

Assembling the seabed: Pan-European and interdisciplinary advances in understanding seabed mining

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Introduction

Seabed mining is an extractive process of removing and retrieving resources from the seabed – the solid ‘surface’ that lies at the bottom of the ocean, under the water – otherwise known as the ‘ocean floor’ or ‘sea floor’. Seabed mining is different from other forms of underwater extraction, such as oil and gas exploitation, which derives from deposits which are deeper, existing *below* the seabed. Indeed, seabed mining is the mining of the seabed itself, the very surface layer which can be rich in mineral deposits such as copper, nickel, aluminum, manganese, zinc, lithium and cobalt (IUCN, 2018). In respect of seabed mining, there is mining which may be described simply as ‘seabed mining’ and this may occur at any depth (Carver, 2019). For example, explorations off the coast of Namibia are described as ‘seabed mining’ and exist within the territorial sea (12 nautical miles (nm)) and Extended Economic Zone (up to 200 nm) from the West African country’s coast – but these deposits are not *deep*. Other forms of seabed mining are explicitly named ‘deep-sea mining’ (or DSM) and this refers to the “retrieving mineral deposits from the deep sea – the area of the ocean *below* 200m” (IUCN, 2018, emphasis added), and are located in EEZs globally, as well as the ‘high seas’ (beyond this 200nm limit and within the oceanic global ‘commons’). This chapter is concerned with both seabed and deep-sea mining – in other words, the surface of the seabed – as a space of extraction.

There is much attention now focused on the seabed as a new ocean ‘frontier’ for exploration and exploitation (Zalik, 2018). However, it has been long recognized as a zone of such ‘potential’. In an article in the *American Journal of International Law* in 1969, Louis Henkin noted the existence of an ‘untapped’ global extraction space under the liquid surface of the sea, stating that “a new environment of golden promise looms on the distant horizon” (Henkin, 1969, 504). Some fifty years on, this ‘golden promise’ does indeed ‘loom’ large. As

Matthew Taylor has recently noted, “the world’s oceans are facing a ‘new industrial frontier’ from a fledgling deep-sea mining industry as companies line up to extract metals and minerals from some of the most important ecosystems on the planet” (Taylor, 2019, n.p). Indeed, the seabed holds ‘promise’ because it is a lucrative space that may provide access to precious minerals that are now more difficult to access on land, from terrestrial mining sites, where resources are depleting (IUCN, 2018). Seabed mining opens-up a new space to retrieve minerals that are essential to the production of today’s “high-tech applications such as smartphones and green technologies such as wind turbines, solar panels and electric storage batteries” (IUCN, 2018). Yet, whilst there is the promise of such extraction, there is also a wide acknowledgement of the potential legal complexities of such activities at sea (in spaces beyond national jurisdiction); of the global challenges of enabling mining where it may be driven by profit and multinational corporations rather than local concerns; and where technologies, access and processes of extraction may impose irreversible harm to the seabed environment and ecosystems. To return to Henkin, then, there are many ‘looming’ issues in respect of seabed mining as it finally comes to fruition and into reality, as a new offshore industry, alongside the more conventional or traditional ‘extractive’ industries of fishing and the piping of oil and gas reserves.

Given this ‘looming’ issue, this chapter *assembles* a unique set of pan-European insights on the seabed. These perspectives derive from the interdisciplinary work of members of the ‘Seabed Management’ working group of the Ocean Governance for Sustainability COST Action Network, a group of scholars working independently and collaboratively across Europe on seabed issues, but united under the shared ‘umbrella’ of the Action. The chapter features a series of linked interventions – assembling a dialogue – which highlights how researchers are grappling with this ‘frontier space’ – legally, socio-economically, environmentally and geopolitically. However, the chapter, whilst highlighting contemporary research and approaches for understanding the seabed, does not offer a definitive answer in how we manage such rich, varied, contentious sites, but rather, it aims to provoke – in one piece – a conversation on the complexities of seabed science and management, where the anthropogenic drivers, historic development and future climate impacts as well as approaches for such an aim differ across space, and through the lenses of different disciplinary approaches.

