Photographs of Invertebrate Megafauna from Abyssal Depths of the North-Eastern Equatorial Pacific Ocean[1]

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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.

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INTRODUCTION

The abyssal invertebrate megafauna of the north-east equatorial Pacific is poorly known, and reports on collections 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 (f), were obtained in a portion of the CCFZ near DOMES Site C between 13°30'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 Hennigar et al. (1984), was normally used as a guide for triggering the remote-controlled Benthos 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

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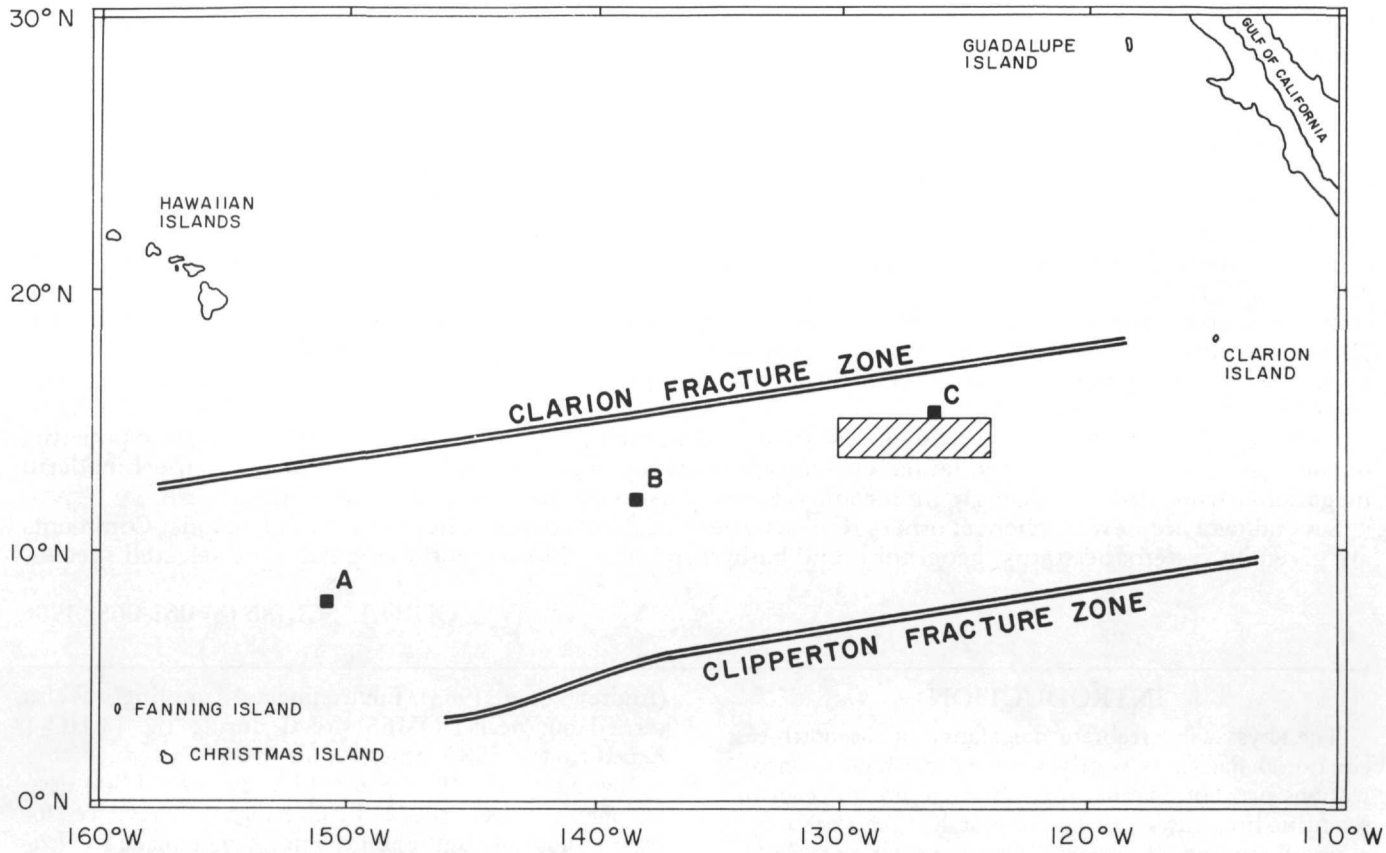

