Biological Community and Sediment Fatty Acids Associated with the Deep-Sea Whale Skeleton at the Torishima Seamount

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A whale skeleton was discovered on the flat-topped summit of the Torishima Seamount, 4037 m deep, northwest Pacific Ocean, during a dive by the submersible Shinkai 6500 in 1992. The skeleton was encrusted with mytilid mussels and harbored benthic animals such as galatheid crabs, echinoderms, sea anemones, and unidentifiable tube worms. The whale skeleton was revisited in 1993. Sediment samples were collected to outline the chemical-microbial distribution in the sediment associated with the skeleton. In the sediment, there was a gradient of sulfide concentration with the peak of 20 n moles per gram sediment just beneath a bone. Corresponding gradients were observed in thiosulfate-oxidizing enzyme activity, bacterial colony counts and fatty acid amounts. Direct analysis of the sediment fatty acid composition suggested the occurrence of methane-oxidizing bacteria and sulfur-reducing bacteria in close association with the whale skeleton. These observations imply that the methane and sulfides were formed during the saprogenic process and utilized for the chemosynthetic bacterial production to feed the whale skeleton-animal community.

1. Introduction

Deep-sea biological oases, that provide reducing chemical energy for chemosynthesis-based communities, have been found and characterized at hydrothermal vents (reviewed in Tunnicliiffe, 1991, 1992; Lutz and Kennish, 1993) and cold seeps (e.g., MacDonald et al., 1990). The vestimentiferan tube worm community at submarine volcanic vent in the euphotic zone (82 m deep; Hashimoto et al., 1993) is thought to be a variety of, or a shallow-water counterpart of the deep-sea hydrothermal vent communities. Examples of other types of reducing environments include the dense clam beds in Laurentian Fan (Mayer et al., 1988) and the shipwreck tube worms in the northeastern Atlantic Ocean (Dando et al., 1992).

The discovery of a whale skeleton-associated biological community (Smith et al., 1989) added a new site of deep-sea oases for chemosynthesis-based fauna. However, the hypothesis proposed by Smith et al. (1989) that whale carcasses serve as “stepping stones” for the dispersal of some vent organisms was controversial, because the carcass-associated fauna was not necessarily vent-specific (Tunnicliiffe and Juniper, 1990; Tunnicliiffe, 1992); and because large whales and vent/seep communities appeared at different geological/evolutionary times (Squires et al., 1991). Yet, the co-occurrence of fossil whale bones and fossil Calyptogena-Lucina clams (Hachiya,
1993) suggests those whale bones as chemosynthetic habitats for those bivalves, whose modern species are specifically adapted to vents, seeps and other reducing environments (e.g., Turner, 1985).

A whale skeleton was found near the eastern summit of the Torishima Seamount (4037 m deep), in the Western Pacific Ocean, during a dive by the DSV Shinkai 6500, Japan. According to the initial observation (Fig. 1; Fujioka et al., 1993; Wada, 1993), the skeleton consisted of 22 vertebrae and an assemblage of jawbones. The vertebrae were colonized by mytilid mussels, and harbored galatheid crabs resembling the species found in the Western Pacific back-arc vents such as in the North Fiji Basin (e.g., Jollivet et al., 1989; Desbruyères et al., 1994), Mariana Trough (e.g., Williams and Baba, 1989; Hessler and Lonsdale, 1991) and the Mid-Okinawa Trough (Naganuma et al., 1990). Thus, we assumed that the whale skeleton serves as a deep-sea oasis for benthic animals including vent taxa as well as more cosmopolitan ones.

A year after the discovery in 1992, the whale skeleton was revisited, and the bone-associated sediment cores were collected. This communication reports the chemical and the corresponding microbial gradients in the sediment, assuming the gradients formed in association with the whale carcass degradation. Also the involvement of bacteria metabolizing methane and sulfur in the whale carcass degradation is discussed.

2. Materials and Methods

2.1 Observation and sample collection
The whale skeleton at the Torishima Seamount (30°55.45' N, 141°49.72' E, 4037 m deep) was revisited during the 174th dive of the DSV Shinkai 6500 (September 18, 1993; observer, H. Wada). Identification of the whale species was made by examining an ear tympanic bone collected by the submersible. Preliminary identification of the invertebrates associated with the skeleton was made according to Brusca and Brusca (1990) and Barnes (1980), with some collected samples and video/photo records.

Sediment core samples were collected at the points of 1.5 m, 1 m, and 0.2 m from a posterior vertebral bone (Fig. 1). The points were arranged on a line to the vertebral axis. Another core sample was taken from beneath a mid-vertebral bone (0 m; Fig. 1). The core samples, about 15 cm long, were divided into three depth parts of 0–5 cm (upper), 5–10 cm (middle) and 10–15 cm

Fig. 1. Map of whale skeleton, reconstructed from Shinkai 6500 photographs and videotapes. Sites of sediment collection are shown. Shaded bones were collected.