A NEW BOTTOM-SAMPLER

By N. A. Holme, B.A.
Zoologist at the Plymouth Laboratory

(Plate I and Text-figs. 1–4)

Introduction

At Plymouth the bottom-fauna is usually sampled by the trawl and dredge, but for quantitative work the $\frac{1}{10}$ m.^{2} Petersen grab is sometimes used. Allen (1899) surveyed the bottom-fauna, on grounds between the Eddystone and Start Point, by means of trawling and dredging only. Ford (1923) has made collections of the bottom-communities near Plymouth, and gives lists showing the densities of species taken with the Petersen grab. Steven (1930) also used this grab for a survey of a limited area, but Smith (1932) resorted to a conical dredge with canvas bag, having found the grab ineffective in shell-gravel.

Davis (1925) has attempted to analyse some of the inaccuracies due to sampling with the grab. To some extent variations in the fauna in successive hauls are due to a patchiness of the fauna in any one soil, and also to the patchy distribution of soils in any one area. Rolling of the ship affects the size of the sample by altering the rate at which the grab hits the bottom and hence the size of the 'bite'. Drifting of the ship tends to decrease the size of the sample, as the grab must be pulled vertically from the soil to take its maximum 'bite'. The volume of the sample also depends on the consistency of the soil, which will affect not only the depth to which the jaws penetrate, but also the amount of material lost during hauling. Thus Smith (1932) found that when sampling on shell-gravel the grab frequently came up almost empty, the jaws having failed to close because of pieces of shell wedged between the teeth.

A further source of error is emphasized by Steven (1930): this is the ability of certain species to evade the grab, either by active burrowing or by normally living at a depth beyond its reach.

Thamdrup (1938) gives an account of the van Veen bottom-sampler, which differs from the Petersen grab by having long arms to the ends of which are attached the cables actuating the closing movement. A considerable leverage effect is thus exerted to close the jaws. In addition, the instrument is probably less likely to leave the bottom prematurely if there is a sudden jerk on the cable due to rolling of the ship. On a sandy bottom the van Veen sampler takes two or three times as much soil per unit area as does the Petersen grab.

Knudsen (1927) describes an ingenious sampler capable of digging to a depth of 30 cm. in sand. Comparable hauls against the Petersen grab (see Johansen,

1927) showed that it brought up ten to twenty times as much soil and four to five times as much animal tissue (by weight) as the latter. This instrument would hardly be suitable for use in the open sea in its present form owing to the risk of loss of material during hauling.

A new sampler has been designed to overcome some of the difficulties of bottom-sampling in the Plymouth area. These may be summarized as: the coarseness of the deposits, which makes penetration difficult and tends to result in considerable loss while hauling; Atlantic swell which makes perfectly calm days rare, so that the speed with which the sampler hits the bottom is variable; and currents which cause the sampler to descend rather obliquely, whether the ship is anchored or not.

I am indebted to Dr H. W. Harvey, F.R.S., and Mr G. A. Steven for suggestions and criticism in the design of the apparatus, and to Mr F. G. C. Ryder for constructing a working model of the grab and for help in many ways. I am also grateful to Captain C. Hoodless and the crew of R.V. *Sabella* for their skill in working the sampler at sea.

