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Underwater Observations on Performance of Clam Dredges of Three Types

by

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ABSTRACT

When towing speeds, warp lengths and water pressures were skilfully controlled, the two types of "wet" (hydraulic) dredge were nearly 100% efficient in catching ocean clams (Arctica islandica) on sandy bottom. The shells of more than 80% of uncaught clams were broken. However, because of high dredge efficiency, there were few uncaught clams. Breakage in catches was generally less than 20%.

The "dry" (non-hydraulic) dredge was less than 1% efficient on sand and broke the shells of 80% of uncaught clams and of 50% of the clams it caught.

The edges of wet dredge tracks in sand crumbled soon after the dredge passed, but the tracks were deep and filled in slowly. The dry dredge left a shallow track that soon disappeared.

Several species of demersal fish and bottom invertebrates congregated in dredge tracks and fed on broken clams and other exposed materials.

This study involved scuba diving and observations from submersibles. Submersibles were advantageous in several respects.

INTRODUCTION

A fishery for ocean clams began in 1970 on the south coast of Nova Scotia and is now landing 50 metric tons per month. The exploited stocks are in shallow-water inlets on sand and sand-mud bottoms at depths of 7-12 m with high uniform densities of clams (30 to 40/m^2). The clams live in the upper 12 cm of soil and fishing is done with "wet" (hydraulic) dredges. Smaller and simpler "dry" (non-hydraulic) dredges have been used, but give smaller catches and are reported to damage catches and unharvested clams. A comparative study of three types of dredge was initiated in 1970 using scuba and submersibles to observe dredge performance, incidental breakage of clams by dredges, and aggregations of scavengers and potential predators in dredge tracks.

METHODS

The dredges compared are described in Figure 1 and Table 1.

1. Tracks made by a Rhode Island commercial "dry" dredge towed on mud bottom at 50 m in Passamaquoddy Bay, New Brunswick, were observed from the submersible Pisces I in 1970. Motion pictures of the tracks were analyzed for track configuration and presence of possible predators.

2. Divers descended warps of a commercial wet dredge and studied its performance and efficiency during 12 to 15 min (400 to 500 m long) test hauls on clean sand bottom in 10-12 m depths in Medway Harbour, Nova Scotia, in June 1971. They took 0.25 m^2 bottom samples to determine abundance of clams inside and outside the tracks. Observations on clam mortalities and subsequent aggregation of fish and invertebrates were also made by scuba and from the submersible SDL-1.

3. Further scuba studies on performance of the commercial dry dredge and of a wet sampling dredge (a research dredge) were carried out on sand bottom in 7.5 to 11 m depths in Shelburne Harbour, Nova Scotia, in July 1971.

RESULTS

Dredge Performance

Commercial Wet Dredge. Divers viewing this dredge made the following observations, which indicate that its operating efficiency, although high (Table 1), could be improved:

1. At the regular 1 knot towing speed, there was a large clearance (5-10 cm) between the dredge teeth and the face of the track being cut by the hydraulic jets. At no time did the teeth touch the face, which was being washed away in front of them. The jets carried many clams down the face, past the teeth and under the dredge where they escaped capture.

2. When this dredge was tested at Medway Harbour, the towing warp was too short. The front ends of the dredge shoes were usually 8 to 10 cm off bottom, and they lifted still higher with wave surges. As a result 35% of the clams harvested had broken shells (Table 1). At Shelburne the warp was adjusted so that the ratio, warp length:water depth, was 3:1. With this arrangement shell breakage was reduced to 18%.

Wet Sampler Dredge. Trials with this research dredge were carried out from a 28-m long side-trawler with inadequate speed control at the low speeds required for hydraulic dredging. This undoubtedly led to less than optimal performance. Divers found this dredge sensitive to speed of tow. When there was a brief pause in the tow, the dredge sank, mouth-down, to depths of 0.5 m into the substrate and spilled its catch. At towing speeds below 1 knot, the jets carried clams down the face of the track and under the dredge teeth where they escaped capture. At greater speeds (1 1/2 knots), the dredge lifted and made a shallow track. When this occurred, divers noted a continuous noise of breaking shells.

When hydraulic pressure was increased from 2.8 to 4.2 kg/cm^2, the dredge sank more than 30 cm into the bottom.

Commercial Dry Dredge. When towed at 1 knot on sand, this dredge tilted forward with the rear end off bottom and failed to dig in. The teeth, in a vertical position, combed the sand to a depth of 5 to 6 cm. At towing speeds above 2 knots, it lifted off bottom in a series of leaps 2-3 m long and took shallow bites out of the bottom. At all speeds it made small catches on sand and broke 50% of the clams it caught (Table 1).

