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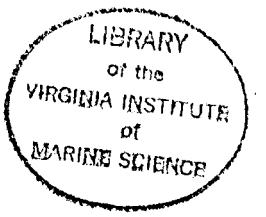

A Final Report to Virginia Department of Highways on Hard Clam (*Mercenaria mercenaria*) Populations in the Vicinity of the Hampton Roads Bridge-Tunnel (I-64).

by

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INTRODUCTION

I-664 will be constructed in Hampton Roads in an area where the hard clam Mercenaria mercenaria is fished commercially. Because of this clam's economic value and because Hampton Roads is the major producing region for this species, it is worthwhile that every precaution be taken during construction of I-664 to minimize the possibility of damage to this resource.

To achieve this objective, this study was undertaken to evaluate the possible impact of I-64 and of construction activities around I-64 on adjacent populations of the hard clam. The objective of the study was that if damage or potential damage is noted, construction techniques may be modified during I-664 construction so that damage in the vicinity of the new area is minimized.

Sampling was in two stages: 1) before construction of the tunnel portion was completed and prior to most of the dredging operations; and, 2) after dredging and fill operations were completed. The first stage was carried out during June and July, 1973. The second series of samples were collected in February, 1974, adjacent to the North approach and in July, 1974, in and South of the channel.

The objective of this segment of this contract has been to determine:

1. If the existing structures have influenced population of clams.
2. If activities associated with the present construction have had any detectable adverse effects on populations.

These two objectives were evaluated in four types of areas.

1. The areas adjacent to the existing and new trestle approaches.
2. The borrow pits on Willoughby Bank and Hampton Bar.
3. The areas adjacent to the two Portal Islands.
4. The tunnel area in mid-channel.

We have evaluated in this study whether or not there has been any effect principally on the basis of differences in numbers of living or dead hard clams per unit area of the bottom at varying distances from the four types of areas outlined in the preceding paragraph. We have also estimated if a difference exists in populations before the tunnel portion was completed and after dredging operations were finished. The rationale behind these concepts follow:

A. If sediments associated with the construction of the islands, the borrow pit, or the approaches, accumulated to such depth as to kill hard clams, then there should be at these sites an increase in numbers of dead clams (boxes)* both with decreasing distances and when the before and after samples are compared. The highest values would be at or near areas of maximum deposition, with values decreasing with increasing distance. A similar situation in respect to mortality would exist in areas where the bottom was being rapidly erroded.

* A box is composed of two valves still hinged at the ligament; boxes are thought to persist in an area for a year or more.

B. Sublethal effects of abnormal accumulation of sediments were evaluated on the basis of length studies. The rationale of this method is that hard clam larvae do not "set" or develop in soft mud, but prefer a firm bottom composed of sand, silts and clays. It is evident, therefore, that if an existing bottom which was favorable for setting were over lain by a thin cover of soft mud then there would be only marginal recruitment after this, but the larger animals would survive. Over a period of a year or two this would lead to a situation in which the population would consist mostly of large individuals with few of the smaller size. To determine if this has occurred, we have calculated mean length and compared initial and final mean size.

The study area is heavily fished by commercial clammers and it was not possible to evaluate the impact of their harvest on clam density. It is quite possible but not demonstrable that a portion of the numerial differences noted may have been due to this aspect.

METHODS

Location of Stations

To locate the sampling stations, we superimposed a grid over a hydrographic chart of lower Hampton Roads showing I-64 and the adjacent waters (National Ocean Survey Chart 400). This enabled us to locate stations in a series of parallel lines (transects) at varying distances

from the trestle approaches, the submerged tunnels, the Portal Islands and the Willoughby Bank and Hampton Bar borrow pits (Figure 1). Distances were as follows:

A. For the mid-channel tunnel area, stations were located on the area to be excavated, and 250 to 500 feet on either side. Thereafter, distances were from 250 or 1000 feet.

B. In the vicinity of the borrow pits stations were located inside and within 150 to 600 feet of the edge. Thereafter, stations were spaced at 150 to 500 feet intervals close to the pit and at about 1000 feet intervals further out.

C. Near the Portal Islands and the approach trestles, station spacing was similar to that outlined in (B).

If the first study showed a large area to be devoid of clams, it was not resampled; critical areas received increased sampling effort during the final study.

Selection of Sampling Dates

Sampling dates were chosen to be before or after events associated with the construction of I-64 across Hampton Roads. A chronology follows:

A. North of the Hampton Roads channel around the North Portal Island and the approach trestle, the initial sampling was concluded in July, 1973. After the construction of the island there was dredging on Hampton Bar just to the West of the island. Dredging was completed in January, 1974, with the cumulative total

of material dredged being approximately 325,000 cu yds. Final sampling occurred in February, 1974.

B. In the Hampton Roads channel where the tunnel was located, the initial samples were collected in June, 1973. At this time dredging of the trench for the tunnel (sections 12 through 17) had not been completed and tunnel sections 9 through 17 remained to be laid. By July, 1974, all the tunnel sections were laid. Final sampling was completed in late July, 1974, after all but one small area had been backfilled.

C. To the South of Hampton Roads channel, the initial samples were collected in June, 1973.

1. This was before approximately 400,000 cu yds. of material was dredged from the Sewell's Point Spit area in May and June, 1974.
2. This was before about 250,000 cu yds was removed from the Willoughby Bank borrow pit just to the East of Fort Wool. The area, however,had been used to obtain fill material prior to June, 1973.
3. This was after the concrete pilings for the South approach were in place and after the South Portal Island was completed.

The final sampling in Area C was completed in July, 1974.

Method of Sampling

A commercial hard clam harvesting rig under charter to VIMS was used to obtain samples. The rig consisted of a 37 foot boat with a

boom and a pair of "patent tongs". This boat was operated by the owner, who is a commercial clammer and, therefore, experienced in the use of this gear.

Patent tongs were chosen as the sampling device since data obtained with them may be analyzed quantitatively. That is, they cover the same area of bottom each time. Those used in this study covered (1.2 yd^2) and retrieved everything over an inch in size.

At each station the boat was anchored and 10 grabs or samples were taken. The boat was allowed to move slightly between grabs by letting out the anchor lines; in this way, each grab sampled a new spot. Live hard clams and clam boxes taken in each grab were counted and average number per grab were calculated. Later, average numbers per 10 grabs along specific transects were calculated. All clams collected were measured to the nearest mm, later mean lengths were determined. A total of 304 locations were sampled (Figure 1).

VIMS personnel directed the positioning of the boat to the sampling locations and recorded and tabulated all data. Sample locations were determined with the help of a sextant and a National Ocean Survey Chart 400[1].

Sediment samples were collected at most stations and analyzed for percent sand, silt and clay. These data will be reported with another segment of this contract. Observations at the time of collections, however, enable us to state the general composition at each station.

The depth of the water at each station was recorded with a portable fathometer which was also used to record three profiles of the bottom in the Willoughby Bank borrow pit area, and two in the Sewell's Point

[1]The accuracy of the positioning was attested to when five stations were unitentionally sampled a second time. The second set of results was nearly identical to the first set.

borrow pit (Figure 1). On Hampton Bar three profiles were obtained (Figure 2).

Reporting Data and Statistical Evaluations

Data collected during the initial and final sampling in each area are presented in two ways:

1. Figures show the mean number of living hard clams per grab (1.2 yd^2) for every station occupied in the study for the pre and post sampling periods. These data are the basis for all statistical studies and they are utilized in two ways:
    a. Stations occupied both in the initial and final phases were subject to a paired "t" test to determine if there were differences in mean numbers of clams for certain areas.
    b. Stations were divided into series of parallel transects at increasing distances from borrow pits or bridge structures. These data were tested for product moment correlation to determine if there was a relation between clam density and distance. The product moment analysis utilized all data collected in a given sampling period (not just stations sampled in both the initial and final periods).

2. The data shown in the figures was summarized numerically in a series of tables for transects parallel to bridge structures or borrow pits. These tabulated data show locations of transects, number of stations, year, average number of live and dead clams per 10 grabs, and average mean length.

The average number of live clams per transect are calculated from data on individual stations, and are indicative of the trends which were analyzed by the product moment analysis. The mean values shown here are used to calculate percentage dead (number alive + number of boxes $\div$ number boxes). However, as outlined previously, stations occupied in 1973 were not always resampled in 1974. Therefore, our "t" tests and the mean numbers of live clams per grab discussed in this report are based only on stations occupied during both periods.

RESULTS

1. Area Around North Portal Island

Sediments in this area were predominantly sand with lesser quantities of silts and clay. This mixture formed a firm substrate typical of a good clam bottom.

Data on station location, depths, sample number, mean lengths, mean box counts and mean number live are shown in Table 1.

A total of 89 stations were occupied in the area in 1973, and 94 were studied after construction activities were completed in 1974

(Figures 3 and 4). These figures show that hard clams seemed to be equally abundant in the area in both years, but that numbers varied widely from station to station. This uneven distribution is characteristic of clams in most regions in Virginia. Of the number of stations sampled, hard clams were found at 81% of the stations in 1973 as compared to 85% in 1974.

A summation of data shown in Figures 3 and 4 indicated mean numbers of clams to the East of the approach and the Island declined from 20.2 to 13.3 between initial and final sampling; to the West for the same period number of clams declined from 16.4 to 15.4 per grab (Table 2). Analysis by paired "t" tests show both declines as non-significant.

Product moment correlation between numbers of live clams and distance was non-significant. For 1973 the values were: East $r = -.10$; West $r = .09$; in 1974 values were: East $r = -.40$; West $r = .14$.

Analysis of data shown in Table 1 suggested that few clams died in the area during the past year. To the East of the approach, comparable mean values for 1973 and 1974 were respectively: length, 74 and 74; number dead per 10 grabs, 0.3 and 0.1. Box counts represented only 2% of the population (live and dead) in 1973 and 1974. West of the trestle between 1973 and 1974 the respective mean values were: number dead per 10 grabs, 0.4 and 0.4 and lengths, 75 and 77. Box counts in the area represented less than 2% of the total in 1973 and 1974. That is, on the basis of box counts, there was no evidence of a recent mortality.

Approximately 325,000 cu yds. of material were removed from the borrow pit on Hampton Bar. Initial sampling was conducted in

the area in July 1973 prior to dredging activity; a final study was made in February after dredging had ended. Fathometer tracings (Figures 5, 6, and 7) of this area were made on 14 February, 1974, after the completion of dredging. A total of three transects were run (Figure 2). These show the top of Hampton Bar with a depth of 5-8 feet and the holes where deposits were removed to a depth of 20 to 35 feet.

Data shown in Figures 3 and 4 were tabulated for areas to the North, South and West of the borrow pit and subject to statistical analysis using a paired "t" test. A significant decline in mean numbers of live clams per grab was shown within the borrow pit from 0.8 to 0.1 per grab. Outside the pit, however, no significant difference was shown. Mean values for 1973 and 1974 were respectively: South of the pit, 17.0 and 17.7; North of the pit, 16.9 and 15.8; and to the West, 21.4 and 20.4 (Table 2). In summary, clam density within the pit area had decreased as might be expected after dredging; densities in the surrounding area were almost identical for both periods.

