Photographs of Invertebrate Megafauna from Abyssal Depths of the North-Eastern Equatorial Pacific Ocean

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ABSTRACT. A series of RV PROSPECTOR cruises to survey ferromanganese nodule deposits at depths of 4000-5200 meters in the Clarion-Clipperton Fracture Zone of the north-eastern equatorial Pacific Ocean resulted in the acquisition of over 70,000 seafloor images. Real-time television, coupled with 35-mm remote-controlled still photography, revealed a conspicuous epibenthic invertebrate megafauna of more than 70 species. Approximately 38 species are echinoderms. Porifera and Cnidaria are each represented by approximately 12 species. Several molluscs and arthropods, a bryozoan, a hemichordate, and an ascidian urochordate constitute the remainder.

Although there has been increasing international commercial interest in developing the economic potential of the region, knowledge of the faunal elements present remains very limited. Many of the non-echinoderm megafauna from this increasingly important area are illustrated here in seafloor photographs.

Several taxa are new to science; others represent new locality records or depth range extensions. Comments are given on systematic status, geographic and bathymetric distribution, and living habits of selected species.

INTRODUCTION

The abyssal invertebrate megafauna of the north-east equatorial Pacific is poorly known, and reports on collectors or photographs from the area are scarce in the scientific literature. During the past 100 years or so, only a small number of research vessels, most notably the CHALLENGER in 1875 and the ALBATROSS in 1904-05 (Menzies et al. 1973), have made collections in or near the area, and reports on individual species are scattered in the literature.

Recently the search for economically attractive ferromanganese nodule deposits has resulted in a number of international consortia focusing their attention upon the Clarion-Clipperton Fracture Zone (CCFZ) of the tropical north-eastern Pacific (Fig. 1). Deepsea Ventures Inc. (DVI), as research and development service contractor to Ocean Mining Associates (OMA), has carried out extensive mineral resource assessments in the CCFZ, employing a variety of direct sampling and remote sensing techniques. These activities have provided significant data on distribution, abundance and composition of the nodule deposits and their physical, chemical, and geological settings. Data have also been acquired on the biological milieu of this poorly known but increasingly important area.

Baseline environmental data were also obtained at three sites in the CCFZ (Fig. 1) during the Deep Ocean Mining Environmental Study (DOMES) of 1975-76 (Bischoff and Piper 1979). More than 10,000 bottom photographs were taken during three cruises of the NOAA ship OCEANOGRAPHER (Sorem et al. 1979); these served primarily to provide detailed information on the nodules and other geological features. A review of the megafauna appearing on these photographs is currently in progress.

Three additional sites in the CCFZ were examined during the International Cooperative Investigation of Manganese Nodule Environments (ICIME) in 1978-79 (Andrews et al. 1983). Environmental sampling was also carried out near DOMES site C during the ECHO-1 Expedition of 1983 (Spiess et al. 1984).

Beginning in 1982, the approximately 70,000 deep sea photographs in the DVI collections were reviewed for their biological data content. Efforts were made to identify organisms depicted and to extract as much information as possible with respect to their habitat preferences, population densities and general distribution. To date, over 70 megafaunal taxa have been identified on photographs. Some of the animals are new to science or poorly known; others represent new distribution records or have been photographed for the first time in situ. They appear in the form in which they occur naturally, without the distortion or damage often associated with recovery of delicate organisms from abyssal depths. In most cases, photographs alone do not allow description of a new species. Therefore, the full characterization of several newly discovered life forms awaits the collection of suitable specimens for more detailed study.

Over half of the species photographed in the CCFZ area are Echinodermata and are more fully reviewed elsewhere (Pawson 1983, Foell and Pawson 1985, Pawson and Foell 1985, Pawson and Foell in press). The present article discusses some of the rarer or more unusual taxa that are not echinoderms.

