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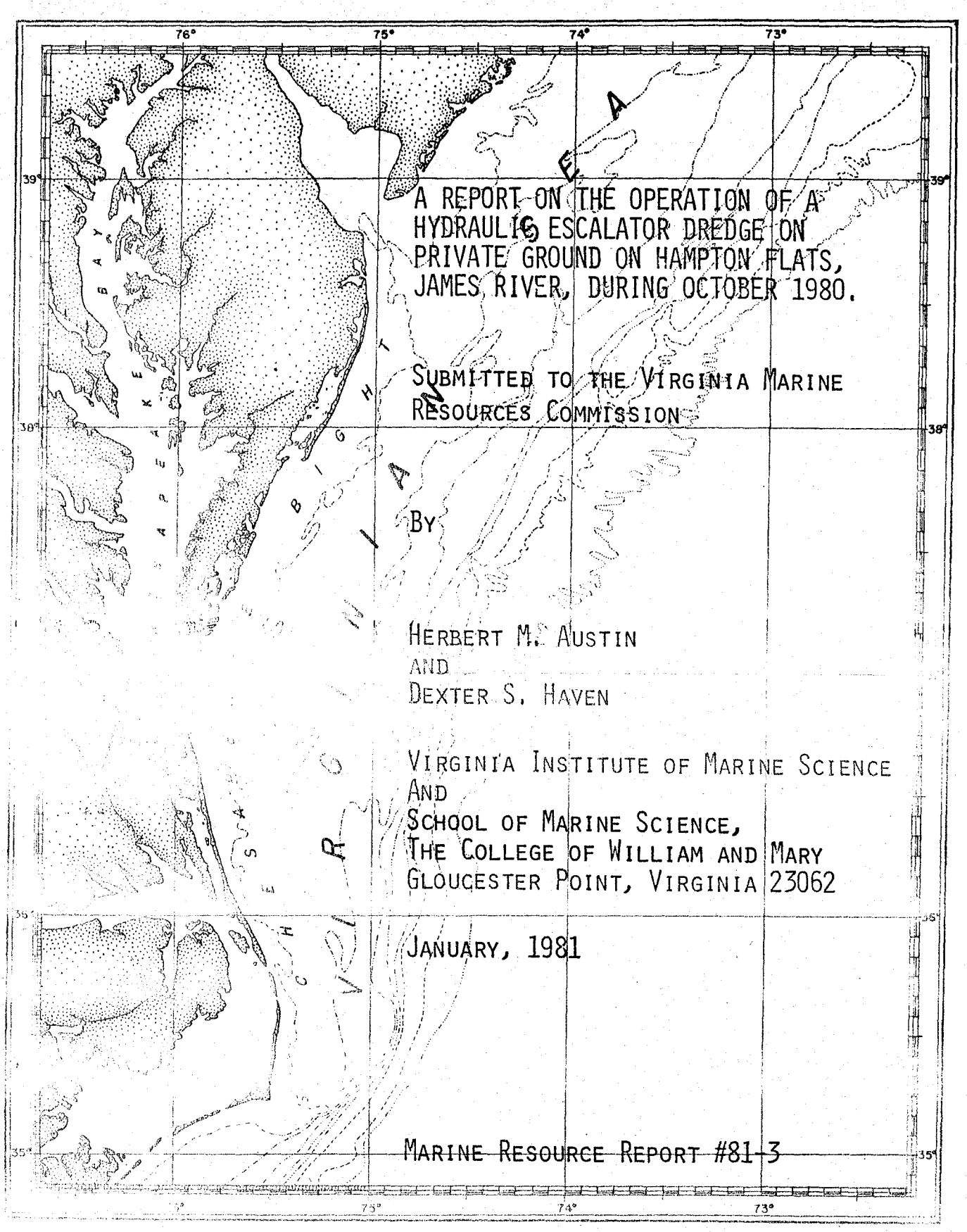

A REPORT ON THE OPERATION OF A HYDRAULIC ESCALATOR DREDGE ON PRIVATE GROUND ON HAMPTON FLATS, JAMES RIVER, DURING OCTOBER 1980.

SUBMITTED TO THE VIRGINIA MARINE RESOURCES COMMISSION

BY

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SUMMARY

The Department of Applied Biology of the Virginia Institute of Marine Science, at the request of the office of the Governor of the Commonwealth and the Virginia Marine Resources Commission, monitored the operation of the hydraulic escalator hard clam dredge deployed by Mr. William P. Hunt, Jr. on Hampton Flats in the James River. Catch and effort data were obtained during the monitoring period of 17 September to 31 October 1980.

Only littlenecks and cherrystones (mean lengths were 60.9 mm and 77.9 mm, respectively) were retained by the crew, and larger (chowder) clams were discarded. The highest average daily catch rate of retained clams were 4,330 clams per hour (72 clams per minute) with an average catch rate of retained clams of 2,888 clams per hour (48 clams per minute). Chowder clams constituted an average of 30% of the total catch. Consequently, the average catch rate of clams of all sizes was 4,126 clams per hour (69 clams per minute). Catch rates of clams varied considerably throughout the day, from a high of 105.6 per minute during a 33 minute period to a low of 0 per minute observed many times for short periods.

To examine the effects of the hydraulic dredge and the patent tongs on bottom organisms, four experimental plots were designated on unworked portions of Hampton Flats. Two of these serve as controls and are to remain untouched by any commercial shellfish harvesting gear. The two remaining plots are experimental; one was worked by the hydraulic dredge and the other by the patent tongs.

Prior to any work by either of the commercial gear on the plots, benthic samples were obtained on all four to characterize the animal communities which existed before dredging or tonging. Analysis of these samples has not been completed. More samples will be taken in the summer of 1981 to observe any effects of dredging or tonging on the animal communities.

Observational dives conducted prior to dredging and tonging of the experimental plots showed that the bottom was essentially featureless, composed of silt, mud and sand in both plots. Oyster shell existed in a layer approximately four to six inches under the bottom's surface, with more surface shell observed in the patent tong plot. Sponge colonies were distributed across the bottom and many animals

(young-of-the-year blue crabs, hermit crabs, mysid shrimps, blennies, etc.) were associated with them.

Three dives were conducted after the experimental plots had been worked by the gear. On the first dive, four days after the operation of the hydraulic dredge, troughs left by the gear were approximately four feet wide and 5-3/4 inches deep in the center. The buried-oyster shell layer was found either on the surface or along the sides of the troughs. No buried shell was found in the trough. The large sponge colonies which existed prior to dredging were observed in smaller pieces. Their associated fauna had either disappeared or was dispersed over the bottom. Some of the chowder clams discarded by the crew had not reburied themselves. During subsequent dives on the hydraulic dredge plot, the troughs became less distinct and shallower, filling in approximately two inches twenty-one days after being formed. Much of the shell that was on the surface during the first dive was covered by a layer of silt and mud by the third dive.

The area worked by patent tongs was also observed four days later, and holes left by the gear were approximately four feet by three feet and 6-8 inches deep. Shell was scattered all over the bottom and not associated with the holes. However, the holes collected large amounts of drifting sponge and their associated fauna. The holes left by the tongs did not fill in with sediment to the same degree as did the troughs left by the hydraulic dredge. The holes were approximately 6 inches deep twenty-one days after the gear had been worked. One more observational dive is planned for the spring or summer of 1981 on both experimental plots.

The relative efficiency of the hydraulic dredge and the patent tongs was observed during the working of the two experimental plots. The catch rate of the hydraulic dredge was 7.5 times greater for littlenecks and cherrystones than that of the patent tongs. In other words, the hydraulic dredge can capture in an hour as many clams as the patent tongs can in an 8-hr day. It is this aspect of the hydraulic dredge, and the economics of the industry, which deserves further study.

Clams caught by the hydraulic dredge were rarely damaged. Approximately one out of 2,000 clams captured was damaged.

INTRODUCTION

At the request of the Governor's office and the Virginia Marine Resources Commission (VMRC), the Virginia Institute of Marine Science (VIMS) monitored the operation of the hydraulic escalator hard clam harvester owned and operated by Mr. William P. Hunt, Jr., of Seafood Harvesters, Inc., Poquoson, Virginia. VIMS was instructed to place qualified personnel on board the dredge boat, the PHOEBE JO, so as to provide complete monitoring of its operations. The Department of Applied Biology supervised the monitoring study and provided the following personnel, who, on a rotating basis, observed and recorded the deployment and catches of the gear: Reinaldo Morales-Alamo, James Whitcomb, Paul Kendall, Lowell Fritz, Kenneth Walker, and James Bristow.

