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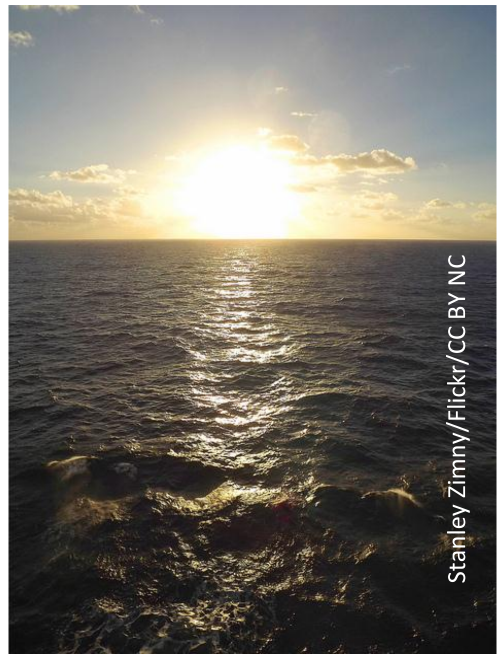
Thematic focus: Environmental governance, Resource efficiency

Wealth in the Oceans: Deep sea mining on the horizon?

The deep ocean, the largest biome on Earth at over 1 000 metres below the surface of the ocean, holds vast quantities of untapped energy resources, precious metals and minerals. Advancements in technology have enabled greater access to these treasures. As a result, deep sea mining is becoming increasingly possible. To date no commercial deep sea mining operation has taken place, but plans to open a deep sea mine have recently been announced. Our ability to anticipate the impacts of mining is limited by the lack of knowledge about deep sea biodiversity, ecosystem complexity, and the extent of environmental and social impacts from mining operations. As such, it is important that policies guiding mineral extraction from the deep seas are rooted into adaptive management – allowing for the integration of new scientific information alongside advances in technology. Governance mechanisms for international waters and the seabed need to be strengthened. The precautionary approach should be used to avoid repeating instances of well-known destructive practices associated with conventional mining.



Why is this issue important?

Minerals and the metals they contain are an essential component of the modern high-tech world. As global stocks of raw mineral resources continue to dwindle due to increasing material consumption, intense demand for valuable metals has pushed up global prices. The result is that manufacturing industries are now seeking access to previously unattainable mineral deposits in the ocean depths. The deep ocean is predicted to hold large quantities of untapped energy resources, precious metals and minerals (Ramirez-Llodra et al., 2010) including three types of potentially economically viable mineral resources: sea-floor massive sulphides (SMS), cobalt-rich ferromanganese crusts, and polymetallic (manganese) nodules (Figure 1).

Deep sea mining is appealing to many countries, including Small Island Developing States, as a means of economic development and revenue generation. In April 2014, Nautilus Minerals, a Canadian company, and the Independent State of Papua New Guinea signed an agreement to begin the world’s first deep sea mining for ores of copper, gold, and other valuable metals (Nautilus Minerals, 2014). Mining companies, and national governments, have leases to explore margin sediments for phosphates off Namibia, New Zealand, and Mexico (Mengerink et al., 2014). Some of the contracts are further summarised in Table 1 (ISA, 2014b).

