

Mining the Deep Ocean : Does catastrophe lie ahead?

Probably the largest pristine global natural habitat, not yet seriously violated by mankind, exists in the deep ocean and on its seabed.

The deep ocean has been described by the United Nations' [First World Ocean Assessment 2015](#) as a “vast realm which constitutes the largest source of species and ecosystem diversity on Earth, supporting ecosystem processes necessary for our planet’s natural systems to function.”

At a time of planetary crisis generated by a wide range of factors, amongst which are the consequences of [acidification](#) and [warming](#) of the ocean due to CO2 emissions leading to an incipient [sixth mass extinction](#) of species, there can scarcely be a part of our planet in more urgent need of protection than the deep ocean in order to ensure that the outcome of this crisis is not terminal for our species and life more generally.

Despite this there are now active proposals to mine the deep ocean’s seabed, at a depth of between 4000 and 6000 metres, for minerals.

The United Nations has established an [International Seabed Authority](#) with instructions to develop regulations by 2020 so that ocean seabed mining will be “open for business”. This means developing regulations to allow seabed mining on “behalf of mankind as a whole” whereby exploration licences can become operative as a precursor to actual mining licences.

The World Ocean Institute reports ([2019](#)) that there are currently [29 licences](#) issued to explore for deep sea minerals, covering 1.5 million km² of the Atlantic, Indian and Pacific Oceans. 19 of these exploration licences are in the Pacific Ocean and 15 of these are sited in the Clarion-Clipperton Fracture Zone which is located 1000 miles west of Mexico and extends 4500 miles in the direction of Hawaii. We report below on one of the [current EIAs](#) for exploration in the Clarion-Clipperton Fracture Zone.

These prospective seabed mining areas are located along fracture zones on the seabed where geological tectonic plates meet, causing volcanic upwellings in the form of seamounts along with associated seabed plains. The World Ocean Institute reports ([2018](#)) that in these plains there are extensive fields of potato-sized polymetallic nodules (PMN) which form in the high-pressure crucible of the deep, more or less like a pearl, lying naked on the ocean floor so that no drilling, only harvesting, is required for their removal. The nodules are made of manganese (c.30%), along with cobalt, copper and nickel (c.5%) with traces of gold, silver, lithium, specialty metals (tellurium) and rare earths (neodymium, dysprosium) – all highly attractive to mining companies.

The World Ocean Institute's 2018 report argues that because the deep seabed and its mineral resources are regarded in International law (UNCLOS) as "the common heritage of mankind" the principles governing use of these areas are, first, to maintain the environmental and ecological health of these areas and, second, to ensure economic equity in the use of these areas because all states communally own these areas beyond national jurisdiction and this mineral resource is potentially of trillion dollar value.

The deep ocean is a [unique world](#) of no sunlight and total darkness, freezing cold, great pressure and silence. Life has evolved there in very exceptional circumstances and it has essentially been undisturbed since the very beginning. Indeed some scientists believe the deep ocean may hold the secret as to how life on the planet first began.

Disturbance by mining will introduce continuous noise and light into this world and so is likely have a profound impact. In addition, mining will involve hoovering up the top 15 cm of the silt-like ooze and layer of minerals which lie on the seabed, then discharging the silt back into the water column where it will travel as a plume on the ocean current, slowly settling out over an extended area and smothering the adjacent seabed and creatures living there. The proposed mining areas are governed by deep ocean currents moving anywhere between 2 cm per second (0.072 km per hour) and 8 cm per second (0.288 km per hour, i.e. potentially travelling 6.912 km in one day).

An informative discussion of these issues can be heard on [BBC Scotland](#) where the need for deep ocean seabed mining is debated. The discussion considers whether there are existing adequate reserves of these seabed metals on land, along with their recycling (see Save The High Seas Organisation, [2016](#)) and the fear of a severe adverse impact upon this exceptional, pristine and almost totally unexplored realm of ocean life.

There are profound questions to be asked and answered.

Who benefits? Is mankind's global economic model, which demands such mining, actually sustainable?