The monitoring effort was the first phase of this study and was conducted with no restrictions or control placed on Mr. Hunt or the crew of the PHOEBE JO (Joe Blanchard and E. T. Firth) by VIMS with regard to the use or design of the dredge, locations to be dredged, effort expended or any operation of the boat. All of these decisions were made by Messrs. Hunt, Blanchard or Firth. Locations to be worked, however, were restricted to a lease on Hampton Flats in the James River (Figure 1; drawn from NOS Chart 12245). VIMS

personnel, however, were required to be present at all times during their work. The second phase of the study was designed to observe the biological and ecological effects of the escalator dredge and the traditional gear, the patent tongs. Four test plots were designated and the corners staked by Mr. Hunt and VIMS and surveyed by VMRC on the lease (Figures 1, 2 and 3). The bottom in each of these plots had not been previously worked by the dredge. Two of the plots were designated as controls; two were to be thoroughly worked by the two types of gear: one plot by the patent tong and one plot by the escalator dredge. Before the two test plots had been worked by the commercial gear, benthic samples were taken from all four plots to characterize the existing animal communities. Observations of the physical appearance of the bottom were also made by divers on two occasions prior to the working of the test plots and on three occasions after. Photographs of the bottom contours in both the patent tong and escalator dredge plots were taken after the gears had worked the plots. Benthic sampling on all four plots will be conducted again in the spring or summer of 1981 to observe any changes in the benthic community resulting from the use of either of these gears. At least one more dive to observe the bottom terrain is also planned at this time.

Two views of the hydraulic dredge are presented in Figure 4. Measurements of the boat and the hydraulic gear are given in Appendix I. The catch rates during the time when the bottom

photo was taken were relatively low. However, the condition of the catch and lack of sediment in it is representative of all catches observed.

METHODS AND RESULTS

Monitoring Operation

VIMS began on-board monitoring of the dredge operations on 17 September 1980 and continued until 31 October 1980 when the experimental permit for the use of the dredge expired. The following types of data were collected by the monitoring personnel:

1. The total number of clams captured in a timed period;
2. The number of clams retained by the crew in a timed period;
3. The number of clams discarded by the crew in a timed period;
4. For those days that clams were landed, the number of bags and total number of retained clams at the end of each day;
5. The duration of actual dredging operations;
6. Lengths of representative samples of crew-culled littlenecks and cherrystones and samples of all sizes of clams captured;

7. Non-target species captured and their condition.

These data are tabulated in Tables 1, 1A, 2A, 2B, 2C, 3 and 4 at the end of this report. By concentrating on the types of data listed above, estimates of the following characteristics of the hydraulic dredge system could be obtained:

1. Average catch per unit of effort per day for each of the groups of clams (total catch, clams retained, and clams discarded);
2. Variations in the catch per unit of effort throughout the day for each of the groups of clams;
3. Size criteria of the crew for littlenecks and cherrystones (or those clams retained) and chowders (those discarded).

Table 1 contains the daily totals of the clams retained (littlenecks and cherrystones) at the end of each day, as well as the total actual working time per day. The highest daily average catch rate was 4,330 clams per hour on 7 October 1980 (72 clams per minute). The average catch rate for the entire monitoring study was 2,888 clams per hour (48 clams per minute). These data are based on the landed catch of clams by Mr. Hunt at the end of each day.

During selected working days, monitoring personnel recorded catch and effort data during periods throughout the day which varied from several minutes to about one hour (Tables 2A, 2B, and 2C; see tables for explanation of data recorded during each day). In these tables the variation in catch rates throughout the day is evident. However, these data obtained during short periods agree favorably with the daily average catch rates as they appear in Table 1. For example, on 6 October 1980, catch rates of littlenecks and cherrystones varied from 7.5 to 60.6 clams per minute for an average of 46.9 clams per minute for the five hour period of monitoring. The highest catch rate of littlenecks and cherrystones recorded was 105.6 clams per minute during a 33 minute period of 8 October 1980 (Table 2A).

Estimates of the catch rates of chowder clams were obtained by counting the number of clams in a timed period which were left on the belt and allowed to return to the bottom. When the catch rate for all sizes of clams was high, some littlenecks and cherrystones were missed and inadvertently allowed to return to the bottom. They formed a small percentage of the discarded clams only when the crew had difficulty culling all littlenecks and cherrystones off the belt. These clams are included in the estimates of the catch rates of discarded clams, which appear in Tables 2A, 2B, and 2C. The catch rate of chowders was consistently lower than the catch rate of littlenecks and cherrystones. However, the proportion of the total catch that was composed

of chowders (discards) varied from a low of 12% to a high of 50%. An average for the entire period monitored is 30% or roughly one-third of those clams caught were chowders and thus, discarded by the crew. Consequently, to estimate the catch rate of the hydraulic dredge for all sizes of clams, the average catch rate of retained clams for the monitored period (Table 1: 2,888 clams per hour or 48 clams per minute) was divided by 0.7. This yielded an average catch rate for all sizes of clams of 4,126 clams per hour or 69 clams per minute.

Table 3 contains the lengths of the crew-culled littleneck and cherrystone samples. At the beginning of the monitoring period, the crew explained that their culling by size was not as accurate as it should have been due to the rapid movement of a large number of clams up the belt. Consequently, these may not be readily comparable to size criteria of the industry for littlenecks and cherrystones.

Table 4 contains a brief summary of the catch and condition of non-target species by the escalator dredge. Monitoring personnel were instructed to make counts of the numbers and physical condition of these animals during a timed period. Oftentimes, these counts were performed simultaneously with counts of clams. The most important animals captured (judged by their frequency of appearance) are grouped in Table 4.

Clams caught by the hydraulic dredge were rarely damaged. A total of 56 broken clams were observed during the monitoring operation which yields an approximate rate of one clam broken for every 2,000 clams captured.

Biological and Ecological Effects of Escalator Dredge and Patent Tongs

Four test plots located on the lease were designated and the corners of each were staked (Figures 1, 2 and 3). Two of these serve as controls and are to be left unworked by any commercial gear. The other two are experimental plots, one of which was worked by the hydraulic dredge and the other by the patent tongs (Figures 2 and 3). The patent tong plot is the smallest of the four at 0.48 acre, while the other three closely approximate an acre: Control area 1 (between the two experimental plots) contains 0.85 acre, Control area 2 (upriver from the patent tong plot) contains 1.1 acres, and the hydraulic dredge plot contains 0.95 acre.

This phase of the study involved three parts:

1. Benthic sampling to characterize the animal communities in each of the four plots prior to and after dredging and tonging;
2. SCUBA diving to observe the bottom prior to and after dredging and tonging;
3. Working of the two experimental plots by the two commercial gears.

Benthic Sampling

On 16-17 October 1980 benthic samples were taken with a Smith-MacIntyre grab and sieved in a 1 mm mesh from

each of the four plots. All samples were placed in a 5% ethyl alcohol-seawater solution in the field and preserved in 5% formalin at the lab. Each plot was divided by a grid into various numbers of subplots. One benthic sample was taken in each subplot. The number and dimensions of each subplot are listed below.

Plot	No. of Subplots	Subplot Size (ft^2)
Control 1	9	4,107
Control 2	9	5,459
Patent Tong	10	2,072
Hydraulic Dredge	21	1,970

These samples have yet to be analyzed. Further sampling will be conducted in the spring or summer of 1981 in each of the four plots.

SCUBA Diving

Two dives were conducted prior to dredging on the patent tong and dredge plots, on 23 and 27 October 1980. The divers, Dr. Herbert Austin and Nancy Brown-Tucker, were instructed to follow a transect line laid across the plot and make observations of the terrain, the biota, and the gross structure of the sediment. A square metal frame (0.25 m^2) was placed on the bottom at 20 foot intervals

along the transect and the surface and subsurface features recorded. A summary of the notes of both diver's from both dives follow.

Dive 1 - Hydraulic Dredge Plot (23 October 1980)

- Visibility was 2.5-3 feet.
- Depth at both ends of transect was 13 feet (200 foot transect). The bottom was soft brown mud which was stirred up easily even by movement of the fingers. The mud turned black at a depth of about 1-2 inches. There was no shell hash on the surface save for an occasional broken razor clam shell. At a depth of approximately 4-6 inches, there appeared to be a heavy oyster shell bed. This was checked every 50 feet along the transect and the same found to be true. The bottom was generally smooth with slight undulations, no apparent ripple or scour marks. There was an occasional burrow tube the diameter of a larger finger, and on several occasions when tried digging down (into) one of these and into the shell layer the diver was unable to find anything. Most (surface) life was clustered around the regular sponge colonies;

sponges were in groups of 4 to 5 and distributed every 10 to 20 feet. Each of these sponge colonies contained one or two young-of-the-year blue crabs, several small blennies, hermit crabs, and occasionally small amounts of attached seaweed. Almost all (epibenthic) life was found in and among these sponge colonies. Clams were extremely abundant as the divers came across one or two clams every foot or so.

Dive 2 - Patent Tong Plot (27 October 1980)

- Very strong current.
- Fewer hermit crabs, blue crabs or fish of any type as on 23 October 1980. More surface shell than on 23 October 1980. General bottom type was similar - soft, gently rolling mud. Many worm and clam burrows and some of the "yellowish-brown" (Craniella sp.) and "red-beard sponge" (Microciona prolifera).
- Eight 0.25 m^2 quadrants were observed.