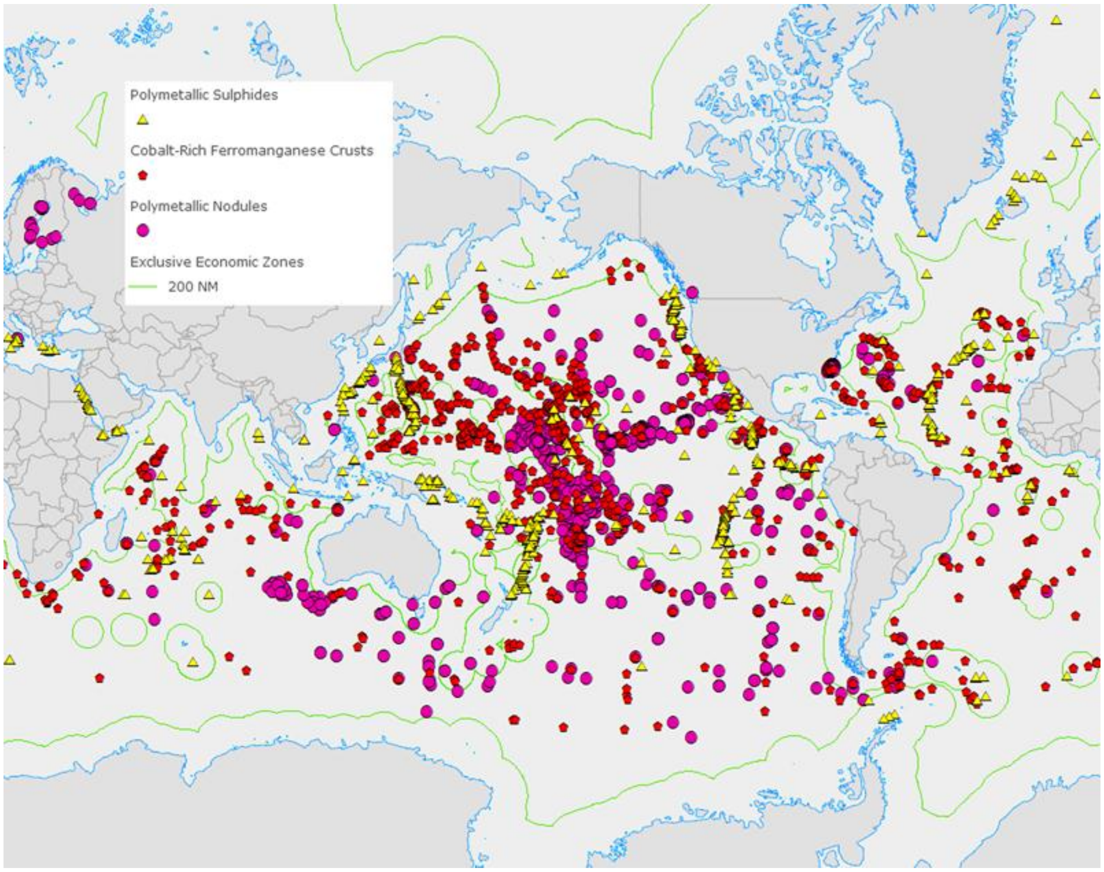


Figure 1. Global distribution of three major types of deep sea mineral resources (UNEP/DEWA adapted from ISA, 2014a).

Type of mineral deposit	Sponsoring State	General location of the exploration area under contract	Contractor	Date of entry into force of contract	Date of expiry of contract
Sea-floor polymetallic sulphides	France	Mid-Atlantic Ridge	Institut français de recherche pour l'exploitation de la mer	To be signed	
	Korea	Central Indian Ridge	Government of the Republic of Korea	To be signed	30.04.2029
		Mid-Atlantic Ridge	Government of the Russian Federation	29.10.2012	28.10. 2027
	China	Southwest Indian Ridge	China Ocean Mineral Resources Research and Development Association (COMRA)	18.11.2011	17.11.2026
Cobalt-rich ferromanganese crusts	China	Western Pacific Ocean	COMRA	29.04.2014	28.04.2029
	Japan	Western Pacific Ocean	Japan Oil, Gas and Metals National Corporation (JOGMEC)	27.01.2014	26.01.2029
Polymetallic (manganese) nodules	Kiribati	Clarion-Clipperton Fracture Zone (CCZ)	Marawa Research and Exploration Ltd.	To be signed	
	United Kingdom of Great Britain and Northern Ireland	CCZ	UK Seabed Resources Ltd.	08.02.2013	07.02.2028
	Belgium	CCZ	G-TEC Sea Mineral Resources NV	14.01.2013	13.01.2028
	Tonga	CCZ	Tonga Offshore Mining Limited	11.01.2012	10.01.2027
	Nauru	CCZ	Nauru Ocean Resources Inc.	22.07.2011	21.07.2026
	Germany	CCZ	Federal Institute for Geosciences and Natural Resources of Germany	19.07.2006	18.07.2021
		Indian Ocean	Government of India	25.03.2002	24.03.2017
	Japan	CCZ	Deep Ocean Resources Development Co. Ltd.	20.06.2001	19.06.2016
	France	CCZ	Institut français de recherche pour l'exploitation de la mer	20.06.2001	19.06.2016
	China	CCZ	COMRA	22.05.2001	21.05.2016
		CCZ	Government of the Republic of Korea	27.04.2001	26.04.2016
	Bulgaria, Cuba, Czech Republic, Poland, Russian Federation and Slovakia	CCZ	Interoceanmetal Joint Organization	29.03.2001	28.03.2016
	Russian Federation	CCZ	Yuzhmorgeologiya	29.03.2001	28.03.2016

Table 1. Contracts for exploration of deep sea mineral deposits (adapted from ISA, 2014b).