2. Tunnel Area

Sediments in the area varied from a hard shell bottom off Fort Monroe to sand and soft mud. However, the bottom in the vicinity of the tube was soft, and consisted largely of silts and clays with a small amount of sand.

Extensive activity associated with the bottom took place in this area due to excavating a trench for the tube sections, laying the tubes and backfilling. A total of 76 stations were occupied prior

to completion of the tube in June of 1973; samples were collected at 25 stations in July, 1974.

Data on sampling at individual stations for 1973 and 1974 are shown as mean numbers of clams per grab (Figures 8 and 9). In 1973, hard clams occurred at only 35% of the stations. An inspection of Figures 8 and 9 shows that mean number collected at the stations varied from zero to 6.6 which again reflects the "patchy" nature of their distribution.

Product moment correlation between numbers of live clams and distance was non-significant. To the West of the tunnel, r values for 1973 and 1974 were respectively: $r = 0.66$ and $r = 0.14$. To the East of the tunnel in 1973, $r = 0.39$; in 1974 stations were not occupied.

A comparison of density of live clams for the before and after periods in the tube area was made for 1973 and 1974. To the East of the structure clams were too scarce for any adequate study. The bottom was hard shell or soft mud which was not suited for this species.

The average number of clam boxes per unit area East of the tunnel for 1973 and 1974 respectively were per 10 grabs: 0.4 and 0.8. While number is quite low, numbers of live clams collected were also low, therefore, percentage dead was high. That is, the boxes represent 25% of the total in 1973 and 24% in 1974. It is noted that while these figures are high, no increase was noted in the period. Mean length decreased between initial and final sampling from 86 to 78 mm (Table 3).

To the West of the tunnel, mean hard clam density at the same location for 1973 and 1974 were compared. Mean values for 1973 and 1974 were respectively: 12.1 and 7.7 clams per 10 grabs. This difference was significant (Table 2). Analysis of box counts, however, indicated that there had been no recent mortality in the area. For example, respective mean values West of the tunnel for 1973 and 1974 were: number dead per 10 grabs, 1.4 and 0.2. Number of boxes represented about 18% of the total in 1973 and only 2% in 1974, a decrease of about 16% (Table 3).

Length of clams for the two years was identical: 71 mm in 1973 and 71 mm in 1974.

It is concluded that the observed decline in hard clam density West of the tunnel may have been due to harvest from the area by commercial clammers. The reason for this is that the decline in density was not accompanied by an increase in box counts.

3. Willoughby Bank Borrow Pit Area

The Willoughby Bank area East of Fort Wool was used during the construction of I-64 as a source of fill and a site for dumping dredged material. This area was sampled in July 1973 and again a year later (Figures 10 and 11). Sediments in the area were largely sand mixed with small quantities of silts and clays. At most stations the bottom was firm. Fathometer tracings across the borrow pit area revealed that approximately the western two thirds had been disturbed by dredging and filling. The eastern one third had been disturbed very little or none at all (Figures 12, 13 and 14).

In the borrow area 83% of the stations sampled in 1973 and 58% in 1974 had live clams. To the North live clams were found at 60% of the stations in 1973 and 60% in 1974. To the East live clams were found at 69% of the stations in 1973 and 93% in 1974. To the South clams were found at all stations sampled in both periods.

Product moment correlation between numbers of live clams and distance was not significant. For the area to the North $r = 0.20$ and .003 for 1974. To the East $r = 0.31$ in 1973 and -.12 in 1974. To the South $r = 0.32$ before and 0.26 after.

There was no significant difference in numbers of live clams (Table 2) between initial and final sampling around the pit. Mean densities (per 10 grabs for similar stations) obtained from data shown in Figures 10 and 11 follow for before and after, respectively: to the North, 15.5 and 15.9; to the East, 15.6 and 17.0 and to the South, 37.1 and 26.8. Within the pit mean values for before and after were: 7.5 and 2.3; this difference was significant, as might be expected.

Box counts show no evidence of mortality in the areas. To the North of the borrow pit for 1973 and 1974 means for number dead per 10 grabs were respectively: 1.9 and 0.7. Calculations show the percentage total dead was high for 1973 (13%), but low in 1974 (4%). Mean length decreased in the period from 80 to 76 mm. To the East of the borrow pit the mean box counts per 10 grabs for 1973 and 1974 were respectively: 1.4 and 2.2; and length, 74 and 79 mm. Box counts were lower for 1973 (8%) than for 1974 (14%). To the South, mean box counts for before and after were respectively: 1.5 and 2.1. Expressed as percent of the total there were 4% for 1973 and 8%, respectively (Table 4).

4. Area East and West of South Approach

Sediments in this area were largely sand with smaller amounts of silts and clays. Therefore, the bottom in most areas was moderately firm. A total of 91 locations were sampled in 1973 and 66 in 1974. Of the total stations sampled, 95% showed clams in 1973; in 1974, 83% had clams.

Data for the two sampling periods are shown as mean numbers of clams per grab (Figures 10, 11, 15 and 16). An inspection of these data show that distribution of hard clams here was highly variable.

Before and after data for clam density were subject to statistical evaluation.

Product moment calculation between numbers of live clams and distance was non-significant for both the area to the East ($r = .32$ in 1973 and .26 in 1974) and to the West ($r = .09$ for 1973 and .01 for 1974).

Comparison of initial and final density to the West of the approach for 1973 and 1974 respectively were: 10.8 and 12.0 live clams per 10 grabs; to the East values were: 37.1 and 26.8 per 10 grabs for 1973 and 1974, respectively. These differences were not significant (Table 2).

Data on boxes and lengths are summed in Table 5 for transects parallel to the approach. To the East of the approach, means for 1973 and 1974 periods were: box counts per 10 grabs, 1.8 and 2.4. Box counts represented 5% of the population in 1973 and 9% in 1974 (a difference of only 4%). That is, the observed reduction in numbers of live clams to the East was not accompanied by a corresponding increase in numbers of boxes. Lengths ranged from 74 mm to 76 mm.

Table 1

A summary of depth ranges, numbers and lengths of live hard clams and number of clam boxes along transects at varying distances from the North Portal Island and Approach. Initial sampling July 1973 (B); Final sampling February 1974 (A).

Direction	Distance	Range of Depth (ft)	No. of Stations Sampled		Avg. No./ Station *		Mean Length (mm)		Avg. No. Boxes/ Station *	
			B	A	B	A	B	A	B	A
East	50	6-16	3	-	10	-	65	-	0	-
	375	7-19	4	4	12	12	77	78	0.2	0
	930	4-20	5	5	6	8	79	75	0.2	0
	1,500	10-22	4	4	38	1	74	82	0.8	0.2
Average					16	6	74	74	0.3	0.1
West	15	9-10	3	-	16	-	77	-	0.3	-
	50	8-10	2	2	23	8	82	78	0	0
	400	4-10	3	3	14	39	76	74	0.7	0.7
	1,050	5-30	8	7	17	15	75	79	0.1	0.3
	1,620	4-28	8	8	7	6	77	79	0.2	0.4
	2,340	8-13	3	3	24	11	74	75	0.7	0
	2,550	4-38	5	5	9	4	76	82	0.4	0
	3,050	7-13	3	1	22	51	75	76	2.7	0
	3,550	5-32	8	8	14	15	74	76	0.1	0.1
	4,550	5-21	8	8	12	11	66	78	0.4	0.1
	5,550	4-21	8	8	16	14	78	77	0.1	0.2
	6,550	6-21	5	4	27	32	75	72	0.4	0
	7,250	8-19	3	-	24	-	76	-	0	-
	7,850	7-15	-	6	-	15	-	74	-	0.3
	8,850	8-14	-	6	-	7	-	76	-	0.3
	9,250	9-11	2	-	22	-	76	-	0	-
	9,800	9-15	-	5	-	10	-	77	-	1.0
	10,750	10-15	-	5	-	17	-	79	-	0.2
	11,350	12-14	2	-	23	-	75	-	0	-
	11,700	10-13	-	2	-	11	-	74	-	0
	13,750	14	2	-	23	-	75	-	0	-
	17,100	12	-	1	-	34	-	78	-	3.0
Average					18	18	75	77	0.4	0.4

* 10 grabs

Table 2

Conclusions from statistical comparison of numbers of live hard clams found when the same stations were sampled before and after ("student's" t test used to test for significance)

Area	No. Stations Analyzed	Mean Number/ Station		Signicant Difference(s) or Non-significant Difference (ns)	P
		Before	After		
North Approach					
East	13	20.2	13.3	N. S.	>.50
West	53	16.4	15.4	N. S.	>.50
Hampton Bar borrow area					
In the area	8	0.8	0.1	S	>.09
South	10	17.0	17.7	N. S.	>.50
North	29	16.9	15.8	N. S.	>.50
West	11	21.4	20.4	N. S.	>.50
Tunnel					
West	23	12.1	7.7	S	>.04
East	34	1.4	Not sampled		
South Appraoch					
West	26	10.8	12.0	N. S.	>.50
East	37	37.1	26.8	N. S.	>.50
Willoughby Bank borrow area					
In the pit	12	7.5	2.3	S	>.15
North	10	15.5	15.9	N. S.	>.50
East	15	15.6	17.0	N. S.	>.50
South	37	37.1	26.8	N. S.	>.50

Table 3

A summary of depth ranges, numbers and lengths of live hard clams and number of clam boxes along transects in the channel of Hampton Roads compared to distance from the tunnel. Initial sampling June 1973(B);Final sampling July 1974(A).

Direction	Distance (ft)	Range of Depth (ft)	No. of Stations Sampled		Avg. No./ Station *		Mean Length (mm)		Avg. No. Boxes / Station *	
			B	A	B	A	B	A	B	A
East	500	12-70	14	1	3.5	5.0	72	78	1.0	2.0
	1,500	20-76	11	2	0.1	0	85	-	0.1	0.5
	2,500	30-83	10	-	0.2	-	99	-	0.1	-
Average					1.3	2.5	86	78	0.4	0.8
West	250	55-83	4	-	0.0	-	-	-	0	-
	500	11-72	12	-	3.1	-	71	-	0.6	-
	1,500	16-66	13	11	6.1	6.0	73	70	1.7	0.1
	2,500	12-65	13	11	14.8	9.0	70	72	3.4	0.3
Average					6.2	7.5	71	71	1.4	0.2

* 10 grabs

Table 4

A summary of depth ranges, numbers and lengths of live hard clams and number of clam boxes along transects at varying distances away from the Willoughby Bank borrow pit. Initial sampling June 1973 (B); Final sampling July 1974 (A).

