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The effect of a beam trawl on the sea bed

by

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INTRODUCTION

In 1970 a study was made of the effect of an inshore otter trawl, fitted with tickler chains of various diameters, on the sea bed of a restricted locality in the English Channel (Bridger 1970). This work has recently been extended to include the effect of a beam trawl with tickler chains on several English Channel grounds, including those worked in 1970.

The aim was to make direct observation both of the ground over which the trawl was known to have passed and of the untrawled ground adjacent to it, to compare the two, to describe the condition of each and to relate, if possible, features of the trawled ground to the rig of the trawl. This experiment was not designed to evaluate the effect of trawling on benthos and fish life, although some incidental observations were made on the zoobenthos.

EXPERIMENTAL TECHNIQUES

On a short cruise of RV CORELLA to the English Channel between 21 June and 3 July 1971, observations were made by scuba divers and by underwater television. The divers observed around and in the wake of the trawl while it was being towed at 1.0-1.5 knots and also examined the ground in the accurately marked wake of the trawl about 5-10 minutes after the trawl had passed at a towing speed of 2.2-3.0 knots. The television was used suspended from the now anchored ship over the accurately marked path of the trawl, 60 minutes and more (but not less) after the trawl had passed at a towing speed of 2.2-3.0 knots.

In each locality where observations were made a sample of the sea bed was taken. This was done either by the divers collecting a small jar of soil from close by the trawl track or by using a conical dredge immediately after the trawl was hauled.

THE TRAWL USED

RV CORELLA used a single Dutch beam trawl. The beam was 9.1 m long, of steel, and together with the two steel trawl heads weighed 324 kg in air.

The sole plates or runners on each head were 0.2 m wide x 0.7 m long. The trawl was towed on a single steel warp of 22 mm diameter with a three-part bridle arrangement of 18 mm wire, the two to the heads being 9.1 m long and the centre one to the beam being 8.2 m long. The length of single warp used was 82 m from the sea surface in depths about 20 m. The net was of nylon, total length 11.3 m, with mesh sizes 65 mm in the fore part and 45 mm in the double braided cod-end. The weight of the net alone in air was 40 kg. The groundrope was 13.7 m long, of 12.5 mm wire threaded with 75 mm diameter rubber discs; its total weight in air was 70 kg. Tickler chains were attached between the trawl heads. These were of 17 mm chain; in the first three tows one was used, in the next four tows three were used, of lengths 10.75, 11.50 and 12.25 m, and in the later tows a fourth of length 13.0 m was added. The chain used weighed 5.68 kg/m, so the weights of the four ticklers were respectively 57, 64, 71 and 78 kg. The total weight in air of the trawl with tickler chains, but excluding warp and bridles, was 704 kg. Towing speed was about 2.5 knots (as measured by ship's Chernikeef log) except when the divers were swimming around the trawl. Although the beam, heads and first four ticklers were typical of the gear used by many double beam trawlers, the total number of ticklers was less than is used commercially and the towing speed was also lower.

FISHING GROUNDS AND CONDITIONS

All the trawling observations on this cruise were made in coastal waters off southern England at depths of not more than 22 m. All the grounds worked were known trawling grounds fished by inshore trawlers. An attempt was made to examine trawl effects on a range of different types of sea bed. The period 23-26 June was used for scuba diving and 28 June-1 July for television.

The scuba divers' observations commenced at the eastern end of Lyme Bay where underwater visibility range was about 5 m at 20 m depth, the tides were not strong, and the working depths ranged from 15 to 22 m. The grounds worked on eight observed trawl hauls in this locality were mostly of the type referred to by fishermen as being of hard sand with some gravel and stones; they were clear trawling grounds. Noticeable small differences in the conformation and constitution of the sea bed were reported by the divers between different hauls (Table 1, stations 2-8). The composition of a seabed sample from this locality is given in Table 2, station 2.

The divers' observations were continued with four trawl hauls in Start Bay where the tide was moderate and the working depth was 14-17 m. The sea bed (muddy sand) was softer there than on the previous grounds; divers' descriptions and sample analysis are given in Table 1, stations 10-13, and Table 2, station 11. One haul was made in Tor Bay where the depth was 14 m and the sea bed was of soft mud (Table 1, station 14).

