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An investigation, testing and modifying of gear to harvest oysters and shell : final contract report for the period 1 July, 1973 through 30 June, 1975

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AN INVESTIGATION, TESTING AND MODIFYING OF GEAR TO HARVEST OYSTERS AND SHELL

Final Contract Report for the Period
1 July 1973 through 30 June 1975

Contract No. 3-193-R

By

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glenn file in Hydraulic escalator files along with requests for letters etc

INTRODUCTION

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During the 1974-75 contract period the hydraulic escalator[1] was modified and tested in the York and Rappahannock Rivers. The tests showed that the harvester was capable of raising large quantities of oysters from various types of bottoms. Moreover, these oysters were not broken or crushed, were free of silt or grit, and the apparatus caused only minimal damage to the bottom.

The modification were made from January to April and field testing began in May 1975 in the York and Rappahannock Rivers on public and leased bottom and on several types of substrate. The device was demonstrated for oyster growers, television companies, the press, representatives of the Virginia Marine Resources Commission, the Maryland Department of Tidewater Fisheries and a representative of the National Marine Fisheries Service.

A total of 16 trials or demonstrations were completed which are listed in detail chronologically in the appendix.

MATERIALS AND METHODS

Modifications 1974-75

Modifications consisted of the construction of a new escalator frame, and modifying the suspension system of the harvester head.

[1] The essential operational details of the harvester are shown in a series of detailed photographs in last years annual report (3-192-R, 1973-74). Therefore the details will not be repeated here.

The construction of the new escalator was necessary for several reasons. The older one has been in use for many years and corrosion had reduced the thickness of the steel to the point that the structure was unsound. Also, it was too long and heavy for efficient use with our research vessel the Mar-Bel. The new escalator was constructed in January and February by the LeMay Welding Company at Greenville, Maryland. It measured 29.5 ft long as contrasted to 32.5 ft for the older one and was constructed using expended metal to strengthen the side; it weighed about 200 pounds less than the one it replaced (Figure 1). The installation and testing of the new escalator was completed during April 1975.

The second modification was to change the method of suspending the forward end of the harvester from the boat. During the previous year it had been suspended by a wire cable directly below the out-board end of a 2.5 inch horizontal steel pipe which projected 3 ft out-board from the starboard-side of the boat. This pipe (at right angles to the length of the boat) was welded to the top of the two verticle 4 in. steel stantions located just behind the cabin of the boat. The wire connected to a short bridal, one end of which was attached to the end of the escalator the other to the top of the harvester head. This method of suspension was unsatisfactory since tests indicated that it did not allow the harvester head to slide over the bottom at the correct angle.

The modification consisted of suspending the harvester head from the end of a steel boom which projected forward at about a 45 degree angle toward the bow of the boat. This modification made it possible to adjust the height of the harvester head over the bottom with much greater accuracy than previously (Figure 2).

Operational Parameters of the Harvester

Studies during May, June and July 1975 established operational parameters of the harvester. That is, water pump pressure, rotational speed of the drums to which the steel tines are affixed, boat speed and escalator belt speed. A summary of these tests follow:

A. Rotational speed of the flexible steel tines. A basic part of the harvester developed under this contract, was the concept of the two rotating drums to which were affixed flexible steel tines. These tines "dug" or pulled oysters or shell from the bottom prior to their being pushed by water jets onto the moving escalator belt which carried them to the surface.

It was established after a series of tests in the York River on various types of bottom that a rotation about 1 rps gave optimal results. A more rapid rotational speed up to 5 rpm, the harvester actually took fewer oysters. Also, when the drum revolved about 5 rps or higher, a vortex was created in the water which disturbed bottom sediment.

B. Water pressure of the jets. Tests indicated that a water pressure of 50 pounds was sufficient to push oysters from the tines onto the escalator belt. Moreover, it was sufficient to remove almost all the mud or sand adheaved to shells or oysters. Several tests in which the water jets were turned off showed that the harvester would not function without their assistance.