Marinet has been following the track record of seabed mining over many years in UK coastal waters at depths of 40 metres or less. It is very poor, see [here](#) and [here](#).

Therefore is it a realistic expectation that mining companies can do better in the deep ocean at a depth of 4000 metres and more, where the consequences are wholly unknown?

If the answers to these questions are uncertain or negative, then are we about to create a catastrophe from which the deep ocean will never recover?

German Exploration Licence in the Clarion-Clipperton Fracture Zone, Pacific Ocean.

The United Nations' International Seabed Authority (ISA) has issued 15 exploration licences to the organisations listed below, see map for exact location. In the text following we record some of the principal features of this deep ocean area and its mining potential along with the method of mining extraction as recorded in the EIA (Environmental Impact Assessment) submitted to ISA by the Federal Institute for Geoscience and Natural Resources (BGR) in Hanover, Germany, see EIA [here](#).

[China Minmetals Corporation](#)

[China Ocean Mineral Resources Research and Development Association](#)

[Cook Islands Investment Corporation](#)

[Deep Ocean Resources Development Co Ltd](#)

[Federal Institute for Geosciences and Natural Resources of Germany](#)

[Global Sea Mineral Resources NV](#)

[Government of the Republic of Korea](#)

[Institut française de recherche pour l'exploitation de la mer \(Ifremer\)](#)

[Interoceanmetal Joint Organization](#)

[Marawa Research and Exploration Ltd](#)

[Nauru Ocean Resources Inc](#)

[Ocean Mineral Singapore Pte Ltd](#)

[Tonga Offshore Mining Limited](#)

[UK Seabed Resources Ltd \(I and II\)](#)

[Yuzhmorgeologiya](#)

The German exploration licence area encompasses a total area of 75,000 km², divided into two regions with an area of 15,000 km² in the central part and 60,000 km² in the eastern part. The Clarion-Clipperton Fracture Zone is located between Hawaii and Mexico and is characterised by water depths between 4000 and 6000 metres. It is extensively covered with polymetallic nodules (PMN), also called manganese nodules. On average these nodules contain 30% manganese and about 3% copper, nickel and cobalt. Other trace metals in economically significant concentrations in the nodules are titanium, molybdenum, lithium and neodymium. The manganese nodule resource in the German licence area is approximately 600 million tons (dry weight).

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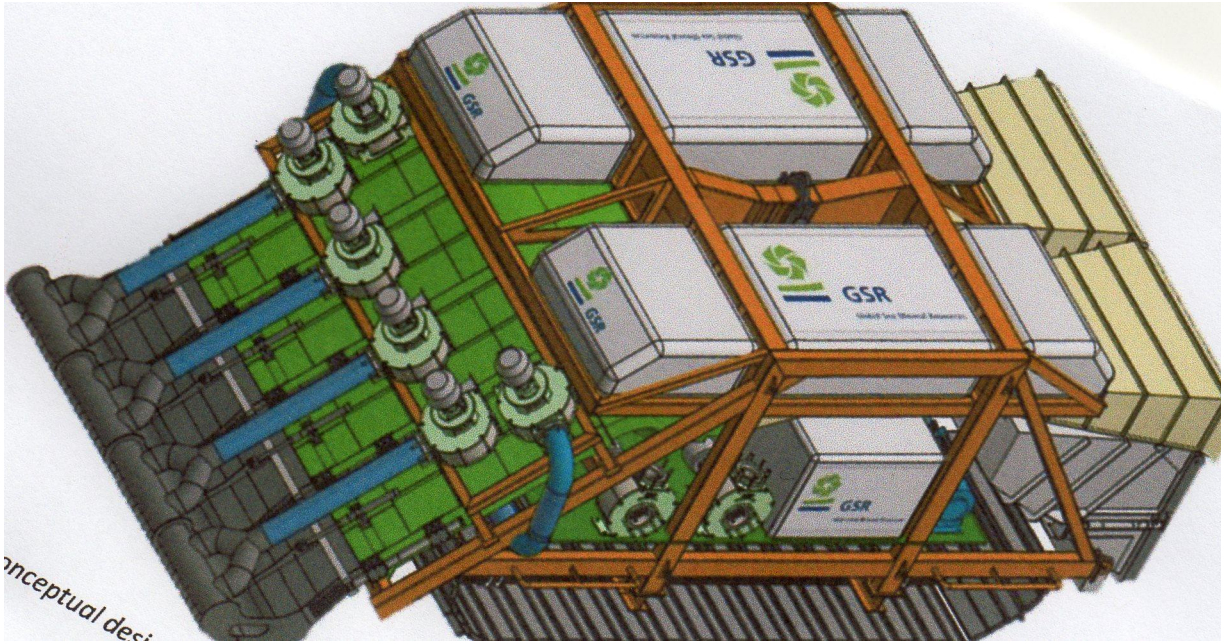
[Nauru Ocean Resources Inc](#)
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[UK Seabed Resources Ltd \(I and II\)](#)
[Yuzhmorgeologiya](#)