MATERIALS AND METHODS

The deep sea photographs and ancillary data used in this publication were acquired during RV PROSPECTOR cruises from 1979 to 1982 and, with the single exception of Plate 3 (d), were obtained in a portion of the CCFZ near DOMES Site C between 15°39'N to 15°00'N and 124°00'W to 130°00'W (Fig. 1). The DVI real-time television survey system, as described in Henninger et al. (1984), was normally used as a guide for triggering the remote-controlled Bentho 372 still camera and 382 flash that obtained the seafloor photographs in Plates 1-3. The still camera has a capacity of 800 exposures on standard 35-mm film (1600 exposures with thin base film).

The cameras, associated lights, and other instrumentation were mounted on a tripod carrier vehicle (Fig. 2) that was towed at an altitude of 1-5 m over the seafloor at a speed of about one knot. Control signals to and data from the tripod were multiplexed on a 7600-m-long electro-mechanical cable. A single operator at the winch control console regulated the altitude of the tripod over the seabed and...
FIGURE 1. Map of the north-eastern equatorial Pacific region showing the location of the CCFZ and of DOMES sites A, B, and C. The cross-hatched rectangle indicates the primary study area referred to in the text.

FIGURE 2. OMA/DVI deep submergence television survey system instrumentation mounted on tripod carrier vehicle.

RESULTS AND DISCUSSION

A list of invertebrate megafauna (excluding echinoderms) identified to date from OMA/DVI photographs or specimens is given in Table 1. Several of the more unusual and rarely photographed organisms are depicted in the plates. Specific collection data for each photograph are provided in Table 2. Commentary regarding the taxa that were observed follows below.

*Hyalonema* sp. (Porifera, Hexactinellida) Plate 1 (a-c)

Various examples of this large genus of sponges were photographed throughout the area. The body of these organisms is white in color, more or less cup-shaped, and elevated above the seafloor by a stalk consisting of intertwined strands of glass rods that may be up to 1-m in length.

A few types, such as the form on Plate 1 (a), are relatively common in the study area, appearing in numer-
from the eastern Pacific at depths of approximately 700 m. If identified correctly, the photos in the DVI collections document new depth and locality records.

The species is uncommon in the study area.

P. eucnactus (Porifera, Hexactinellida) Plate 1 (f)

This form is a white sponge characterized by erect and cylindrical main branches, each carrying a series of smaller sponges or "spongelets." This species is uncommon-to-rare in the study area, appearing on only two photographs. If correctly identified as *E. euctum*, the occurrence in the study area represents a considerable depth range extension, since it was previously known only from the eastern Pacific area at 700-800 m.

Other sponges (Porifera, Hexactinellida) Plate 1 (g-h)

These photographs depict sponges that may be new to science. Until specimens are obtained for detailed study, a more exact classification can not be attempted.

Sea anemones (Cnidaria, Anthozoa) Plate 2 (a-c)

Sea anemones are among the most ubiquitous megafaunal elements in the study area. Most are attached to nodules or other hard substrates such as the fossilized whale skull in Plate 2 (b). Plate 2 (c) also shows a large anemone that appears to drift or roll slowly over the seafloor, as evident from both photographic and videotape observations. Classification of this group again awaits the availability of specimens.

Symposium euctus (Cnidaria, Anthozoa) Plate 2 (d)

The stem of the organism shown carries scattered polyps reminiscent of the genus *Symposium*, first reported from the Indian Ocean. The translucent mass at the top of the stem cannot be identified with any certainty, although it somewhat resembles an animal identified by Menzies et al. (1973) as the stalked tunicate *Caulolus* sp. The single photograph of these forms would indicate that they are rare in the area.
PLATE 1. (a-h) Glass sponges (Porifera, Hexactinellida). Scale bar in each photograph is 25 cm.
**CONCLUSIONS**

Components of the abyssal invertebrate megafauna of the north-eastern equatorial Pacific have been photographed in situ. Several taxa in the photographs were documented as present in an area rich in ferromanganese nodules. This area is the focal point for international interest in ocean mining. In some cases, the data provide depth range extensions and, in most cases, new locality records.