1. 1st quadrant (210 foot mark)

   - 1 surface shell
   - several buried shells
   - no clams
   - 1 hermit crab
   - 1 large clear circular burrow

2. 2nd quadrant (190 foot mark)

- 1 red-beard sponge colony
- 6 large burrows
- 1 surface shell
- several buried shells
- no clams

3. 3rd quadrant (170 foot mark)

- 1 silted burrow
- 1 clam (buried)

4. 4th quadrant (150 foot mark)

- nothing on surface
- several buried shells
- no clams

5. 5th quadrant (130 foot mark)

- 2 parts of yellowish-brown sponge colony
- 2 clams (buried)

6. 6th quadrant (110 foot mark)

- 3 small, silted burrows
- 1 large clear burrow
- 1 clam (buried)

7. 7th quadrant (90 foot mark)

- 3 large clear burrows
- 1 hermit crab
- 1 surface shell
- 1 clam (buried)

8. 8th quadrant (70 foot mark)

- 1 clam (buried)
- 1 surface shell
- 3 large clear burrows

Three dives were conducted after the working of the two experimental plots by the commercial gear.

No paired (U-tube) openings were observed in areas where the dredge had worked. On unworked bottom in the plot, these were still visible. Large chowder clams (presumably those discarded by crew) were observed laying flat (on a side) on the bottom. Two or three were visible in the area visible to the divers at any time. Visibility was estimated at 6-8 feet.

2) Patent Tong Plot - At the beginning of the transect (near offshore upriver stake) the bottom was uniformly and intensely worked by the tongs as evidenced by many craters. These measured approximately 4 X 3 feet and were about 6-8 inches deep. The formerly buried oyster shell was scattered over the bottom. Inside the holes were blue crabs, red-beard sponge colonies and pieces of the yellowish sponge colonies. The yellow sponge existed in larger colonies than was observed over the dredged plot but these were also loose over the bottom. Slender, protenaceous tubes were observed inside the holes just as they had been observed in the trenches of the hydraulic dredge plot. Only

one chowder was seen on the surface, but two recently dead chowders (as evidenced by the attached valves and parts of muscle still attached) were observed. The bottom sediments were softer inside the patent tong holes than on unworked bottom nearby. The sides of the holes were much steeper than the sides of the trenches in the hydraulic dredge plot. A tan diatom mat had become established on the undisturbed area of both plots. This mat was not observed before dredging, but may have no connection with it.

Dive 4 - 1) Hydraulic Dredge Plot; 2) Patent Tong Plot (14 November 1980)

- Visibility 4-5 feet.

1) Hydraulic Dredge Plot - The depth of the troughs had decreased to 3-4 inches near the sides and 5-6 inches in some near the center. Much of the shell that was on the surface on 3 November was now just below the surface and covered by a thin layer of silt. Mysid shrimps were observed over the entire bottom and not exclusively in

the troughs. Several deep-burrowing bivalves (i.e. Barnea, angel-wing clams) were observed inside troughs and had been apparently unaffected by the action of the dredge. The troughs appeared to be less well defined than on 3 November with the sides sloping more gently to the bottom. The bottom terrain appears to have been restored faster in the dredged area than the tonged area. Ripple marks, a sign of sediment transport were noted and photographed.

2) Patent Tong Plot - The general outline of the holes was still apparent, although the sides were more gently sloping than on 3 November. The craters left by the patent tong had collected a large variety of animals and debris, including the red-beard sponge, mysid shrimp, yellow sponge and some mud and blue crabs. The crabs, however, did not appear more frequently within the holes than on the unworked bottom within the plot. Apparently, the holes left by the tongs allow refuge for mysids from the tidal currents scouring the bar, for they were much more common in the holes than on unworked bottom.

- No quadrants were examined on this dive.

Dive 5 - 1) Hydraulic Dredge Plot; 2) Patent Tong Plot (20 November 1980)

- Visibility 5-6 feet.
- This dive was solely for the purpose of taking pictures. The bottom was essentially similar to the dive on 14 November.

1) Hydraulic Dredge Plot - In Figure 5, a composite view across a trough left by the hydraulic dredge is presented. The string is level with the bottom and held taught on the ridge on either side of the trough in Photos 3 and 8. The string in Photos 5 and 6 is four inches off the bottom showing the depth of the trough in its center. These photos were taken 21 days after the trenches were made. The troughs had been filled in with almost two inches of sediment since 3 November 1980.

2) Patent Tong Plot - In Figure 6, a composite view across a hole left by the patent tong is presented. The string is level with the bottom and tied to the stake in Photo 5. The string in Photo 3 is 6.5 inches off the bottom showing the depth of the hole at its

edge. This is 2.5 inches deeper than the trough. The holes left by the patent tong had not filled in to the same extent as had the troughs. The collection of sponges in the hole is evident in Photo 2.

Commercial Gear Experiments

On 30 October 1980, the PHOEBE JO, rigged with the hydraulic dredge, and the NORMA JEAN, a patent tong boat owned and operated by E. T. Firth, worked the two beds for slightly over three hours each. The catch and effort of the patent tongs on the 0.48 acre plot are summarized in Table 5. A total of 589 clams were captured in 260 grabs during 184 minutes of tonging. This resulted in a total catch rate of 3.2 clams/minute, but only 1.5 littlenecks and cherrystones per minute. The catch rate of the hydraulic dredge on 30 October 1980 are summarized in Table 6. A total of 4,327 clams were captured in 200 minutes of dredging resulting in a total catch rate of 21.6 clams per minute. However, littlenecks and cherrystones were captured at the rate of 11.3 clams per minute or 7.5 times greater than the patent tong catch rates. The operators of both gear remarked that, if they had been involved in actual commercial operations, they would not have remained in this area due to the scarcity of clams.

The catch per minute of the patent tong is directly related to the speed of the operator at deployment of the gear. This is not the case with the hydraulic dredge. If the dredge is deployed properly, the catch rates more accurately reflect actual population densities. Consequently, the 7.5 times greater efficiency of the dredge than the tongs would depend greatly on the tong operator's efficiency. This figure comparing the efficiencies of the two gears should be considered conservative.

DISCUSSION

The results from the monitoring study aboard the PHOEBE JO demonstrate that the hydraulic dredge is an efficient harvesting gear for hard clams. On the plots studied the rates of harvest are at least 7.5 times as great with this gear than with the patent tongs. Other organisms captured were few in number compared to the large numbers of clams harvested. Hard clams were not damaged by the escalator.

The texture and sediment composition of the bottom was modified after dredging and tonging. Observations suggest that the depth of the crater left by the patent tong gear was slightly deeper than the trough left by the hydraulic escalator. Subsequent studies in the spring of 1981 and analysis of benthic populations will show the possible impact of this modification.

The relative efficiency of the two gears as determined by the working of the experimental plots as discussed previously is a most important result of this study. That is, the hydraulic dredge can harvest as many clams in an hour as the patent tongs can in an 8-hour day.

Table 1. Summary of the catch and effort of Hunt's hard clam escalator dredge on Hampton Flats, 17 September-31 October 1980, as monitored by VIMS personnel. Unlanded catch from 17 September-3 October based on counts of clams during dredge operations. Landed catch from 6 October-31 October based on daily totals.

Date	# Bag Nicks	# Clams[1]	# Bags Cherrystone	# Clams[2]	# Clams For Day	# Bags For Day	Hours Worked[3]	Average Clams Per Hour	Landed
Sep 17	*[4]	*	*	*	*	0.8	0.6	--	No
22	*	*	*	*	406	*	2.2	184	No
Oct 1	*	*	*	*	2,915	*	2.0	1,458	No
2	*	*	*	*	1,307	*	2.1	622	No
3	*	*	*	*	2,136	*	2.0	1,068	No
6	26	7,800	88	13,200	21,000	114	5.0	4,200	Yes[6]
7	30	9,000	93	13,950	22,950	123	5.3	4,330	Yes
8	16	4,800	58	8,700	13,500	74	5.7	2,368	Yes
9	MISSING								No
10	13	3,900	60	9,000	12,900	73	4.8	2,688	Yes
13	25	7,500	110	16,500	24,000	135	6.6	3,636	Yes
14	26	7,800	101	15,150	22,950	127	5.5	4,173	Yes
15	15	4,500	72	10,800	15,300	87	6.0	2,550	Yes
16	17	5,100	75	11,250	16,350	92	6.0	2,725	Yes
17	25	7,500	100	15,000	22,500	125	--	--	Yes
20	16	4,800	85	12,750	17,550	101	8.0	2,194	Yes
21	5	1,500	20	3,000	4,500	25	4.5	1,000	Yes
22	7	2,100	49	7,350	9,450	56	3.5	2,700	Yes
27	10	3,000	50	7,500	10,500	60	4.0	2,625	Yes
30[5]	2	600	10	1,500	2,100	12	3.3	636	Yes (with 31st)
31	14	4,200	80	12,000	16,200	94	5.5	2,945	Yes
TOTALS	247	74,100	1,051	157,650	238,514	1,298	82.6	2,888	--

[1] 1 bag nicks = 300 clams.
[2] 1 bag cherrystones = 150 clams.
[3] Refers to the amount of time that dredge was active.
[4] The symbol (*) indicates data not obtained.
[5] Date of experimental work on escalator and tonged plots.
[6] Work done prior to Oct. 6 not considered successful; consisted primarily of testing and modification of the dredge system.