What are the findings?

Between 2000 and 2010, the price of many non-energy raw materials increased annually by about 15%, mainly as a result of consumer demand in emerging economies (WTO, 2010). Advances in technology as well as concerns over security of supply have encouraged mining companies to consider what the seabed can provide. By 2020, 5% of the world's minerals, including cobalt, copper and zinc could come from the ocean floors. This could rise to 10% by 2030. Global annual turnover of marine mineral mining can be expected to grow from virtually nothing to €5 billion in the next 10 years and up to €10 billion by 2030 (EC, 2012).

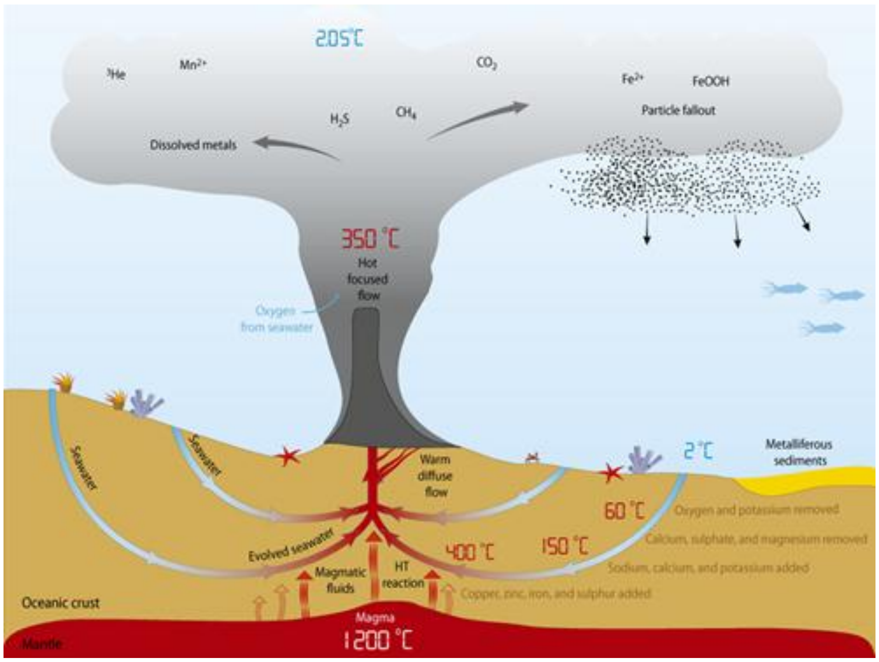
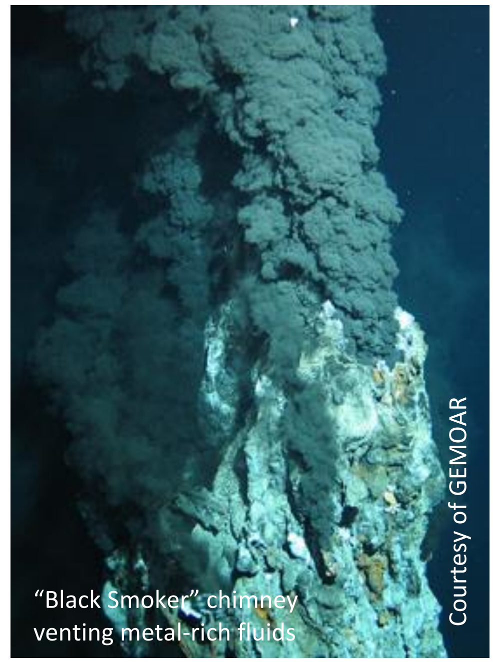


Figure 2. Basics of a hydrothermal vent (GRID – Arendal).



Sea-floor massive sulphides deposits are created by hydrothermal activity (photo above and Figure 2) when extremely hot fluids, in excess of 350°C, are released onto the sea-floor. They were first documented in 1977 and are now known to be present throughout the world's oceans in areas of tectonic activity. These deposits contain copper, lead, zinc, silver and gold, barium, nickel and other trace metals (Baker and German, 2009). While these deposits are mostly located within areas under national jurisdiction, there are deposits outside jurisdictional marine areas.

Polymetallic (manganese) nodules are rocky lumps (Figure 3) that vary from between five and ten centimetres in size. They form from iron and manganese hydroxides at water depths between 4 000 and 6 500 meters. The metals within – including nickel, copper, and lithium, among others – hold commercial value for many technological applications. The most significant known concentration of these deposits is found in the Clarion Clipperton Zone of the equatorial Pacific (see Figure 4).