Table 1 Divers' description of sea bed

Station number	Locality	Sea bed
2	Eastern Lyme Bay	Coarse sand and silt over gravel; few stones
3	"	Shell and sand, ridged 0.3 m high x 1.2 m apart, with silt in troughs between ridges
4	"	Soft muddy sand, not ridged
5-8	"	Hard sand, rippled 25 x 150 mm
10	Start Bay	Sand, rippled
11	"	Soft muddy sand, smooth ridges
13	"	Soft sand, small undulations
14	Tor Bay	Very soft silty mud over firmer substratum

The conical dredge samples and those collected by divers were analysed using a simplified version of Folk's (1968) technique. The grade classification of sediments is that used by Folk (1954).

Table 2 Seabed soil on English Channel fishing grounds

Station number	Locality	Classification*	Composition
2	Eastern Lyme Bay	sG	53% sand (mainly fine), 43% gravel, 4% mud
11	Southern Start Bay	mS	16% mud, 84% sand (mainly fine)
17	Western Lyme Bay	Ms or Sm	50% mud, 50% fine sand
20 and 21	Northern Start Bay	S	96% fine sand, trace of mud and of broken shell
23	Off Brighton	gmS	90% medium and fine sand, 5% pebbles and granules, 5% mud
24	Off Peacehaven	gS	83% sand (mainly fine), 16% shell (numerous whole _Echinocardium_ spp. in this sample)

* After Folk (1954).

Underwater television observations were made first on two trawl hauls off Teignmouth at the western end of Lyme Bay at depth 16 m on muddy sand (Table 2, station 17), with rather turbid but calm water. Then observations continued on two trawl hauls on the sandy grounds in Start Bay (Table 2, stations 20 and 21) at depths of 15-16 m. Finally, grounds near Brighton, in the same locality as the 1970 otter trawl observations were made (Bridger 1970), were worked under calm weather but strong tidal conditions; the depths there were 14-20 m, and the sea bed consisted of hard sand with shell and small stones (Table 2, stations 23 and 24).

Artificial light was so scattered by the numerous suspended particles in the water that all trawl-track observations had to be made under natural lighting. Lights were used with the television at Smith's Knoll on 2 July, in a depth of 50 m, for a close-up study of the sea bed with a very strong tide running.

RESULTS

1. On all of their five dives on to the track of the trawl the divers were able to quickly find where the trawl had been by close inspection of the sea bed. This was from 9 to 18 minutes after the trawl had passed and on inshore grounds where tides were not then strong (less than 1 knot). The bottom types ranged from muddy sand through fine sand to hard coarse sand. The trawl tracks were most easily identifiable on the muddy sand. On hard coarse sand the track was scarcely discernible, being found only because the divers knew precisely where to look. The track was ill-defined on the very soft and rather featureless ground in Tor Bay. The trawl track was most conspicuous when its path lay across the natural sand ridges on the sea bed.

2. On none of the grounds where the divers operated did the trawl dig in deeply. Usually it was possible to identify separately the marks left by the trawl heads, the ground swept by the tickler chains, groundrope and net, and the adjacent untrawled ground.

The marks left by the trawl heads were straight ruts of the same width as the shoes (200 mm). On the muddy sand the trawl heads, which at this time were travelling nose down with the shoe at an angle of about 20^{o} to the horizontal, were seen to plough into the bottom to a depth of about 80-100 mm, pushing a small heap of soil along in front. This heap of soil was shed to one side periodically. On sandy ridged ground the mark left by the heads was 200 mm wide x 15 mm deep where it had cut through the tops of the ripples (which were about 150 mm apart x 25 mm

Start Bay and one on sand, mud, shell and granules off Brighton) the trawl track was positively identified. One attempt failed because a change of tide prevented the ship from falling back over the track. On one lowering (off Brighton) nothing seen could be identified as a trawl track and on the other two lowerings (one on hard sand in Start Bay close to where the divers had barely been able to find the trawl marks, and one off Brighton) what were thought to be trawl tracks were seen but their character was different from those identified positively elsewhere under different conditions. It is, of course, possible that these latter three observations were nevertheless valid.

