ARTICLES

A submersible pump produced results comparable to those of a vessel-mounted system.

DEVELOPMENT OF A SUBMERSIBLE PUMPING SYSTEM FOR A HYDRAULIC SURF CLAM DREDGE

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An electrically driven submersible pump was tested as a means of supplying water to a surf clam dredge. A 65-horsepower submersible pump was mounted on a 48-inch clam jetting dredge. The pump supplied 2,000 gallons per minute directly to the jet manifold of the dredge. Comparison tows were made with the submersible system and the standard vessel-mounted pumping system to determine their relative efficiencies. The submersible pump operated satisfactorily and gave results comparable to the vessel-mounted system. Advantages of the new system are ease of handling and greater efficiency in power transmission.

The history of the development of surf clam harvesting gear, like that of most other fishing gear, reflects a long, slow, evolutionary process. Advances have been dictated by the need to increase efficiency to keep the fishery economically feasible. Surf clam gear is advancing today at a more rapid rate than the early change from hand tonging to dredging. The use of a dredge towed by a vessel began in the 1920s, and the development of a hydraulic jet dredge took place during the mid-1940s. Since then, little change has taken place in the basic principles of hydraulic dredging, but the size and efficiencies of the gear have grown to the point where larger dredges do not appear feasible (fig. 1).

As dredges increase in size and greater flow rates to the jet manifold are required, the problems of handling the large hoses and the lost efficiencies in transferring water through them lead to the conclusion that a submersible pump mounted directly on the dredge would be a desirable development in the evolution of the surf clam dredge.

A submersible pump, driven by an electric motor, would eliminate the bulky, cumbersome hoses now used (fig. 2) and replace them with a single electric power line, which could be handled and stored on a winch (fig. 3). The

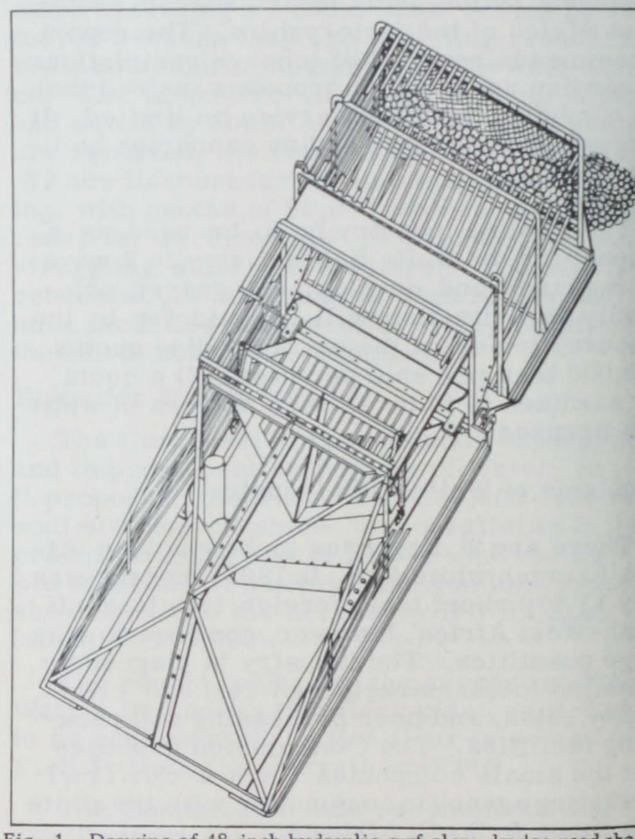

Fig. 1 - Drawing of 48-inch hydraulic surf clam dredge used aboard the "Delaware" for surf clam survey.

