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Rationale and recommendations for the establishment of preservation reference areas for nodule mining in the Clarion-Clipperton Zone

Summary outcomes of a workshop to design marine protected areas for seamounts and the abyssal nodule province in Pacific high seas, held at the University of Hawaii at Manoa, Hawaii, United States of America, from 23 to 26 October 2007

I. Goals

1. The goal of the workshop was to design a set of representative preservation reference areas to safeguard biodiversity and ecosystem function in the abyssal Pacific region targeted for nodule mining (the Clarion-Clipperton Zone). The preservation reference area system will be designed (a) on the basis of sound scientific principles; (b) to be consistent with the legal framework and environmental guidelines of the International Seabed Authority for managing deep-sea nodule mining and protecting the deep-sea environment; and (c) to incorporate the interests of mining claim holders and other stakeholders in the Area.

II. Assumptions

2. Abyssal nodule mining will affect large areas of the sea floor owing to direct mining disturbance (estimated scales of 300-600 km^2 per year) and redeposition from sediment plumes (over scales of 10-100 km from the mining site) (see Rolinski et al. 2001; Thiel 2001; Glover and Smith 2002; Hannides and Smith 2003; and Smith et al. in press, for discussions of the nature and scales of ecosystem impacts). Each mining claim area consists of 75,000 km^2 of sea floor. Over the 15-year timescale of an individual mining operation, virtually anywhere within the claim area could be mined so, for conservation management, the entire claim area must be considered to be potentially directly impacted. Benthic ecosystem recovery from

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mining impacts will be very slow, requiring decades or more for the soft-sediment fauna and thousands to millions of years for the biota specializing on manganese nodules (Glover and Smith 2002; Hannides and Smith 2003; Smith et al. in press). Thus, over the timescales of benthic ecosystem recovery, i.e., millenniums, all current mining claim areas (see figure 1 below) will potentially be exploited. *Hence, the slow ecosystem recovery rates at the abyssal sea floor will cause the environmental impacts of mining to be widespread and simultaneous across the Clarion-Clipperton Zone, requiring that conservation be managed across the region as a whole.*

