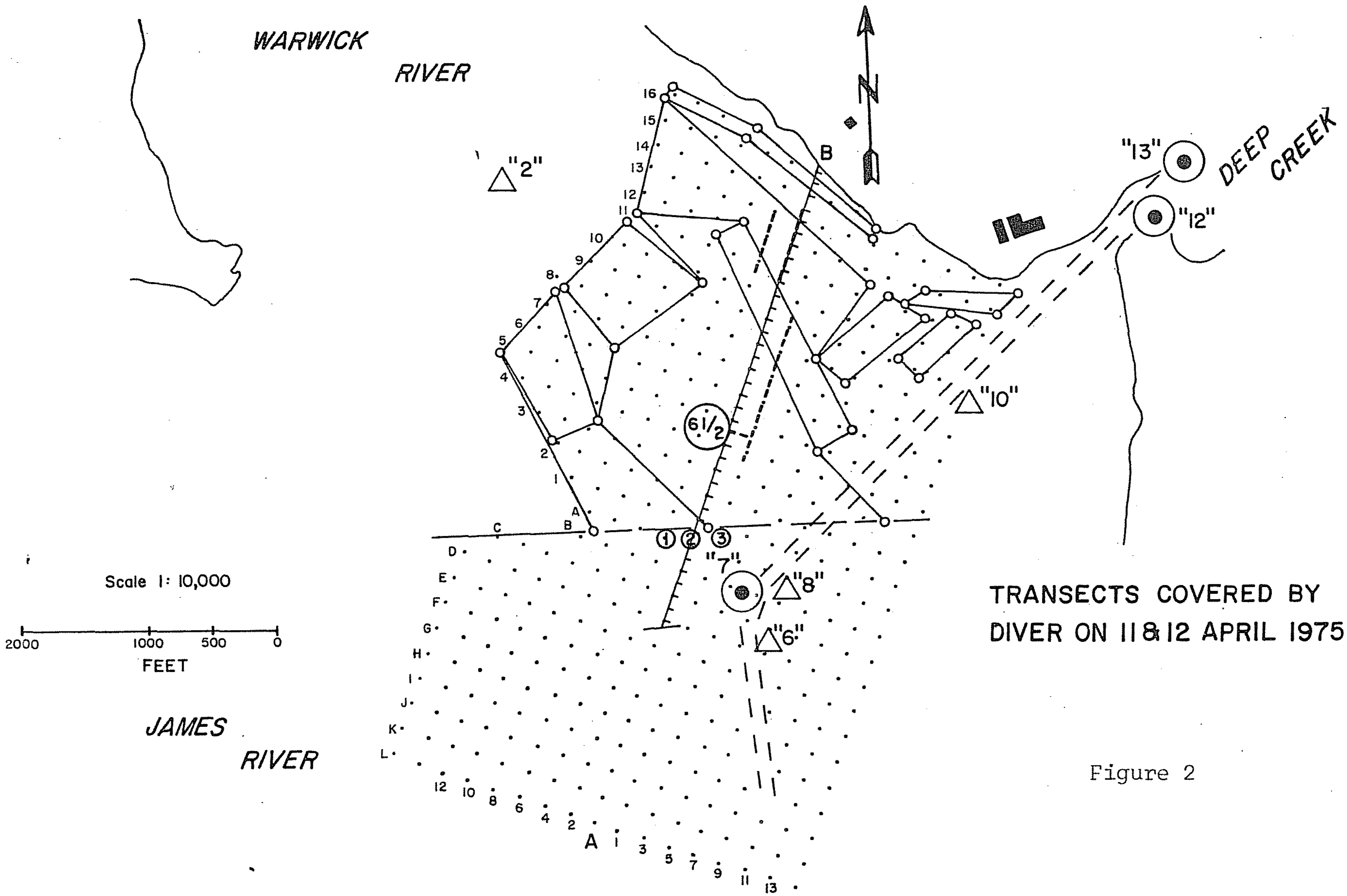


Figure 1

Locations of Areas Studied During 1975 and 1976 Pipeline Investigation.



TRANSECTS COVERED BY DIVER ON 11 & 12 APRIL 1975

Figure 2

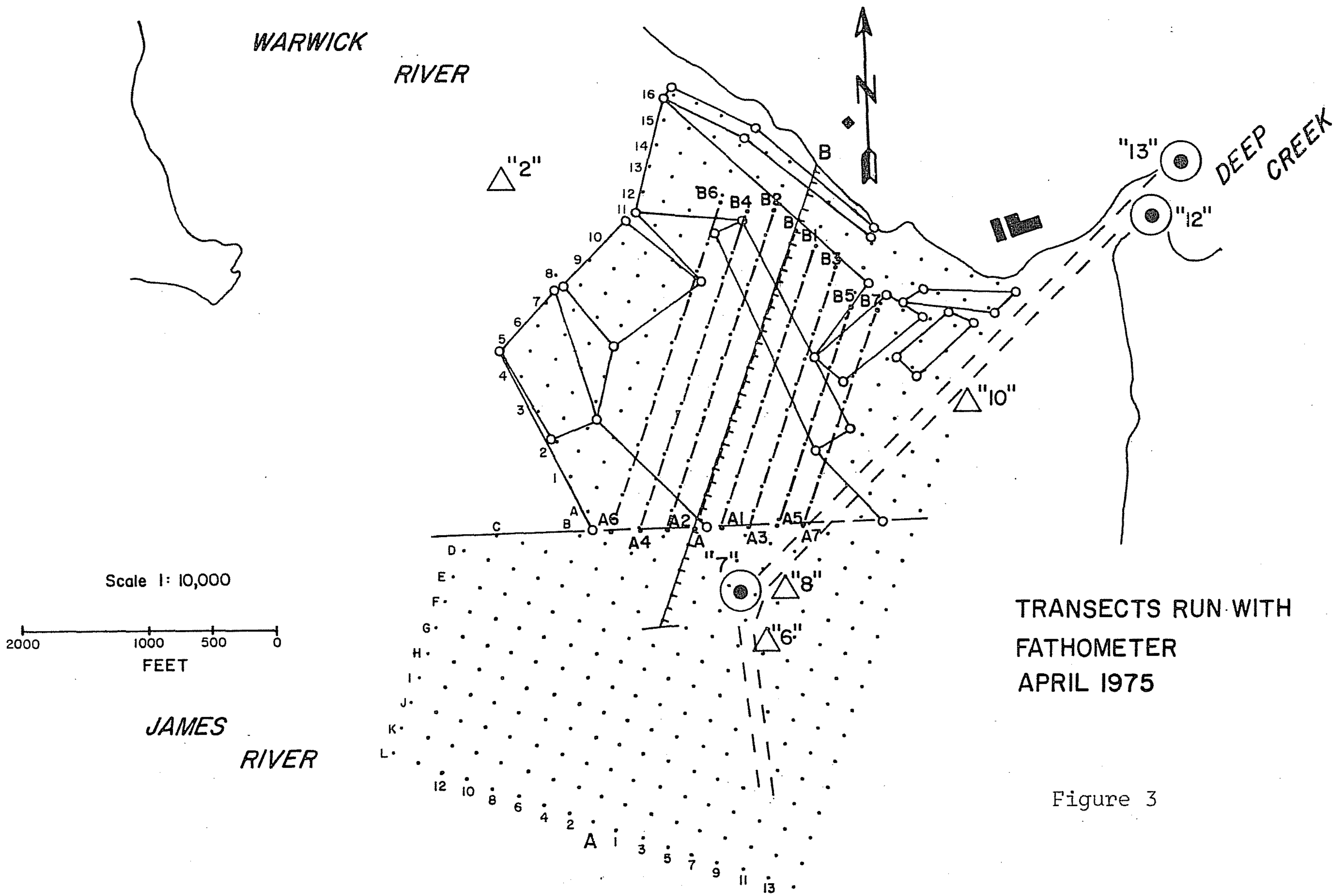

WARWICK
RIVER
DEEP
CREEK
JAMES
RIVER
"2"
"13"
"12"
"10"
"7"
"8"
"6"
N
Scale 1: 10,000
2000
1000
500
0
FEET
TRANSECTS RUN WITH
FATHOMETER
APRIL 1975

Figure 3

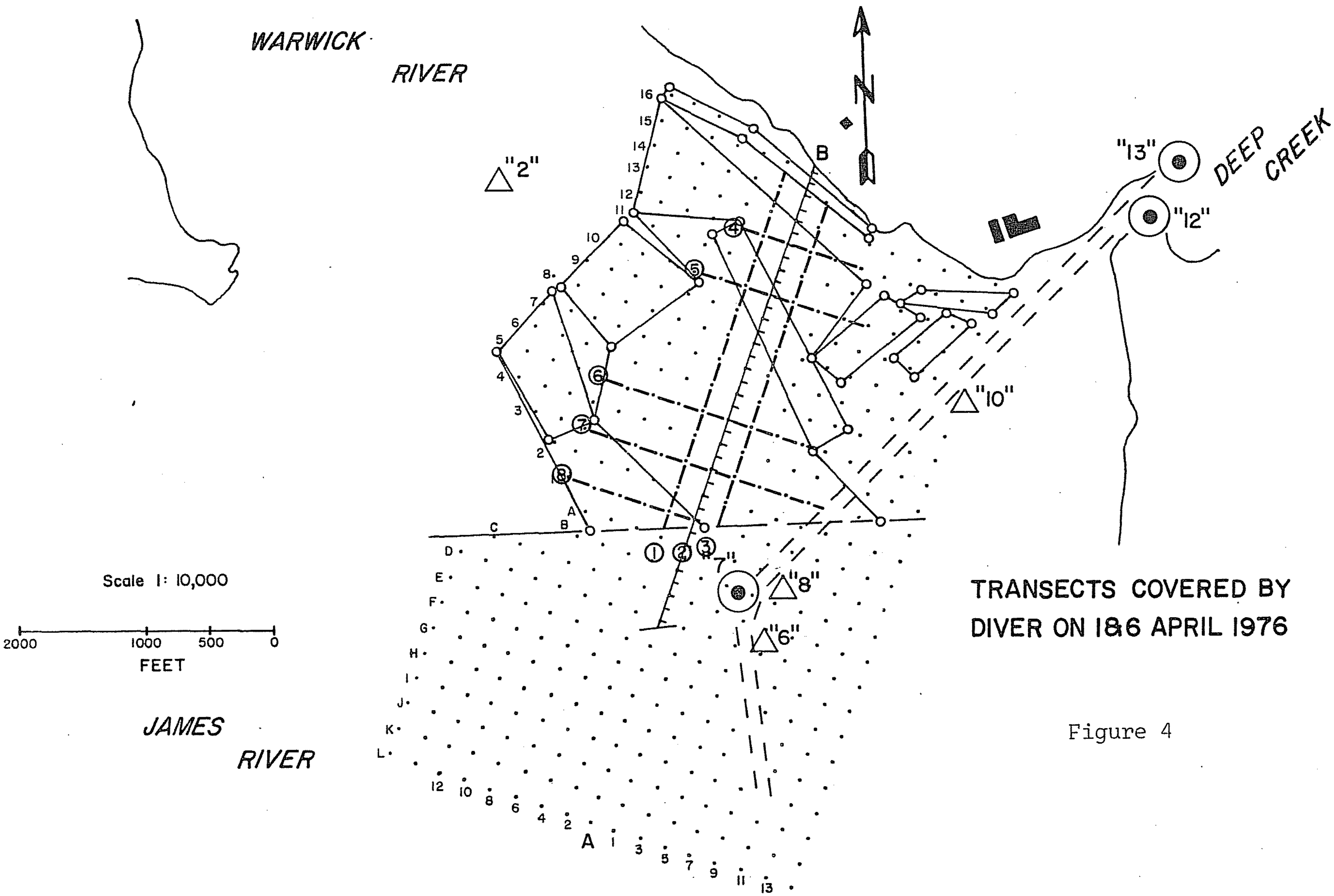
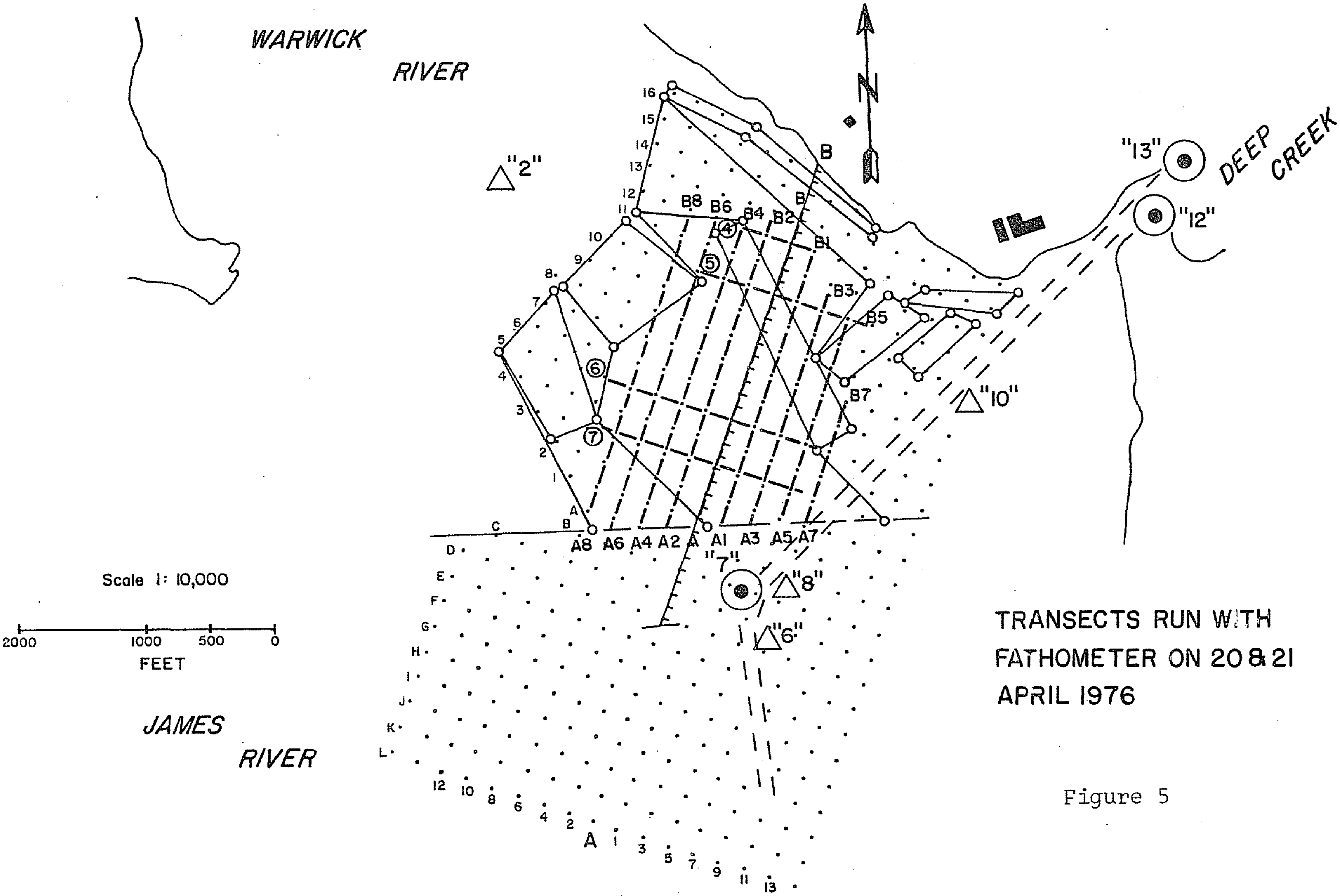
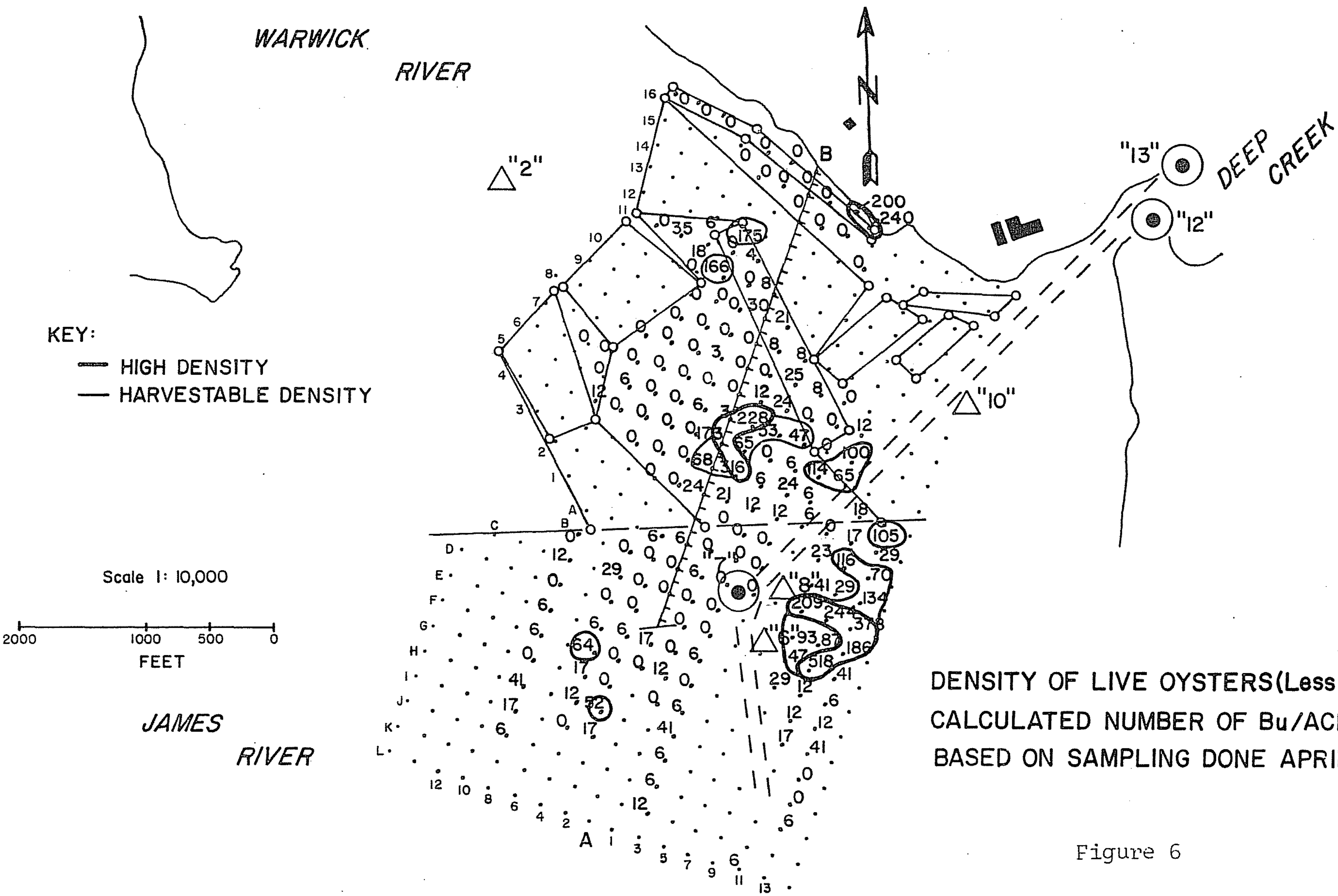

WARWICK RIVER
JAMES RIVER
DEEP CREEK
N
B
A
"2"
"13"
"12"
"10"
"7"
"8"
"6"
Scale 1: 10,000
2000 1000 500 0
FEET
TRANSECTS COVERED BY DIVER ON 1&6 APRIL 1976

