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First insights into macro- and meiofaunal colonisation patterns on paired wood/slate substrata at Atlantic deep-sea hydrothermal vents

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ABSTRACT

In 2006, paired wood and slate panels, each equipped with a temperature probe, were deployed on three different localities on and around the Eiffel Tower edifice (Lucky Strike vent field, Mid-Atlantic Ridge) within close proximity of visible hydrothermal activity. Recovery of these panels took place in 2008. For this two-year deployment period, the composition of colonising organisms (both macro-and meiofauna) was assessed, along with image analyses of the deployment sites in 2006 and 2008. Very few significant differences in colonisation between organic (wood) and inorganic (slate) panels were revealed. Rather, the locality of deployment and the local environmental conditions and hydrothermal activity were found to influence taxonomic composition. Variability in microhabitat conditions and biological interactions were hypothesised to interact jointly in shaping new faunal communities on the colonisation substrata.

1. Introduction

Hydrothermal vent fields represent hotspots of faunal biomass in the generally less-densely populated deep-sea environment. Venting areas are characterised by high temperatures (relative to the ambient seawater at ~2–4 °C) and elevated levels of sulphides and other chemical components, such as heavy metals and radionuclides (Sarradin et al., 2009; Charmasson et al., 2009). Hydrothermal vent fauna inhabit steep physico-chemical gradients and are able to survive due to the presence of chemosynthetic microorganisms. These microorganisms use the energy from the oxidation of reduced chemicals (mainly hydrogen sulphides, methane and iron) found in the vent fluids to produce organic matter (Childress and Fisher, 1992; Bennett et al., 2011). They can either be free-living in the vent habitat, or form symbiotic associations with invertebrates. As hot fluid venting is transient, hydrothermal vent sites are considered ephemeral, though vent fields (containing multiple vent sites) have ages ranging from a couple of years (e.g. 9°50′N at the East Pacific Rise (EPR), Shank et al., 1998; Lutz et al., 2008) to several decades or even centuries (e.g. Mid-Atlantic Ridge (MAR) Lucky Strike vent field, Humphris et al., 2002). Despite the degree of isolation and separation between neighbouring hydrothermal vent fields, nascent vent sites in the Pacific were rapidly (from months to a few years) colonised by a pool of regional species, even when the nearest known populated hydrothermal vent was situated kilometres away (Tunnicliffe et al., 1997; Shank et al., 1998; Tsurumi and Tunnicliffe, 2001; Marcus et al., 2009; Mullineaux et al., 2010). Nevertheless, there are large differences in spatial frequency of venting between the ocean ridges; active high-temperature vent fields can be separated by as little as 5 km on the EPR (Haymon et al., 1991) compared to every 100–350 km on the MAR (Murton et al., 1994; German et al., 1996).

In order to understand the persistence of the local faunal populations, studies of the temporal variations of faunal abundance and community dynamics at intra- and inter-annual scales are fundamental. Since various deep-sea habitats may form a network of suitable environments that contribute to ensure connectivity of deep-sea populations (Génio et al., 2013), the deployment of colonisation substrata can be an effective experiment to better comprehend the colonisation patterns in the deep sea and the possible use of stepping stones, such as organic falls, to colonise new nascent hydrothermal vents. With this purpose, substrata deployment

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experiments have been carried out in different chemosynthetic settings, using a variety of experimental designs (Van Dover et al., 1988; Mullineaux et al., 1998, 2003, 2012; Shank et al., 1998; Pradillon et al., 2005, 2009; Govenar and Fisher, 2007; Kelly et al., 2007; Kelly and Metaxas, 2008; Gaudron et al., 2010; Bienhold et al., 2013). In all of these studies, variations in settlement and colonisation were mainly influenced by the local environmental conditions (such as temperature and sulphides) and proximity to hydrothermal activity, while biological interactions also played a significant role in community composition. The recruitment of vent-associated species on the colonisation substrata (mostly inorganic) was thought to be influenced by a complex interaction between the composition of the surrounding community (Van Dover et al., 1988), the variability in microhabitat conditions and biological interactions (Mullineaux et al., 2003, 2012; Govenar and Fisher, 2007; Kelly et al., 2007). Gaudron et al. (2010) presented the only study that (i) was carried out on the MAR (Rainbow at 2300 m depth) and (ii) included the deployment of both organic (wood, alfalfa) and inorganic (carbonate) substrata at hydrothermal vents. However, these experiments were located about 10 m away from the venting edifice, and therefore beyond the direct influence of the fluids.

