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An Airlift Sampling Device for In Situ Collecting of Biota from Rocky Substrata

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INTRODUCTION

Problems inherent in collecting organisms from the rocky sublittoral zone have undoubtedly limited study of this habitat. Most investigations of benthic biology have dealt with assemblages of organisms on soft or unconsolidated substrata, a fact reflected in the list of marine bottom samplers compiled by Hopkins (1964), where only 3 of 107 devices are capable of sampling (only qualitatively) rocky substrata. The inadequacy of this sampling capability has become obvious with the recent need to produce environmental impact statements as a prerequisite to construction and to other activities in the coastal zone. Typically the quality and comparability of the data generated by these studies have been limited by lack of adequate standardized sampling equipment and procedures.

This report describes a driver-operated airlift sampling device designed to collect organisms on rocky substrata. It is inexpensive but durable, made of readily available materials, and requires neither special talents nor tools for construction or operation. Most important, with it quantitative samples can be taken. I designed the prototype of this airlift in 1967 during studies of benthic assemblages at the USFWS Sandy Hook Marine Laboratory, Highlands, N.J. It was later tested and modified during three years of intensive study of the benthic biota at Catalina Island, California (Hobson and Chess, in prep.). The only limitations found were in sampling forms that were either very motile (e.g. some fishes), deep burrowing, or strongly attached to the substrata.

Sampling devices using the airlift principle are not new. They have taken diverse form, but have the following characteristics in common: Air is introduced into the lower end of a submerged tube and mixes with the water as small bubbles. The specific gravity of the mixture is so reduced that the pressure of the water outside the tube causes the mixture to overflow at the top and suction to develop at the bottom opening. Thus, the device can be used much like a vacuum cleaner, collecting organisms in a bag at the upper end (Figure 1).

Figure 1. Airlift Sampler in operation. (Photo by Edmund S. Hobson)

Airlift samples have been used by Barnett and Hardy (1967) to collect deep burrowing clams, by Emery (1968) to collect plankton, and by Chesher (1969) to collect spatangoid echinoids. These devices, however, are differently designed and are less versatile than the airlift described here. Several groups of investigators on the west coast are currently using airlift samplers based on the design described below.*

DESCRIPTION OF THE APPARATUS IN OPERATION

The major element of the airlift sampler (Figures 1 and 2) is a 3 m length of 55 mm I.D. schedule 40 Polyvinylchloride (PVC) pipe. The pipe is held vertical in the water by a buoy attached near the upper end and enough weight attached near the intake end to create about 1kg negative buoyance.

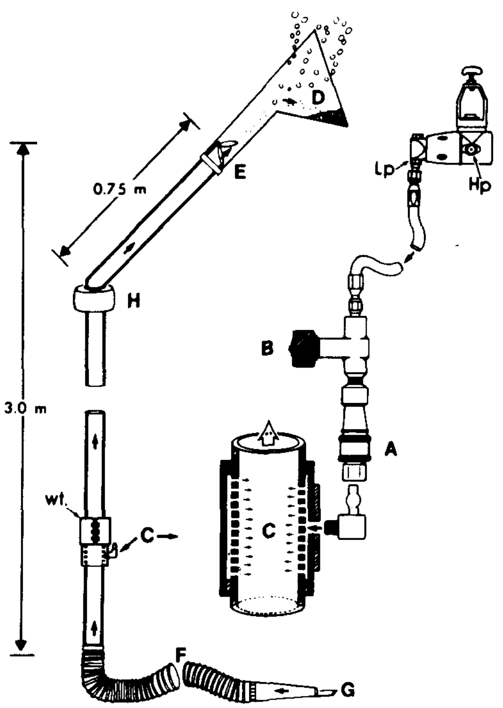

Figure 2. Diagramatic representation of the Airlift Sampler: A) Quick-disconnect coupling; B) Airflow control valve; C) Manifold; D) Collecting bag; E) Flap valve; F) Shop vacuum cleaner hose; G) Scraper attached to nozzle; Lp: Low pressure outlet; HP: High pressure outlet; wt; weight.

The air supply can come from 1) the operator's own air supply via hose from a second low pressure outlet of his scuba regulator, 2) an air supply on the surface, or 3) a separate air tank and scuba regualtor carried by the operator. The latter method seems best for most sampling applications. An air hose 2 m in length is attached to the low-pressure outlet of the regulator (approx. 100 psi) and is connected to the sampler by a stainless steel quick-disconnect air-hose coupling (Figure 2A). An airflow control valve is placed in the hose before the coupling (Figure 2B).

Air is introduced into the pipe through 1 mm perforations within the air manifold (Figure 2C) near the lower end of the pipe. The manifold, constructed of a 10 cm length of 75 mm I.D. PVC pipe, is glued around the perforated portion of the pipe. Spacers placed at each end of the manifold create a 6 mm gap between the pipe and manifold, allowing distribution of air to all of the perforations.

When the sample is carried up the tube it is collected in a removable mesh bag fitted over the tube's upper opening (Figure 2D). The bag is designed to allow the air to escape readily yet retain the sample.

The upper 75 cm of the pipe is offset at a 45° angle, and its opening into the bag is fitted with a flexible flap valve (Figure 2E). Both features prevent material from falling back down the tube. The angled portion of the pipe also directs the flow of water and fine sediments (which pass through the mesh) away from the sampling site, thus reducing the amount of materials that would otherwise fall on the operator. The structure of the collecting bag and the offset angle of the tube also tend to prevent the bag from draping over the opening when heavy materials are collected.