Figure 4



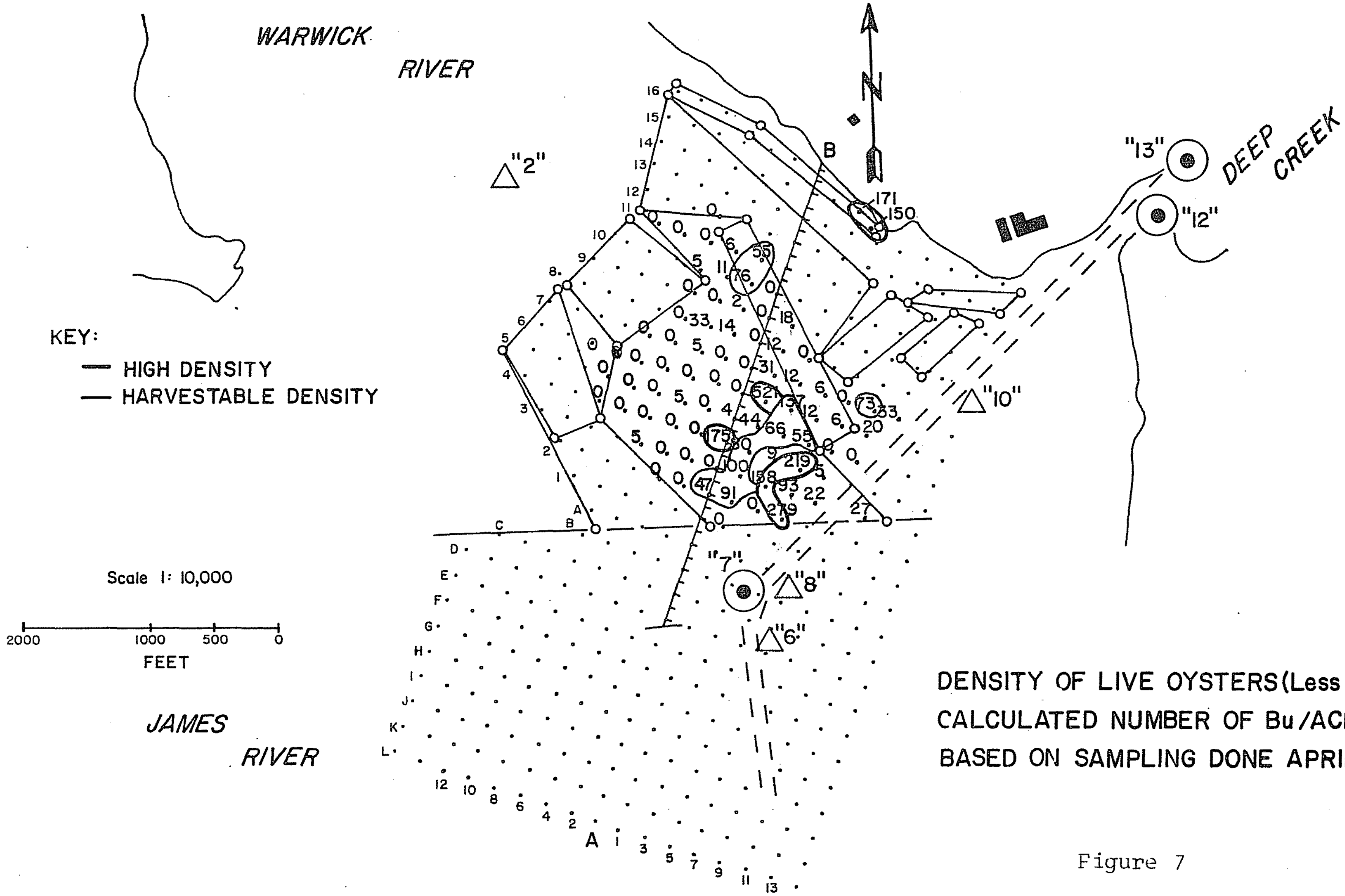
TRANSECTS RUN WITH FATHOMETER ON 20 & 21 APRIL 1976

Figure 5



DENSITY OF LIVE OYSTERS (Less Spat)
CALCULATED NUMBER OF Bu/ACRE
BASED ON SAMPLING DONE APRIL 1975

Figure 6



DENSITY OF LIVE OYSTERS (Less Spat)
CALCULATED NUMBER OF Bu/ACRE
BASED ON SAMPLING DONE APRIL 1976

Figure 7

APPENDIX I

Observations Made By a Diver in the James River on 11 and 21 April, 1975.

Transect Number (as shown on Fig. 2): 1

200 feet NW of and parallel to the old pipeline

OBSERVATIONS

Segment of Transect**	
0 - 200'	Plot 17: Bottom was soft mud with sparsely scattered shells.
200 - 300'	Plot 34: Bottom soft mud with sparsely scattered shells.
300 - 400'	Plot 34: Bottom changed gradually into firm sand; angel wing clams present.

** Starting on the mid-line of plot 17 and going inshore.

Transect Number (as shown on Fig. 2): 2

Over the old pipeline

OBSERVATIONS

Segment of Transect**

0 - 100'	Plot 34: Bottom covered with shells and live oysters.
100 - 500'	Plot 34: Bottom mud with occasional shells.
500 - 600'	Vacant Ground: Bottom changed gradually to firm rippled sand; some *Rangia*.

** Starting on the offshore line of Plot 34 and going inshore.

Transect Number (as shown on Fig. 2): 3

200' SE of and parallel to the old pipeline

OBSERVATIONS

Segment of Transect**	
0 - 200'	Plot 29: Bottom was soft mud with scattered shells ($5-10/m^2$) and live oysters ($1-2/m^2$).
200 - 350'	Plot 29: Bottom covered with shell and some oysters ($7-10/m^2$).
350 - 375'	Plot 29: Bottom soft mud with scattered shells ($5-10/m^2$).
375 - 600'	Plot 29: Sand bar covered with broken shell fragments.
600 - 675'	Plot 29: Bottom soft mud with scattered shell ($5-10/m^2$).
675 - 750'	Plot 29: Bottom covered with shell and a few live oysters ($5-15/m^2$).
750 - 800'	Plot 29: Bottom soft mud with sparse shells ($1-2/m^2$).
800 - 1000'	Plot 17: Bottom soft mud, sparsely covered with shells ($1-2/m^2$).
1000 - 1200'	Plot 17: Bottom soft mud with scattered shells ($8-10/m^2$).

** Starting 500' inshore of offshore line on plot 29 and proceeding inshore.

Transect Number (as shown on Fig. 2): 6-1/2

Near middle of pipeline and perpendicular to it.

OBSERVATIONS

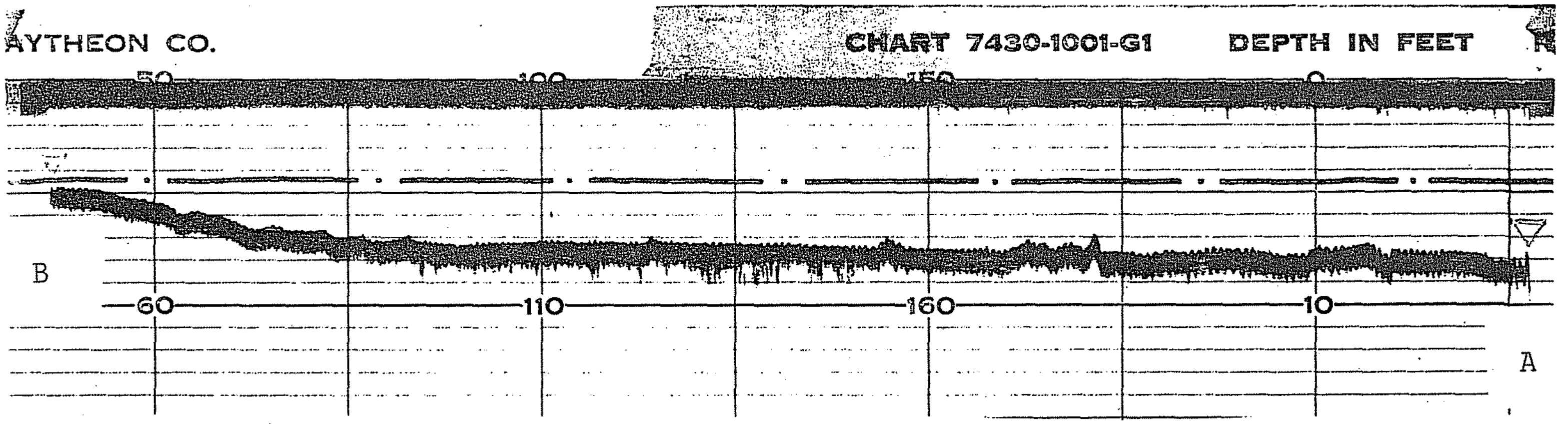
Segment of Transect**

0 - 40'	Plot 29: Bottom covered with shell.
40 - 200'	Plot 29: Bottom soft mud with scattered shell (5-10/m^2).

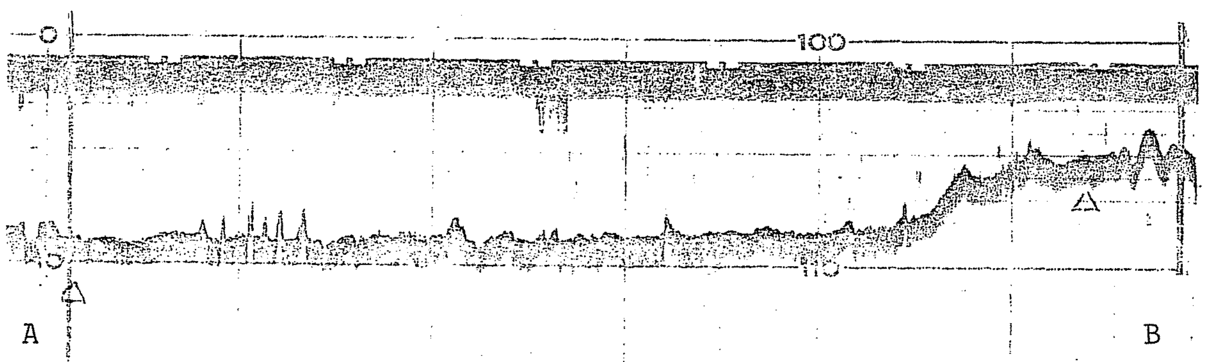
** Starting over the old pipeline and going SE.

APPENDIX II

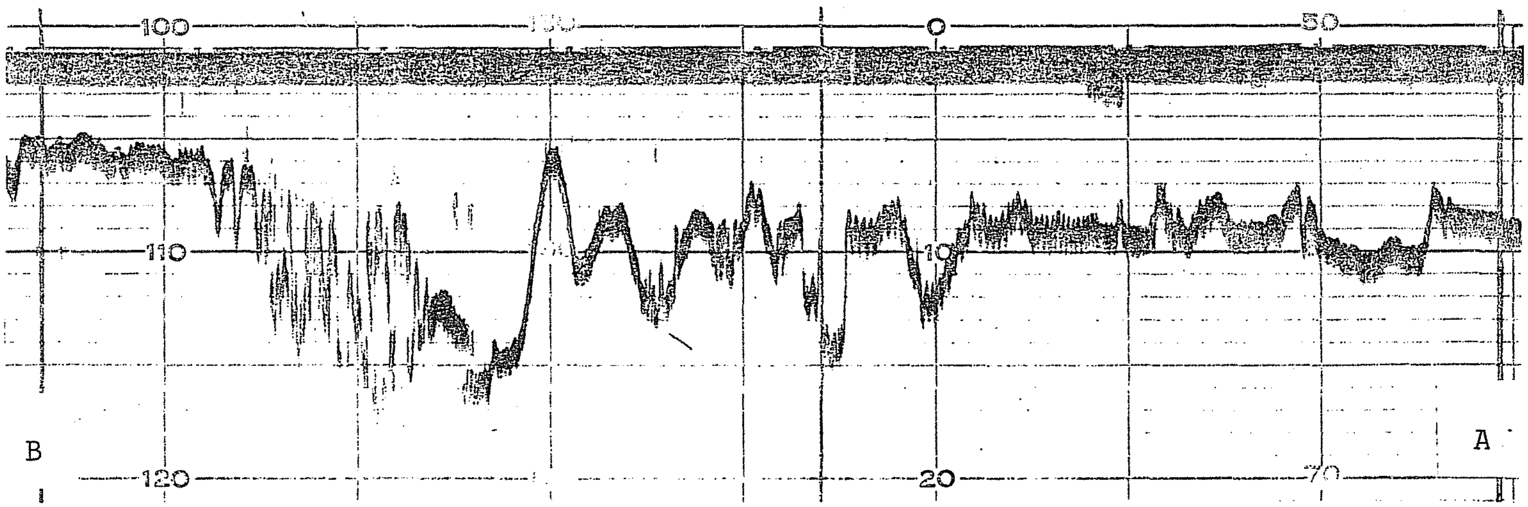
Transect A-B Over the old pipeline (April 1975 Inshore to Offshore)



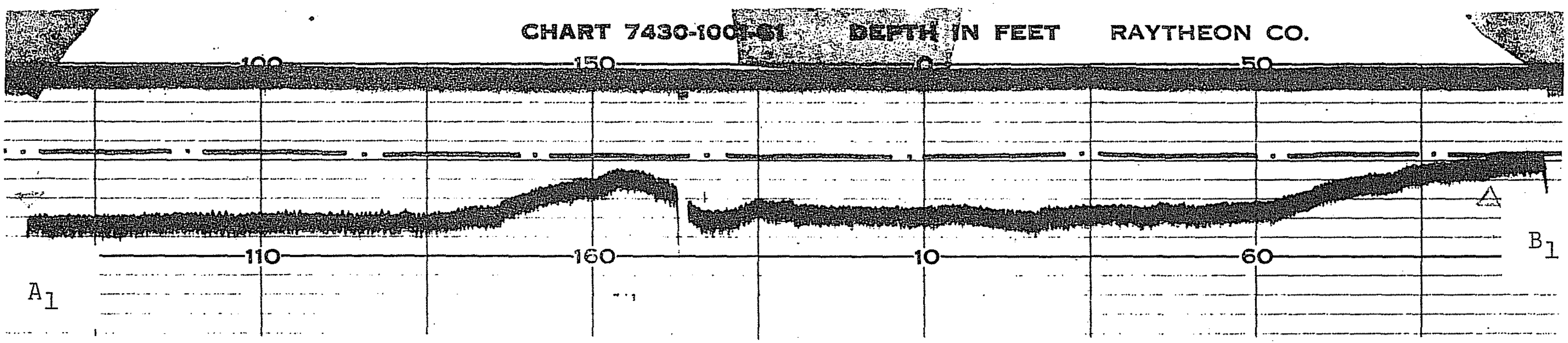
Transect A-B Over the old pipeline (April 1976 Offshore to Inshore)



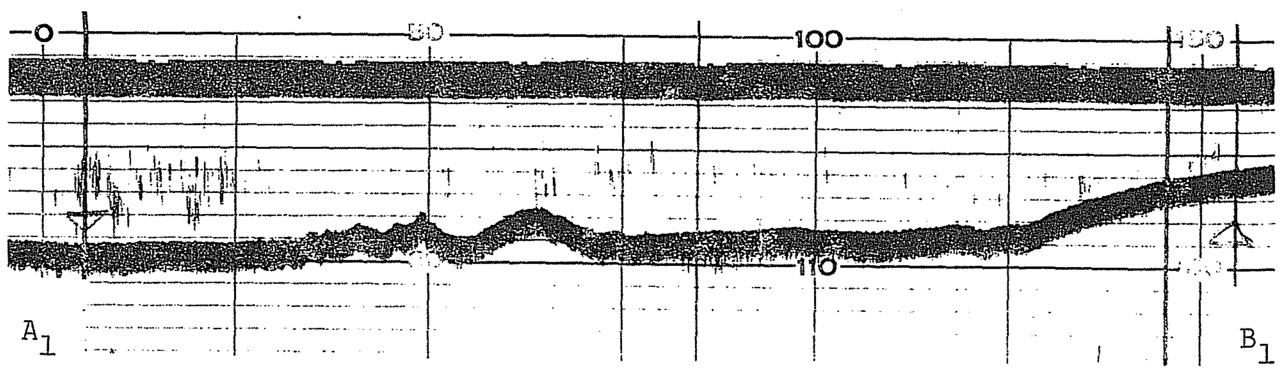
30-40 ft NW of Transect A-B over new pipeline (April 1976 Inshore to Offshore)



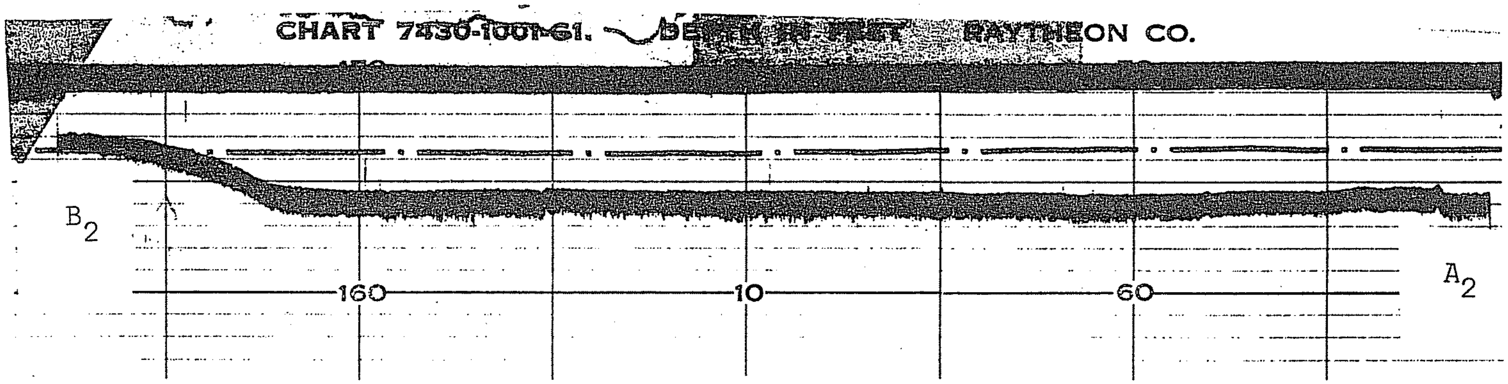
Transect A_1-B_1 200 ft SE of old pipeline (April 1975 Offshore to Inshore)



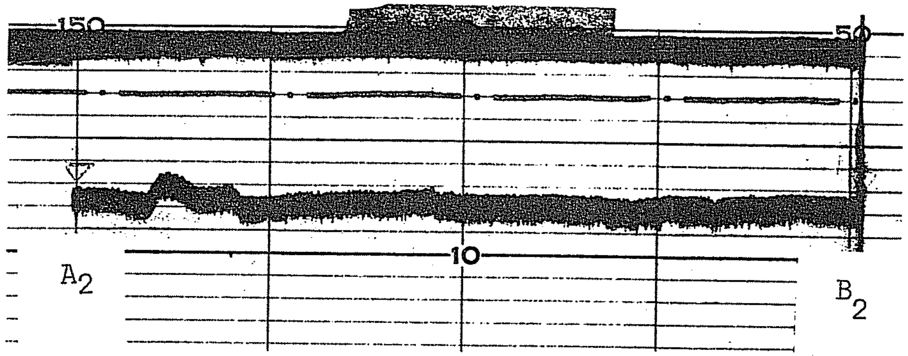
Transect A_1-B_1 200 ft SE of old pipeline (April 1976 Offshore to Inshore)



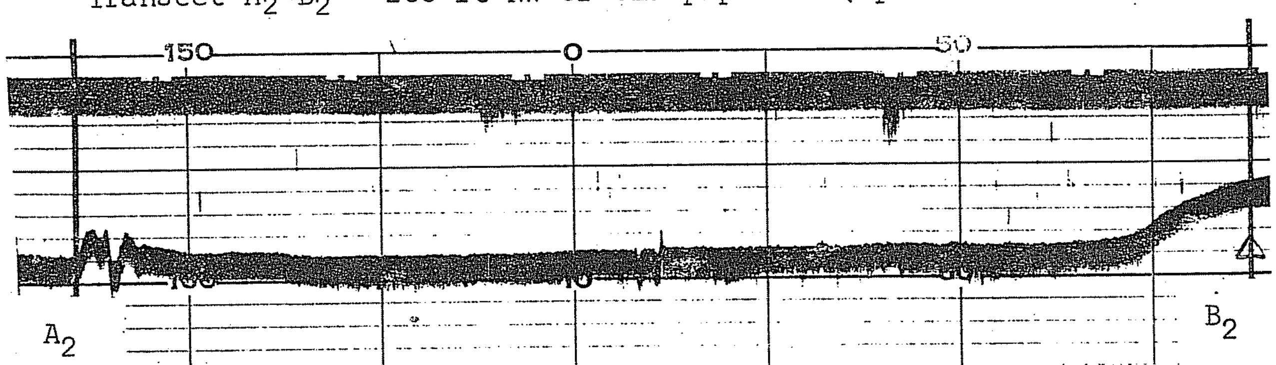
Transect A_2-B_2 200 ft NW of old pipeline (April 1975 Inshore to Offshore)



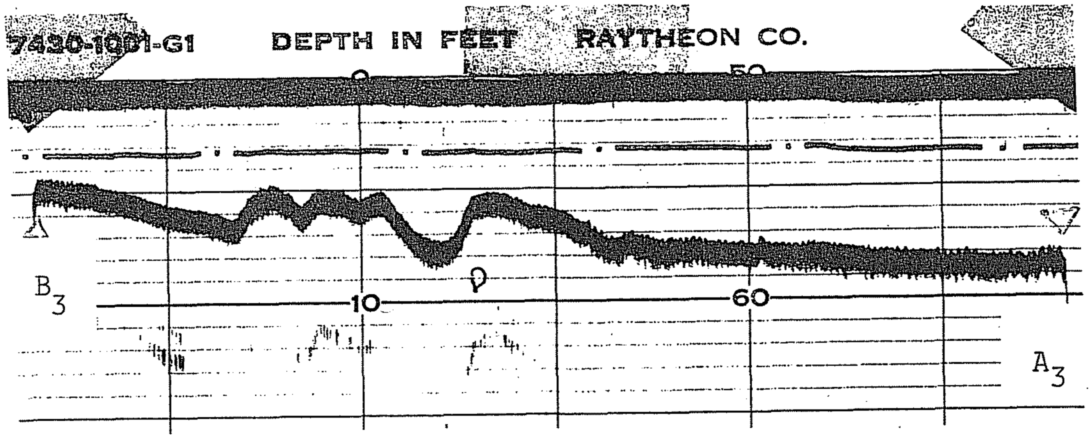
Transect A_2-B_2 200 ft NW of old pipeline (April 1975 Offshore to Midway Inshore)
[Trace stopped due to equipment malfunction.]