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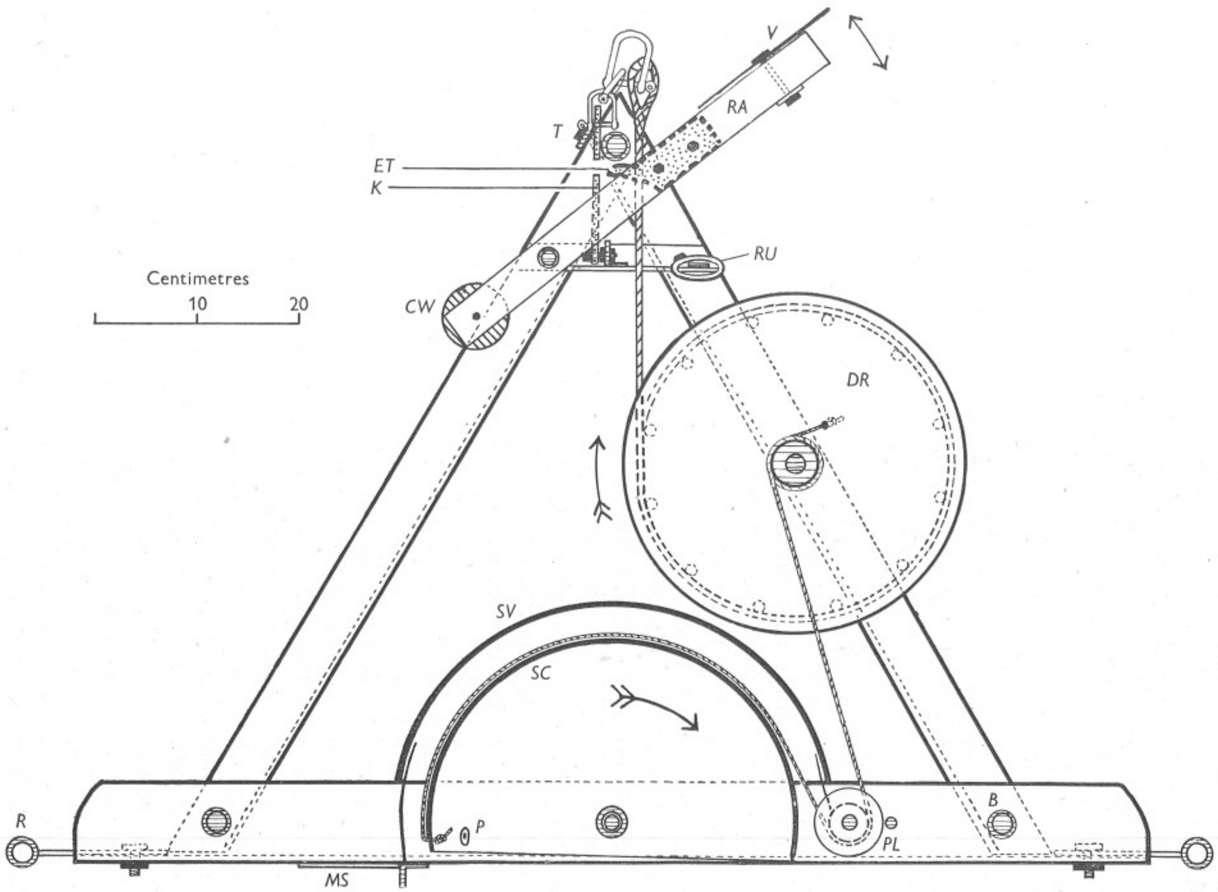
The echinoderms shown in Table I were kindly identified by Mr H. G. Vevers, and some of the molluscs by Miss U. M. Grigg.

The Sampler

This is shown in Text-fig. 1 and in Pl. I, fig. 2. It consists of a frame supporting a semicircular scoop (SC), which rotates through 180° to take a sample. The scoop is actuated by unwinding cable from a large drum (DR) by the side of which is a smaller drum, which winds in a thin cable attached to the scoop. By this means a considerable mechanical advantage is obtained, so that the upward pull on the cable required to close the apparatus is small. Since there is only a single scoop there is no risk of the jaws not closing, and washing out during hauling is probably small, judging by the appearance of the sampler when it is coming up just beneath the surface. The sample is protected by a semicircular cover (SV), but there is a slight loss of soil when the grab breaks the surface and water empties from it. The sampler weighs rather more than 45 kg., and in use it is weighted to about 110 kg. The theoretical size of the 'bite' is a rectangle of $\frac{1}{20}$ m.^{2} surface area, semicircular in section, with a maximum depth of 15 cm. Some animals undoubtedly live below this depth, but observations on the shore and in baths of sand indicate that a very much greater force is required to dig deeper than this.



Text-fig. 1. Side view of the sampler, seen as if the frame on one side were removed. The key and the engaging tooth are stippled. B, frame bolt and distance piece; CW, counterweight; DR, drum; ET, engaging tooth; K, key; MS, transverse metal sheet; P, hole for wooden peg; PL, pulley; R, ring; RA, release arm; RU, metal strip protected by rubber hose; SC, scoop; S V, scoop cover; T, cross-piece holding key in position; V, vane.