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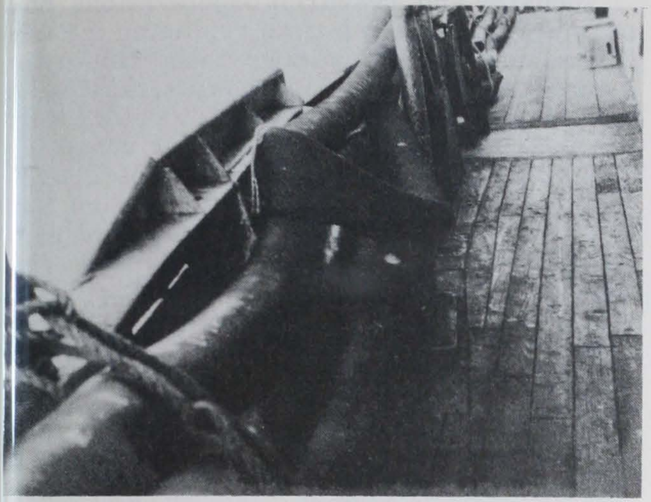


Fig. 2 - Clam jetting hose faked out aboard the Delaware.

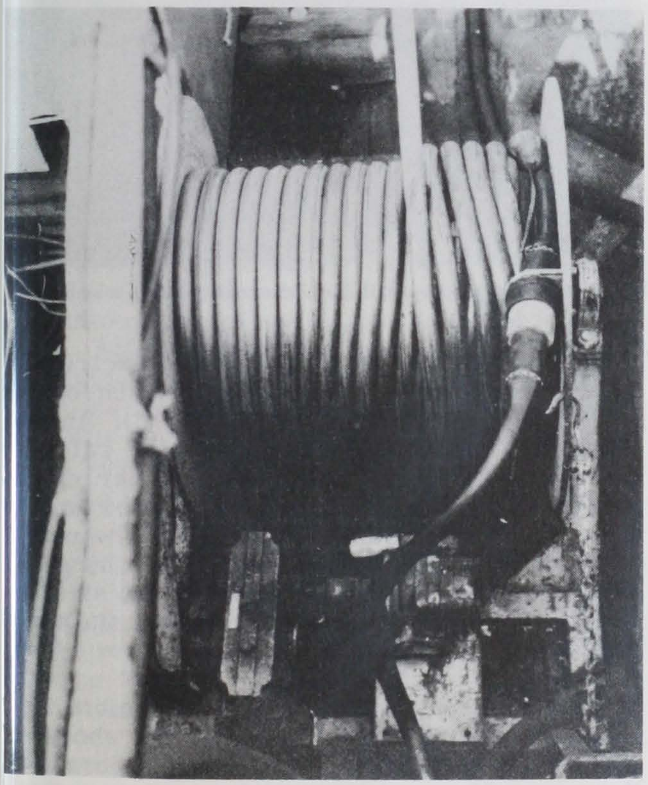


Fig. 3 - Electrical cable wound on winch showing shipboard termination watertight plug.

efficiency of transmitting electrical power to the pump is far greater than transporting water through hoses, a factor that becomes increasingly important as the water volume and pressure and length of hose increase.

DEVELOPMENT

Before the 1920s, hand tonging and hand raking were the common methods used to harvest surf clams; during the 1920s, dredges were developed that were towed with powered vessels. The dredges were commonly 18 to 28 inches wide with a scraper or knife blade attached between the dredge shoes at a fixed depth. These dredges were prone to clogging with sand and mud, and many clams were broken by the blade. These deficiencies and the need for even more efficient equipment led to the development of the hydraulic jet dredge in the 1940s (Westman, 1946).

Hydraulic dredges, a logical step from the dry scraper types, were developed by adding to the dredge a pipe manifold with a few nozzles or jets directed downward in front of the blade. A fire hose connected the manifold to a pump mounted on the towing craft. Because the water jets loosened the bottom, the dredge could cover a greater area in the same amount of time, and areas were opened to dredging that were too hard for the dry dredges to operate effectively (Westman, 1946). The incidence of broken clams (Parker, 1966) and damaged meats in the catch were reduced substantially by this new development (Ruggiero, 1961).