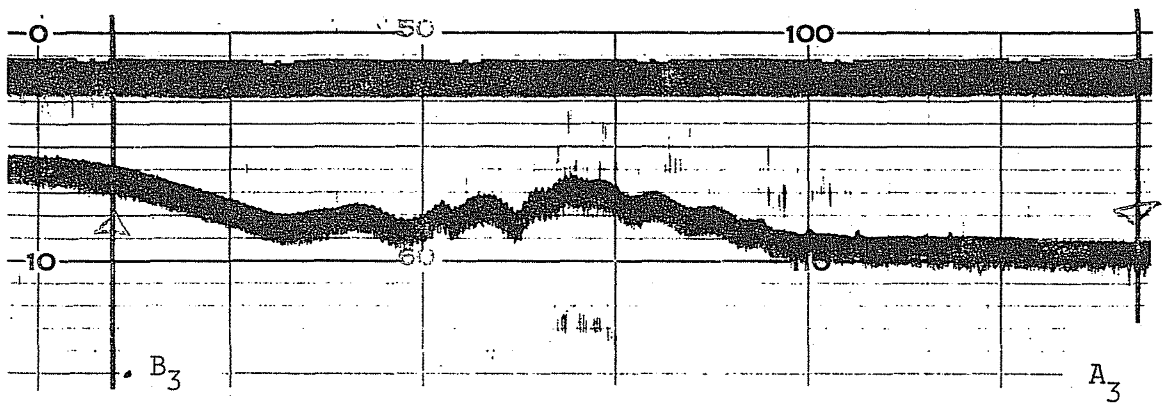
Transect A_2-B_2 200 ft NW of old pipeline (April 1975 Offshore to Inshore)



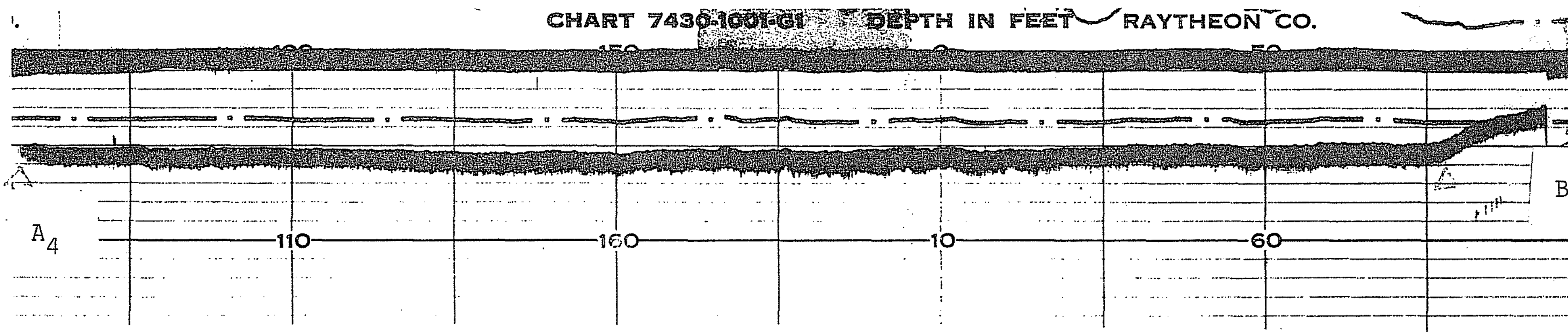
Transect A_3-B_3 400 ft SE of old pipeline (April'1975 Inshore to Offshore)



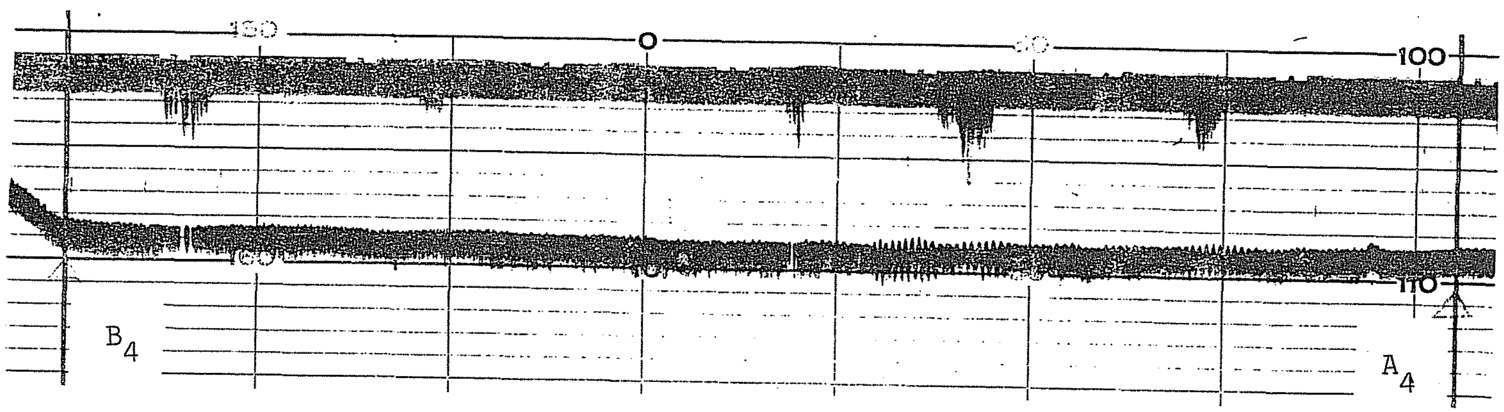
Transect A_3-B_3 400 ft SE of old pipeline (April 1976 Inshore to Offshore)



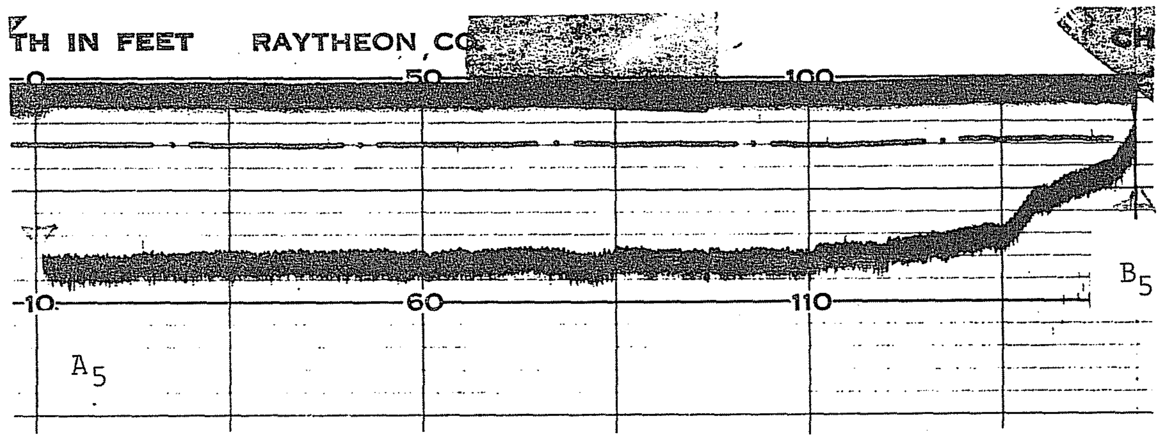
Transect A_4-B_4 400 ft NW of old pipeline (April 1975 Offshore to Inshore)



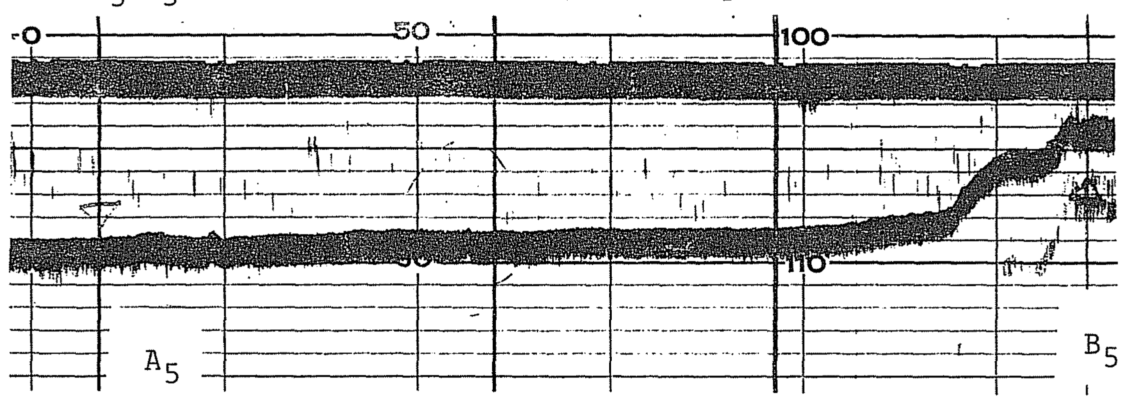
Transect A_4-B_4 400 ft NW of old pipeline (April 1976 Inshore to Offshore)



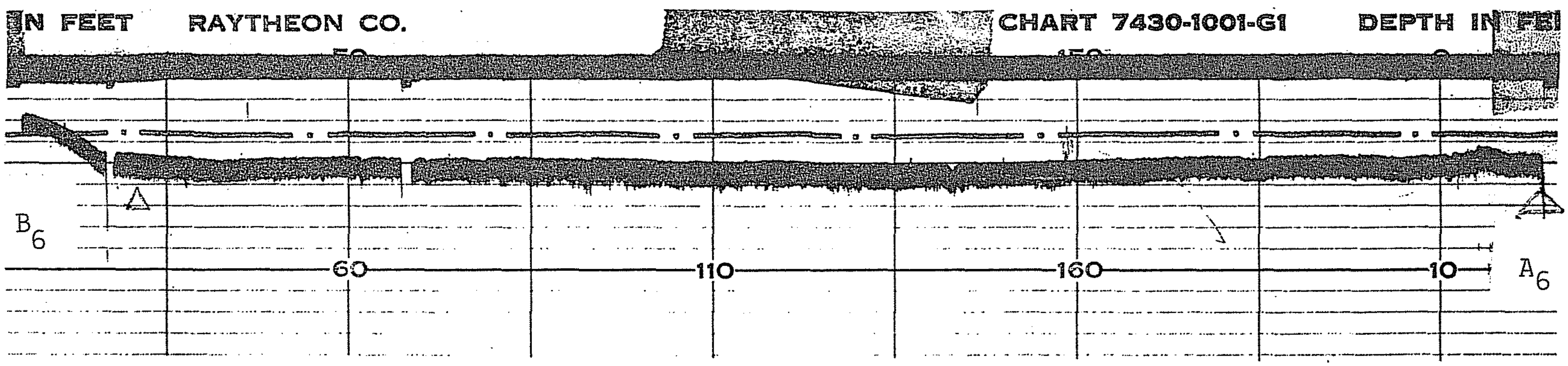
Transect A_5-B_5 600 ft SE of old pipeline (April 1975 Offshore to Inshore)



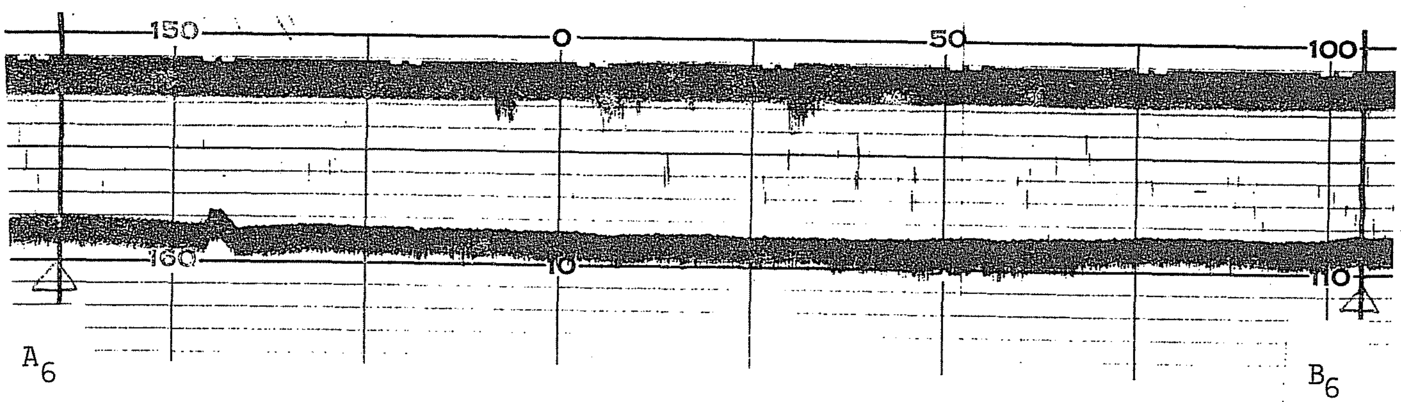
Transect A_5-B_5 600 ft SE of old pipeline (April 1976 Offshore to Inshore)



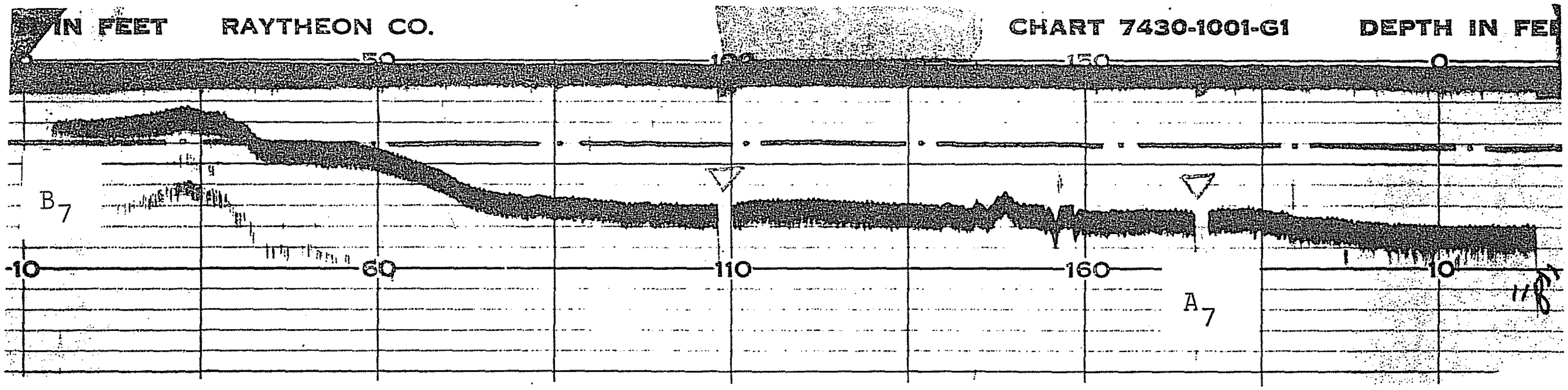
Transect A_6-B_6 600 ft NW of old pipeline (April 1975 Inshore to Offshore)



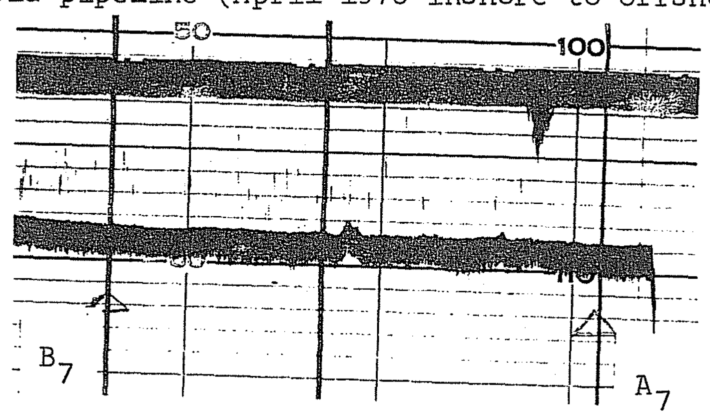
Transect A_6-B_6 600 ft NW of old pipeline (April 1976 Offshore to Inshore)



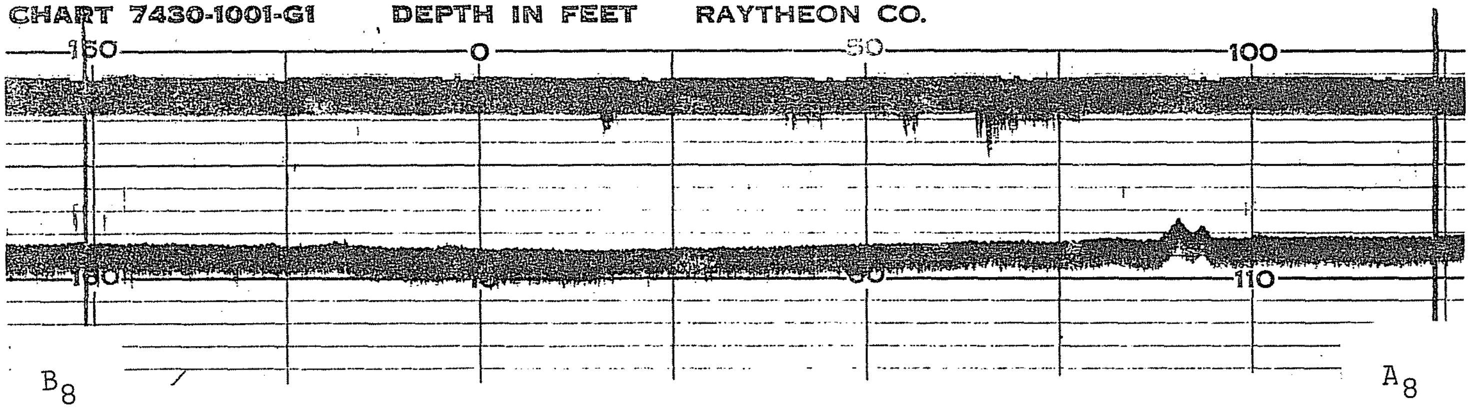
Transect A_7-B_7 800 ft SE of old pipeline (April 1975 Inshore to Offshore)



