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Observations of fauna attending wood and bone deployments from two seamounts on the Southwest Indian Ridge

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ABSTRACT

The Southwest Indian Ridge is an ultraslow-spreading mid-ocean ridge with numerous poorly-explored seamounts. The benthic fauna of seamounts are thought to be highly heterogeneous, within even small geographic areas. Here we report observations from a two-year opportunistic experiment, which was comprised of two deployments of mango wood and whale bones. One was deployed at 732 m on Coral Seamount (~32 °S) and the other at 750 m on Atlantis Bank (~41 °S), two areas with little background faunal knowledge and a significant distance from the continental shelf. The packages mimic natural organic falls, large parcels of food on the deep-sea floor that are important in fulfilling the nutritional needs and providing shelter and substratum for many deep-sea animals. A large number of species colonised the deployments: 69 species at Coral Seamount and 42 species at Atlantis Bank. The two colonising assemblages were different, however, with only 11 species in common. This is suggestive of both differing environmental conditions and potentially, barriers to dispersal between these seamounts. Apart from *Xylophaga* and *Idas* bivalves, few organic-fall specialists were present. Several putative new species have been observed, and three new species have been described from the experiments thus far. It is not clear, however, whether this is indicative of high degrees of endemism or simply a result of under-sampling at the regional level.

1. Introduction

The deep sea is an ecosystem primarily dependent on the supply of food from surface waters, mostly in the form of particulate organic carbon. Large animal falls deposited on the deep-sea floor from surface waters can include the carcasses of marine mammals such as whales ('whale falls'), squids, large fish and also swarms of gelatinous animals such as salps (Billett et al., 2006; Smith and Baco, 2003; Stockton and DeLaca, 1982). A range of plant matter can also sink to the deep-sea floor including seagrasses, macroalgae and terrestrial plant material such as wood, termed 'wood falls' (Harrold et al., 1998; Wolff, 1979). Large food falls are thought to play an important role in the ecology of the ocean floor by providing shelter and substrata for fauna, and by fulfilling the nutritional needs of many deep-sea species that feed either directly on the organic matter or on smaller fauna that have come to also feed on or be sheltered by the falls (Smith and Baco, 2003; Turner, 1977; Wolff, 1979).

Whilst their origins may be very different, the remains of wood and whale on the seafloor share some interesting ecological similarities (Glover et al., 2013). For example, whales, once the flesh has been removed in the early decompositional stages, can persist on the seabed as a pile of bones for years to several decades (Schuller et al., 2004; Smith and Baco, 2003; Smith et al., 2015). They thus present an organic-rich hard substratum, in some cases, of a similar size and nature to a pile of wood on the seafloor (Glover et al., 2013). Wood and whale bone are consumed by a

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range of organisms, including specialist biodegraders such as wood-eating Xylophagaidae bivalves (Knudsen, 1961; Turner, 1955, 1973, 1977) and bone-eating *Osedax* worms (Fujikura et al., 2006; Glover et al., 2005; Rouse et al., 2004). In addition, the anaerobic degradation of sunken wood and the bacterial decomposition of lipids from whale bones can also support chemosynthetic communities in a similar way as at deep-sea hydrothermal vents and cold seeps (Duperron et al., 2008; Samadi et al., 2010; Smith, 1992).

Despite the fact that the deep-sea floor close to terrigenous sources of wood (e.g. tropical and temperate forested zones) is likely to be hugely influenced by this food source, there have been remarkably few studies of wood falls beyond the work undertaken in the tropical west Pacific (Pailleret et al., 2007a, 2007b; Samadi et al., 2010) and experimental work off the west and east coasts of the USA (Bernardino et al., 2010; McClain and Barry, 2014; Romey et al., 1994; Turner, 1973; Voight, 2007, 2009). Two species of *Xylophaga* have been recorded from the Indian Ocean, but the plant matter they were presumed to be eating was not recorded, and there is no information on their ecological characteristics (Knudsen, 1961, 1967).

At our study sites on the Southwest Indian Ridge (SWIR), very little has been observed biologically (Rogers et al., 2012). Deep-sea research in the Indian Ocean has been concentrated in the Arabian Sea and is quite limited elsewhere (Banse, 1994; Ingole and Koslow, 2005). A prevailing theory has been that seamount fauna are, in general, characterized by high levels of endemism as a result of the geographic isolation of clusters of seamounts (Richer de Forges et al., 2000). This view has been challenged in the last ten years however (Clark et al., 2010; McClain, 2007). The fauna inhabiting seamounts in the Indian Ocean are particularly poorly known with the main source of information thus far coming from scientific reports from past Soviet fishing expeditions (Romanov, 2003). Following a 'boom-bust' fishery on the SWIR in the early 2000s, two of the seamounts, Coral Seamount and Atlantis Bank were designated as voluntary Benthic Protected Areas. It is only with further studies, that a comprehensive picture of the biodiversity and productivity of the region can be completed (Demopoulos et al., 2003).