Since its introduction, the hydraulic dredge has increased steadily in size until now 40-inch blades are common, and a dredge with an 84-inch blade is in service on the east coast. The volume of water required has increased correspondingly with the dredge size; a 40-inch or 48-inch dredge requires about 1,600 to 1,800 gallons per minute--at about 60 pounds per square inch differential pressure between the inside of the manifold and the outside water pressure, regardless of depth. Vessels fishing with these size dredges use a 5-inch or 6-inch inside diameter hose of rubber and fiber especially developed for the clam dredging industry. The largest dredge (84 inches) needs two pumps and two hoses to supply water to the manifold (fig. 4).

The use of hose to supply water to the manifold has some disadvantages that can be overcome by the use of a pump mounted directly on the dredge. The head loss or energy drop of the water in a hose is proportional to both the hose length and flow rate; in the usual lengths (200 to 250 feet) used aboard commercial vessels, this loss is 20 to 30 pounds per square inch, or about 25 percent (table 1--see note on p.). Transmission losses can be reduced greatly by transmitting energy to the dredge in the form of electricity. This factor becomes more important as deeper depths are fished. An electric cable is easily stored on a powered reel, eliminating the heavy work of handling the hose. The installation of a generator, switches, cable, and cable handling winch is a good deal simpler than installation of large sea chests, valves, pump, and piping in either new construction or conversion work.

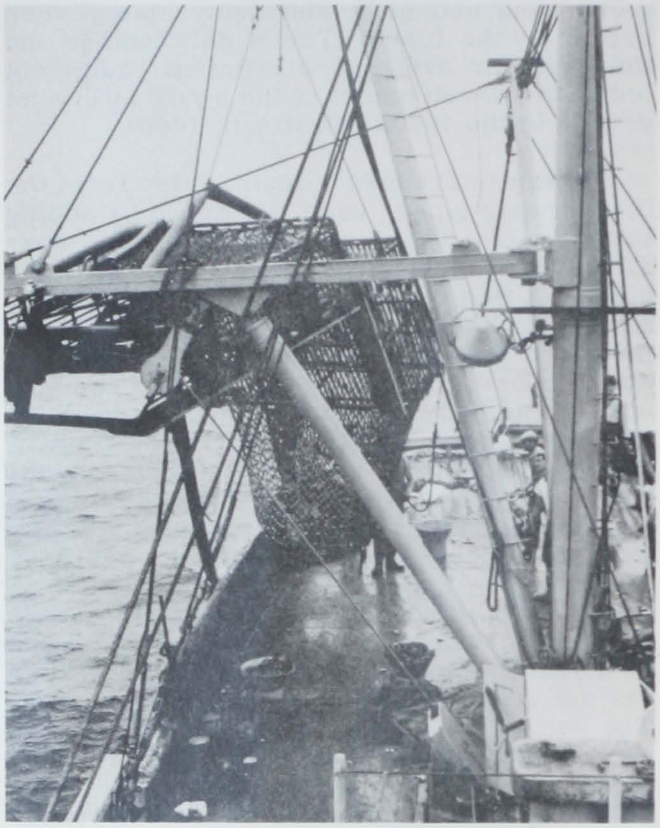


Fig. 4 - An 84-inch dredge used aboard the "Gail Borden" for commercial surf clamming.

METHODS AND PROCEDURES

Early in 1965, the M/V "Delaware" was fitted out for a surf clam survey along the coast of the Mid-Atlantic Bight. A sea chest, a 6-inch centrifugal pump powered by a 110-horsepower diesel engine, and the necessary deck piping and hose were installed to supply water to a 48-inch dredge. The jet manifold on the dredge is V-shaped and has 14 nozzles pointed downward and 4 additional nozzles (blowback nozzles) pointed aft to help keep the cage and chain bag clear of sand and mud. During our surf clam surveys, many different-sized jets have been tried ranging from 0.50- to 0.81-inch diameter, and we have concluded that 0.625-inch diameter nozzles produce the optimum flow and pressure with this equipment (table 1).

Industry and research organizations have considered for some time replacing the vessel-mounted pump and hose connection with a submersible pump. Such a system was envisioned for the Gloucester Exploratory Fishing and Gear Research Base's new vessel, the "Delaware II," which is to have ample electric power available for a submersible pump. Delays in delivery of the new ship, however, made it desirable to progress with plans to refit the Delaware for such an operation.