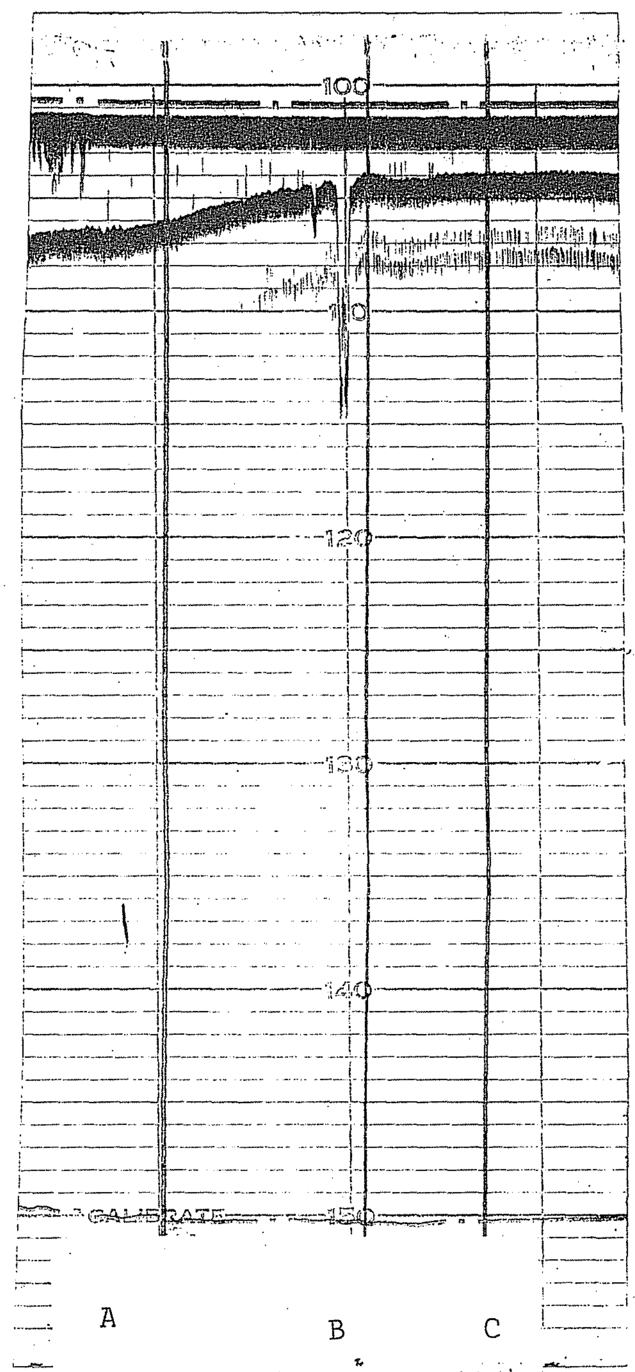
Transect A_7-B_7 800 ft SE of old pipeline (April 1976 Inshore to Offshore)



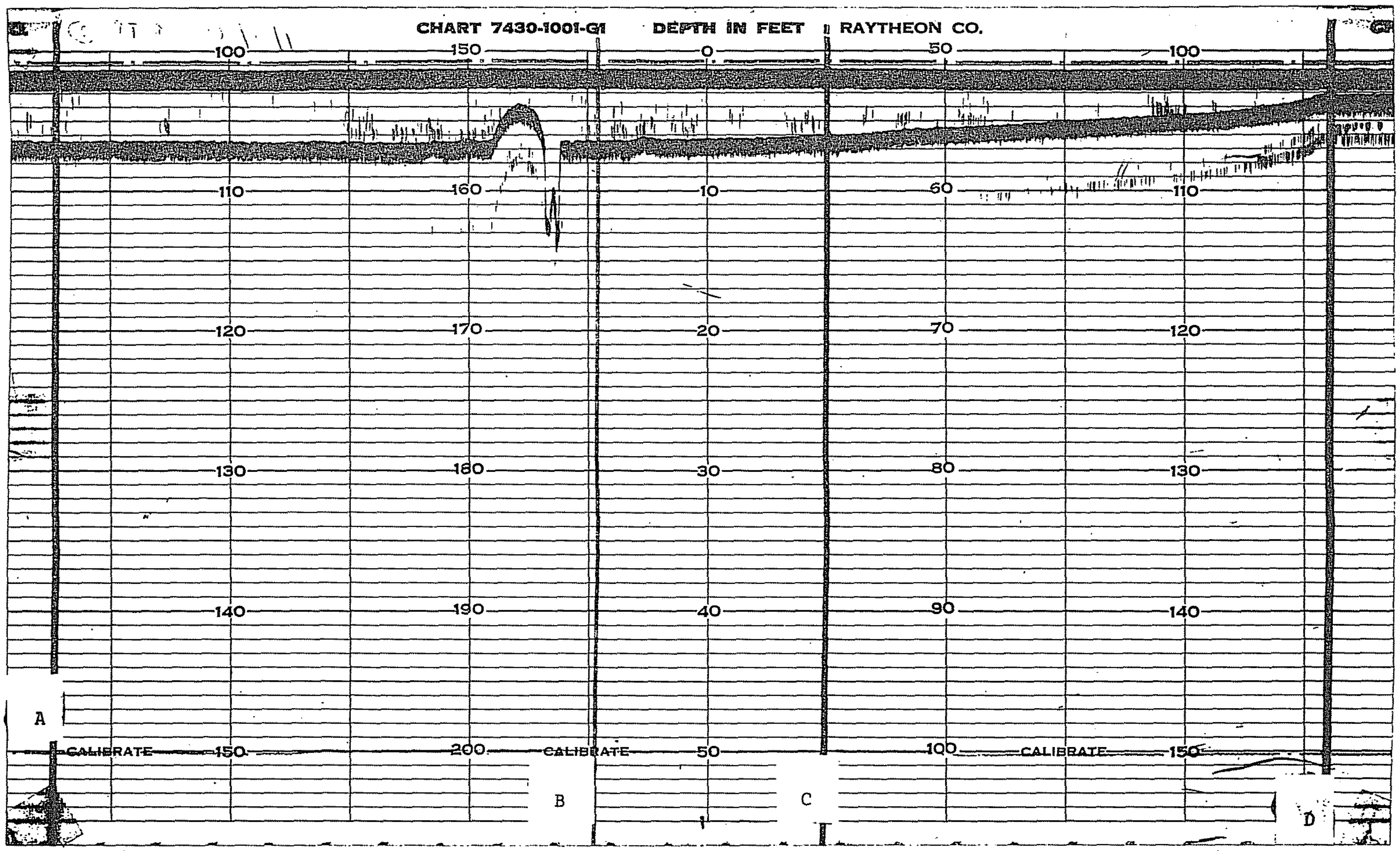
Transect A_8-B_8 800 ft NW of old pipeline (April 1976 Inshore to Offshore)



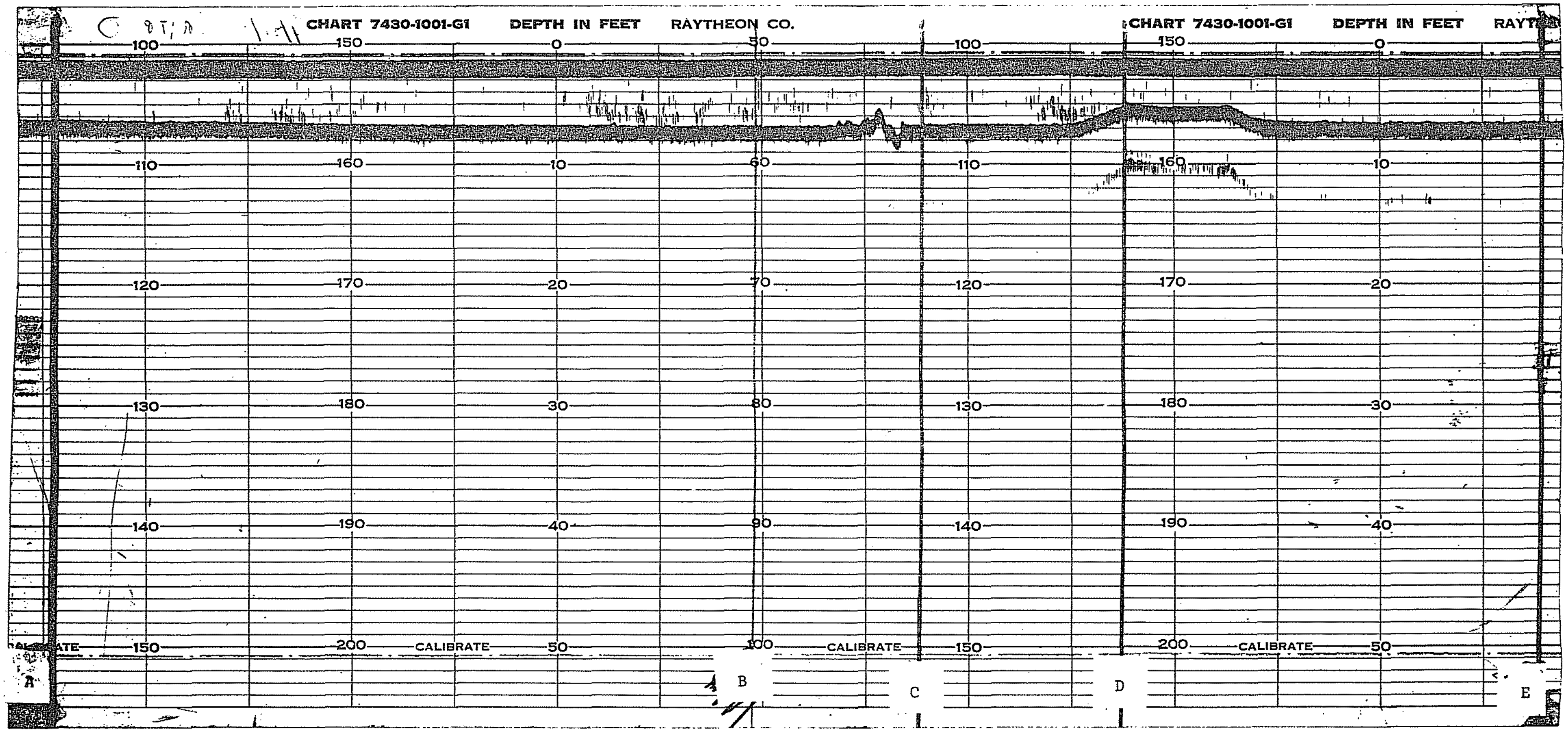
Transect 4 (See Fig. 5) April 1976 NW to SE



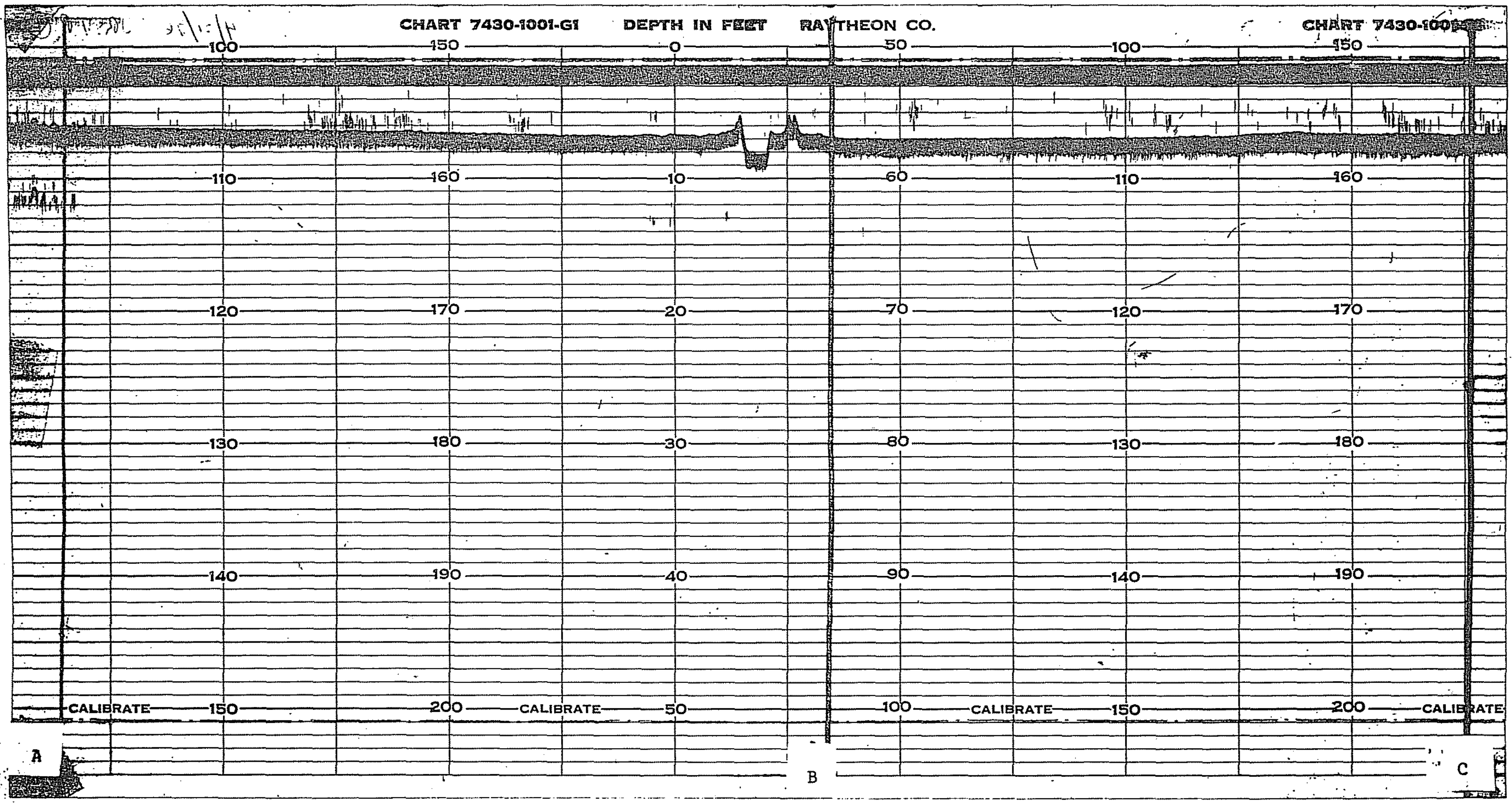
Transect 5 (See Fig. 5) April 1976 NW to SE



Transect 6 (See Fig. 5) April 1976 NW to SE



Transect 7 (See Fig. 5) April 1976 NW to SE



APPENDIX III

Observations Made By a Diver in the James River on 1 and 6 April 1976.

Transect Number (as shown on Figure 4): 1

200 feet NW of and parallel to the old pipeline.

OBSERVATIONS

Segment of Transect**	
0-300'	Plot 39: Scattered patches of oysters; bottom was firm and covered with shells;
300-600'	Plot 29: Bottom was soft mud; some shell.
600-800'	Plot 29: Bottom was mud with scattered oysters.
800-1000'	Plot 29: Bottom was mud with scattered patches of oysters; clay balls.
1000-1200'	Plot 29: Bottom was soft mud with dense (approx. $12/m^2$) patches of oysters.
1200-1400'	Plot 29: Bottom was mud.
1400-1600'	Plot 29: Bottom was soft mud; very few oysters.
1600-1800'	Plot 29: Bottom was mud covered with some shell.
1800-2400'	Plot 17: Bottom was mud covered with shell and live oysters (max. density $11/m^2$)
2400-2600'	Plot 34: Bottom was mud covered with shell and oysters.

Transect Number: 1

Page 2

Segment of Transect**	
2600-2800'	Plot 34: Bottom shallower and sandier; no oysters.
2800-3900'	Vacant ground: Bottom was sandy; no oysters.

** Starting offshore at the Baylor line and going inshore.

Transect Number (as shown on Figure 4): 2

Approximately over the new pipeline.

OBSERVATIONS

Segment of Transect**	
0-50'	Plot 39: Bottom was soft mud; nothing on surface.
50-200'	Plot 29: Bottom was soft mud; nothing on surface.
200-400'	Plot 29: Bottom mud; bottom lumpy due to lumps of clay on surface; sand bunches; several holes 2-3' deep.
400-600'	Plot 29: Surface changed very quickly - ie. as soon as the diver was out of one hole he was into another hole; soft mud and oysters outside of trench cut for the new pipeline; gravel seen in patches
600-800'	Plot 29: Bottom soft, clay mud; hole - approx. 6' X 6' or deeper.
800-1000'	Plot 29: 4' deep hole; clay balls; wide, 6-7' deep holes; 3' deep hole.
1000-1200'	Plot 29: Bottomwas mud; clay balls; 6-8' hole.
1200-1500'	Plot 29: 3-4' deep hole; bottom sandier.
1500-1700'	Plot 17: 3' deep hole; bottom hard and consists of a mixture of shells, mud, clay and sand.

Transect Number: 2

Page 2

Segment of Transect**	
1700-1900'	Plot 17: Bottom as before; in pipeline trench, bottom was predominantely soft mud, while bottom beside the trench was hard sand with natural wave ripples; three holes, ranging in depth from 8 to 12'.
1900-2400'	Plot 34: 4' deep hole; clay clumps, bottom predominately sand; 5' deep hole; other holes; no animals seen.

** Starting offshore at the Baylor line and going inshore.

Transect Number (as shown on Figure 4): 3

200' SE of and parallel to the old pipeline.

OBSERVATIONS

Segment of Transect**	
0-400'	Plot 29: Scattered patches of oysters.
400-800'	Plot 29: Mud and shells on bottom for most part, some sand; scattered oysters.
800-1000'	Plot 29: Bottom mud with some oysters.
1000-1300'	Plot 29: Bottom was mud with buried shell; oysters.
1300-1700'	Plot 17: Bottom was mud and flat; covered with shells and scattered oysters.
1700-2000'	Plot 34: Bottom was mud with oysters.
2000-2300'	Plot 34: Sand bottom; no visible life on it.
2300-2600'	Vacant ground: Flat, sand bottom; barren.

** Starting offshore at the Baylor line and going inshore.

Transect number (as shown on Figure 4): 4

Close Inshore and Perpendicular to Pipeline

OBSERVATIONS

Segment of Transect*	
400-200'	Plot 17: bottom was mud, with buried shells; Plot 34: bottom was mud with buried shells; 6"holes 6" deep**; scattered oysters, maximum density approx. 3-5/m^2.
200'-pipeline	Plot 34: mud bottom; Increasingly more sand in bottom; wide depression, 1 ft deep, loose fluffy silt in bottom-near new pipeline; chest deep hole over pipeline.
Pipeline-200'	Plot 34: Large (2 ft) clumps of clay resting on bottom, not much else on the hard sand bottom; 6" X6" hole.**
200-400'	Plot 34: bottom was sand and flat; oysters are very few and very scattered; one Rangia.
400-600'	Vacant Ground: bottom was sand; no fauna

* Given in feet away from old pipeline starting from upriver (west) side.

** The diver stated later that the holes which were, in general, approximately 6 inches in diameter and 6 inches deep were regular in shape and the bottoms were covered with 1-3 inches of soft, anaerobic sediment. He also stated that where holes were stated as "numerous" that there were 10-15 per 100 lineal feet of transect.

Transect number: 5

(As shown on Figure 4)

400 feet offshore from transect 4 and perpendicular to pipeline

OBSERVATIONS

Segment of Transect*	
500-400'	Plot 29: Bottom was soft mud; numerous 6" diameter holes**; no oysters observed.
400-200'	Plot 29: Mud bottom; one oyster; broken shell; 6" diameter hole - very deep; other holes also.
	Plot 17: Mud bottom covered with abundant shell; no oysters seen.
200'-pipeline	Plot 17: 6" diameter holes numerous** and gave rough appearance to bottom; broken shells and few oysters; near the pipeline the bottom was hard sand with clumps of clay resting on the bottom; pipe uncovered (diver felt the actual pipe; fathometer also showed pipe- see App. II, Fig. 2).
Pipeline-100'	Plot 34: Bottom was soft mud; many 6" diameter holes observed.**
100-200'	Plot 34: Shells buried under mud; many oysters - some 6" long - maximum density approx. 6/m^2; many 6" diameter holes**; bottom is rough.

Transect 5

Page 2

Segment of Transect*	
200-400'	Plot 34: Scattered oysters - approx. $1/m^2$; one 8" X 4" hole.
400-600'	Plot 34: Scattered oysters - approx. $1/m^2$
600-700'	Vacant Ground; no oysters.

* Given in feet away from old pipeline starting from upriver (west) side.

** The diver stated later that the holes which were, in general, approximately 6 inches in diameter and 6 inches deep were regular in shape and the bottoms were covered with 1-3 inches of soft, anaerobic sediment. He also stated that where holes were stated as "numerous" that there were 10-15 per 100 lineal feet of transect.

