# Asdic as an Aid to Spawning Ground Investigations

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## Introduction

The nature of herring spawning grounds has long been a matter for investigation. An early report by WALKER (1803) points out that the herring selects a bottom "neither rocky nor sandy", but consisting "of gravel more or less coarse". ALLMAN (1863) reported that evidence from dredging and diving on the Isle of May spawning grounds showed that herring spawn "was deposited on the surface of stones, shingle and gravel, on old shells and coarse shell sand, and even on the shells of small living crabs and other crustacea".

The Ballantrae Bank spawning ground in the Firth of Clyde was studied by COSSOR EWART (1884) using divers, dredges and tallow-coated sounding leads. He found that not only did the herring select hard ground but also that they preferred to deposit their spawn in basin shaped gravel-coated areas. Subsequent work by RUNNSTRÖM (1941), BOLSTER and BRIDGER (1957) and PARRISH *et al.* (1959) has tended to confirm most of the previous findings. In March 1953, Dr. H. BARNES of the Scottish Marine Biological Association Laboratory, Millport (in co-operation with the Marine Laboratory, Aberdeen), carried out a preliminary survey using underwater television in the same area and showed the value of the equipment as a means of identifying different bottom textures.

In view of these results it could be of value, for biological work, to be able to determine the position of suitable textures, and also their relation to the depth and immediate relief. As part of the long-term study of herring spawning, the Aberdeen Marine Laboratory decided to make a detailed study of the Ballantrae Bank spawning ground. Initially dredges and grabs, then camera and television were used to determine the texture of the sea bed. Considerable information was acquired, but obtaining this in sufficient detail using such methods is an extremely long and expensive operation.

At the National Institute of Oceanography an Asdic equipment had been found to be a powerful tool for studying the surface geology of the sea floor. During discussions between the two Laboratories the suggestion was made that an asdic survey should be made of the spawning grounds. Previous asdic surveys had been made in areas having clearly defined geological structures (STRIDE, 1961 and DONOVAN and STRIDE, 1961). It was known that the Ballantrae Bank area was complex but it was still thought that a survey would be useful and might: —

(a) Indicate the areas with similar characteristic textures;
(b) define the limits of the various areas; and
(c) provide some indication of the relief.

## Ballantrae Bank

Ballantrae Bank in the Firth of Clyde is a well-known spawning ground for spring spawning herring (*Clupea harengus* L.). The area is the centre of a long standing local fishery, is well defined topographically, and is conveniently accessible to research vessels.

The bank extends seawards from the coast in the vicinity of Ballantrae at the mouth of the River Stinchar. Depths on the bank range from 6–10 fms (12–18 m) and increase sharply at the seaward edge. This ground contains a wide range of bottom textures (e.g. mud, sand, shingle, gravel, stones, boulders, and rock outcrops) whose distribution may depend on the strong tidal streams which affect the area.

The bank is about 3 miles E-W by 9 miles N-S, the central part of which has been extensively studied by conventional methods (dredge, grab, etc.). This central area extends from the coast for about 2 miles E-W by 5 miles N-S centred on Ballantrae (Fig. 1).

## Sampling Surveys

In February and March 1957, scientific staff on F.R.V. "Clupea" carried out a preliminary but intensive herring egg survey by means of a series of dredge hauls over Ballantrae Bank. During November of that year, a number of survey lines across the bank were completed with the Aberdeen Laboratory's underwater television camera. A tripping anchor technique permitted the television camera to be drifted slowly over the ground with regular stops for timing and checking purposes. At each stop the camera was allowed to rest on the sea bed and focused accurately so that size estimates did not vary seriously throughout the survey. Simultaneously a Decca Track Plotter chart was annotated, providing a continuous record of the ship's sampling position against time. A continuous written record of the material viewed was maintained throughout by one observer. The two records were combined to give a detailed picture of the sections traversed.

In February and March 1958 a more detailed dredge survey than in 1957 was undertaken by F.R.V. "Clupea" and F.R.V. "Kathleen" and this was continued until herring spawn had been located. Thereafter a small grab (designed for use with the Aberdeen Laboratory's underwater television