The current study is the first to evaluate the composition of macro- and meiofauna on paired wood and slate panels, equipped with temperature probes and deployed in close proximity (<20 cm) of hydrothermal venting and within the fluid flow on the MAR. These panels were positioned on and around the Eiffel Tower hydrothermal edifice of the Lucky Strike vent field. Wood was chosen due to its organic nature and known occurrence in the deep sea. Sunken woods are widely distributed in the oceans and have been considered as evolutionary stepping stones for hydrothermal vent colonisation (Distel et al., 2000; Bienhold et al., 2013). This is because their decomposition eventually leads to the production of hydrogen sulphide, which attracts chemosynthetic life. Although there are no formal records of wood falls south of the Azores, it is likely that these are present in the deep Atlantic Ocean (e.g. sunken vessels). Slate was chosen as a settlement substrate because it is smooth, inert and resembles basalt. It is therefore a good proxy for the surrounding deep-sea floor at the basalt-hosted Lucky Strike site.

The main hypotheses tested were the following: (a) there is a difference in colonisation between organic and inorganic substrata, (b) environmental conditions and proximity of hydrothermal venting influence the composition and abundance of colonists. This study will provide information about the composition of the species pool at the Lucky Strike vent field and on the environmental heterogeneity within this area, as well as allowing us to compare the habitat and fauna of the experimental substrata with those of the surrounding environment.

2. Material and methods

2.1. Study site

The Lucky Strike vent field is situated at a mean depth of 1700 m on the Mid-Atlantic Ridge (MAR), south of the Azores. The 11 m high Eiffel Tower (at 37°17.59N–32°169W) is a well-defined active edifice and is one of the most-visited sites within Lucky Strike (Fig. 1). It has been the focus of numerous ecological studies over the last 10 years (e.g. Van Dover et al., 1996; Comtet and Desbruyères, 1998; Desbruyères et al., 2001; Cuvelier et al., 2009, 2011a, 2012; De Busserolles et al., 2009) and a recent long-term temporal variation study (Cuvelier et al.; 2011b).

2.2. Experimental design and sample collection

Two types of substrata, one inorganic (slate as a proxy for basalt, A) and one organic (wood, B), were deployed in pairs (A and B) during the MoMARETO 2006 cruise, on three different localities up and around the Eiffel Tower edifice (Fig. 2), at varying distances to visible hydrothermal activity. Each panel measured 25 cm long and 20 cm wide. The thickness of the slate was 1 cm (adding up to

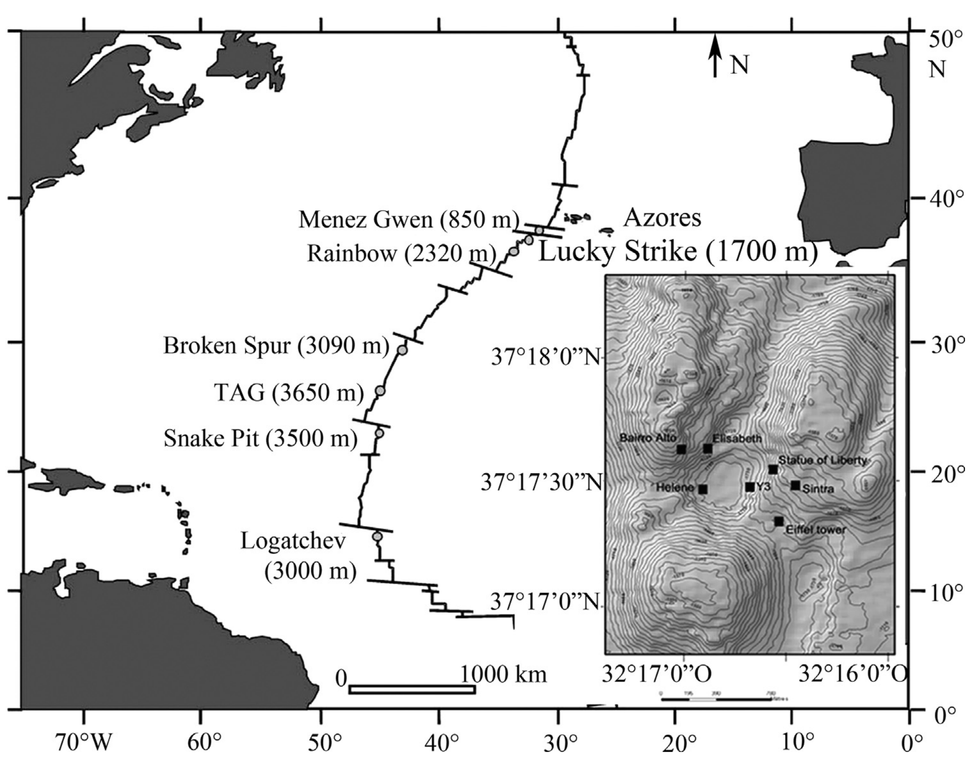

Fig. 1. Location of the Lucky Strike vent field on the Mid-Atlantic Ridge (MAR) at 37°17.59N, 32°169W. The inset shows the hydrothermal vent field with the location of several active sulphide edifices around a central lava lake, including the Eiffel Tower edifice in the south-east.