Transect Number: 6

(As shown on Figure 4)

Approximately midway along the length of the pipeline and perpendicular to it.

OBSERVATIONS

Segment of Transect*	
1000-800'	Plot 29: Bottom soft mud with no shells either on top or buried; many 6" dia. holes.**
800-600'	Plot 29: Bottom soft mud with buried shells; 2 oysters; one 6" dia. hole observed.
600-400'	Plot 29: Several 6" dia. holes**; occasional oysters.
400-200'	Plot 29: Bottom soft mud sometimes with clumps of clay resting on mud; broken shells under mud; many 6" dia. holes - some deeper than 6".**
200'-pipeline	Plot 29: Bottom was soft mud with broken shells, mostly buried; numerous 6" diameter holes, 1-2 ft deep;** waist deep hole over new pipeline.
Pipeline-50'	Plot 29: (Same bottom as above)
50-200'	Plot 29: Bottom covered with oyster shell; some live oysters.
200-400'	Plot 29: Bottom covered with oyster shells and some oysters - density live oysters varied from 2-6/m^2; pebbles observed on surface.

THIS PAGE IS BLANK

Transect Number: 7 (as shown on Figure 4)

Offshore and perpendicular to pipeline

OBSERVATIONS

Segment of Transect*	
950-800'	Plot 39: Small patches of shell and oysters on surface - maximum density of oysters approx. 9 m^2; remainder of bottom is mud with buried shell.
800-600'	Plot 29: Bottom soft mud with buried shell and scattered oysters on top.
600-400'	Plot 29: Bottom soft mud with a few broken shells and scattered oysters.
400-200'	Plot 29: Bottom was soft mud covered with patches of shell.
200' to pipeline	Plot 29: Bottom soft mud covered with scattered shells; at 100' there was a patch of continuous oysters and shells; shoulder deep hole over pipeline.
Pipeline to 200'	Plot 29: Bottom very hard; covered with many oysters; even at 100' some oysters had been recently turned over into the mud and died.
200-400'	Plot 29: Bottom was soft mud with buried shell.

Transect Number: 7

Page 2

Segment of Transect*	
400-600'	Plot 29: Bottom soft mud with buried shell.
600-700'	Plot 29: Bottom soft mud.

* Given in feet away from old pipeline starting from upriver (west) side.

Transect Number: 8 (as shown on Figure 4)

Offshore, near Baylor Survey line, and perpendicular to the pipeline.

OBSERVATIONS

Segment of Transect*	
800-600'	Plot 39: Bottom soft mud with a few buried shells; scattered oysters - approx. $1/m^2$.
600-400'	Plot 39: Bottom soft mud with a few buried shells; scattered oysters - density approx. $1/m^2$.
400-200'	Plot 39: Mound, 2-3' high of oyster shells around 350'; another mound of shells with some oysters around 300'; bottom between mounds was mud.
200-100'	Plot 39: Bottom had more sand-harder; very scattered oysters.
100' to pipeline	Plot 39: Bottom soft mud; a 2' clump of clay on the mud bottom beside the trench for the new pipeline.
Pipeline to 100'	Plot 39: Bottom very soft mud; no live oysters; scattered shells.

* Given in feet away from old pipeline starting from upriver (west) side.

Section II.

ENVIRONMENTAL EFFECTS OF THE JAMES RIVER SEWAGE TREATMENT PLANT OUTFALL CONSTRUCTION: SOFT BOTTOM MACROBENTHOS

A report submitted to
the Hampton Roads Sanitation District

by

Robert J. Diaz
and
Donald F. Boesch

Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

April 1976

Introduction

A new sewer outfall was constructed parallel to the existing 1200 yard (1100 m) outfall of the James River Sewage Treatment Plant of the Hampton Roads Sanitation District. The new outfall pipe is of larger diameter than the old and is equipped with more efficient diffuser system. The new outfall line was laid in a trench excavated by bucket dredge in water depths of up to 2.5 m MLW and crossing several leased oyster growing plots and public (Baylor Survey) oyster bottom.

Excavation of the outer portion of the trench began in mid-March 1975 and the sediment removed to the Craney Island confined disposal site. Excavation ceased at the end of June 1975 after which the outer portion of the pipeline was laid. Dredging of the inner portion of the trench recommenced in the beginning of October and continued into December 1975. This dredged material was used for backfill over the pipeline which lay in the 9 feet deep excavation.

The Virginia Institute of Marine Science conducted studies to estimate the impact of the construction activity on the shellfish beds and macrobenthic communities in the area and to determine any water quality changes related to construction and/or initial operation. This report relates the results of investigations of the impact of construction on benthic communities in the "soft" sediment bottoms. Assessment of the comparative composition, abundance, diversity and productivity of the benthic macrofauna in the vicinity of the pipeline route and control areas was made twice, once while early construction activity were underway in June 1975 and again after activities ceased in January 1976.

Methods

On 26 June, 1975 and 7 January, 1976 duplicate 0.1 m^2 Smith-McIntyre grab samples were taken at 12 locations around the Warwick River mouth and one site (Station 13) down the James River on the south shore near the James River Bridge. Stations 3 and 6 were located over the existing outfall. Stations 2 and 5 were just upestuary, and 4 and 7 just downestuary of the existing outfall. The location of the new outfall was not known when sampling commenced. The new outfall has been emplaced approximately 100 ft. (30 m) upestuary of the existing outfall, and thus about midway between Stations 3 and 6 and 2 and 5. Stations 8 and 9 were at the mouth of the Warwick River, and 10, 11 and 12 were outside the mouth in the James River (Fig. 1). Positions were located using a three-point fix method and horizontal sextant angles.

Samples were washed through a 0.5 mm sieve and the retained material placed in 10% formalin solution containing the vital stain phloxine-B. Samples were sorted under a dissecting microscope and all organisms placed in 70% ethyl alcohol for later identification and enumeration.

Wet weight biomass was determined after blotting organisms on absorbent towels. Individual species biomass was determined for most molluscs, barnacles, *Nereis succinea*, and *Peloscolex* spp. Amphipods and isopods and other worms were weighed as groups. Oysters and *Rangia cuneata* were removed from their shell for weighing but weights of other molluscs include the shell.

Species diversity was measured by the commonly used index of Shannon (Pielou 1975), which expresses the amount of information content per individual. The index denotes the uncertainty in predicting the specific identity of a randomly chosen individual from a multispecies assemblage. The more species there are, and the more evenly they are represented, the higher this uncertainty. The index is given by:

$$H' = - \sum_{i=1}^{s} p_i \log_2 p_i$$

where s = number of species in a sample and p_i = proportion of the i^{th} species in the sample. Species diversity, particularly as expressed by the Shannon measure, is widely used in impact assessments and correlates well with environmental stress (Wilhm and Dorris 1968; Armstrong et al. 1971; Boesch 1972). More adverse and stressful environmental conditions generally exhibit lower species diversity.

As considered above, species diversity is a composite of two components: species richness, the number of species in a community, and evenness, how the individuals are distributed among the species. We used two measures of species richness: the number of species per unit area (in this case $0.2m^2$) or areal richness, and the other a measure standardized on the basis of the size of the sample in terms of numbers of individuals:

$$SR = (S-1)/\ln N,$$

where S = number of species and N = number of individuals in a sample. Evenness was expressed as:

$$J' = H'/\log_2 S \quad \text{(Pielou 1975).}$$

Salinity samples were analyzed in the laboratory with a Beckman Instruments Model RS-7B salinometer. Percent sand, silt and clay was determined by sieving and pipette analysis following procedures of Folk (1968).

Results

Stations were all located in 5 to 8 feet (1.6-2.5 m) of water. Salinity in the area has been relatively low for the past few years because of high freshwater flows. Highest salinity at time of sampling was at the down-river station (7.3‰, January 1976) and lowest at the most upriver station (1.7‰, January 1976). Average salinity in the vicinity of the outfall extension was 4.8‰. Sediment composition was mostly of silt and clay with Stations 10 and 12 located in fine sand (Fig. 2). Sediments at several stations (e.g. 8, 9 and 13) were considerably sandier in January than in June. This may be due to imprecise station relocation (e.g. Station 13) but may also reflect seasonal changes in surface sediments. Varying amounts of shell hash were present at all stations but 10. This portion of the James estuary has historically supported one of the major oyster grounds in the Chesapeake Bay region, and shell has been spread throughout the area by harvesting and transplanting activities.

From the 26 grab samples taken in June, 6335 individuals were recovered comprising 39 macroinvertebrate taxa (Table 1) and January samples yielded 2388 individuals in 36 taxa (Table 2). A total of 51 taxa was taken in both sampling periods.

The fauna was characteristic of shallow soft bottoms of meiomesohaline salinity (5 to 10‰) that have been studied around the Bay (Pfitzenmeyer 1970, Boesch et al. 1974, 1975, Huggett et al. 1975). Numerically the most dominant species in June were the amphipod Leptocheirus plumulosus, the oligochaetes Peloscolex spp., the polychaete Nereis succinea, and the bivalves Macoma balthica and Brachidontes recurvus (Table 3). The dominant species in terms of biomass were bivalves, which comprised 98.1% of the total wet weight of the June collection with M. balthica comprising 76.4% and B. recurvus 15.3% of the total weight. Although oligochaetes of the genus Peloscolex outnumbered any other congeners, they composed only 0.00064% of the biomass (Table 4).

The January numerical dominants were similar to June, with reordering and the addition of the polychaete Scolecolepides viridis, the isopod Cyathura polita and the barnacle Balanus improvisus. Peloscolex spp. dropped greatly in importance with only sporadic occurrences (Table 3). Bivalves were again the biomass dominants comprising 92.4% of the total wet weight. Brachidontes recurvus, Macoma balthica, and the oyster Crassostrea virginica accounted for 44.5, 34.0, and 11.1% of the total weight respectively (Table 5). The increase in numbers and weight of Crassostrea, Brachidontes and Balanus was due to variations in locating sampling sites close to the edge of oyster beds in the area. In January there was a general decrease in the biomass of the soft bottom infaunal bivalves (except Rangia) that is most likely seasonal. M. balthica exhibited the largest change in biomass with a drop from 442 g to 214 g total weight from June to January (Tables 4 and 5). Biomass of *M. balthica* was greatest for both collections in the immediate vicinity of the sewer outfall (Figs. 3 and 4).

Many species were widely distributed among the stations, but a few were more habitat restricted. The polychaete *Laeonereis culveri* and the amphipod *Lepidactylus dytiscus* were found primarily on the sandier substrates (Stations 10 and 11 in June and Stations 8, 9, 10, and 11 in January) while the oligochaete *Peloscolex* spp. tended to be less abundant there than at other stations. A number of species were only found or were more abundant in association with shell material and thus tended to cooccur. The mussel *Brachidontes recurvus*, the barnacle *Balanus improvisus*, the polychaetes *Polydora ligni* and *Nereis succinea*, and the amphipods *Gammarus mucronatus* and *Melita nitida* occurred preferentially at Stations 1, 3, 4, 9 and 12 in June. *Brachidontes*, *Balanus*, *Nereis*, *Gammarus*, *Melita* and the crab *Eurypanopeus depressus* and the isopod *Cassidinidea lunifrons* were associated with shell substrates at Stations 9, 12 and 13 in January.

Species diversity values (Tables 6 and 7) fell within the range reported for meiomesohaline macrobenthic communities in the Chesapeake Bay (Boesch 1972, Huggett et al. 1975, Roberts et al. 1975). Species richness and diversity was generally greater at those stations where shell debris was exposed (Stations 1, 3, 4, 9 and 12 in June and Stations 9, 12 and 13 in January), thus supporting hard-substrate epifaunal species in addition to infaunal forms.

No concordant changes in diversity occurred between collecting periods to suggest either strong seasonality or widespread effects of the construction activities. However, species richness and diversity did decline from June to January at 4 stations in the immediate vicinity of the construction (Stations 2, 3, 4 and 7). Changes in species composition responsible for the decline in richness were examined carefully for these stations (Tables 1 and 2). Several epifaunal species present at Stations 3 and 4 in June were absent in January probably because shell substrate microhabitats at these sites were missed in sampling and other species were only common in June throughout the study area. Of the infaunal species which were abundant in June only the oligochaetes _Peloscolex_ _gabriellae_ and _P_. _heterochaetus_ and the amphipod _Leptocheirus_ _plumulosus_ were greatly reduced in abundance at the sites around the outfall pipeline. The _Peloscolex_ species are hardy opportunists and are among the most resistant and resilient of the macrobenthos of the Bay. Their absence or reduced abundance in many of the January samples may have been due to true seasonality or may have resulted from the tiny thread-like worms passing through the 0.5 mm sieve or being overlooked by sample sorters. The great reduction of _Leptocheirus_ at the sites around the outfall in January remains an enigma. Notice that *Leptocheirus* was, however, present in small numbers at these stations.

The bivalve *Macoma balthica* was an important member of the community studied. It was the biomass dominant and was represented by dense populations consisting of at least two year classes. Unusually large individuals were present in the population. It was reasoned that if effects of construction activities on the benthic communities of the area were substantial, they should be reflected in size distribution of the *M. balthica* populations. *M. balthica* populations declined markedly from June to January, reflecting normal mortalities after spring recruitment. Mean length increased from 15.9 to 17.6 mm due to selective mortality of young clams (4-8 mm class) and growth (Figs. 5 and 6). Within the area adjacent to the outfall, mean length remained fairly static but the size-frequency histograms show the survival of large *M. balthica* (<20 mm) which are at least 2 to 3 years old. These data suggest survival of *Macoma balthica* in the vicinity of outfall construction throughout the period under consideration.

Discussion

The macrobenthos of the study area was typical of low salinity soft bottom communities in the Chesapeake Bay and was dominated by *Macoma balthica*, *Nereis succinea*, *Peloscolex* spp., and *Leptocheirus plumulosus*. Most species were eurytopic in their distribution patterns over the study area, however a few were found preferentially on sandy bottoms and a sizeable number were found only in association with exposed shell. Biomass was high in the area, due principally to dense populations of large individuals of the bivalve *Macoma balthica*. The possibility exist that the high standing crop of *M. balthica* may be in response to the organic loading in the vicinity of the outfall.

Although changes in the composition and species diversity at sites near the outfall pipeline construction did occur between sampling periods, most can be explained by seasonal patterns of occurrence or the capture of hard substrate microhabitats. Size-frequency analysis of populations of *Macoma balthica* shows no unusual mortality patterns in the vicinity of the pipeline construction. Thus, in summary we uncovered no evidence of deleterious effects of construction activities on the macrobenthos. It should be remembered, however, that stations sampled were probably no closer than 100 feet (30 m) of the path of excavation and pipeline burial. Impacts on bottom life directly in this path must have occurred, but these effects must have been very localized, i.e. along a path much less than 200 feet (60 m) wide.

Literature Cited

Armstrong, N. E., P. H. Storrs and E. A. Pearson. 1971. Development of a gross toxicity criterion in San Francisco Bay. Proc. 5th Int. Conc. Water Pollut. Res. III, 1-15.

Boesch, D. F. 1972. Species diversity of marine macrobenthos in the Virginia area. Chesapeake Sci. 13:206-211.

Boesch, D. F., R. J. Diaz, and R. W. Virnstein. 1974. Effects of Tropical Storm Agnes on soft bottom macrobenthic communities of the James and York River estuaries and the bay mouth, p. D51-D76. In J. Davis (ed.) Report on the effects of Tropical Storm Agnes on the Chesapeake Bay estuarine system. Chesapeake Research Consortium.

Boesch, D. F., R. J. Diaz, and L. Dibrell. 1975. Biological and chemical studies of dredged canals, Topping Creek, Poquoson, Virginia. Part I. Benthic communities. Report to the U.S. Army Corps of Engineers, Norfolk District. Virginia Inst. Mar. Sci. 22 p.

Folk, R. L. 1968. Petrology of sedimentary rocks. Hemphill's, Austin, Texas. 170 p.

Huggett, R. J., R. W. Virnstein, and D. F. Boesch. 1975. A chemical and biological survey of the lower Potomac River in the vicinity of Piney Point, Maryland, Final Report to Steuart Petroleum Co. VIMS. 16 p.

Pfitzenmeyer, H. T. 1970. Project C. Benthos. In: Gross physical and biological effects of overboard spoil disposal in upper Chesapeake Bay. NRI Special Report No. 3, p. 26-38.

Pielou, E. C. 1975. Ecological diversity. Wiley-Interscience, New York. 165 p.

Roberts, M. H., Jr., D. F. Boesch and M. E. Bender. 1975. The Chesapeake Bay: A study of present and future water quality and its ecological effects. Vol. II: Analysis and projection of ecological conditions. Final Report to National Commission on Water Quality. Special Report No. 91, Va. Inst. of Mar. Sci. 199 p.

Wilhm, J. L. and T. C. Dorris. 1968. Biological parameters for water quality criteria. BioScience 18:447-481.

Table 1. Summary of collections from 13 stations in the Warwick River and adjacent James River area taken in June, 1975. Abundances are reported by species and are the combined totals from two grab samples representing a total of 0.20 m^2.

	Stations												
Species	1	2	3	4	5	6	7	8	9	10	11	12	13
Cnidaria													
Bougainvillia rugosa			+										
Garveia franciscana			+										
Nemertina	11	4	8	6	2	4	8	6	5		5		4
Polychaeta													
Eteone heteropoda			1							1			
Laeonereis culveri										49		3	
Nereis succinea	42	7	26	20	7	15	6	13	38	4	6	33	2
Glycera dibranchiata											1		
Heteromastus filiformis	15	12	20	3	6	1	6		3	9		4	2
Polydora ligni	4		13	4					2			14	
Paraprionospio pinnata												4	
Scolecolepides viridis	1	6	8	2		3			2	7		6	
Streblospio benedicti		6	1	1						2	2		
Scoloplos sp.		3			1		2		3	1	5		2
Oligochaeta													
Peloscolex gabriellae	107	125	214	33	211	149	82	25	34		5	106	10
Peloscolex heterochaetus	170	194	128	41	217	165	179	18	18		2	56	2
Paranais litoralis			1										
Hirudinea													
Illinobdella moorei										2			

Table 1 (Continued)

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13
Gastropoda													
Mitrella lunata		1											
Odostomia bisuturalis										4			
Odostomia trifida	10			2			1						
Bivalvia													
Brachidontes recurvus	239	2	56	12	1			1	2	1	1	252	
Crassostrea virginica			1										
Congeria leucophaeta	1												
Macoma balthica	16	49	51	59	41	63	76	88	52	2	72	1	23
Macoma mitchelli	10	22	13	12	5	7	12	4			6		1
Mulinia lateralis							1						
Rangia cuneata	1	2	2				1	1		1	1		
Mya arenaria				4							4		
Cirripedia													
Balanus improvisus	25		12	7				3	4		1		
Mysidacea													
Neomysis americana			1										
Tanaidacea													
Hargeria rapax										1			
Isopoda													
Edotea triloba		1						1		5		1	
Cyathura polita	34	2	6	12		2	2				1		

Table 1 (Continued)

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13
Amphipoda													
Leptocheirus plumulosus	62	409	221	82	278	241	176	24	98	58	141	14	
Corophium lacustre	2		24	10									
Gammarus mucronatus												6	
Melita nitida			2						1				1
Lepidactylus dytiscus									1	136			
Decapoda													
Ogyrides limicola												2	
Insecta													
Cryptochironomus sp.										1			

Table 2. Summary of collections from 13 stations in the Warwick River and adjacent James River area taken in January, 1976. Abundances are reported by species and are the combined totals from two grab samples representing a total of 0.20 m^2.

