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Instruments and Methods

The NIWA seamount sled: An effective epibenthic sledge for sampling epifauna on seamounts and rough seafloor

Malcolm R. Clark*, Rob Stewart

NIWA, Private Bag 14-901, Wellington, New Zealand

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ABSTRACT

Epibenthic sleds, sledges and dredges have been widely used for sampling deep-sea macro and megafaunal communities, providing extensive information on benthic biodiversity and distribution patterns. Different countries and institutes have developed a variety of gear types, but these are often unsuitable for sampling rough seafloor, such as seamount and ridge topography. The NIWA seamount sled, a form of epibenthic sledge, is an inexpensive yet robust and versatile sampling device used to obtain invertebrate and rock samples. It incorporates features from a number of existing designs that have produced a versatile sled that can be used on all habitats from mud through to steep and rocky seamounts. It has been used for many research surveys around New Zealand, where it has proven an efficient sampler of target fauna (large macro- and mega-benthic epifauna). Its design has also been adopted by institutes in France and China for surveying seamounts, and it is suggested it could be used as a simple standardised design for sampling seamounts internationally.

1. Introduction

The deep sea, areas beyond the continental shelf, have seen a considerable increase in scientific activity in recent decades. Human activities such as fishing, oil and gas extraction, as well as minerals exploration have moved offshore into deeper waters (e.g., Ramirez-Llodra et al., 2011). There has been an associated need for research information on species composition and community structure to help environmental managers tasked with balancing exploitation and conservation.

A large number and variety of sampling devices have been successfully deployed in the deep sea (e.g., Gage and Tyler 1991, Brenke, 2005, Jamieson et al., 2013), their design and operation driven by scientific or management objectives, and the types of animals being studied. These have included gears that are designed to capture epibenthic invertebrates living on, or near-to, the surface of the seafloor. Brenke (2005) and Kaiser and Brenke (in press) have given an historical overview of different sleds and sledges, which they define by having runners, on which they are towed along the sea floor. Dredges and sled-type gears date back to the 19th century, although many had been designed and used predominantly in shallow waters for catching small macrobenthic soft-bottom fauna. The development of the Woods Hole Oceanographic Institution epibenthic sled in the early 1960s (Hessler and Sanders 1967) was mainly to sample deep-sea epibenthos. A number of additional sled-type sampling gears evolved from this, such as the IOS sledge (Aldred et al., 1976) and the Sneli sledge (Sneli, 1998). These proved effective for sampling various deep-sea habitats and fauna (Kaiser and Brenke in press), but, as found by Lewis (1999), many are not robust enough to sample rough seafloor habitats, such as ocean ridges and seamounts.

Seamounts are common topographic features in the deep sea, and are subject to extensive research describing their biodiversity, and impacts on their benthic communities from human activities such as fisheries (e.g., Clark et al., 2010a). However, seamounts often have strong current flows and rugged seafloor with lava flows and boulders. There is a high likelihood that gear can get snagged or broken, and nets are prone to damage; and so seamounts are frequently surveyed using underwater cameras deployed from ROVs, submersibles, or towed camera frames. However, there is generally a need for direct sampling as well, for species identification, specimen collection for various studies (e.g., tissue for genetic analysis), or gaining semi-quantitative data on benthic community composition and abundance. Hence, bottom sampling sleds/sledges (these terms are now used interchangeably) and trawls continue to have an important role to play in deep-sea research.

Lewis (1999, 2009) described the development of the CSIRO (Commonwealth Scientific and Industrial Research Organisation) seamount epibenthic sampler (SEBS = "Sherman sled"), which was more robust and heavier (at 1200 kg) than previous sleds, and able to withstand the hard knocks on rough terrain. However, one size does not fit all, and the Sherman sled is large and heavy, and can

* Corresponding author.
E-mail address: malcolm.clark@niwa.co.nz (M.R. Clark).

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be difficult to work on small vessels. In 1999 when New Zealand researchers at the National Institute of Water and Atmospheric Research (NIWA) started carrying out benthic invertebrate surveys on seamounts (Clark et al., 1999), gear as sophisticated as "Sherman" was too expensive, and could not be used on NIWAs smaller research vessels safely because of its size and weight. Hence there was the need to develop a new design, but incorporating key elements from the CSIRO gear, as well as NIWA experience with several other benthic sleds and trawls used in early surveys.

