J. Mar. biol. Ass. U.K. (1955) 34, 545–551
Printed in Great Britain

AN IMPROVED 'VACUUM' GRAB FOR SAMPLING THE SEA-FLOOR

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(Text-fig. 1)

The sampler to be described takes a small unstratified sample of the sea-bed, the sample being subject to a minimum of loss while being brought up. Such samples are of use in survey work, or for studies on grade size, mineralogical composition, chemical properties, or microfauna and flora of the deposits.

Although core-samples, in which the original stratification is retained, can be taken in soft muddy sediments without difficulty, it is not at all easy to take cores of sand or gravel. On such deposits an unstratified sample may be the best that can be obtained. Coarse sediments may be sampled by a dredge fitted with canvas bag, but when a small sample is required quickly, a light instrument which can be lowered vertically from the ship on a rope or hydrographic wire is needed. 'Snapper' samplers do not always take a satisfactory sample as the jaws may be prevented from closing by a pebble or shell wedged between them, much of the sample being lost while hauling up (cf. Stetson, 1938, p. 7). Stetson describes an instrument which takes a small semicircular core of sediment, the sample being sealed in the coring tube while being brought up, so preventing any loss of material. While no doubt taking good samples, the instrument is rather heavy (57 kg) and complicated in construction.

When large numbers of samples are to be taken, an 'underway' sampler as described by Pratje (1952) may be used with advantage. This requires, however, a suitably positioned winch to run out the wire as fast as the sampler descends, whereas the sampler described here can be worked either by hand or from any small winch.

The new sampler was constructed in the first place to take samples for mineralogical analysis. It is a modification of the original 'Vacuum' grab described by Hunt (1926), which is still used at Plymouth from time to time. Hunt's sampler consists of a metal cylinder containing air at atmospheric pressure, with an opening sealed by a glass plate. On reaching the sea-bottom the glass is broken by a bayonet-striker, and the resulting inflow of water to compress the air in the chamber is used to draw in a sample of sediment. Although an efficient instrument under favourable sea conditions, it was considered that the original sampler was open to considerable improvement. The most serious disadvantage is that broken glass gets mixed in with the soil sample, and the removal of the remaining fragments at the mouth of the chamber is an unpleasant operation, made more difficult by the presence of grease which is smeared round the glass to give a watertight joint. In rough weather it is difficult to obtain a satisfactory sample, probably because the sampler does not hit the bottom in an upright position. To remove the sample it is necessary to unscrew the base-plate of the chamber through a number of turns, and a quicker method of emptying out the sample was clearly desirable.

The new sampler, while retaining many of the features of the original 'Vacuum' grab, differs in having the chamber sealed by a metal plug instead of a glass plate, the shape is rather more streamlined to aid vertical descent, and the chamber can be opened more quickly to remove the sample.

Description of the Sampler

The sampler (Fig. 1) consists essentially of a cylindrical pressure chamber (*C*) with detachable lid (*L*) having a central opening or 'gullet' (*G*) in the bottom connected to the exterior by a downwardly directed sampling tube, consisting of two components, an upper fixed 'gullet-tube' (*T*) and a lower sliding funnel-shaped 'mouth-tube' (*M*). An extension of the gullet-tube upwards into the chamber serves as a trap-tube (*A*), which enables the sample to be retained in the chamber. The gullet is sealed by a plug (*P*) which is held in position by three retaining hooks (*H*), while the sampler is being lowered. On reaching the sea-bed, the mouth-tube slides upwards over the gullet-tube, so releasing the plug, which flies up through the trap-tube into the chamber, followed by an inrush of water and sediment collected from around the entrance to the mouth-tube.