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13
Cnidaria													
Anemone													1
Turbellaria													
Stylocus ellipticus									2				
Nemertina													
Nemerteans	7		2	3	2			5					1
Polychaetes													
Laeonereis culveri							3	26			65		
Nereis succinea	2	5	6	10	12	7	4	3	59	21	3	79	50
Glycinde solitaria			3		2	3	2	2			1	2	5
Heteromastus filiformis	11	10		5	47	9	1	19	4	1	2	8	
Paraprionospio pinnata													1
Scolecolepides viridis		1	4	4	11	7	4	8	9	5	1		
Spiochaetopterus oculatus						2							
Scoloplos spp.													4
Lysipiddes grayi					1								
Oligochaetes													
Peloscolex gabriellae					13	27		1	52				1
Peloxcolex heterochaetus				1	11	46			34				

Table 2 (Continued)

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13
Hirudinea													
Illinobdella moorei								1					
Gastropoda													
Acteocina canaliculata													6
Pyramidella sp.										1			
Bivalvia													
Brachidontes recurvus									219			153	18
Crassostrea virginica									18			7	6
Macoma balthica	10	18	30	20	35	27	42	63	7	5	35	2	2
Macoma mitchelli	6	2	3	2	5	6	4	10	3	10	4		
Rangia cuneata	3	1		1	1		1			2			
Mya arenaria									1		1		1
Cirripedia													
Balanus improvisus	1								83			261	25
Tanaidacea													
Hargaria rapax										1			
Isopoda													
Cyathura polita	1	5	4	1			4	3			6		
Cassidinidea lunifrons									7			3	
Amphipoda													
Leptocheirus plumulosus	85	2		1	80	57	52	112		2		4	12

Table 2 (Continued)

Species	Stations 1	2	3	4	5	6	7	8	9	10	11	12	13
Amphipoda (cont.)													
Corophium lacustre					1				2	1		4	1
Gammarus sp.					2								
Melita nitida									27			9	3
Lepidactylus dytiscus									11	32			
Listriella clymenellae		1											
Decapoda													
Callinectes sapidus									1				
Eurypanopeus depressus									4			1	
Pisces													
Gobiosoma sp.		1										2	1

Table 3. Numerical dominants of communities in area of the Warwick River mouth near the HRSD plant sewer outfall construction. Based on a 5 point per station rank score with a highest possible score of 65, all stations included.

June 1975

A	*Leptocheirus plumulosus*	47.5
O	*Peloscolex gabriellae*	34.8
O	*Peloscolex heterochaetus*	31.3
B	*Macoma balthica*	30.0
B	*Brachidontes recurvus*	17.0
P	*Nereis succinea*	11.3
A	*Lepidactylus dytiscus*	5.0
B	*Macoma mitchelli*	4.5
P	*Heteromastus filiformis*	3.8
	Nemerteans	3.3
P	*Laeoneris culveri*	3.0

January 1976

B	*Macoma balthica*	39.0
P	*Nereis succinea*	29.0
A	*Leptocheirus plumulosus*	29.0
P	*Heteromastus filiformis*	15.0
B	*Brachidontes recurvus*	13.0
P	*Scolecolepides viridis*	9.5
I	*Cyathura polita*	9.5
C	*Balanus improvisus*	9.0
P	*Laeonereis culveri*	8.0
O	*Peloscolex gabriellae*	7.5
B	*Macoma mitchelli*	6.5
O	*Peloscolex heterochaetus*	6.0
A	*Lepidactylus dytiscus*	5.0

A - Amphipod
B - Bivalve
O - Oligochaete
P - Polychaete
C - Barnacle
I - Isopod

Table 4. Biomass of various species taken in June, 1975 in the Warwick River and adjacent James River area. All values are wet weight grams/0.2 m^2.

STATION	*Macoma balthica*	*Macoma mitchelli*	*Brachidontes recurvus*	*Rangia cuneata*	*Nereis succinea*	*Peloscolex* spp.	Other Worms	*Balanus improvisus*	Amphipods and Isopods	TOTALS
1	36.42	0.92	47.94	5.12	2.95	0.047	0.13	1.72	0.48	95.73
2	37.42	1.91		0.48	0.72	0.048	0.32		1.70	42.60
3*	21.31	1.27	11.80	1.17	2.82	0.037	0.57	0.18	0.90	40.06
4	10.44	2.79	4.46		1.08	0.008	0.10	0.76	0.86	20.50
5	45.91	0.42			0.84	0.052	0.04		0.64	47.90
6	69.04	1.00			1.22	0.056	0.03		0.89	72.24
7	58.36	0.62			0.24	0.029	0.38		0.64	60.27
8	67.81	0.87		0.24	1.34	0.011	0.02	0.16	0.04	70.49
9	39.24		0.14		2.18	0.012	0.13		0.60	42.30
10	0.03		0.05		0.12		1.49		0.57	2.26
11	40.32	0.47	0.06		0.61	0.010	0.10		0.44	42.01
12	0.13		23.89		1.38	0.059	0.30	0.50	0.04	26.30
13	15.68	0.13			0.30	0.002	0.11			16.22
TOTAL	442.11	10.40	88.34	7.01	15.80	0.371	3.72	3.32	7.80	558.88
$\bar{x}$	34.00	0.80	6.79	0.53	1.21	0.028	0.29	0.26	0.60	44.53
σ	23.35	0.79	14.22	1.41	0.92	0.022	0.40	0.50	0.45	25.58

* one oyster 19.50 g.

Table 5. Biomass of various species taken in January, 1976 in the Warwick River and adjacent James River area. All values are wet weight grams/0.2 m^2.

STATION	*Macoma balthica*	*Macoma mitchelli*	*Brachidontes recurvus*	*Rangia cuneata*	Oysters	*Nereis succinea*	Other Worms	*Balanus improvisus*	Amphipods and Isopods	Other	TOTALS
1	9.91	0.34		2.89		0.09	0.19		0.98		14.40
2	8.22	0.19		1.89		0.22	0.14		0.27	0.08	11.01
3	25.34	0.23				1.04	0.05		0.22		26.88
4	11.11	0.12		0.61		1.26	0.01		0.05		13.16
5	34.87	0.41		7.94		1.07	0.03		0.74		45.06
6	24.82	0.70				0.86	0.44		0.50		27.32
7	30.40	0.24		0.86		0.17	0.20		1.27		33.14
8	43.08	0.51				0.05	0.75		0.96	0.43	45.78
9	3.90	0.15	81.08		20.15	2.56	0.02	1.77	0.07	14.07	123.77
10	0.27	0.10				0.13	0.04		0.15		0.69
11	20.13	0.20				0.13	1.25	0.05	0.17		21.93
12	1.81		198.05		47.54	1.63	0.03	10.45	0.08	0.40	259.99
13			1.02		2.21	1.26	0.05	1.15	0.02	0.16	5.87
TOTAL	213.86	3.19	280.15	14.19	69.90	10.47	3.20	13.42	5.48	15.14	629.00
$\bar{x}$	16.45	0.25	22.33	1.09	7.08	0.80	0.25	1.03	0.42	1.16	46.76
σ	14.29	0.20	57.24	2.25	13.13	0.77	0.37	2.88	0.42	3.88	69.32

Table 6. Statistics for community parameters of the 13 stations in the Warwick River and adjacent James River area in June, 1975 (per 0.2 m^2).

Station	Number of individuals	Number of species	Diversity H'	Evenness J'	Richness S-1/ln N
1	750	17	2.90	0.71	2.42
2	845	16	2.17	0.54	2.23
3	811	23	2.99	0.66	3.28
4	425	17	3.07	0.75	2.64
5	769	10	1.99	0.60	1.35
6	650	10	2.16	0.65	1.39
7	552	13	2.31	0.63	1.90
8	184	11	2.38	0.69	1.92
9	263	14	2.61	0.69	2.33
10	283	17	2.28	0.56	2.83
11	253	15	1.94	0.50	2.53
12	502	14	2.25	0.59	2.09
13	48	10	2.39	0.72	2.32

Table 7. Statistics for community parameters of the 13 stations in the Warwick River and adjacent James River area in January, 1976 (per 0.2 m^2).

Station	Number of individuals	Number of species	Diversity H'	Evenness J'	Richness S-1/ln N
1	126	9	1.76	0.55	1.65
2	46	10	2.58	0.78	2.35
3	52	7	2.04	0.73	1.52
4	48	10	2.54	0.77	2.32
5	180	14	2.61	0.69	2.50
6	191	10	2.69	0.81	1.71
7	117	10	2.07	0.62	1.89
8	254	12	2.37	0.66	1.99
9	538	18	2.82	0.69	2.70
10	72	11	2.29	0.66	2.34
11	116	8	1.70	0.57	1.47
12	535	13	1.96	0.53	1.91
13	118	17	2.91	0.71	3.35

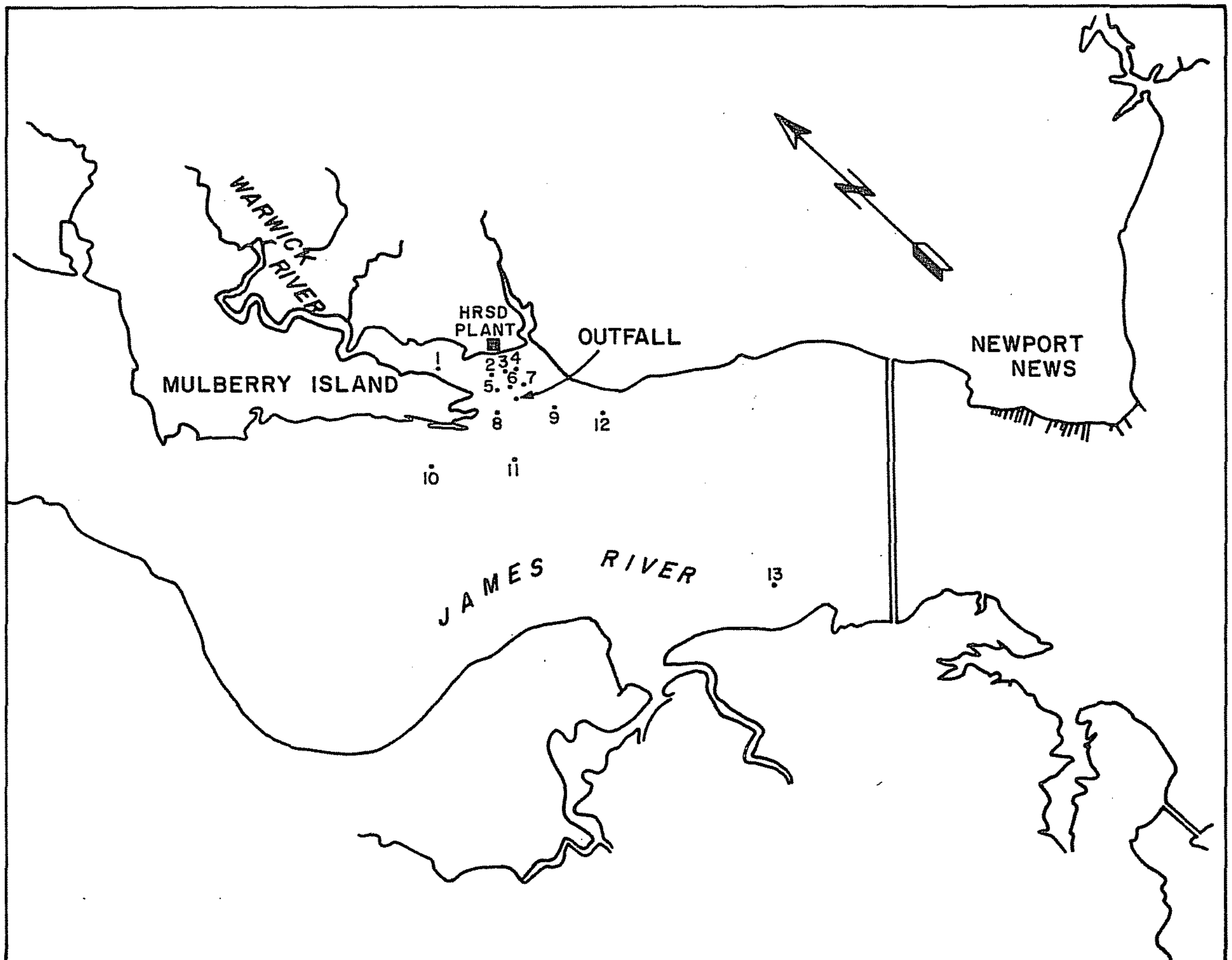


Figure 1. Location of sampling sites at the HRSD James River Sewage Treatment Plant.

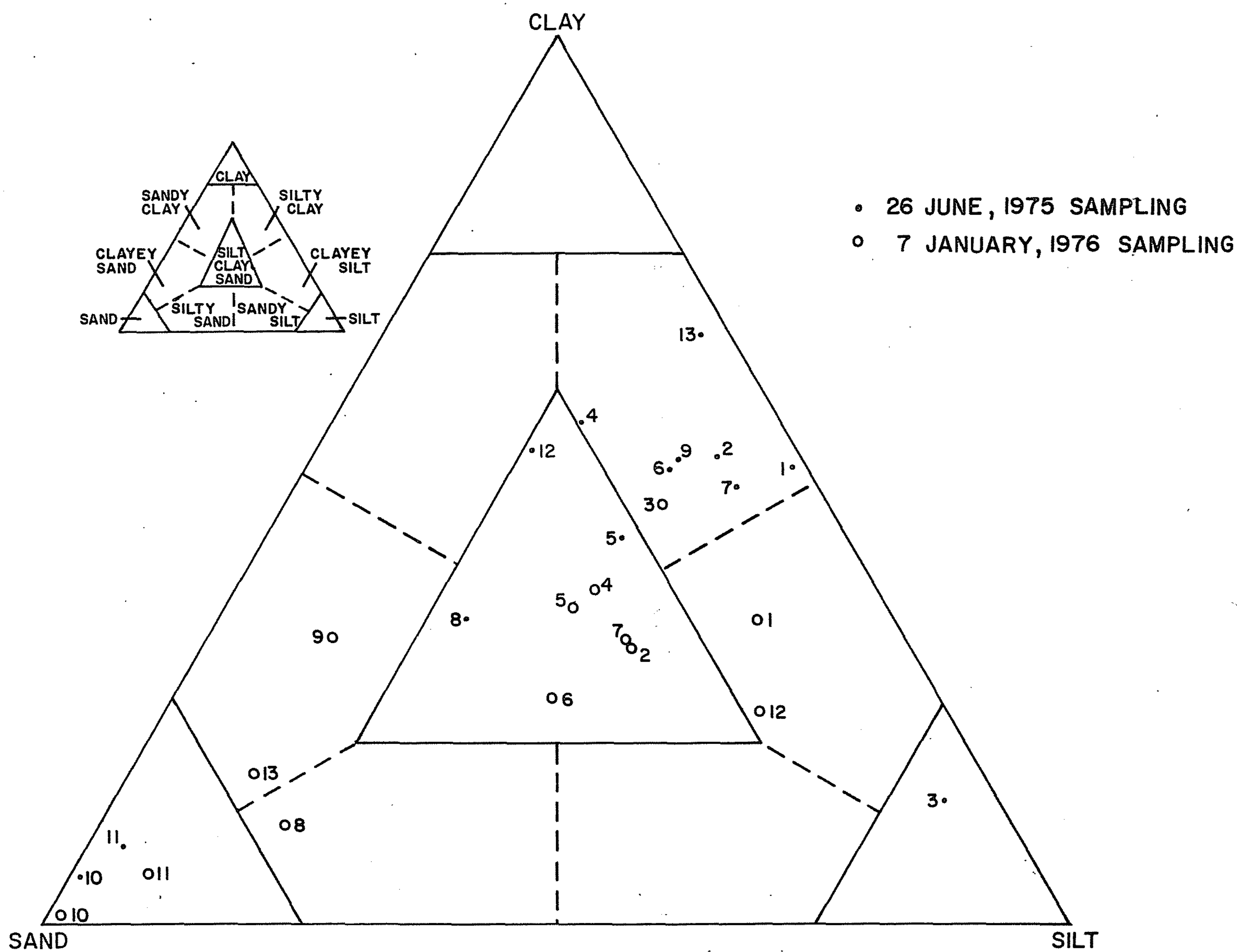


Figure 2. Sediment composition at the 13 sites sampled in June 1975 and January 1976.

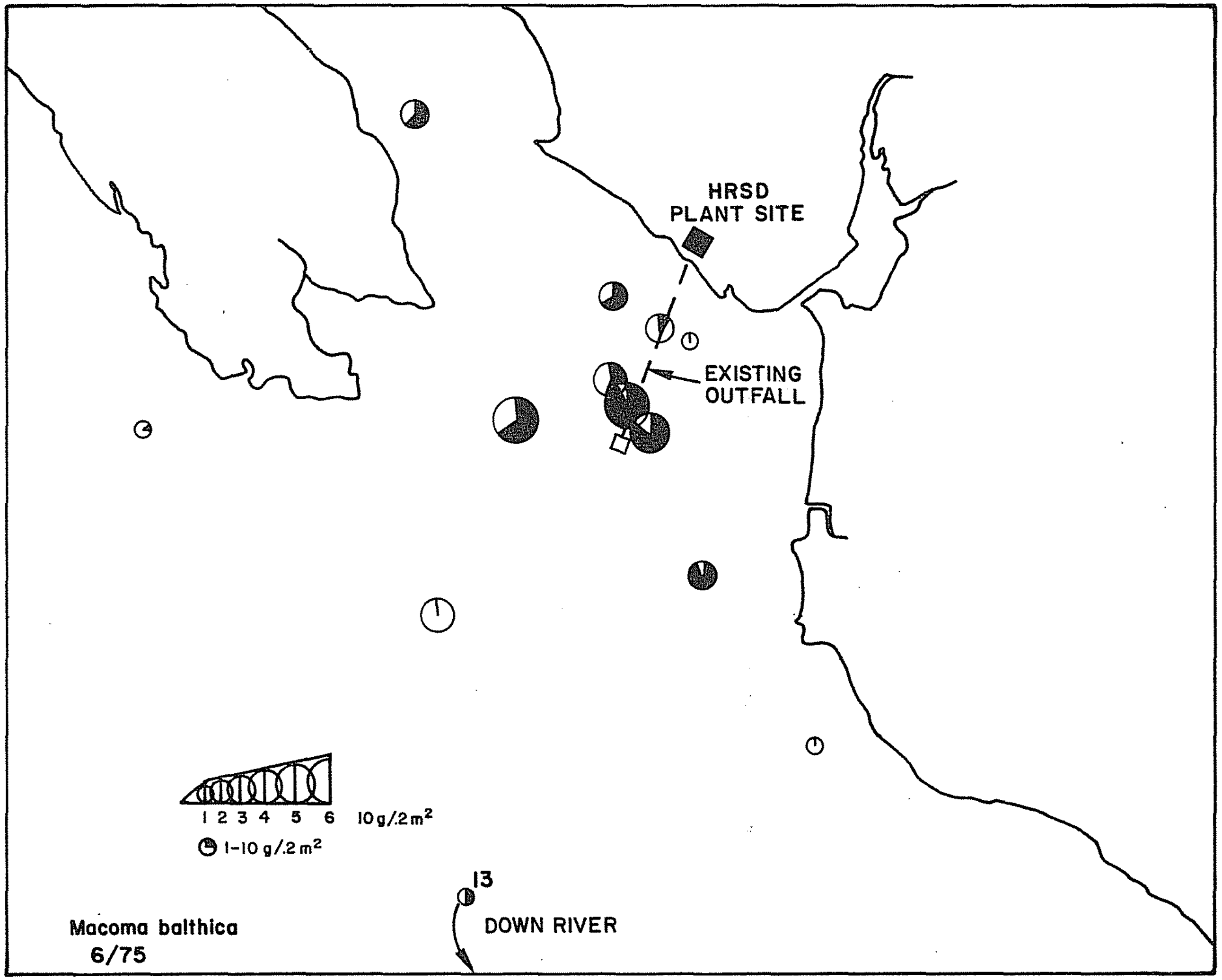


Figure 3. Wet weight biomass of Macoma balthica at the 13 sites in June 1975.