The chapter unfolds in the following way. It begins with an analytic consideration of ‘assemblage’ – a theoretical tool used for drawing together heterogeneous parts, into a ‘whole’ (DeLanda, 2006). In outlining this approach to configure the chapter, it makes possible the recognition of how *assembling* a set of disparate debates, which tend to remain separate in discussions of the seabed, can create new modes of knowing and making sense of seabed governance issues. Following this framing, the chapter then ‘assembles’ a series of interventions, collating and linking these into the chapter ‘whole’ to enliven an understanding of the range of actors, issues, knowledges, techniques and practices that must combine to understand seabed and deep-sea mining, past present and future. In doing so, it aims to demonstrate the potential of combining numerous voices for an integrated understanding of the impacts of the development of the new industry. The chapter ends with a conclusion of future possibilities and required knowledge for deepening our understandings of the seabed further.

Assembling knowledge: assembling the seabed

Assemblage thinking or ‘theory’ is a mode of post-structural understanding, attuned to understanding the multiplicity of the world (Murdoch, 2002). It aims to provide a means of making sense of how phenomena are always emerging and ‘becoming’ (in other words, is never ‘finished’ but always in the making). As such, it is attuned to the ongoing co-constitution of given issues, rather than presenting a situation, place, or politics as static, unchanging and complete. Moreover, rather than only allowing a dominant narrative in understanding a particular place, phenomenon or issue to be revealed, assemblage thinking enables scholars to consider the multiple, heterogeneous, seemingly separate, ‘parts’ (human and non-human actors, influences, discourses, environments) that ‘hold together’, making known complexity (DeLanda, 2006). Indeed, key to assemblage is that there is a ‘pause’ – a moment of stability – at which a phenomenon and its parts ‘territorialise’ for us to assess it. However, it is always acknowledged, such an assemblage is always open, and could ‘deterritorialise’ and change in future as new parts are added or detracted (a new stakeholder opinion, scientific finding, or policy, for example). As Dovey states, any assemblage comes “from flows becoming...which then produce relative points of stability” (2010, 15), only for that stability to be shaken as parts of a particular assemblage are ‘unplugged’ or different parts become ‘plugged in’. In sum, as Venn notes, assemblage allows a focus on “the dynamic character of interrelationships between heterogeneous elements” in the case of any given phenomena (2006, 107). It thus, arguably, can enable a more detailed, careful and

critical consideration of the world.

For Deleuze and Guattari, the key ‘architects’ of assemblage thinking, we can think of virtually anything as an ‘assemblage’ – be it a person, animal, home (2004, 503-4), or as DeLanda shows, a city, or even something more intangible such as an ‘issue’ or ‘discourse’ (DeLanda, 2006). Indeed, under the remit of ‘assemblage’ thinking, assemblage is a device that can be used for understanding almost any given topic that is emergent and complex. For example, scholars have used this framework for making sense of the ongoing construction of places (cities, streets, towns, see Cresswell, 2011; Dovey, 2010); for understanding social movements and protest (McFarlane, 2009); environmental justice regimes (Bickerstaff and Agyeman, 2009) to a mode of thinking about the Blue Economy (Winder and LeHeron, 2017). Accordingly, then, as Anderson and McFarlane note, “there is no single ‘correct’ way to deploy the term” (2011, 124) and it may be applied in a variety of contexts.

Although seemingly abstract, the theory provides a useful framework for this chapter, in collating a series of insights about seabed mining. Seabed mining can be understood as an issue – one that does not exist in and of itself – but that is *assembled* of emergent and evolving ‘parts’ (law, local communities, material resources, technology, economic concerns and so on) that come together to define it at any given moment. Assemblage theory enables us to look past the ‘dominant’ narratives of deep-sea mining (which have been science focused on seabed ecologies and conservation) to combine this instead with other ‘parts’ of the issue (around legislation, law, jurisdiction, economy and society). With this aim in mind, the chapter now assembles a series of voices and perspectives on seabed mining.