C. Boat speed and speed of escalator belt. Tests indicated that a forward speed of the boat between 1/4 to 1/7 knot gave good results. At this speed, a belt speed of about 1/2 to 1 ft/sec seemed optimum. When the belt speed was increased to higher rates, 2-3 ft/sec, it had the effect of "washing" shells or oysters back down the belt.

Efficiency of the Harvester

The harvester was successfully operated on types of oyster bottom in the York and Rappahannock Rivers during May, June and July 1975. In these tests it obtained oysters in commercial quantities with few if any mechanical problems. Moreover, it operated satisfactorily under marginal weather conditions with waves 2 to 2.5 ft high.

In the Rappahannock River on leased bottoms where oysters were planted over 6 to 12 inches of shells embedded in a soft mud matrix, oysters were raised on the escalator belt at rates ranging from 30 to 120 bu/hr. In the York River, on planted leased bottoms, where the substrate was a moderately firm sand-clay overlain with a thin layer of shell, 24 bu/hr was harvested. In the same river, on public oyster ground, where the substrate was very firm and composed of a sand-clay shell matrix, the harvester obtained 30 bu/hr. On bottoms which had previously been harvested in both river systems the catch ranged from 1 to about 7.5 bu/hr.

In the preceeding tests it was obvious that the rate at which oysters were raised under any given belt speed, boat speed and rotational speed of the harvesting drum was largely a function of density of

oysters on the bottom. That is, the higher the oyster density, the higher would be the catch per hour. However, this study did not evaluate density of oysters on the bottom prior to the tests.

The harvester was most efficient in raising shell. In the York River on old leased bottom where shell was partially or wholly buried in a moderately firm sand-clay matrix, from 30 to 120 bu/hr were collected. On a harder bottom in the same system on Green Rock, which was classed as a natural oyster rock and where shell was more abundant, the harvest of shell was from 180 to 774 bu/hr. On a third type of bottom in the York, with a moderately firm sand-clay bottom overlain by a thin layer of shell, the harvest rate was estimated at from 60 to 180 bu/hr.

In the Rappahannock River on leased bottoms where 6" to 12" of shell were used to harden the bottom prior to planting oysters up to 906 bu/hr of shell was harvested.

Quality of Oysters Raised by the Harvester

In all tests the shells and oysters raised by the harvester were free of adhesing sand or mud. The reason for this was that they were washed free of this material by the jets of water which pushed the oysters and shell material from the tines onto the moving escalator belt. Also the material was "washed" while it was transported to the surface by the belt.

In almost no instances were oysters broken, cracked or fragmented by the action of the harvester under the operational speeds tested.

Effect of the Harvester on the Substrate

A test was made to evaluate what effect the harvester had on the bottom. This test was made by first operating the harvester on Green Rock in the York River over a distance of about 200 feet. This was followed by a study of the area by a diver using SCUBA. The tract covered by the harvester was marked by buoys and stakes. The bottom in the study area was classed as a natural oyster rock composed of a matrix of sand-clay and shell which extended to a depth of at least 2 to 3 feet. During this test the harvester raised shell at the rate of 774 bu/hr and oysters at about 30 bu/hr.

The diver reported that the path covered by the harvester was from about 3 to 4 inches deep which is just about the distance the rotating tines extended below the surface of the runners which slide over the bottom. The width of the tract is about 28.5" which is about the width of the rotating drum to which the flexible tines are attached.

The shells and oysters raised by the harvester fell back partially in the shallow trench and also in an area about 2 to 3 feet on each side. The diver did not observe any crushing or depression of the bottom associated with the steel runners on which the harvester slid over the bottom.

There appeared to be no change in the bottom density immediately below the harvested area. The diver reported that he probed the bottom of the trench with a steel rod and observed that the bottom was as firm in the trench as it was a foot or two outside.

It was concluded that the harvester removed the oysters and shell with only a minimal effect on the bottom layer immediately below that which was removed.

Working Depth of the Harvester

The harvester was tested to a depth of about 9 feet. The escalator used in these tests was 29.5 ft. If a longer one was used (35 ft) we estimate the escalating might be worked at a depth of about 15 ft.