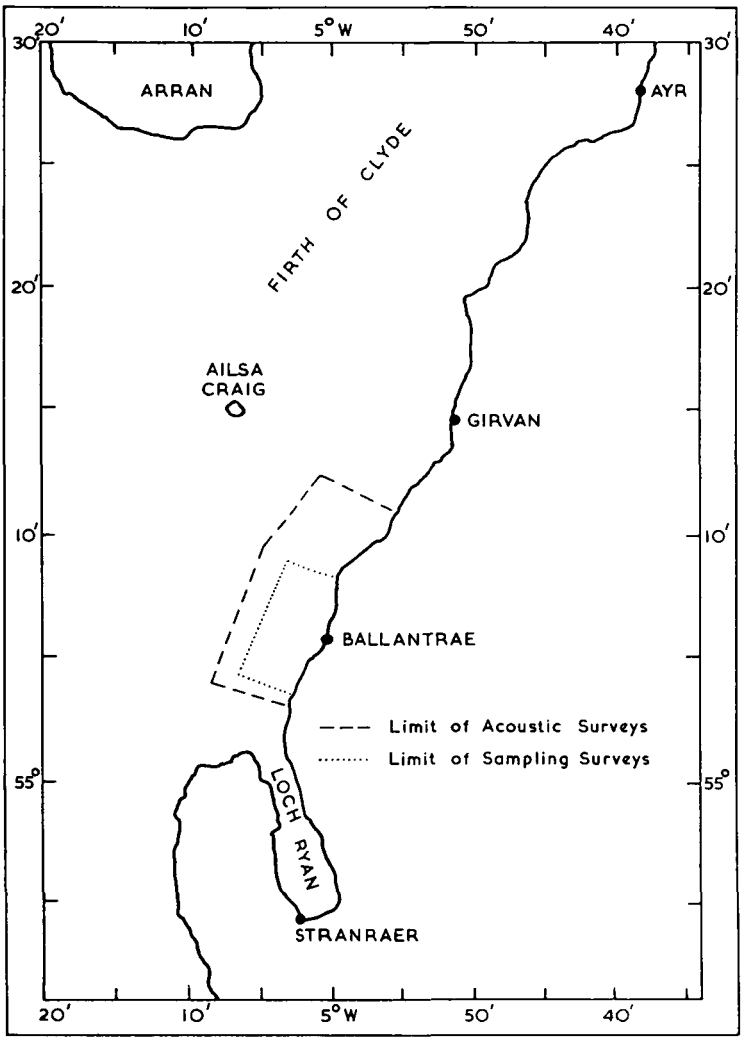


Figure 1. Map of the region around Ballantrae showing the survey areas.

camera and having a mouth aperture of 20 × 20 cm) was used to sample the egg patch and delineate its boundaries. A record of the materials sampled was kept throughout on the Decca Track Plotter. Using the television camera it was just possible to identify the spawn on this patch and to see the substratum where the spawn was sparse or missing. For future use a number of colour transparencies were obtained with the Aberdeen Laboratory's Mark V. Underwater Electronic Flash camera.

Finally, in February and March 1959, the survey was repeated to give the yearly variation, using the grab mainly, and the usual records were prepared.

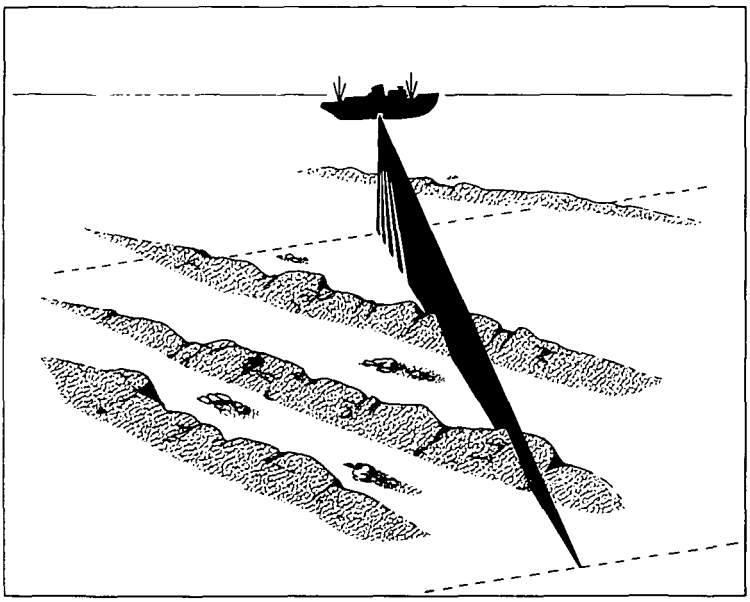

Figure 2. Diagrammatic arrangement of the asdic beams. The beams are 1½° wide in plan, i.e. extending over 20 yards (18 m) at 800 yards (730 m) range, and the main beam is 12° wide in the vertical plane.

## The Acoustic Surveys

### (a) Asdic survey

The narrow beam echo-ranger (TUCKER and STUBBS, 1961) fitted to R.R.S. "Discovery II" operates at 36 kc/s. The beam points sideways from the ship and can be tilted to any angle between the horizontal and the vertical. For this survey the beam was tilted a few degrees below the horizontal as shown in Figure 2.

The survey was carried out early in March 1959 at the beginning of the spawning season on an area off the Ballantrae coast about 9 miles N-S and 3 miles E-W. This area was chosen to give complete coverage of the area already examined by the Aberdeen biologists and also to cover any possible spawning grounds outside this area but still on the bank.