Direction	Distance (ft)	Range of Depth (ft)	No. of Stations Sampled		Avg. No./ Station *		Mean Length (mm)		Avg. No. Boxes/ Station *	
			B	A	B	A	B	A	B	A
In the pit area		13-21	12	12	8	2	74	72	0.5	0.2
North	300	16-23	5	5	7	16	80	77	0.6	1.2
	800	21-35	5	5	21	16	80	76	3.2	0.2
Average					14	16	80	76	1.9	0.7
East	150	13	1	1	0	3	-	81	0	1.0
	300	15	1	1	0	23	-	72	1.0	3.0
	500	15-18	4	4	14	17	69	77	0.2	2.2
	650	18	1	1	20	9	73	82	5.0	1.0
	1,000	15-18	4	3	20	12	79	85	0.5	1.3
	2,070	14-19	5	5	23	23	73	78	1.4	4.4
Average					15	14	74	79	1.4	2.2
South	600	14-15	7	6	34	16	76	70	0.7	1.3
	1,125	14-17	12	11	35	30	75	76	3.2	1.8
	1,650	14-19	1	8	38	25	78	78	1.0	2.5
	2,150	6-21	9	5	56	41	75	78	4.3	5.8
	2,700	14-21	1	4	12	38	72	83	0	1.0
	3,000	6-8	5	4	37	2	78	80	1.0	0.2
	3,300	8-19	6	-	34	-	79	-	1.5	-
	4,200	6-20	5	-	32	-	74	-	1.8	-
	4,400	8-20	6	-	48	-	78	-	0.5	-
	5,325	6-13	8	-	15	-	67	-	0.6	-
Average					35**	25**	75	78	1.5	2.1

* 10 grabs

** for comparable stations

Table 6

A summary of depth ranges, numbers and lengths of live hard clams and numbers of clam boxes along transects in the Sewells Point Spit borrow area. Only sampled in July 1974.

Number of Stations Sampled	Range of Depth (ft)	Average Number/ Station *	Mean Length (mm)	Average Number Boxes/ Station *
6	12-33	1	77	0.7

* 10 grabs

Table 5

A summary of depth ranges, numbers and lengths of live hard clams and number of clam boxes along transects at varying distances from the South Portal Island and Approach. Initial sampling July 1973(B); Final sampling July 1974(A).

Direction	Distance (ft)	Range of Depth (ft)	No. of Stations Sampled		Avg. No./ Station *		Mean Length (mm)		Avg. No. Boxes/ Station *	
			B	A	B	A	B	A	B	A
East										
	20	9	3	-	66	-	61	-	1.3	-
	330	6-17	6	5	14	30	70	74	1.0	3
	800	8	2	1	2	0	70	-	0	0
	1,000	14-17	4	4	32	35	74	78	2.8	1.2
	1,500	5-18	6	5	27	26	75	71	1.3	1.2
	2,150	8-15	6	5	37	13	78	75	1.0	1.2
	2,800	15-18	6	3	38	24	74	79	1.5	1.6
	3,300	15-21	3	2	48	34	80	76	2.7	4.5
	4,230	15-23	6	4	49	29	78	75	2.3	3.5
	4,350	16	1	-	57	-	76	-	7.0	-
	5,250	15-25	7	4	53	24	74	78	2.1	0.7
	5,800	20	1	1	4	36	65	80	0	7.0
	6,400	16-23	7	4	43	30	75	75	1.9	2.7
	6,900	17-18	2	-	10	-	81	-	0	-
Average					34	26	74	76	1.8	2.4
West	375	8	1	-	12	-	64	-	0	-
	725	9-14	7	5	28	4	70	77	0.1	0.4
	1,225	8-12	7	5	22	1	77	75	0.6	0
	2,225	9-28	6	7	23	30	76	76	0.2	2.1
	3,225	12-31	5	6	12	11	74	76	0.6	0.5
	4,225	8-12	5	4	8	12	72	76	0.4	0.2
Average					18	12	72	76	0.3	0.6

* 10 grabs

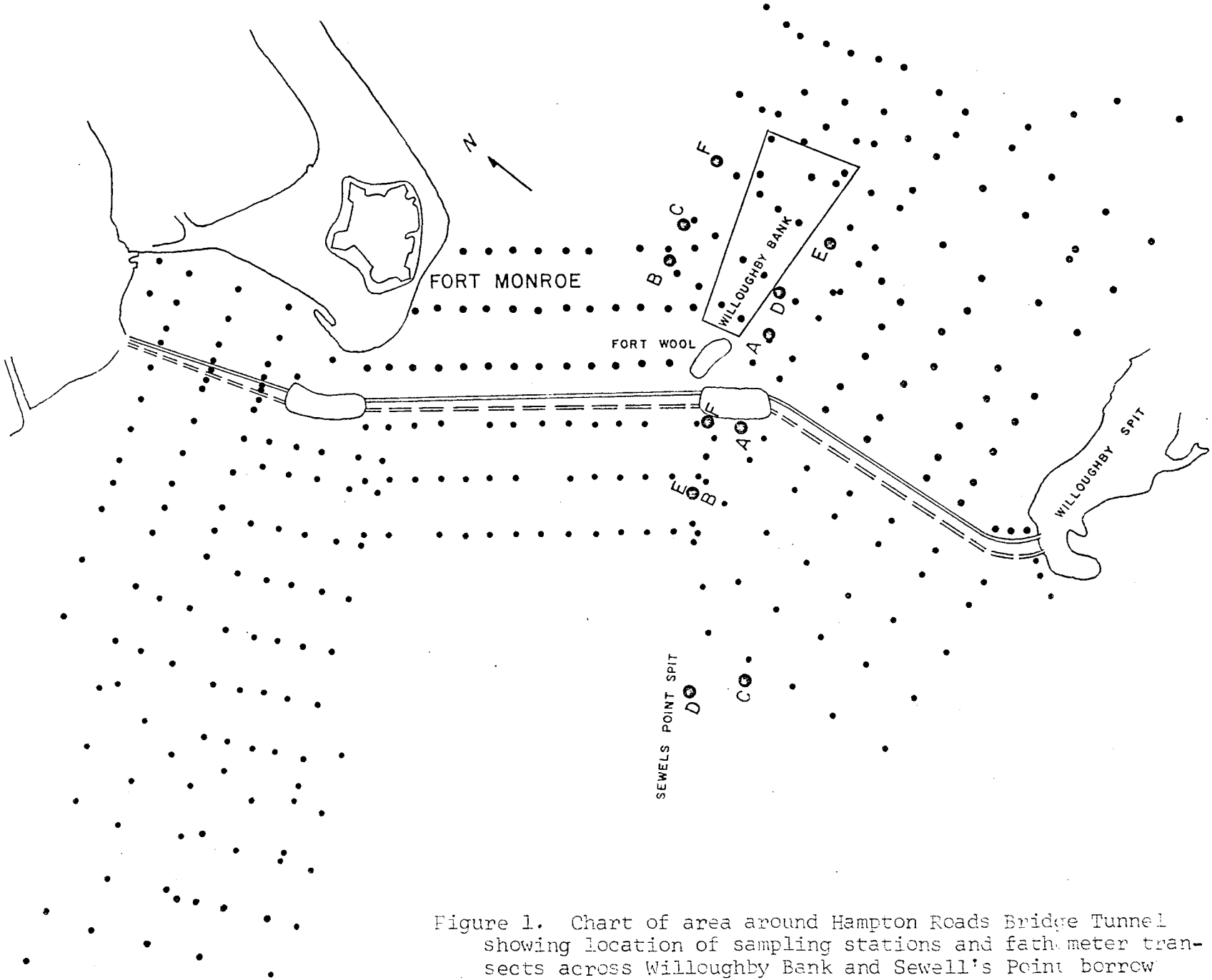

Figure 1. Chart of area around Hampton Roads Bridge Tunnel showing location of sampling stations and fathometer transects across Willoughby Bank and Sewell's Point borrow areas.

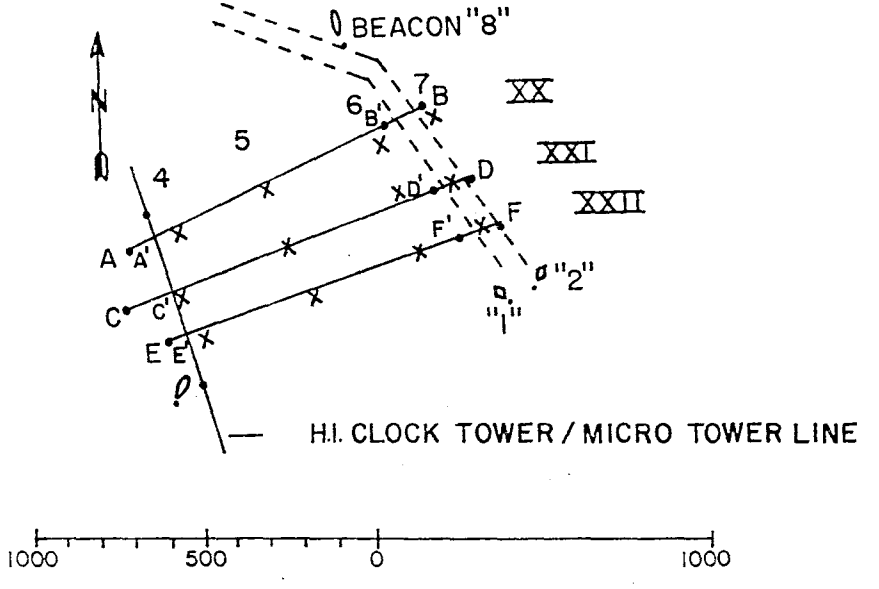

Figure 2. Locations of fathometer transects across Hampton Bar. 14 February, 1974.

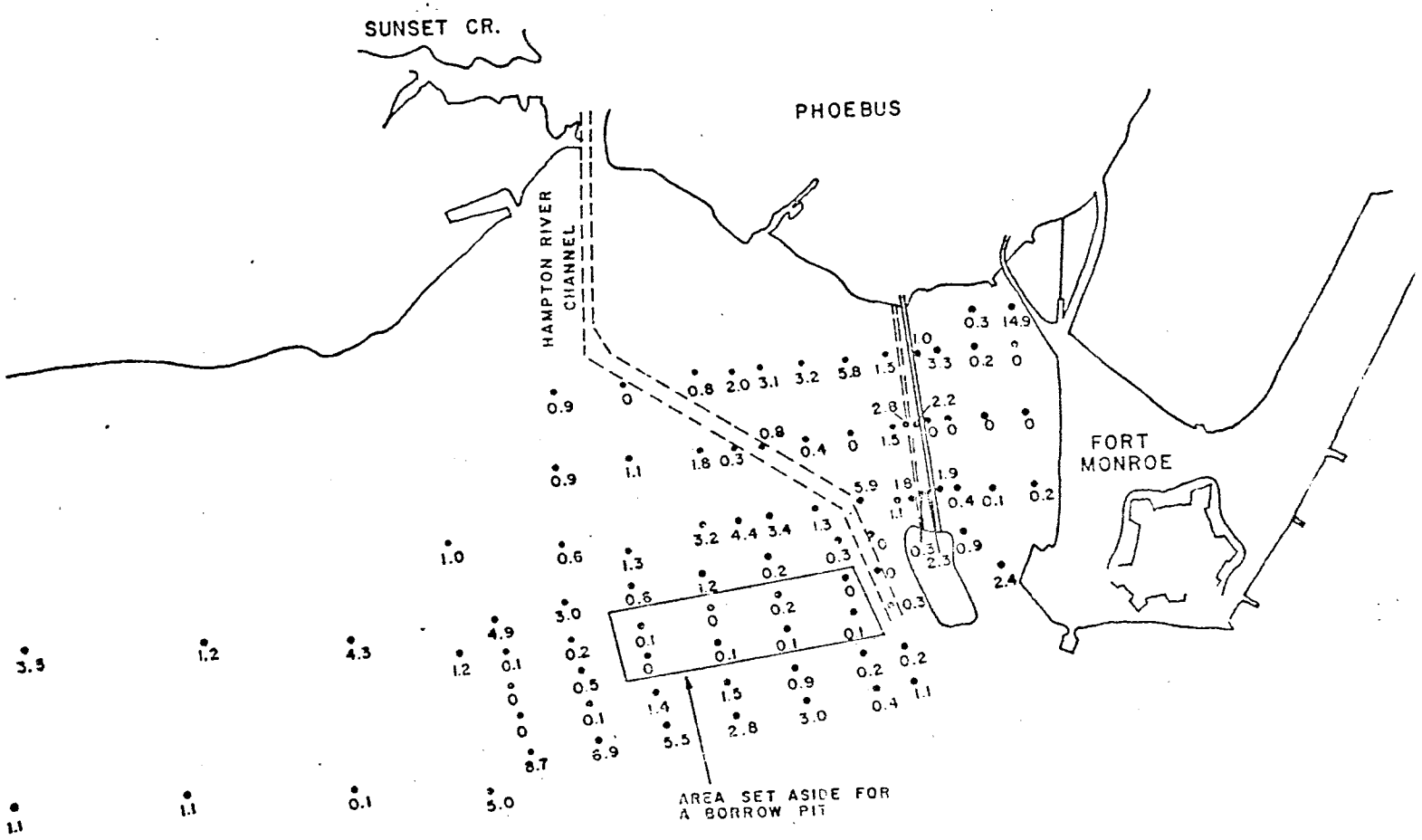

Figure 3. Mean numbers of living hard clams per grab (1.2 yd^2) at stations North of the Channel. July, 1973.