FIGURE 1. Map of the north-eastern equatorial Pacific region showing the location of the CCFZ and of DOMES sites A, B, and C. The cross-hatched rectangle indicates the primary study area referred to in the text.

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

triggered the still camera/flash units when objects of interest appeared on the TV monitor.

Absolute depths at the photograph locations were obtained by summing the readouts from the altimeter (height over the seafloor) and pressure sensor (depth of the tripod) for cruise 92 data. On other cruises, depths were determined from a precision depth recorder (PDR) chart after adjusting for the speed of sound in seawater and for the relative positions of the tripod vehicle and the survey vessel. Since the topography of much of the study area is characterized by low relief and gentle slopes, these depths were considered sufficiently accurate for purposes of this paper.

Infrequent satellite navigation fixes, and some uncertainty in tripod position relative to the ship, introduced errors precluding more exact estimates of location than to the nearest minute of latitude and longitude. Scale of the photographs was calculated from the camera lens characteristics and the altitude of the tripod at the instant of film exposure.

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-

TABLE 1

List of megafaunal taxa based on photographs and specimens.

PORIFERA
- Hexactinellida
  - *?Hyalonema* spp — at least 4 species
  - *?Poecillastra tricornis* Wilson
  - *?Eurete erectum* Schulze
  - *?Euplectella* sp.
  - *Holascus* sp.
  - *Caulophacus ?elegans*
  - *?Pheronema* sp.
  - Other sponges — at least 3 species

CNIDARIA (COELENTERATA)
- Anthozoa
  - Actinaria (sea anemones) — at least 5 species
  - "Sea pens" — at least 2 species
  - *Sympodium encrustans* Thompson and Henderson
  - *?Stephanophyllia* sp.
  - *Cerianthus* sp.
- Scyphozoa
  - *?Periphylla* sp.
- Hydrozoa
  - *Branchiocerianthus* sp.

MOLLUSCA
- Cephalopoda
  - Cirrate octopod
  - Incirrate octopod
- Gastropoda
  - Nudibranch — new species
  - "White gastropod"

ARTHROPODA
- Crustacea
  - *Aristeomorpha* sp.
  - *Munidopsis* sp.
  - *Scalpellum* sp.

ECHINODERMATA[1]

BRYOZOA
- Ascophora
  - "Bifaxariidae" sp.

HEMICHORDATA
- Enteropneusta
  - "Lophenteropneust"

UROCHORDATA
- Ascidiacea
  - *Culeolus* sp.
  - Sessile tunicate

[1]Approximately 38 species of echinoderms occurring in the area are reviewed elsewhere and are not listed here.

TABLE 2

Photograph location and ancillary data.