Table 1A. Clams landed by Hunt's escalator dredge as reported by VMRC inspectors in August[1] and October 1980, and VIMS data on catch as recorded on board of dredge boat.

	VMRC Data on Clams Landed						VIMS Data	
Date	# Bags Nicks	# Clams	# Bags Cherrystone	# Clams	Total # Clams For Day	Total # Bags	# Bags Reported By VIMS	# Clams Reported By VIMS
Oct 6	--	--	--	--	21,000	103	114[2]	21,000
7	--	--	--	--	23,000	126	123	22,950
8	--	--	--	--	15,000	76	74	13,500
10	--	--	--	--	13,000	73	73	12,900
13	--	--	--	--	24,000	135	135	24,000
14	--	--	--	--	24,000	127	127	22,950
15	--	--	--	--	15,000	87	87	15,300
16	--	--	--	--	16,500	93	92	16,350
17	25	7,500	104	15,600	23,500	129	125	22,500
20	16	4,800	83	12,450	18,000	99	101	17,550
21	--	--	--	--	4,500	25	25	4,500
22	--	--	--	--	9,600	56	56	9,450
27	10	3,000	50	7,500	10,500	60	60	10,500
31	16	4,800	88	13,200	18,250	104	106	18,300
TOTALS	--	--	--	--	235,850	1,293	1,298	231,750

Date	Total # Clams	Hours Worked	# Clams Per Hour
Aug 14	10,500	6	1,750
15	19,200	5	3,840
18	18,100	6	3,017
19	18,500	6	3,083
20	17,500	6	2,917
21	19,200	6	3,200
22	20,000	6	3,333
TOTALS	123,000	41	3,000

[1]August information supplied to VMRC by Mr. W. P. Hunt, Jr. as per their request. Clams harvested with dredge boat from Maryland.

[2]Afternoon catch (38 bags of cherrys; 11 bags of nicks) dumped on deck and tallied; shoveled into bags at dock without re-measuring, ending up with eleven more bags.

Table 2A (Contd.)

Date	Time Period (Minutes)	Number of Clams Discarded	Rate of Catch	Number of Clams Retained[1]	Rate of Catch[1]	All Clams Caught	Total Catch Rate	Ratio of Catch Rate of Discards to Total Catch Rate X 100
10/ 8/80	33	1,460	44.2	3,484	105.6	4,944	149.8	30
	60	1,210	20.2	4,891	81.5	6.101	101.7	20
	30	580	19.3	1,817	60.6	2,397	79.9	24
	18	450	25.0	1,243	69.1	1,693	94.1	27
	19	280	14.7	644	33.9	924	48.6	30
TOTALS	160	3,980	24.8	12,079	75.5	16,059	100.3	25
10/13/80	4	16	4.0	114	28.5	130	32.5	12
	4	50	12.5	123	30.8	173	43.3	29
	2	12	6.0	26	13.0	38	19.0	32
	2	20	10.0	29	14.5	49	24.5	41
	3	12	4.0	21	7.0	33	11.0	36
	2	50	25.0	96	48.0	146	73.0	34
TOTALS	17	160	9.4	409	24.1	569	33.5	28
10/14/80	30	565	18.8	2,152	71.7	2,717	90.5	21
	40	665	16.6	2,533	63.3	3,198	79.9	21
	30	670	22.3	2,812	93.7	3,482	116.0	19
	25	505	20.2	2,146	85.8	2,651	106.0	19
	4	120	30.0	394	98.5	514	128.5	23
	30	640	21.3	2,315	77.2	2,955	98.5	22
TOTALS	159	3,165	19.9	12,352	77.7	15,517	97.6	20

[1]Obtained by subtracting the number and rate of clams discarded from the number and rate of catch of all clams.

Table 3. Size of clams captured by Hunt's hard clam escalator dredge on Hampton Flats, October 1980, in mm of length.

I. Littlenecks (as culled by crew)[1]

Date	10/3/80	10/6/80	10/21/80	Total
Mean	64	64	59	60.9
Range	37- 80	38- 81	40- 72	37- 81
S.D.	8.97	11.79	8.10	--
n	78	113	309	500

[1]Early in study, the crew mentioned that their separation by size was haphazard due to the fast rate and large quantities of catch.

II. Cherrystones (as culled by crew)[1]

Date	10/6/80	10/14/80	Total
Mean	80	74	77.9
Range	61- 89	65- 83	61- 89
S.D.	4.72	4.49	--
n	126	69	195

III. Unculled Sample (with clams normally discarded included)

Date	10/7/80	10/8/80	10/10/80	10/13/80	10/14/80	10/15/80	10/16/80	10/21/80	Total
Mean	77	76	79	79	75	81	77	79	
Range	43- 98	40-103	41-100	38-100	41-102	56- 99	38- 98	42- 97	
S.D.	11.80	13.89	11.48	11.59	14.54	12.46	12.81	9.39	
n	80	66	68	123	138	69	129	118	
Mean		68	77	79	77	81	79	80	
Range		37-100	39-101	44- 99	44- 97	41-101	38-100	44- 99	
S.D.		15.83	12.40	9.67	11.60	12.08	13.22	12.17	
n		86	75	118	123	72	124	118	

Table 3 (Contd.)

III. (Contd.)

Date	10/7/80	10/8/80	10/10/80	10/13/80	10/14/80	10/15/80	10/16/80	10/21/80	Total
Mean		74							
Range		40-102							
S.D.		13.83							
n		146							
Totals for day									
Mean	77	73	78	79	76	81	78	80	77.4
n	80	298	143	241	261	141	253	236	1653
Range	43- 98	37-103	39-101	38-100	41-102	41-101	38-100	42- 99	37-103

The first dive, on 3 November 1980, was an observational dive, while the following two, on 14 November and 20 November were primarily for the purpose of taking photographs of the modified bottom in each of the two experimental plots.

On 3 November, the divers, Dr. Herbert Austin and Lowell Fritz, followed the transect line as in the two previous dives. However, to observe a large number of the trenches left by the dredge and holes left by the patent tong, the lines were laid down with respect to the known patterns which the commercial gear had been worked (Figures 2 and 3). The hydraulic dredge was worked in an upriver-downriver direction, parallel to the shoreline. Consequently, the line was stretched across the plot perpendicular to the direction the dredge had been worked (which was similar to the "pre-worked" transect). The patent tong operator had concentrated in the upriver-offshore corner of the plot. The transect began at the stake marking this corner and ran diagonally across the plot, terminating several feet upriver from the downriver-inshore corner stake.

Dive 3 - 1) Hydraulic Dredge Plot; 2) Patent Tong Plot (3 November 1980)

1) Hydraulic Dredge Plot - The transect was laid from near the inshore-upriver stake

perpendicularly across the plot to the offshore side. The inshore 2/3 of the plot was worked most intensely. The troughs were four feet wide and unworked bottom (ridges) separated the trenches. The trough and ridge pattern alternated along the transect. The depth of the trough was 5-3/4 inches in the center; however, in some areas of the plot it was difficult to detect where the dredge had worked. Some of the troughs had considerable amounts of formerly buried shell on the surface, but most of the shells were found along the ridges alongside the troughs. The bottom inside one of the troughs was investigated - no shells were buried below the surface and it consisted of a very soft muddy-sand. The bottom was softer inside the troughs than on the ridges. The yellow-brown sponge that formed large colonies on the bottom prior to dredging was only found in loose pieces after dredging. Hermit crabs, which were only found near the sponge prior to dredging, were seen all over the bottom and not associated specifically with the sponge.

Table 2A. Summary of the rate of capture of clams on Hampton Flats by the escalator dredge; October 1980.

For each day, both the total number of clams captured and the number discarded were recorded simultaneously for each time period.

Date	Time Period (Minutes)	Number of Clams Discarded	Rate of Catch	Number of Clams Retained[1]	Rate of Catch[1]	All Clams Caught	Total Catch Rate	Ratio of Catch Rate of Discards to Total Catch Rate X 100
10/ 2/80	9	5	0.5	14	1.6	19	2.1	24
	14	18	1.3	44	3.1	62	4.4	30
	8	5	0.6	10	1.3	15	1.9	32
	7	8	1.1	13	1.9	21	3.0	37
	43	305	7.1	623	13.8	928	20.9	34
	2	6	3.0	17	8.5	23	11.5	26
	23	58	2.5	113	4.9	171	7.4	34
	8	8	1.0	20	2.5	28	3.5	28
TOTALS	114	413	3.6	854	7.5	1,267	11.1	32
10/ 6/80	50	700	14.0	2,660	53.2	3,360	67.2	21
	46	471	10.2	2,062	44.8	2,533	55.0	19
	8	8	1.0	60	7.5	68	8.5	12
	33	360	10.9	1,709	51.8	2,069	62.7	17
	28	390	13.9	1,316	47.0	1,706	60.9	23
	54	800	14.8	2,800	51.9	3,600	66.7	22
	6	20	3.3	149	24.8	169	28.1	12
	21	210	10.0	800	38.0	1,010	48.0	20
	35	740	21.1	2,122	60.6	2,862	81.7	26
	6	60	10.0	245	40.8	305	50.8	20
	12	70	5.8	263	21.9	333	27.7	21
	67	1,050	15.7	2,985	44.6	4,035	60.3	26
TOTALS	366	4,879	13.3	17,171	46.9	22,050	60.2	22

Table 2B. Summary of the rate of capture of clams on Hampton Flats by the hydraulic escalator dredge; October 1980,

The number of clams discarded or the total number of clams captured was recorded individually during timed periods.