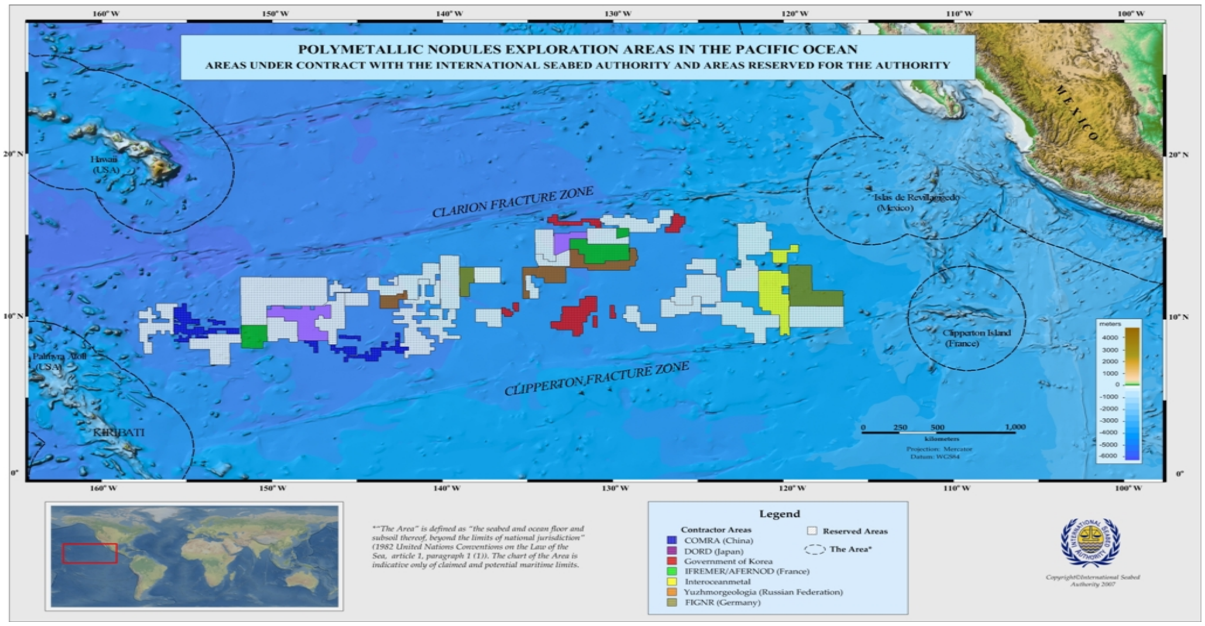

Figure 1. Polymetallic nodule exploration areas in the Pacific Ocean under contract with the International Seabed Authority and areas reserved for the Authority. Dashed lines indicate the boundaries of the national exclusive economic zones. Map courtesy of the International Seabed Authority.

III. Guidelines and rationales

3. Below we provide the general design guidelines for a system of preservation reference areas in the Clarion-Clipperton Zone, and the rationales for the development of these guidelines.

Guideline 1
The design and implementation of preservation reference areas should fit into the existing legal framework of the International Seabed Authority for managing seabed mining and protecting the marine environment.

4. The International Seabed Authority guidelines stipulate that prior to the issuance of test-mining and exploitation permits, preservation reference areas will be delineated “in which no mining will occur to ensure representative and stable biota of the seabed in order to assess any changes in the flora and fauna of the

marine environment" (ISBA/4/C/4/Rev.1, annex 4, sect. 5.6). "The preservation reference zone[s] should be carefully located and large enough so as not to be affected by the natural variations of local environmental conditions. The zone[s] should have species composition comparable to that of the test mining area[s]. The preservation reference zones should be located upstream of the test mining area[s]. The preservation zone[s] should be outside of test mining area[s] and areas influenced by the plume" (International Seabed Authority 1999, p. 226).

5. Thus, International Seabed Authority guidelines stipulate that prior to test mining and mining, preservation reference areas must be erected in areas beyond any potential influences of mining. The preservation reference areas should be designed (as a whole) to sustainably preserve representative biota for all mining claim areas in terms of species composition and biodiversity. Thus, the full range of habitat and community types potentially found in mining claim areas must be represented in preservation reference areas, and the scale of preservation reference areas must be large enough that these community types are "stable", i.e., sustainable.

Guideline 2

The interests of all stakeholders (including the International Seabed Authority, signatories to the United Nations Convention on the Law of the Sea, nodule-mining claim holders, non-governmental organizations, and the science community) will be incorporated into the design process. In addition, preservation reference areas should be established as soon as possible so that sound, ecosystem-based management principles can be incorporated into mining strategies and into the positioning of future claim areas.

6. To the extent scientifically sound, we have nested the proposed preservation reference areas within the existing framework of nodule-mining claims granted by the International Seabed Authority. The design guidelines incorporate flexibility in the location of specific preservation reference areas to allow input from mining contractors, and to facilitate adaptive management (i.e., to allow evolution/addition of marine protected areas as claim areas change in location and number).

Guideline 3

The preservation reference area system is designed with the following conservation goals within the management area (the Clarion-Clipperton Zone): (a) to preserve representative and unique marine habitats; (b) to preserve and conserve marine biodiversity and ecosystem structure and function; and (c) to facilitate the management of mining activities to maintain sustainable, intact and healthy marine ecosystems.

7. These goals are in agreement with the International Seabed Authority's mandate to protect the marine environment and to manage seabed mining in a way that sustains the ocean environment and its resources as the common heritage of mankind. These goals are also consistent with the principles of ecosystem-based management, which now underpin the general design of marine protected areas worldwide (National Research Council 2001).

Guideline 4

The Clarion-Clipperton Zone should be divided into three east-west and three north-south strata for conservation management because of strong productivity-driven gradients in ecosystem structure from east to west and south to north. This stratification yields nine distinct subregions within the Clarion-Clipperton Zone, each requiring a preservation reference area.

