SCALLOP GEAR TRIALS

Preliminary
Project Report

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Introduction

The Sea Scallop Oversight Committee of the New England Fishery Management Council is in the process of developing a management plan for the sea scallop fishery. Their objectives include considerations for increasing yield per recruit. Presently this may be accomplished by either increasing the minimum size of the harvested scallop and/or decreasing mortality on the pre-harvestable sizes, two goals that may be attained with proper fishing gear design.

The Council requested funding to conduct scallop gear research in order to identify management options available. In January, the Northeast Fisheries Center received thirty thousand dollars to begin the study. A meeting was held on 26 March 1979 between Scallop Oversight Committee members, scallop advisors, and Council and NEFC technical staff to map out strategy. Prior to this meeting, NEFC completed a scallop gear literature search and research summary to acquaint all those in attendance with what the state of knowledge was.

The general consensus from this meeting was that with the limited funding available and with expectations of future funding the initial efforts should concentrate on developing methodology to study the operation of the existing New Bedford type drag currently in use. This study was to assess the feasibility of making the gear more selective and less destructive of young scallops.

Past Research Summary

One of the first reports discussing the scallop fishery was by Hugh Smith (1891), which examined the fishery in 1889 along the coast of Maine. The fishery was just beginning on a few small local beds, and very little was known about the extent of the resource. The Albatross and the Fish Hawk were expanding this knowledge using beam trawls.

The first commercial vessels used oyster dredges to fish for scallops. There were soon many local variations to that design. The basic design had a handle or "pull-bail" consisting of two iron bars that came together to form a towing eye. This eye was about 4 to 5 feet from the rectangular mouth of the dredge, which was formed of flat iron bars (1-1/2" x 1/4") three feet long and nine inches high. The frame had holes all around to which the "bag" was attached. The lower side of the bag consisted of iron rings 2-1/2 to 4 inches in diameter to permit small unmarketable scallops to slip through. The top and sides were of twine, and the length of the bag was about four feet. From the illustration of the dredge accompanying Smith's text, it appears the rings actually passed through each other as opposed to today's method of being clamped together.

The dredge was fished by two men from a small boat usually under oars but sometimes under sail. Another method was to "anchor dredge" similar to today's anchor seining technique. Eventually, larger sailing vessels came into the fishery, but the fishing was still performed from the vessel's boats, usually dories and pea-pods.

The evolution of the dredge during the next half century or so appears to be straightforward. With the use of mechanical propulsion and deck equipment, the dredge became larger, taking on some aspects of a beam trawl. Weight was not too critical anymore, so more iron rings were used in the bag and a club stick attached. Some refinements were made to improve the efficiency, such as attaching the lower

part of the bag to a sweep chain, using an adjustable bale to compensate for bottom type, and adding depressor plates to keep the dredge tending bottom.

During this period, otter trawls were also being modified for use in scalloping. A Bureau of Fisheries report from 1914, based in part from exploratory fishing conducted from the Grampus, indicated modifications that could be made to a Cape Cod flounder trawl. Among those changes recommended were:

(a) making the bag shorter,

(b) using heavy twine,

(c) having a mesh size of 2 to 2-1/2 inches (bar-measure),

(d) using a small chain sweep,

(e) having split links in the footrope in case of fouling,

(f) using plenty of chafing gear, and

(g) towing with a bridle.

As in most fisheries, the subject of "savings gear" came up when the catch of undersized scallops was thought to pose a problem. The most obvious solution was to increase the mesh or ring size, though many argued that trash accumulates in the drag too fast, making this an ineffective approach. Experiments were conducted to study the effects of increased ring size.

Medcof (1952) tested in Canadian waters six different ring sizes: 2-5/8", 3", 3-1/4", 3-1/2", 4", and 4-1/2". The dredges were fished together, randomly attached to a common drag bar, in various populations of scallops and over different bottom types. He summarized the results as follows: "Of every 10 sub-legal (<4 inches) scallops caught by the standard 2-5/8" ring, 4 escaped 3" rings, more than 6 escaped 3-1/4" rings, about 7-1/2 escaped 3-1/2" rings, about 8-1/2 escaped 4" rings, and more than 9 escaped 4-1/2" rings. Of every 10 legal scallops caught by the standard gear, hardly any escaped the 3" or 3-1/4" rings, and even the 3-1/2" rings lost only one half-scallop, but 4" rings lost more than 2 and 4-1/2" rings about 5-1/2." The experiment demonstrated

that the space between the rings played the important role in the selection process. The larger mesh drags also brought up less trash than the smaller.

