A Mechanical Escalator Harvester for Live Oysters and Shell

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ABSTRACT–A mechanical oyster harvester has been developed by coupling a newly designed head with a chain-link conveyor. The head consists of a rectangular steel frame set on steel runners and two rotating drums armed with spring-loaded teeth. The teeth of the outermost drum rake oysters from the substrate. The teeth of the second drum and water jets impell the oysters to the escalator where they are brought to the surface. Harvest rates of 500 bushels of oysters an hour and 774 bushels of shell an hour have been achieved.

Introduction

A mechanical oyster harvester was designed, constructed and tested in Chesapeake Bay, Va., from 1972 to 1976.[1] It couples the escalator system of a conventional Maryland soft clam dredge with a newly designed head. Revolving spring-loaded teeth attached to two drums in the head pull or rake oysters from the bottom and horizontal water jets and the action of the revolving teeth impel the oysters onto a conveyor belt which carries the oysters to the boat. This design eliminates several problems associated with previously designed harvesters.

Most mechanical devices for harvesting molluscs are based on the design Fletcher Hanks developed in Maryland in 1954 to harvest the soft clam, *Mya arenaria*. It jetted water at high pressure into the bottom just ahead of a boxlike device which slices through the bottom. A blade extending about 16 inches below and slightly behind the jets guides the soft clams loosened by the jets onto a moving chain-link conveyor belt (Manning, 1957).

This design was later modified to harvest oysters in Canada (Medcof and MacPhail, 1955). Wheels were added, and the depth at which the blade cut the bottom was decreased. This oyster harvester was again modified to harvest hard clams, *Mercenaria mercenaria,* and other species (MacPhail, 1961; Godcharles, 1971; and Jolley, 1972).

Two harvesters have been developed on the west coast to harvest the Japanese oyster, *Crassostrea gigas*. One, the Bailey harvester, is very large, and it is based on the principle by which water currents set up by large impellers are used to create a flowing mixture of sand, water, and oysters under a head which rests on and makes a seal with the bottom. The moving oysters are deposited on a conveyor (Bailey, 1950[2]). The device is reportedly about 25 percent efficient (Quayle, 1969).

The second was developed by the Olympia Oyster Company in Washington. This harvester (patent pending) uses three units. The first consists of a 15- × 30-foot barge containing the pilot house, propulsion unit, an air compressor, and a powerful water pump. The second component is open and supports a harvester head and scoop similar to that developed by Hanks, which is towed over the bottom. As this head slides over the bottom, powerful horizontal jets of water sweep the oysters off the bottom into a collecting box. From this latter unit they are transported to the surface through a pipe by the air lift principle. The water-shell mixture is expelled into a barge with a screened bottom (Malloch and Kolbe, 1976).

The cutting blade is a necessary component to all but the Bailey harvester. The cutting blade operates satisfactorily on soft bottoms, but when bottoms contain significant quantities of embedded or buried shells, the scoop often encounters so much resistance that the efficiency of the gear is greatly reduced. Such hard substrates are common in many oyster growing regions.

Design and Construction

The harvester utilizes a conventional chain-link conveyor 39 feet long, suspended from a 40-foot Chesapeake Bay workboat with an 11-foot beam (Fig. 1). The harvester head consists of a rectangular boxlike structure which slides over the bottom on steel runners (Fig. 1, 2). Within this rectangular box are two chain-driven rotating drums powered by a variable speed hydraulic motor located on the top of the box. Each drum has six rows of spring-teeth (Fig. 3). In operation, the harvester's forward drum teeth are set to dig 3 inches into the bottom. The back drum teeth are set, permanently, to rotate flush with the base of the steel runners and about ½ inch forward from a short inclined plane which ends at the escalator belt; the inclined plane is set flush with the steel runners.

To operate the harvester the vessel is moved forward at about ¼ knot (25 feet/minute) and the teeth are set to rotate clockwise, facing the right side, at one revolution per second (60 rpm); at these speeds the harvester head slides forward on the runners and the teeth of the forward rotating drum separates the oysters from the substrate. The back drum teeth sweep oysters and shell

[1] Virginia Institute of Marine Science. 1973. VIMS scientists develop oyster harvester. Mar. Res. Inf. Bull. 5(11):1-2.