The pressure chamber is a cylinder of 4 in. bore brass-tube, $\frac{1}{4}$ in. thick and 13 in. long, closed at the bottom by a heavy-gauge circle of metal. The lid has a rubber ring set in a lip to ensure a watertight joint, and is kept in position by a 'samson' (*S*) which can swivel sideways on bolts attached to the pressure chamber. A set screw bears down on the centre of the lid. The trap-tube (*A*) is a length of 1 in. bore pipe, 10 in. long. To the base of the pressure chamber is bolted the gullet-tube (*T*) bearing attachments for the three

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Legend to Fig. 1.

Fig. 1. Vertical section through the sampler. *A*, trap-tube; *C*, pressure chamber; *E*, stop; *G*, 'gullet'; *H*, retaining hooks (three in all, set at 120° to one another round the gullet-tube. They are pivoted between pairs of lugs attached to the gullet-tube); *L*, lid of pressure chamber; *M*, mouth-tube (stippled); *O*, collar on mouth-tube; *P*, plug; *R*, rubber washer; *S*, 'samson' securing lid; *T*, gullet-tube; *W*, brass washer; *X—X*, the trap-tube, washers and gullet-tube are attached to the pressure chamber by three bolts (not shown) along this axis, and opposite the retaining hooks; Y_1, slot in mouth-tube which allows limited vertical movement relative to the gullet-tube; Y_2, slot in mouth-tube to allow retaining hook to disengage completely.

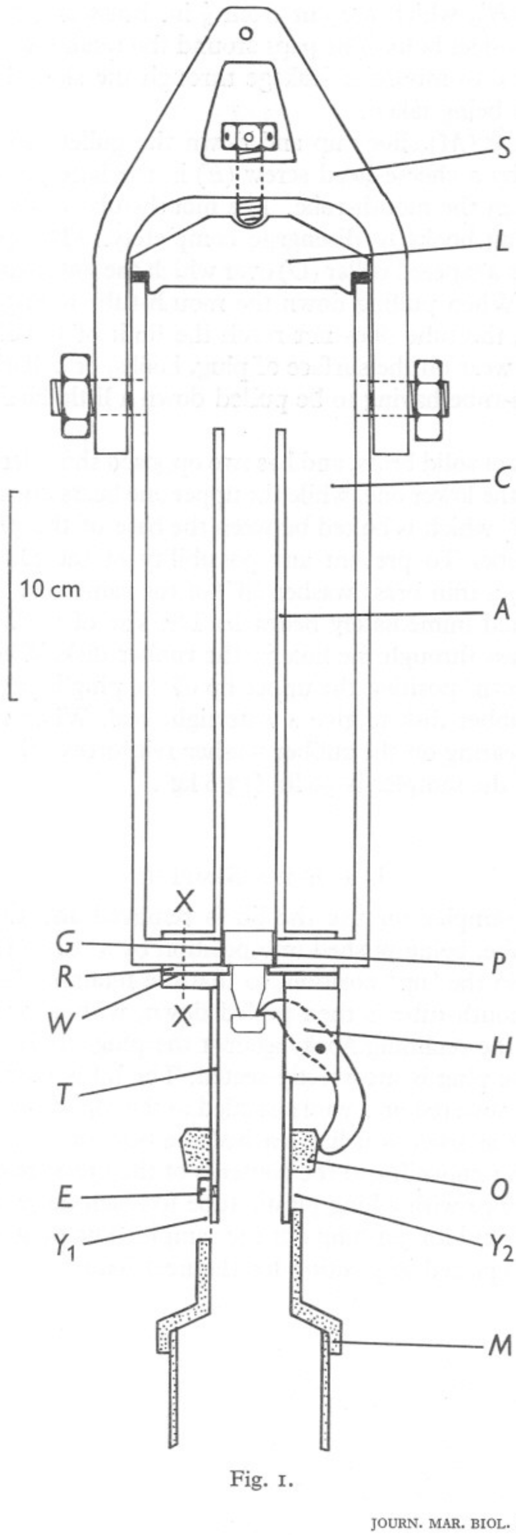

Fig. 1.

retaining hooks (*H*), which are cut from $\frac{1}{4}$ in. brass and pivoted on $\frac{3}{16}$ in. diameter stainless steel bolts. The gaps around the retaining hooks are kept as narrow as possible to minimize leakage through the side of the gullet-tube while a sample is being taken.