Plate	Locality Latitude	Locality Longitude	Corrected depth (m)	Date (d-m-y)	Time (GMT)	Cruise/ station
1 (a)	14°42'N	126°04'W	4507	5- 3-82	0108	92/01
1 (b)	14°01'N	124°37'W	4417	6-11-81	0225	89/02
1 (c)	14°43'N	126°04'W	4545	4- 3-82	2355	92/01
1 (d)	14°02'N	129°38'W	4770	2-12-80	0058	79/01
1 (e)	13°50'N	126°02'W	4626	8- 3-82	0233	92/02
1 (f)	14°40'N	125°49'W	4451	15- 3-82	0652	92/06
1 (g)	13°50'N	125°47'W	4520	8- 3-82	1454	92/02
1 (h)	14°02'N	124°30'W	4475	6-11-81	1258	89/02
2 (a)	13°50'N	125°51'W	4541	8- 3-82	1143	92/02
2 (b)	14°26'N	125°59'W	4460	5- 3-82	1725	92/01
2 (c)	14°40'N	126°03'W	4502	5- 3-82	0324	92/01
2 (d)	14°04'N	124°42'W	4535	5-11-81	1704	89/02
2 (e)	14°23'N	125°49'W	4518	15- 3-82	2114	92/06
2 (f)	14°02'N	129°25'W	4714	2-12-80	1421	79/01
2 (g)	14°30'N	126°05'W	4603	13- 3-82	2154	92/05
2 (h)	14°02'N	128°38'W	4616	4-12-80	1420	79/01
3 (a)	14°30'N	126°13'W	4470	13- 3-82	1510	92/05
3 (b)	13°49'N	126°03'W	4594	8- 3-82	0134	92/02
3 (c)	13°50'N	125°54'W	4558	8- 3-82	0855	92/02
3 (d)	13°48'N	126°00'W	4520	6- 3-82	2317	92/01
3 (e)	14°23'N	125°59'W	4473	5- 3-82	1909	92/01
3 (f)	9°51'N	146°54'W	5099	21-10-79	0818	76/05
3 (g)	14°30'N	126°17'W	4639	13- 3-82	1159	92/05
3 (h)	13°50'N	126°06'W	4616	7- 3-82	2342	92/02

ous photographs and videotape segments. Most others, including Plate 1 (b-c), are uncommon (appearing in fewer than five photographs) or rare (appearing in only a single photograph).

Caulophacus ?elegans (Porifera, Hexactinellida) Plate 1 (d)

This form is a stalked sponge with a body consisting of a thickened disc attached, flower-like, to the end of the stalk, either singly or in a branched cluster as shown. Several anemones are attached to the stalk of the specimen in the photograph. *Caulophacus elegans* was only seen in four photographs, and is considered to be uncommon in the study area.

?Poecillastra tricornis (Porifera, Hexactinellida) Plate 1 (e)

The photograph depicts a prostrate, cushion-like sponge with an upper surface perforated by numerous oscula. *Poecillastra tricornis* was previously known only 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.

?Eurete erectum (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. erectum,* 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.

Sympodium encrustans (Cnidaria, Anthozoa) Plate 2 (d)

The stem of the organism shown carries scattered polyps reminiscent of the genus *Sympodium,* 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 *Culeolus* sp. The single photograph of these forms would indicate that they are rare in the area.