The centre of the fracture zone is a volcanic area characterised by high pressure and high temperature vents, populated by deep ocean creatures, see [here](#). Volcanic structures (single volcanoes and seamount chains) range in height from hundreds of metres to a few kilometres. In the eastern German licence area (61,700 km²) the seafloor consists of large deep-sea plains and [horst and graben structures](#) (horst = ridge, graben = valley).

It is in the seabed plains that the polymetallic nodules that are to be mined are located. They are fist-sized lumps and lie on the surface of the seabed in extensive quantities. The surface of the seabed beneath the nodules is sediment. Mining removes the nodules by suction (harvesting) and the top 15 cm of sediment. The uppermost sediment (3cm to 10 cm) is semi-liquid. Nodule abundance in the harvesting (mining) areas varies between 24 kg and 33 kg per square metre.

Removal of the nodules from the seabed at a depth of 4000 metres will be done by remotely controlled vehicles which move along the seabed sucking up the nodules and associated sediment into the vehicle, hence the term 'harvesting' because no actual drilling or digging (conventional mining) occurs. The suction process is reliant on the intake of substantial quantities of sea water, both to facilitate the suction and to aid separation of solid material from the seabed's silt.

The solid material is directed into a storage hopper within the vehicle and the silt is expelled from the rear of the vehicle along with used water. Mining is undertaken in straight lines inside the harvesting area and at the end of each line the hopper empties itself of its cargo before embarking on the next line.



The illustrations above, below and overleaf show a mining vehicle. At the front of the vehicle (left of picture above) are the suction chambers or modules. The exploratory vehicle has four and an actual mining vehicle would have 16. Each module is 1 metre wide. At the rear of the vehicle is the storage hopper and exhaust vents. Approx. 3 tonnes of nodules can be stored in the hopper before it empties itself.