DISCUSSION

The harvester developed by VIMS has been demonstrated to be efficient in harvesting oysters from planted and natural bottoms and we believe that one of similar but modified design might be used to advantage by the private sector of the Virginia Oyster Industry.

Suggested modifications would include:

A. The escalator system should be mounted on a catamarran type hull with the escalator between the hulls. This arrangement would give those culling oysters or shell better access to the catch as it came up on the belt and would make culling more convenient than a side mounted system.

B. Construct the catamarran hull so the end of the escalator belt would empty onto a flat-topped barge which could be towed behind. In this way, if culling was not necessary, large quantities of shell or oysters could be harvested with a minimum of effort.

C. Construct the harvester head out of light weight alloys.

The advantages of using the present design rather than tongs or dredges now used to harvest oysters are as follows:

A. When tongs or a dredge are used to harvest oysters the oysters and shell raised from the bottom are dumped on the deck of a boat. Here the oysters and unwanted shell are separated by hand and the unwanted shell is either shoveled or pushed over the side.

In using the escalator, one step is eliminated. The oysters may be culled from the moving belt and the unwanted shell is returned to the bottom with no effort on the part of the culler. This, of course, is a saving on labor.

B. A harvester similar to that developed by the Institute may be operated by two persons. Frequently, a dredge boat must have a crew of three for efficient operation.

C. The oysters are raised by the escalator free of adhering mud or sand. This is seldom the case with oysters tonged or dredged from the bottom. Clean oysters are a decided advantage since mud or sand adhesing to oysters must often be washed off prior to their being shucked.

D. Oyster tongers are becoming increasingly difficult to hire because of changing socio-economic conditions. The harvester offers a satisfactory substitute for this type of labor.

E. The harvester is most efficient in harvesting shell partially or wholly buried in the bottom and neither tongs or a dredge can do this with any degree of efficiency.

Shells are used as cultch material as sites for attachment of oyster larvae. Shell which is buried in the bottom is useless for this purpose and oyster gerowers often pay 25¢/bu for shells. Our tests indicate that the harvester may harvest up to 900 bu/hr or about 7200 bushels in an 8 hour day. Therefore, the harvester would be of value in obtaining cultch.

SUMMARY

The harvester developed by VIMS under contract 3-192-R is capable of harvesting oysters at rates up to 120 bu/hr. The oysters are not damaged by the action of the harvester and are raised on the belt largely free of mud and sand. Of major importance is that the device has a minimal impact on the bottom. Because of these reasons we feel that the harvester should have a defenite place in the future of the Virginia Oyster Industry.

APPENDIX

There follows the results of a series of demonstrations and tests of the escalator harvester completed in the 1974-75 contract period.

23 May 1975

The harvester was operated for about 1.5 hours on a private oyster lease belonging to a Mr. Tillage, located in the York River about 0.5 mile above Gloucester Point, Virginia (5.5 miles above the mouth of the system). This bottom had not been planted with oysters in about 15 years. It contained scattered oyster shells buried from 1 to 2 inches in a firm sand-clay mixture. The depth was about 9 ft MLW. Test on this date evaluated various rotor speeds and several methods of suspending the harvester from the boom.

In these tests the gear obtained shell at an estimated rate of about 1.5 to 2.0 bu/min.

27 May 1975

The harvester was operated again on Mr. Tillage's leased beds for about two hours. Tests were made to determine the optimum angle of suspending the harvester head from the boom. Shells were raised at an estima ted rate of 0.5 to 2.0 bu/min (30 to 120 bu/hr). Tests were made to determine the optimum rotational speed for the drum to which was affixed the flexible steel tines which dug oysters from the bottom. These tests suggested a rotational speed of from 1 to 5 rpm; one were more effective than higher rates but that more tests were

needed. During these tests the belt speed of the escalator was from about 0.5 to 1.0 ft/sec.