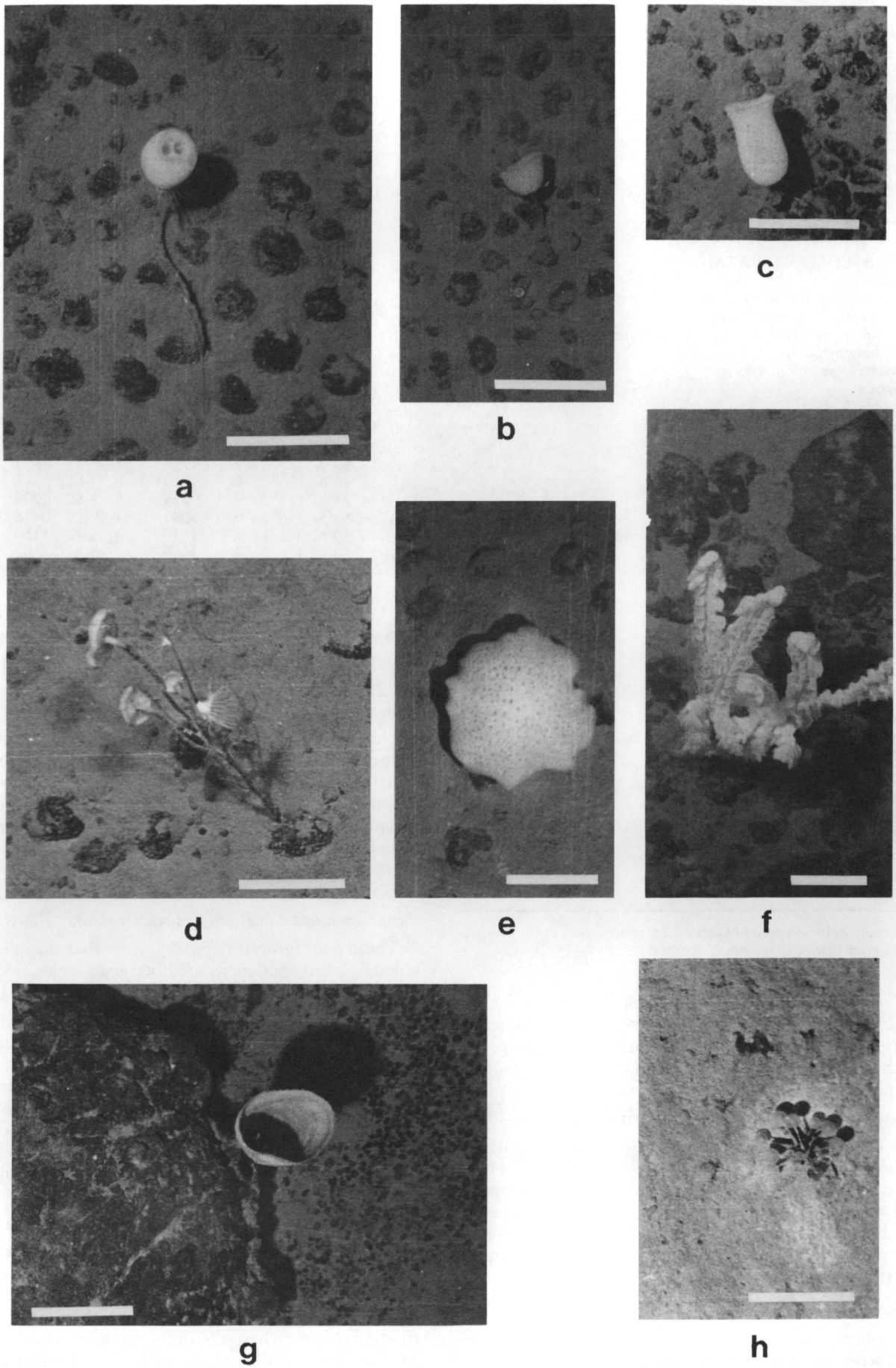

PLATE 1. (a-h) Glass sponges (Porifera, Hexactinellida). Scale bar in each photograph is 25 cm.

?Stephanophyllia sp. (Cnidaria, Anthozoa) Plate 2 (e)

This organism is a solitary coral which, owing to its appearance in a single photograph, is considered to be rare in the study area. More exact classification is not possible because of the absence of specimens.

Cerianthus sp. (Cnidaria, Anthozoa) Plate 2 (f)

Uncommon in the area, this tube-dwelling, anemone-like cnidarian is characterized by very long tentacles that usually stream out along the direction of the current.

?Periphylla sp. (Cnidaria, Scyphozoa) Plate 2 (g)

Appearing in only one photograph, this animal shares some features with the jellyfish genus *Periphylla*. The scale bar on the photograph is dimensioned for the seafloor, and can not be used to establish the size of the animal that is swimming at some distance above the seabed.

Branchiocerianthus ?imperator (Cnidaria, Hydrozoa) Plate 2 (h)

Members of the genus *Branchiocerianthus* are long-stalked hydroids of unusual structure, having a central oral disc surrounded by 50-180 distal and 100-200 proximal tentacles (Lemche et al. 1976). The stalk may attain a length of 2 m.

About five species of this strange genus are known, occurring from sublittoral to hadal depths. The specimen shown here may be *B. imperator* (Allman), which is the only abyssal species of this group of organisms that has been described (Lemche et al. 1976). During feeding, the animal sweeps the seafloor with its tentacular crown. Since it appears in only one photograph, the animal is considered to be rare in the study site.

