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EFFICIENCY AND SELECTIVITY OF THE CANADIAN OFFSHORE SCALLOP DREDGE

by

J. F. Caddy

Fisheries Research Board of Canada
Biological Station, St. Andrews, N. B.

Introduction

Although there have been several comparative studies of different types of scallop dredges (e.g., Medcof, 1952; Bourne, 1966), few assessments have been made of dredge efficiency.

Baird (1959) estimated the efficiency of the toothed European scallop dredge as 8.5% for all sizes of scallops, and up to 16% for scallops larger than 115 mm. Dickie (1955) found that efficiency of Canadian inshore Digby dredges on smooth, offshore grounds increased from 1.6% for 60-80 mm. scallops to 13% for scallops larger than 100 mm. Similar estimates were obtained by the present author, with a light offshore dredge, of around 1% for scallops smaller than 75 mm. and 8% and over for larger scallops (Caddy, 1968). In this last study, scallops were observed by divers to evade capture by swimming.

Both tag and recapture methods (Dickie, 1955) and preliminary *in situ* population census (Baird, 1959; Caddy, 1968) suffer from a large indeterminate error caused by the difficulty of precisely defining the area of operations under water, and local variations in scallop density (Caddy, 1970). Tag and recapture methods require that the area containing the tagged scallops be accurately known, and fishing confined to that area, while the second method requires that fishing be restricted to the area surveyed by the diver. Both of these requirements are difficult to realize in deep water (50-110 m.) Canadian offshore grounds.

This paper describes a method of studying dredge efficiency in which scallop density in the path of the dredge is compared with dredge catch. Estimates of overall gear efficiency were resolved into components due to efficiency of capture and mesh selection, by experiments in which a mesh cover was used in conjunction with the release of tagged scallops in the dredge.

Methods

Efficiency estimate by underwater photography

In order to make camera surveys of scallop populations, and take photographs directly in front of a dredge, dredge design was modified by removing the drag bars and replacing them with lateral skids, so as to provide an uninterrupted view in front of the pressure plate (Fig. 1). Although this reduced the effective width of the dredge mouth from 244 cm. to 224 cm., the design of the dredge remained otherwise unchanged. Preliminary paired tows with modified ("camera") dredge and unmodified dredge have so far revealed no significant difference between them, both with regard to total catch and its size frequency.

A multi-exposure automatic camera was mounted just behind the pressure plate, with the lens 89 cm. above bottom and facing inwards and downwards at 45° to the vertical, so as to photograph the sea floor directly in front of the pressure plate. Descent of the dredge in an upright position was ensured by a bridle attached to the camera and flash supports with three 20-cm. steel trawl floats (111 kg. buoyancy) at its mid-point (Fig. 1). The dredge was towed at the commercial speed of 3-4 knots, and ship's position recorded every 2 min. by decca and loran cross bearings.

Camera calibration

To estimate the area in the camera field, camera and light source were mounted at the same angle and height as on the dredge, above a grid of 50-mm. squares, and an underwater photograph of the grid taken. The grid photograph was superimposed on the bottom photographs and used to measure the size of objects in the field of view. Scallops were counted in three size categories - less than 50 mm., 50-100 mm., and 100+ mm.

Gear selection experiments

I. Use of a mesh cover

A mesh cover of buoyant 1 1/2-inch mesh (3.8 cm.) polypropylene, 0.6-1.0 m. longer than the dredge, was stretched loosely over the entire back of the dredge (Fig. 2), enough slack being left in the cover to reduce any masking effects on dredge selection. The cover lifted about 1 m. clear of the back of the dredge when trailed just under the surface at the start of each tow. Scallops caught in dredge and cover were measured to the nearest 5 mm.

II. Tag and recapture method

A tagging technique was devised for estimating the proportion escaping through the belly of the dredge. This method rests on the assumption that tagged and untagged scallops show similar behaviour once they have entered the dredge. This assumption may be questioned for slow towing speeds, where swimming through the rope back has been observed (Caddy, 1968), but evidence for its general validity was provided by the fact that the ratio of numbers in cover and dredge was substantially the same for tagged and untagged scallops.

Tagged scallops were measured, placed in plastic bags and tied inside the sweep chain of the covered dredge (Fig. 2). During fishing, these bags ruptured and released tagged scallops inside the dredge. Tagged scallops could then either pass through the bottom of the dredge and be lost, pass through the top of the dredge into the cover, or be retained in the dredge. The proportion lost through the bottom of the dredge could, therefore, be calculated from dredge and cover catches. Retention rates of tagged scallops were used to estimate selectivity of the gear.