Based on these results, commercial drags of 3-1/4" ring size were given to a commercial boat to fish. The new gear decreased the catch of sub-legals by two-thirds and appeared to decrease the trash brought up. However, problems with handling and bag breaks as well as inexperience in fishing the new gear caused a lower overall catch per trip.

Cameron (1955) reported that investigations conducted by the Canadians indicated an efficiency of about 5 percent for scallop drags. To determine why this low efficiency existed, a special camera sled was towed forward of a scallop drag to photograph it in action. They found that the drag tended to bulldoze the substrate in front of the mouth, rolling scallops forward and down under the drag.

Baird (1955) reported that underwater observations of toothed Irish scallop dredges showed a leaping motion over the bottom. To overcome this problem, a dredge was designed with runners and a diving (depressor) plate. This dredge outfished the standard dredge, except on bottoms that had small ridges.

Baird and Gibson (1956) began to study the apparent low efficiency of dredges on small scallops. Using SCUBA observations, they found the teeth of the dredge to affect selectivity and recommended tooth size and spacing to be controlled. However, they did not observe much in the way of escaping response from scallops encountering the gear.

Posgay (1958) indicated that increasing the age of first capture from 4 to 6 years in the Georges Bank fishery would increase yields. He comparison-fished dredges of 2" rings vs. 3", 3-1/2", and 4". To calculate percent retention, he related the midpoint of the size class to the inter-ring spacing. He found that a scallop which was 28mm smaller than the inter-ring space had a 50 percent chance of escaping.

Baird (1959) discussed the effects of diving plates in regard to lift and cleansing action. He also quantified tooth spacing; the sizes at which 50 percent are selected are between 20-50 percent larger than the tooth spacing. For teeth to be effective, there must be clearance between the dredge bar and the bottom. The optimum angle of attack of the teeth is about 45°.

Bourne (1960) reported on a commercial test of 3" vs. 4" ring size. He found the selectivity of the dredge is decreased with increased linkage (number of links) between rings. His data showed a 10% increase in efficiency on market size (>105mm) scallops and a decrease in the catch of trash and undersized scallops. There was no distortion or increase in bag failures with larger rings.

Bourne (1962) summarized U.S. and Canadian data obtained during ring size comparison experiments in 1961. The Canadian data showed that a 4" ring bag retained 100% of scallops 105mm and over and may have been more efficient for these sizes than the 3" ring bag. The 4" ring caught 16% less trash by volume, and 22 percent less undersized (<100mm) scallops.

The U.S. data showed the same 100 percent retention of 105mm scallops by the 4" ring with possible increases in efficiency. In both the U.S. and Canadian data, the selection curves were much flatter than those found for trawl nets, and two explanations were put forth. The first is that scallops don't make attempts at escaping like fish do, and, secondly, the drags tend to trash up.

The results of both countries from their studies of multiple linkage, indicated that selectivity was not appreciably altered; thus, the inter-ring space may not be as important as previously considered.

Five inch ring bags were tested, but the results were inconclusive due to problems in the bag construction that may have affected the fishing characteristics of the drag. There were indications though that a five inch ring may be

satisfactory if the age of first capture was to be 6-year-olds. The four inch ring did not significantly alter the catch of 5-year-olds (95-100mm).

Rivers (1962), in discussing the North Carolina calico scallop fishery, indicated that a scallop trawl was more effective than a dredge on hard sand bottoms. Fishermen use the trawl even though it requires more maintenance.

Medcof and Bourne (1964) reviewed the causes of natural and fishing mortality of the scallop. They referenced work that indicates that, on soft bottom, drags may force mud into scallops, killing them. Drags may also reduce the settlement of scallop spat or even cause anerobic conditions that may kill any scallop present. On hard bottom, scallops may be mechanically damaged when the drags pass over them. Undersized scallops retained in the drag are subject to much punishment; thus, when they are returned to the bottom they may not survive. The on-deck treatment of boarding, dumping, culling, and shovelling must also exact its toll as well as the exposure to extremes of air temperature. In a study conducted near Digby, they found an average of 15 percent lethally damaged scallops in the discards, the more rocks in the drag, the higher the damage rate.