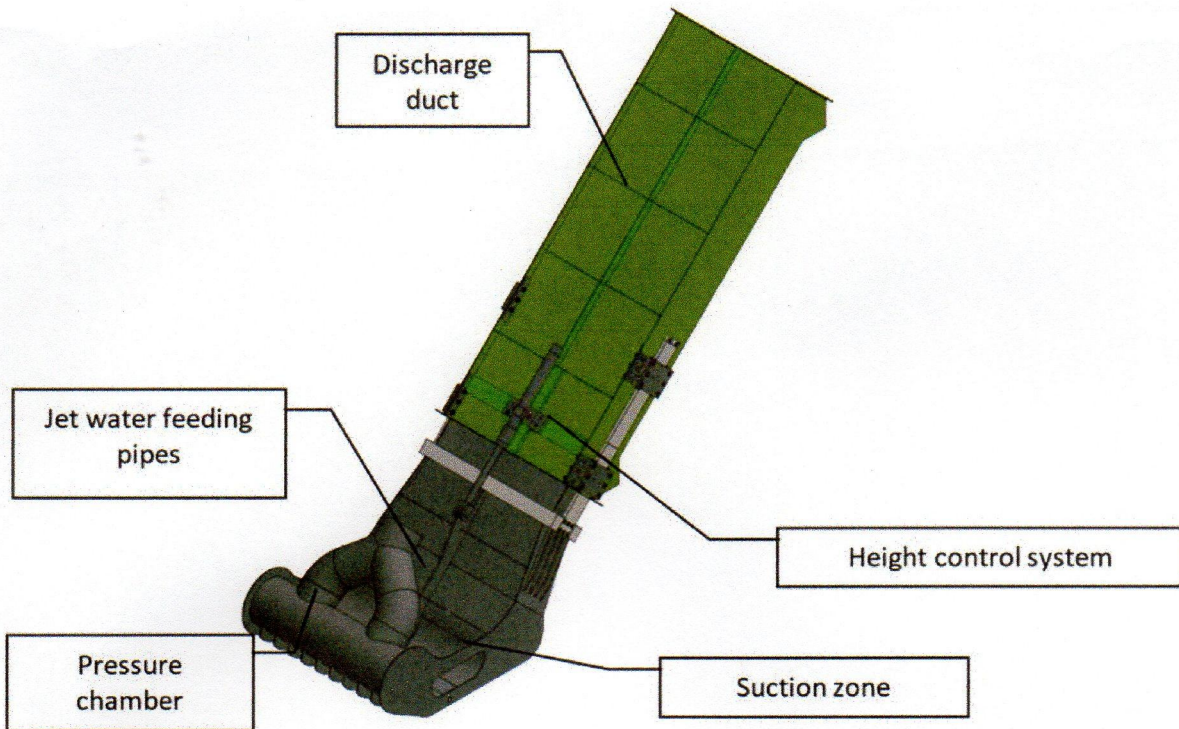


Figure 3.8: Nodule collector head.

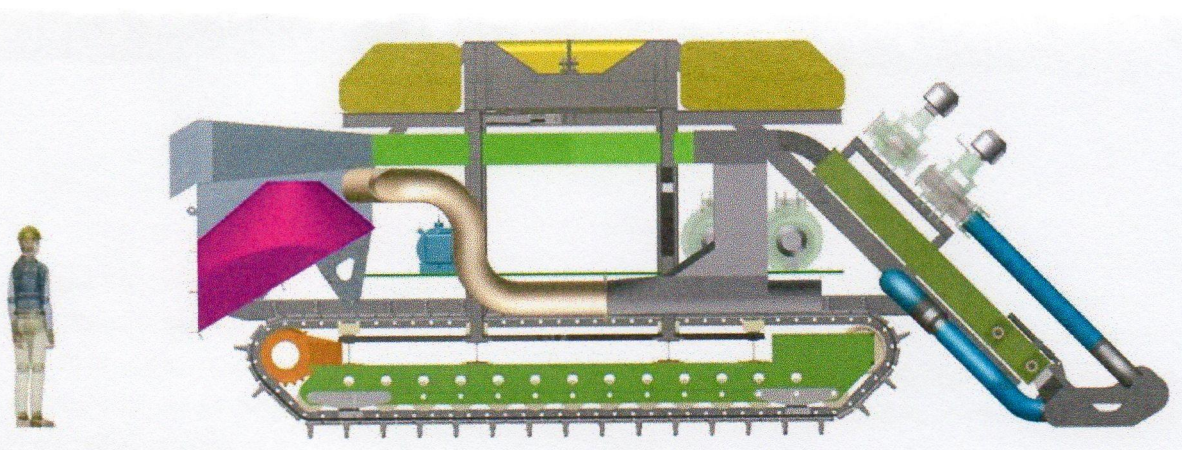


Figure 3.11: Nodule separation system. The nodule container at the back of the vehicle is indicated in purple.

The ‘harvesting’ vehicle will lift the top 15cm of the seabed’s sediment and then discharge it at the end of the harvesting procedure. This will create a large body of sediment suspended in the seawater which will travel away as a plume on the prevailing ocean current. This will slowly settle out of suspension, falling back onto the seabed.

The dangers arising from this is that it will bury seabed creatures and clog their respiratory organs, it will lead to oxygen depletion in the blanketed seabed and the water body inside the plume. It may also result in the release and deposition of toxic metals from the sediment which can lead to bioaccumulation of these contaminants.