In this paper we describe the design and construction of the NIWA seamount sled which has proven successful in sampling seamounts and other rough-seafloor topography over many years, and has since also been used as a pattern by other institutes sampling seamounts (e.g., Ifremer, France; Institute of Oceanology, China).

2. Sled description

2.1. Overview

The sled has overall dimensions of 1900 mm length, 1420 mm width, and 500 mm height. The total weight is 400 kg, which includes the net and chain bridles. The effective net mouth opening is approximately 1130 mm width by 380 mm height (Fig. 1). A scaled-down sled has also been constructed for use off smaller vessels (overall dimensions 1550 mm length, 980 mm width, 510 mm high, weight about 250 kg)

2.2. Frame construction

The main rectangular frame is constructed of steel 90° angle iron for vertical and horizontal sections (Fig. 2). The longitudinal framing comprises either steel channel beams or lengths of angle iron. Further support half way along the top, bottom and sides are provided by lengths of angle iron or steel rod/pipes. For added lengthways support a series of vertical steel rods are interspaced on the sides of the frame. Dimensions of the materials are given in Fig. 2.

The paired ends of the broad 150 mm wide runners consist of four 180° rolled plates to form a smooth entry in an attempt to reduce the likelihood of the sled becoming snagged on the seafloor. Semi-circular steel rod lugs or a chain link are welded to the middle of each of the front runners to provide an attachment point for the bridle chains. A further lug can be welded to the aft steel cross-member as an attachment point for the break-out chain.

Fig. 1. The NIWA seamount sled, showing the net opening, bridles and break-away chains, and the location beacon mounted on the side (photo, NIWA).

The top and bottom of the sled are reinforced with steel rods mounted longitudinally to provide a protective grille reducing abrasion on the internal net. This grille also protects sensors (such as depth), which can be secured inside the frame but outside the mesh cod-end.

2.3. Net details

The sled has two nets. The inner net is the main catching one, and is a four panel construction to fit the rectangular sled frame (Fig. 3). It is protected by an outer anti-chafing net, which is a simpler two seam construction. The mesh size used for much of NIWA's deep-sea research is a nominal 34 mm diagonal knot to knot polyethylene mesh with a strand width of around 1.6 mm (although mesh shrinks with use to 27–29 mm). Finer mesh linings can be used, but on seamounts they are easily torn and damaged by rocks. As seamount surveys around New Zealand have focussed mainly on sampling benthic mega-epifauna, there has not been the need for standard use of fine mesh nets.

The outer anti-chafing net is typically 9 mm × 120 mm knotless mesh but variations of this would still be adequate as its role is mainly protection of the inner net. The net is typically 2.2 m long, so it is largely retained inside the sled cage. The very slightly longer overall length is to enable ease of operation in tying off the cod-end at the back of the sled. This also makes the untying and tipping operations easier and safer for the crew handling the sled on deck. When the cod-end is tied off, the net is about flush with the back of the sled, and the tail of the net is then lashed to the back of the sled so that it cannot wash forwards.

2.4. Towing chains

The overall length of the ground gear including chain bridle, connectors, swivels and additional chain approaches five to six metres depending on its final configuration. The towing chains of the sled form a bridle joined together by a 16 mm hammerlock (Fig. 4). Each bridle chain is lashed to the towing lug. This can be done in a number of ways, including with multiple turns of rope (biodegradable should be used to reduce rubbish and pollution effects if it breaks completely), or smaller chain/shackles with a known breaking strain (Fig. 1). We have found a strain of 10 t to be effective.

Further chain (about 2 m) is used between the bridle and the towing warp to add additional weight to the front bridles to ensure the front of the sled remains firmly on the seafloor if towing speed increases beyond the normal 1–1.5 knots. To reduce the effects of the wire trawl warp twisting at least two 10 t swivels are required: this is essential if the sled should flip and rotate at any stage during the deployment. Swivels are attached to the ground gear by using a combination of recess links and hammerlocks at both ends.

The towing chain assembly is usually attached to 100– 200 m length of sacrificial 28 mm wire (right hand lay when used off a port winch) to protect the main warp from abrasion or damage if it is towed along rough seafloor.

2.5. Weak link system

This system is based on that used by CSIRO (Lewis, 1999). Both bridle chains are lashed to the towing points on the front of the sled, the breaking strength depending on the number of turns of rope used or breaking strain of a shackle/hammerlock. The break-out chain extends from the second towing point around to the back of the sled, where it is shackled to a strong-point in the middle of the back bar or on to a central lug welded to the rear cross member.