29 May 1975

The harvester was operated on leased bottom in the York River belonging to the J. W. Ferguson Oyster Company, Remlic, Virginia. This bottom was located 14.5 miles upriver from the mouth of the system, 0.5 mile above Clay Bank, Virginia. The bottom was moderately firm sand-clay overlain with a thin layer of shell. The water depth was about 6-7 ft MLW. The belt speed was about 1 ft/sec; rotor speed was about 1 rps.

A part of the bottom tested had previously been harvested; the remainder was unharvested and contained a marketable crop of 3 to 4 inch oysters. The oysters brought up by the belt on both types of bottom were picked off the escalator belt and the volume measured; the results follow.

Trial Number	Catch oysters bu/min. Harvested Bottom	Area Not Harvested	Shells
1	0.1		Estimated 1.0 to 3.0 bu/min.; about 25% of this was buried shell.
2		0.3	
3		0.5	
4		0.5	
5	0.1		
6	0.1		
7		0.5	

On the bottom previously harvested the average catch was 0.1 bu/min or 6 bu/hr; on the unharvested bottom it was 0.4 bu/min or 24 bu/hr. Shell made up about 75% of the catch. The oysters and shell brought up by the escalator were exceptionally free of sand or mud. Also the oysters raised by the harvester were not broken, chipped or crushed.

30 May 1975

The harvester was evaluated on leased bottom on the south side of the York opposite Gloucester Point (5.0 miles above the mouth). This bottom was used by a lease holder about 20 years ago to culture oysters, but has not been used since that date. At the time of this test the bottom contained few living oysters but much shell embedded just below the surface in a firm sand-clay bottom. The water depth was about 8-10 ft MLW; belt speed was from 0.5 to 1 ft/sec. Shell was from 1-3 in. thick on the belt were free from sand or mud; none were broken by the action of the escalator.

6 June 1975

On this date tests were made in the Rappahannock River on leased bottom belonging to Mr. Fred Garrett, Center Cross, Virginia, 25.5 miles above the mouth of the system. The bottoms on which the tests were conducted were "made" since large quantities of shells (10 to 15 thousand bu/acre) were initially planted on a soft mud bottom. This was a necessary preliminary step to firm the bottom prior to planting seed oysters.

Four areas were evaluated:

A. An area where shells had been planted 6-12 in. deep but containing few living oysters.

B. An area where shells had been planted 6-12 in. deep and then overplanted with oysters several years ago, but the oysters were harvested in March prior to the test. A few live oysters remained on the plot.

C. An area where shells had been planted 6-12 in. deep; this was planted in early spring 1975 with James River seed oysters (about 500/bu/acre).

D. An area where shells had been planted 6-12 in. deep; this was planted in 1973 with seed oysters. At the time of the test the oysters were mature and ready to be harvested.

The test of the harvester on each of the four bottoms lasted from 5 to 15 minutes. The rotor speed was about 1 rps; belt speed was about 1 ft/sec.

On Plots A and B shell were raised almost continously 2 to 5 in. deep on the belt. The rate at which shell was raised was estimated by assuming an average depth of shell on the belt of 3.5 in. and a belt speed of about 1 ft/sec. Since the width of the escalator belt was 18 in. it may be calculated that in 1 minute the belt raised about 45,360 cubic inches of shell (60 sec. X 12 in. X 18 in. X 3.5 in). In a Virginia bushel there are 3,004 cubic inches, therefore, in one minute the belt raised about 15.1 bushels (45,360 ÷ 3,004) or about 906 bu/hr.

The harvest rate of oysters was determined by picking oysters from the belt as they were raised into a 10 qt measure. On Plot C oysters were abundant; they raised at about 0.5 bu/min or about 30 bu/hr. On Plot D they came up at about 2 bu/min or 120 bu/hr. On Plots A and B oysters were scarce.

The oysters and shell raised were very clean; none appeared to be broken by the action of the harvester.

Mr. Garrett, the leaseholder, witnessed this demonstration.