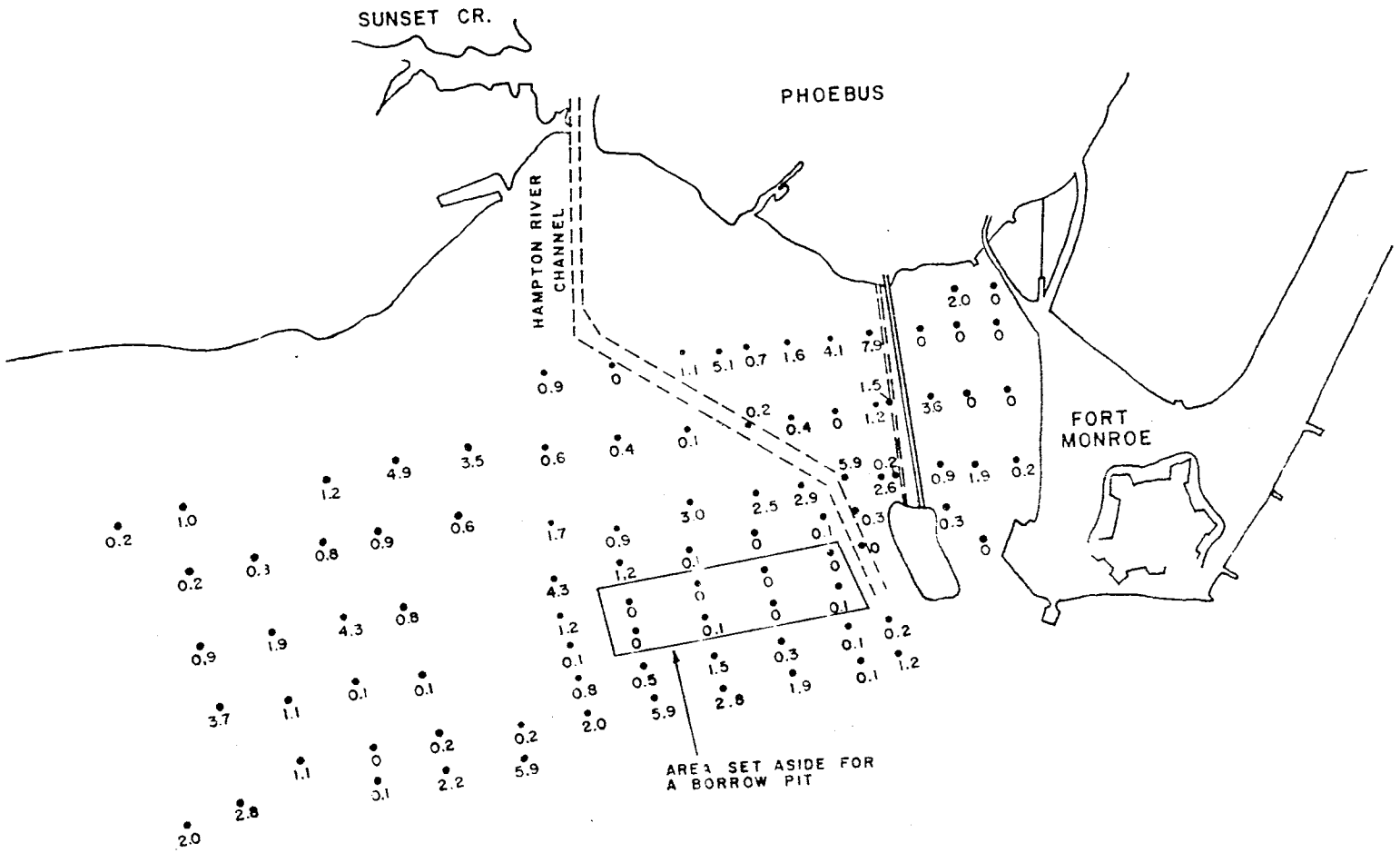

Figure 4. Mean numbers of living hard clams per grab (1.0 yd^2) at stations North of the Channel. February, 1974.

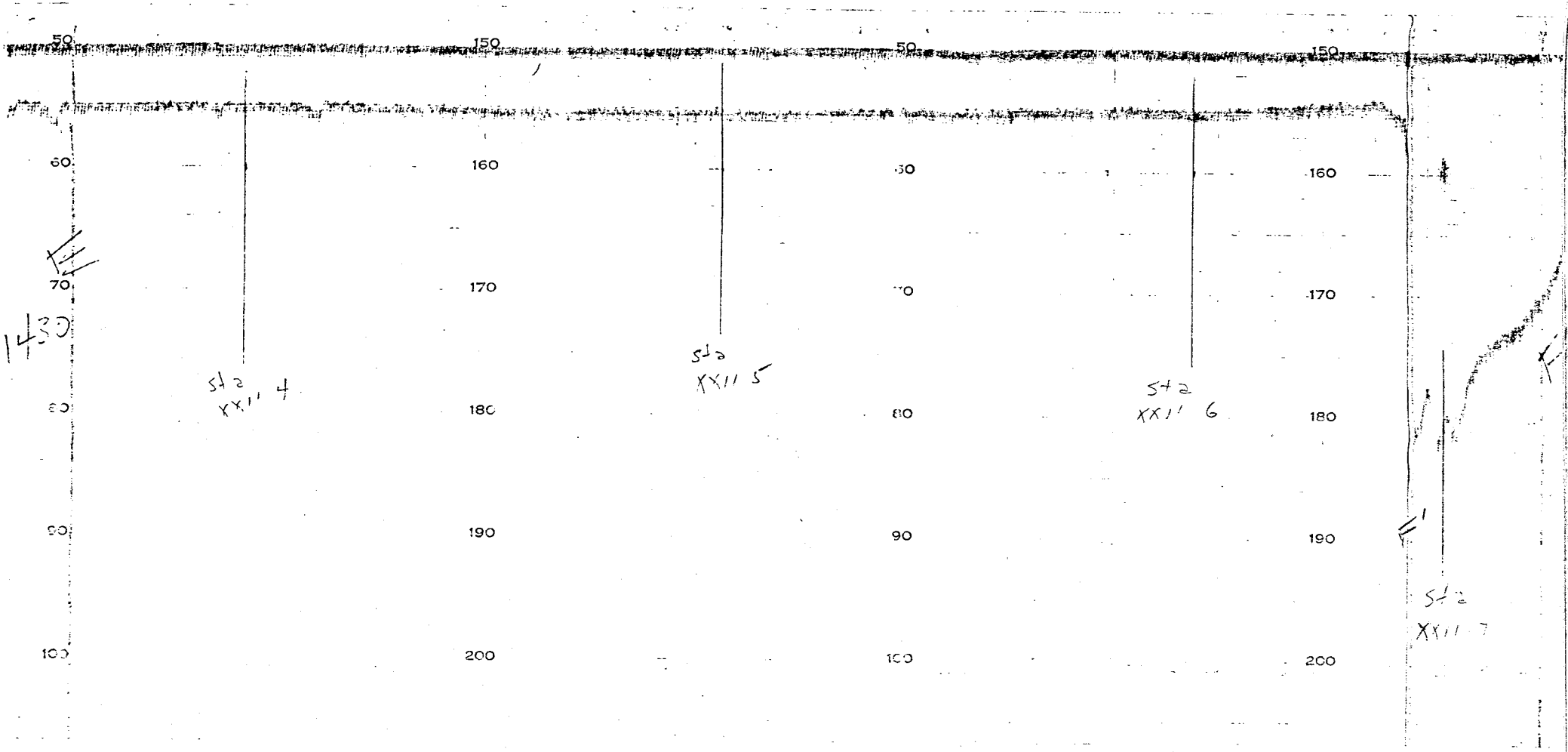

Figure 6. Fathometer tracing across Hampton Bar borrow area: C-D. 14 February, 1974 (See Fig. 2).

