Biodiversity in the Clarion-Clipperton zone

Deposits of polymetallic nodules containing high proportions of valuable metals are are found in significant quantities in the deep ocean. Pressure to exploit these resources has driven a need for better awareness of how the deep-sea environment and related faunal communities will be affected. The Clarion Clipperton Zone (CCZ), located in the equatorial eastern Pacific, is one of the most important areas under consideration for polymetallic nodule mining. Here we describe what is known on the biodiversity of the CCZ and how it varies across the region.

Biodiversity trends in the CCZ...

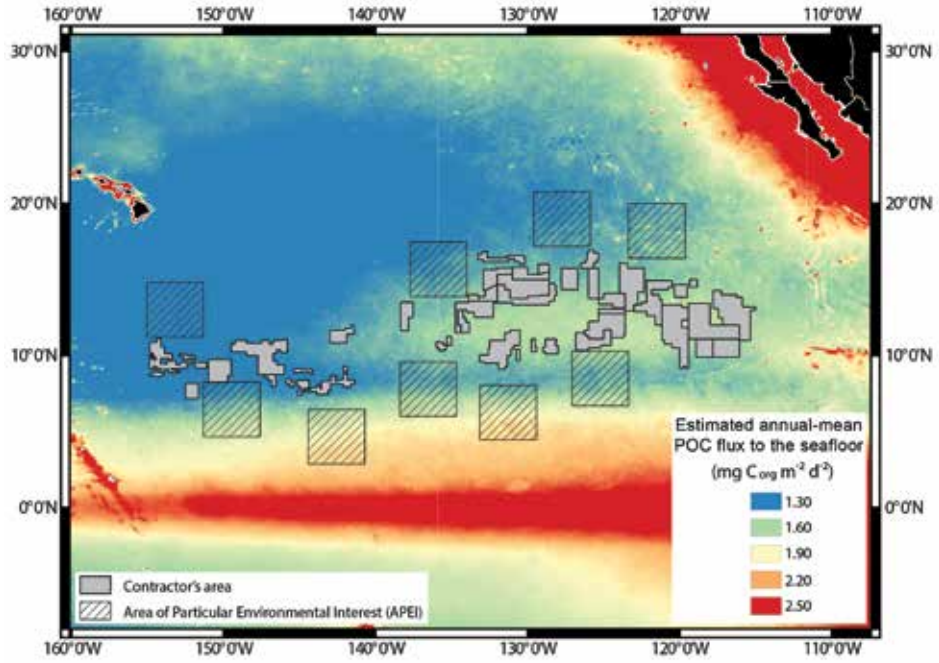
...from east to west

The CCZ is a very heterogeneous region, characterised by variable seafloor geomorphology of troughs and ridges with a relief of several hundreds of metres in some places. Some areas also have seamounts which may be thousands of metres high. Deep-sea biodiversity and biogeography on local to regional scales are controlled by a number of drivers, including supply of organic material from surface ocean productivity, water depth and (micro-) habitat diversity such as nodule size and coverage, amongst many other factors.

In the CCZ the supply of organic material from sea surface productivity shows a marked decrease from east to west and from south to north (see map below). Organic matter produced in surface waters is thought to provide the main food source for animals living at or in the deep seafloor, so changes in primary productivity are directly linked to variations in faunal composition, abundance and diversity across the CCZ. Faunal densities are much lower in the western region (where food is more limited) compared to eastern part of the CCZ (where productivity is higher and therefore food is more abundant). Similarly, there are increases in biodiversity linked to latitudinal changes in productivity.

... from corals to microbes

Nodule-bearing areas in the CCZ are quite different to soft-bottomed abyssal environments in other regions, which are relatively homogeneous. Polymetallic nodules provide a hard substrate to support encrusting fauna such as corals, bryozoans, xenophyophore protists and sponges, whilst smaller animals such as foraminiferans and nematodes colonise nodule surfaces and crevices.



Above left: Estimated annual Particular Organic Carbon (POC) flux to the seafloor in the Clarion Clipperton Zone. Note the E-W and N-S gradients in POC flux to different Contractor areas and Areas of Particular Environmental Interest. Map courtesy P. Martínez Arbizu (Quantum GIS, POC flux model derived from Lutz et al., 2007). Upper right: polymetallic nodules of different sizes and densities cover large parts of the CCZ and provide important habitats for larger encrusting fauna, as well as small-sized organisms living on and inside the nodule. Right: fauna associated with seamount habitats in the CCZ. Seafloor images courtesy of IFM GEOMAR, EcoResponse (SO239) cruise.

In the soft seafloor sediment between the nodules, the fauna is similar to other abyssal regions of the deep ocean. The dominant meiofaunal groups are nematodes and harpacticoid copepods, whilst polychaetes and isopod crustaceans are the most important macrofaunal taxa. Typical megafauna include holothurians, fish and giant protists. The latter provide shelter for numerous invertebrate groups such as nematodes and isopods.

It is still not clear whether the CCZ nodule province harbors a unique faunal community, or if it represents an extension of the fauna inhabiting adjacent abyssal areas. However, there is evidence from a number of studies covering a wide variety of benthic taxa (including bacteria and invertebrates) that shows diversity is very high both locally and at greater spatial scales.

…from unknowns to knowns

The CCZ spans a vast area of six million square kilometres. Despite biological investigations dating back to the 1970s, to date only a fraction of this region has been sampled. The scarcity of data is reflected in the high proportion of taxa found that are new to science, with up to 90% of species being undescribed. Our knowledge of different taxonomic groups varies greatly: some animal groups (e.g. echinoderms, fish, isopods, polychaetes) are better known than others. Smaller-sized groups, such as the meiofaunal taxa, are poorly known. Specimens from the CCZ have been identified to varying taxonomic resolution (e.g.to Class, Order, Family. Genus or Species) so data are often difficult to compare across the region. Furthermore, information on how diversity and species' distributions change across the CCZ are lacking.

Concerted international efforts are now underway to close these gaps by improving sampling resolution, standardisation of taxonomy and applying modern molecular techniques to accelerate species identification. Only then will faunal turnover and species ranges across the CCZ be known, and for informative predictions to be made on the potential impacts of mining on the deep-sea fauna.

Further reading

Glover A.G. et al. (2002) Polychaete species diversity in the central Pacific abyss: local and regional patterns, and relationships with productivity. Marine Ecology Progress Series, 240, 157-169.

Janssen A. et al. (2015) A reverse taxonomic approach to assess macrofaunal distribution patterns in abyssal Pacific polymetallic nodule fields. PLoS One, 10(2), e0117790.

Smith, C.R. & Demopoulos, A.W. (2003) The deep Pacific ocean floor. Ecosystems of the World, 179-218.

Veillette J et al. (2007). Ferromanganese nodule fauna in the Tropical North Pacific Ocean: Species richness, faunal cover and spatial distribution. Deep Sea Research Part I: Oceanographic Research Papers, 54(11), 1912-1935.

Top: Nematode worm sampled during the BIONOD voyage to the CCZ (image D. Miljutin, SGN). Middle: polymetallic nodules such as this one represent important habitats for a great variety of organisms living on and inside the nodules (image S. Kaiser, SGN). Bottom: polychaetes are the most dominant macrofaunal group in the CCZ - this specimen was collected during the JPIO EcoResponse cruise SO239 (image P.H. Bonifacio, L. Menot (IFREMER) & L. Neal (U. Gothenburg).

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