9 June 1975

The harvester was demonstrated on Mr. Garrett's bottoms to Mr. Cranston Morgan and Mr. Alan Drewer who are affiliated with two of the major oyster companies in Virginia. During this demonstration the harvester was operated on the bottom described as A, B and C on 6 June. Boat speed, rotor speed and belt speed were about the same as during the preceeding test. The harvester operated satisfactorily as it did previously on the same bottoms.

10 June 1975

The harvester was demonstrated on Mr. Garrett's bottoms again to Mr. Lawrence H. Couture of the National Marine Fisheries Service and to Mr. Cowart, an oyster grower. Also present was Mr. Howard Hudnall, Chief Repletion Officer of the Virginia Marine Resources Commission. The harvester was operated for about 20 minutes on bottoms A, B and C. The water was quite rough with waves 2 to 2.5 ft high. Even under these marginal conditions the harvester operated

successfully and catch of shell and oysters was about the same as on 6 and 9 June.

18 June 1975

At the request of Mr. Cranston Morgan, Weems, Virginia, we evaluated the harvester on one of his leased areas in the lower Rappahannock River. This area was barren, and the harvester raised only about 1 bushel of oysters in 1 hour of operation.

9 July 1975

The oyster harvester was evaluated again at Green Rock in the York River. This is a public rock located 11 miles up river from the mouth of the system. It has a firm sand-clay bottom in which shell is embedded to a depth of 2 to 3 ft or more. The water depth was about 6 ft MLW. It was planted with oysters by the Commonwealth in 1974, but most of the oysters had been tonged from the area prior to our test.

During the tests we maintained a boat speed of about 0.25 knot; the escalator belt speed was about 0.5 ft/sec. It was calculated that shell raised at the rate of about 1-2 bu/min (60-120 bu/hr). The catch of oysters was measured by picking them off the belt by hand and measuring the catch in a 10 qt bucket.

A series of tests confirmed our earlier observations that a rotational speed of 1 rps of the drum gave a higher catch rate than more rapid rates of rotation.

Test No.	Time needed/min. to catch 1 bu.	Rotor Speed rps	Bu. shell/min.
1	12	5	
2	10	5	
3	12	5	
4	6	1	From 1-2 bu/min. estimated
5	8	1	
6	10	1	
7	9	1	
8	10	2	
9	9.5	2	

SUMMARY

Rotor Speed rps	Avg. time in minutes to catch 1 bu. of oysters	Catch oysters bu/hr
5	11.3	5.3
2	9.7	6.2
1	8.2	7.3

At 5 rps the spinning rotors set up a vortex in the water which seemed to erode the bottom beneath the rotating tines. Therefore, 1 rps was used as a standard speed in all further tests.

10 July 1975

A trial was made in the York River on a leased bottom belonging to the York River Oyster Company, Gloucester Point, Virginia. Mr. Windom Hogge, owner of the company accompanied us. The bottom of the work area was soft mud overplanted with shells and then with seed

oysters. However, the area had been harvested prior to our trials. The boat was "run" about 500 ft over the bed for a period of about 8 minutes. During this time shell was raised at 2 to 3 bu/min. The oysters raised on the belt were culled from the shell and about 1 bushel was taken. Calculations indicate that this is at the rate of about 7.5 bu/hr. The belt and rotor speed were about 1 ft/sec. and 1 rps, respectively.

15 July 1975

The Institute on this date gave a demonstration of the harvester in the York River at Green Rock for three local television companies which are affiliates of CBS, NBC, and ABC, and for four local newspapers. Television coverage of the harvester in operation appeared on all local stations (Newport News, Norfolk, and Richmond) and later on in Rhode Island, Oregon, New Mexico and other locations. Articles concerning the harvester appeared in all local newspapers.

17 July 1975

The Institute gave a demonstration of the harvester to supervisory personnel of the Virginia Marine Resources Commission at Green Rock in the York River. The following members of the Commission were present:

Mr. James E. Douglas, Commissioner

Mr. Robert Hancock, Chief Law Enforcement

Mr. Herbert Sadler, Supervisor

Mr. Edgar Miles, Supervisor

Mr. Ralph Dameron, Jr., Supervisor

Mr. Ben Daniel, Supervisor

Mr. Howard Hudnall, Conservation Officer

Mr. S. Sewell Headley, Board Marine Resources Commission

The harvester worked well in tests lasting over one hour. The harvester consistantly raised from 1-3 bu shell and about 1/2 bu of oysters per minute.