Survey lines about 1,200 yards (1,095 m) apart were steamed parallel to the coast in both directions; this gave an overlap of about 400 yards (365 m) as the recorder range is 800 yards (730 m). The ship's echo-sounder was in operation to provide a depth profile along the ship's track to facilitate interpretation of the asdic records. Decca readings at intervals of between 5 and 15 minutes were taken to determine the track of the ship and time marks were made every 15 minutes on both the asdic and echo-sounder records. Also a course recorder was run to provide a record of ship's head bearing against time.

The weather conditions were quite good but hazards presented themselves in the form of fishing boats and trammel nets around the region where the spawning was taking place.

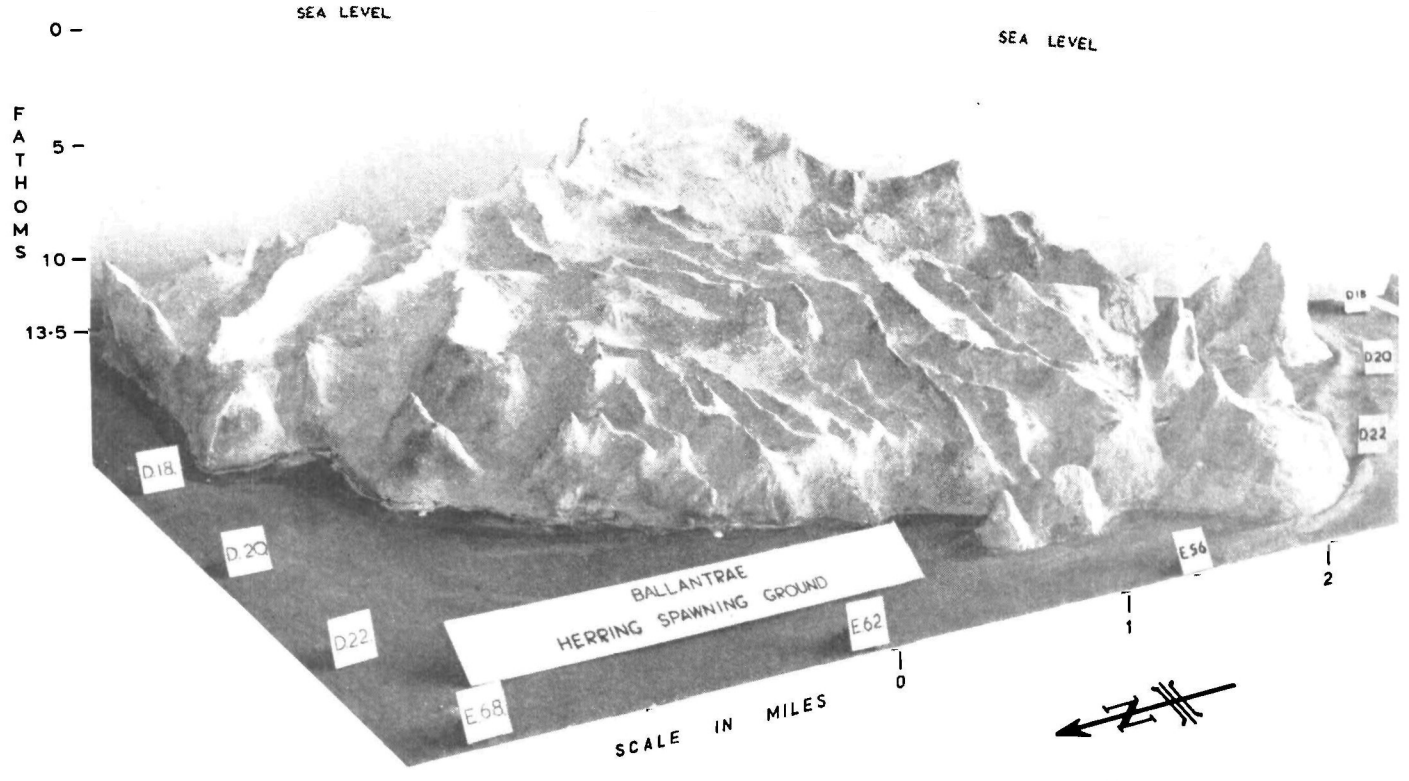


Figure 3. Plaster of Paris model of the Ballantrae Bank. Vertical exaggeration about 100:1.

### (b) Echo-sounder survey

During examination of the asdic records it became apparent that the available echo-sounder records did not provide sufficient information. It was not possible to decide whether a change of pattern on the asdic record was due to a change of composition on a flat sea floor or whether it was due to a change in the slope of the floor itself. Thus it became clear that a detailed echo-sounder survey of the area was required.

This was carried out by F.R.V. "Clupea" in August 1959, and covered an area slightly larger than the central area referred to earlier. The amount of time available and the spacing between the lines thought necessary to give adequate information limited the size of the area surveyed. Instead of steaming parallel to the coast the lines were made along the Purple Decca Lanes which are approximately N-S as the proximity of the coast would have made E-W lines difficult. The spacing between the lines was half a Red Decca Lane, i.e., about 350 yards (300 m). The Decca Track Plotter was a great asset for following a Decca Lane and for determining the actual track.