Setting the scene: Defining who and what

Deep-sea mining (known as DSM), is currently being pursued by industry and national governments worldwide. At the same time, it is being heatedly opposed-to by environmental and local groups who fear the unknown and potential impacts this activity can cause on the environment and the affect this may have on lives and livelihoods. Currently, regulations to manage DSM are being drafted by several countries as well as the International Seabed Authority (ISA), the authority in charge of overseeing this process in the ‘Area’ – the seabed beyond national jurisdiction (see Boschen et al. 2017; Mengerink et al. 2014; Van Dover, 2011 and Wedding et al. 2015, on advances, possible impacts and regulatory frameworks related to seabed mining). However, in spite of this work, two fundamental questions remain largely

underexplored. First, how, ontologically, do we understand what the seabed *is* (see Childs, 2020), and secondly, who is the stakeholder to whom seabed issues relate? Who will profit and exploit, who will be impacted, who will take decisions and govern, and vitally – who is excluded?

These definitions are vital because how the seabed is defined influences governance in national and international settings and shapes regulations in innumerable ways. At the most basic level, in respect of defining the seabed, this space is regarded as either an extension of land (in which case seabed mining could be regulated by adapting terrestrial mining laws) or an area of ocean (in which case there is a greater need to consider a broader range of ecological impacts on, for instance, the water column and its users). Some governments have considered the seabed as an extension of land seeking inspiration in regulatory instruments for on land mining activities. For example, Papua New Guinea, the country that is arguably most advanced in pursuing DSM, has issued permits based on an extension of onshore mining protocols that, for purposes of the seabed, redefine “land” as “the offshore area being the seabed underlying the territorial sea from the mean low water springs level of the sea to such depth as admits of exploration for or mining of minerals” (Mining Act, 1992). Other countries such as Japan, Canada, and several European Union members, will likely extend existing onshore mining regulations to the seabed to allow for seabed mining in areas of national jurisdiction (Ecorys, 2014). As a point of contrast, New Zealand has developed and applied specific regulations on seabed mining, the Exclusive Economic Zone and the Continental Shelf Act 2012 (EEZ, 2012), which rather than taking land as their reference point, place seabed mining within New Zealand’s overall marine management strategy. Building on a recognition of the divisions within New Zealand’s maritime space – the territorial sea, exclusive economic zone, and outer continental shelf – New Zealand mandates that when permitting seabed mining “the [Environmental Protection Authority] must take into account the...effects that may occur in New Zealand or in the waters above or beyond the continental shelf” (EEZ, 2012). This understanding implies that models for best practice might come *less* from the onshore mining and *more* from forms of marine management such as Marine Protected Areas (MPAs). As we can see, then, the definition of the seabed ultimately matters how use, and governance, emerge.

Similarly, although there has been an increasing interest in, and attention to, ‘stakeholders’ – how they might engage in Environmental Impact Assessments and their limited participation (see Lallier et al., 2016; Lodge, 2014; Jaeckal et al., 2017) – a careful analysis of *who*

stakeholders are (and could be) in the first place, remains underexplored. For DSM, where people have different connections and dependencies to this contentious and inhabited space, it is crucial to develop a new understanding of who stakeholders are, and by default, who is excluded from debates. Who is identified and recognized as having a legitimate connection or interest, who is included (or has access) in the drafting of the regulations, who is involved in decision-making if a project is to go ahead, who has in effect has meaningful participation its governance? All these questions become more complex to answer when it comes to the ABNJ.

Turning again to New Zealand's regulations, the EEZ (2012) provided not only for a Māori Advisory Committee that can 'advise' and 'comment on' regulation changes, but also allows for the wider participation of stakeholders: 'any person' that the EPA considers to "have existing interests that may be affected by the application" can provide 'submissions' in favour or against a marine project (EEZ Act, 2012, 46-47). Other legislations have also similar understandings of who a stakeholder is but its implementation has been criticized. For instance, the Cook Islands' Seabed Minerals Policy (2014) stated that "the entire nation and its people are the "community" affected by seabed mining activities and that related decisions are best-handled with participation of all concerned citizens, at the relevant level" (Cook Islands, 2014: 5). However, the Cook Islands Seabed Minerals Advisory Committee created for this endeavour has been criticized for lack of representation and transparency (Cook Islands News, March 9 2013). Accordingly, seeking inclusion of varied stakeholders does not ensure such representation manifests.