The distance travelled by the plume and the rate of deposition are variables. The distance travelled depends on the speed of the ocean current (maximum measured to date: 8 cm per second = 0.288 km per hour, i.e. potentially travelling 6.912 km in one day). The rate of deposition is also governed by the size of the particles, with larger particles tending to fall out of suspension over a period of a day or so whilst smaller particles may take several days.

The faunal community (marine creatures) is made up of the following categories. Macrofaunal which are visible to the naked eye, usually on the seabed surface but also in the sediment (e.g. worms). Meiofaunal which are minute animals, not readily visible and present both above and below the seabed’s surface. Microbial organisms which live both in the water column and seabed and which require specialist detection methods. All faunal categories are present at the bottom of the deep ocean, thus exhibiting a complex fully structured ecological system of life.

Surveys to date have revealed different densities of all of the three types of faunal communities and a high number of rare species. Diversity is very high on a local scale and throughout the Clarion-Clipperton zone. Connectivity between communities (the question of whether the character of a community in one area is linked or readily repeated elsewhere) is at present largely unknown.



Figure 5.1: Typical megafaunal organisms observed by video sledge during cruise SO-240 from the Eastern German license area. a,d: Porifera; b-c, e-f: Cnidara, Hexacorallia; g: Cnidara, Octocorallia; h: Mollusca, Cephalopoda; i,j: Echinodermata, Asteroidea; k: Echinodermata, Ophiuroidea, l-n, q-r: Echinodermata, Dolothuridea; o: Echinodermata, Echinoidea; p: Crustacea, Mysida; s: Pisces, Actinopterygii.

Source of data: EIA (Environmental Impact Assessment) submitted to ISA by the Federal Institute for Geoscience and Natural Resources (BGR) in Hanover, Germany, see the full EIA [here](#).

See Marinet commentary overleaf.

Marinet's Comments.

We comment below on what it is likely to mean for the deep ocean if mining is licensed there. However let us first take a lesson from the same activity as practised just a few miles offshore from the UK's coast in shallow waters.

Marinet has been studying and commenting upon the practices and consequences of the [marine extraction of minerals](#) (aggregate in the form of sand and gravel) from the seabed in UK coastal waters since Marinet's inception in 2002. Marine aggregate extraction has been a practice licensed by the UK government since the 1960s and occurs in relatively shallow waters (c. 40 metres or less) on the UK's continental shelf.

The UK has become reliant upon marine sourced sand and gravel for use by the construction industry, now supplying around 25% of its need from the sea, around 50% from land quarries and 25% from recycling, see [here](#). This conceals regional variations and in the case of London nearly all construction activity is now reliant on marine sourced sand and gravel. This reliance on marine sourced sand and gravel need not be so. There are adequate land reserves which are withdrawn from exploitation due to a lack of willingness by government to grant unpopular land-based planning consents for quarries. At the same time there are now recycling technologies available which will convert quarry waste into whatever grade of sand and gravel is required, see [here](#). Such technology is widely deployed in Japan and is now being used in Australia, but the UK aggregate industry refuses to entertain such investment due to its strategy of capital investment in its marine infrastructure (25 vessels and 65 seabed extraction licences in 2018) aided by an unwillingness of UK government to direct otherwise upon the matter.

UK marine aggregate extraction is focused upon two particular features of the seabed. One is offshore sandbanks and the other is the remnants of ancient riverbeds (dating from the last Ice Age) which are now located out at sea. In the latter case, such ancient river beds are rich in gravel as well as sand and thus feature strongly in the list of potential extraction sites.

However there are consequences from dredging such offshore locations. In the case of sandbanks these are often features in a larger offshore system of banks which shield the coast from erosion during storms and are part of a complex dynamic offshore system which supplies sand to beaches and sand dunes which in their own turn provide an extensive natural coastal defence system, as well as a unique habitat for wildlife. Thus if these offshore sandbanks are substantially altered or removed the adjacent coastline becomes liable to severe erosion. The most infamous case is at [Hallsands in Devon](#), but the [same erosion](#) is being experienced around the coasts of England and Wales where aggregate dredging occurs and particularly so along the [coast of East Anglia](#).