The apparatus resembles in some respects the dredge used by Stetson (1938) for taking a small semicircular core of bottom-sediments. Since the design of the sampler was liable to alteration it was largely constructed by bolting rather than welding. The only parts requiring to be made professionally were the large ring, the drum, the scoop, and the scoop cover.

Details of Construction

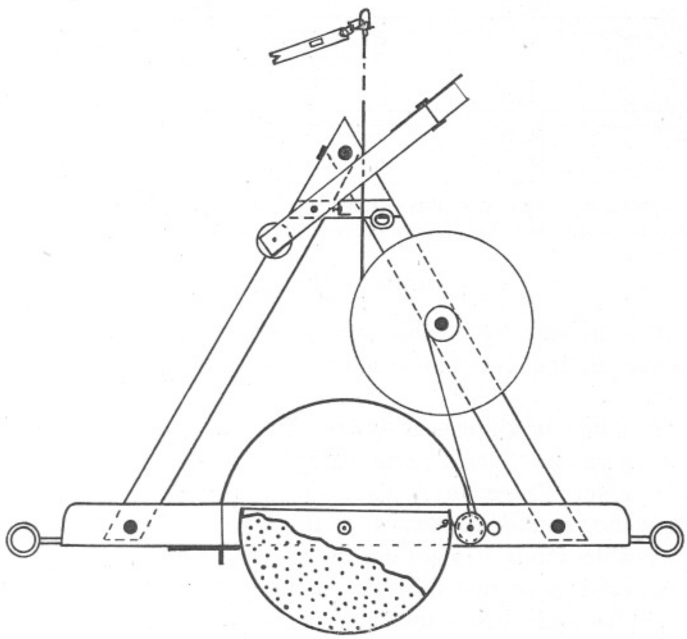
The frame consists of six pieces of heavy angle-iron, bolted to form two triangles separated at their bases by 17 cm. and at the top by a slightly greater distance. The two sides of the apparatus are joined by bolts and distance-pieces of iron piping ('gas-pipe').

The ring (R) is of iron piping, attached to the base of the frame by welded lugs and bolts. The function of the ring is to keep the grab level on the sea-bottom, and also to prevent it damaging the ship's side.

The scoop (SC) is of steel plate 3 mm. thick welded to form a parallel-sided semicircular structure of external radius 17·5 cm. and width 15 cm. At the centre is welded a length of iron pipe through which passes an iron bar on which the scoop rotates. The bar is removed when the scoop is to be emptied. The cable attached to the small drum is fastened through a hole at one end of the scoop. During the descent the scoop is kept in an inverted position by a small wooden peg (P) passing through a hole in the scoop and the frame: this is sheared off when digging commences. The cutting end of the scoop is filed to a rather blunt edge. (Another scoop is being tested which has a pair of long teeth which precede the scoop and may help to anchor it in the soil.) While digging, the scoop tends to pile up soil in front of itself, but this falls back into the scoop when it is closing. There may be a slight loss of this soil through the gap between the scoop and the frame. Thus any stratification in the soil is partially disrupted. Outside the arc of the scoop the soil is prevented from piling up by the wide frame-base and a transverse sheet of metal (MS) pressing down on the soil surface. The arrangement of parts during hauling is shown in Text-fig. 2. The thin cable passes over the top of the scoop, round a pulley (PL), and is attached to the small drum on to which it is wound when the scoop closes. Should the scoop be unable to close, owing perhaps to catching on a piece of rock, a force of over 500 kg. is exerted on this cable, which is sufficiently thin to break and thus free the scoop. In practice the axle of the pulley tends to bend owing to the force exerted on it when the scoop is cutting through shells, etc., and this has had to be replaced by a thicker bar.