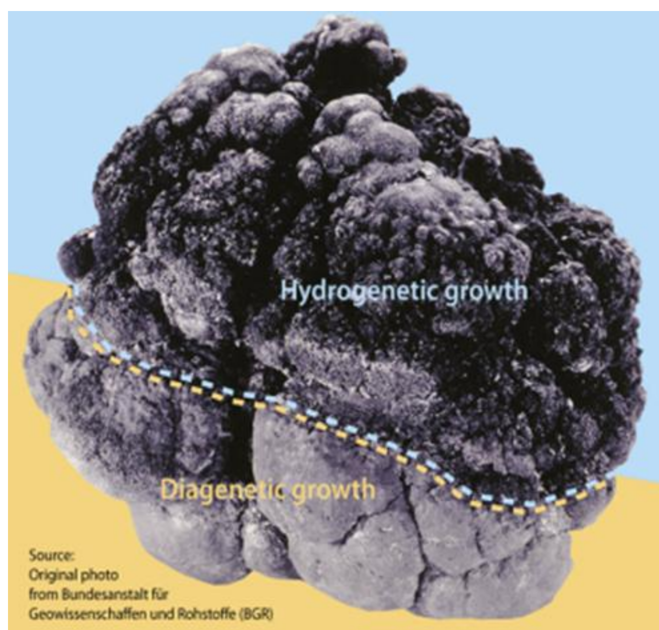


Figure 3. Picture and description of a manganese nodule recovered from the Clarion Clipperton Zone in the Pacific Ocean (Adapted by GRID-Arendal).

Figure 4. Average abundance of polymetallic (manganese) nodule in four major locations (GRID-Arendal adapted from Hein et al., 2013).

Cobalt-rich ferromanganese crusts are hard, solid layers up to 25 centimetres thick that form when manganese and iron precipitate out of cold seawater (Figure 5 and photo below). They may contain cobalt, nickel, and some rare earth elements and could provide up to 20% of the global cobalt demand (Ramirez-Llodra et al., 2010). These crusts are firmly adhered to the surfaces of seamounts, ridges, and plateaus at water depths of 400-7 000 metres. Initial licences issued by the International Seabed Authority are targeted at the flat tops of seamounts (guyots) in the western Pacific Ocean where thick cobalt crusts have been formed and where the geology is relatively 'benign' (ISA, 2013a; b).

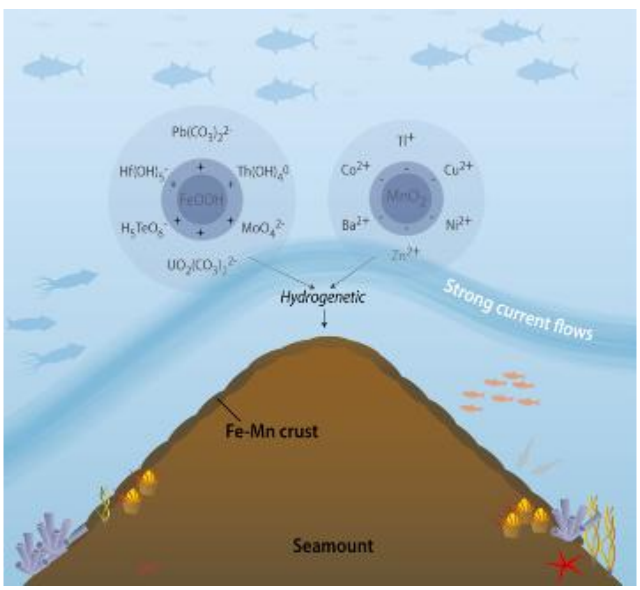
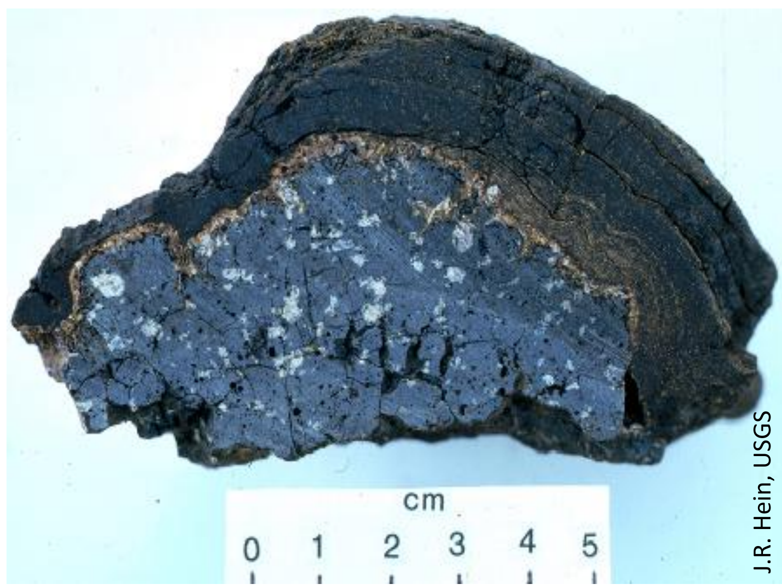