SAMPLING PROCEDURES

Sampling Easily Accessible Horizontal Surfaces

Various large organisms such as certain asteroids, echinoids and molluscs cannot be collected by the airlift, and are usually removed from the sample area by hand after being identified and enumerated.

Many motile forms, including various shrimps and small fishes, can be captured by first passing the airlift intake carefully over the sample area, working from the periphery inward to reduce escapement. The substrate

*Organizations known to be currently using airlift devices of the design described in this report include National Marine Fisheries Service, the University of Southern California, Scientific Application Inc., U.S. Bureau of Land Management, Dames and Moore, Marine Biological Consultants, Inc., University of Alaska, and Alaska Coastal Research.

is then scraped with a sharpened tool, such as a stiff putty knife, while holding the intake end of the pipe a few cm above. The sessile organisms and associates are drawn up the tube and into the collecting bag. Other tools such as small picks and scrapers of various design are useful when collecting cryptic forms on substrata with many interstices; the quality and completeness of a sample is largely dependent upon how thoroughly the substrate is cleaned.

Sessile organisms which are firmly attached to the substratum, such as serpulid polychaetes and molluscs, as well as rock borers, are often difficult or virtually impossible to collect quantitatively. Those that remain on the sampled substrata after the collection are, to the extent possible, identified and enumerated.

Sampling Surfaces Inaccessible to Standard Procedures

Surfaces inaccessible to the standard procedure—vertical surfaces and beneath overhangs, where it is difficult to maintain position—can often be sampled by attaching a flexible corrugated shop vacuum cleaner hose to the intake end of the pipe (Figure 2F). (Remember that the pipe must remain near vertical to operate satisfactorily.) A scraper attached directly to the nozzle of the hose (Figure 2G) is effective for collecting organisms in crevices, holes and areas where the operator cannot use both hands.

Sampling Soft Substrata

Assemblages of organisms associated with soft substrata can be quantitatively sampled by first pushing an open-ended cylinder or cofferdam into the substrata, and then collecting the contents to the desired depth. This procedure has limitations and problems, however. If the sediments do not pass through the mesh, they will be retained in the bag, and its weight may tilt the pipe to the horizontal, at which position it ceases to operate. Furthermore, when collecting organisms frome coarse sand substrata, mysidaceans, small polycheates and other fragile organisms tend to become macerated by the sand that accompanies them up the tube.

A seived sample may be obtained if the sediments are fine enough to pass through the mesh of the collecting bag. This is possible, however, only when the sediment is drawn slowly up the tube, a small amount at a time, to avoid its accumulation in the bag.

Miscellaneous Aspects of the Airlift Operation

- The efficiency of the airlift increases with decreasing size of the bubbles entering the lumen of the tube (a fact related to the greater surface to volume ratio of small spheres). Reduced bubble size is a function of the small perforations in the tube within the manifold.

- A small amount of airflow up the pipe is sufficient for most applications. A typical $0.25m^2$ quadrat can be sampled in 10 to 15 minutes, and the material from 2 to 6 quadrats can be collected with the air contained in a standard 72 ft^3 compressed air tank, depending upon water depth, type of substrata and the efficiency of the operator.

- Generally it is preferable that the airlift be accompanied by a separate tank and regulator. An independent air supply provided by additional air tanks can be made available when necessary, and the operator can leave the unit on the bottom to attend to other tasks unencumbered. When air is supplied to the airlift from the operator's own supply, or from the surface, the operation becomes either less efficient or more complicated, or movement is restricted. Under certain circumstances, however, when the airlift operation requires more compressed air, and extensive mobility is unnecessary, a surface air supply might be more expedient. On the other hand, in operations that require mobility but need only a small volume of air, the operator might find advantage in using air from the scuba system supplied for a second low-pressure outlet of his regulator.

- The fine mesh in most collecting bags tends to inhibit the escapement of air, thus reducing the efficiency of the airlift. Bags of the design illustrated in this report, however, make it possible to use mesh sizes as small as 0.25 mm and still have adequate air passage. Escapement of air from the bag is increased by a localized pressure differential established within an enverted conical air chamber formed in the uppermost corner. Nitex* material with 0.333 mm mesh was used in fabricating these bags, but 0.5 or 1.0 mm material would be more compatible with most other sampling procedures.

- Increasing the vertical stability is helpful where currents or surge are strong. This can be achieved by attaching additional or larger buoys and weights to the top and bottom of the unit. If a doughnut-shaped buoy is used, it can be fitted around the pipe and slid down to the weighted end when the device is to be moved. The vertical stability is thus lost and the pipe easily tilted to the horizontal where it is more portable for a swimmer.

- Although the efficiency of an airlift pipe is generally directly proportional to its length, longer pipes are in most cases more awkward to handle. Although short airlift tubes use more air for a given amount of work, they operate satisfactorily. Jeffery G. Grovhoug, (Naval Under Sea Center, Hawaii, pers. comm.), used a tube 127 cm in length and 10 cm I.D. to sample in depths as shallow as 1.5 m. An airlift can be fabricated in sections for easy transport and for changing its length for use at various depths. An overall length of 3 m seems to be a good compromise between reasonalbe mobility and efficiency.

- At greater depths the efficiency of an airlift is reduced because increasing amounts of compressed air are required to drive the unit. Also the ratio of hydrostatic pressure between both ends of the vertical pipe decreases with depth. At depths where most divers work, however, this reduction in efficiency is negligible. The airlift described in this report has worked satisfactorily to depths of 40 m.

***Note:** Reference to trade names does not imply endorsement by the National Marine Fisheries Service (NOAA).

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