8. The fauna of the Clarion-Clipperton Zone exhibits high local species diversity (especially in the macrofauna and meiofauna) and variations in community structure and composition from east to west and south to north (e.g., Glover et al. 2002; Smith et al. 2007). For example, the abundance of polychaete worms (a major component of the macrofauna) decreases fourfold from the east to the west end of the Clarion-Clipperton Zone (Glover et al. 2002). Other major components of the macrofauna and meiofauna show similar decreasing abundance trends from east to west and south to north in the Zone (Mincks and Smith in prep.). There is strong evidence that the species structure of the soft-sediment fauna varies along with these abundance gradients. For example, more than 30 per cent of the polychaete and isopod species collected at the eastern end of the Clarion-Clipperton Zone have not been collected in the western end (Wilson 1992; Glover et al. 2002). Very recent results from the Kaplan project show similar patterns of species turnover across the Zone (Smith et al. 2007). For example, two families of polychaete worms (the predatory lumbrinerids and amphinomids) are very abundant at the eastern end of the Zone under more productive waters, and are rare or absent under less productive waters of the central and western regions (Glover, Smith and Altamira in prep.). One species of foraminifera (an important meiofaunal group in deep-sea sediments) is overwhelmingly abundant in sediments in the central region of the Clarion-Clipperton Zone but has not been collected in the eastern part of the region (Smith et al. 2007; Ohkawara, Gooday and Kitazato, in prep.). The nematode worms exhibit a high diversity of potential novel genera in the eastern Clarion-Clipperton Zone, suggesting adaptive radiation and a potentially unique fauna in this region (Smith et al. 2007; Lambshead et al. in prep.).

9. In summary, there are strong north-south and east-west gradients in productivity in the Clarion-Clipperton Zone (Smith et al. 1997; Hannides and Smith 2003), and these gradients appear to drive major changes in benthic community composition across the region. Thus, for conservation management purposes, we recommend that the zone be divided into three east-west and three north-south strata, with representative preservation reference areas being placed in each of the nine resultant subregions (see figure 2 below).

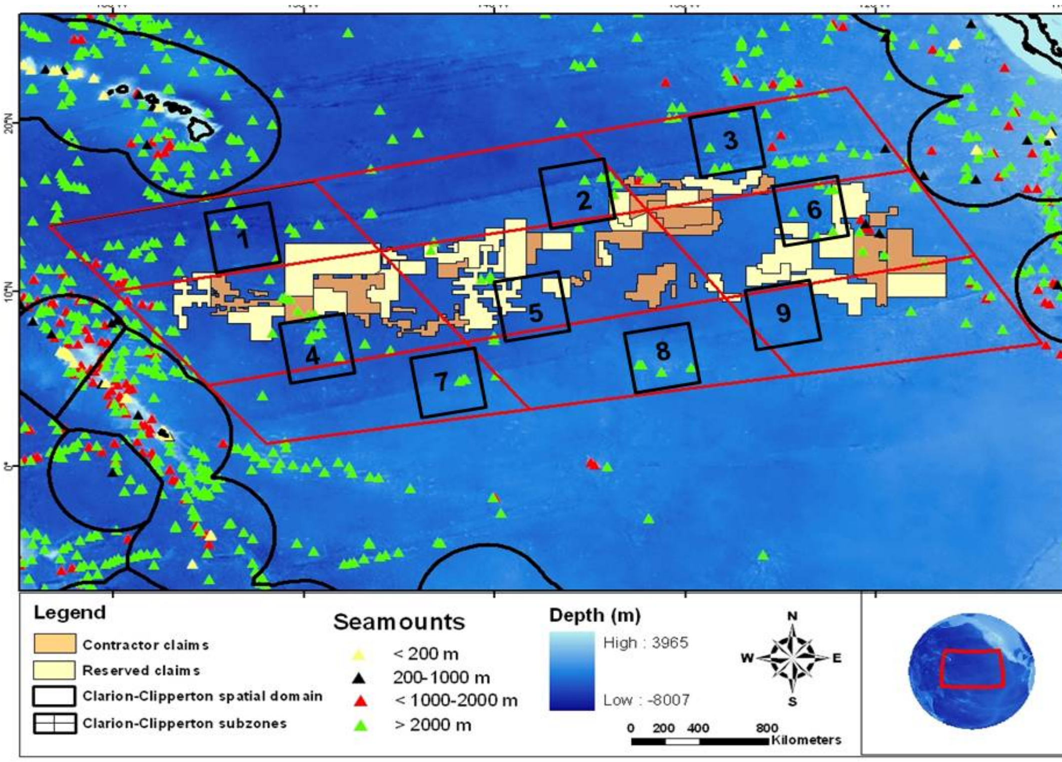

Figure 2. Clarion-Clipperton Zone divided into the nine management subregions, with one 400 x 400 km preservation reference area centred in each subregion. This figure shows one of many options for location of preservation reference areas within the management subregions.