When towed at 1-2 knots on mud, it performed more satisfactorily with higher catches and lower breakage rates, although it sometimes clogged with mud.

Efficiency

Efficiency of dredges in capturing clams from sandy ground was calculated by one or other of two methods:

1. By comparing abundance of clams per m^2 of track (as determined

by diver sampling) with abundance in undisturbed soil outside the track;

2. By comparing the number of clams captured from a known length of track with the number of clams in that length as estimated from diver sampling.

Method 2 (above) gave an efficiency of 92% for the commercial wet dredge on sand. Method 1 gave an efficiency of 76% for the wet sampler dredge. Method 2 gave an efficiency of <1% for the commercial dry dredge on sandy bottom.

No efficiency estimates were made for dredges on mud bottom.

Configuration of Tracks

Commercial Wet Dredge. Immediately after towing, the track of this dredge, in sand and sand-mud, was easily recognized by its steeply cut walls and flat floor. The track depth averaged 20 cm but depths reached 30 cm where tracks crossed depressions in the bottom (e.g. old tracks), or where towing had slowed or ceased momentarily. Depths decreased to 5 to 10 cm in the last 15-30 m of the tow during haul-backs of the dredge for boarding and dumping catches.

On sandy bottom the cloud of sediment behind this dredge seldom exceeded 0.5 m in height and it settled quickly and evenly. It usually disappeared within 1 minute after the dredge passed. The track floor was liquescent with many shell fragments, polychaetes, and small bivalves (no juvenile ocean clams were observed) lying on the surface. Immediately after passage of the dredge about 10 cm of the track shoulders slumped carrying a few embedded clams onto the floor of the track.

Commercial wet dredge tracks were still easily recognizable after 2-3 days, despite tidal action vigorous enough to produce sand ripples on bottom. Slight concavities in the bottom, sometimes stretching to limits of vision, were noted in Medway Harbour on 20 June 1971. These may have been dredge tracks from fishing that had terminated there a month previous.

Wet Sampler Dredge. This small dredge made a track whose depth varied from 10 to 25 cm with occasional holes up to 0.5 m deep. The holes often contained clams apparently spilled from the dredge. The track floor was liquescent.

Commercial Dry Dredge. The track of this dredge varied with substrate. On sand it had an inconspicuous raked appearance and was only 3 cm deep. The soil in the track floor was loose to a depth of 5-8 cm, but not liquescent, and showed a series of longitudinal ridges probably left by rings of the bag.

On mud bottom, the track was conspicuous and uniform, varying from 5 to 10 cm in depth and 40 to 50 cm in width. It was rounded in cross section and its walls were smoothed, possibly by passage of the bag. Along each margin of the track there was an even spoil ridge up to 20 cm wide and 5 to 10 cm high.

Tracks more than a week old were observed on mud. They seemed to be filling in by sediment-transport rather than by slumping of sediment from the walls and the spoil heaps which were still obvious.

Mortalities Caused by Dragging

Observations in the main part of a 3-hour-old track of the commercial wet dredge revealed few clams. This is consistent with the high efficiency (>90%) of this dredge. Ocean clam shells are brittle and >80% of the uncaught clams were broken. Sometimes the only parts found were meats that had few or no shell fragments attached. These may have been clams that were washed under and then crushed by the dredge. One estimate put the density of these clams at about 0.8 per m^2 of track. The clam population density in that area approximated 8.5 clams/m^2, indicating a mortality due to fishing of about 10% of the original stock.

Mortalities in the shallow parts of the track that were made during haul-back approached 100% and involved a high proportion of the original stock. The lower parts of most clams were still embedded in the track floor with their siphonal ends sliced off horizontally revealing the viscera within. This may have been caused by the teeth, or by the trailing edge of the dredge.

The wet sampler dredge was estimated to be 76% efficient (Table 1) and it broke >90% of the uncaptured clams. A high fraction of these were large animals that burrow 10 to 12 cm into the substrate and are therefore most likely to be damaged by the shallow teeth of this dredge.

No broken clams were observed from the submersible in tracks made by the commercial dry dredge in mud and broken clams were rarely seen in tracks in sand. However, a diver riding this dredge during a tow on sand reported hearing a continual sound of breaking shell and he took four 0.25 m^2 samples from the track. These yielded 83 clams, still buried in the track, and 67 (80%) were broken. Damage by dry dredges in heavily stocked areas must be great.