Results

Efficiency estimate from underwater photographs

Forty tows were made over distances ranging from 1.4-3.0 km. with the camera dredge, in which catch per kilometer was compared with the mean number of scallops in the bottom photographs by separate regressions for each of four size groups: $<$50 mm., 50-100 mm., 100+ mm., and all sizes combined (Table 1).

Since the effective width of the camera dredge is 2.24 m., the area swept per km. is 2240 m^2. The area in a photograph was 1.29 m^2, so that the estimated number of scallops per kilometer of dredge path is given by:

$$\text{Mean number of scallops per photo} \times \frac{2240}{1.29}.$$

But overall dredge efficiency can be defined as:

$$\frac{\text{No. scallops caught per km.}}{\text{Estimated no. in 1 km. dredge path}} \times 100\%$$

$$= \frac{\text{No. of scallops caught per km.}}{\text{Mean no. per photo}} \times \frac{129}{2240}$$

But $\frac{\text{No. of scallops caught per km.}}{\text{Mean no. per photo}}$ = slope (see Table 1);

Therefore, overall dredge efficiency = $\frac{129 \times \text{slope}}{2240}$ %

The efficiency rose from 9.6% for <50-mm. sized, to 20.3% for scallops between 50 and 100 mm., and declined slightly for commercial-sized scallops (100 mm.) to 16.9% (Table 1). This last estimate is less reliable than the others because of the smaller number of scallops. The efficiency for all sizes was 15.4%, which is considerably higher than that estimated by scuba techniques for similar gear over sand bottom in the Gulf of St. Lawrence (overall dredge efficiency: 2.1%). This discrepancy probably reflects a difference in scallop behaviour in relation to substrate type; whereas most scallops on sand showed escape responses to the approach of a dredge, only 0.1% of those seen in photographs taken over gravel bottom on Georges Bank were swimming, and most small scallops caught were attached to gravel by a byssus.

Mesh selection through the top and bottom of the dredge

Mesh selection through the back of the dredge was expressed as the number in each 5-mm. size-class retained in the dredge, as a percentage of the total number in that size-class caught in dredge and cover combined. An ogive was drawn through the points by eye, which gave a 50% selection size of 73.5 mm. (Fig. 3). This estimate must be below the true 50% selection size of the gear as a whole, since some escapement must also have occurred through the belly of the dredge.

Tag and recapture experiment

The tag and recapture experiment provided an estimate of the true size at 50% selection of 87.5 mm. (Fig. 3). This is 14 mm. larger than the apparent 50% selection point for the back of the gear, and supports the conclusion that escapement is not confined to the meshes at the back of the gear. In fact, tagging results suggest that from three to four times as many scallops are eliminated through the belly as pass out through the back. This is directly at variance with the conclusions of Baird (1957) for the European dredge.

Selection factor

Studies on selectivity of trawls and other moving fishing gear have defined a factor to represent the relationship between mesh size and size of fish retained in the gear:

$$\text{Selection factor} = \frac{\text{50\% retention point of the gear}}{\text{Internal mesh size}} \quad \text{(Clark, 1963)}$$

Two measures of mesh size can be employed for Canadian offshore gear which is knit from 3-inch internal diameter steel rings held together by split links (Fig. 4). These two measures are the internal ring diameter (76.5 mm.), and the width of the inter-ring spaces. Inter-ring spaces measure 97 mm. when single links are used, 89 mm. when 2 links are used, or even less if up to 6 links per ring are used, as is the case in gear designed for rocky bottom (Bourne, 1965).

The selection factor calculated from the 50% retention point found during the tagging experiment is either:

$\frac{87.5}{76.5} = 1.14$, if selection is considered to take place exclusively through the rings, or

$\frac{87.5}{97.0} = 0.90$, and $\frac{87.5}{89.0} = 0.98$ respectively, if selection is considered to occur solely through the inter-ring spaces of the single linked back, or double linked belly of the experimental gear. Shell height of a scallop is a good measure of the size determining mesh selection, so that a selection factor of more than one is impossible for inflexible dredge rings, and indicates that much of the selection takes place through the inter-ring spaces. This finding is in disagreement with the conclusions of Bourne (1965) for offshore gear, but is substantiated by earlier findings of Medcof (1952) for inshore gear.