[2] R. H. Bailey. 1950. U.S. Patent No. 2,508,087.

loosened by the forward drum up the inclined plane and onto the upward moving escalator belt. Jets of water (50 psi) are directed toward the escalator to help move the oysters or shell up the inclined plane and to wash debris from the shell.

Most of the details of construction and the critical measurements may be obtained from the figures and Appendix, but certain aspects need emphasis.

The central core of each drum is a hollow 3-inch outside diameter (OD) pipe. Each end of this pipe is welded to a circular 5-inch diameter plate reamed at its center to receive a bushing; this basic unit turns freely on a 1⅜-inch stainless steel shaft (Fig. 4). Bolted to each 5-inch end plate is a circular 10-inch plate; around its circumference are six equally spaced 2-inch tapered plugs bolted to the disc. These plugs and their duplicates on the opposite disc hold six 28-inch long 1¾-inch OD hollow pipes. On each pipe are strung (through their central spring coil) the rows of flexible tines. The basal end of each tine is held firmly in a grooved strip welded to the 3-inch pipe. This system of construction allows removal of each row of drum teeth to replace broken teeth.

The cog-wheel drives for the drums are bolted to the outer face of each 10-inch disc.

The depth to which the forward tines penetrate the bottom may be adjusted. Each end of the spindle shaft of the rotating drum nearest the escalator passes through two elliptical steel plates fitted with bushings; this shaft also has bushings in the outer rectangular frame. This construction assures that the spring-loaded teeth always remain in a fixed position relative to the bottom and to the inclined plane. In contrast, the forward rotating drum has its bushings only in the two elliptical plates. Consequently, the forward drum may be adjusted and bolted in the most effective position for a particular type of substrate (Fig. 3, 5).

The high pressure water jets impact on the inclined plane inside the head just behind the after drum unit.

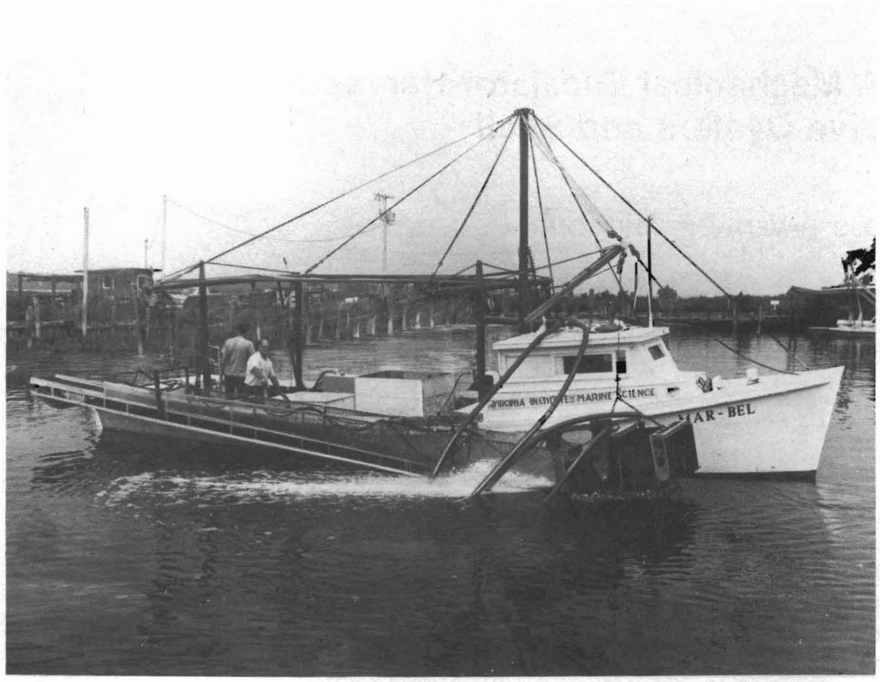

Figure 1.—Research vessel *Mar-Bel* showing escalator and mechanical head. Water pipes to jets are shown on the outside of the rectangular frame.