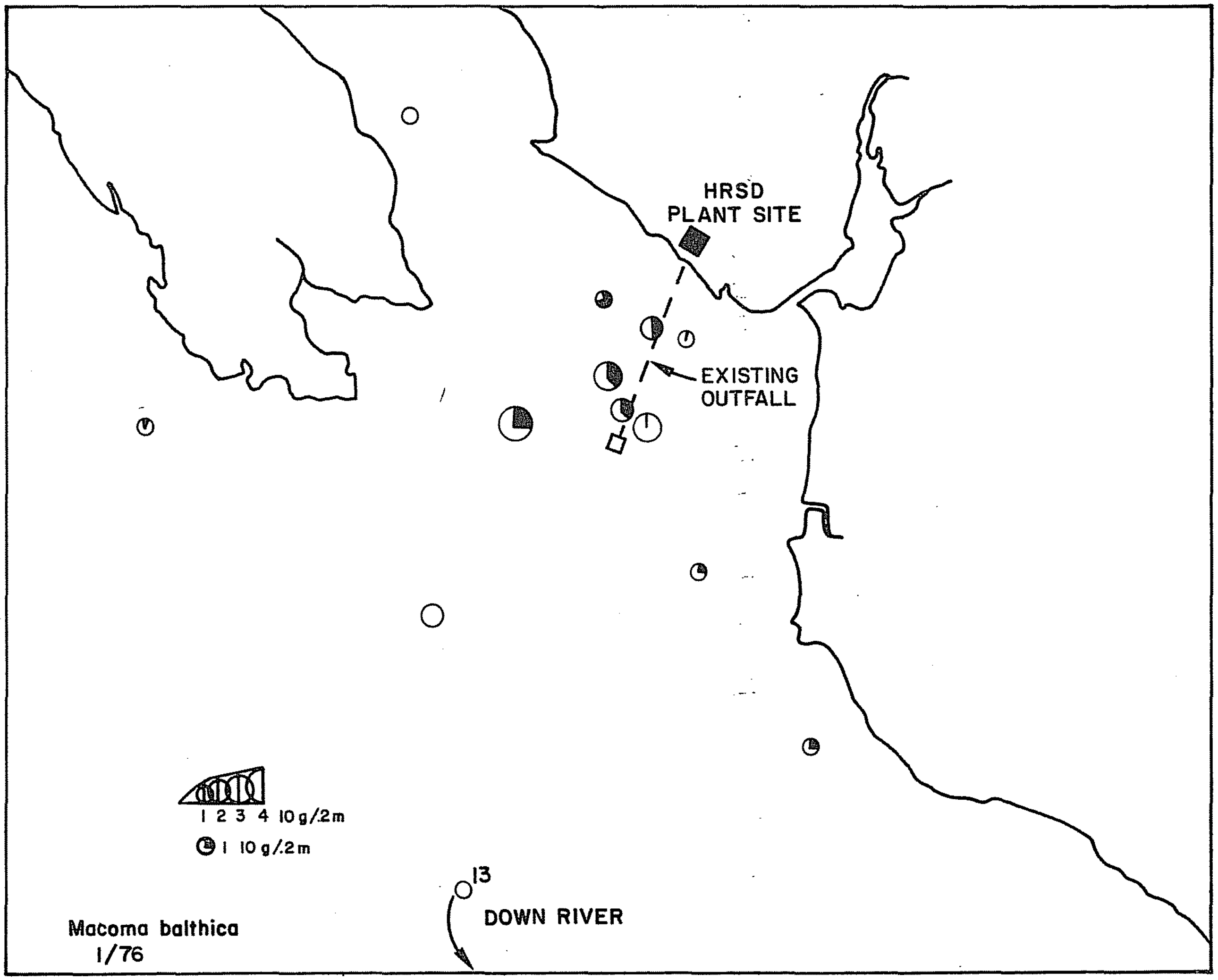


Figure 4. Wet weight biomass of Macoma balthica at the 13 sites in January 1976.

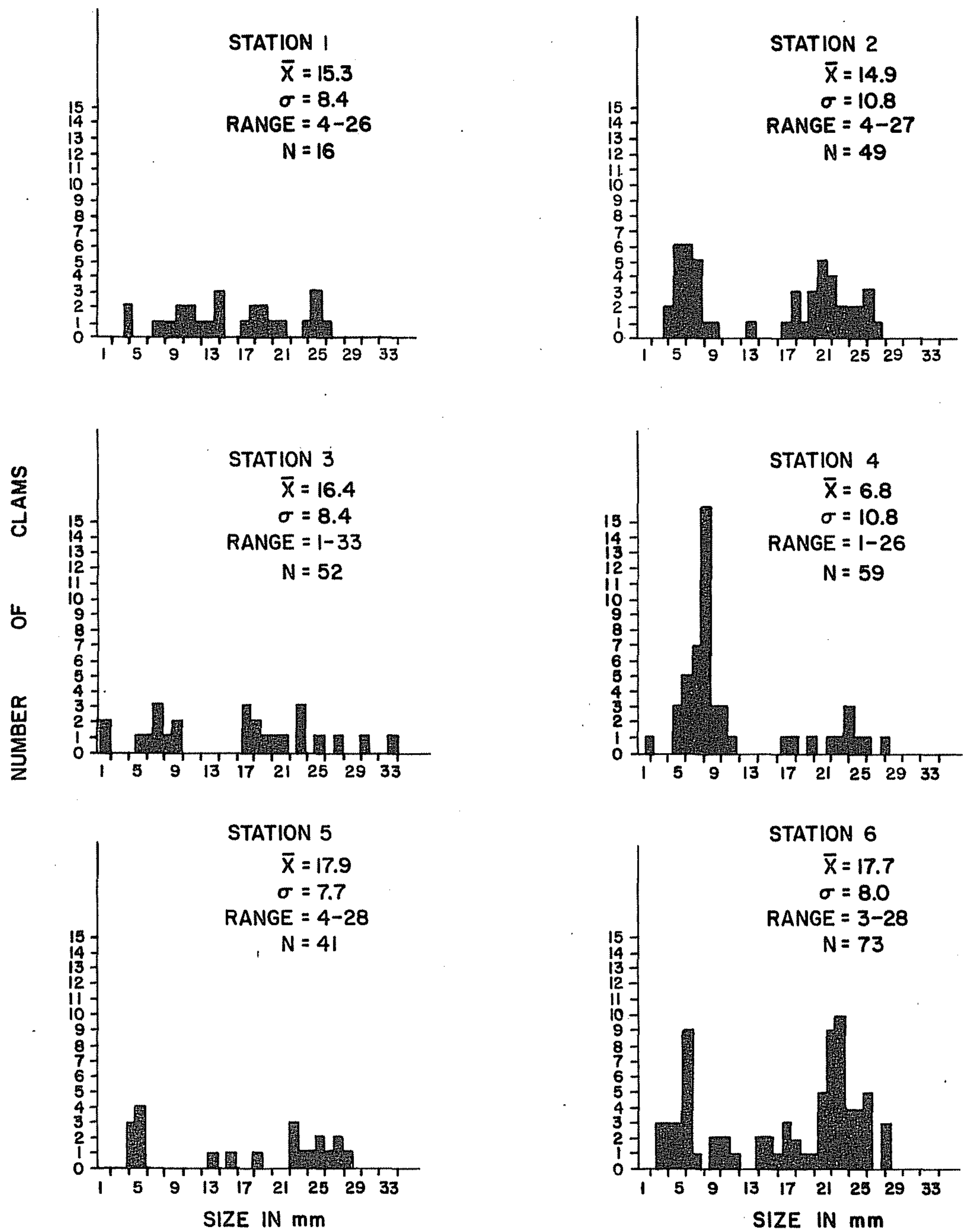
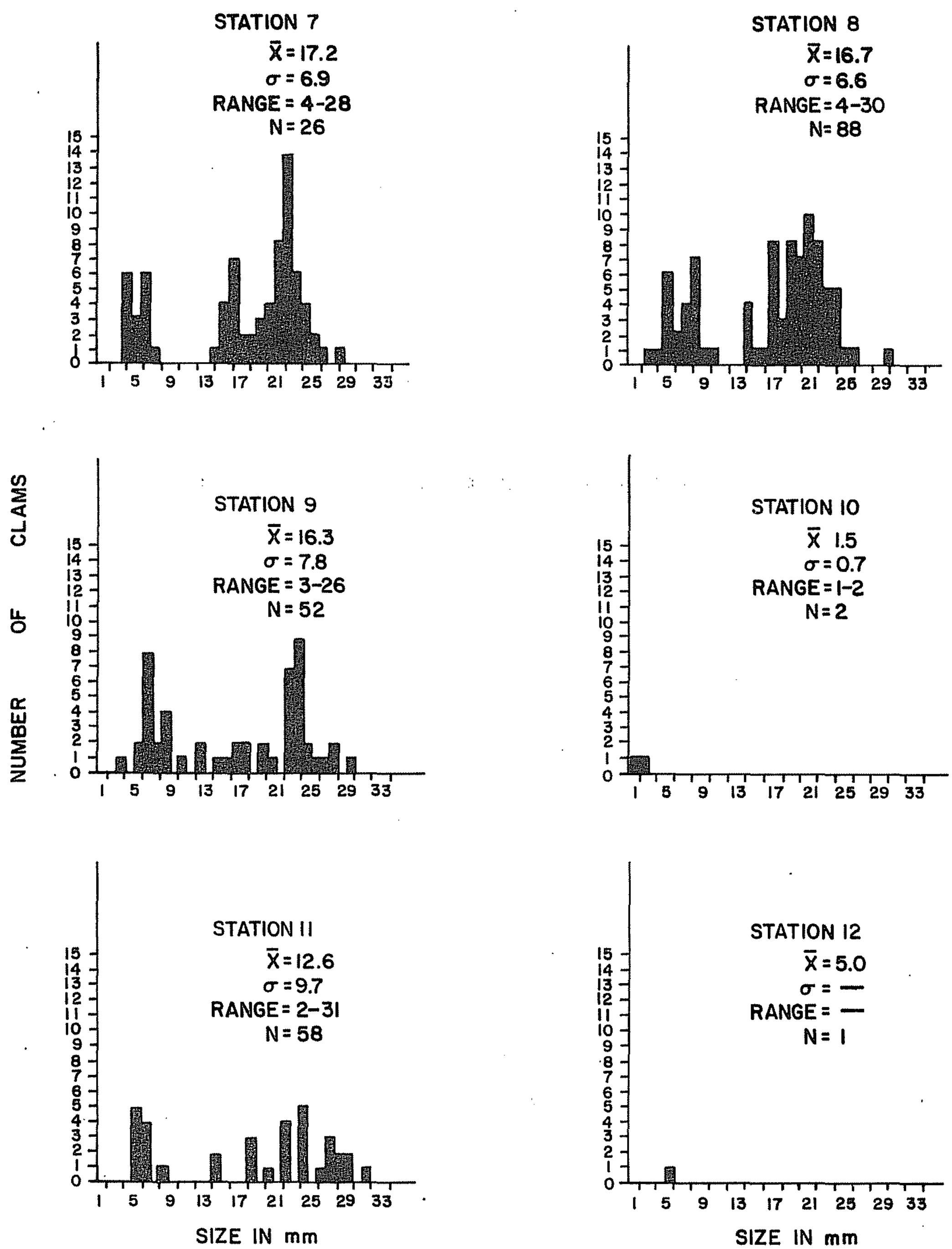
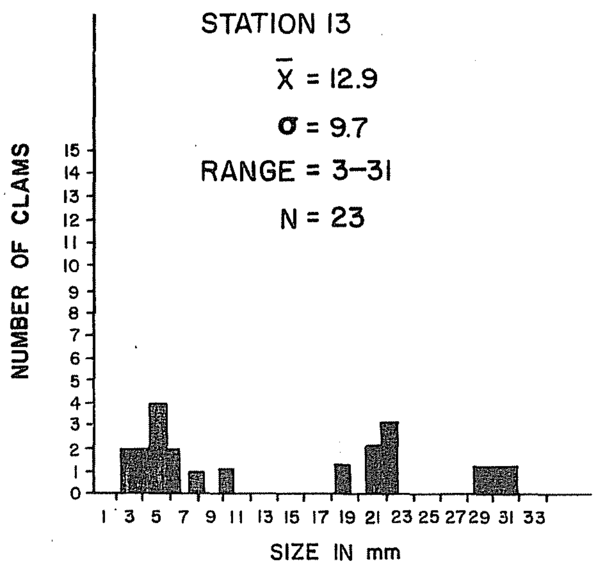
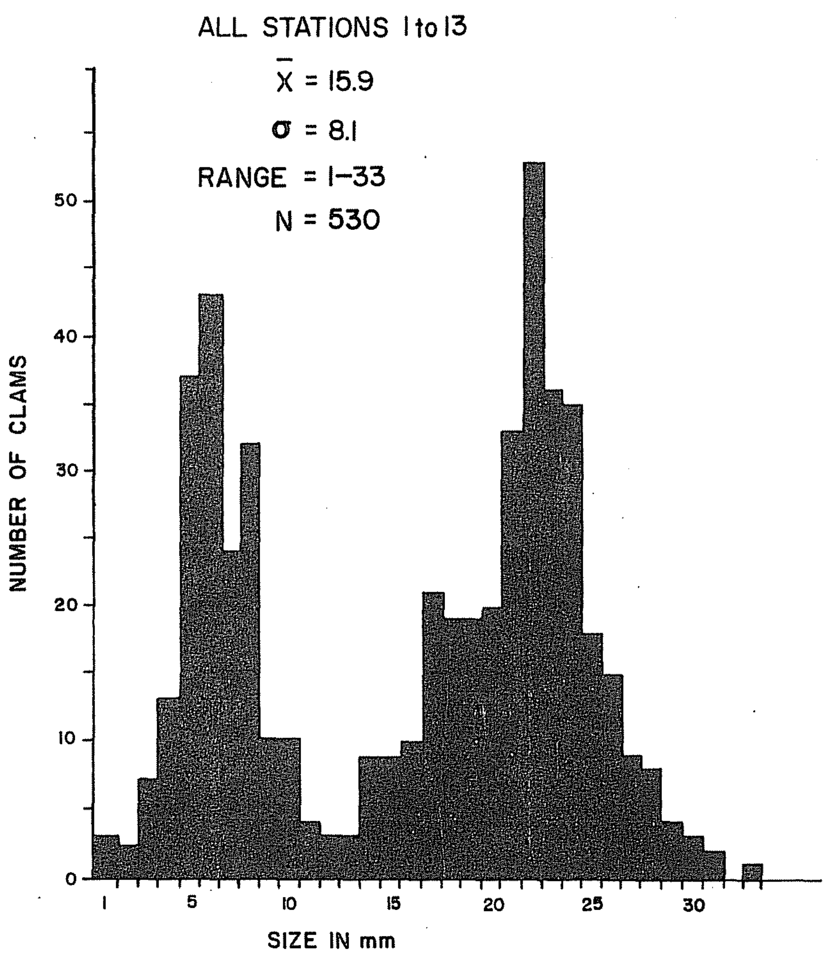


Figure 5. Shell length frequency distribution histograms of *Macoma balthica* at the 13 sites in June 1975.


STATION 7
X̄ = 17.2
σ = 6.9
RANGE = 4-28
N = 26
STATION 8
X̄ = 16.7
σ = 6.6
RANGE = 4-30
N = 88
STATION 9
X̄ = 16.3
σ = 7.8
RANGE = 3-26
N = 52
STATION 10
X̄ 1.5
σ = 0.7
RANGE = 1-2
N = 2
STATION 11
X̄ = 12.6
σ = 9.7
RANGE = 2-31
N = 58
STATION 12
X̄ = 5.0
σ = —
RANGE = —
N = 1
NUMBER OF CLAMS
SIZE IN mm
SIZE IN mm


STATION 13
X̄ = 12.9
σ = 9.7
RANGE = 3–31
N = 23
NUMBER OF CLAMS
SIZE IN mm
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15


ALL STATIONS 1 to 13
X̄ = 15.9
σ = 8.1
RANGE = 1–33
N = 530
NUMBER OF CLAMS
SIZE IN mm
1 5 10 15 20 25 30
0 10 20 30 40 50