Efficiency of capture

Previous attempts at assessing dredge efficiency defined an overall gear efficiency (e) where

$$e = \frac{\text{Number of scallops caught}}{\text{Number of scallops in dredge path}} \times 100\%$$

However, overall dredge efficiency is a resultant of two processes; namely, efficiency of capture and mesh selection, defined as follows:

$$\text{Efficiency of capture } (E) = \frac{\text{Number of scallops entering dredge}}{\text{Number of scallops in dredge path}} \times 100\%$$

$$\text{and gear selectivity } (s) = \frac{\text{Number of scallops caught}}{\text{Number of scallops entering dredge}} \times 100\%$$

From these definitions it is evident that:

$E = \frac{e}{s}$, so that an estimate of efficiency of capture may be obtained from estimates of overall efficiency and selectivity. Since e and s were obtained in different areas from different vessels, the estimates of E given in Table 2 are only preliminary.

These estimates of efficiency of capture are higher than any previous estimates of efficiency and suggest that on average, one in every 3 scallops in the dredge path enters the dredge. They also suggest that efficiency of capture decreases with size from almost one in two for 50-100 mm. scallops, to one in five for scallops larger than 100 mm. This may indicate that conventional gear is less efficient for the capture of commercial-sized scallops than for small scallops.

Summary

1. An offshore scallop dredge was modified for use as a camera platform without significantly altering its performance.

2. The efficiency of the modified gear was determined by comparing the catch per km. of travel with the number of scallops seen in bottom photographs in front of the dredge.

3. The overall efficiency of the dredge was higher over gravel on Georges Bank (15.4%) than on sand in the Gulf of St. Lawrence (Caddy, 1968). This probably reflects a difference in scallop behaviour in relation to sediment. While most scallops on sand swam away from the dredge, very few scallops were seen swimming in bottom photos taken on Georges Bank. Scallops caught were frequently attached to gravel by a byssus thread.

4. Tagging experiments reveal that more selection takes place through the belly than the back of the dredge; much of the selection taking place through the inter-ring spaces.

5. Overall dredge efficiency can be resolved into two components--efficiency of capture, and gear selectivity. The efficiency of capture for all sizes of scallops by offshore dredges was estimated at approximately 30%.

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Table 1. Regression analysis of the relationship between number caught per km. (y), and mean number of scallops per photo (x) in the same tow - (data for 40 tows).

Size Group (mm)	<50	50-100	100+	Total
Slope	166	351	293	267
S. E. Slope	16	47	90	31
t	10.4***	7.5***	3.3*	8.8***
Correlation	0.89	0.80	0.48	0.82
Overall Efficiency	9.6%	20.3%	16.9%	15.4%

(*** - significant at 0.05 level)
(* - Significant at 0.5 level)

Table 2. Estimates of efficiency of capture by the offshore dredge.

	Dredge Selectivity				
Size Group (mm)	No. released into drag	No. retained in drag	Selectivity (s)	Overall efficiency (e)	Efficiency of capture (E)
50-100	399	191	47.9%	20.3%	42.4%
100+	45	34	75.6%	16.9%	22.4%
All sizes	454	225	49.5%	15.4%	31.1%

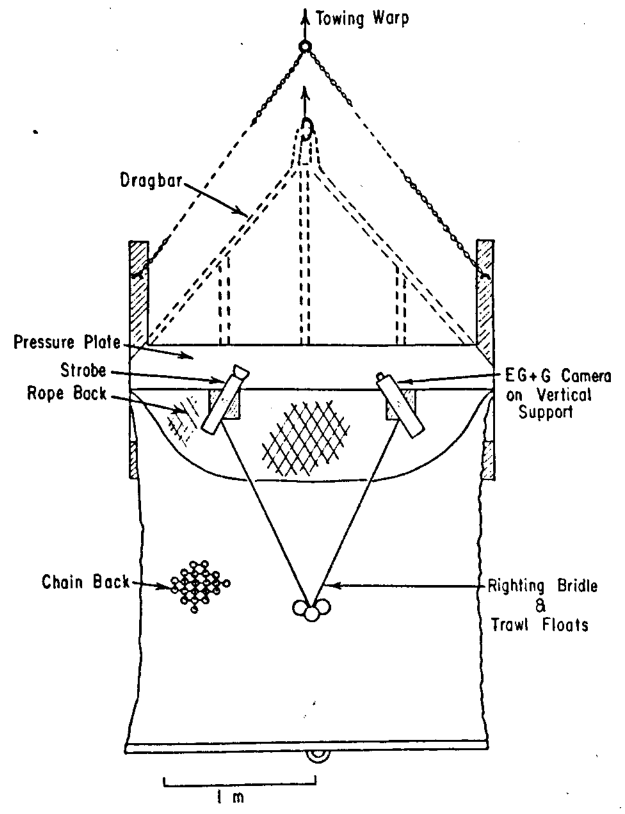

Fig. 1. Canadian offshore dredge showing modifications for use with EG & G Camera. (Shaded areas: additions to dredge; dashed outlines: deletions).