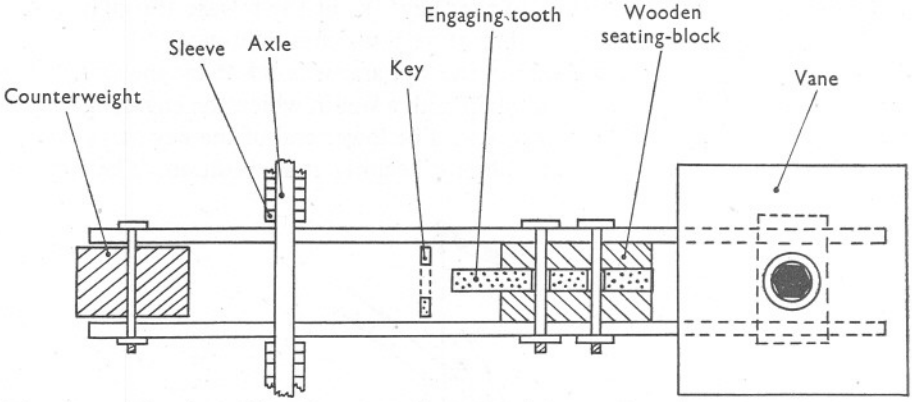
The large drum (DR) consists of two circular sheets of iron between which are welded short lengths of iron bar on which the large cable is wound. The latter is 3·5 m. in length and 25·5 mm. circumference. It is secured at one end to the centre of the drum by a shackle and short length of chain (these are not shown in Text-fig. 1). During hauling the cable has completely unwound from the large drum (to which it is still attached by the chain) so that there is no longer any tension on the thin cable. The upper end of the cable passes between the top bolt of the frame and a metal strip protected by a piece of rubber hose (RU). It is attached to the 'key' (K) of the release through three shackles and to a cable from the ship of 32 mm. circumference.

During the descent the weight of the apparatus is taken by the key. The key is a short length of thick metal strip with a slot in which the engaging tooth on the release arm grips during descent. The lower end of the key has a notch which slides on to a bolt head, thereby keeping it in position. The key is



Text-fig. 2. Position of parts when the instrument is closed. The soil sample is stippled.

prevented from lateral movement in one direction by the sides of the release arm, and in the other by the top bolt of the frame and a transverse metal strip (T). The release arm (RA), shown also in Text-fig. 3, consists of two metal strips separated by about 45 mm. internally. The engaging tooth (ET) is held between the strips, gripped between two blocks of hard wood. The base of the engaging tooth is slotted to allow adjustment of its position relative to the arm. The release arm pivots on an axle, being counterweighted so that the long arm just tends to drop. During descent it is kept in the upward position by the force exerted on the engaging tooth. When the sampler reaches the bottom the cable slackens, the arm drops and the key can slide out while cable is unwound from the drum. A vane (V) has been fitted to one end of the arm, as was done by Stetson (1938), to minimize the chances of release if the cable should momentarily slacken while the grab is descending. The release has proved most successful, and only occasionally fails to work. The key is kept to a minimum size as it has to pass over a roller-sheave while hauling.



Text-fig. 3. Top view of the release arm. Transverse bolts are shown in section. The key and engaging tooth are stippled. The sleeves prevent lateral movement of the arm on its axle.

Method of Use

The sampler is hoisted by a cable attached to the winch and passing over a roller-sheave on the boom, the latter being swung over the ship's side (Pl. I, fig. 1).

The routine while sampling is as follows. The cable is wound on to the large drum and the release set, strain being maintained by taking some of the weight on the ship's cable. The scoop is placed in the 'closed' position, and its axle inserted. It is then rotated backwards to the 'open' position, care being taken that the thin cable winds straight across its top. The peg is inserted and the apparatus lowered over the side. As soon as the cable slackens, hauling commences. The cable need not be vertical while the sampler is closing, as the latter is extremely stable on the bottom. Since the efficiency of the sampler does not depend on the force with which it strikes the bottom, it may be lowered at any speed.

When the sampler is on board again, the cable is immediately rewound on to the large drum and the release set. The scoop is then removed and emptied. This is less damaging to the animals than merely inverting the scoop *in situ*.

In a depth of 30 m. a sample can be taken every three minutes.

A 'safety rope' is often used to minimize the risk of loss. This is attached from the end of the ship's cable to the ring. In common with all heavy gear, the sampler is difficult to work in a moderate sea.