To make the task of plotting the results much easier and to reduce errors, various precautions were taken. The spacing between time marks was made standard at 5 minute intervals and these were made simultaneously on both the echo-sounder record and the track plotter. Also the marks were made exactly on the minute, a count down system being employed to facilitate this. The ship's speed over the ground will vary depending on the ship's engine speed, wind and tide. A constant engine speed was therefore employed to eliminate one of these variables. The survey occupied more than twenty-four hours and a tide recorder was therefore set up at Cairn Ryan to record the tidal heights, providing for correction of the echo-sounder record.

From the records a Plaster of Paris model was constructed (Fig. 3), and continuous reference was made to this while the information obtained from the asdic records was being plotted.

## Discussion

### (a) Sampling methods and interpretation

In evaluating the conventional methods of sampling used between 1957 and 1959 on Ballantrae Bank the limitations of the techniques must be considered carefully. Table 1 shows a summary of the main points of each method, together with those for an asdic survey for comparison.

It can be seen that television and camera, although requiring some preparation, are convenient and accurate instruments for use in surveys to determine the nature of the sea bed in a herring spawning area. Television provides immediate information whereas with the camera, which is almost as quick, processing is necessary before results are available. Suitably qualified staff are necessary for both these techniques, which are limited by weather conditions.

The dredge and the grab can be used in slightly rougher weather conditions and require no preparation. In contrast to the dredge the television type grab is a very convenient device for locating "gravel more or less coarse". The staff analysing dredge and grab samples must be experienced in estimating

## Table 1

**Summary of the various methods used in the Ballantrae Bank survey**

| | METHOD | | | | |
|---|---|---|---|---|---|
| | Dredge | Grab | Camera | Television | Asdic |
| Area Sampled | Indefinite strip Not uniformly sampled | $\frac{1}{20}$ m² | ½ m² | About ½ m² | Continuous strip 800 yds (730 m) wide |
| Depth Sampled | Varies considerably | About 2″ (5 cm) unless very hard ground | Surface | Surface | Surface |
| Position Sampled | Uncertain | Known precisely | Known precisely | Known precisely | Known precisely |
| Selectivity Fine | Often lost | Accepts finer material up to medium stones | All material photo-graphed | All material viewed | All material viewed, but tends to over-emphasize coarse material when there is a mixture |
| Coarse | Pre-dominant | | | | |
| Rock | By feel of wire | None | | | |
| Outcrops | By broken pieces | | | | All precisely located |
| Time per Sample | 20 minutes | 3–4 minutes | 1 minute | ½ minute | 1 km² per 7½ min. at 6 knots |
| Handling | Inconvenient and tedious | Very convenient | Convenient, but requires preparation | Convenient, but requires preparation | Convenient, but needs experienced operators |

material sizes to the same standard and reference samples or appropriate sieves should be available.

The major limitations of all these methods is the considerable time required to survey in detail an area as large as Ballantrae Bank. In addition, the plotting of results is time consuming, and interpretation presents several problems due to: —

(i) the particularly complex nature of the sea floor in this area;
(ii) the selectivity factors mentioned in Table 1;
(iii) the varied intensity of sampling on different parts of the ground. Once an area of suitable texture had been located, sampling was concentrated there to determine its limits and find herring eggs;
(iv) the inaccuracies of position fixing.

