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Meiobenthos in the Sub-equatorial Pacific Abyss

A Proxy in Anthropogenic Impact Evaluation

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To my Mother

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Contents

Prologue

The deep seafloor (understood here as the oceanic bottom at depths exceeding 1,000 m) is the largest habitat on Earth. It is a highly diverse part of the oceanic mega-system and comprises a number of sub-habitats, each supporting specific benthic communities (e.g. Buhl-Mortensen et al. 2010; Vanreusel et al. 2010). These communities and their spatial variability are assumed to be, to a great extent, shaped by the type of their sedimentary environment, primarily the bottom sediment and its properties (Gray and Elliott 2009; Greene et al. 1999). Sediment properties in turn are a net result of numerous and complex interactions involving, i.e. the depth gradient, sedimentation regime, proximity to land masses, near-bottom hydrodynamics, underwater tectonics, seismicity, and volcanism (Brown et al. 1989; Seibold and Berger 1993). Current knowledge on these processes and on the way they affect the deep seafloor environments and the life forms these support is, despite extensive research efforts, particularly in the recent decades, still incomplete (Ramirez-Llodra et al. 2010). However, in the currently expounded framework of appreciation for ocean goods and services (e.g. Armstrong et al. 2012), there is a growing realisation worldwide that the deep seafloor can, and should, fulfill an important role—that of a provider of material goods in the form of biotic and abiotic resources (Armstrong et al. 2012).

With respect to the latter, it is already well established that the deep seafloor is a repository of a variety of mineral resources some of which are—or have a potential to be—of a key importance for human activities on Earth, both at present and in the future (Gage and Tyler 1991; Glover and Smith 2003; Summerhayes 1996). In addition to the raw materials such as placer deposits, oil, and gas that are being exploited at present, the seafloor stores certain resources which—when their terrestrial equivalents will have been exhausted and analogues will be impossible to find or will be too costly to develop—are an important wealth to be tapped (Glover and Smith 2003). This type of resources includes oceanic polymetallic nodules, also known as (ferro)manganese nodules (Hein and Petersen 2013; Hoffert 2008; Kotliński 1998a). Discovered during the 1882–1876 "Challenger" expedition (Hoffert 2008), the nodules occur as more or less spherical concretions (Fig. 1)

Fig. 1 *Left* Polymetallic nodules from the sub-equatorial NE Pacific's Clarion-Clipperton Fracture Zone (CCFZ) on the ship's deck, assembled for analysis (*Photo* T. Radziejewska); *Right* a close-up of a polymetallic nodule, with abundant epifauna (*Photo* B. Wawrzyniak-Wydrowska)

Fig. 2 A fragment of nodule-bearing seafloor in the CCFZ, featuring a holothurian (megabenthos) (*Photo* courtesy of IOM)

consisting of metal hydroxides, ores, and a variety of other minerals (Hein and Petersen 2013) strewn on the oceanic bottom (Fig. 2), mostly in the oceanic abyss.

Particularly abundant nodule deposits have been discovered on the deep seafloor of some areas in the Atlantic, Indian, and Pacific Oceans, characterised by low sedimentation rates (Hoffert 2008; Kotliński 1998a, 1999; Ross 1980; Seibold and Berger 1993). The most abundant nodule deposits in the Pacific Ocean are found on the abyssal bottoms of the Peru Basin in the southern part and between the Clarion and Clipperton fractures (the Clarion-Clipperton Fracture Zone, CCFZ) in NE Pacific (Hein and Petersen, 2013; Kotliński 1999; Glover and Smith 2003).

It is now commonly accepted that commercial mining of polymetallic nodules is imminent, although the commencement of mining operations still remains a matter of the future (Glover and Smith 2003; Berge et al. 1991; Hoffert 2008; Kotliński 1998b; Padan 1990; Thiel et al. 1992, 1998; Sharma 2011). In view of the imminence of mining, it has been deemed necessary to establish a legal framework for this activity (Hoffert 2008). Such framework has been indeed provided by the United Nations Convention on the Law of the Sea (UNCLOS) and regulations and activities stemming from it. Based on the UNCLOS provisions, the International Seabed Authority (ISA) was set up as an international body charged with management of the seafloor resources beyond the national jurisdiction of coastal states; those resources are recognised as the common heritage of Mankind (Hoffert 2008; Kotliński 1998b, 1999). The ISA's mission includes, i.a. making sure that the heritage is managed in a responsible and sustainable manner (http://www.isa.org.jm).

Responsible approach to developing seafloor resources, including the polymetallic nodules, requires that potential effects, particularly the adverse ones, of such an activity for the bottom habitat and its communities be realised, assessed and minimised (Berge et al. 1991; Jumars 1981; National Research Council 1984; Ozturgut et al. 1978; Thiel 1992; Thiel et al. 1992, 1998). At the present stage of preparations to commercial mining, the major actors (formerly termed the "pioneer investors" and currently known as the ISA contractors) are aware that they will be obliged to assess environmental consequences of mining, that is changes to the abiotic environment (bottom sediment and water column) and to the benthic and pelagic biota, resulting from mining activities. This obligation has been formalised in specific guidelines required by UNCLOS provisions and prepared by ISA, constituting the Mining Code (ISBA 2013) as well as in the guidelines pertaining to the assessment of environmental consequences of exploration activities in nodule-bearing areas (ISBA 2010). Efforts towards establishing a regulatory legal framework for the development of polymetallic nodule deposits have been recently summarised in ISA Technical Study No. 11 (ISA 2013).