6. On the muddy sand and with a moderate tide running the marks left by the trawl heads and the tickler chains were clearly visible 90 minutes after the trawl had passed, and were as described above. The camera first passed across untrawled ground, then the rut of one trawl head, then the 'chain-harrowed' track of ticklers and groundrope, then the rut of the other trawl head and finally over more untrawled ground. This track could still be seen $3\frac{1}{2}$ hours after it had been made by the trawl. Off Brighton, on a bottom of sand, shell and granules, and where there was a very strong tide, what was taken to be the trawl track was very different from those seen earlier elsewhere. On two lowerings, exactly where the trawl track was expected to be found, a change in the appearance of the bottom was evident. The presumed trawl track had a very barren look, almost as though it had been thoroughly hosed down, giving it a generally streaky appearance and leaving more dead shell exposed there than elsewhere; the edges of the track were not clearly delimited.

7. Most of the zoobenthos seen by television in the trawl track appeared to be alive. One specimen of Asterias lying in the rut made by a trawl head appeared to be dead. It was interesting to note that, of the few fish seen, the dabs on the trawl track seemed to be more numerous and were more actively seeking and finding food than elsewhere.

8. The marks left where the ship's anchor chain had lain on the bottom were, after about 10 minutes, more clearly defined than a trawl track even where the latter was seen most clearly.

9. Although the grounds where the 1970 otter trawl experiments were made were revisited, when using the television there no partially embedded or dislodged boulders were seen. It is to be noted that the television technique samples only a very short stretch of a trawled track.

10. Significant local changes in ground type within any one fishing ground were noticed. As the areas of observation of trawl tracks were very limited, care must be taken when relating the trawl observations to the seabed type.

high) leaving a smoothed-out track. Subsequently, when the trawl towing points had been adjusted and more ticklers added (total four) the trawl heads ran level and then, on hard sand, their tracks were barely discernible.

Only the first of the array of tickler chains could be seen by the divers. This was reported, even on the softish muddy sand into which a diver's hand could be easily pushed as far as to the wrist, to be travelling on the surface with only the lower part of alternate links going a few millimetres deep into the sea bed. On soft sand the track of the chains and groundrope appeared as small parallel ridges and furrows running in the direction of towing, the small natural bottom ripples having been obliterated. This was the same as illustrated by Bridger (1970) for an otter trawl with tickler chains. On hard rippled sand and on mud the only apparent effect of the trawl was a smoothing of the sea bed. It was noticed that, on the area of rippled hard sand (stations 5 and 8) smoothed by the trawl, small globules apparently of mud were left rolling about. Where stones were seen in the mouth of the trawl, these, of up to about 250 mm diameter, were rolled along by the tickler, turning over two or three times before the tickler passed underneath them.

3. The zoobenthos on the grounds where the divers worked was not very abundant, Corystes, tube worms, hermit crabs, whelks, brittle stars and Astropecten being the most evident. A number of these were seen apparently undamaged in the trawl track only a few minutes after the trawl had passed. Tube worms re-opened and whelks and starfish were soon on the move again, leaving their tracks on the trawled ground. A living Corystes with one of its claws detached and lying on the bottom near it, and some brittle stars with broken arms, were seen in the trawled area. An Astropecten was seen moving away from the imprint of where it had probably been when the shoe of the trawl head passed over it.

4. On the sandy and muddy sand grounds, the turbid cloud stirred up by the trawl was still not completely dispersed or settled some 10 minutes after the trawl had passed.

5. The underwater television technique was successful. It is a viable technique only in calm weather and when a tide is running, and is restricted to daylight conditions unless the water is very clear. By this method, when the one ship must both do the trawling and operate the television, the soonest that observation of trawl tracks can be made is about one hour after the trawl has passed.

Eight lowerings of the television camera over trawl tracks were made. On four of these (two on muddy sand off Teignmouth, one on fine sand in

11. At Smith's Knoll, on a regular trawling ground at a depth of 50 m with a very strong tide running, the television with artificial lights used very close to the bottom showed much shifting of bottom particles. The close-up view of the bottom sand ripples was like an aerial view of sand dunes being blown by a very strong wind.