Results

During 1948 the new sampler has been used at sea on a number of occasions, and in August a total of 100 hauls were made at thirty-seven stations during a cruise in Great West Bay. This provided a fair test of the instrument in continuous use under favourable sea conditions. On the whole the instrument has worked successfully, and has taken good samples on sands, fine gravels and muds: adequate hauls have been taken at nearly all stations so far attempted.

The maximum volume of a sample is about $5\frac{1}{2}$ l. In practice the scoop is seldom quite full, usually bringing up 3–4 l. of soil. A number of hauls with this instrument and with the Petersen grab have been made to show the comparative increase in sampling efficiency. Sample volumes were:

Muddy gravel off Mewstone. Ship anchored.

New sampler: 5·25, 5·6, 5·25 l. in successive dips, i.e. average of 10·7 l./$\frac{1}{10}$ m.^{2}.
Petersen grab: total of 8 l. in three dips, i.e. 2·67 l./$\frac{1}{10}$ m.^{2}.

Muddy sand in Bigbury Bay. Ship anchored.

New sampler: first five dips—12+l., i.e. *c.* 4·8 l./$\frac{1}{10}$ m.^{2}; second five dips—11+l., i.e. *c.* 4·4 l./$\frac{1}{10}$ m.^{2}.
Petersen grab: five dips—1 l., i.e. 0·2 l./$\frac{1}{10}$ m.^{2}.

Muddy sand in Cawsand Bay. Ship anchored.

New sampler: first five dips—10·75 l., i.e. 4·3 l./$\frac{1}{10}$ m.^{2}; second five dips—10·5 l., i.e. 4·2 l./$\frac{1}{10}$ m.^{2}.
Petersen grab: five dips—1·75 l., i.e. 0·35 l./$\frac{1}{10}$ m.^{2}.

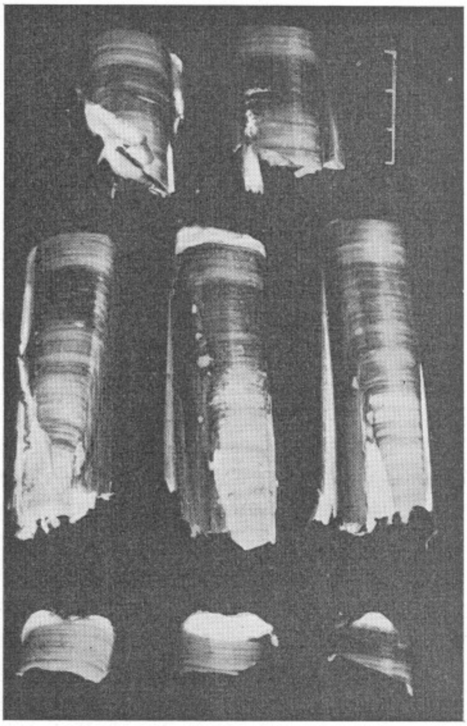
Johansen (1927) made a similar comparison between the Knudsen and Petersen grabs. On sand the former brought up an average of 25·6 l., whereas the Petersen grab only collected an average of 1·2 l./$\frac{1}{10}$ m.^{2}.

Thamdrup (1938) gives a number of comparisons of the van Veen and Petersen grabs. In a typical haul, in sand, the former brought up 3·4 and the latter 1·7 l./$\frac{1}{10}$ m.^{2}.

The collections made in Bigbury Bay show that the new instrument samples the bottom-fauna more efficiently than does the Petersen grab. The results of collections of 0·5 m.^{2} area are given in Table I. It will be seen that for nearly all species the Petersen grab gives too low a figure. In addition, only five species were recorded as against thirteen with the new sampler. It must be emphasized that this soil, being very tightly packed, is most unfavourable for bottom-sampling, and that on other grounds the differences in sampling efficiency would be rather less. The depth to which the various instruments were digging is indicated by fragments of *Ensis* shells taken (Text-fig. 4). The Petersen grab failed to capture any individuals, possibly because its jaws were not powerful enough to cut through the shell; while the new sampler cut off three individuals about 8 cm. from their upper ends, and shorter lengths of two other specimens. A dredge haul over the same ground cut off the top 2 cm. of three individuals. Assuming that the tops of the shells lie near or at the surface of the sand, and that the animal burrows nearly vertically,