Bourne (1965) reported in detail the results of his past ring studies. He concluded that a four inch ring would not be more of an effective savings gear than a three inch ring. He suggested the development of an entirely new type of scallop drag as the solution.

Bourne (1966) comparison-fished New Bedford drags, Digby (tumbler) drags, and scallop trawls. The New Bedford drag was the most efficient, followed by the tumbler drags and then the trawls. All three types of gear showed poor selection.

Caddy (1968) studied the behavior of scallops in relation to the drag using SCUBA obtained observations. Comparing drag catches to diver surveys, they found drag efficiency to vary with scallop size. Efficiencies of 0.69% ,

1.39%, and 8.31% were found for size groups <50mm, 50-75mm, and 75-100mm, respectively. Scallops were observed fleeing from in front of the drag. Few scallops larger than 100mm could be induced to swim. The swimming response seems to be stimulated by visual means.

It was also found that drag samples may not give a valid result in regards to the population structure or density of scallops in an area, due to the different behavior patterns by size class and bottom type. The efficiency of the drag varies with speed and size of catch (scallops and trash).

Rolfe (1969) calculated the efficiency of a Baird scallop dredge in the English Channel, using the method of DeLury (1947) and the Petersen (1896) method of marking. These two methods gave results of 33.2% and 46.1%, respectively, but possibly have many flaws.

Caddy (1971) used a camera mounted to take photographs in front of the drag to gain data on drag efficiency. In addition, drag bag covers and tagged scallops were used to gain selectivity data. The camera data showed efficiencies of 9.6%, 20.3%, and 16.9% for size groups <50mm, 50-100mm, and >100mm, respectively. These efficiencies were higher than his previous work, the reason given being the substrate here was gravel and most small scallops were attached to the gravel by a byssus hampering their escape response. His tagging data indicated that three to four times as many scallops escape through the belly as pass out through the back. The data also showed, contrary to Bourne (1962), that inter-ring spacing is important, with indications that the gear is less efficient in capturing commercial size scallops than for small scallops.

Gruffydd (1972) studied the mortality caused by Manx scallop dredges using tagging and laboratory holding techniques. He found that the natural mortality and indirect fishing mortality was at least 10 percent and possibly as high as 56 percent. In lab tests, the mortality of severely damaged dredge-caught scallops was 5 to 13 times greater than undamaged ones.

Caddy (1973), in a study aimed at determining the effects of dredges on the sea floor, used a submersible to examine the dredge tracks. He found mortalities of 13 to 17 percent for scallops remaining in the dredge track.

Mason, Chapman, and Kinnear (1973) studied the efficiency of Scottish scallop dredges. One type had fixed teeth, and the other had spring loaded teeth. The spring loaded dredge tended to catch fewer small scallops (<80mm), and both dredges had overall efficiencies of about 20 percent.

Drinkwater (1974) found that for Scottish dredges a combination of 12 teeth, for a four foot dredge, and 3-1/4 inch mesh size caught the most scallops. The mesh size was the more important of the two factors.

The Canadians conducted some gear experiments last year and plan to continue them this summer. In 1977, they ran a comparison fishing experiment with two commercial boats, using 3 and 4 inch rings on standard 15 foot drags.

In 1978, they conducted tests inshore to determine gear performance on different bottoms, indirect fishing mortality, and lobster capture. They fished both toothed and untoothed tumbler drags, using covers and liners.

Glen Jamieson, who conducted these experiments, suggested that if we were going to study scallop gear, we should set out to understand the operation of the gear on the bottom. Despite all the studies, there are still too many unknowns in this regard. Caddy (1971) suggested that the development of savings gear will require looking at gear design from scratch.

Field Tests

Field tests were conducted from the R/V Rorqual during the period 12 through 29 June 1979. Each week of this three week period, the vessel made a three day trip to a different area searching for test sites and conducting trials. The first week, the vessel operated out of Woods Hole working Vineyard Sound, Nantucket

Sound, and the south shore of Martha's Vineyard. The time was spent mostly in debugging the operation and gaining experience in handling, riding, and filming the drags.