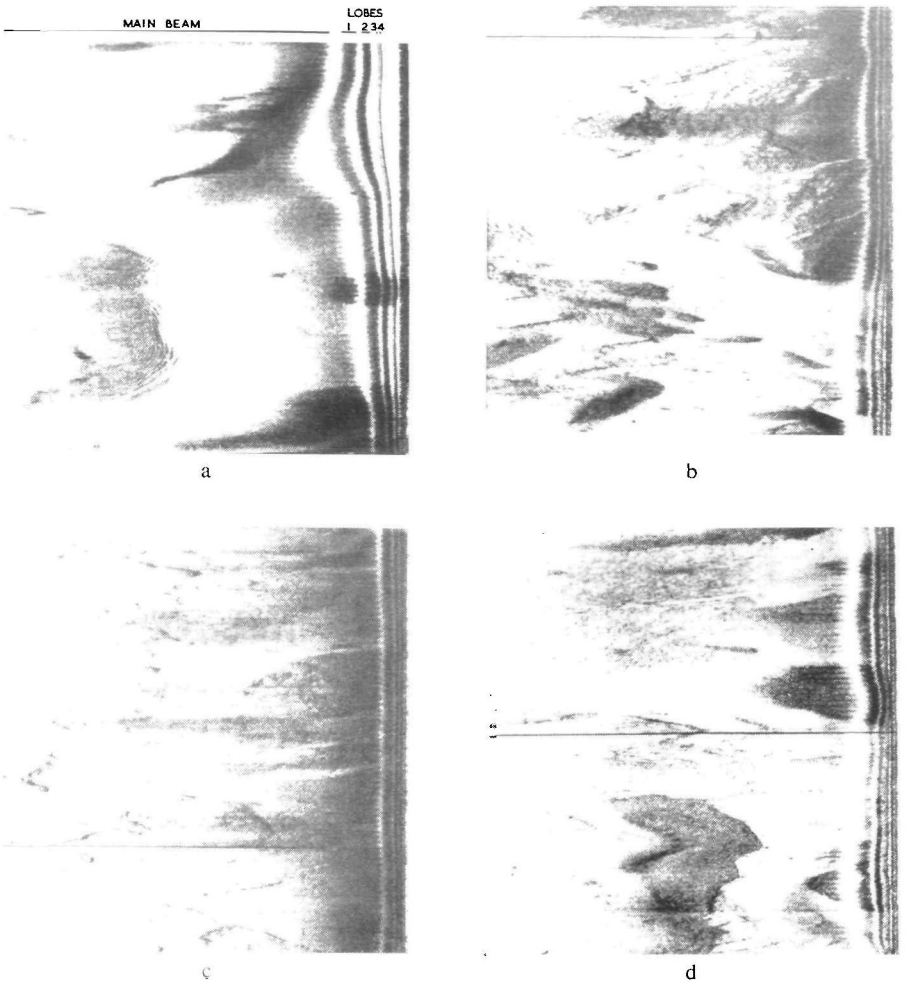


Plate 1. (a) Asdic record to the north of the spawning area. Here, deep and undulating ground shows very clearly the disposition of the various asdic beams.
(b) Asdic record well to the north of the area. This illustrates the rough and undulating nature of this region.
(c) Asdic record of the locality containing the spawn patches. Stones and gravel are indicated by the general half-tone appearance, whereas rock and outcrops appear as darker dot and line echoes.
(d) Asdic record just to the south of the central area. Here undulating ground is primarily responsible for the dark and light patches.
Each record represents an area 800 yards (730 m) wide and about 2 miles long.

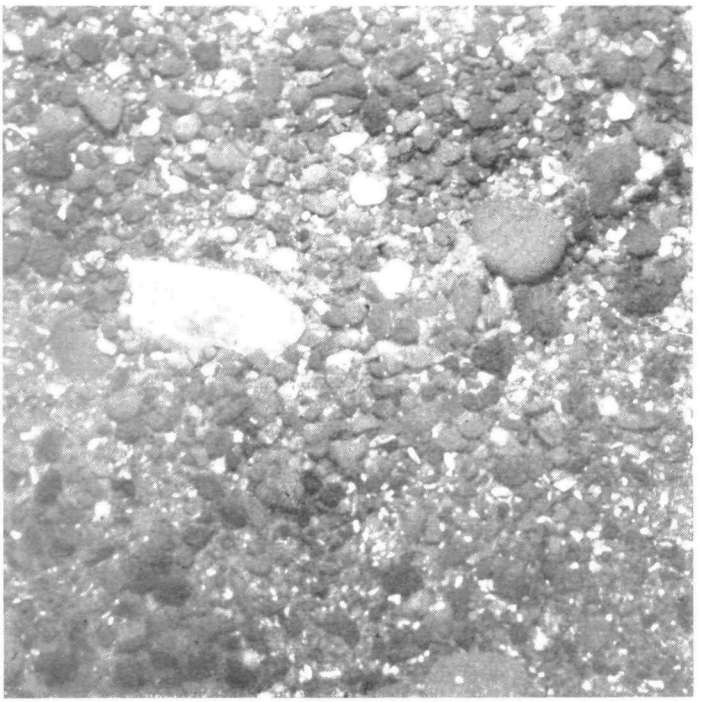

Figure 4. Photograph of the sea bed in the spawning area. This shows an area of ground about 2½ feet square (80 cm²) covered by gravel and a few stones.

As a result of all these factors the composite picture, which was produced from all the data collected, lacks precise detail but is more accurate in the main gravel area. Sampling there was carried out mainly with the grab supplemented by underwater television. In the summarized plot (Fig. 5) only the dominant materials are shown.

**(b) Acoustic surveys and interpretation**

An asdic can be likened to an echo-sounder that has been turned to the horizontal, the functioning of the equipment being quite unaltered. For an echo-sounder the denser the shoal of fish the darker the mark on the recorder; similarly for an asdic, the coarser the bottom material the stronger the recorded echo. Further a sea bed slope facing the ship will increase the echo strength and a bottom sloping away will decrease it.

Also it is important to realize the difference that occurs on an asdic record between pointing the beam ahead and pointing it athwartships. When pointing ahead, echoes are received from a narrow strip of ground which lies along the ship's track. Depending on the ship's speed, a piece of ground will return echoes from several transmissions, and a feature on the sea bed will change its range as the ship approaches. For a sideways pointing asdic however, features on the sea bed are presented at their correct ranges from the ship; echoes from successive scans are laid alongside one another providing an immediate plan-position map of the sea floor to one side of the ship.

