Deep-Sea Research I 104 (2015) 92–105

Contents lists available at ScienceDirect

Deep-Sea Research I

journal homepage: www.elsevier.com/locate/dsri

Benthic megafaunal community structure of cobalt-rich manganese crusts on Necker Ridge

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ARTICLE INFO

Article history:
Received 28 August 2014
Received in revised form
3 July 2015
Accepted 4 July 2015
Available online 9 July 2015

Keywords:
Cobalt-rich manganese crust mining
Seamounts
Deep-sea octocorals
Deep-sea sponges
Deep-sea crinoids

ABSTRACT

In the North Pacific Ocean, the seamounts of the Hawaiian Archipelago and the Mid-Pacific Mountains are connected by Necker Ridge, a 600 km-long feature spanning a depth range of 1400–4000 m. The Necker Ridge is a part of a large area of the central and western Pacific under consideration for cobalt-rich manganese crust mining. We describe the fauna and community structure of the previously unsampled Necker Ridge based on explorations with the submersible *Pisces IV*. On five pinnacles and a portion of the Ridge ranging from 1400 to 2000 m deep, 27 transects were recorded using HD video, and voucher specimens were collected to aid in species identification. The video was analyzed to identify and count the megafauna found on each transect and to characterize the substrate. Diversity increased from south to north along the feature. There was a significant difference in community structure between southern and northern pinnacles, with southern pinnacles dominated by crinoids of the Family Charitometridae and northern pinnacles dominated by octocorals, especially the Families Isididae and Chrysogorgiidae. DistLM demonstrated a correlation between community structure on the pinnacles and at least six environmental variables, including latitude, sediment cover, and oxygen concentration, but not including depth. The discontinuous and patchy nature of these distinct megafaunal communities highlights growing evidence that cobalt-rich seamounts are highly heterogeneous habitats, and that managing seamounts may require more complex regulations than treating them as a single ecological unit. These results suggest that extensive community analysis should occur at a given site to determine management priority areas, prior to consideration of that site for exploitation of natural resources.

1. Introduction

Seamount habitats can be found in every ocean (Wessel et al., 2010; Yesson et al., 2011) and provide hard substrate for sessile fauna in areas that are otherwise open ocean or sedimented abyssal plain. Seamounts and related features like banks and ridges often have steep relief, and these steep sides are thought to locally accelerate currents (Genin et al., 1986; White et al., 2005). Increased flow rates can prevent sedimentation (Hjulström, 1935), disperse propagules more effectively (Thistle, 2003), and possibly increase the availability of food particles for filter feeders (Rogers, 1994).

The impacts of fisheries trawling on the dominant sessile seamount megafauna, in particular deep-sea corals and sponges (e.g. Wilson and Kaufmann, 1987; Hogg et al., 2010), have been relatively well-documented (Probert et al., 1997; Koslow et al., 2001; Clark and Rowden, 2009; Clark et al., 2010; Anderson and Clark, 2003; Niklitschek et al., 2010; Althaus et al., 2009; Williams et al., 2010). However, another major threat to seamount fauna that is less understood is the proposed mining of deep-sea substrates for minerals like cobalt from manganese crusts (Clark et al., 2009; Hein et al., 2009, 2010; Mengerink et al., 2014). Mining practices would remove all biogenic structures along with the crusts from a target area, and could cause large sediment plumes that could smother sessile fauna >100 km outside of the mining location (Schlacher et al., 2014). Manganese crusts were previously expected to have overall lower abundances of deep-sea megafauna (Grigg et al., 1987), but Schlacher et al. (2014) reviewed data to demonstrate that seamounts with cobalt-rich manganese crusts in the Hawaiian Archipelago had abundant megafauna with different community structure than seamounts outside the cobalt-rich area.

Management of areas targeted for mining may be hindered by a

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http://dx.doi.org/10.1016/j.dsr.2015.07.003
0967-0637/

lack of understanding of the communities present on targeted features as well as a lack of understanding of species distributions and spatial variability in community structure on seamounts in general. Although we now have more insights into the communities on cobalt-rich crusts in the Hawaiian Archipelago (Schlacher et al., 2014), the Archipelago is outside the targeted mining area. Within the area targeted in the central Pacific for cobalt-crust mining, few seamounts have been explored. Thus, the goal of our study was to explore a feature, Necker Ridge, within the targeted area and to characterize the deep-sea invertebrate megafauna on cobalt-rich manganese crusts of the Ridge in terms of abundance, diversity and community structure. Necker Ridge is a >600-km-long razorback ridge feature, centered at approximately 22°N and 167°W, and trending north at about 32° (Hein et al., 1985). This unexplored feature is a prime first study target within this region because it lies just outside of the Papahānaumokuākea Marine National Monument of the Northwestern Hawaiian Islands (NWHI). Besides having cobalt-rich manganese crusts, Necker Ridge appears to be the only bathyal, hard-substrate feature properly situated to connect deep-sea fauna on the Mid-Pacific Mountains, which are also under consideration for cobalt-rich manganese crust mining, to the nearest protected areas in the NWHI.