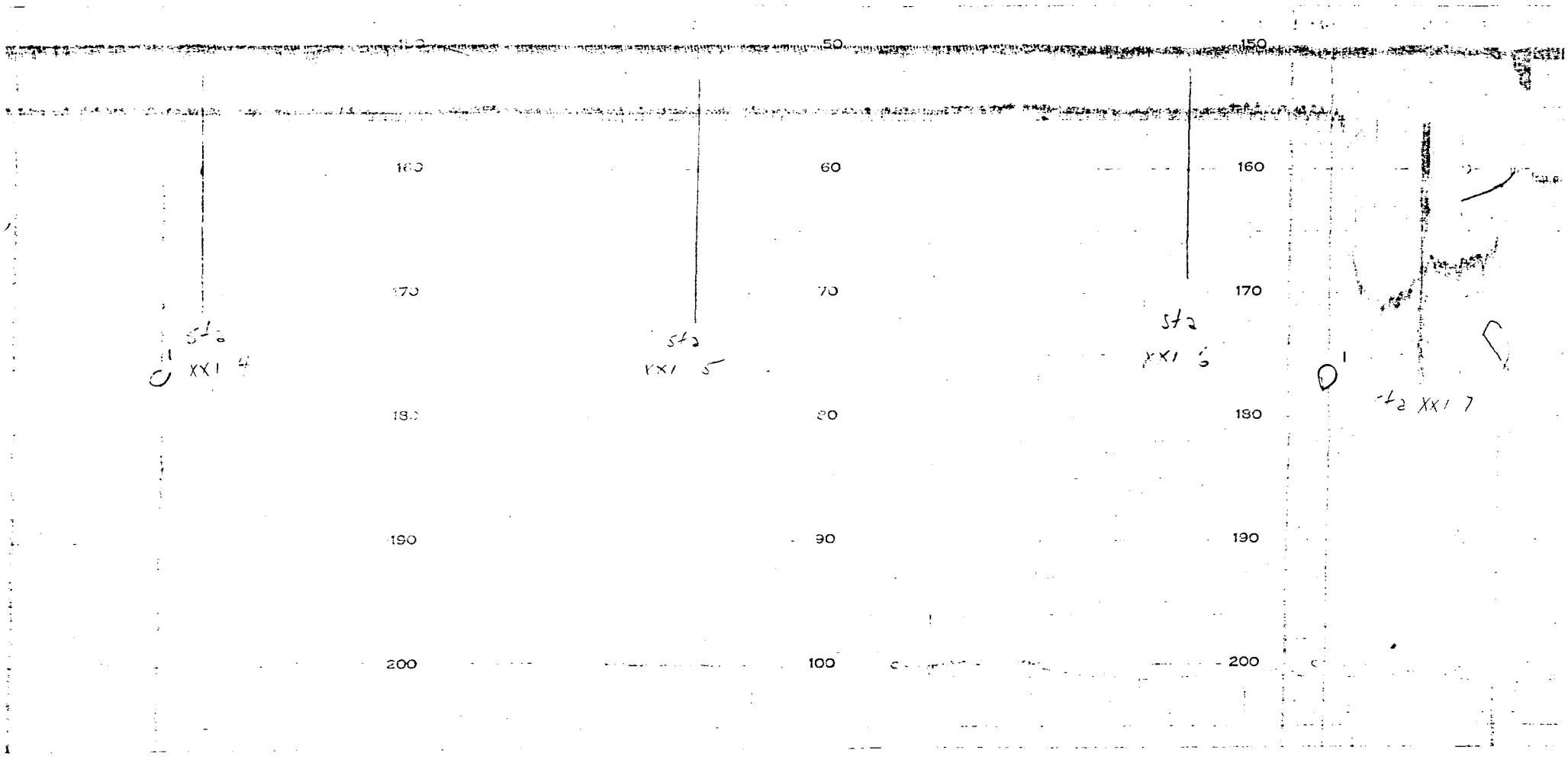

Figure 7. Fathometer tracing across Hampton Bar borrow area: E-F. 14 February, 1974 (See Fig. 2).

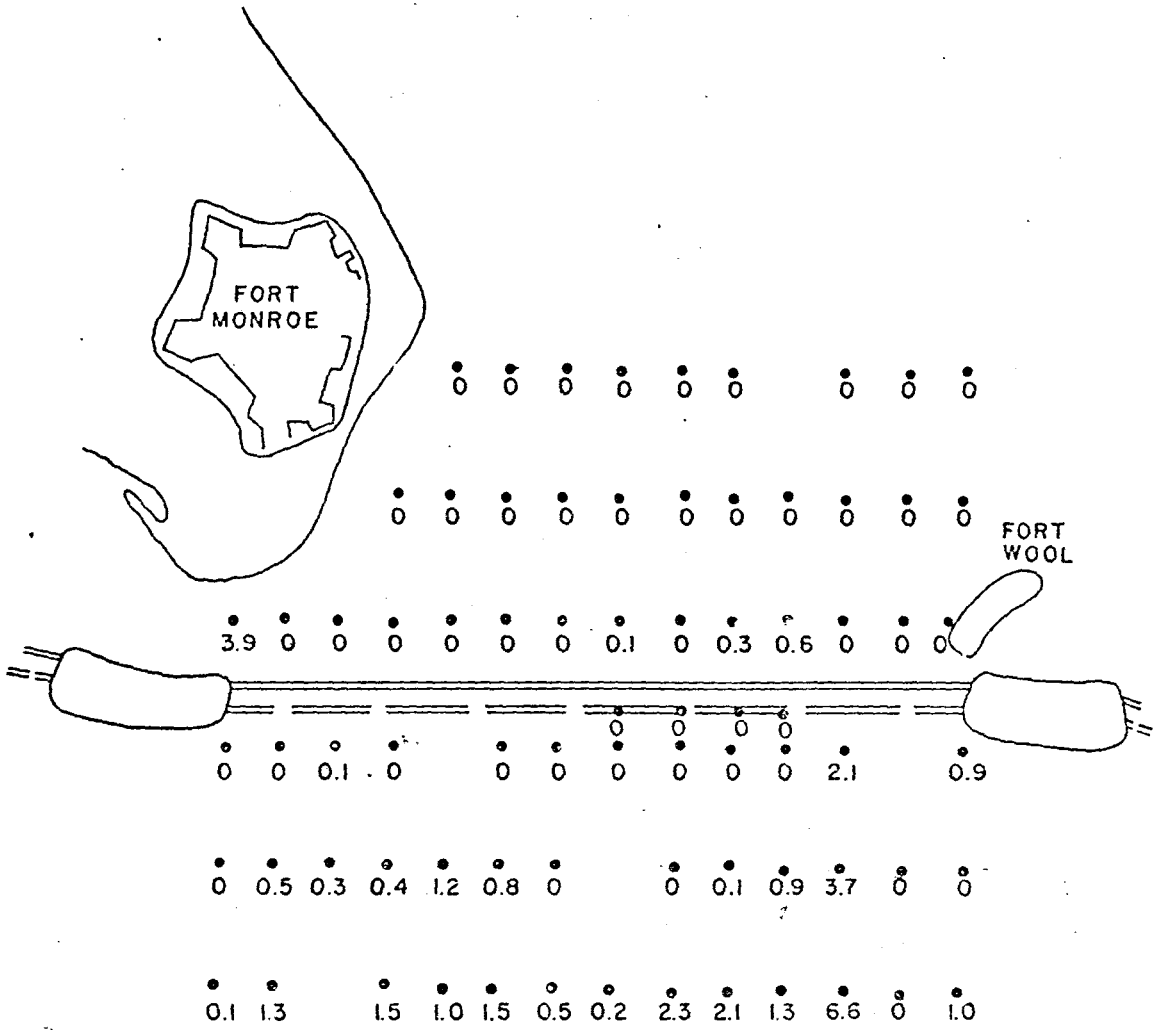

Figure 8. Mean numbers of living hard clams per grab (1.2 yd^2) at stations in the channel. July, 1973.

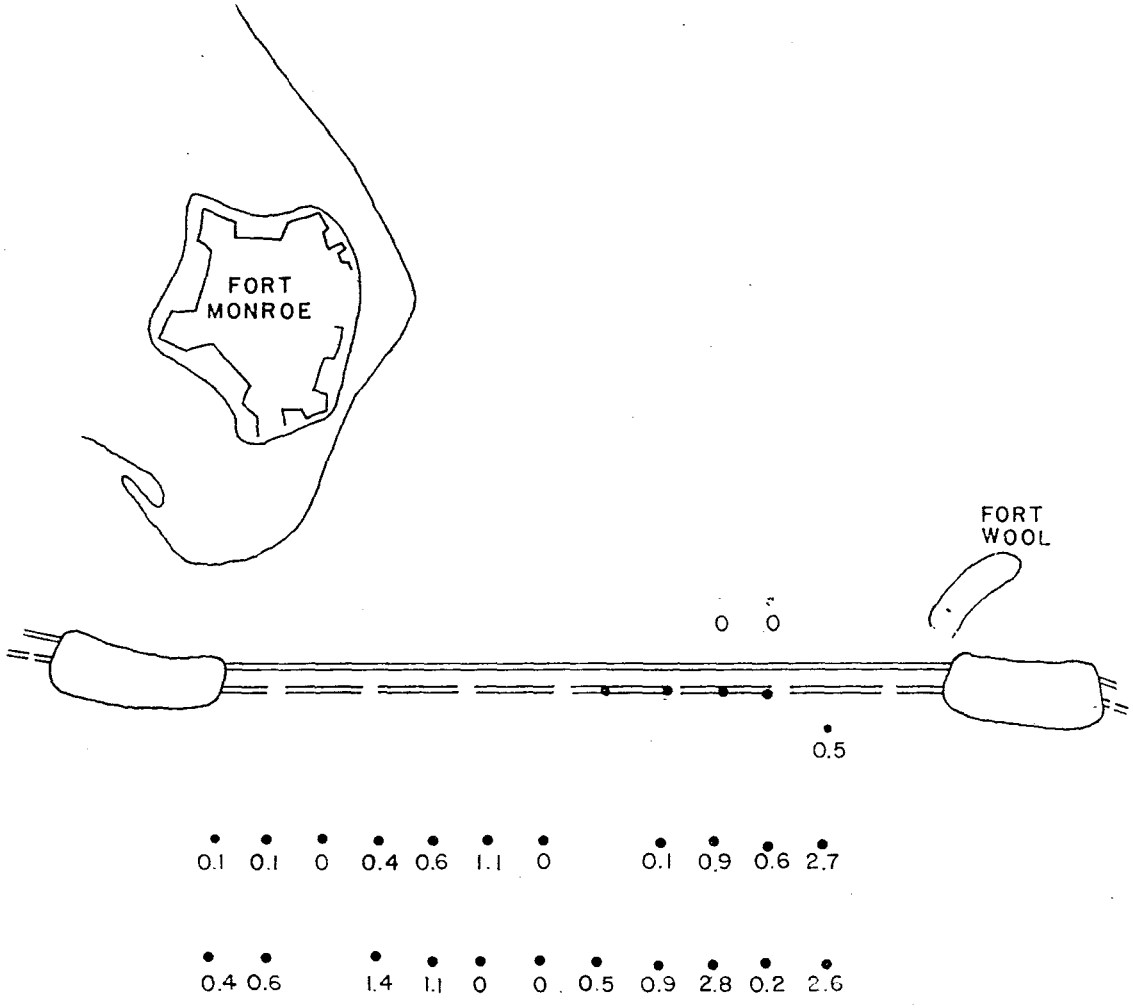

Figure 9. Mean numbers of living hard clams per grab (1.2 yd^2) at stations in the channel. July 1974.

