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Macrofouling of deep-sea instrumentation after three years at 3690 m depth in the Charlie Gibbs fracture zone, mid-Atlantic ridge, with emphasis on hydroids (Cnidaria: Hydrozoa)

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ABSTRACT

Macrofouling is a common problem when deploying underwater instrumentation for long periods of time. It is a problem which can effect scientific experiments and monitoring missions though the creation of artificial reefs (thus increasing local biological activity) and reduce the quality of scientific data. Macrofouling is an issue typically considered to be restricted to the photic zones and is absent or negligible in the deep sea. To the contrary, the recovery of an accidentally lost deep-sea lander after 3 years submergence at 3960 m on the Mid-Atlantic Ridge (North Atlantic) revealed dense colonisation of macrofouling organisms. These organisms were found attached to all surfaces of the lander regardless of orientation and materials. The occurrence of such deep-sea macrofouling should be carefully investigated given the recent developments in long-term deep-sea observatory networks.

1. Introduction

Recent advances in underwater technology such as data storage, remote sensing, lower power components, greater battery capacity and corrosion-resistant materials have led to scientific instrument platforms being deployed in the deep sea for longer periods of time (e.g. Bett et al., 2001; Person et al., 2006; Vardaro et al., 2007). Even more recently this has led to instrumentation remaining on the seafloor on a more permanent basis, such as semi-permanent observatories (e.g. Vardaro et al., 2010; Walls et al., 2010), underwater neutrino telescopes (e.g. Migneco, 2008; Margiotta, 2010) and fully-cabled observatory networks (e.g. Chave et al., 2004; Barnes et al., 2008), which must remain operational on decadal time scales.

Despite overcoming many technological challenges of operating for extended periods of time underwater, the physical presence of equipment and structures must still interact with the natural environment. Such interactions present themselves rather conspicuously in the form of biofouling. Although biofouling is most problematic in the coastal and shallower water environments of the photic zone, it is still known to occur in the deep-sea (> 200 m).

Typically biofouling in the deep sea is in the form of thin biofilms, an aggregate of microorganisms adhering on hard surfaces. These are particularly problematic to the long-term use of optical sensors which require certain materials, such as glass or sapphire, to maintain a high optical quality, therefore, the accumulation of biofilms has the potential to reduce the quality of data (Amram et al., 2003; Manov et al., 2004).

Following the accumulation of biofilms (microfouling), macrofouling is known to take place in shallower environments, whereby larger organisms begin attaching themselves to hard surfaces. Macrofouling is generally most prolific in the 0–40 m range (Lehaitre and Compère, 2005). The macrofouling assemblages include a variety of organisms such as bivalves, bryozoans, polychaetes, algae and hydroids, however the succession pattern of micro- to macro-fouling remains unclear as macro-organisms do not necessarily need the presence of a biofilm to initiate settlement (Roberts et al., 1991; Delauney et al., 2009).

There have been several studies relating to biofouling of scientific instruments in the deep sea (Venkatesan et al., 2002; Galluci et al., 2008; Bellou et al., 2011) which reported little evidence of anything other than biofilms. Further studies have even reported on the absence of macrofouling in the deep sea (Venkatesan et al., 2002) and therefore absence of artificial reef effects in long-term deep sea applications (Vardaro et al., 2007). Generally macrofouling is not considered to be a significant problem with scientific instrumentation in the deep-sea over typical long-term operations.

To the contrary, a long-term lander system was accidentally lost at 3690 m on the Mid-Atlantic Ridge, but was subsequently recovered some 3 years later and found to be colonised by

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macrofouling organisms. This, albeit serendipitous finding, suggests that if future long-term observatories were to be placed in the deep sea, then there are areas where macrofouling (and the potential reef effect) could become a serious problem.