Regulations in other countries have a 'fuzzy' or incomplete understanding of what a stakeholder is. For Portugal, where seabed mineral exploration has started in the Azorean sea, the specific regulations developed in 2015 state that a "compulsory consultation" shall be carried out "of the municipalities in their respective areas of territorial jurisdiction (...)" (Lei 54/2015 Portugal). Although stakeholders seem to be represented here through the municipalities and competent bodies, the extent of 'territorial jurisdiction' of these municipalities on marine areas and how exactly the stakeholders will be involved, is unclear. Other countries are still developing specific regulations for DSM. In the case of Namibia the new Minerals Policy draft made public in 2018 it states that "the Government will ensure community participation through consultation before companies are allowed to commence metallurgical operations" however, it is unclear how 'communities' are to be defined in the context of the seabed or if 'metallurgical' applies to the seabed (Minerals Policy Draft, 2018, 3.2)

As such, at the start of any discussion of seabed or deep-sea mining, unpacking what the seabed is and who the stakeholders are, is not a purely academic or philosophical exercise, is a *political decision* which shapes outcomes for potential use, and governance. It is a key ‘part’ of understanding DSM. Specific definitions of the seabed are likely to influence governance in national and international settings, from what particular ministry is given lead regulatory authority, to the scope of Environmental Impact Assessments, to the calculation of risk, and a host of related decisions that have wide implications for the future governance of DSM.

Tackling the legal perspectives: insights from law and policies

As we have previously seen, a key ‘part’ of the ‘assemblage’ of how we understand seabed and deep-sea mining relates to how we define the seabed. But law is an equally important ‘part’ that combines with such debates. Given the complexity previously described, the regulation of deep seabed mining, particularly in areas beyond national jurisdiction (or what is termed as the ‘Area’), represents a unique challenge legally. From the perspective of the United Nations Law of the Sea (UNCLOS), the seabed has garnered great attention, and this before any real activity has taken place (an unusual feat in maritime governance, to seek to govern a still largely unpracticed mining activity). Yet with the *exploitation phase* rapidly approaching, many interests are at stake and research on legal dimensions are highly relevant, not only for academics and lawyers, but for all parties involved in exploration and exploitation of the continental shelf and the deep seabed. Moreover, future issues can be anticipated and remedied through thoughtful analysis of changes in international regulations and national legislation. By studying all the relevant legal sources, including the applicable conventions, the regulations, guidelines and standards of the International Seabed Authority, the national legislation of sponsoring states, pertinent case law and authoritative literature, research can offer insights into a legal regime that is often perceived as very complex and non-transparent. Furthermore, research may fill the blanks and make a substantive contribution to the legal literature surrounding this topic by ‘zooming in’ on issues which have been largely neglected until now, such as the effective implementation of the status of common heritage of mankind, the interaction between the regimes of the deep seabed and the continental shelf and the differences between relevant national laws.

Legal designation of the seabed began as early as 1970, with the ‘Area’ and its mineral resources, declared as the ‘common heritage of mankind’ (sic). Since this point, the ‘Area’ (as

well as seabed resources *within* national boundaries, have been the subject of regulation on the scales of national to international politics. Some research is, crucially, exploring the legal conflicts in the ‘Area’ between deep sea mining, the status of the seabed and its natural resources as the ‘common heritage’ of all (Willaert, 2018). The objective of this work has been to find out if the current international legal framework and the national legislation of selected states fully respect applicable legal principles. As the research has observed, fairly quickly, the legal framework with regard to the deep seabed is not in a final state and keeps progressing (like any assemblage it is in a state of ‘becoming’).