The second week was spent operating out of Provincetown working Cape Cod Bay and Stellwagon Bank. Excellent TV footage of the drags in action was taken in the clear waters of Stellwagon, but few scallops were present in the diveable depths (down to 80 feet). Scallop beds were found in Cape Cod Bay, but poor visibility and a silty bottom made trials in this area undesirable.

The third week was spent operating out of Nantucket, working Nantucket Sound, the Great Round Shoal Channel, and due east to the 35 fathom line. Additional tape footage was taken, and some comparison fishing of the commercial and survey drags was performed. Tows were made on sand heaps (or ridges) and on rocky bottom.

During the nine days, thirty-seven tows were made, some with divers and others with the camera mounted on a trolley. In addition, camera lowerings were made at twelve stations to determine visibility and bottom type.

What follows is an item by item description of the different equipment and methods developed and tested during this study.

R/V Rorqual

The trials were conducted from the Northeast Fisheries Center's 65 foot research vessel Rorqual. The seventy ton vessel was rigged to fish eight-foot-wide scallop drags from the stern. In addition, berthing was added to enable nine persons to sleep aboard, the minimum necessary to carry out this project. Navigation equipment included a Decca radar, Internav 101 loran, Northstar 6000 loran, Epsco plotter, General Oceanics speed log, and an Elac depth sounder.

Underwater Television System

A Sub-Sea Systems CM-30 underwater color television camera was used during this study to film the scallop drags in action. The camera was used in one of three modes: diver held, trolley mounted, and surface lowered. Lighting was provided by two 250 watt lights mounted on the camera housing. A multi-conductor cable, 500 feet long, provided for the video signals, camera power, lighting, and diver communications. The cable was handled on deck using a hand-powered winch with fourteen sliprings.

The video and audio signals were monitored on the surface with a JVC 13 inch color TV monitor (7280UM) and recorded on video tape with a JVC color portable video cassette recorder (HR-4100AU).

Scallop Drags

Two different eight-foot-wide drags were fished during this study. The first type, an NEFC survey drag, was constructed of 5/16 inch rings two inches in diameter. The total weight of the drag was 1,425 pounds, the frame weighing 725 pounds. The bottom or "bag" was double linked, 32 rings wide by 15 rings deep with 12x12 diamonds. The top or "apron" was 32 rings by 18 rings with a 3-inch mesh twine back. The sweep chain was 5/8-inch, case-hardened steel 77 links long hung to the bag with 7 link straps of 1/4-inch chain. The clubstick was made up of 6-inch diameter rubber "cookies." The entire drag was lined with 1-3/8 inch polypropolene mesh.

The commercial drag was built and assembled by Dockside Repair, Inc., of New Bedford. It was constructed of 3/8 inch rings three inches in diameter. The bag was double linked, 24 rings wide by 9 rings deep with 9x9 diamonds. The apron was 24 rings by 8 rings, and the side pieces were 3 rings by 13 rings. The twine back was of 5-inch mesh 46 meshes across by 12 meshes deep. The

sweep was 67 links of 5/8-inch, case-hardened chain, and the clubstick was contructed of 3-inch pipe and angle iron. The frame was of slightly lighter construction than that of the survey drag.

Diving Equipment

The divers wore Unisuit variable volume dry suits and Cressi full face masks. Standard 72 ft^3 air tanks filled to 2,250 psi supplied Posidon regulators. The tanks were filled using an onboard Mako diving compressor. A Helle diver communications system was used with some in-house modifications. A diver call back system was also available for emergency signalling to the divers.

Other Equipment

Trolley - An aluminum trolley with two sheaves was used to send the camera down the main towing warp. The camera was held on by hose clamps to an adjustable carriage that allowed the filming angle to be pre-set.

Hoods - Hood frames of 3/4-inch, stainless steel bar stock were constructed that bolted on to the top of the main drag frame. The frames were 8-feet-long and 2-feet-high, the top thus being about 3 feet off the bottom. The hood "bag" was of 1-3/8 inch polypropolene mesh about ten feet deep with codend rings and rope attached.