The study area is unique in terms of biological exploration. Nodules are a dominant feature; yet until now very little exploration has been done in nodule-rich areas.

A number of photographs depict organisms that probably represent previously unknown or undescribed taxa. Detailed description, classification, and naming of these species will in most cases require the availability of study specimens. However, the photographs complement specimens in that they show what these animals look like in vivo, and in natural surroundings. When and if specimens are retrieved, the delicate organisms are often damaged beyond recognition, in part owing to changes in temperature and pressure, but mostly owing to the relatively coarse collection methods currently used. Furthermore, collection devices such as dredges, trawls, sledges, and traps provide little information on the immediate and preferred surroundings of both sessile and motile forms. Even alternative modes of locomotion, such as swimming by an animal that more commonly crawls over the seafloor, may go unrecognized if not evident in imagery captured by photography or videotape (Pawson 1982, Pawson and Foell in press).

The diversity of the megafauna and importance of echinoderms determined in the present study compare favorably with results obtained by other authors. Heezen et al. (1980) found about 90 species, including 35 echinoderms, at 3000-m depths and approximately 25 species, including 10 echinoderms, at 4000-5000-m
PLATE 2. (a-c) Sea anemones, (d) octocorallid, (e-f) hexacorallids (Cnidaria, Anthozoa); (g) jellyfish (Cnidaria, Scyphozoa); (h) hydroid (Cnidaria, Hydrozoa). Scale bar in each photograph is 25 cm.
PLATE 3. (a-b) Octopods (Mollusca, Cephalopoda); (c) nudibranch (Mollusca, Gastropoda); (d-e) decapods (Arthropoda, Crustacea); (f) acorn worm (Hemichordata, Enteropneusta); (g-h) ascidian tunicates (Urochordata, Asciidae). Scale bar in each photograph is 25 cm.
depths off the north-eastern United States. Using the research submersible ALVIN in 1938-2141-m depths in the Tongue of the Ocean, Bahama Islands, Pawson (1982) identified 38 megafaunal taxa of which 27 were echinoderms. Smith and Hamilton (1983) found 39 species, including 14 echinoderms, at 1300-m off southern California. Other studies have also found a large diversity of echinoderms in bathyal to abyssal depths (Sibuet 1977, Gage et al. 1983).

The fauna observed in the present study contains many interesting elements. Available information is too limited, however, to permit statements on the degree of endemism in the fauna. Although we describe some of the organisms as rare or uncommon, it should be noted that few areas of the deep sea have been photographed as intensively as the areas of interest to the developing ocean mining industry. There are some widespread species present, but others seem to have a more restricted distribution. Certain species may be more typical of strictly hard bottom areas. Most of the species present are probably not confined to the north-eastern Pacific nodule belt and will ultimately be found in other areas. The CCFZ has been subject to intensive exploration for nearly two decades. It is not surprising that the research efforts of the consortia conducting mineral exploration surveys would significantly contribute to the knowledge and understanding of the occurrence and distribution of deep-sea life forms in this region.

Additional exploration will be required for more accurate species characterizations, determinations of population densities, patchiness of distribution patterns, and species interactions. These investigations should include studies of nearby nodule-free areas, so that some estimate can be made of the extent to which some of the faunal elements may be nodule-dependent.

Since submersibles capable of reaching abyssal depths of 4000-6000 m are few in number and expensive to operate, study methods that rely on direct observation and capture of deep sea organisms will continue to be supplemented by traditional sampling and imagery techniques for a number of years to come. Television is one of the best observational devices for deep sea studies (Rowe and Sibuet 1983). Although not specifically designed for that purpose, the OMA/DVI remote-controlled 35-mm photo-on-command system, coupled with the deep submergence real-time television system, is an excellent tool for study of deep sea epibenthic and pelagic megafauna.

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LITERATURE CITED