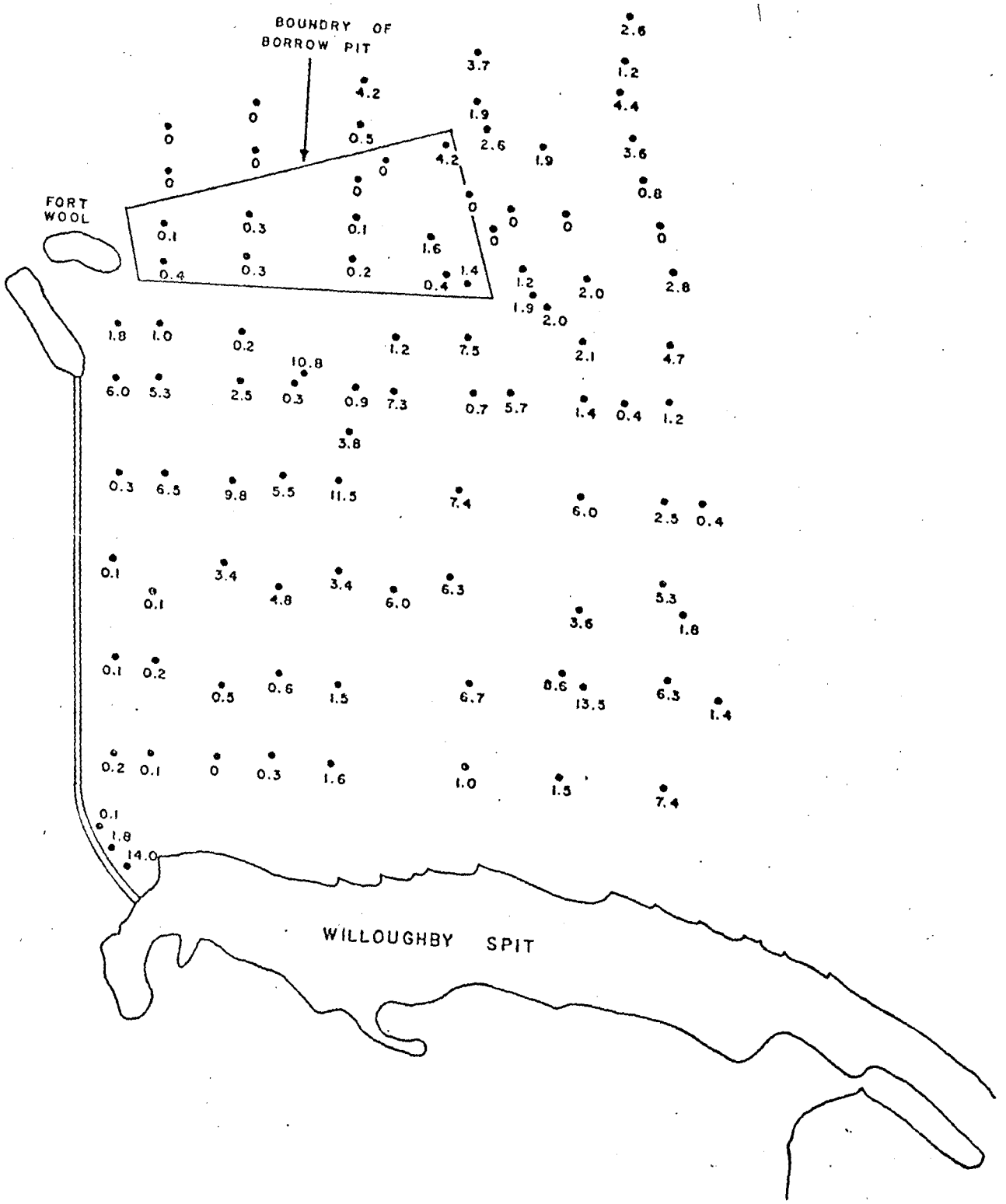

Figure 10. Mean numbers of living hard clams per grab (1.2 yd^2) at stations South of the channel and East of the approach. June, 1973.

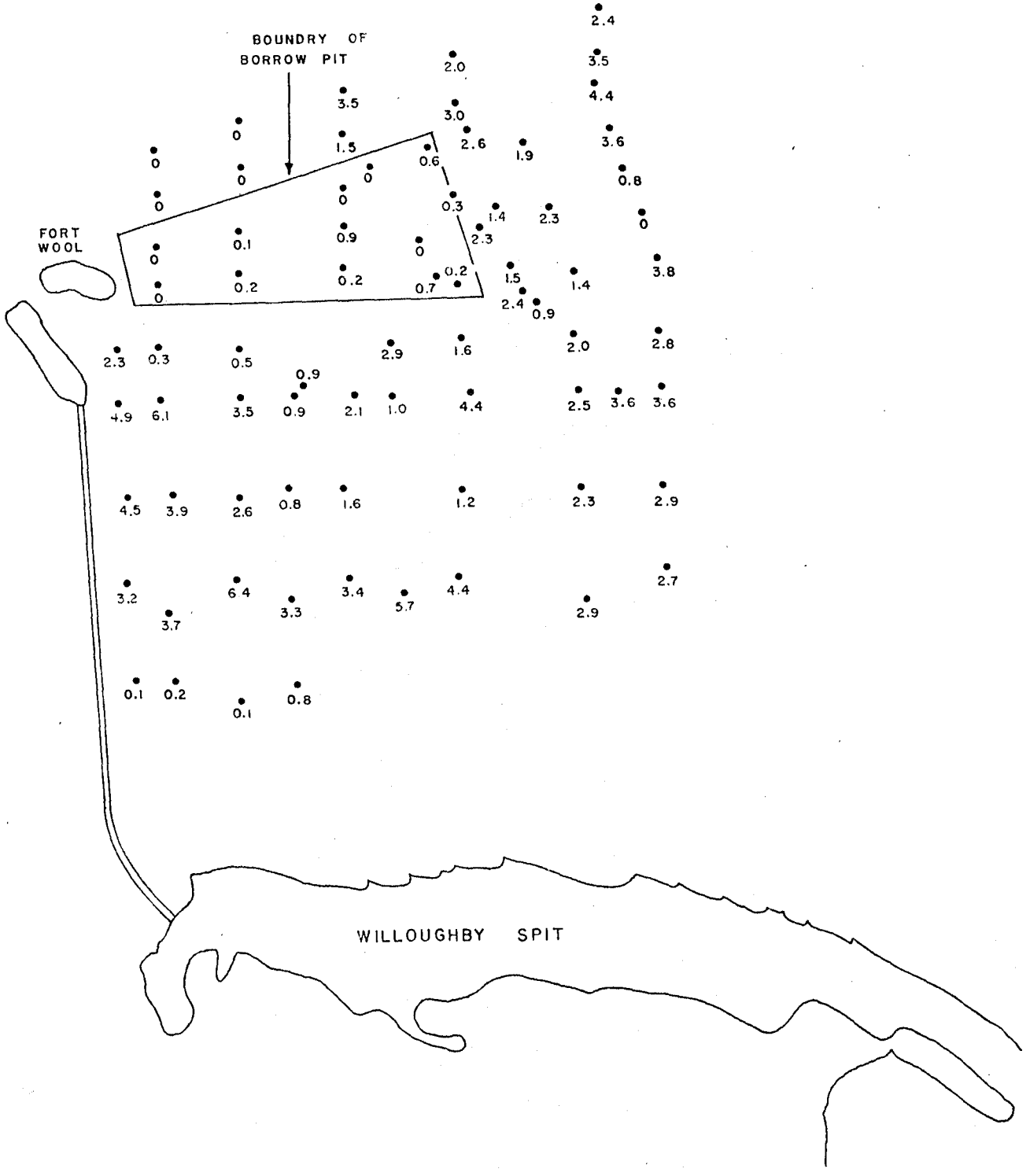

Figure 11. Mean numbers of living hard clams per grab (1.2 yd^2) at stations South of the channel and East of the approach. July, 1974.

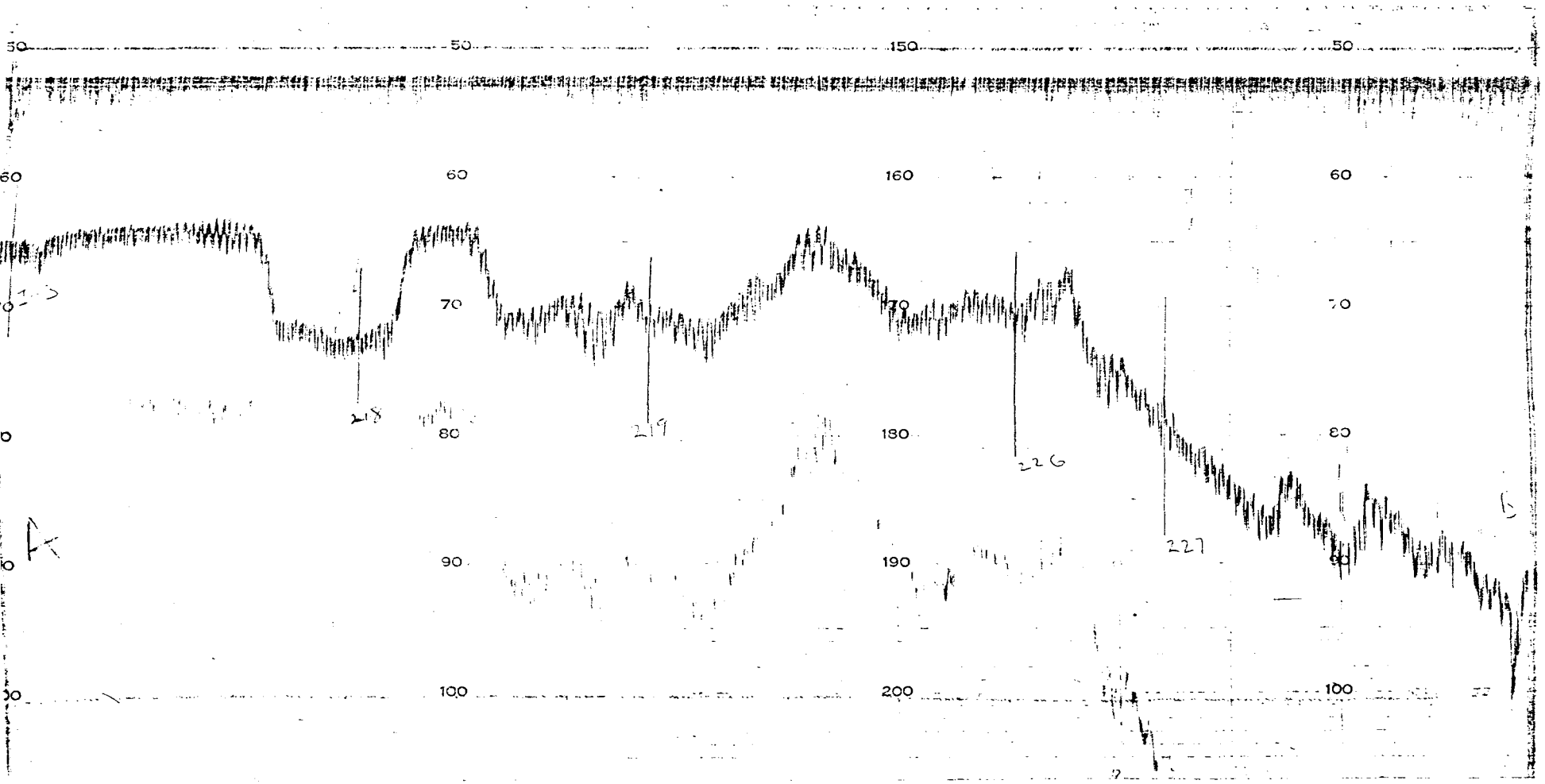

Figure 12. Fathometer tracing across Willoughby Bank borrow area: A-B. 15 July, 1974 (See Fig. 1).