Covers - Covers were also constructed of 1/3-8 inch polypropolene mesh to cover portions of or the entire top of the drag. The covers were not field tested during this study.

Procedures

Diver observations - The procedure for having divers ride and film the drag in action was as follows: the vessel set the drag in a regular manner heading down current (or wind or sea, whichever prevailed) and then stopped so as to be anchored by the drag. Two standby divers, in a Zodiac rubber boat, tied up to a tag line and float that was attached to the drag. The camera was lowered down the main warp via a snap hook arrangement to the water's surface. The two divers that were to ride the drag entered the water and escorted the camera down the warp to the drag. There, they unsnapped the camera, mounted the drag, and had the TV cable length adjusted via diver communications with the surface tenders. When they were ready, they informed the surface, and the vessel started up. The filming was monitored on deck, and instructions continuously were passed back and forth between the surface and divers.

At the completion of the ride, the vessel stopped, the divers re-snapped the camera to the warp, and then surfaced. The camera was hauled up by the deck crew, and then the drag was retrieved. In some cases, the drag was left on the bottom, and the second team of divers went down to ride it.

An emergency float was attached to the drag by a small piece of twine. The divers, in an emergency, would cut the twine, sending the float to the surface and signalling the vessel to stop.

Trolley operations - The procedure used was to set the drag in the regular manner and then tow at slow speed. The camera trolley was attached to the warp and lowered using the TV cable with the camera operating. The camera was lowered until it was in position, usually right up against the towing eye splice, and the vessel speed increased to normal tow speed (3.5 knots).

Camera drops - Camera lowerings were used to determine bottom visibility, bottom type, and presence of scallops. The vessel was stopped and the camera lowered using its own cable with an attached strength member of #102 nylon twine. A six-foot-long pole with a weight attached was lashed to the camera housing in such a manner so as to have the weight in the camera's field of vision four feet distant. The camera was held so that the weight just contacted the bottom. The drift of the vessel provided enough movement to get a good idea of what the bottom was like.

Comparison tows - The survey and commercial drags were fished alternately over the same bottom. Speed and scope were held constant.

Results

1. The R/V *Rorqual* was successfully modified to support scalloping, diving, and underwater TV operations.

2. Six NEFC divers gained experience riding scallop drags and made visual observations of how they fished. The divers were able to ride the drag at speeds of 2 knots with the camera gear and possibly 3 knots without.

3. A new underwater color video system was assembled and successfully operated in three modes: diver held, trolley mounted, and surface lowered. Six hours of video tape were recorded.

4. Hoods, to catch scallops going over the drag, were constructed and tested. No scallops were caught in these hoods.

5. At speeds up to 3.5 knots, both the commercial and survey drags on smooth bottom were observed to operate as follows: the forward part of the bale was several feet off the bottom, the cutting bar was several inches off the bottom, the drag rode on the after part of its shoes, and the sweep chain

tended bottom doing the actual fishing. On soft bottom, the sweep chain dug in a little while on hard sand it closely bounced along.

6. In an area with sand heaps 12 to 18 inches high, the cutting bar plowed into them, shearing the tops off. The sweep still tended bottom, though how well is uncertain.

7. On one occasion, the commercial drag was operated in 70 feet of water with a 4 foot sea, wind speeds of 25 knots, scope of 2.5:1, and a heading downwind. Divers observed the drag to ride roughly and leave the bottom at a towing speed of only 1.5 knots.

8. There is apparently significant escapement of small scallops during haulback. This was observed but not quantified.

Discussion

The 30K funding for this project was mostly spent on equipment and operating costs; base salaries were funded from other projects. Even with this limited funding, ten sea days were made on the R/V Rorqual.

Most of the techniques we wanted to try were sucessfully tested. We still need to test and develop methods for measuring scallop density and escapement through various parts of the drag.

The next step is to proceed to gather the actual data that is needed to answer some of the management questions. We feel we have gained enough background with the work completed to date to design improved drags if this is the direction the council wishes to take.

We do not plan to analyze any of the catch data from this preliminary study as the quantity is insufficient for gear research purposes. We do plan to make a video tape of the highlights of the study for public viewing.

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