But beyond this, what is at stake legally? With respect to activities in the ‘Area’, mining practices are considered to comprise of the exploration and exploitation for three different types of minerals. These are polymetallic nodules, polymetallic sulphides, and cobalt-rich ferromanganese crusts. UNCLOS clearly stipulates that minerals of the Area cannot be subject to any sovereign claim by an individual state. As such, access to the resources is only possible through the regime designed by the UN Convention – the International Seabed Authority (the ISA). The ISA comprises of 168 Member States and is headquartered in Kingston, Jamaica. The Convention provides the regulatory framework to govern deep seabed mining in the Area. However, it confers upon the ISA the requisite mandate to actually develop all the necessary rules, regulations and procedures to administer the resources of the Area. Accordingly, since its inception in 1994, the ISA has been working to this end. Member States of the ISA, all of whom are represented in the UN Assembly, meet annually. In recent years, the executive organ of the ISA, the Council, has been meeting twice a year (a sign of increasing demands for legal decision-making in respect of the seabed). It is noteworthy to mention that a number of non-Member States, most notably, the United States of America, regularly participates in the work of the Authority by attending annual sessions.

Regulations for the exploration of minerals have been in place since the year 2000, in the case of polymetallic nodules (amended in 2013), while exploration regulations for polymetallic sulphides were adopted in 2010, and the same for cobalt-rich ferromanganese crusts in 2012. Since 2014, the ISA has shifted its focus towards developing regulations to govern the exploitation of mineral resources. Instead of designing individual regulations for each type of minerals, the Member States have proceeded to develop one set of regulations that applies across the board. An advanced set of draft regulations is currently under consideration (as of

October 2019); however, it is expected that the draft regulations will only be finalized in 2021.

One area that raises some significant questions when it comes to the exploitation of mineral resources is the harm that will be inflicted on the marine environment. Harm is another key ‘part’ or factor to be considered in an assemblage of understanding DSM and seabed mining per se. It is widely accepted that mining activities could cause irreparable harm on the marine environment and ecosystems at the mining site, and plumes that are generated from mining activities could spread well beyond the mining site, thereby disrupting surrounding ecosystems. In response to this, numerous Member States have called for the development of Regional Environmental Management Plans or REMPs. The prevailing view is that REMPs should be in place *before* any mining activity is permitted within a specific region. However, there is yet to be clear consensus on the actual legal force that REMPs actually connote. Like any assemblage, then, the legal and management provisions of mining remain emergent, ever in process.

One view is that REMPs are merely planning instruments that guide decision-making, while another view is that REMPs are binding instruments that instruct decision-making processes. If the latter view is adopted, this would mean that the ISA could actually reject exploitation applications on the basis that its approval would not conform with the goals and objectives of the applicable REMP. It is expected that some progress would be made 2020 and beyond, with respect to the legal force or effect of REMPs and the dynamics between REMPs and decision-making at the ISA. Similarly, discussions pertaining to the adoption of Standards and Guidelines that should apply to exploitation activities are also currently ongoing. The regulatory assemblage of DSM, then, is in an ever-changing and evolving state, which it will be important for scholars to keep abreast of.

However, such instruments, and other regulative apparatus are not the only legal considerations that are a ‘part’ of making sense of seabed mining. Competent legal knowledge is also vital. An important area of research which arguably requires more detailed interrogation is the actual ability of the ISA to ensure the effective protection of the marine environment. From an institutional perspective, it appears that the ISA lacks the appropriate expertise in this regard. While it has an expert subsidiary body, known as the Legal and Technical Commission (LTC), the current composition of this body lacks environmental-

related expertise. A significant majority of the Commission's members are lawyers and geologists, and do not have environmental-related expertise. Based on its present composition, it appears that only 10-20% of the LTC members have environmental-related expertise. This is extremely worrying, given that the LTC is entrusted to make recommendations to the Council on environmental-related matters such as the design of appropriate regulations, the consideration of environmental impacts (including the need for emergency action), and whether or not to approve environmental management plans submitted by contractors. To add further, it should be noted that it is difficult for the Council to disagree with any recommendations made to it by the LTC, as this would require two-thirds majority of Council members present and voting in most cases.