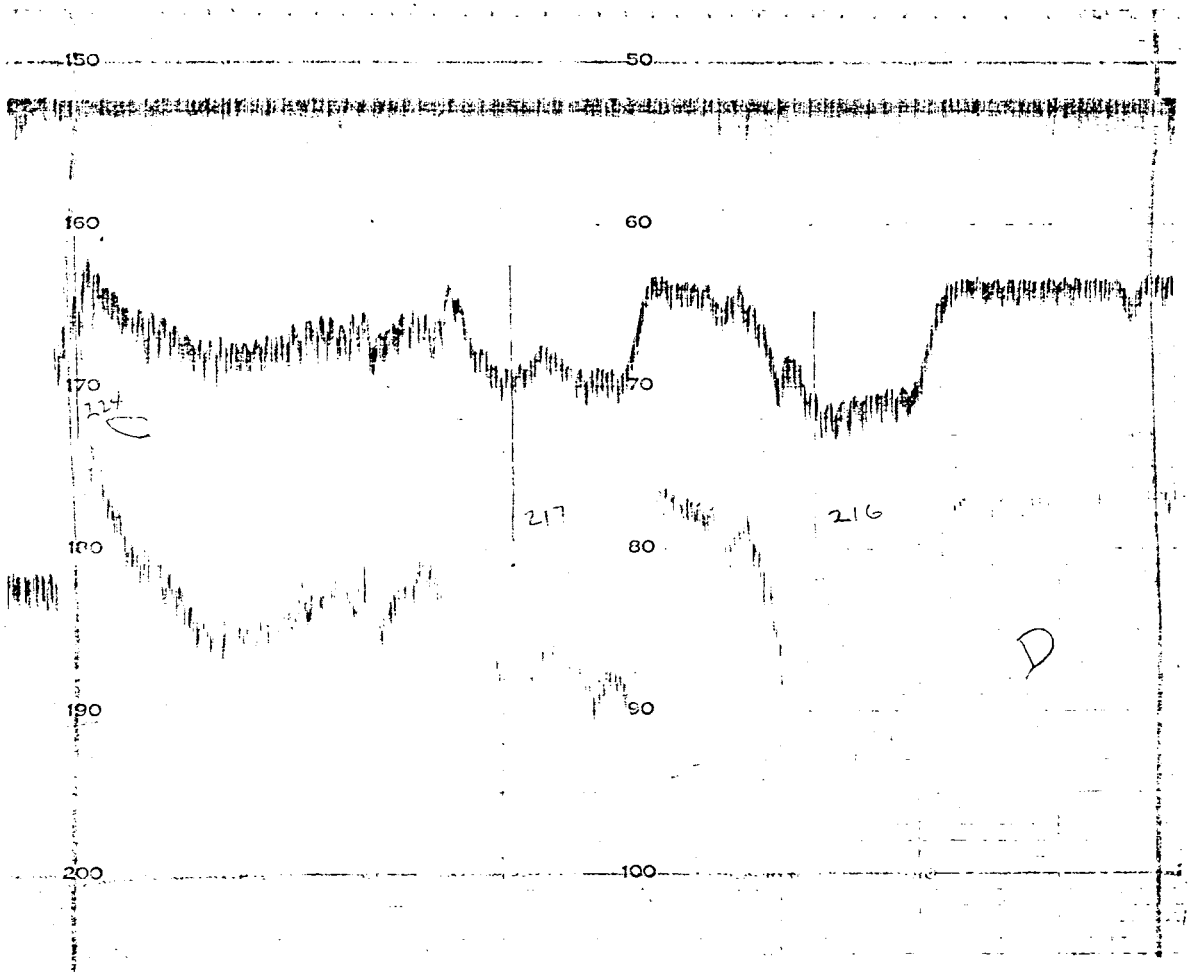

Figure 13. Fathometer tracing across Willoughby Bank borrow area: C-D. 15 July, 1974 (See Fig. 1).

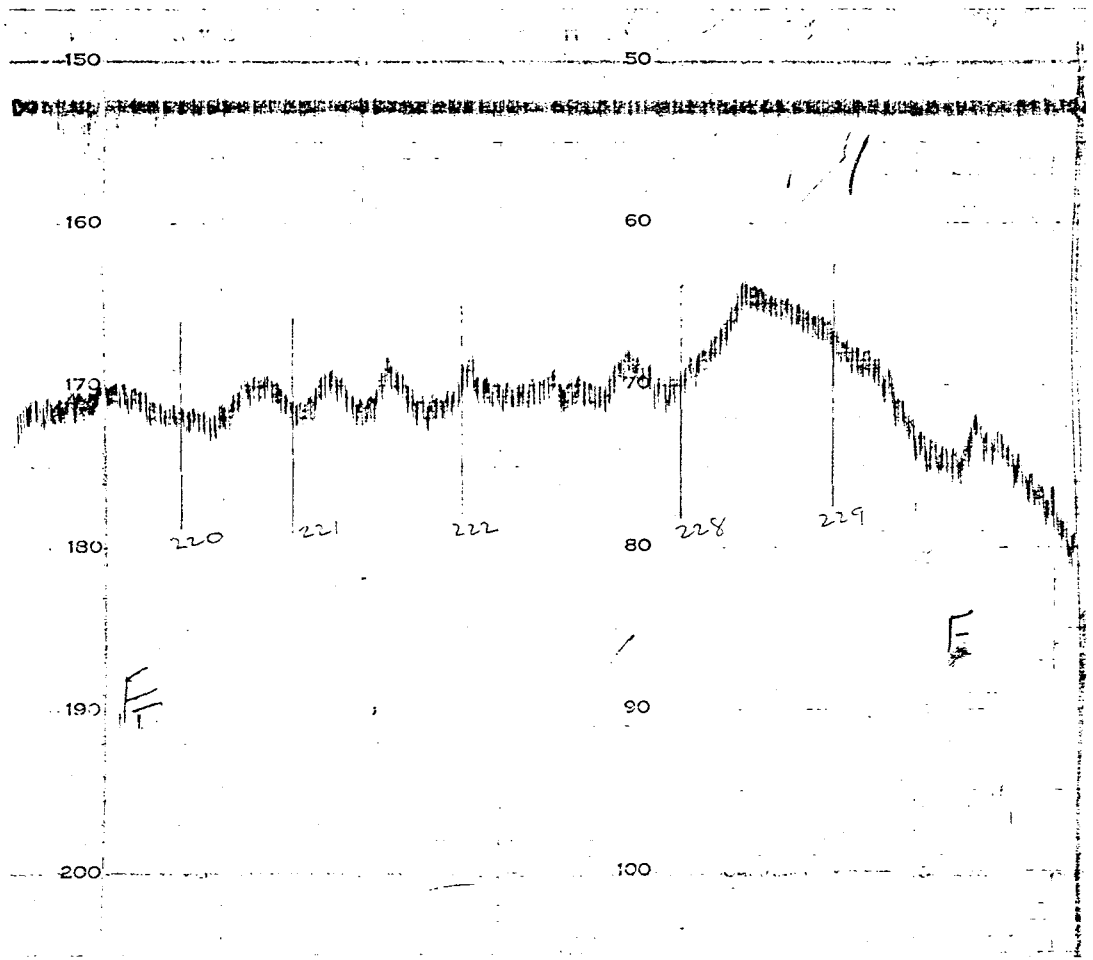

Figure 14. Pathometer tracing across Willoughby Bank borrow area: E-F. 15 July, 1974 (See Fig. 1).

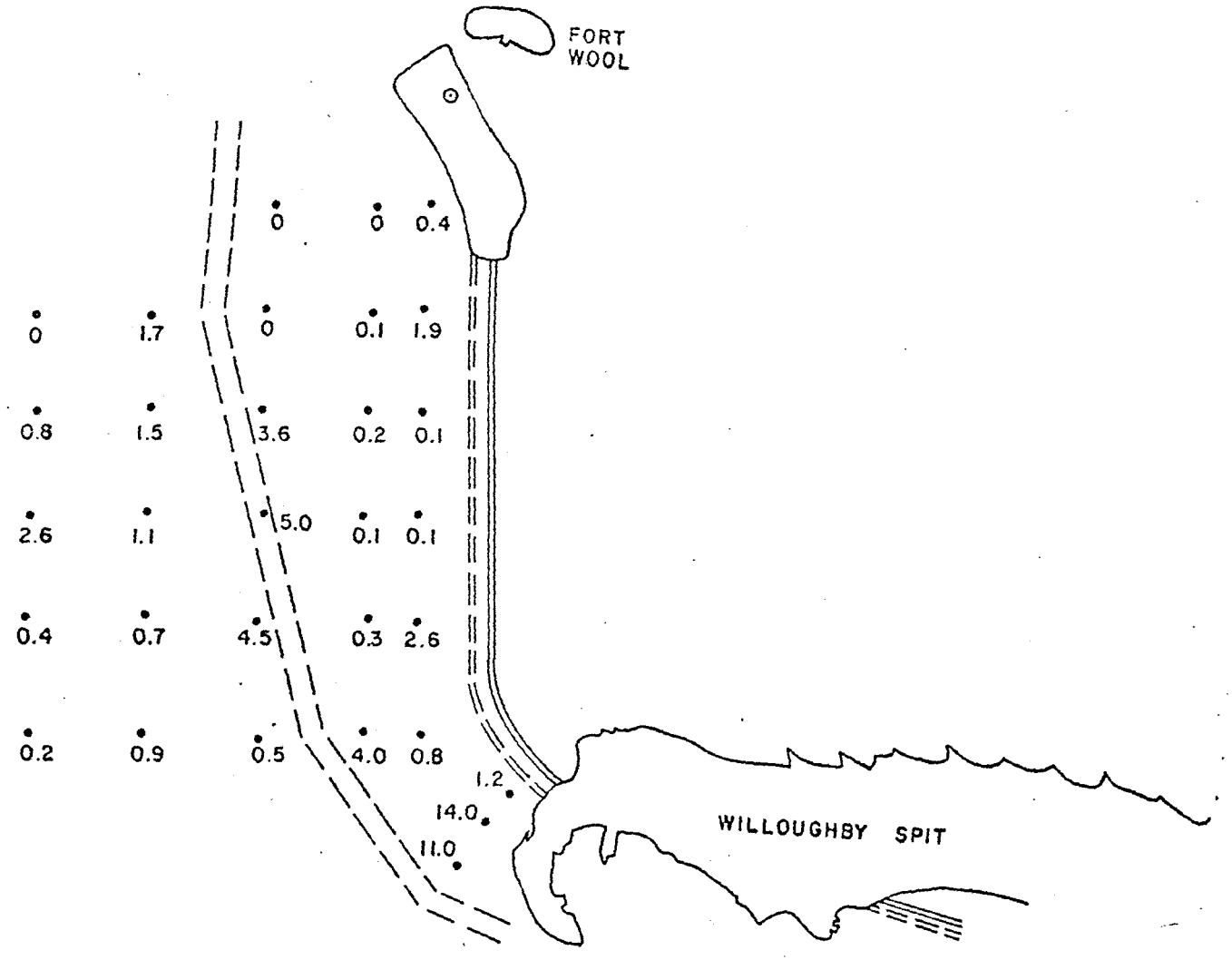

Figure 15. Mean numbers of living hard clams per grab (1.2 yd^2) at stations South of the channel and West of the approach. June, 1973.