Cirrate octopod (Mollusca, Cephalopoda) Plate 3 (a)

Common in the study area, cirrate octopods possess arms carrying suckers and two rows of papillae or cirri. There is always a well developed web between the arms, and the mantle has two fins.

There are about 30 species of these deep sea animals, and all are very poorly known (Roper and Brundage 1972). Exact classification is possible only if specimens are available.

Incirrate octopod (Mollusca, Cephalopoda) Plate 3 (b)

Uncommon-to-rare in the study area, incirrate octopods lack cirri, and the web between the arms is poorly developed or absent. Fins are also absent. As with cirrate octopods, identification cannot be done from photographs alone.

Nudibranch (Mollusca, Gastropoda) Plate 3 (c)

This large nudibranch is probably new to science. Seen in only two photographs in the DVI holdings, this animal is considered to be uncommon-to-rare in the study area.

Aristeomorpha sp. (Arthropoda, Decapoda) Plate 3 (d)

This large penaeoid shrimp is common in the area. It most likely represents a member of the genus *Aristeomorpha* which is characterized by deep-red coloration, large size, and long fan-like pleopods (Crosnier and Forest 1973). Often seen actively swimming or scurrying over the seafloor during television surveys, these animals are the most conspicuous of the arthropod megafauna captured in video and photographic images.

Munidopsis sp. (Arthropoda, Decapoda) Plate 3 (e)

Galatheid crabs of the genus *Munidopsis* are also common in the study site, often crawling over nodules, rocks, sunken wood, and other objects on the seafloor. Usually very light in color, these crabs are readily distinguishable on a dark-colored nodule background.

Acorn worm (Hemichordata, Enteropneusta) Plate 3 (f)

The name "lophenteropneust" was suggested by Lemche et al. (1976) for these hemichordates. This large worm is locally common in portions of the western CCFZ. The animal ingests great quantities of bottom sediments from which organic material is digested and absorbed. The remaining sediment is passed out as fecal casts that form the characteristic coils and loops often seen in bottom photographs from regions where the worms are abundant. Pictures of the worm itself are less readily available in deep-sea photographic collections.

Ascidian tunicate (Urochordata, Ascidiacea) Plate 3 (g-h)

Lemche et al. (1976) published a series of photographs of animals that they describe as solitary, stalked ascidian tunicates from hadal depths (>6000 m) of south-west Pacific ocean trenches. Two photographs depicting the same or very similar organisms exist in the DVI collections and are shown in Plate 3. The animals are uncommon-to-rare in the study area.

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. Haedrich 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