The main aim of these opportunistic organic-fall deployments was to characterise the faunal assemblages of bone and wood falls in the SWIR in terms of taxonomic composition. The assemblages found colonising the bone and wood on each seamount were compared to test whether faunal presence was driven more by site (related to the water temperature and biological characteristics of the surrounding environments) or substratum type, thus evaluating the relative degrees of connectivity at a species level between both the seamounts and the different types of organic fall.

2. Methods

2.1. Mooring deployments in the SWIR

The SWIR is a seafloor spreading centre stretching from the Bouvet Triple Junction in the south Atlantic to the Rodriguez Triple Junction in the central Indian Ocean (Fig. 1). Intermittency of magma supply at this ultraslow-spreading ridge has resulted in the formation of seamount features in many ridge segments (Dick et al., 2003; Escartin et al., 2008). The Sub-Tropical Front runs through this region, separating the Agulhas Front (which marks the southern boundary of the Agulhas Return Current) to the north and the Antarctic Circumpolar Current to the south. This results in the bodies of water within and on either side of the Sub-Tropical Front having very different physical, chemical and biological characteristics (Pollard and Read, In Press; Read et al., 2000).

Two moorings with wood and whale-bone packages attached to each were deployed in the SWIR as part of the 410th voyage of the RV Dr. Fridtjof Nansen (Rogers et al., 2009) (Fig. 1). Given the unexplored nature of the area, a decision was made to use this 'expedition of opportunity' to investigate the bone- and wood-colonising fauna of this region. The whale bones used were collected opportunistically from dead stranded whales several years prior, frozen and transported to the waiting vessel. The mango wood (*Mangifera indica* L) came from a tree cut two weeks before the deployment cruise in the port on Reunion Island. The whale bones and wood were sewed into separate coarse-net bags which were then attached by rope to the mooring.

The first mooring was deployed on 18th November 2009 at 32°42.71′S, 57°16.31′E at a depth of 750 m (Fig. 1). This deployment site was located on the summit of the seamount, Atlantis Bank (Fig. 1). This seamount is located north of the Sub-Tropical Front (Fig. 1). The whale bones attached included ½ sperm whale (*Physeter macrocephalus* Linnaeus, 1758) vertebra (12.65 kg), a minke whale (*Balaenoptera acutorostrata* Lacepede, 1804) vertebra (1.05 kg), three ribs from a humpback whale (*Megaptera novaeangliae* Borowski, 1781) and a northern bottlenose whale (*Hyperoodon ampullatus* Forster, 1770) (4.15 kg). There were also three logs of *M. indica* (wood) attached separately (4.40, 4.80 and 10.90 kg).

The second mooring was deployed on 4th December 2009 at 41°22.38′S, 42°54.64′E at a depth of 732 m (Fig. 1). This deployment was on the slope of Coral Seamount, which is located to the south of the SWIR and within the Sub-Tropical Front (Fig. 1). The whale bones attached to this mooring included two minke whale (*Balaenoptera acutorostrata*) vertebrae (3.60 and 1.20 kg), a minke whale (*Balaenoptera acutorostrata*) vertebral cap (0.20 kg), two ribs from a humpback whale (*Megaptera novaeangliae*) and a northern bottlenose whale (*Hyperoodon ampullatus*) (4.15 and 4.50 kg). There were also four *M. indica* logs attached separately (4.50, 2.15, 6.15 and 5.30 kg).

2.2. Mooring recoveries in the SWIR

Mooring recovery took place during the 66th voyage of the RRS *James Cook* using the Remotely Operated Vehicle (ROV) *Kiel 6000*. Each package was filmed in detail prior to any disturbance by the ROV. It was noted that the wood and bone packages on each seamount had landed within one metre of each other and were resting on the seabed. The moorings from Coral Seamount and Atlantis Bank were collected on the 20th November 2011 and 14th December 2011 respectively. Each package was cut from the mooring and then placed in a closed biobox on the ROV in an effort to keep the substrate types apart. Some specimens may have fallen from the packages during collection, so richness and faunal counts must be considered lower limits.

2.3. Analysis of the fauna recovered from the moorings

Once the ROV was on deck, the packages were transferred to containers containing chilled seawater. Biobox residues were washed through a 250-μm sieve. Examination followed in the 4 °C cold room. All epifauna was removed from the bones and wood and preserved in 70% ethanol, 100% ethanol or 4% formalin depending on the specimen. Bones were preserved in either 70% ethanol or 4% formalin. The wood was too large to be preserved in this manner and so was frozen to −20 °C. All of the water that the packages had been sitting in was also sieved for macrofauna, which were then preserved in 100% ethanol or 4% formalin. (The 250-μm sieved samples did not encompass meiofauna and thus future studies should ensure that several sieve sizes are used). When samples arrived at the Natural History Museum, London,

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