Moreover, more clarity is needed with respect to the confidentiality of data related to DSM decision making by the ISA. On the one hand, contractors insist on the need to protect proprietary interests and by extension, can withhold data obtained. On the other hand, the Convention clearly states that all environmental data should be promptly released to the ISA. Such environmental information, such as baseline data, is essential for the ISA to take necessary measures to ensure the effective protection of the marine environment. As such, there is a crucial need to clarify which information can be deemed as confidential, and which information is essential for environmental-related measures and must be disclosed.

Finally, two critical 'parts' that require greater attention from a legal perspective are the financial terms of exploitation contracts, and the appropriate mechanism for benefit sharing. With regards to the former, the ISA is currently taking steps to design a suitable method to calculate how payments that emerge from mining, should be made (and who they should be made to). This will likely include a hybrid between royalties and profit sharing. As concerns the latter, efforts in this respect remains to be at a preliminary stage and are currently, as of writing this, elusive. It is anticipated that efforts to make some progress in the appropriate benefit-sharing mechanism will intensify in coming years (altering the assemblage of DSM). The chapter next turns to economic dimensions, particularly ecosystems services, in greater detail.

However, it should be noted that legal research on the seabed is challenging. It is highly likely that new developments, in the form of new agreements, regulations or changes to relevant national legislation, may occur during any given research period. However, these

risks will be limited by closely observing recent evolutions and anticipating such changes, thereby ensuring that the research results do not lose their relevance if these developments eventually take place. Indeed, apart from studying the *existing* legal framework, Much focus has been put on the law-making process of the International Seabed Authority by attending and observing the annual sessions of the ISA Council, which is the executive organ for the purposes of decision-making and policy development¹, in order to enhance knowledge with regard to the future regulations on deep-sea mining and the topical issues under discussion. Under this remit, scholars are engaging with classical legal research methods, integrating semi-structured expert interviews informed by the findings of the desk research. Interviewees will be deliberately chosen to represent all sides who are involved in deep-sea mining, such as environmental NGOs, commercial mining operators, sponsoring states, developing states and the International Seabed Authority. By interviewing a representative of each of these involved parties, the various points of contention will be underlined, allowing for a better analysis of the different factors influencing stakeholder perceptions of the current legal framework and enabling a more accurate assessment of future policy changes.

Socio-economic dimensions: marine ecosystem services and values of deep-sea mining

The Ecosystem Services (ES) framework, linking the environment to human well-being, is important for sustainable management of the deep-sea, providing a quantitative basis for Marine Spatial Planning (MSP), a crucial ‘part’ of understanding emerging DSM regimes by recognizing various values, including economic values. *Figure 1* shows how the ecosystem services framework can be incorporated into the various stages of MSP.

(Insert Figure 1 here: Relationships among ecosystem services, their study and phases in environmental planning where ecosystem services can be incorporated. Source: Le et al (2017))

Le et al. (2017) identify, in detail, the Ecosystem Services (ES) that could potentially be affected by deep-sea mining in terms of polymetallic sulfides mining, ferromanganese crusts mining, polymetallic nodules mining and phosphorites mining. ES which considering provisioning of fish catch, for example, will be affected by disrupted breeding grounds and nursery habitat, altered secondary production and trophic support, and dispersal connectivity.

¹ Article 162 LOSC.

Pharmaceuticals and biomaterial provisioning ES will also be affected by the changes in biodiversity and metabolic activities. Regulating services will be impacted through many channels such as surface photosynthesis, chemosynthesis, carbon flux, bioturbation, bio-irrigation, aerobic methane oxidation, greenhouse gas regulation, biological control of population and waste absorption. As noted already in this chapter, with the deep-sea regarded as the ‘common heritage of mankind’ (sic) deep-sea mining will also affect the *cultural* ES that the deep-sea and seabed provides; such as the educational, aesthetic including arts, existence and stewardship values; often termed ‘non-use’ values.