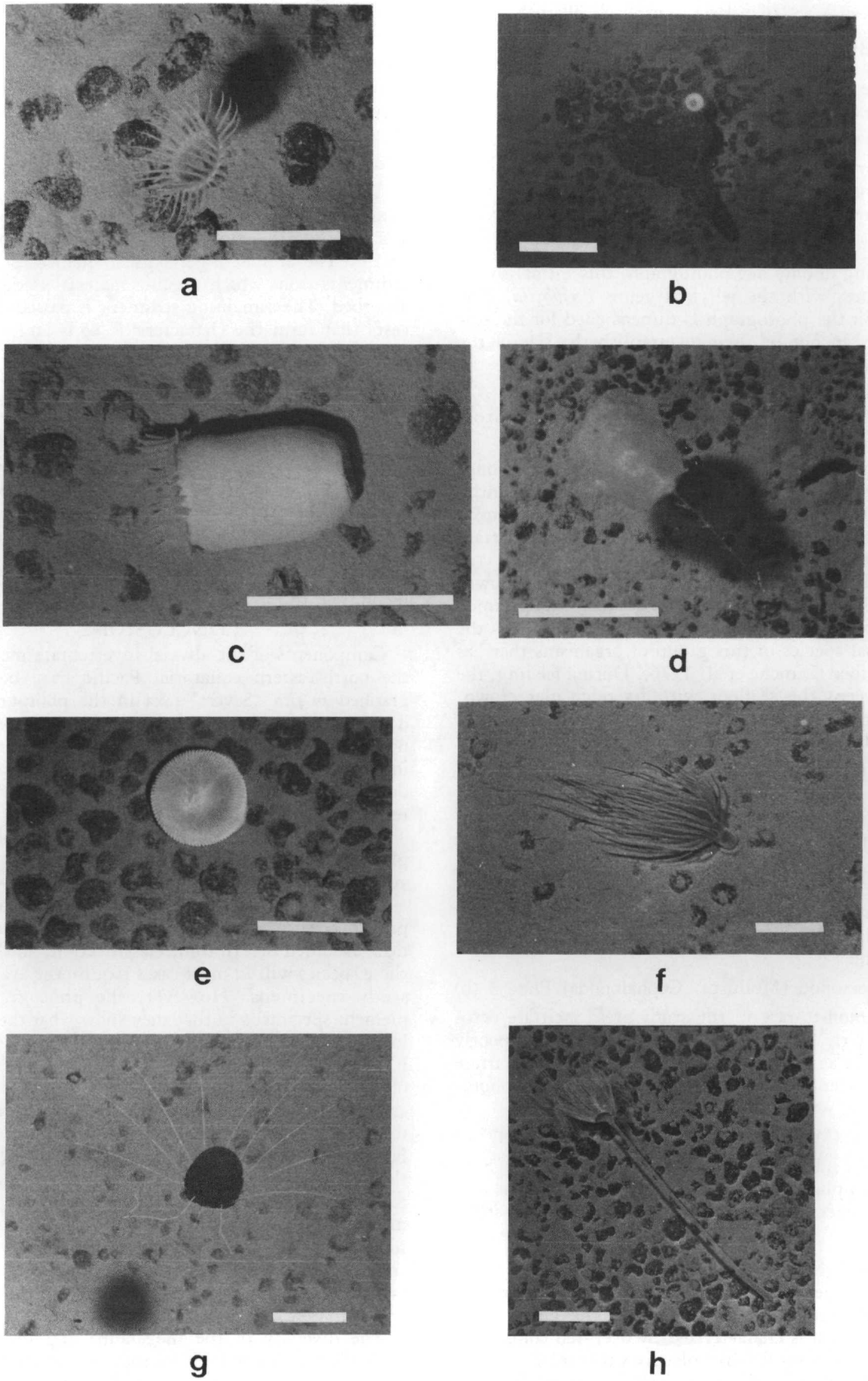

PLATE 2. (a-c) Sea anemones, (d) octocorallid, (e-f) hexacorallids (Cnidaria, Anthozoa); (g) jellyfish (Cnidaria, Scyphozoa); (h) hydroid (Cnidaria, Hydrozoa). Scale bar in each photograph is 25 cm.