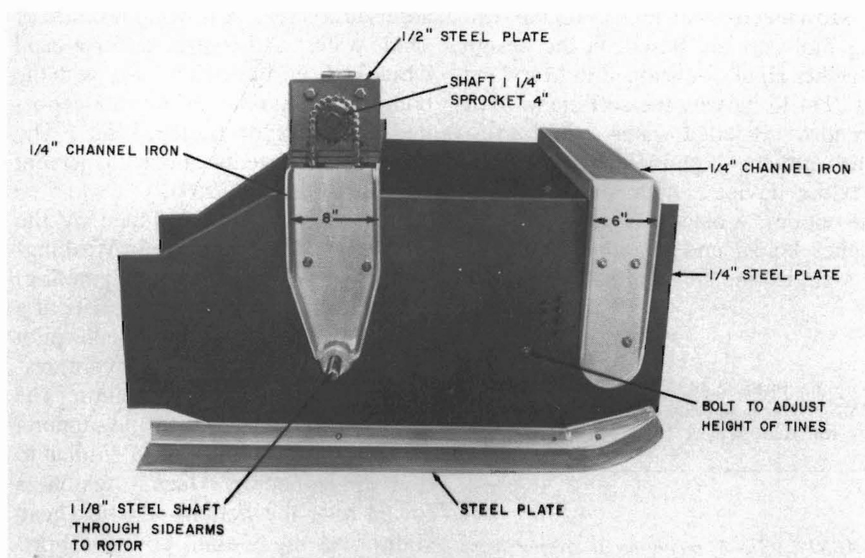

Figure 2.—Side view of escalator during construction showing method of attachment of hydraulic drive motor and details of frame construction.

Field Tests

The harvester underwent extensive field trials in Virginia during 1976 and 1977 on a wide variety of subaqueous substrates. In all instances, it removed the shell and/or oysters in its path to a depth of 3-4 inches.

In a typical trial in the Rappahannock

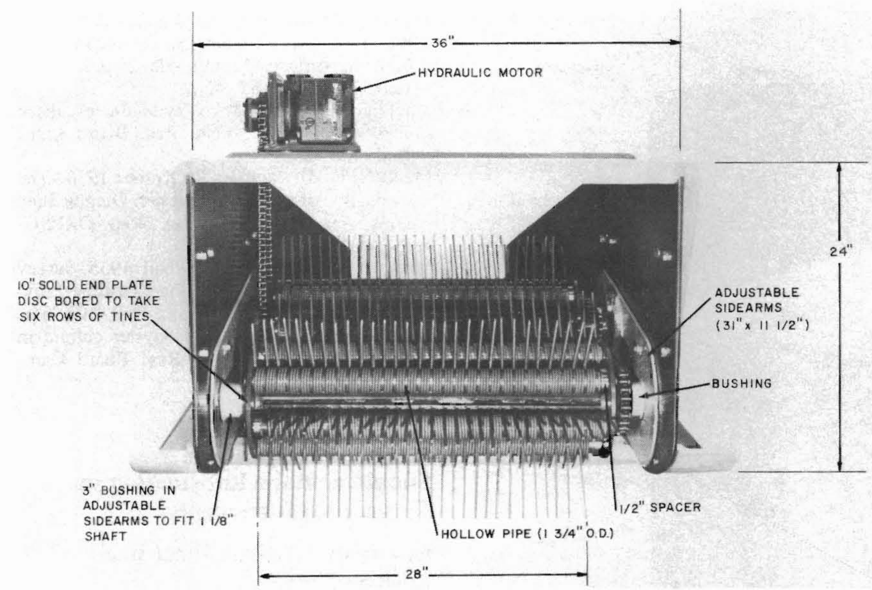

Figure 3.—Front view of head showing details of drums and the steel rake teeth.