As knowledge of deep-sea ecosystems and their dynamics is still limited, it has – to date – been difficult to connect the ecosystem function with the services they provide (Hanley et al 2015), and it has been yet more difficult to quantify the impacts of deep-sea mining on the affected ES (Le and Sato, 2013). If impacts could be quantified on provisioning services like lost fish catch, this can be valued using market prices. Impacts on regulating services can also be valued by market prices through the replacement costs approach, but it can be difficult to find a perfect substitute project that in theory could replace the loss in these ES. However, impacts on cultural ES can be very challenging to put an economic value on, as people are unfamiliar with these deep-sea, with ES and the long term risk to these ES posed by deep-sea mining (Hanley et al 2015). However, some environmental valuation studies have tried to address this issue.

For example, a Delphi based method was developed by Jobstvogt et al (2014a) to communicate the ecological value of the deep-sea ecosystem. Jobstvogt et al (2014b) conducted a Stated Preference (SP) survey (Johnston et al 2017) in terms of a Choice Experiment (CE) to elicit households’ willingness-to-pay (WTP) for creating additional marine protected areas (MPAs) in the Scottish deep-sea in order to protect them from potential destructive impacts from for example deep-sea mining. Aanesen et al (2015) and Sandorf et al (2016) conducted CE surveys of Norwegian households’ WTP for extending the national MPAs for deep water cold water corals (CWCs), including also the uncertainty of the ecological role of CWCs in their assessment. They experimented with different survey modes and different ways of presenting the ES of these unfamiliar public goods to the general public in order to improve the validity and reliability of these non-use values. These CWC valuation estimates were later included in a bioeconomic fisheries model of destructive bottom trawl versus non-destructive coastal gear (Armstrong et al 2017); that clearly showed the

importance of incorporating impacts on cultural ES and their non-use value into economic analysis of extraction of natural resources.

The uncertain linkage between the deep-sea ecosystem, ecosystem services and their benefits to humans should not preclude the inclusion of ecosystem services and their economic values into strategic environmental impact analysis (SEA) and monitoring systems. Deep-sea mining has strong economic motivation but impacts on ecosystem services and their values to humans should also be considered in the economic analysis in order to support a sustainable development path. This is crucial ‘part’ in understanding deep-sea mining.

Ecosystem Accounting (EA), a framework proposed by UN, views nature as an asset, and aims to incorporate the environmental assets into the system of national accounts (UN 2014). EA involves not only the physical terms of ecosystem such as ecosystem extent and condition, but also the supply and use account of ecosystem services, and the monetary valuation of supply and use, as well as the periodic revision of asset values based on changes in predicted future flows of ecosystem services (UN 2017). Although marine ecosystem accounting is still in an early stage, EA is a potentially valuable ‘part’ to consider in seabed mining assemblages as it can enhance transparency in governance, and link stocks and flows of natural resources with a broad spectrum of ecosystem services and benefit values (Chen et al. 2019). In the context of deep-sea mining, EA could provide a flexible monitoring framework (Grimsrud et al 2017) to support ecosystem-based management as it maps the changes in ecosystem extent, condition, or physical supply and use of the ES or changes in the economic value of the ES if there is sufficient knowledge to monetize the ES. The spatial focus of EA could highlight the different geographic impacts of deep-sea mining, helping to identify management hotspots and create MPAs, if needed. However, it has to be admitted that EA faces the similar challenge as those related to quantifying ES and ES values mentioned in the section above. Yet it is still a crucial arena of research and key ‘part’ of the assemblage in helping to make sense of the current ‘state of play’ in emergent mining activities.

The crucial ‘part’ of science: The Deep-Ocean Stewardship Initiative

The body of scientific literature relating to environmental aspects of deep-seabed mining has exploded in the past few years with examples too numerous to cite here. Of course, this is excellent news for increasing scientific knowledge of the remote areas of the deep ocean that maybe targeted for mineral extraction. It provides far more information to work with to try to

gauge potential impacts for those that inhabit our deep oceans and the effects on the important services they provided to the planet and its occupants. However, this wealth of information can be overwhelming in complexity for scientists who work in this field, let alone for other stakeholders who have alternative interests in this realm (however those stakeholders may be defined).