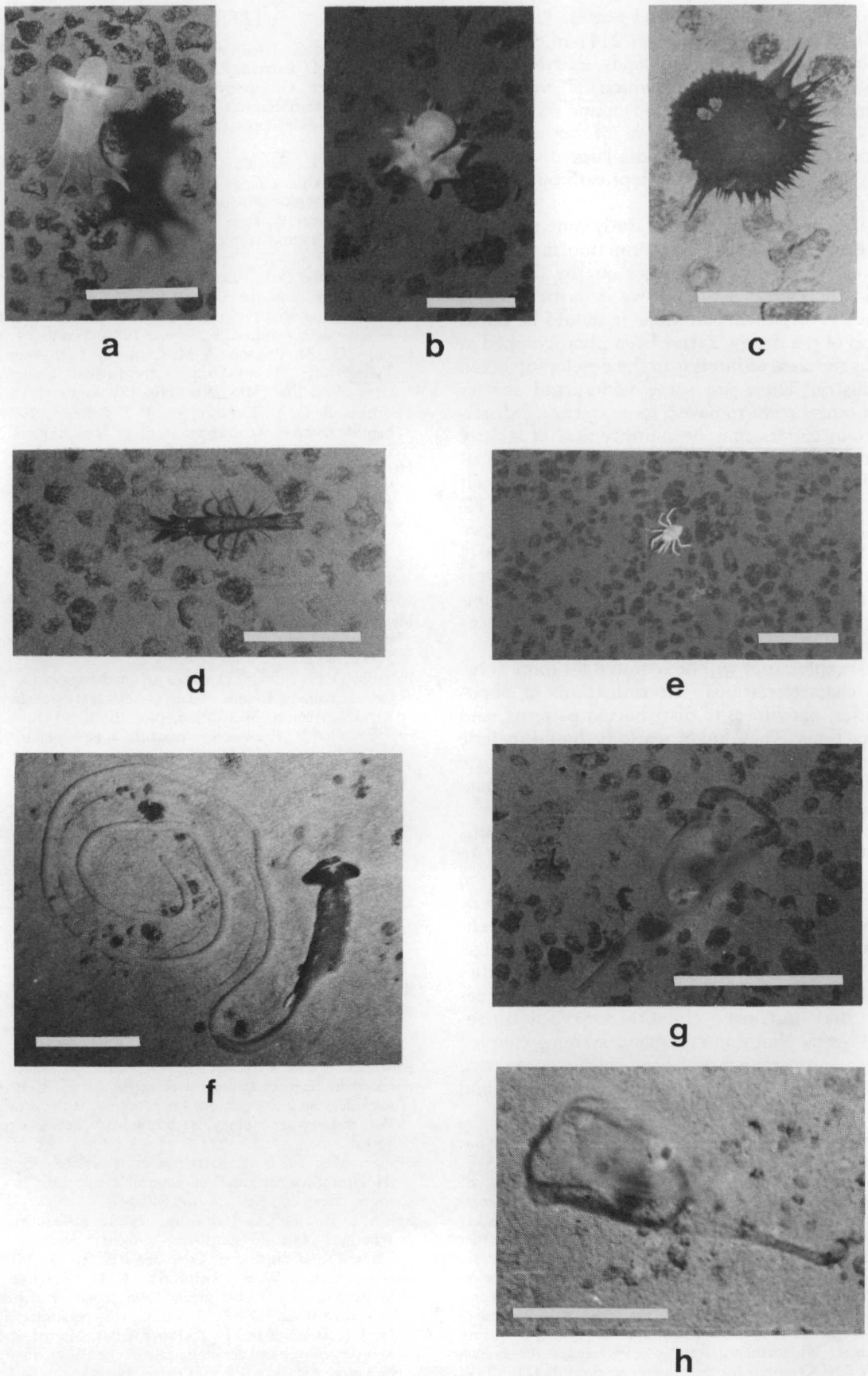

PLATE 3. (a-b) Octopods (Mollusca, Cephalopoda); (c) nudibranch (Mollusca, Gastropoda); (d-e) decapods (Arthropoda, Crustacea); (f) acorn worm (Hemichordata, Enteropneusta); (g-h) ascidian tunicates (Urochordata, Ascidiacea). Scale bar in each photograph is 25 cm.

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

Andrews, J., G. Friedrich, G. Pautot, W. Pluger, V. Renard, M. Melguen, D. Cronan, J. Craig, M. Hoffert, P. Stoffers, S. Shearme, T. Thijssen, G. Glasby, N. LeNotre, and P. Saget 1983 The Hawaii-Tahiti transect: the oceanographic environment of manganese nodule deposits in the central Pacific. Mar. Geol. 54: 109-130.

Bischoff, J. L. and D. Z. Piper (eds.) 1979 Marine sciences: Vol. 9: Marine geology and oceanography of the Pacific manganese nodule province. Plenum Press, New York, 842 p.

Crosnier, A. and J. Forest 1973 Les crevettes profondes de l'Atlantique oriental tropical. Faune Tropical, Vol. 19. ORSTOM, Paris, 409 p.