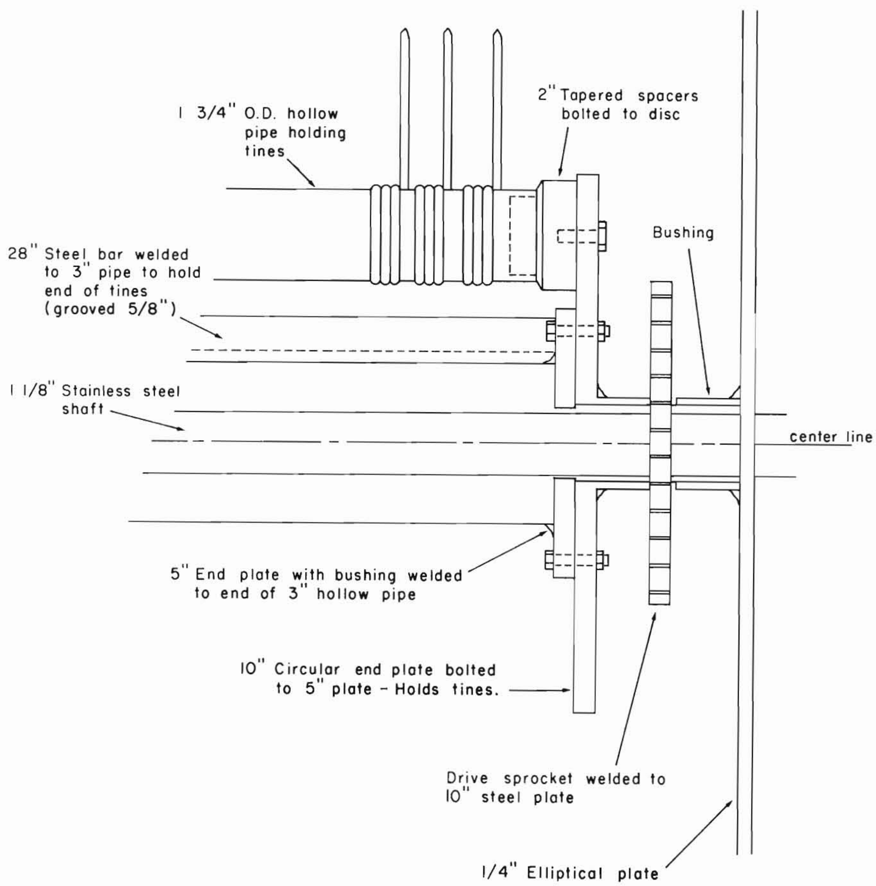

Figure 4.—Frontal view of the forward drum showing details of its construction.

River where seed oysters had been planted and oyster density was high, oysters were harvested at rates ranging up to 138 bushels per hour. The bottom was originally soft mud, but application of 5,000 bushels of shell per acre had firmed the bottom prior to planting the seed oysters.

In the York River on a firm sand-clay bottom where oyster density was very low, it harvested oysters at the rate of 27 bushels per hour. In the same estuary on a very hard shell bottom where oysters were scarce, shell material was raised at rates ranging from 180 to 774 bushels per hour.

In all trials, the oysters raised by the harvester were virtually undamaged. Moreover, the shell material and oysters had been washed free of sand or mud by the action of the jets. In all trials, it was observed that the harvester obtained less than about 5 percent blackened shell material (with the tines set at 3 inches), indicating that the harvester was skimming off only the surface layer and not harvesting the lower anaerobic substrate.

The preceding observations were corroborated by a diver. The harvester was first operated on an oyster bottom where the substrate was a hard matrix of sand, clay, shell, and a few oysters. During this test, shells and oysters were raised at the rates of 774 and 30 bushels per hour, respectively. Inspection of the bottom by a diver showed the teeth had dug a shallow trench 3 to 4 inches deep and 28 inches wide (the width of the rotating drums). The bottom of the trench was firm. It was concluded that the disturbance of bottom substrate was minimal and that it did not exceed that of drag-type oyster dredges.

In 1978 a slightly modified copy of the VIMS harvester was constructed by the North Carolina Division of Marine Fisheries and used during 1978 to harvest seed oysters (Burnett, 1979). The harvester worked well and harvested up to 500 bushels an hour.[3]

[3] Walter Godwin, Regional Coordinator, North Carolina Division of Marine Fisheries, Wilmington, NC 28405, pers. commun. August 1979.