Date	Time Period (Minutes)	Number of Clams Discarded	Rate of Catch	Number of Clams Retained	Rate of Catch	All Clams Caught	Total Catch Rate	Ratio of Catch Rate of Discards to Total Catch Rate X 100
10/15/80	10	348	34.8	--	--	--	--	--
	20	--	--	--	--	1,030	51.5	--
	19	855	45.0	--	--	--	--	--
	13	--	--	--	--	1,546	119.0	--
	12	551	45.9	--	--	--	--	--
	8	--	--	--	--	772	96.5	--
	20	927	46.4	--	--	--	--	--
	19	--	--	--	--	2,117	111.4	--
SUMMARY								
Discards	61	2,681	44.0	--	--	--	--	--
All	60	--	--	--	--	5,465	91.1	--
Total[1]	121	5,324	44.0	5,699	47.1	11,023	91.1	48

[1]The catch rates of discarded clams (44.0 per minute) and the total catch rate (91.1 per minute) were applied to the total time period observed (121 minutes). The number of clams retained and their rate of catch were obtained by subtracting the number and rate of clams discarded from the number and rate of catch of all clams.

Table 2C. Summary of the rate of capture of clams on Hampton Flats by the hydraulic escalator dredge; October 1980.

For each day, the number of clams discarded or the number of clams retained was recorded individually during timed periods.

Date	Time Period (Minutes)	Number of Clams Discarded	Rate of Catch	Number of Clams Retained	Rate of Catch	All Clams Caught	Total Catch Rate	Ratio of Catch Rate of Discards to Total Catch Rate X 100
10/16/80	12	--	--	594	49.5	--	--	--
	4	85	21.3	--	--	--	--	--
	4	134	33.5	--	--	--	--	--
	23	--	--	852	37.0	--	--	--
	31	1,203	38.8	--	--	--	--	--
	12	--	--	557	46.4	--	--	--
	23	1,066	46.3	--	--	--	--	--
	20	--	--	1,099	55.0	--	--	--
	12	709	59.1	--	--	--	--	--
	25	731	29.2	--	--	--	--	--
SUMMARY								
Discards	99	3,928	39.7	--	--	--	--	--
Retained	67	--	--	3,102	46.3	--	--	--
Totals[1]	166	6,590	39.7	7,686	46.3	14,276	86.0	46
10/21/80	11	380	34.5	--	--	--	--	--
	8	--	--	275	34.4	--	--	--
SUMMARY[1]	19	656	34.5	654	34.4	1,310	68.9	50

[1]The catch rates of discarded clams (39.7 and 34.5 per minute) and retained clams (46.3 and 34.4 per minute) were applied to the total time periods observed (166 and 19 minutes). The total number of clams caught and their catch rate were obtained by adding the numbers and rates of catch of discarded and retained clams.

Table 4. Catch and condition of species other than hard clams by Hunt's escalator dredge during October, 1980.

I. Common (20-200 occurrences per hour)

1) Yellow sponge Craniella sp.
2) Red-beard sponge Microciona prolifera

The yellow sponge listed above is a long, coiling mass as it appears on the bottom. When captured by the dredge, however, it was often broken into smaller pieces of lengths of approximately 4-18 inches. Consequently, each piece of sponge was counted and may represent far fewer original whole colonies. Diving observations on dredged and undredged plots confirm these observations: that dredging disrupted the large colonies and the sponge existed in smaller pieces after dredging.

II. Frequent (5-20 occurrences per hour)

1) Razor clams Tagelus sp.
2) Unidentified protenaceous tubes (phoronids)
3) Sea squirt clumps Molgula sp.
4) Soft clams Mya arenaria

III. Rare (1-5 occurrences per hour)

1) Blue crabs Callinectes sapidus
2) Moon snails Polinices duplicatus
3) Angel wings Barnea truncata
4) Young toadfish Opsanus tau
5) Young flounder Paralichthys dentatus
6) Oyster Crassostrea virginica
7) Horseshoe crabs Limulus polyphemus
8) Spider crabs Libinia sp.
9) Conchs Busycon sp.
10) Hogchokers Trinectes maculatus
11) Polychaetes
12) Mud crabs
13) Hermit crabs

In one typical 8-hour day the dredge raised only 30 hard crabs. Of this total 3 show some damage such as loss of a claw or leg.

Table 5. Summary of catch and effort for patent tong gear on VIMS-designated plot on Hampton Flats; October 30, 1980.

Time (Min.)	# Grabs	Total # Clams Captured	Total # Per Min.	Total # Per Grab	# of Littlenecks and Cherrystones	Retained Clams As % of Total	Discards As % of Total	Retained Clams Per Min.	Discards Per Min.
30	42	98	3.3	2.3					
30	40	116	3.9	2.9					
30	45	93	3.1	2.1					
30	42	96	3.2	2.3					
11	15	31	2.8	2.1					
30	43	99	3.3	2.3					
23	33	56	2.4	1.7					
Totals									
184	260	589	3.2	2.3	282	48	52	1.5	1.7

Table 6. Summary of catch and effort for escalator dredge on VIMS designated plot on Hampton Flats; October 30, 1980.

1. Catch and Effort

	Time Period (Minutes)	Number of Clams Discarded	Rate of Catch	Number of Clams Retained	Rate of Catch	All Clams Caught	Total Catch Rate	Ratio of Catch Rate of Discards to Total Catch Rate X 100
A. Initial Period	32	635	19.8	691	21.6	1,326	41.4	48
B. Totals for Day	200	2,077[1]	10.3	2,250	11.3	4,327[1]	21.6	48

2. Daily Tallys of Catch

Number of Bags Nicks	Number Clams	Number of Bags Cherrystones	Number Clams
2.5	750	10	1,500

3. Ratio of Catch Rates of Two Gears

	Dredge / Tong
1. Littlenecks and Cherrystones (Retained)	$\frac{11.3^2}{1.5^3} = 7.5$
2. Chowders (Discarded)	$\frac{10.3^2}{1.7^3} = 6.0$

[1]Obtained by using ratio of discards to total from A.

[2]From Table 6.

[3]From Table 5.