We expect that there will be some variation in communities found along the Necker Ridge. Although globally only 200–300 seamounts have been biologically sampled (e.g. Rowden et al., 2010), patterns of community structure are beginning to emerge that indicate seamounts and similar features like ridges are not homogeneous habitats (e.g. Baco, 2007; Etnoyer et al., 2010; McClain et al., 2010; Rowden et al., 2010; Schlacher et al., 2014; Long and Baco, 2014). Seamounts typically have rough and heterogeneous topography, which can create irregular current patterns and uneven distributions of sediments, resulting in extensive areas of hard substrates as well as soft substrate habitats. The microhabitats that result from these changes in topography and substrate type (Auster et al., 2005) can result in patchy distribution of initial recruits that serve to enhance the heterogeneity. The types of organisms that recruit to each microhabitat then provide biological structures for epifauna (e.g. Buhl-Mortensen et al., 2010), and further increase the biological patchiness found on seamounts (McClain et al., 2010).

Variation in other environmental parameters also contributes to observed heterogeneity on seamounts. Like other deep-sea ecosystems, seamount communities may be structured by depth (Baco, 2007; McClain et al., 2010; Schlacher et al., 2014; Long and Baco, 2014). In fact, species turnover of 93% can happen over depth ranges as small as 200 m (Long and Baco, 2014). Similarity between communities has also been shown to decrease with distance between communities, even on a single seamount (Halfar and Fujita, 2007; Schlacher et al., 2014). On some features other environmental variables, e.g. oxygen, salinity, substrate chemical composition, and substrate type, appear to structure community changeover rather than depth or distance (Levin et al., 1991; Wishner et al., 1990; McClain et al., 2010; Bo et al., 2011; Sautya et al., 2011). Thus, a second goal of this study was to examine the relationship of observed faunal patterns on Necker Ridge to environmental parameters such as depth, temperature and substrate type. In the process of addressing these goals we gain further insights into the fauna of cobalt-rich crusts within the targeted mining area, as well as into the relationship of observed community structure to environmental parameters on seamounts in general.

2. Materials and methods

2.1. Video surveys and analyses

To sample and explore each site at Necker Ridge we carried out video transects and specimen sampling in October 2011 using the submersible *Pisces IV*, operated by the Hawaii Undersea Research Laboratory. Necker Ridge is approximately 1400–4000 m below sea level. Pinnacles along the ridge were chosen as optimal sampling sites (Fig. 1) due to the depth limitations of the submersible (max 2000 m) and the likelihood of finding similar habitats to those studied on Hawaiian Archipelago seamounts. We define pinnacles as features conical in shape with steep sides, which do not have enough vertical relief to be classified as knolls. One dive

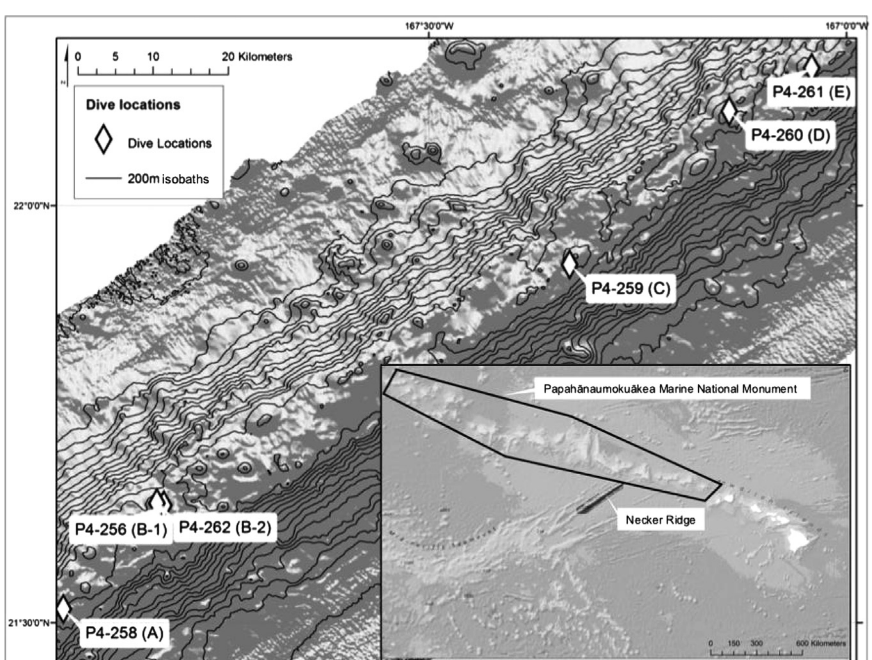

Fig. 1. Dive locations shown by diamonds and labeled by the *Pisces IV* dive number. Inset: Location of Necker Ridge relative to the Hawaiian Archipelago.