Representative examples of the asdic records are shown in Plate 1. Each record represents an area 800 yards (730 m) wide and about 2 miles (3 km) long. The ship was travelling approximately north to south down the right-hand edge of each record with the acoustic beam pointing away from the coast. The main beam covers most of the record out to the extreme range; the side lobes produce the continuous lines towards the right-hand edge. The distance of these from the edge will vary depending on the depth of water, as illustrated in Plate I (a). The hard line of echoes nearest the ship's track is produced by side lobe 4 pointing straight down and thus is an echo-sounder record, giving some indication of the relief, the scale is cramped however, as compared to an ordinary echo-sounder.

The need for an accurate indication of relief became apparent when it was found difficult to interpret the asdic information. The relief, say 400 yards from the ship, could be very different from that directly under the ship and a dark region on a record could either be coarse material on a flat bottom or a slope facing the ship. The production of a model from the subsequent echo-sounder survey made the whole problem much easier. Reference to the model showed the slope of an area under consideration and hence gave an indication of the bottom texture producing the echo pattern.

It was not possible to obtain a correlation which fitted all the acoustic information over the whole region. This was firstly, because there was some uncertainty in fixing certain parts of the ship's track during the asdic survey, and secondly, because the echo-sounder survey lines were still not quite close enough to provide an accurate correlation in some areas. The amount of uncertainty, however, was not large and Figure 6 shows a summarized plot of bottom textures in relation to the main relief features.

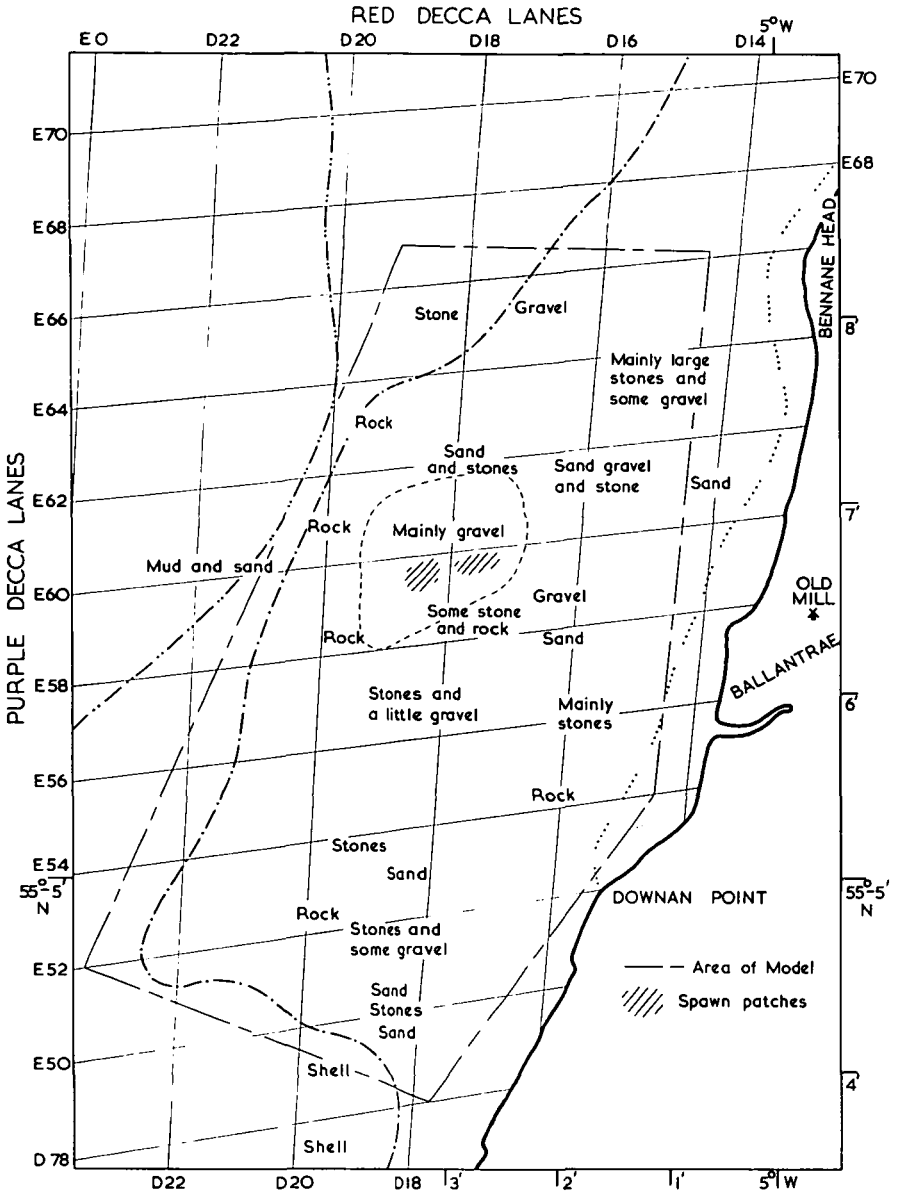


Figure 5. Chart showing a summary of the results obtained from the sampling surveys.