TABLE I. COMPARISON OF HAULS MADE IN BIGBURY BAY, 18 MAY 1948. MUDDY SAND, SHIP ANCHORED

Instrument ...	New sampler	New sampler	Petersen grab
No. of dips	5	5	5
Total area (m.^{2})	0·25	0·25	0·5
Nephthys sp.	2	*c.* 4	1
Magelona papillicornis	*c.* 73	*c.* 50	2
Cirratulid	—	—	1
Gephyrea	1	—	—
Annelids *indet.*	10	7	—
Cellaria sp.	—	—	1
Cumacea	3	4	—
Bathyporeia elegans	71	27	28
Amphipods *indet.*	2	1	—
Natica alderi	1	3	—
Cylichna cylindracea	4	—	—
Mactra corallina	—	1	—
Ensis ? *siliqua*	4	1	—
Amphipholis squamata	2	—	—
Echinocardium cordatum	1	—	—



Text-fig. 4. *Ensis* from Bigbury Bay. Top two rows: individuals caught in new sampler; bottom row: individuals caught in dredge. For further explanation see text. The scale is 3 cm. long the new sampler would seem to be digging about 8 cm., which is consistent with the volume of sand (*c.* $2\frac{1}{2}$ l.) brought up.

Discussion

In the last section it was shown that the new sampler is very much more efficient than the Petersen grab as a quantitative sampler on certain grounds in the Plymouth area. Other workers have compared the Knudsen and van Veen samplers against the Petersen grab and have also found that better results were obtained, when working on a sandy bottom.

While the Petersen grab is no doubt suitable for working in sheltered waters and on a soft muddy bottom, it is clearly relatively inefficient on a hard bottom. It has, however, been used by a number of workers under the latter conditions and has been found a useful instrument for semi-quantitative evaluation of the benthos. The variability in the size of sample taken on any one ground and on different grounds is in itself sufficient to show its unreliability in making an accurate estimate of biomass.

The Knudsen sampler, which digs to a depth of 30 cm., has shown the need for sampling to a considerable depth in order to capture the deeper-burrowing invertebrates. The use of the Knudsen sampler is, however, restricted on account of its weight (about 200 kg.), and its inability to dig into deposits other than sand.

The van Veen sampler is a considerable improvement on the ordinary type of grab, as judged by the volume of sample brought up. But there is still some risk of losing material through stones becoming wedged in the jaws.

The new sampler was designed to take a sample of sand or gravel which should be subject to the minimum of loss during hauling. In addition, it has been shown to dig considerably deeper than the Petersen grab, and to the same order of depth as the van Veen sampler. The area sampled ($\frac{1}{20}$ m.^{2}) is, however, rather small, and the apparatus rather heavy, and so difficult to work except in calm weather.

One of the most serious drawbacks to maximum efficiency appears to be the lateral shifting of the frame while the scoop is digging; this causes a decrease in sample volume. The addition of extra weights appears to be of little advantage in stopping this movement, and it is suggested that the only solution is a grab with two scoops working independently and rotating in opposite directions. The alternative of spikes or cross-pieces of angle iron on the base of the frame, to increase the grip on the soil, has not been very successful, as these tend to damage the ship's rail and do not seem to increase the size of the sample appreciably.

A half-scale model made in wood proved to be successful and took samples of about 300 c.c., being worked by hand from R.L. *Gammarus*. It is suggested that a sampler of this size might be used for survey purposes where a rather larger volume than that obtained by the 'snapper' is required.

Summary

A bottom-sampler is described for use under open-sea conditions, particularly where the bottom is of sand or coarser material.

It takes a sample of $\frac{1}{20}$ m.^{2} area of semicircular cross-section and maximum depth 15 cm. There is probably little loss of material while hauling and no danger of the apparatus losing soil through being wedged open by shell fragments, etc. The instrument weighs over 45 kg. and is weighted to 110 kg. in use.