Guideline 5
The boundaries of preservation reference areas should be straight lines to facilitate rapid recognition by all stakeholders.

10. This is a basic principle of the design of marine protected areas that will facilitate recognition, monitoring and enforcement of preservation reference areas as no-mining zones.

Guideline 6
The core area of each preservation reference area should be at least 200 km in length and width, i.e., large enough to maintain minimum viable population sizes for species potentially restricted to a subregion of the Clarion-Clipperton Zone.

11. Macrofaunal and meiofaunal invertebrates constitute the vast majority of biodiversity in the Clarion-Clipperton Zone and almost certainly include species with the most limited dispersal capabilities and biogeographic ranges. A number of studies in shallow-water habitats suggest that mean dispersal distance for most benthic invertebrate species is less than 100 km (e.g., Botsford et al. 2001; Kinlan and Gaines 2003). While available current-meter data from the Clarion-Clipperton Zone (e.g., Demidova 1999) indicate that the physical transport processes at the abyssal sea floor in the Zone are weaker than in many shallow-water settings,

dispersal exceeding 60 km on a monthly timescale was directly observed during a recent abyssal tracer-release experiment carried out near the Zone (Jackson et al., in prep.). To ensure that a substantial fraction of dispersing larvae and adults of targeted species remain within a preservation reference area, an accepted conservation approach is to make the length and width of the area at least twice the mean faunal dispersal distance (Botsford et al. 2001). This dictates a size of the core area of each area of 200 km x 200 km.

12. An alternate approach to maintaining viable populations within a subregion is to set up a network of smaller preservation reference areas connected by faunal dispersal (Botsford et al. 2001). However, this requires that the spacing between preservation reference areas be less than the mean dispersal distance for most benthic fauna (<100 km). Because the linear dimensions of individual mining claim areas and their areas of impact substantially exceed the mean dispersal distance of most benthic species (<100 km), ecological connectivity across a network of small preservation reference areas within a subregion is precluded by the size (75,000 km^2) of intervening claim areas. Thus, the network approach for preservation reference areas is not feasible, given the current size and distribution of mining claims (see figure 1 above).

Guideline 7
Each preservation reference area should contain the full range of habitat types found within its subregion.

13. To preserve representative and unique habitats, all habitat types for a subregion should be included within a preservation reference area. A variety of general habitat types can be recognized within the Clarion-Clipperton Zone, including abyssal plains/abyssal hills, seamounts and fracture zones.

14. Abyssal plains/abyssal hills cover most of the Clarion-Clipperton Zone floor. Nodule abundance within this habitat type varies from zero to nearly complete coverage of the sea floor (e.g., Smith et al. 2007; International Seabed Authority archived data). This habitat type also includes occasional scarps. Although habitat distributions are not known well enough to completely map habitat patterns within the entire Clarion-Clipperton Zone or within subregions, a number of studies indicate that abyssal plain habitats exhibit their full range of variability over spatial scales of 10 to 100 kilometres (French Research Institute for Exploitation of the Sea, unpublished data; International Seabed Authority archived data; Smith et al. 2007; C. Smith, personal observations). Thus, a preservation reference area with a core area of 200 x 200 km is very likely to capture the full range in habitat variability for the subregion.

15. Seamounts, defined as topographic features with summits over 1,000 metres above the general sea floor, as well as fracture zones, also occur in the Clarion-Clipperton Zone. These features represent distinct habitat types because of substrate and flow conditions, and the potential to harbour geographically isolated populations of fishes and invertebrates. They also may harbour unique or particularly vulnerable communities, and provide critical ecological habitat, for example sites for fish spawning aggregations. The distribution of seamounts and fracture zones is relatively well known from recent topographic syntheses (see the database of the Census of Marine Life on Seamounts). However, the biota of seamounts and fracture zones within the Clarion-Clipperton Zone remain essentially

unstudied so the uniqueness of associated biota cannot be assessed. Seamount communities, in particular, have a high potential to be impacted midwater sediment plumes which may disperse large distances (Rolinski et al. 2001). Thus, it is recommended that as many seamounts from a subregion as possible (with a target of at least 40 per cent), and portions of known facture zones, be included within preservation reference areas.