Figure 5. Formation of cobalt-rich ferromanganese crusts. (GRID-Arendal adapted from Hein et al., 2013).



Ferromanganese crust on basalt (photo by J.R. Hein, USGS, cruise L5-85-NC, D33-1, Gorda Ridge, NE Pacific).

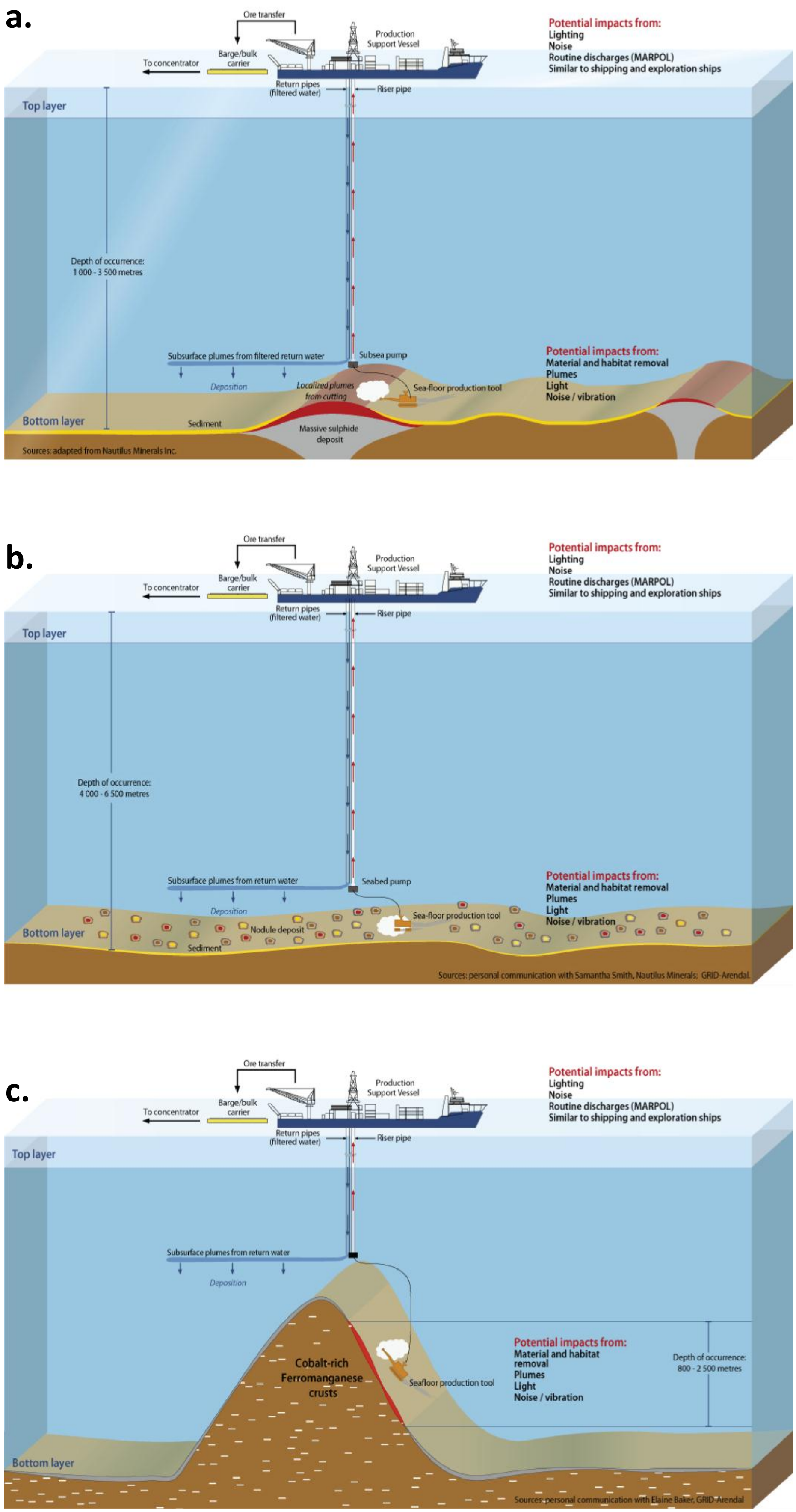


Figure 6. Schematic of deep sea mining of (a) sea floor massive sulphides (b) manganese nodules and (c) cobalt-rich ferromanganese crusts (GRID-Arendal).

Deep sea mining process

Mineral extraction generally involves three basic processes that are common across each mineral type as shown in Figure 6 (Clark and Smith, 2013a; b). After separation of the mineral crusts from the sea-floor, the crusts are crushed and ground to dislodge the attached deposits. The disaggregated material or slurry is then lifted in a pumping mechanism through the water column to a processing vessel. Excess water is removed from the slurry and returned to the ocean.

Environmental considerations

Several impacts are common across the extraction of the three types of deposits (Clark and Smith, 2013a, b). Impacts associated with the presence of marine vessels primarily occur at the surface. These impacts include the inadvertent introduction of invasive species, noise and air pollution generated by ships, fluid leaks and discharges from vessels and equipment, and vibrations.

More specific to mining is the introduction of light into sea floor environments that are normally light-deprived. Light may attract or deter some fish species, and may alter normal feeding and reproduction behaviours.

Impacts to the water column occur when the mined material is lifted from the sea floor to the mining vessel at surface level, when the ore is dewatered and as a result of routine discharges and spills from the vessel. Dewatering of the slurry in the water column (versus as near to the sea floor as possible) may have a clouding effect, resulting in localised impacts on primary productivity and potentially reducing oxygen levels. In addition, the released seawater will be different in composition from when it was collected with the ore and is likely to contain different levels of salinity, temperature and trace amounts of toxic chemicals. Ingestion of the contaminated water by organisms may create a potential for bioaccumulation through the food chain (Coffey, 2008).