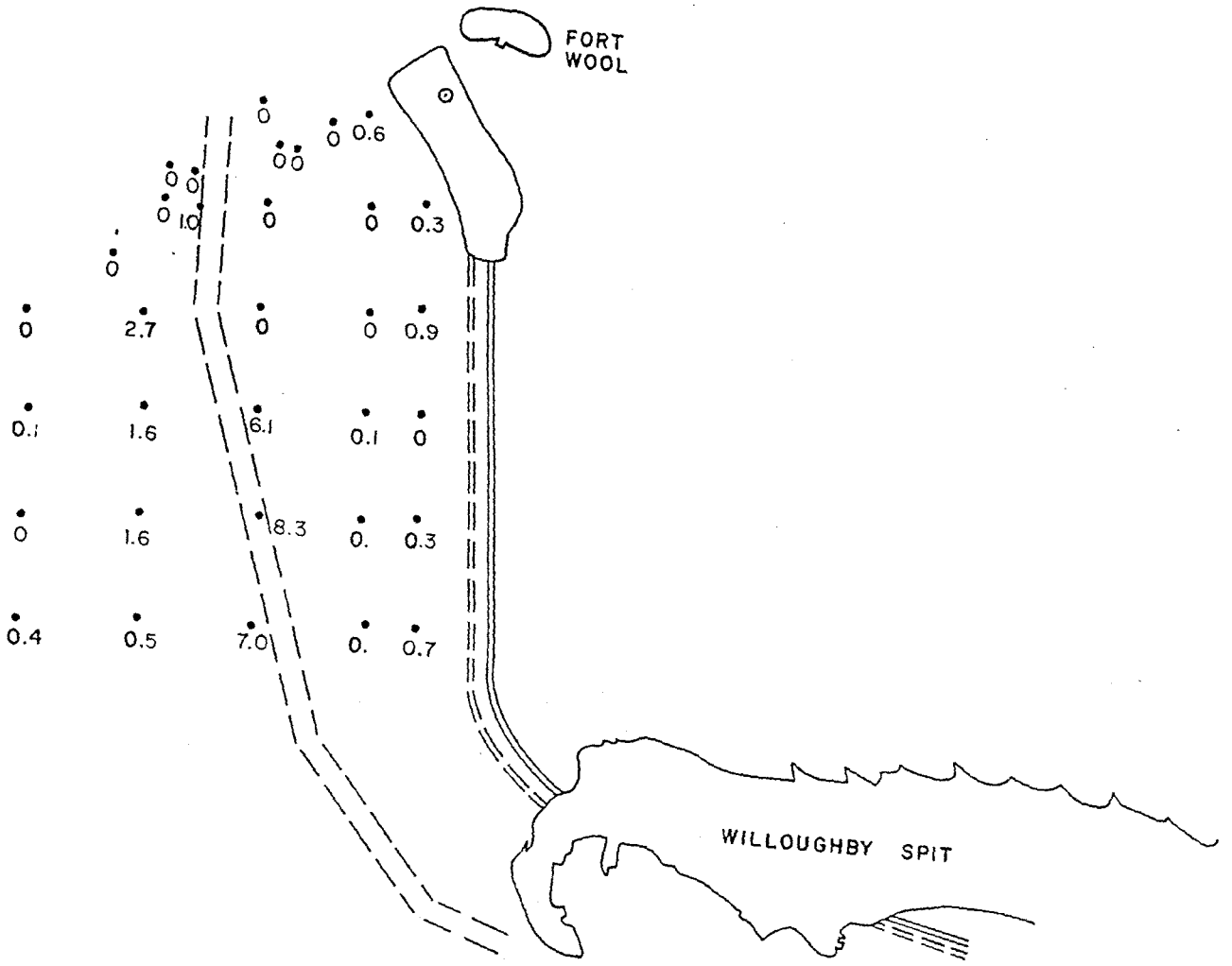

Figure 16. Mean numbers of living hard clams per grab (1.2 yd^2) at stations South of the channel and West of the approach. July, 1974.

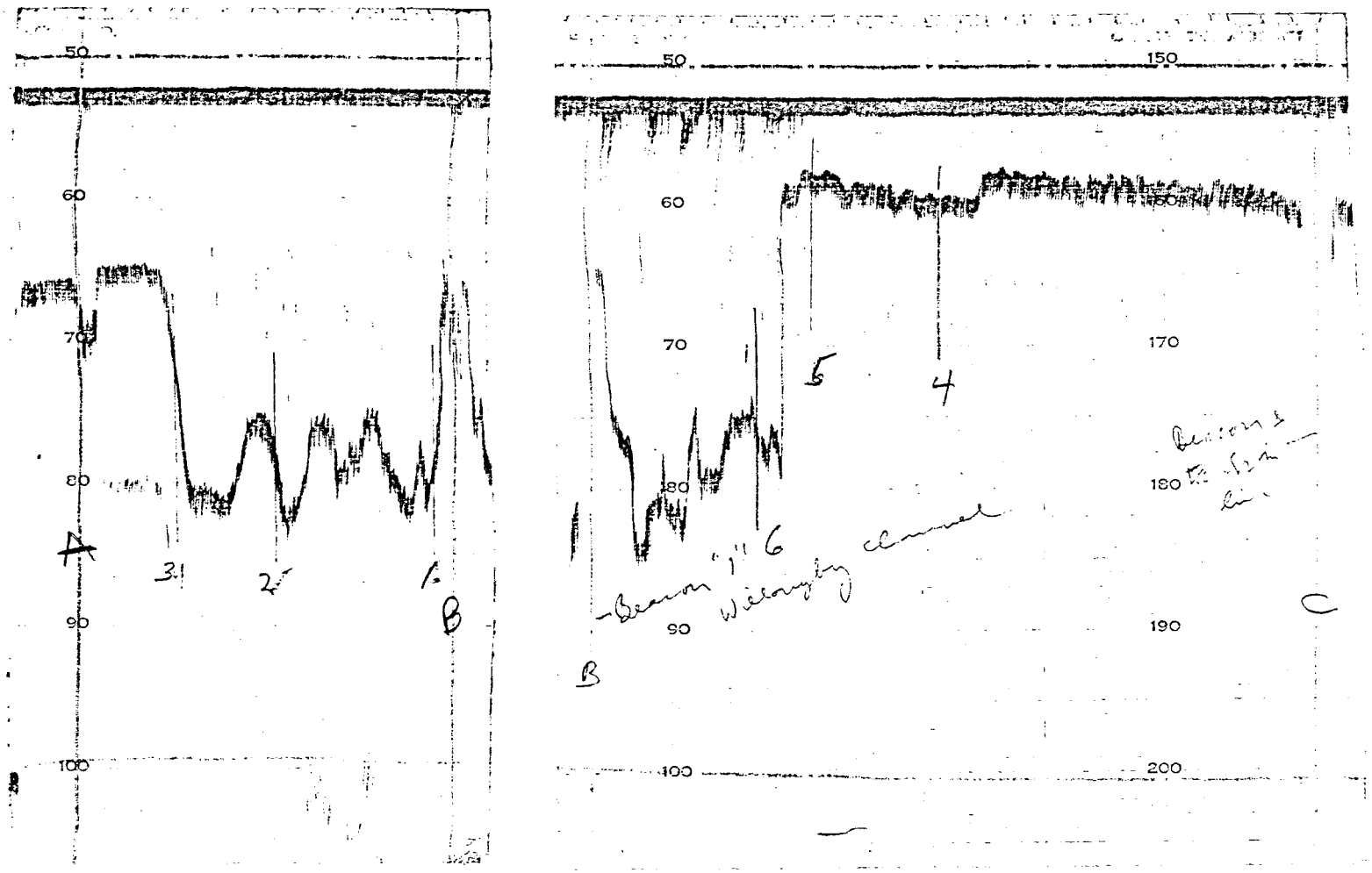

Figure 17. Fathometer tracing across Sewell's Point Spit borrow area: A-B-C. 8 July, 1974 (See Fig. 1).

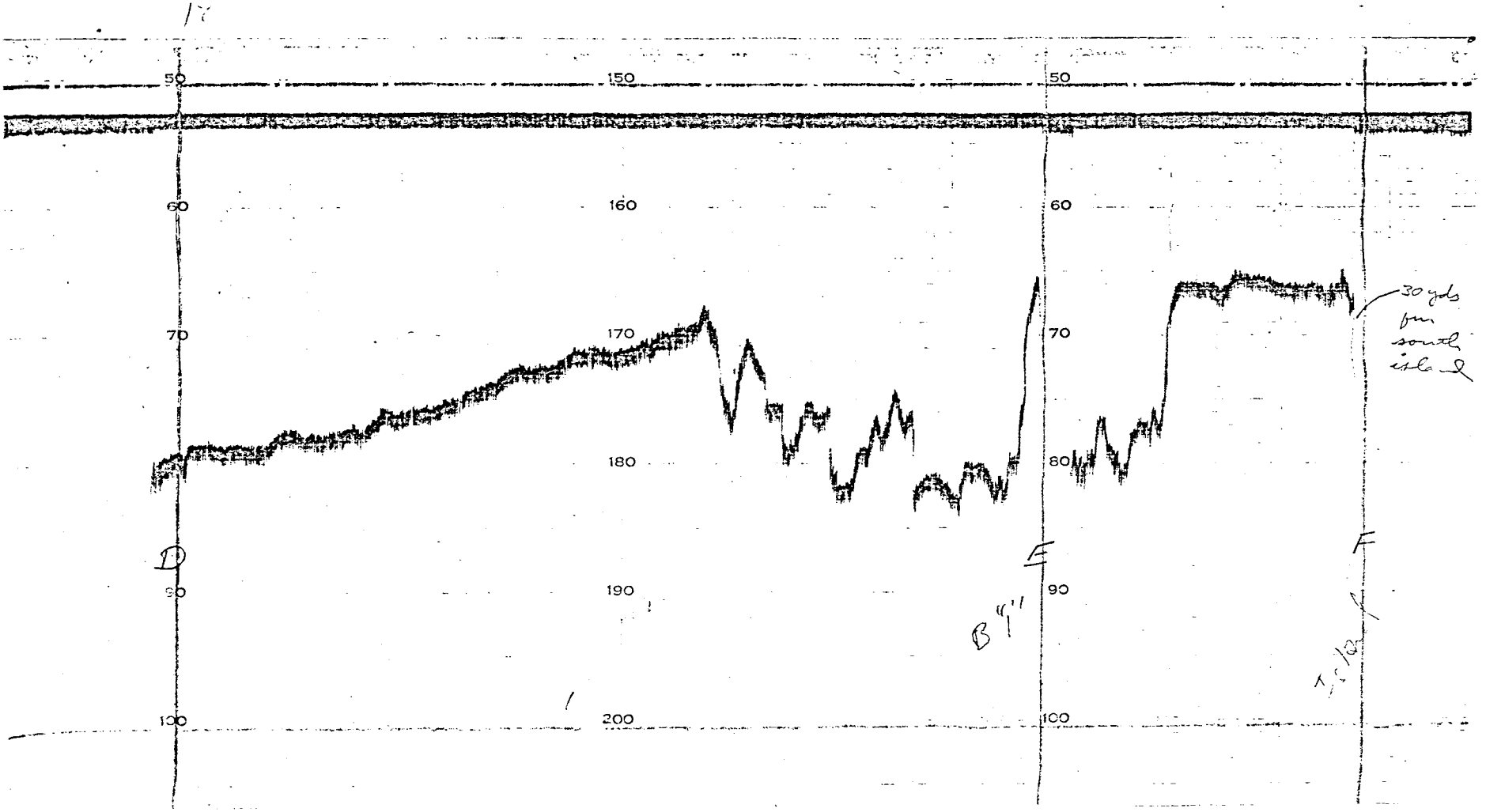

Figure 18. Pathometer tracing across Sewell's Point Spit borrow area: D-E-F. 8 July, 1974 (See Fig. 1).