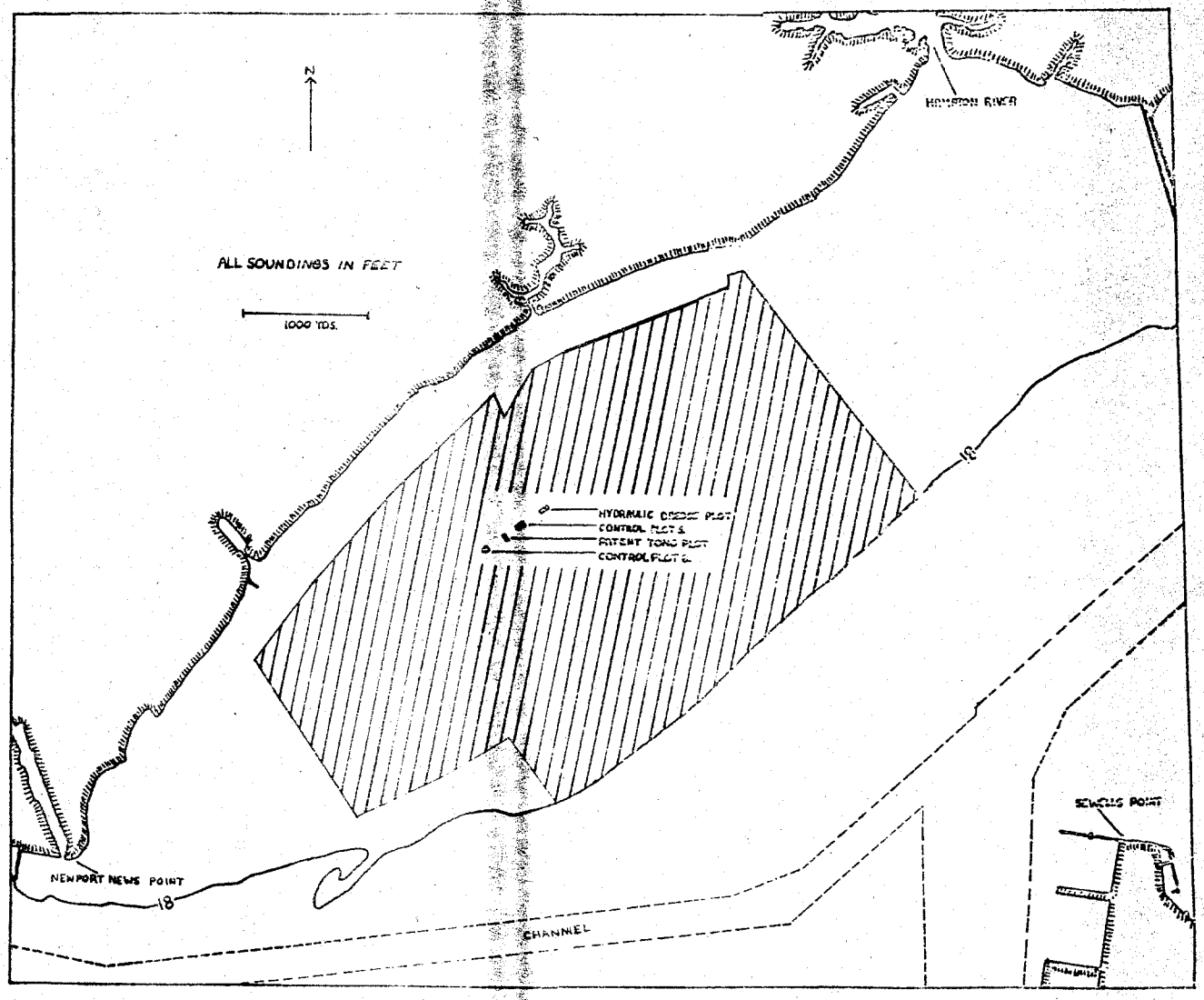


Figure 1. Map of Hampton Flats, James River, showing location where Mr. Hunt's hydraulic dredge was permitted to work. The four test plots designated by VIMS are also shown.

Figure 2. Detail of the VIMS-designated hydraulic escalator experimental plot showing areas most intensively worked and observational dive transect of 3 November 1980.

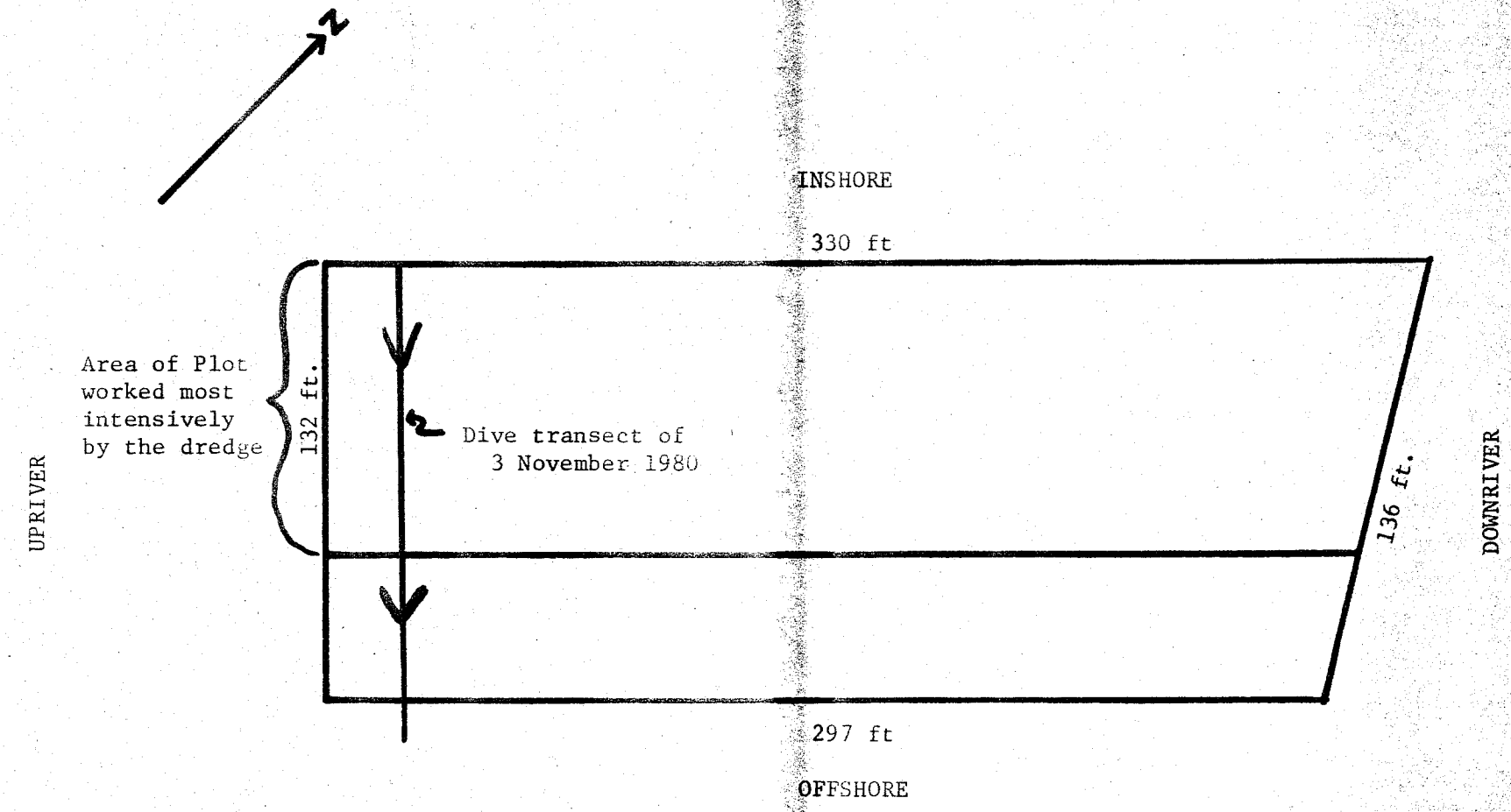


Figure 3. Detail of the VIMS-designated patent tong experimental plot showing areas most intensively worked and observational dive transect of 3 November 1980.

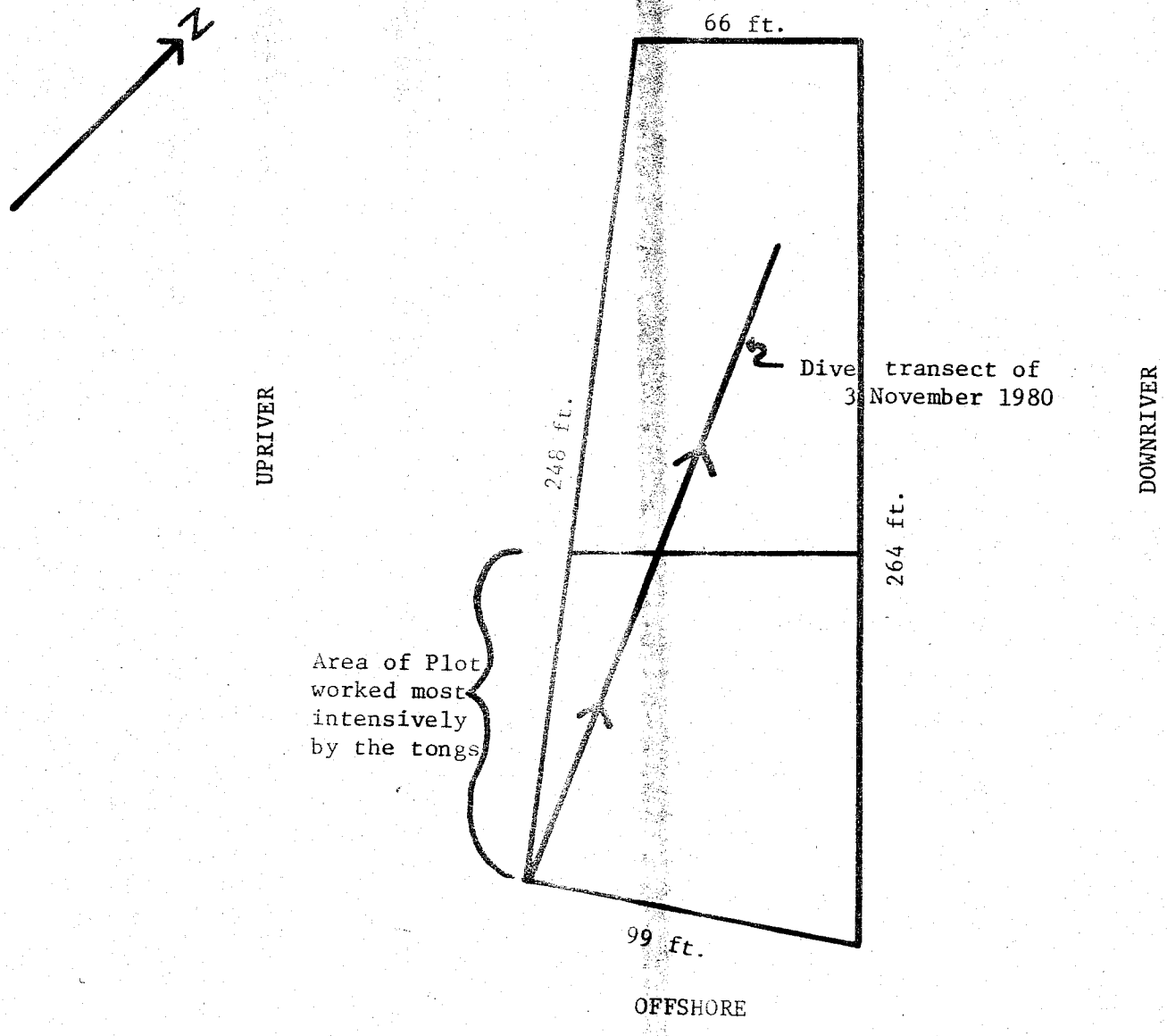
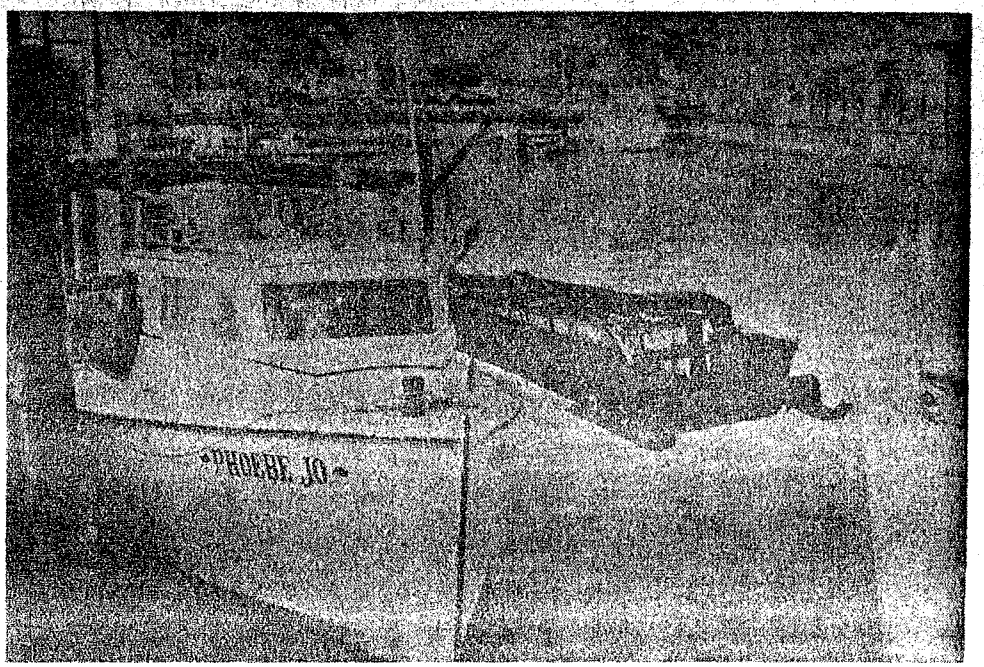