Species found in active hydrothermal vent sites where sea floor massive sulphides deposits occur, include vent-endemic organisms such as barnacles, snails, mussels, crabs, tubeworms, shrimps, and various fish (German et al., 2011). Because these communities are localised, even small-scale mining activities can wipe out vent communities (Van Dover, 2011a). Studies show that some species may possess the ability to re-colonise quickly following an event that is detrimental to their habitat (Van Dover et al., 2011). However, species at dormant vent sites may take more than a 10-year period to re-colonise (Van Dover 2011b; Williams et al., 2010).

Away from the vent sites there are other species that reside on the sea floor (Figure 7). These are often filter feeders, such as cold deep-water corals and sponges that rely on a clean current to supply their nutrients. During mining, sediments on the sea floor are disturbed and the presence of particulate matter can alter food supply. Large amounts of disturbed sediment can also have a smothering effect on certain sea floor residents. Mining manganese nodules is expected to occur over large areas. In the process all living organisms on the sea floor, and perhaps to some depth below the surface in the mine area, could be destroyed (Figure 6b). The increased turbidity from very fine sediments may adversely impact the surrounding fauna which may be poorly adapted to cope with disturbance (Stoyanova, 2012; Zhou, 2007). Experiments carried out in both the Peru basin and the Clarion Clipperton Zone (see Figure 4) show that even though mobile species may return after disturbance, sessile species do not recover (Kaneko et al., 1997; ISA, 1999; Thiel et al., 2001; Bluhm, 2001).