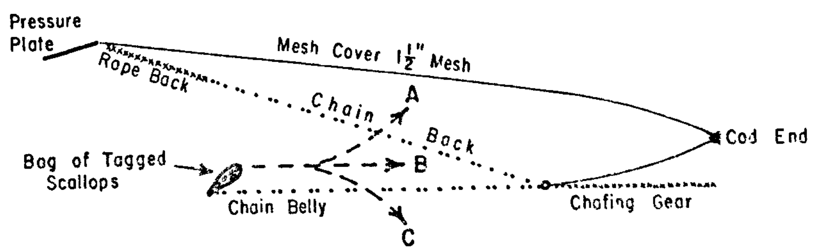

Fig. 2. Diagrammatic vertical section through covered offshore dredge showing method of release of tagged scallops and possible escape routes:

A. Passage through back into cover.
B. Retention in dredge.
C. Lost through dredge belly.

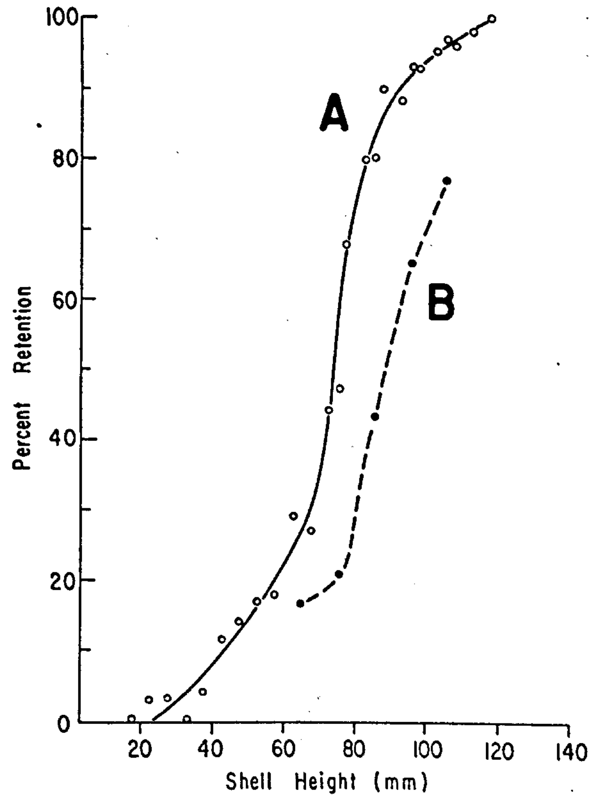

Fig. 3. Eye-fitted selection curves showing:

A. Selection of untagged scallops through back of dredge:

$$\text{Per cent retention} = \frac{\text{scallops in dredge} \times 100\%}{\text{scallops in dredge and cover}}$$

B. Selection of tagged scallops through back and belly of dredge:

$$\text{Per cent retention} = \frac{\text{tagged scallops in dredge} \times 100\%}{\text{tagged scallops released}}$$

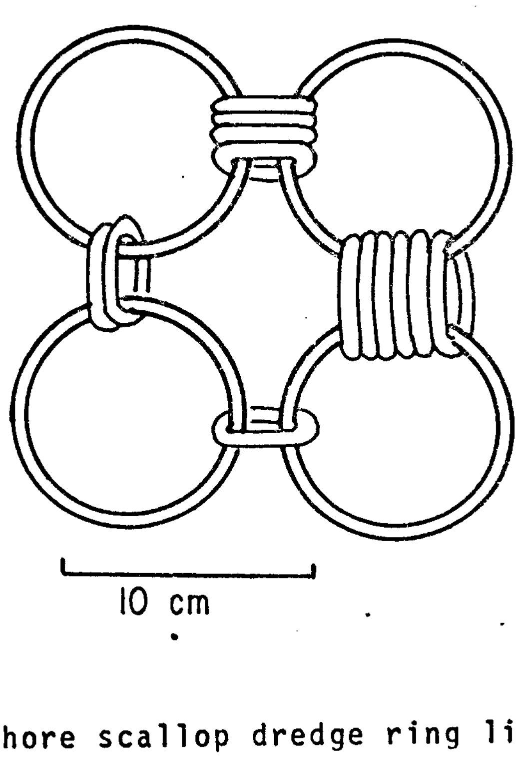

Fig. 4. Canadian offshore scallop dredge ring linkage with 1-6 links per ring.