Foell, E. J. and D. L. Pawson 1985 Photographic atlas of abyssal megafauna from the Clarion-Clipperton Fracture Zone, north-eastern equatorial Pacific (abstract). Fourth International Deep-sea Biology Symposium, 23-29 June 1985, Hamburg, Germany.

Gage, J. D., M. Pearson, A. M. Clark, G. L. J. Paterson, and P. A. Tyler 1983 Echinoderms of the Rockall Trough and adjacent areas. Bull. Brit. Mus. Nat. His. (Zoology) 45(5): 263-308.

Haedrich, R. L., G. T. Rowe, and P. T. Polloni 1980 The megabenthic fauna in the deep sea south of New England, U.S.A. Mar. Biol. 57: 165-179.

Hennigar, H. F., Jr., E. J. Foell, and R. E. Dick 1984 Real-time television survey for manganese nodules. 50th. Annual Meeting of the American Society of Photogrammetry, ASP-ACSM Convention, 11-16 March 1984, Washington, D. C., Technical Papers, Vol. 1: 385-394.

Lemche, H., B. Hansen, F. J. Madsen, O. S. Tendal, and T. Wolff 1976 Hadal life as analyzed from photographs. Vidensk. Meddr dansk naturh. Foren. 139: 263-336.

Menzies, R. J., R. Y. George, and G. T. Rowe 1973 Abyssal environment and ecology of the world oceans. Wiley and Sons, New York, 488 p.

Pawson, D. L. 1982 Deep-sea echinoderms in the Tongue of the Ocean, Bahama Islands: A survey, using the research submersible ALVIN. Austral. Mus. Mem. No. 16: 129-145.

——— 1983 *Psychronaetes hanseni*, a new genus and species of elasipodan sea cucumber from the eastern central Pacific (Echinodermata: Holothuroidea). Proc. Biol. Soc. Wash. 96 (1): 154-159.

——— and E. J. Foell 1985 An annotated atlas of echinoderms from the Clipperton-Clarion Fracture Zone, equatorial eastern north Pacific (abstract). Proceedings, Fifth International Echinoderm Conference, 24-29 Sept. 1984, Galway, Ireland. Balkema, Rotterdam.

——— and E. J. Foell in press *Peniagone leander* new species, an abyssal benthopelagic sea cucumber (Echinodermata: Holothuroidea) from the eastern central Pacific Ocean. Bull. Mar. Sci. 38 (2):_____.

Roper, C. F. E. and W. L. Brundage, Jr. 1972 Cirrate octopods with associated deep-sea organisms: New biological data based on deep benthic photographs (Cephalopoda). Smithsonian Contributions to Zoology 121, 46 p.

Rowe, G. T. and M. Sibuet 1983 Recent advances in instrumentation in deep-sea biological research. *In*: G. T. Rowe (ed.), The sea: Ideas and observations on progress in the study of the seas: Vol. 8: Deep-sea biology, 81-95, John Wiley & Sons, New York, 560 p.

Sibuet, M. 1977 Repartition et diversité des echinodermes (Holothurides-Asterides) en zone profonde dans le Golfe de Gascogne. Deep-Sea Res. 24 (6): 549-563.

Smith, C. R. and S. C. Hamilton 1983 Epibenthic megafauna of a bathyal basin off southern California: patterns of abundance, biomass, and dispersion. Deep-Sea Res. 30 (9): 907-928.

Sorem, R. K., W. R. Reinhart, R. H. Fewkes, and W. D. McFarland 1979 Occurrence and character of manganese nodules in DOMES sites A, B, and C, east equatorial Pacific Ocean. *In*: J. L. Bischoff and D. Z. Piper (eds.), Marine sciences: Vol. 9: Marine geology and oceanography of the Pacific manganese nodule province, 475-527, Plenum Press, New York, 842 p.

Spiess, F. N., R. Hessler, G. Wilson, M. Weydert, and P. Rude 1984 ECHO-1 Cruise Report. SIO Ref. 84-3, 22 p.