In the case of the ancient river beds, which are a mixture of sand and gravel and thus highly prized by the aggregate industry as an easily accessible mining resource, these areas provide a range of [especially important](#) seabed marine habitats. The presence of gravel (small stones and cobbles) also makes them ideal spawning and nursery grounds for some fish species and, importantly, certain locations are favoured by certain species which return every year to exactly the same place to breed.

Sandbanks tend to be shifting and mobile whilst ancient river beds are stationary and fixed. Both provide habitat for marine species which are adapted to these different environments. However these different physical environments do not exist in isolation from each other. In terms of biodiversity, they display inter-connectivity whereby species migrate and sustain each other within the wider, total marine ecosystem.

Sandbanks are often closed systems which means that they do not readily share their total body of sand with the wider surrounding seabed. This means that if they are mined (dredged) the total amount of sand within the sandbank is diminished and not replenished. Hence the sandbank declines.

Where dredging for sand takes place in flatter areas of the seabed it causes a cavity or pit in the seabed. These cavities will be filled, either by sand brought in from outside on seabed currents or by draw-down from nearby sandbanks. This [cavity in-fill process](#) contributes in its own particular way to wider stress and erosion.

Biodiversity will recover in the long-term in sandbank areas because the marine animals which live there are used to disturbance and so have an in-built adaptability. Additionally, recovery will also occur as a result of populations recolonising from outside the dredged area.

Ancient river beds and their sand and gravel are non-replenishable. Once the sand and gravel, particularly the gravel, has been removed the essential features of the habitat are destroyed and recovery to levels of the area's former biodiversity is very slow and may not occur at all when the dredging has been very intense because the essential features of the original habitat (its richness in gravel and cobbles) no longer exists, see [here](#). For a fish species like herring which needs such habitat to spawn successfully the impact of aggregate dredging in those areas can be devastating and the same injury to breeding success applies to many other fish species which need particular areas of seabed habitat as a sanctuary for juveniles to survive their nursery stage, see [here](#). When dredging also occurs in an established commercial fishing area fishing often becomes impractical so fishing is displaced to other areas which, as a consequence, are more intensively fished. This can have an adverse effect, see [here](#).

The reality therefore is that offshore sand and gravel extraction mines the seabed and has a profound impact on marine abundance (size of populations) and upon

biodiversity (range of species), devaluing the wealth and health of the marine environment considerably where it occurs; and also, when occurring at several places simultaneously, it affects the resilience of the ecological structure generally.

It is argued by the industry that mining the seabed is very limited in respect of its overall footprint relative to the seabed as a whole and also that licences forbid the removal of the whole sand or sand/gravel resource at any particular dredging area. Thus ecological impact, in overall terms, is more modest than at first appears.

However this optimistic view does not take account of several factors. First, the extraction can be over a long period with licences issued for 10-15 years and capable of renewal. This means that impact is ongoing and, in biological terms (life cycles), is thus severe. Second, dredging the seabed results in a discharge plume of unwanted material (sand and mud) from the dredging vessel which is carried away on the prevailing current. This material settles over a period of days on the surrounding seabed, the distance travelled by the plume being dependent on local current speeds. This suspended sediment de-oxygenates the water column and also smothers the marine creatures on which it settles, many being sedentary in habit and therefore unable to relocate. This smothering causes asphyxiation. Therefore the adverse impact zone extends considerably further afield than the dredging site itself. Third, areas that are dredged are often subject to not just one licence but several in close proximity to one another, many often operational at the same time. Thus the adverse impact is intensified and has a cumulative character.

If this is so, one may legitimately ask why offshore dredging licences are granted and whether such damage is not forecasted in the environmental impacts assessments (EIAs) which accompany the licence applications?

The problem is that EIAs, whilst undertaken by professional marine scientists and providing a source of considerable data, are actually tame documents. Nearly all EIAs are produced by a small number of professional consultative companies which assert their professional independence but which are, in reality, dependent for their economic existence (their pay day) upon the extraction companies which hire them. Hence Marinet has yet to see a single EIA which asserts that the activity seeking a licence should not actually take place because the environmental consequences are too great and unacceptable. Where damage is forecasted, ameliorative actions of one kind or another are always recommended as a palliative. Therefore rarely, if ever, will an EIA conclude that the licence should not be granted.