Figure 4. The Hydraulic Escalator Dredge.

TOP - The dredge as mounted on the port side of the PHOEBE JO, showing the head with manifold and water jets and part of the enclosed conveyor belt assembly.

BOTTOM - A close-up of the conveyor belt and catch.


PROVERBS 10

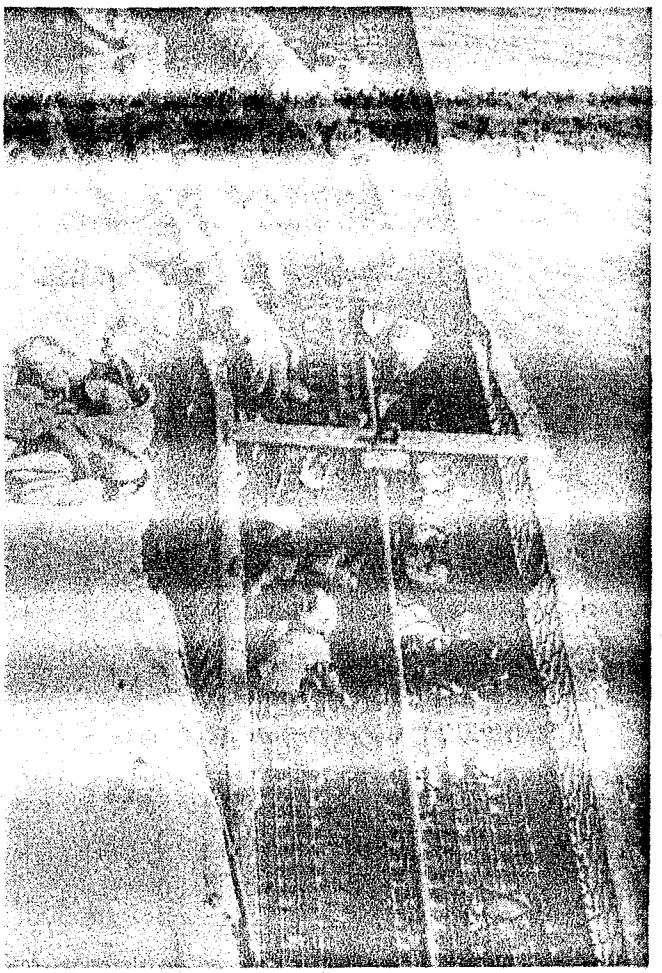
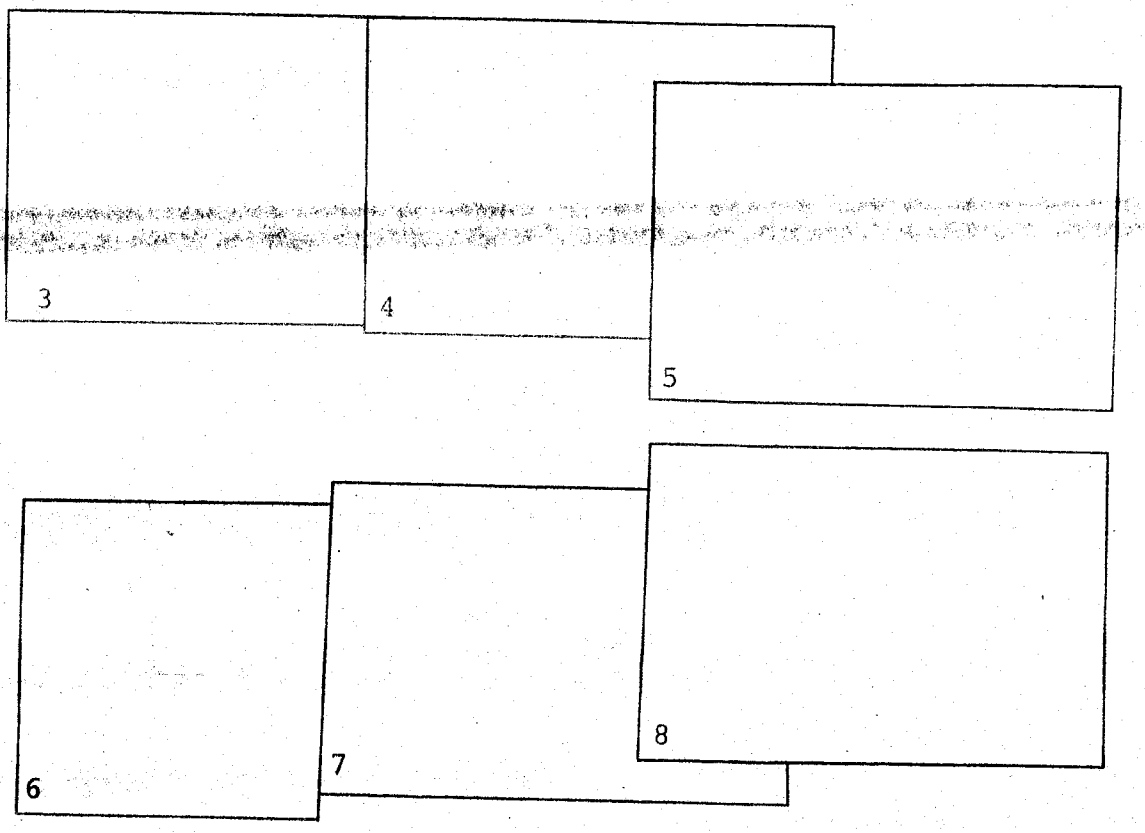


Figure 5. A composite view across a trough left by the hydraulic escalator dredge. Photos 3, 4, and 5 (top, left to right) form the left side of the trench and 6, 7, and 8 (bottom, left to right) the right side. (The stake in the right side of Photo 5 is the same stake as in the left side of Photo 6.) The scale divisions on the stakes are 1 inch. Photos taken on 20 November 1980.