The mouth-tube (*M*) slides up and down the gullet-tube, its movement being restricted by a cheese-head screw (*E*) in the latter, sliding in a longitudinal slot (Y_1) in the mouth-tube. The mouth-tube is also slotted (Y_2) to allow the retaining hooks to disengage completely. The upper part of the mouth-tube bears a tapered collar (*O*) over which the lower ends of the retaining hooks slide. When pulling down the mouth-tube to engage these hooks against the plug, the tube does not reach the limit of travel defined by the screw. Thus any wear on the surface of plug, hooks, or collar is compensated for by the mouth-tube having to be pulled down a little farther to retain the plug.

The plug (*P*) is of solid brass, and has two opposed shoulders. The retaining hooks engage on the lower one, while the upper one bears down on a $\frac{1}{8}$ in. thick rubber washer (*R*) which is bolted between the base of the pressure chamber and the gullet-tube. To prevent any possibility of the plug being pushed through the hole, a thin brass washer (*W*) of the same size and shape as the rubber one is fitted immediately below it. The size of the *lower* shoulder is such as just to pass through the hole in the rubber disk. When the sampling tube is in the 'down' position the upper lip of the plug is pressed against the surface of the rubber disk to give a watertight seal. When under water, the water pressure bearing on the rubber washer reinforces this seal.

The weight of the sampler is 30 lb. (13·6 kg).

Use of the Sampler

To prepare the sampler for use the lid is removed and the plug dropped down the trap-tube, being pushed into position by a stick. This is done with the mouth-tube in the 'up' position, so that the retaining hooks are clear of the plug. The mouth-tube is then pulled down, without exerting excessive force, to engage the retaining hooks against the plug. It is at once apparent at this stage if the plug is incorrectly seated. The lid is then replaced.

The sampler is lowered on a wire shackled to the top of the 'samson', and is brought up again as soon as it has reached the bottom.

The lid is then removed, and the contents of the pressure chamber washed into a jar. A syringe with a long plastic tube to reach down to the bottom of the chamber is useful for washing out the sample. The plug is retrieved from the sample and replaced in position for the next haul.

The samples obtained consist of about $\frac{1}{2}$ l. of sediment and $1\frac{1}{4}$ l. of water. If allowed to settle in a jar the excess water can be poured off, but for some purposes it would be sufficient to strain off the water by pouring the sample into a fine mesh sieve.

Efficiency of the Sampler

In shallow water, the volume of sediment taken increases with depth. Experiments in Cawsand Bay on a bottom of muddy sand gave the following approximate volumes of soil at different depths:

2·7 m	10 ml.	11·9 m	35 ml.
7·3 m	20, 20 ml. (2 samples)	12·8 m	100, 90, 90 ml. (3 samples)
11·0 m	100 ml.	16·5 m	250 ml. (shell gravel)

In deeper water off Plymouth (50–70 m) the sample volume is usually over 500 ml., occasionally much more. The sampler has been tested in fairly rough weather, and samples have been successfully obtained, although these are sometimes of a smaller volume than those taken under favourable conditions. Under normal sea conditions it is exceptional for the instrument not to bring up a sample.

Mr G. R. Forster has made underwater observations on the sampler in a depth of *c.* 10 m, which explain the small samples obtained in shallow water and in rough weather. On a sandy bottom the sampler drew in a crater of sand about 5 cm deep and a little wider than the mouth of the sampling tube (7·5 cm). When lowered in the normal way the sampler fell over on its side almost at once, so that the volume of sand taken should depend on the amount sucked in during the brief period when it is still upright. In very shallow water the rate of suction is such that only a small amount of sand is collected before the sampler falls on its side. In deeper water of say 30 m or more the rate of suction should be sufficient to fill the chamber before the sampler falls over, so that the sample volume should not vary greatly with depth (cf. Hunt, 1926, p. 533). When the sampler was held upright on the bottom while taking the sample a much larger volume than usual was taken, the sampling-tube penetrating for about its full length.