## (c) Navigation, position and timing

The nature of the work involved on sampling surveys dictates that these be carried out at a different time to the acoustic surveys, the emphasis being placed on determining Position. It became apparent after the asdic survey that the arrangements for the operation could have been much better. Thus

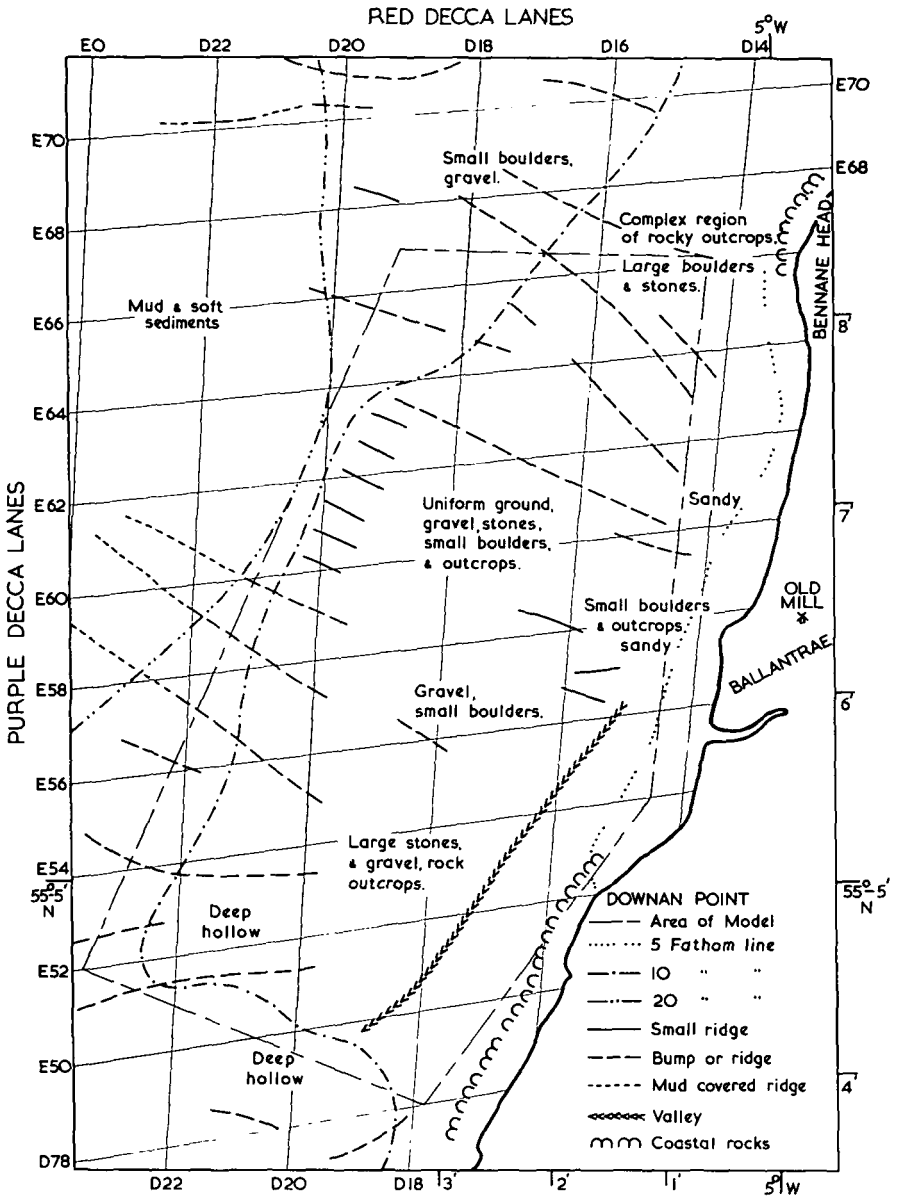


Figure 6. Chart showing a summary of the information obtained from the acoustic surveys.

the subsequent echo-sounder survey was carried out using a much more rigid programme. The following is therefore presented to indicate the precautions to be followed to reduce errors and to facilitate interpretation.

(i) *Navigation*

It is readily apparent that the acoustic surveys should be carried out simultaneously — this will not only save time but will assist greatly in the correlation of the two sets of information. The number of lines required for the echo-sounder survey is greater than the number required for the asdic survey. There is no reason, however, why asdic information should not be obtained on the additional lines. If it is possible a further set of lines at right-angles to the first will be of great value. Although this means increasing the overall time a compromise may be obtained by increasing the spacing between lines.