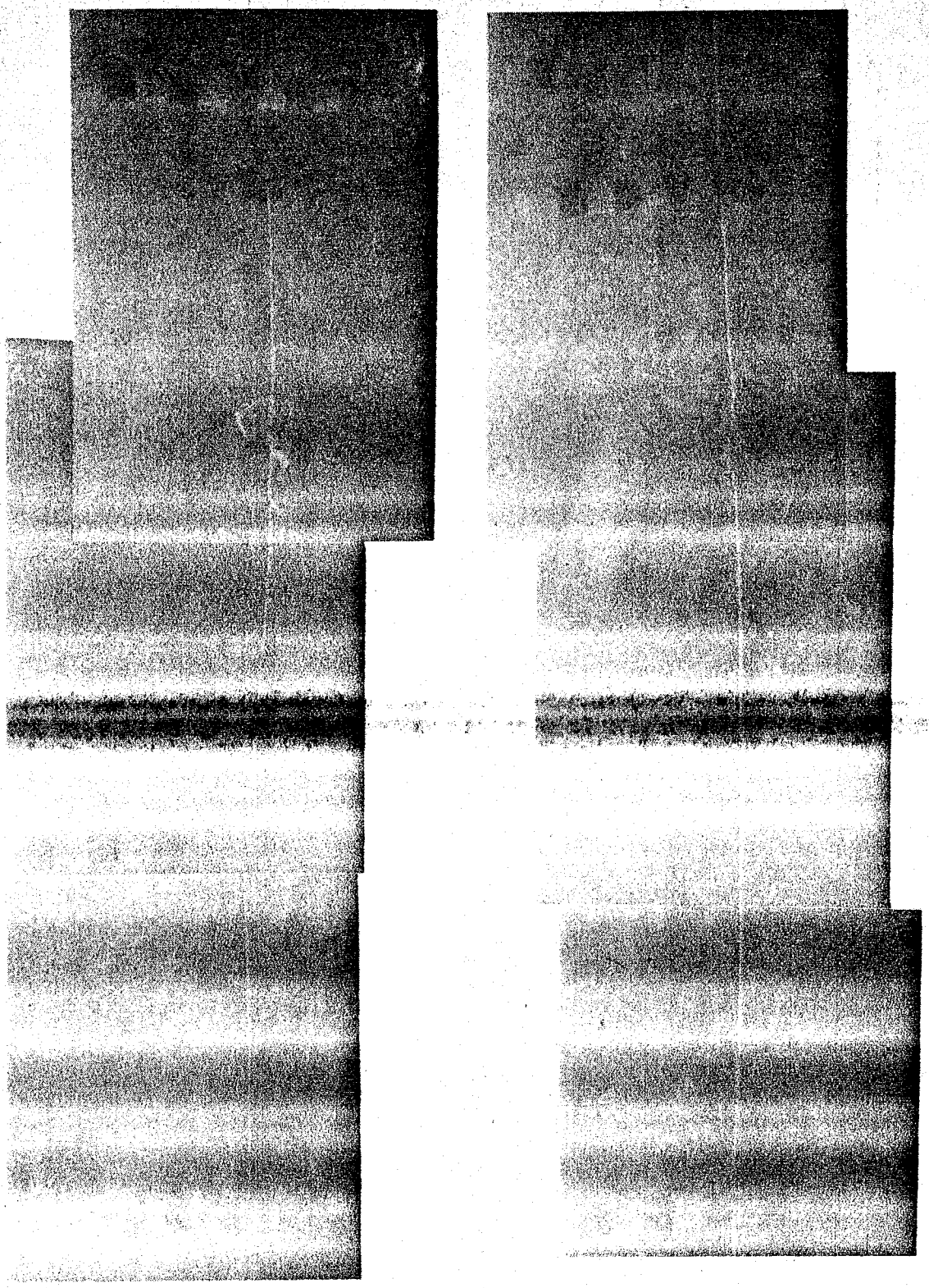
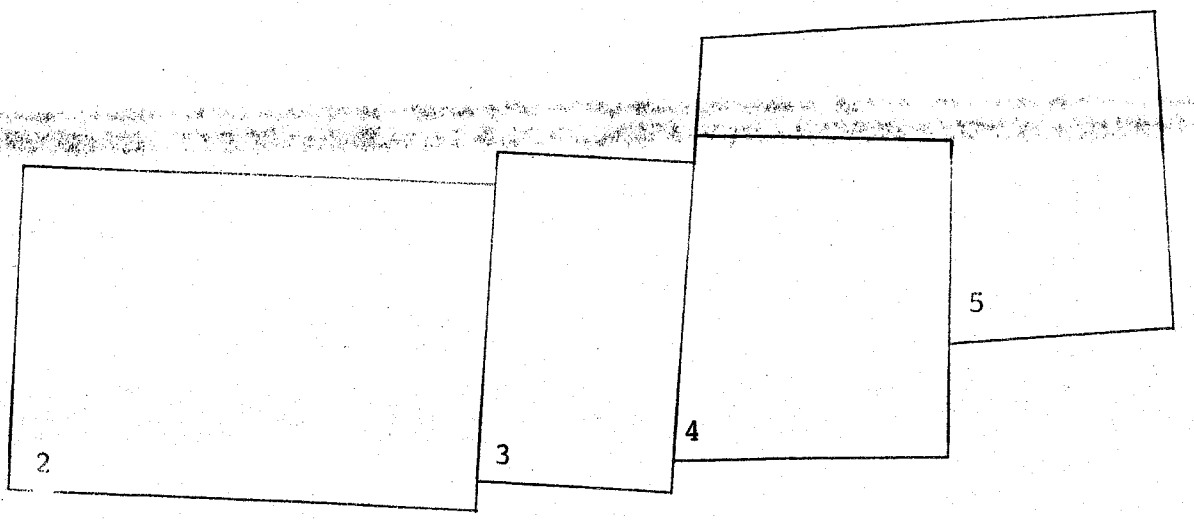
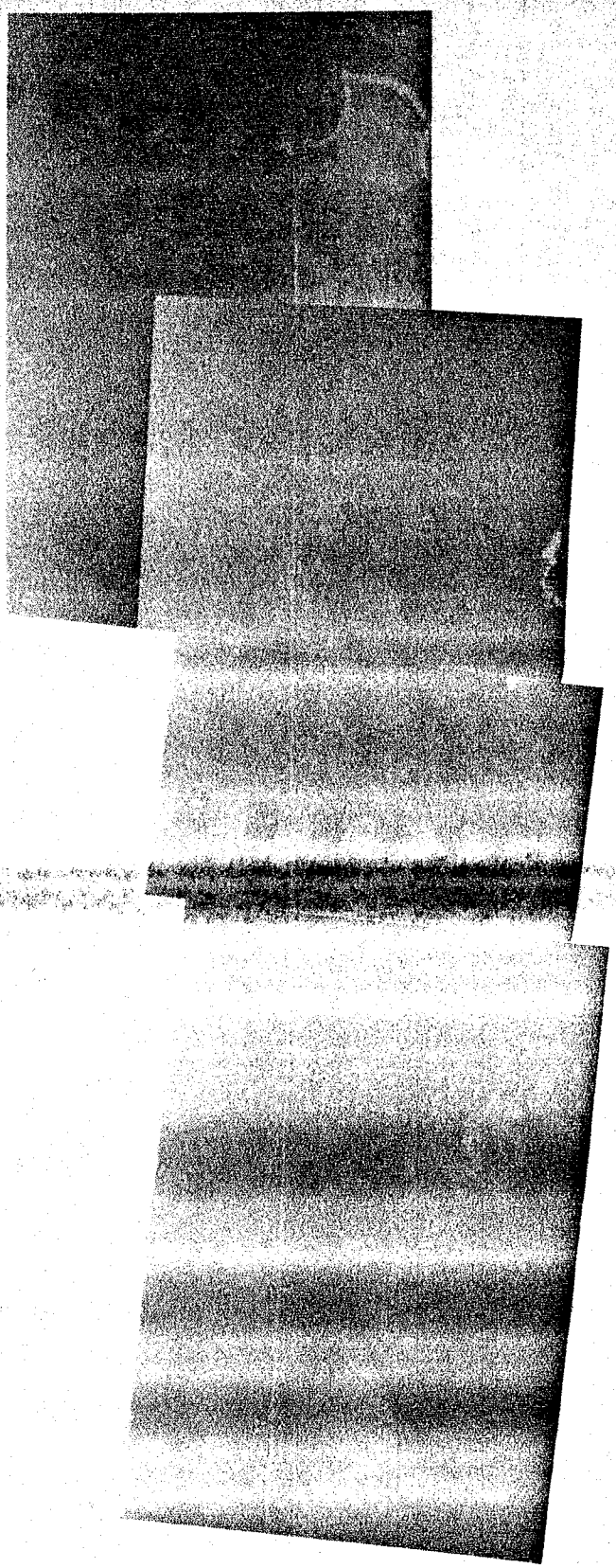


Figure 6. A composite view of the right side of a hole left by the patent tong. Photos from left to right, are numbered 2 through 5. The left edge of Photo 2 is approximately halfway across the hole. The scale divisions on the stakes are 1 inch. Photos taken on 20 November 1980.





APPENDIX I

Measurements on Vessel and Escalator Dredge Used in Hampton Flats During September and October 1980.

A. Vessel (PHOEBE JO)

Length: 44 ft

Beam: 21 ft

B. Escalator dredge

Width of opening at head of dredge: 36 inches

Width of water manifold (10 jets): 37 inches

Depth of cut: 5 inches

Width of runners: 4 inches

Length of conveyor belt: 39 feet

Width of conveyor belt: 18 inches

Width of water intake pipe: 6 inches

Width of hose from pump to manifold: 4 inches

Operating water pressure: 40 lb/in^2