DISCUSSIONS AND CONCLUSIONS

1. From examination of the trawl tracks either 10 minutes or more than an hour after the trawl had passed, and from observation of the trawl in action, it is clear that a fairly heavy beam trawl with four tickler chains does not dig deeply into a sea bed of sand or muddy sand. The disturbance caused by the trawl varies, both in character and degree, with the nature of the bottom. These observations were made at speeds of about 1 knot and 2½ knots, which are lower than the normal speed of commercial beam trawling. It is to be expected that the effect of the weight of a trawl (but not necessarily of tickler chains - see 4 below) on the sea bed would be somewhat reduced at higher trawling speeds. Also it is possible that the observations of tracks made some time after the trawl had passed gave an underestimate of depths of penetration of the trawl into the sea bed, because some of the disturbed sediment would by then have re-settled on the ground that the trawl went over. However, it was found that the divers' observations of the action of the trawl heads matched closely with later observations of their tracks.

2. Where the bottom contains a high proportion of mud and the tide is not strong, a beam trawl towed at 2.5 knots leaves a distinct track which persists for at least several hours. On a bottom of coarser sand when a strong tide is running it appears that the track of the trawl across the tide is almost obliterated fairly quickly. The constant movement of particles on the sea bed under strong tidal conditions as seen at Smith's Knoll, together with differences between the bottom soils in the two places, may explain the differences between the trawl tracks seen in strong tides off Brighton and those in weaker tides in Lyme Bay.

3. The observations made on a beam trawl in 1971 revealed its effect to be closely similar to that of an otter trawl as seen in 1970. The action of tickler chains will be the same (subject to considerations discussed in 4 below) on a beam trawl as on an otter trawl. The 283 kg weight in water of the beam and heads is supported on two shoes each of 0.14 sq m if they are level on the sea bed or less if they are tilted as in some of the hauls observed by divers. A commonly used type of deep-sea otter board with backstrop weighs about 556 kg in water, and this weight

is transmitted to the sea bed through a shoe of area 0.24 sq m. Thus, assuming no upwards pull by the warps in either case, the respective pressures on the sea bed of an otter board and a beam trawl head are of the order 2360 kg/sq m and 1010 kg/sq m.

4. A consideration of the action of tickler chains must take into account the following factors: weight of chain per unit length, number of chains, their spacing, towing speed and the composition of the sea bed. Because of the disturbance caused by tickler chains it has been possible to observe in action only the first of an array of tickler chains. Where this has been done (which does not yet include on a soft mud bottom) the tickler chain has not penetrated the bottom by more than what was judged to be about 5-10 mm. Its effect has been to stir up the top of the sediment and leave it in a thin turbulent layer close above the bottom in its wake.

It is likely that the effect of an array of tickler chains spaced one behind the other is for each to 'emulsify' successively deeper layers of the sea bed before much of the soil disturbed by the chain or chains in front of it has had time to settle. Thus the cumulative effect of the array could be fairly deep scouring of the sea bed - maybe to about 80-100 mm by 15 ticklers on muddy sand. Towing speed, sediment particle size and the spacing of the tickler chains will be interrelated in affecting the scouring depth of a tickler array. At any one speed a number of ticklers spaced far apart would not be expected to scour so deeply as the same number close together, because of settlement between the passage of each. Faster speed will reduce the inter-chain settlement of sediment but will tend to offset the weight of the chains. As settling time is a function of particle size, the depth of soil scoured by a given number of tickler chains will increase as the particle size decreases. Thus the effect of a given rig will be least on gravel and greatest on mud.

5. From what has been seen in the experiments of 1970 and 1971 it appears that some zoobenthos in the bottom, such as tube worms, may be disturbed by the oncoming trawl and retract, to re-emerge after it has passed. Their re-emergence after four tickler chains had passed over indicated that the scouring depth was not great. Animals on the bottom were mostly knocked by the tickler chains and taken into the trawl in a shallow layer of turbulent water. The number of animals damaged by the trawl and left in its wake rather than caught in the net was apparently small, although it is possible that some of them were left buried.

6. These investigations show that the individual observations are in many cases dependent upon the conditions of environment under which they

were made. They need to be supported by yet more evidence, especially as to what happens on mud and with yet more tickler chains, before general conclusions can be drawn with full confidence.

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