As a step towards fulfilment of their legally binding obligations, some states and consortia enjoying the prospect of future commercial activities in their respective claim areas in the abyssal nodule-bearing oceanic bottom (Fig. 3) had embarked on research programmes aimed at collecting information on natural variability of the abyssal environment and on potential effects of mining-related intervention into it (Kotliński and Stoyanova 1998; Schriever et al. 1997; Sharma et al. 2001; Thiel 2001; Yamazaki and Kajitani 1999; Zhou 1997).

It was during one of such programmes, conducted by the Interoceanmetal Joint Organization (IOM)—an intergovernmental body (an ISA contractor) set up in 1985 to prepare commercial mining of polymetallic nodules in an area located within the sub-equatorial NE Pacific's Clarion-Clipperton nodule field (Kotliński 1998a, b)—that the present author was, in 1995–2000, a member of a team studying deep-sea environment and its biota (Radziejewska 2002; Radziejewska and Kotliński 2002; Radziejewska and Stoyanova 2000). The studies were aimed at collecting data that would augment the then existing body of knowledge on the

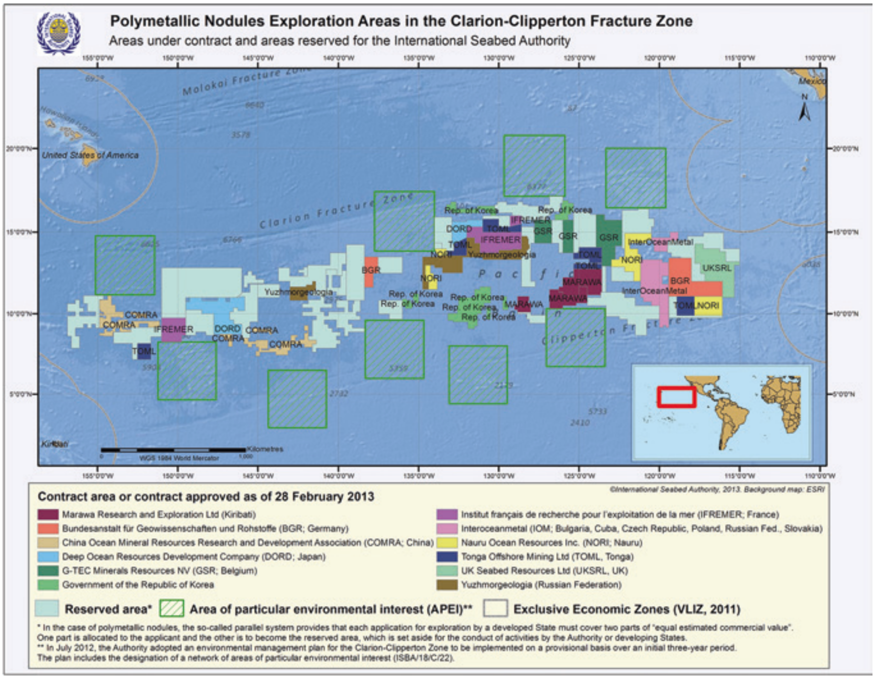

Fig. 3 Subdivision of the CCFZ (www.isa.org.jm)

Pacific abyssal environment and its communities, and at providing insights into the structure and responses of certain compartments of benthic faunal assemblages to man-made disturbance. It was hoped that, in addition to its inherent cognitive value, this information should aid in strengthening the groundwork on which to base future monitoring and assessment activities focused at evaluating consequences of polymetallic nodule mining-related environmental disturbance.

The first several years of the twenty-first century have been, and are, witnessing a renewed international interest in securing rights and claims to the oceanic nodule deposits, and an increasingly higher number of states and consortia rush to join the group of ISA contractors (e.g. Lodge et al. 2014; Schrope 2013). At the same time, fortunately, there is a growing realisation that the habitat where such activities are going to be pursued, and its communities, are—although vastly understudied—very fragile and irreplaceable. This realisation has sparked interest in, and resulted in pleas for, studies and conservation plans and concepts with regard to the deep-sea benthic habitats and communities in general (Mengerink et al. 2014; Van Dover 2011; Van Dover et al. 2014) and to those specific for the nodule-bearing areas in particular (Wedding et al. 2013). As elsewhere in such studies, particularly when the assessment of the magnitude of impact likely to be produced is to be a result, appropriate indicators, or proxies, will have to be selected, tested, and used (Jørgensen et al. 2010). A suite of such proxies, abiotic and biotic, has been in use in coastal areas, and includes variables related to the structure of benthic communities, including the meiobenthos. As the meiobenthos is a likely candidate for a proxy also in the deep-sea impact assessments, a synthesis of past research involving this category of benthos in nodule-bearing areas as a response variable in the assessment of effects produced by seafloor disturbance resulting from mining-like activities—the purpose and focus of this book—seems justified and timely.

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