Changes in the course and speed of the ship should be kept to a minimum but both of these will be affected by the wind and tide. It is impossible to keep the speed over the ground constant but by keeping the engine speed constant a better assessment can be made of the external influences. If strong winds or tidal streams are liable to be present, a ship's head recorder should be used to determine the orientation of the asdic beam with respect to the ship's track.

(ii) *Position*

To determine the ship's position a Decca Track Plotter or equivalent system is essential, otherwise Decca readings have to be taken, which is time consuming and can introduce errors. It is an obvious point but it is essential that the Decca dial unit and plotter are set up correctly and that frequent checks are made during the survey.

Allowance should be made for the Decca variable errors but unless there is reason to associate the survey with an adjacent coast the fixed Decca errors can be ignored.

(iii) *Timing*

It is essential that time marks are clearly displayed on all recorders simultaneously. Also that the interval between marks is made short and exact. An interval of 5 minutes with a ship's speed of about 6 knots has been found convenient. If an automatic time marker is available there will be no difficulty; if not, a count down system should be used with an operator on each recorder.

When non-precision recorders are used, steps should be taken to control the driving voltage or to make frequent checks on the recorder speeds.

## Conclusions

The introduction provided three main aims: —

(a) to indicate the areas which have similar characteristic textures;
(b) to define the limits of the various areas; and
(c) to provide some indication of relief.

There is no doubt that the first aim is possible, and is illustrated by Plate 1 (a–d). The flatness and uniformity of the central region is clearly indicated in Plate 1 (c) and is in complete contrast to the other records which show variable

relief and quite complex echo patterns. These latter records also have echo patterns which differ one from another enabling each area to be identified. In some cases it is possible to decide the limit or boundary between the areas but generally the transition from one area to another is gradual.

From the point of view of relief the asdic records do give some indication, but are not adequate to allow a good interpretation of the records. The echo-sounder records did provide this, but the spacing between lines was still too wide in some areas. There is no doubt that a detailed relief map or model is essential for this type of work.

On a general basis there is a fairly good agreement between the two plots. To the north the ground is rough and undulating and is comprised mainly of boulders, and outcrops of rock. The area to the west, off the bank, is composed of soft sediments. Near the coast off Ballantrae, sand is abundant with areas of stones and gravel. A mixed texture of boulders, stones and gravel is to be found to the south where there are also deep hollows and valleys. On and around the central area where the fish spawn, however, the ground is much flatter and is covered with a large amount of gravel, some stones and small amounts of outcropping rocks (Fig. 4).

It has been found in a complicated region such as this that the interpretation of the asdic records is difficult but a great deal of useful information can be obtained, and a qualitative picture of the region built up. Due to the limitations of the methods and uncertainties of navigation it has not been possible on this particular investigation to obtain a detailed correlation between the sampling and acoustic data. Where large features occur however, it is possible to quote the bottom material with some certainty, e.g. the distinct feature in the lower half of Plate 1 (d) has been identified as a large area of stones on sand. Also it is possible to determine precisely the position and size of rock outcrops since they are presented as clearly defined black patterns on the record, e.g. the line features on the left of Plate 1 (c).

By comparing the records taken from each area with that taken from the spawning ground it is concluded that the latter area is the only place where herring are likely to spawn. For example, to the north (Plate 1 (a)) the ground is too deep and undulating and further north (Plate 1 (b)) the ground is too rough; to the south (Plate 1 (d)), the most likely alternative, the ground is undulating and the bottom texture rather coarse. The central uniform region is about a mile square, the fish appearing to spawn only in small areas in the middle. The factors governing the exact positioning of the spawn patches are still not fully understood; there may be slight differences in texture over the bank, but alternatively other influences like water currents or temperatures may be dominant.

The value of an asdic for a preliminary survey of a new ground has been demonstrated. A survey can be carried out in a few days compared with the months required by the more conventional methods. A study of the resulting plot will then show the areas which can be completely ignored and also give an indication as to the amount of sampling required in each area of interest, e.g. an area having a uniform echo pattern may only need a few spot samples instead of an overall survey. Furthermore it should be possible to ascertain from the records the sampling method(s) most suitable for a particular area. Thus, the amount of time needed to obtain the required information will be greatly reduced.

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## Summary

1. An asdic survey of the Ballantrae herring spawning ground was carried out by R.R.S. "Discovery II" (National Institute of Oceanography), to assist in the biological studies being made by the Marine Laboratory, Aberdeen.

2. On a general basis reasonable agreement was achieved between the asdic survey and the previous sampling surveys, but detailed correlation was difficult owing to the limitations of the various techniques.

3. A qualitative picture of the region was obtained and distinct areas identified. It would seem unlikely that herring spawn in any region except the known central area.

4. An acoustic survey carried out on a new ground would provide useful information about the sea floor and would help to reduce considerably the amount of time spent on subsequent sampling surveys.

5. Experience has shown that these surveys require accurate time marking and track plotting; also to interpret the asdic records a good relief map or model is essential.

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