18 July 1975

A demonstration was given of the harvester for Mr. George Milton, Dean Oyster Processer, and a grower, Mr. Harold Stine, President, Charles City Maryland Waterman's Association, and Mr. A. C. Carpenter representing the Potomac River Fisheries Commission. In this test conducted on Green Rock in the York River, the harvester raised from 2 to 3 bushels of shell per minute; catch of oysters was about 0.5 bu/min. The total operating time was about 0.5/hour.

28 July 1975

A study was made of the effect of the oyster harvester on the bottom substrate. The mechanical harvester was operated on Green Rock and the track over which it operated was marked by buoys and stakes. This track was later examined by a diver using SCUBA.

Operational speeds of the boat and gear were as follows:

Drum speed:	1 rps
Water pressure jets:	50 lbs/sq in.
Belt speed:	1 ft/sec.
Speed of boat:	1/7 knot
Shell depth on belt:	2-4 in. (avg. 3")

Under these operating conditions the shells came up on the belt about 3 inches thick. They were clean and free of nearly all sand or mud; none appeared to be broken or fragmented by the action of the harvester. Calculations based on belt speed and depths of oysters similar to those made previously indicate that the gear was raising about 12.9 bu/min or 774 bushels of shell and oysters per hour (60 sec. X 12" X 3" X 18" = 38,800 = 12.9 bu/min).

A distance of one hundred feet was observed along the track with SCUBA gear by Mr. J. P. Whitcomb of VIMS. The width of the track was measured with a yard stick to be between thirty-two and thirty-six inches. This is almost the same width ( ) as the tines on the rotating drum. The depth of the track varied but in heavily shelled bottom the depth was between three and one-half and four inches. Occasionally a deeper depression was observed but these were only about one inch deeper and small in area. It is observed that the tips of the rotating tines are set to dig about 3 inches below the runners on which the head slides over the bottom.

The shell and oysters which fell from the belt back into the water did not appear to have fallen entirely back into the track. Some fell as far as 2 or 3 feet outside. Within the track the shells appeared to be in a horizontal arrangement. Many of the pieces of shell remaining in the track were small white fragments one to two inches across and there were no black shells. These shell fragments were not shell broken by the harvester but were of the kind commonly found in normal shell substrate 2 to 3 inches below the surface.

Outside the track, in a heavily shelled area, the bottom was covered with a light layer of sediment. Here the angles of the exposed shell surfaces would be described as random, making a very rough appearance.

There was no evidence of the runners making a path or crushing oysters and shells. While testing the track area with a three-eights inch diameter metal rod it was noted that the area inside and outside the track where the rod could be forced into the bottom for a distance of one or two inches. However, it was usually impossible to penetrate the bottom in any manner within or outside the track.

While transversing offshore toward the channel the depth of the track decreased to about one inch in depth about fifty feet from the stake. The bottom at this location appeared to be muddy sand. Closer examination revealed the heavy layer of shell was just below the surface covered with about three-eights of one inch of sediment. There were no oysters on the surface in the vicinity of the track. It is assumed that the mechanical harvester lost contact with the upper three inches of bottom here due to a slight increase in depth.

In summary, the harvester removes the upper three or four inches of the substrate without softening or breaking up the bottom below. Shells and oysters are not dumped entirely back into the track but distributed at least 2 or 3 feet outside. The shell in the track was cleaner or whiter than the surrounding bottom. The track was three and one-half to four inches deep, although there were fragments of shell in the track it is thought these fragments were caused not by breaking up larger shell but were similar to those which already existed in the substrate.

30 July 1975

A demonstration of the harvester was given for Harold Davis, repletion officer, Maryland Department of Tidewater Affairs on Green Rock in the York River. Also on the vessel were two of his assistants. The harvester worked well as it did in previous tests in this area.