Aggregation of fish and invertebrates in dredge tracks

Fish and invertebrate predators were not commonly seen by scuba divers in fresh dredge tracks but, during a Medway Harbour dive in the SDL-1 submersible on a one-hour-old dredge track an observer saw cod (*Gadus morhua*), winter flounders (*Pseudopleuronectes americanus*), sculpins (*Myxocephalus octodecemspinosus*), two species of skates and several invertebrates including *Polynices heros* and hermit crabs, that were feeding on broken clams. Fishermen of Medway Harbour report good catches of lobsters in dredged areas immediately following commercial operations. Aggregations of fish and invertebrates were also seen during a Pisces I dive on fresh tracks on mud in Passamaquoddy Bay but there was no direct evidence that they were feeding on ocean clams because there clam breakage was low. However, up to one potential predator/m^2 of track was seen in some sections of track. The principal species observed were hagfish (*Myxine glutinosa*), winter flounder, eelpout (*Macrozoarces americanus*), and the invertebrates, *Asterias*, *Buccinum* and *Colus*. These animals were much less common outside the tracks.

SUMMARY AND DISCUSSION

Wet dredges, like hydraulic escalator harvesters (Medcof, 1961), can operate at close to 100% efficiency in capturing clams. However, dredge efficiency is sensitive to factors such as the ratio, warp-length:water depth, towing speeds and hydraulic pressure of the jets. When these are not optimal, the numbers of uncaught clams increase. Breakage is always high among uncaught clams (Table 1) so damage to clam stocks is inversely proportional to dredge efficiency. The haul-back of wet dredges seems to be a particularly destructive operation.

Commercial dry dredges have consistently low efficiencies in capturing ocean clams on sand bottom and breakage of uncaught clams was high (80%). These dredges are therefore severely damaging to clam stocks. Breakage in catches (50%) is also high. General observations indicate that efficiency is higher on mud bottom, which explains why these dredges are still used in the deep-water Rhode Island ocean clam fishery. But even on mud bottom, low-speed towing may clog dry dredges and reduce their efficiency.

From a fishery management point of view, only wet dredges should be used in harvesting ocean clams from sandy bottoms. From the same point of view, it would be wise to encourage development and use of more efficient and less damaging wet dredges, such as the hydraulic lift dredge described by Kerr (1970), which requires no haul-back for boarding catches. This would eliminate the most destructive phase of fishing with conventional wet dredges.

Tracks of the wet dredge in sand persist for several days, although slumping of the walls of the track begins immediately following fishing. Tracks may persist for long periods as shallow depressions. For a short time after fishing, predators and scavengers aggregate in dredge tracks and feed on broken clams and other dislodged material. Demersal fish in the tracks appeared indifferent to submersibles until they were only 2 or 3 m away, and more fish were seen by observers in submersibles than were seen by scuba divers.

In spite of their high cost, the use of submersibles, even in shallow water, offers advantages: they allow specialists without diving training to make underwater studies; observations can be made in comfort and, in a submersible, a single observer can make long traverses that could not be accomplished in a comparable time without a large team of divers trained as scientific observers.

REFERENCES

Kerr, N. M. and M. I. Mech. 1970. Harvesting of marine biological resources by dredging. Inst. Marine Engineers, Ocean Engr. Sect., Symposium, 3 June 1970, Glasgow.

Medcof, J. C. 1961. Effect of hydraulic escalator harvester on under-size soft-shell clams. Proc. National Shellfisheries Assoc. 50: 151-161.

Table 1. Dredge types and performances under various testing conditions.

Features of dredges and tests	Commercial wet dredge	Wet sampler dredge	Commercial dry dredge
Dredge dimensions			
Weight (kg)	900	180	270
Mouth width (cm)	125	29	66
Depth of teeth (cm)	20	13	15
Hydraulic system			
Pump capacity (l/min)	3400	1350	-
Pressure (kg/cm^2)	4.2	2.8	-
Diam. hose (cm)	20	6.4	-
Testing conditions			
Area (name)	Medway (M) and Shelburne	Shelburne (S)	Passamaquoddy (P) and Shelburne
Depth (m)	8-12 M	8-9 S	50 P
	7.5-11 S	-	8-9 S
Bottom type	hard sand S	hard sand S	hard sand S
	-	-	soft mud P
Towing speed (knots)	1	1-2	1-2
Length of tow (min)	15-20	12	12
Dredge performance Catch (l/tow)	880 S	36 S	<1 S
% catch broken	18 S	17 S	50 S
	35 M	-	15 P
Effic. clam capture %	>90 M	76 S	<1 S
% uncaught clams broken	>80 M	>90 S	80 S