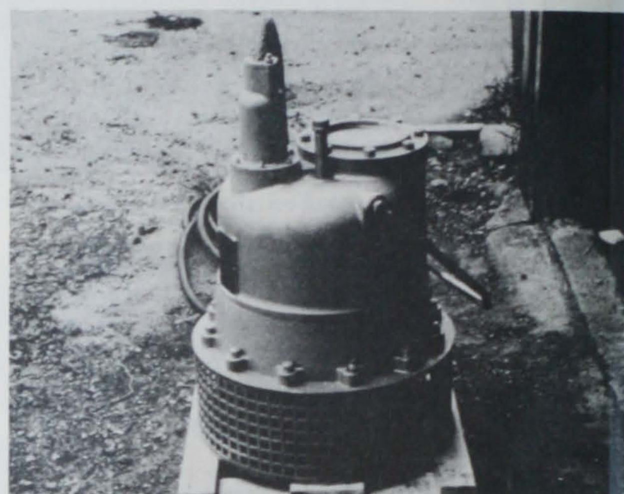
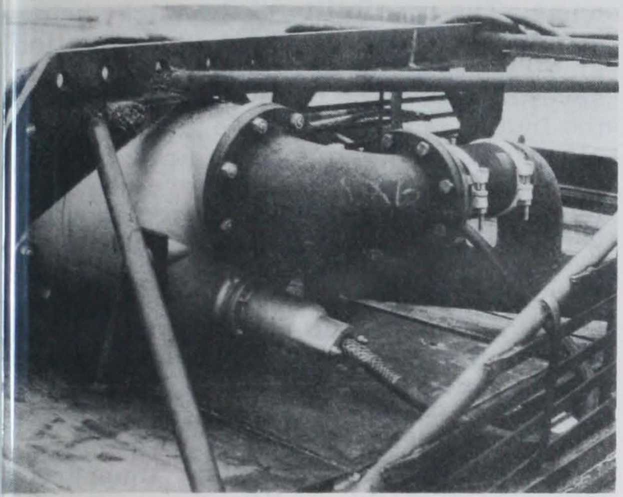


Fig. 5 - Commercially available electrically driven submersible pump.

A commercially available electrically driven submersible pump was acquired for use on a modified 48-inch dredge (fig. 5). An oil-filled synchronous induction motor rated at 65 horsepower at 1,750 revolutions per minute powers the pump. The motor's maximum power requirement is 75 kilowatts. The motor and pump are in a cast aluminum housing, but other pump parts are of stainless steel or Monel. The pump impeller is cast stainless steel $12\frac{1}{4}$ inches in diameter.

The dredge used in this experiment was made to our specifications. It has shoes or runners of longer and heavier proportions than those usually used in industry. A steel plate was fitted between the shoes forward of the manifold to facilitate mounting the pump unit and to protect it from bottom obstructions (fig. 6). The pump was mounted across the forward end of the dredge under the towing bar and braces (fig. 6). The 8-inch pump discharge was connected directly to the manifold with a reducing elbow and a short length of 6-inch hose (fig. 6). The latter was deemed advisable as a precaution against shock and vibration.



ig. 6 - Submersible pump mounted on our 48-inch hydraulic iredge showing position of mounting, discharge connection, and ubber union.

A neoprene-jacketed 4-wire No. 2 Amer-can Wire Gage power cable supplied power to he pump. This cable was fitted with water-ight plugs at the dredge end and the shipboard ermination (fig. 3). The 150-fathom cable was tored on a hydraulically driven reel. Five ouble 8-inch diameter trawl floats were at-ached to the cable along the first 10 fathoms ig. 7). These floats held the cable clear of he bottom during towing and haulback opera-ions. After initial development work in de-ermining the proper leads and flotation for the able, we encountered no difficulties in keeping e cable from between the dredge and the side f the vessel or clear of the bottom.