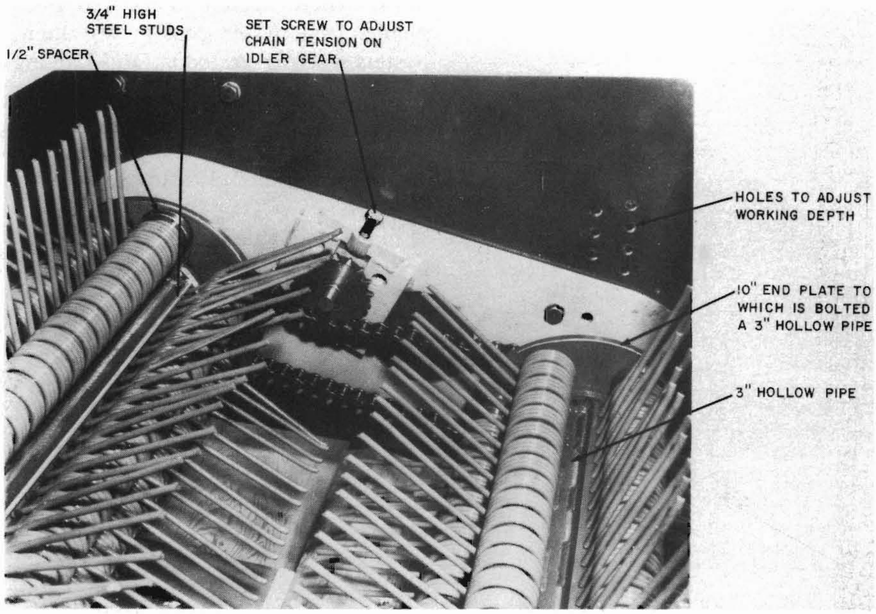

Figure 5.—Details of the elliptical adjustable plate, idler gear, and chain drive.

Discussion and Conclusions

The described harvester performed satisfactorily in a series of trials with catch rates of oysters ranging up to 178 bushels per hour and shell at 774 bushels per hour. A slightly modified design used over a year by the North Carolina Division of Marine Fisheries also performed satisfactorily. Catch rates of about 500 bushels an hour have been reported for this latter unit.

Observations by a diver indicate that when properly operated, only the top 3 to 4 inches of bottom are harvested, and disturbance of the surrounding bottom is minimal.

The harvester developed by VIMS has several advantages over other harvesters. It has no vertical jets which could dig deep trenches in the bottom or a projecting blade which could impede its forward motion on hard shelly bottoms.

During the field trials in Virginia, two persons operated the vessel and the harvester. One person culled the oysters from the belt, another steered and operated the harvester. If oyster density was high, an additional person would be needed to assist in culling.

The harvester constructed by the state of North Carolina utilizes a barge which it positions under the end of the escalator to receive the harvest. If the catch consists largely of oysters this system saves much labor.

While this harvester was primarily designed to harvest oysters, it has proven efficient in raising shell. Shell is an important adjunct to growing oysters since up to 5,000 bushels per acre are often planted as a substrate to collect spat. Cost of shell is about 25 cents per bushel when it is purchased from shucking houses. The use of this gear to obtain shell, we believe, could result in a substantial reduction in cost.

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Appendix

Supplementary Information on Critical Measurements

Box frame: ¼-inch sheet steel.

Bushing: brass.

Chain drive from hydraulic motor: size 50.

Drive sprockets: ⅜-inch thick.

Elliptical steel plate: 31 inches × 11½ inches × ¼ inch.

End plate: 5-inch diameter; ⅜-inch thick.

End plate: 10-inch diameter; ⅜-inch thick; six ⅝-inch holes for bolts around outer diameter; six ⅜-inch holes for bolts around axis.

Hydraulic motor: variable speed (constant torque).

Inclined plane: forward of escalator 18 inches × 12 inches.

Longitudinal bar welded to 3-inch pipe (to hold tines): 28 inches long, ⅞-inch wide, and ⅞-inch high; machined to form a channel ⅝-inch deep, ⅜-inch wide.

Pipes to hold tines: 28 inches long, 1¾-inch O.D.

Rotational speed of drums: 60 rpm.

Set screw to adjust tension: ⅜-inch diameter.

Skid width: 5¾ inches.

Spindle shafts:

- Forward shaft: 28 inches × 1⅛-inch diameter (solid).
- After shaft: 32 inches × 1⅛-inch diameter (solid).

Tapered spacers (2-inch): machined steel.

Water pressure: 50 pounds/square inch.