2. Materials and methods

The Deep Ocean Benthic Observer (DOBO) was an autonomous lander vehicle designed for 6 to 12 months deployments in the deep sea (Jamieson and Bagley, 2005; Kemp et al., 2006). It had a grade 2 titanium framework in which syntactic foam buoys were secured. The scientific payload comprised a video camera, lights and two 12V lead acid batteries. The lander was designed to take time-lapse video of a periodic bait release system designed to simulate conventional short-term baited lander deployments periodically over longer time periods (Kemp et al., 2008). Tethered 20 m above the lander was a passive acoustic hydrophone assembled within two 17″ glass spheres.

As part of the ECOMAR project, the lander was deployed at 52° 41.346′N, 35° 04.166′W in the Charlie-Gibbs Fracture Zone from the RRS *James Cook* (Cruise JC011) on 31 July, 2007 on an intended 12 months deployment. Due to operational error, the ballast release mechanism failed to operate when recalled to the surface the following year and the equipment was subsequently abandoned.

On the 14 June, 2010, on the ECOMAR cruise by RRS *James Cook* (JC048), the UK remotely operated vehicle *Isis* successfully located the lander (Fig. 1a), identified the ballast release problem and managed to release the lander from the seafloor. The lander was then recovered by the surface vessel and significant macrofouling was observed to have taken place (Fig. 1b). The lander was found to have been engulfed by a dense colony of hydroids irrespective of material (e.g. metal, plastic, glass).

Samples of the macrofouling organisms were removed from the lander and preserved in 90% ethanol solution and stored in Nalgene bottles. Using a stereo microscope (Nikon SMZ-10) all specimens were later identified to the lowest taxonomic level possible.

3. Results

The macrofouling organisms had settled on every surface of the lander regardless of material. For example, hydroids were found settled on titanium grade 2 (framework), titanium grade 5 (camera housing), solid moulded polyethylene (battery casing), moulded polyether-urethane (battery membrane), solid moulded neoprene (connectors), flexible polyurethane (cables), solid polyurethane (floatation), polyvinyl chloride (clamps), polyester rope (mooring), glass-reinforced plastic (GRP; battery holders), acrylic (bait canisters), acetal (sub-structure) and borosilicate glass (floatation spheres).

In total, nine taxa belonging to three phyla (Cnidaria, Arthropoda and Echinodermata) were recovered from the lander. The phylum Cnidaria was represented by the classes Hydrozoa (*Garveia* sp., *Bouillonia* sp., and *Opercularella* sp.) and Anthozoa (Hormahiidae indet.) There were five taxa belonging to the subphylum Crustacea, the Ostracoda family Cyridinoidea, a cirriped of the family Scalpellidae and the Amphipoda *Gammaropsis* sp. and *Lepidepecreella* sp. Finally the phylum Echinodermata was represented by a comatulid Crinoidea.

The hydroids were the most abundant fauna on the lander, particularly *Bouillonia* sp. (Tubulariidae; Fig. 1c) and *Garveia* sp. (Bougainvilliidae), and were found living on all surfaces. They settled on every surface regardless of orientation including underneath the components. They had settled on both solid surface and flexible components such as cabling and ropes. There was a general increase in density towards the bottom of the frame, although this was observational and may be an artefact of the removal from the upper structure during the ascent to the surface.

The hydroid colonies were so dense that was it was not possible to estimate density with any degree of accuracy, as they collectively formed a thick, almost 'carpet-like' covering on most of the structure. Provided below is a detailed description of the three species of Hydrozoa recovered.

Hydrozoa Owen, 1843
Bougainvilliidae Lütken, 1850
Garveia Wright, 1859
Garveia sp.

Fig. 1. (a) The Deep Ocean benthic Observer (DOBO) lander prior to recovery after 3 years at 3960 m on the Mid-Atlantic Ridge. (b) Dense colonisation of the lander by hydroids *Bouillonia* sp and *Garveia* sp. (c) Example of the most abundant macrofouling hydroid, *Bouillonia* sp. (each square = 0.5 mm).