To record the pressures at the jet nozzles, remote reading differential pressure gage as used. This instrument recorded the pres-ure on the inside of the manifold relative to e pressure of the water at the dredge's depth. ressures were read at the surface and at orking depths with different combinations of ozzle diameters and pump speeds (table 1). mall variations in the speed of the submers-ble pump were possible by varying the revolu-ions per minute of the generator. This change as limited to about 10 percent of the genera-or's design speed of 1,200 revolutions per minute for 60 cycle per second current.

To assess the operation of the submersible ump relative to that of the usual vessel pump nd hose arrangement, a series of compara-ive tows was made within a confined area with ach rig. To carry out this procedure, the redge was provided with two jet manifolds, ne adapted to the submersible pump, the other o the 6-inch hose from the vessel. Change-over from one rig to the other could then be done in a very short time. The same number of tows was made with each setup in each area.

Fig. 7 - Dredge about to be taken aboard the Delaware showing catch in bag and power cable with attached floats.

RESULTS

Water pressures and volumes obtained with the submersible pump compared quite closely with those obtained at the manifold with the shipboard pump and hose (table 1). Nozzles with a 0.625-inch inside diameter were used during the fishing. The pressure drop in the 250 feet of 6-inch diameter rubber hose, plus deck piping, amounted to 27 pounds per square inch or about 26 percent. The total energy drop was 30.5 percent, resulting in an efficien-cy of 69.5 percent for the conditions selected for fishing. The calculated energy drop in the power cable at full output was only 5.6 per-cent. The resulting savings in fuel costs and equipment handling would help to justify the additional expense of the submersible pump-ing system during its lifetime.

During one group of comparative tows, the submersible pump dredge appeared to be catching only about one-half as much as the conventional hydraulic dredge. Upon inspec-tion of the dredge, we discovered that small stones were being picked up by the pump through the expanded metal screen but were not passing through the nozzles. This situation was remedied by fastening a piece of ½-inch mesh hardware cloth with metal strapping over the expanded metal screen. After this alteration, little or no difference was seen in the performances of the dredges, and the submersible pump, therefore, was used throughout the remainder of the survey (fig. 8).

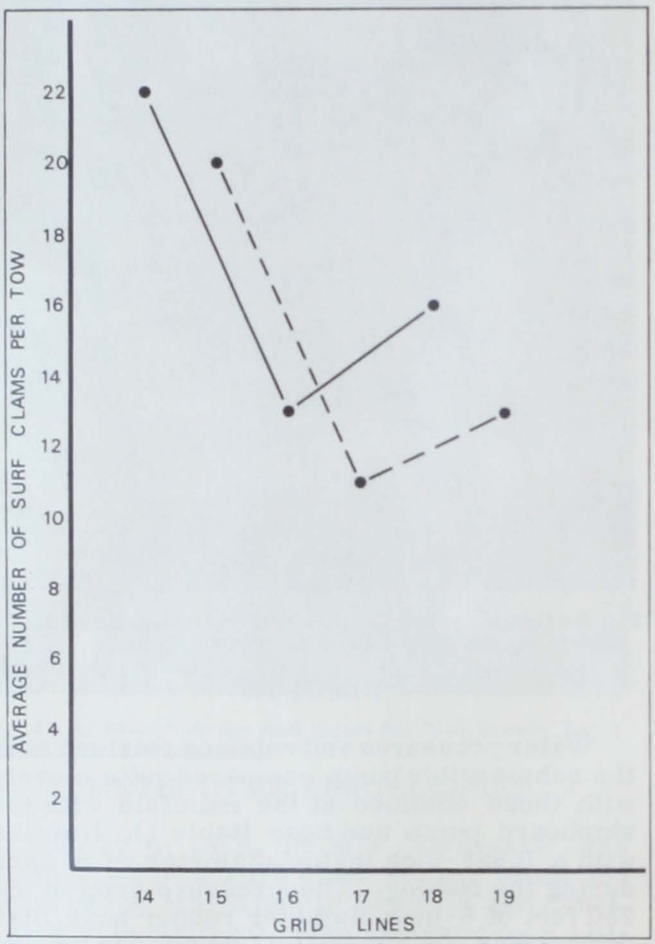


Fig. 8 - Average catch of surf clams for selected grid lines. Solid line, vessel pump; dash line, submersible pump.