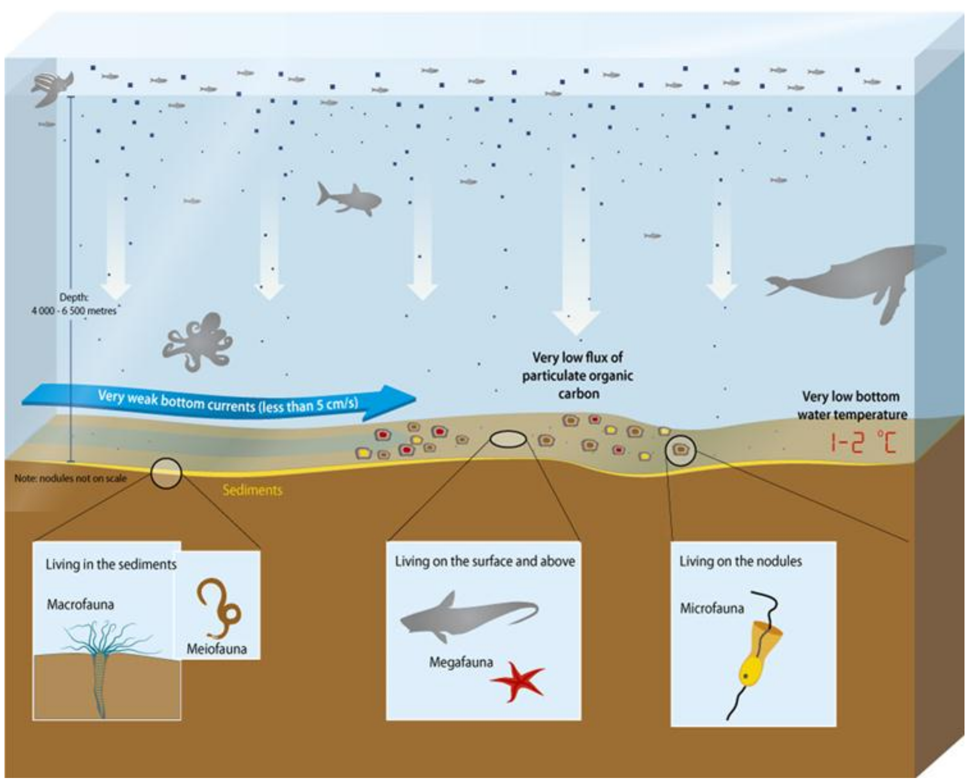


Figure 7. Schematic representation of habitats and biodiversity in areas where manganese nodules have been found (GRID-Arendal).

Many seamounts, where cobalt-rich ferromanganese crusts occur, have been impacted already by bottom trawling. It is evident from impact studies on fishing activities that seamount biota are particularly sensitive to human disturbances (Koslow et al., 2001; Clark and Tittensor, 2010). Recovery may take decades to centuries as revealed by site tests in the offshore areas of New Zealand and Australia (Williams et al., 2010).

The history of Pacific Island states' experiences with terrestrial mining suggests that impacts related to pollution and environmental amenities will be especially important to prioritise. This may include concerns linked to usage of coastlines (such as ports, transport or mooring of mining-related ships and equipment) disposal of waste and any deep sea pollution or disturbance. However, current proposals for sea floor mining in the Pacific region appear to involve little or no onshore presence, and so the direct impacts may well differ from those that have been seen with terrestrial mining projects (Bice, 2011).

Socio-economic considerations

Predicting the impacts of mining on society is a complicated task that will differ from site to site (Vanclay and Esteves, 2011). The presence of mining vessels will necessitate site closures before, during, and potentially after mining activities. Such restrictions may extend beyond the mining site to the shipping routes. This may displace or disrupt fisheries and impact local livelihoods.

Deep sea mining industry will need to address issues of self-determination amidst a growing public awareness of rights. This can be achieved partly through effective and comprehensive implementation of social licenses to operate and free, prior, and informed consent approaches (Nish and Bice, 2012).

Governance in the deep ocean is fragmented. Although the water column and the seabed below 200 metres are interconnected, they are managed on a single-sector basis (Mengerink et al., 2014). The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is an umbrella framework for international ocean management. Multilateral regional fishery management organisations regulate commercial fisheries harvest; the International Maritime Organization manages shipping; and the International Seabed Authority regulates mining of the international seabed. Management of other activities such as dumping, laying submarine cables and military activities that affect the deep ocean is similarly a single-sector approach. In some arenas, like marine genetic resource management, agreements and institutions are substantially lacking. It is important to realise that deep sea mining activities need to be analysed in relation to their location and other surrounding uses that are in close proximity as such multiple actions often contribute to cumulative impacts on the environment.

What are the implications for policy?

Countries in the Pacific region recognised the new opportunities related to offshore minerals as early as 1999 (SOPAC, 1999) where they committed to a regulatory approach to deep sea minerals. The regulatory scope has since been expanded in the SPC-EU Deep Sea Minerals Project's Pacific Islands Regional Legislative and Regulatory Framework (SPC, 2012) and is now being implemented through the development of world-leading national statutory regimes encompassing fiscal, social, and environmental governance. Such governance is essential to ensure that deep sea mining meets development objectives and provides a stable and transparent climate for investment as shown on Table 2 (Franks, 2012).