When the instrument was dropped free through the water from a vertical position it tended to fall with a spiral motion. If dropped from a horizontal position it did not right itself completely during the descent. Under normal working conditions the drag exerted by the wire or rope on which it is lowered would keep the sampler upright, but in rough weather the strain would not be constant and might cause the sampler to veer about during the descent, and so take a small sample or none at all.

Both the above defects might be remedied by fitting light fins or a form of drogue to the top of the instrument, and by lowering the centre of gravity of the sampler. When filled with air the 'centre of gravity' of the sampler under water is at about the mid-point of its length, so that it has no natural tendency to fall the right way up.

These modifications have not been attempted, as the sampler has so far obtained samples whenever required, and any additions would make the sampler clumsy to handle. Where samples of a quantitative nature are required, some such stabilizing attachment would be desirable.

The maximum size of particle taken is limited by the diameter of the gullet, in this instance 18 mm, so that the sampler would be ineffective on bottoms of stones or large shells, as would most other instruments except a dredge. To increase the size of the opening would necessitate strengthening the retaining hooks as the total force exerted by the water would increase with the size of the plug.

Similarly, the sampler would have to be strengthened if it were to be used at a great depth. The present sampler has been tested to a depth of 448 m with success, 1200 ml. of sand being collected in a single haul.

There may be a small loss of material via the trap-tube while the sampler is being brought up. In depths over about 45 m the air in the pressure chamber is compressed to such an extent that when upright the water-level in the chamber is above the top of the trap-tube. While hauling up, the air expands and expels water, with sediment in suspension, down to the level of the top of the trap-tube. If a flap valve were fitted to the top of the trap-tube to prevent this loss some alternative exit for the expanding air would have to be provided. Loss of fine material is considered to be small, however, and very much less than that from most other bottom samplers.

Conclusions

The new sampler has been found to be an improvement on Hunt's 'Vacuum' grab, both in ease of removal of the sample, and in the substitution of a plug for the original glass plate. On the other hand, increasing the length of the sampler has made it less stable so that it falls over almost as soon as it reaches the bottom with the result that samples in shallow water of less than about 15 m depth are not very large.

Although Hunt considered that the 'Vacuum' grab was capable of taking quantitative samples, the author considers that there must be considerable variation in the area and depth of sediment excavated, as the sampler must seldom hit the bottom truly vertically. It is therefore not suitable in its present form for making quantitative estimations related to the area of the sea-floor sampled.

The large volume of water relative to that of sediment in the sample indicates that the diameter of mouth-tube might be increased so as to obtain a larger sample.

In spite of these limitations it is considered that the sampler meets the needs for which it was designed.

I am indebted to Mr F. G. C. Ryder for his skill in making the apparatus from rough drawings, to the crew of M.L. *Gammarus* and the Master and crew of R.V. *Sarsia* for carrying out tests at sea, and to Mr G. R. Forster for underwater observations on the behaviour of the sampler. I am grateful to Mr O. D. Hunt and Dr G. A. Steven for helpful comments on the manuscript.

SUMMARY

A modified form of Hunt's 'Vacuum' grab is described for taking small samples of the bottom. The sample is subject to the minimum of loss while being hauled up, and was designed to take samples for mineralogical analysis.

The new instrument is simpler to use than the original grab, and is capable of taking samples in moderately rough weather, and in depths of 10 m to at least 448 m.

Since the area and depth sampled varies under different conditions, some modifications would be necessary for the instrument to take quantitative samples of the sea-floor.

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