Would it therefore make greater sense if the EIA process did not allow the applicant company (marine dredger) to commission the EIA, but rather relied on the licensing regulator (who issues licences) to commission site specific EIAs with the aim of securing greater scientific objectivity?

On the face of it, the answer is yes. However the reality is that the licensing regulator is invariably an arm of government and, being so, has to implement government policy. Therefore if government policy is to encourage offshore dredging of the seabed for sand and gravel, as is government policy in the UK, the same predisposition to find no overriding harm in the analysis undertaken by the EIA prevails. Hence the net result remains precisely the same.

A further backstop in correcting this bias may be to employ oversight by means of an examination of the consequence of the operation once it has expired (i.e. has completed its licence term). Indeed, the terms of the licence generally stipulate this requirement and it may be undertaken either by the licence holder's professional advisors (the company that produced the original EIA) or an expert body of scientists.

In reality, Marinet has never encountered an EIA evaluation being actually undertaken or, if undertaken, being publicly published by the licence holder upon expiry of the licence; nor an instruction by the licence regulator that these terms of the licence be fulfilled. In the case of an analysis by an expert body of scientists, such studies do exist but they are almost always undertaken by an arm of government.

As a result, there is an in-built predisposition in the licensing system (functioning via the original EIA and supported by monitoring both during and after the licence's term) to arrive at a presentation of reality where the harm being caused is perceived as minimal or, where it is noted, to go on to argue that the cost-benefit balance to society and the national economic need justifies the damage. Indeed, the current economic model in modern society is to regard the exploitation of nature as essential.

It is also to be noted that damage caused on the seabed takes place in a world that is inaccessible and remote from direct human experience. Therefore there is little opportunity for immediate or wider public awareness of the adverse consequences.

In one [recent licence application](#) for the dredging of an offshore sandbank, which is actually classed as a candidate marine conservation zone, the conservation group seeking to prevent the granting of the licence has described the act of extraction as "rapacious mining".

In reality, all mining is rapacious. The sharper question is: how severe and extensive is the rape caused by the mining and what are the consequences?

This question and its answer brings us back to our original question: what will be the likely impact of polymetallic nodule mining upon the deep ocean seabed?

So, based on how mining for minerals is conducted at a depth of 40 metres offshore from the UK coast, let us begin by summarising what we already know:

- Environmental Impact Assessments (EIAs) are well meaning but they are essentially written in support of their paymaster's aspirations, whether the body seeking the licence be the mining company or the government. In short, EIAs never say "Stop, do not do this, the damage is too severe". EIAs only find ways to make the mining possible.
- EIAs are rarely, if ever, written from the starting point of what has been learnt from monitoring the outcome of previous seabed mining activities. They do not look at the history of the overall, historical impact of mining as their primary, opening yardstick. They are in this sense blinkered. In part, this is due to an absence of studies following the long-term impact of licences which have expired. Therefore EIAs are always predisposed to be optimistic about what the impact will be, rather than referential and based on the truths of actual experience.
- EIAs are generally optimistic about the recovery of biodiversity and marine life after their habitat has been excavated or scavenged for its sand and gravel. Some habitats, particularly gravel areas, support a complex ecosystem which has taken many decades to reach its level of biodiversity. Destruction of the physical nature of the habitat (removal of gravel or cobbles) alters that habitat fundamentally and many species, uniquely adapted to the physical character of that habitat, are made 'homeless' and so perish. Thus the ecological structure collapses, both locally at the mining site and, due to the overall inter-connectivity of adjacent yet different habitats, further afield too.
- EIAs frequently fail to give adequate attention to the complexity of ecosystems. Ecosystems are a complicated interplay of the physical habitat (e.g. sand, gravel), the chemical environment (e.g. the salinity and dissolved oxygen level of the seawater) and the biological environment (e.g. the relationship between large macrofaunal species, small meiofaunal species not visible to the naked eye and microbial species). For example, extensive damage to microbial species can cause severe stress on the whole ecological structure. Yet rarely is the impact on microbial species fully evaluated.
- EIAs recognise the existence of the discharge of waste material from the mining machine or apparatus. This takes the form of mud or unwanted minerals (sand, wrong sized stones) and mutilated marine creatures ensnared by the extraction activity and the discharge is released as a plume of waste materials into the water column above the seabed. However the assessment of the adverse impact of this plume is largely conjectural and it is rarely supported in the EIA by any empirical evidence as to the actual severity of the impact. Predictions are made in the EIA about rates of deposition (deposition and smothering causes asphyxiation of marine animals), about reduced levels of oxygen in the water column which fish and other mobile animals occupy, and about the duration of and distance travelled by the plume in the water column (governed by current speeds and the size and weight of the waste materials). In the EIA all these matters are evaluated by forecasts. There is no precise monitoring of impact at the actual time of the mining thus no ground-truth evaluation of the EIA and its predictions.