DISCUSSIONS AND CONCLUSIONS

From the trials conducted aboard the M/V Delaware, the use of an electrically powered submersible pump to supply water to the jet manifold is technically feasible. Standard off-the-shelf pumps are available that will fulfill the requirements. The danger of the cable snagging on a bottom obstruction can be nearly eliminated by the use of flotation schemes. By proper leads and dredge handling techniques, the problem of the cable being crushed between the dredge and the vessel can be overcome. The possibility of the intake being ob- structed by bottom debris or vegetation, o small stones being drawn in, can be avoided i several ways. The pump could be oriented the intake is farther above the bottom a close to the centerline of the dredge, or inta piping can be extended to a more advantageo location. Properly sized screening will pr vent stones clogging the nozzles.

The added weight of the pump on the forwa end of the dredge did not appear to affect a versely the dredge's performance. Possibl it may have been beneficial in causing t dredge to "tend bottom" better.

To make the submersible pump dredge better tool, slight modifications should b made in the design of the dredge sled. Th runners should be extended far enough in fro of the jet manifold to allow ample room for th pump, and bracing for the towing bar shou be altered to suit the pump used. This la alteration should allow convenient access t and removal of, the pump for service a maintenance.

The installation of a submersible pumpi system involves more equipment than the usu vessel-mounted pump and hose arrangeme A generator of sufficient size must be mount in the vessel, together with the proper sta ing equipment and overload protection devic The connector cable is most convenient handled on a powered reel, which could mounted anywhere aboard ship that would b suit the operation. Disconnect plugs are each end of the power cable to enable the dre to be removed from the vessel, or the ca to be reeled in at the end of the fishing. T pump is mounted with brackets to the dred and connected directly to the manifold wit short length of hose or a flexible connecti

The total of the initial and installation co of the submersible pumping system is mo than that of the system in use now. The c and installation of the generating set, howeve compare favorably with the cost of a pu engine, pump, sea chest, and related couplin and installation. As the trend in industry is larger hoses, up to 8-inch diameter are us today, and the cost of this hose and the sleev and clamps for joining sections is a very lar part of the expense of outfitting for cla dredging. In contrast, the cost of cable comparatively small, and this saving i creases as deeper depths are fished.

In addition to the somewhat more elaborate gear necessary aboard the vessel for submersible pumping, the pump unit with an integral electrical motor is mounted on the dredge itself. The cost of this unit, its installation, and the modified dredge probably would run four or five times the price of a conventional dredge. However, this added cost is offset by the greater efficiencies realized and the convenience of handling the comparatively small electric cable. The additional expense is also reduced by the less expensive cable in place of the expensive hoses.

A dredge with a proper pumping unit delivering a like volume and pressure to the jet manifold as a vessel-mounted pump has proved to fish just as well as the latter.

Taking the aforementioned factors relating to cost, efficiency, and catch rates into account, an electrically powered submersible pumping system appears to compare very favorably for conversions or for new construction to the conventional system.

SUMMARY

1. An electrically driven submersible pump was tested and used for a surf clam survey.

2. The pump, powered through a 4-conductor (No. 2 American Wire Gage) cable, furnished up to 2,000 gallons per minute to the manifold jets.

3. The water was supplied directly to the jet manifold by the pump, which was mounted on a plate across the forward end of the dredge.

4. Comparison tows made between the submersible pumping system and the standard vessel-mounted pumping system indicated that the former could be used to replace satisfactorily the vessel unit.

5. To make the submersible pump dredge a good practical tool, slight changes will have to be made in the standard dredge design.

6. The installation of a submersible pumping system will involve more equipment than the standard vessel pump and hose arrangement. Although the total cost is somewhat higher, it is offset generally by the greater efficiencies realized from the submersible pump and convenience of handling the smaller electrical cable.

7. When everything is considered, the submersible pumping system appears to be practical for conversion or for new construction.

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