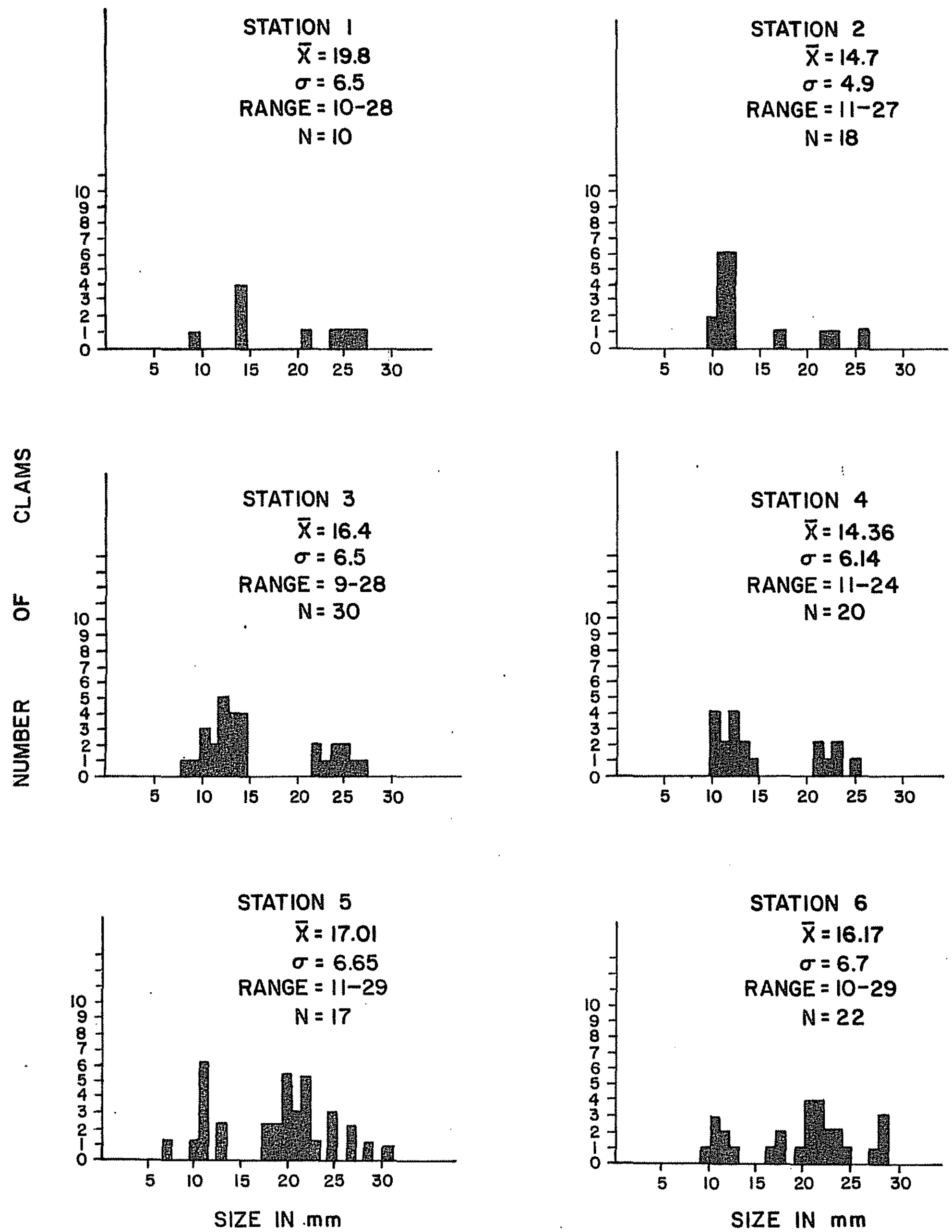
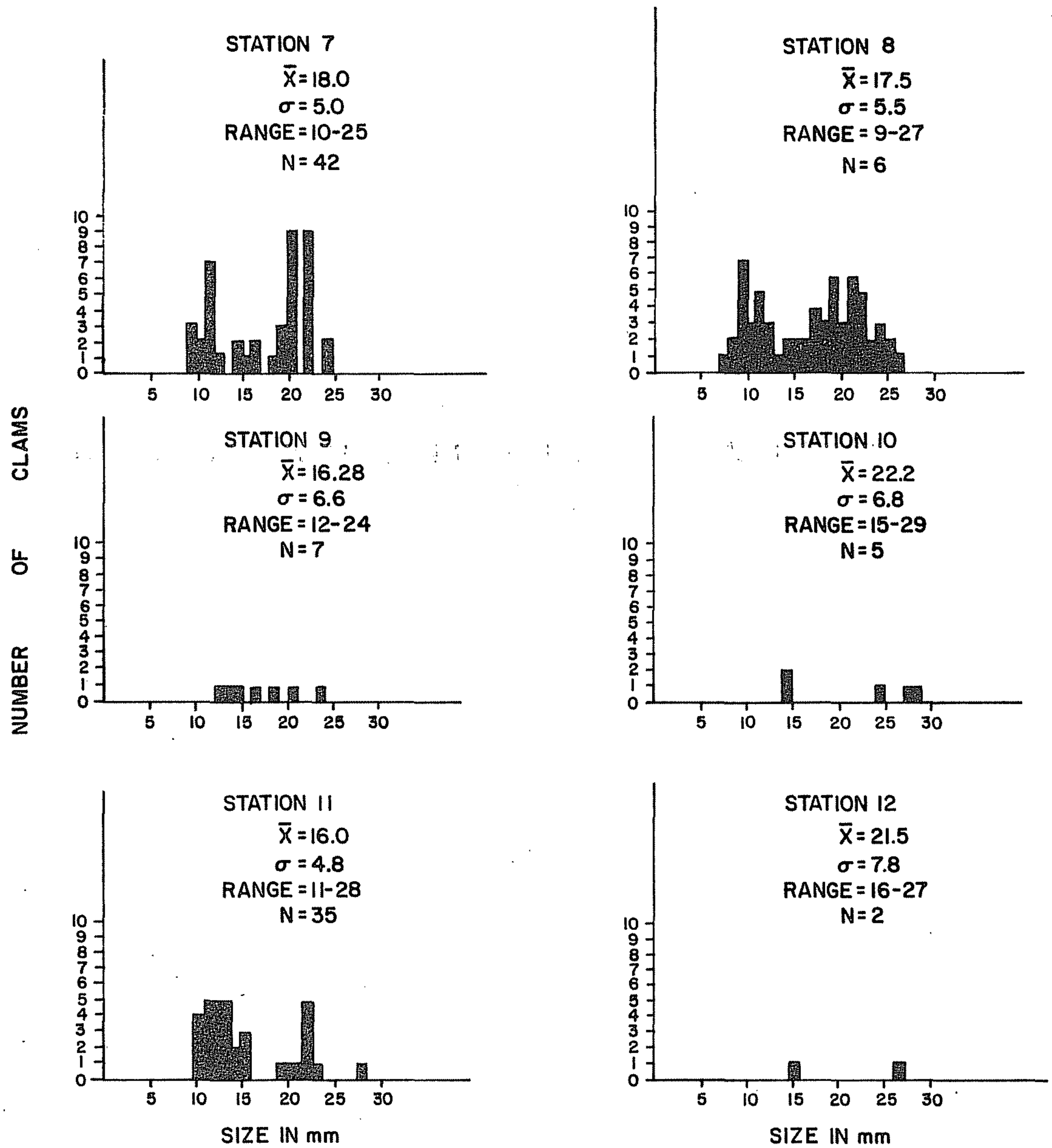
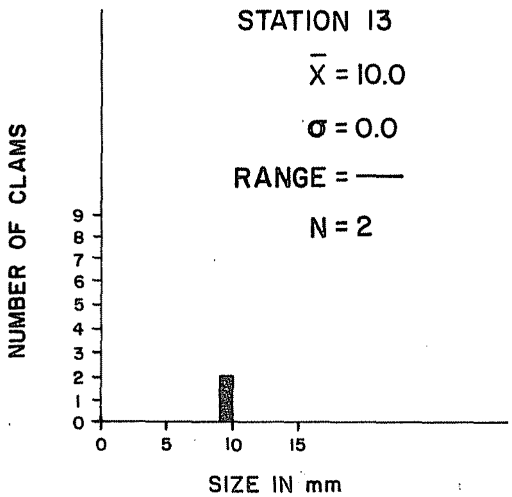
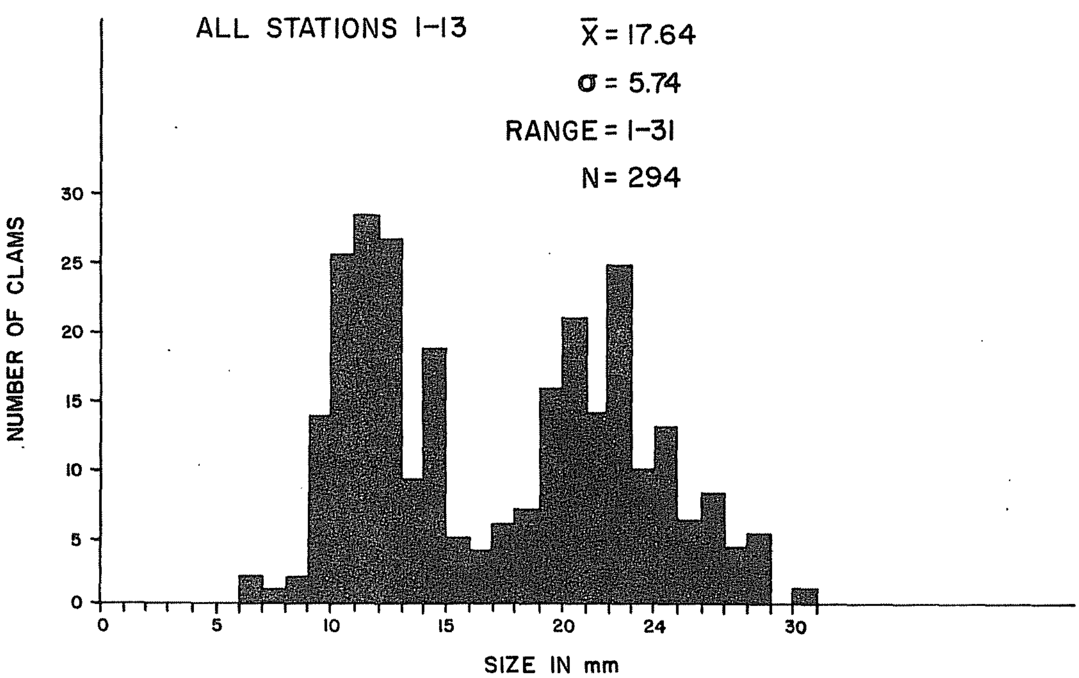


Figure 6. Shell length frequency distribution histograms of Macoma balthica at the 13 sites in January 1976.


STATION 7
X̄ = 18.0
σ = 5.0
RANGE = 10-25
N = 42
STATION 8
X̄ = 17.5
σ = 5.5
RANGE = 9-27
N = 6
STATION 9
X̄ = 16.28
σ = 6.6
RANGE = 12-24
N = 7
STATION 10
X̄ = 22.2
σ = 6.8
RANGE = 15-29
N = 5
STATION 11
X̄ = 16.0
σ = 4.8
RANGE = 11-28
N = 35
STATION 12
X̄ = 21.5
σ = 7.8
RANGE = 16-27
N = 2
NUMBER OF CLAMS
SIZE IN mm
SIZE IN mm


STATION 13
$\bar{X}$ = 10.0
σ = 0.0
RANGE = —
N = 2
NUMBER OF CLAMS
SIZE IN mm


ALL STATIONS 1-13
$\bar{X}$ = 17.64
σ = 5.74
RANGE = 1-31
N = 294
NUMBER OF CLAMS
SIZE IN mm

Section III.

Water Quality in the Vicinity of James River Sewage Treatment Plant Outfall

by

Michael E. Bender
Virginia Institute of Marine Science
Gloucester Point, Virginia

February 1977

Introduction

The original study plan was designed to conduct an analysis of bacterial contamination in the vicinity of the James River Plant outfall as a function of tidal stage and chlorine residuals. Three sampling runs at both high and low slack water were to be scheduled prior to and after the operation of the new outfall. Unfortunately the chlorine monitoring equipment was only functional during two sampling runs prior to the completion of the new outfall, therefore necessitating a reduction in sampling intensity.

Methods

High and low water slack were sampled on two occasions for the enumeration of total and fecal coliforms at the 20 sampling stations shown in Figure 1. Samples were collected from the surface, neutralized with thiosulfate, iced and transported to the laboratory for analysis according to the procedures described by the American Public Health Association (Recommended Procedures for the Examination of Sea Water and Shellfish, 4th Edition, 1970). The multiple-tube fermentation procedure was employed using five tube decimal dilutions. Results referred to as indeterminant (ID) signifies that the coliform levels were below the sensitivity of the most probable number (MPN) technique used, i.e. less than 1.8 total or fecal coliforms per 100 ml water.

Residual chlorine was measured amperometrically in a system in which coulometrically generated iodine is used as a system calibrant (Marinenko, et al., 1976).

Results

Salinity data collected on each of the four slack water runs are tabulated in Table 1. Salinities in April of 1975 at low slack ranged between 5 and 12‰, and at high slack between 6 and 14‰. During late November 1976 low slack salinities ranged between 8 and 15‰, and in early December at high slack between 10 and 19‰.

Total and fecal coliform counts obtained on the four sampling dates are listed in Table 2. Although the data are limited, they do show some rather interesting points: 1) The high levels of total coliforms upstream on the Warwick River at low tide on both sampling dates indicate a source upstream of the outfall; 2) Coliform counts are higher along the northern shore of the James as suggested by the hydraulic model studies. Although the data are admittedly limited and insufficient to account for seasonal fluctuations, they do indicate generally lower levels of both total and fecal coliforms after the operation of the new outfall.

The chlorine residuals measured during the study are shown in Table 3. No residuals were detected during the surveys except at the station directly over the outfall.

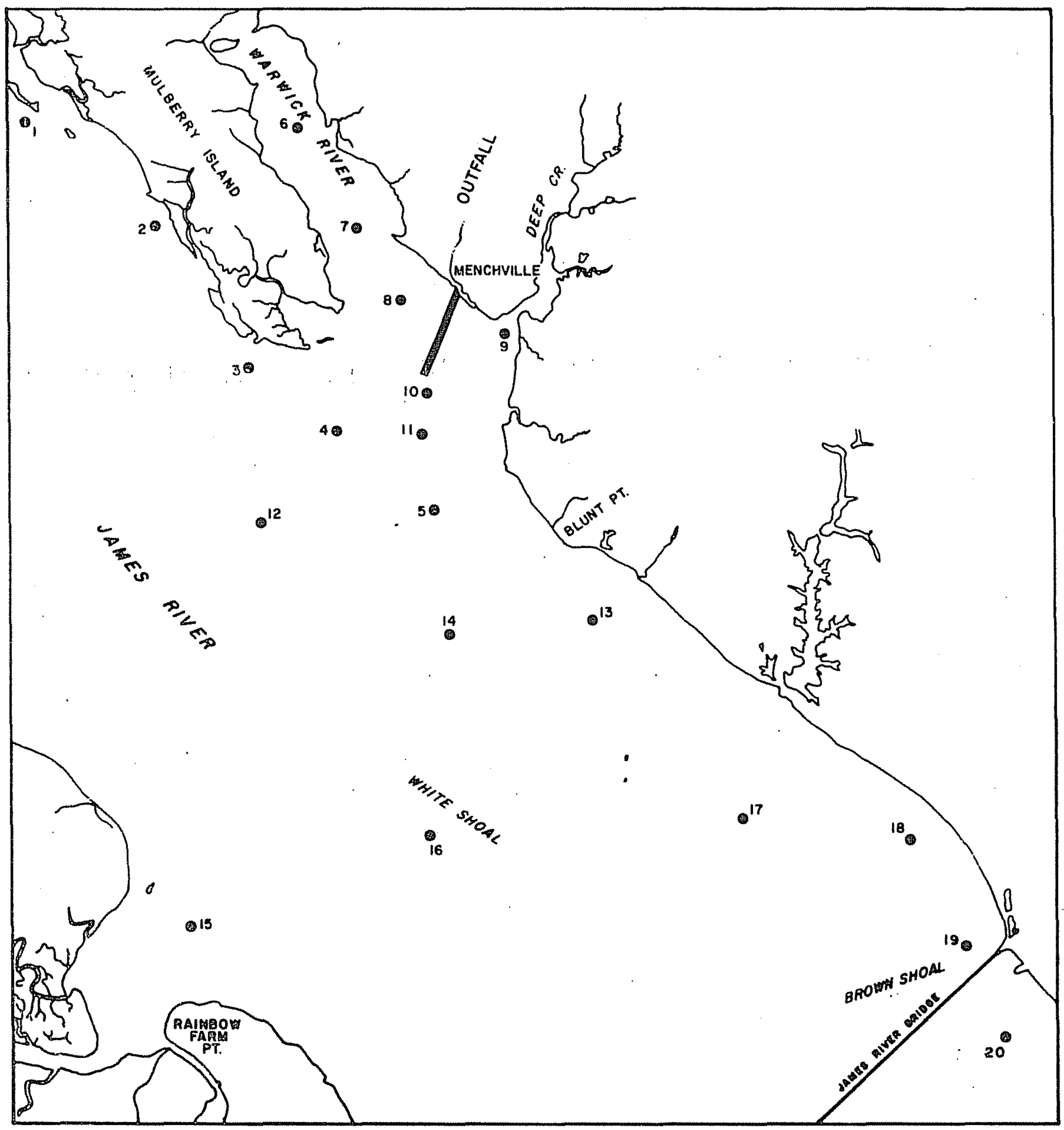

WARWICK RIVER
MULBERRY ISLAND
OUTFALL
DEEP CR.
MENCHVILLE
BLUNT PT.
JAMES RIVER
WHITE SHOAL
BROWN SHOAL
JAMES RIVER BRIDGE
RAINBOW FARM PT.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Figure 1

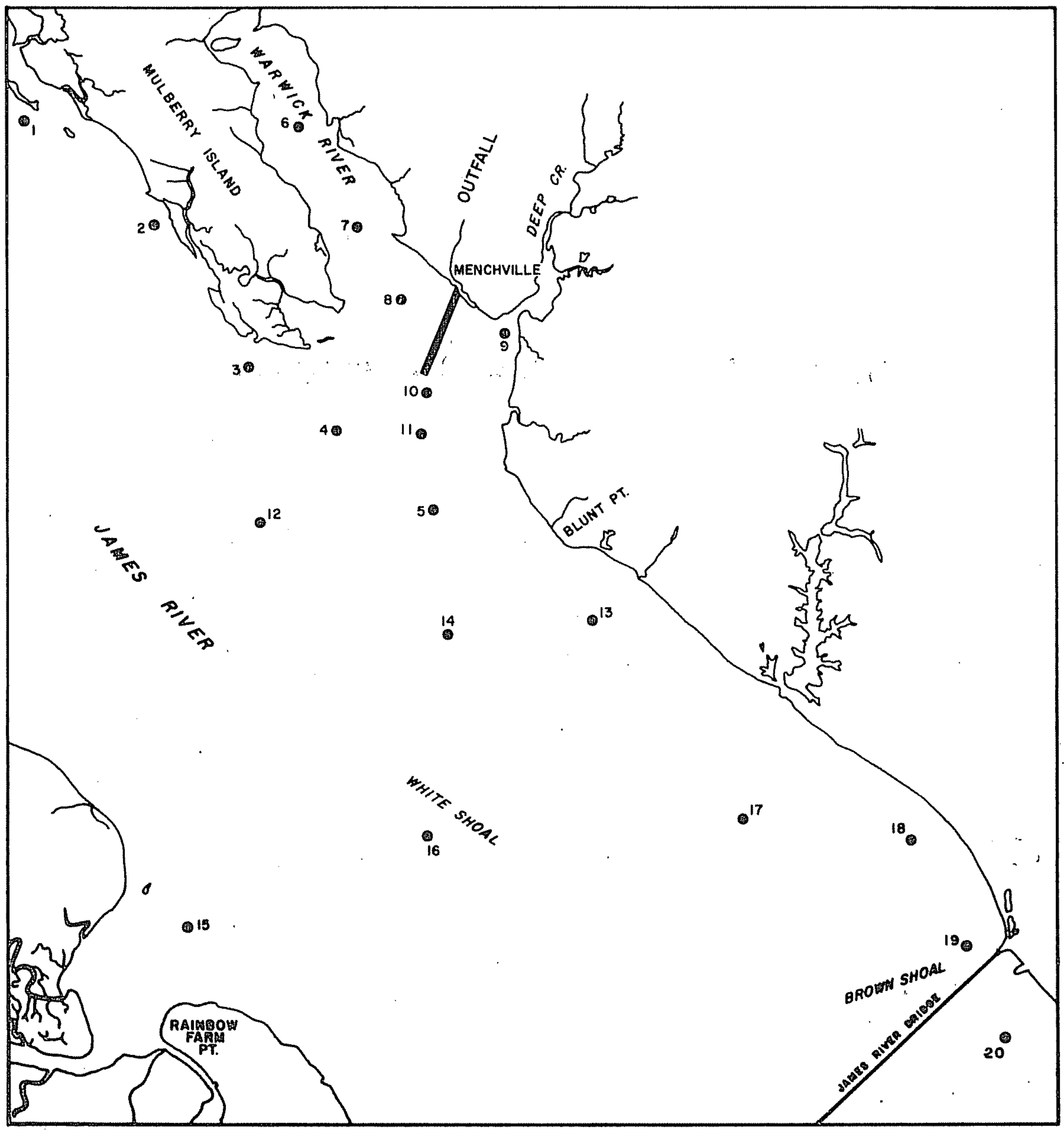

MULBERRY ISLAND
WARWICK RIVER
OUTFALL
DEEP CR.
MENCHVILLE
BLUNT PT.
JAMES RIVER
WHITE SHOAL
RAINBOW FARM PT.
BROWN SHOAL
JAMES RIVER BRIDGE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

TABLE 1

Salinity Data

Station	LSW 4/17/75 ‰	HSW 4/23/75 ‰	LSW 11/29/76 ‰	HSW 12/6/76 ‰
1	5.04	5.83	8.12	9.86
2	5.51	6.31	9.01	11.71
3	7.51	7.77	9.59	13.05
4	8.67	9.94	10.49	13.59
5	9.64	9.47	11.23	13.86
6	6.40	5.17	8.56	12.23
7	7.34	6.63	9.33	12.49
8	7.48	7.67	10.02	13.08
9	8.36	8.01	11.56	13.12
10	8.37	8.44	11.03	13.59
11	9.12	8.87	11.09	13.69
12	8.09	9.67	12.16	14.09
13	9.38	9.47	11.96	14.63
14	9.27	10.40	12.16	14.40
15	6.83	9.21	14.81	10.26
16	8.95	11.68	12.90	13.56
17	9.92	13.15	13.49	-
18	11.57	13.0	14.21	17.46
19	11.68	13.46	14.66	19.14
20	12.26	14.0	15.12	17.82

TABLE 2

Coliform Data

Station	4/17/75 (LSW) TC/100 ml	4/17/75 (LSW) FC/100 ml	4/23/75 (HSW) TC/100 ml	4/23/75 (HSW) FC/100 ml	11/29/76 (LSW) TC/100 ml	11/29/76 (LSW) FC/100 ml	12/6/76 (HSW) TC/100 ml	12/6/76 (HSW) FC/100 ml
1	46	2	33	8	17	2	8	5
2	79	7	56	20	8	ID	7	ID
3	17	2	20	4	13	5	7	2
4	27	2	90	6	13	8	23	1
5	170	13	15	<3	33	33	8	2
6	950	50	180	28	79	17	13	2
7	280	80	64	41	23	8	8	5
8	130	7	36	23	70	46	8	ID
9	790	50	180	36	170	2	27	6
10	79	20	38	5	79	2	8	2
11	49	8	28	<2	70	4	49	13
12	110	11	22	<2	13	5	23	23
13	220	13	48	<5	79	8	23	5
14	33	5	28	<2	13	8	23	8
15	79	5	36	5	8	8	5	5
16	22	7	25	2	23	5	49	13
17	330	33	31	9	5	5	79	33
18	700	220	59	2	13	8	79	33
19	490	33	43	4	17	5	46	33
20	790	220	28	5	49	23	49	49

TABLE 3

Chlorine Data (mg/1)

Station	4/17/75	4/23/75	11/29/76	12/6/76
1	<0.01	<0.01	<0.01	<0.01
2	"	"	"	"
3	"	"	"	"
4	"	"	"	"
5	"	"	"	"
6	"	"	"	"
7	"	"	"	"
8	"	"	"	"
9	"	"	"	"
10	"	"	"	"
11	"	"	"	"
12	"	"	"	"
13	"	"	"	"
14	"	"	"	"
15	"	"	"	"
16	"	"	"	"
17	"	"	"	"
18	"	"	"	"
19	"	"	"	"
20	"	"	"	"
Outfall	0.18	0.12	0.14	0.10