Comparable hauls have been made against a Petersen grab: the new sampler digs four or five times as deep on a sandy bottom, and is thus of similar efficiency to the van Veen sampler. It is probably more efficient, however, than either of these on a bottom of fine gravel.

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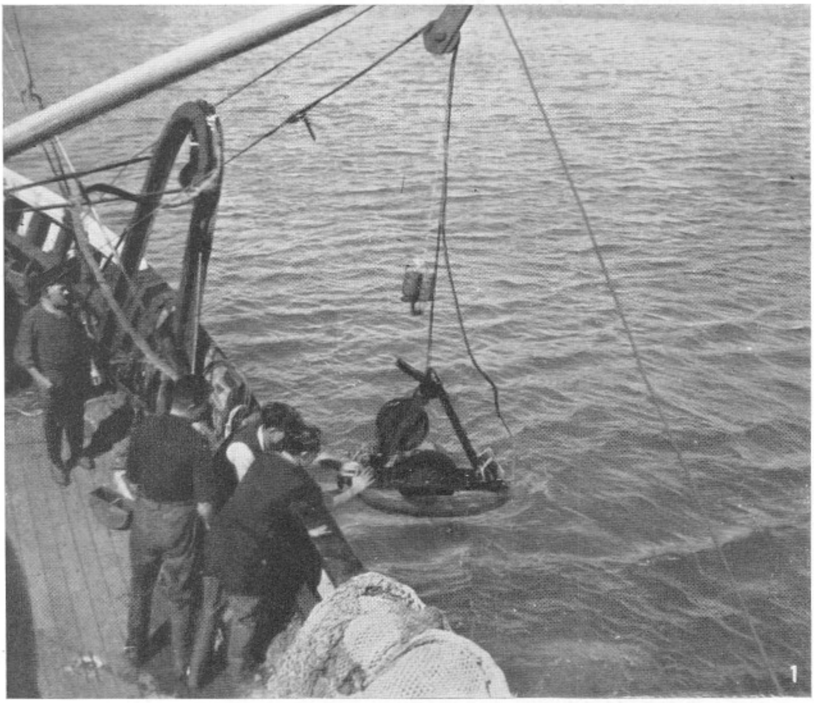
EXPLANATION OF PLATE I

Fig. 1. Working the sampler on R.V. *Sabella*. The instrument is being hauled up. Note that cable has unwound from the drum so that the key has passed over the sheave. The safety rope may be seen on the right of this cable. A toothed scoop is being tested; the type normally used is seen on the deck. Note the weights attached at either end of the frame.

Fig. 2. Photograph of the new sampler. The scoop may be seen under the frame. The two jars of sand together represent the volume of one sample.



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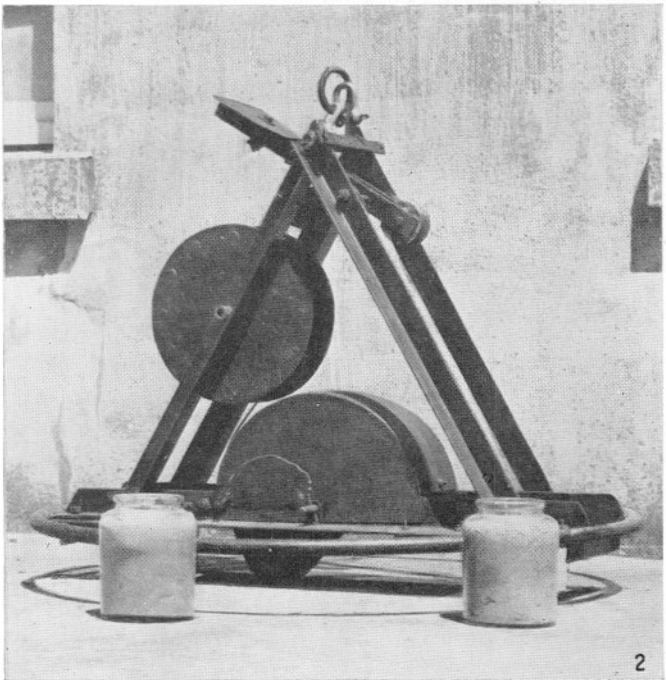

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