Benefits for regional, national and community interests	Benefits for investors and developers
Attracts good companies capable of compliance	Provides a healthy investment climate with greater certainty
Provides an agreed framework for negotiation	Provides an agreed framework for negotiation
Fosters long term success by minimizing the potential for conflict-induced delays, shutdowns, or closure	Fosters long term success by minimizing the potential for conflict-induced delays, shutdowns, or closure
Provides improved prediction of economic benefits – evolved tax regimes, savings strategy, etc.	Ensures efficient and cost-effective project planning and implementation
Enhances employment and training opportunities for local workers	Increased access to a skilled and motivated workforce
Increased environmental awareness, including economic valuation of ecosystems	Fosters development of best practice, supporting sustainability through the project life cycle
Enhances access to new technology	Fosters development of new technologies and applications
Ensures compliance with international principles and standards	Ensures compliance with international principles and standards
Minimizes institutional corruption	Minimizes potential for supporting institutional corruption
	Enhances overall project risk-reduction and realization of mutually beneficial outcomes

Table 2. Benefits of an effective regional deep sea mining policy regime (Franks, 2012).

As part of a green economic approach, five policy design principles could be considered when evaluating potential development (Daly and Farley, 2011). These principles are approaches to representing, monitoring, and accounting for global needs and local goals, while ensuring the integrity and health of priceless natural systems.

1. Economic policy does not involve one goal but many. Each desired goal (for example, poverty reduction and increased resource efficiency) must be addressed, sometimes by its own policy instrument and always in a coordinated way. For instance, a royalty system – developed to promote economically efficient use – would be coordinated with an income distribution system that would help to alleviate poverty.
2. Because of the cumulative impacts of mining, policies should aim to establish the necessary degree of "big picture control", while maintaining critical flexibility to accommodate the need for activity-specific variability. At the national scale, the limiting consideration is cost, in terms of lost ecosystem function and services. This consideration would drive the development of a national policy instrument to limit total habitat impact or loss of ecosystem value, by considering all mining activities in the country, possibly together with all major activities that affect habitat quality and ecosystem value.
3. Policies should be developed with a generous margin of error when dealing with the biophysical environment. Operating near or at system capacity can lead to unexpected and unaffordable costs. Mining development should be designed to avoid areas of critical biological and ecosystem importance, minimise environmental impacts at every stage, and mitigate unavoidable environmental damage.
4. Policies should recognise that the starting point is always based on the current policy-making reality, and should build on existing good environmental and social policies that are effective. Developing policy instruments focused on potential deep sea mining will require reshaping and transforming existing policy processes, regulations, economic frameworks and/or institutions so that they are more effective for investments needed.
5. Policies should be adaptable to conditions and parameters that are likely to change. As society comes to terms with the challenges and opportunities of a reality defined by increasingly scarce natural resources,

policy for the management of emerging unconventional resources such as deep sea minerals will need to adapt to rapidly changing social and ecological conditions and be responsive to long-term goals defined by factors of ecological and social sustainability.

In the face of threats of irreversible damage in the deep ocean, there is a need to take appropriate precaution while enabling use of living and non-living resources (Mengerink et al., 2014). Yet-to-be-discovered species, habitats and functions must be safeguarded while scientific understanding required for ecosystem-based management and mitigation techniques are developed. This calls for appropriate multisector protection of habitat that is ecologically, biologically, and scientifically important. For international waters and the seabed, the United Nations Convention on the Law of the Sea may consider implementing a new agreement for the conservation and sustainable use of marine biodiversity beyond national jurisdiction. Overcoming fragmented governance requires improved collaboration. Marine spatial planning approaches provide a template for deep sea management and will require formal procedures for improved information-sharing and governance among stakeholders.

This bulletin is based in part on work done for the following projects: (1) UNEP Green Economy in a Blue World (2012). http://www.grida.no/publications/green-economy-blue-world/ (2) SPC/SOPAC Pacific Deep Sea Minerals Assessment (2013) http://www.grida.no/publications/deep-sea-minerals/ and (3) European Commission study: Investigating the State of the Knowledge of Deep Sea Mining (2014) http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/seabed-mining/index_en.htm, http://eu-midas.net/, http://cordis.europa.eu/projects/rcn/111346_en.html

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