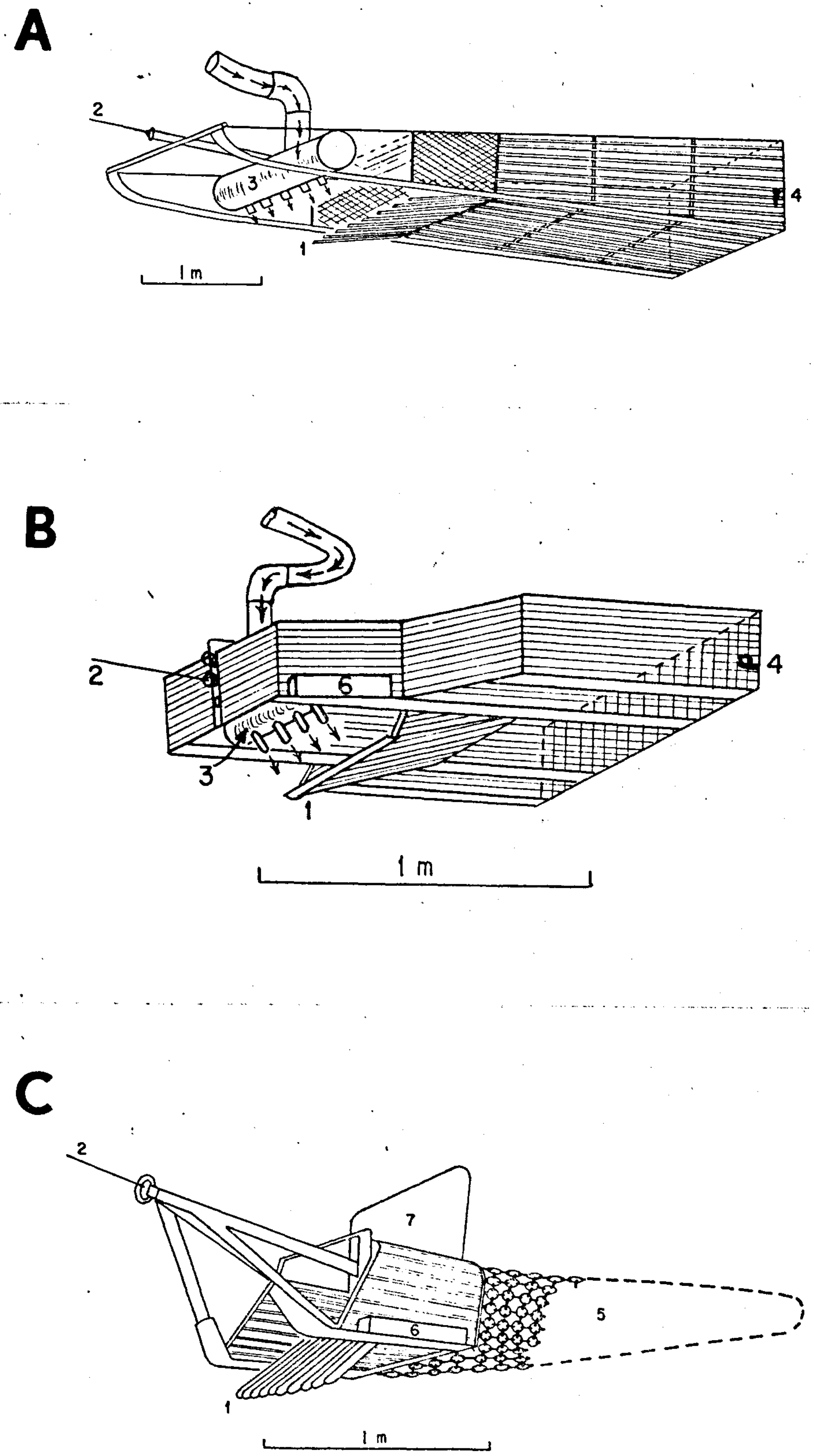

Figure 1. A. Commercial wet dredge.
B. Wet sampler dredge.
C. Commercial dry dredge.

1 - Teeth (joined by lip in wet sampler). 2 - Tow-point. 3 - Manifold. 4 - Lock for dumping door. 5 - Bag of steel rings and links (cod-end dumping). 6 - Lead "bricks" to regulate dredge weight. 7 - Pressure plate.