Guideline 8

Each preservation reference area core area should be surrounded by a buffer zone 100 kilometres wide to insure that the preservation reference area core is not affected by mining plumes. Thus, the dimensions of the each full preservation reference area (including the 200 x 200 km core area surrounded by a 100-km buffer zone) should be 400 x 400 km.

16. Nodule mining is expected to produce two types of sediment plumes that may impact benthic habitats: (a) near-bottom plumes created by tailings from the mining head during nodule extraction from the sea floor; and (b) plumes in the water column derived from sediments attached to nodules during lifting from the seabed (Oebius et al. 2001). More than 99 per cent of the mass of the near-bottom sediment plumes will settle within one month and within 100 km of the mining head for a broad range of hydrodynamic conditions (Rolinski et al. 2001). In situ tracer studies and advection-diffusion models also suggest dispersal scales for neutrally buoyant particles of less than 100 km over timescales of one to two months in abyssal ecosystems (Ledwell 2000; Jackson, Ledwell, Thurnherr, in preparation; A. Thurnherr personal communication). On timescales of weeks to months, and sometimes even years, the mean abyssal velocities in most regions of the deep sea are dominated by mesoscale eddies (e.g. Speer et al., 2003), implying that there is no defined “downstream” direction, i.e. the sediment plumes generated by mining can travel in any direction. Thus, a buffer zone of 100 km around a preservation reference area is needed to protect the core area from significant impacts from the near-bottom sediment plumes, which may come from any direction.

17. Water-column plumes derived from sediment lifted with nodules will contain orders of magnitude less sediment mass than near-bottom plumes (Oebius et al. 2001). However, water-column plumes will include a disaggregated, fine-grained sediment fraction that may drift for years and disperse for several hundred to over 1,000 kilometres, depending on the release depth. Based on the estimated mass flux of lifted sediments (Oebius et al. 2001) and the estimated space scales over which these particles will be deposited after dispersing more than 100 km (most likely 10^5-10^6 km^2: Rolinski et al. 2001), resultant deposition rates will be much less than ambient net sediment accumulation rates in the region (~0.25 g cm^{-2} ky^{-1}: Jahnke 1996). Thus, the benthic ecological impacts of a water-column plume, after dispersing across a 100-km preservation reference area buffer zone, are expected to be negligible.

18. In summary, based on the best available information, a 100-km buffer zone around each preservation reference area is expected to protect the core 200 x 200 km region from the deleterious effects of mining sediment plumes created both from the mining head and the lifting of nodule-associated sediments.

IV. Conclusions

19. Based on the above guidelines and rationales, we recommend that a system of nine preservation reference areas, each 400 x 400 km, be set up within the Clarion-Clipperton Zone. One preservation reference area should be placed in each of the nine subregions defined by productivity gradients and faunal turnover, as indicated in figure 2 above. Preservation reference areas should be situated so as to protect as many seamounts within a subregion as possible and to avoid or minimize overlap with current mining exploration claim areas. Erection of nine such preservation reference areas, with a total area of 1.44 x 10^6 km^2, will place ~25 per cent of the total Clarion-Clipperton Zone management area under protection. This approaches the general conservation guidelines of protecting from 30 to 50 per cent of available habitat to prevent losses of biodiversity (e.g., Botsford et al. 2001). It also approaches, in principle, the Millennium Development Goal of placing 30 per cent of the total ocean in reserves.

20. This preservation reference area system should be adopted by the International Seabed Authority as soon as possible, so that scientifically sound conservation principles are incorporated into the granting and management of nodule-mining claim areas. The setup of a regional system of preservation reference areas will remove the burden from individual contractors of designing their own preservation reference areas, and will initiate conservation management of the Clarion-Clipperton Zone as a whole, an approach necessitated by the space and timescales of expected nodule mining impacts. It will also establish the International Seabed Authority as a leader in the application of modern conservation management principles to international waters. Finally, it will set a precedent for protecting seabed biodiversity, a common heritage of mankind, prior to the initiation of exploitive activities.

Annex I

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Annex II

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