What does this mean therefore in the case of the proposed mining of the deep ocean seabed for minerals?

Do we know what is likely to happen and what the impact will be? Can mining be undertaken safely and without harm to the ecology of the deep ocean?

The short answer to these questions is, no. In Marinet's view, this must also be a clearly emphatic no.

The reasons for this conclusion are as follows:

- EIAs are useful, informative tools. However their use is biased, for the reasons already explained; and their predictions of impact are, at best, largely untested empirically and, at worst, wishful thinking.
- Scientists have only very recently and only in a very limited way been able to visit the ocean at depths of 4000 to 6000 metres. Our knowledge of this world in all its differing dimensions is virtually non-existent. Therefore to imagine that mining the seabed at this depth for polymetallic nodules (little rocks lying on the seabed's surface) can be undertaken safely from an ecological point of view is pure fantasy. To be very clear, there is **no evidence** to support the view that that this can be undertaken safely.
- If the ecological system at this level of the deep ocean is severely disrupted (mining always disrupts ecological systems) we have no idea as to the consequences, either for the ecological system at that depth or for the wider ecology of the ocean itself. Action of this kind, based on this level of ignorance, could be ecocidal and thus foolhardy in the extreme.
- Life at this depth in the ocean exists in a physical world of great extremes: intense pressure, coldness of temperature and a general 'unworldly' character of silence and perpetual darkness. The little we do know suggests that biological reproduction for species in these conditions is very slow relative to life at the surface of the ocean. In turn, this means that any significant mortality in the populations of any species living in the deep ocean must potentially have magnified consequences for the whole ecosystem.
- There are adequate mineral reserves (in terms of forecasted human need) on land of all the minerals to be found on the deep ocean seabed. Consequently there is no economic or technological imperative to mine the seabed.
- The deep ocean seabed and the largely unknown marine biodiversity living there belongs to "the heritage of mankind as a whole". This common resource, physical and ecological, should be exempt from commercial exploitation by any particular corporate interest or national government.

Conclusion:

Marinet regards commercial exploitation of the deep ocean at the present time as likely to result in ecocide and thus a crime against the planet ([The Rome Statute, 2002](#)).

The formulation of The Rome Statute makes provision for the crime of [ecocide](#).

Rome Statute: Article 5(1) The jurisdiction of the Court shall be limited to the most serious crimes of concern to the international community as a whole. The Court has jurisdiction in accordance with this Statute with respect to the following crimes:

1. *The Crime of Genocide*
2. *Crimes Against Humanity*
3. *War Crimes*
4. *The Crime of Aggression*

To be added:

5. *The Crime of Ecocide.*

Marinet supports [reform of The Rome Statute](#) to include Ecocide as a crime against the natural world upon which all humanity depends.

Marinet regards proposals to mine the deep ocean seabed for minerals as likely to be an act of ecocide and thus an urgent reason for the Reform of The Rome Statute.

Recommendation: In the interim, leading up to The Rome Statute's reform, the United Nations and the International Seabed Authority should declare a total ban on all licensing of physical exploration of the deep ocean seabed for the purposes of mining.

Marinet Limited,
March 2019.