An international network – the Deep-Ocean Stewardship Initiative (DOSI) – consisting of mainly scientists but also lawyers, policy makers, economists, conservationists and industry expert from around the globe, help to collate, disseminate and translate the current scientific literature for all. DOSI network members work to advance deep-ocean science in UN and national policy, and translation of science into digestible information at all levels. This is a key occupation for this group who unite to advise on ecosystem-based management of resource use in the deep ocean (both within and beyond national jurisdiction), including on deep-seabed mining.

As the industry is rapidly approaching the transition from exploration to exploitation in our world's oceans (see above), one of the current primary focus areas for DOSI is to provide independent scientific advice to the International Seabed Authority (ISA) and other stakeholders on deep-seabed mining issues to aid the development of exploitation regulations for the international seabed Area. DOSI is in a unique position to be able to collate this knowledge and deliver it directly to policy makers with a neutral voice, neither advocating for mining or opposing it. Moreover, DOSI has been an official observer at the ISA Annual Sessions since 2016, delivering scientific side-events to highlight environmental aspects of deep seabed mining, and producing related policy briefs (for example on climate change considerations, the importance of biodiversity assessment and monitoring, strategic environmental goals and objectives), delivering interventions and working with country delegates and other stakeholders.

The network also actively encourages and funds engagement of scientists from developing nations in these activities – capacity development is an important aspect of DOSI's work, and where there may be unequal power relations between those who seek to extract and exploit resources, and those who will be subject to such extraction and exploitation. Between the Annual Sessions, DOSI Minerals working group members (which number around 175 and constitute a broad spectrum of expertise), contribute expert commentaries to the developing draft

mineral exploitation regulations, produce peer-reviewed publications (for example, Tunnicliffe et al. 2019), reports and outreach materials, convene and attend workshops and meetings relating to environmental planning and management aspects of deep seabed mining, and have regular communications to keep in touch with the enormous flux of information coming from scientific papers and meetings. Proactive development and implementation of comprehensive management practices, frameworks and policies prior to the onset of commercial mining will ensure protection and preservation of the marine environment, whilst enabling the use of seabed mineral resources. The ‘part’ DOSI play, then, is essential to the DSM assemblage.

Recognizing the geopolitical dimensions: a (not so) final part

Whilst this chapter has, so far, addressed the definitional, legal, economic and scientific ‘parts’ that help us understand seabed mining, geo-politics is also crucial in this emergent industry. Through an approach conceptually grounded at the interface of critical geography, political ecology and resource anthropology, research by Childs has been focused on how the seabed has emerged as a new political *terrain* of struggle (see 2018, 2019a, 2019b, 2020). Moving beyond geopolitical approaches that understand the world largely in the narrow terms of interstate relations, this research instead seeks to understand the seabed as a space of politics produced by a relational congregation of socio-natural forces, considering 1) the temporalities of deep-sea mining (Childs 2018); 2) a corporate anthropology of a DSM firm and its strategies (2019a); and 3) the impacts of DSM upon indigenous communities and the political potential of art to counter-narrate the seabed (Childs 2019b). Shifting back to the earlier section on definitions, certainly, a vibrant, unstable and agentive seabed, that is in flux and changing, is seen as generative of DSM’s evolving geo-politics.

The seabed as a geopolitical concern has emerged where, in recent years, it has been re-imagined by industry and policy makers not as an inert edge of a politically insignificant watery volume, but as the latest ‘frontier’ of resource extraction (see also Zalik 2019). Various scripted by global capital as both a solution to global resource security and as a more sustainable alternative to the terrestrial mining industry, DSM has thus emerged as a new iteration of *spatial fix*. This ‘fix’ encompasses both a tendency to ‘sink money into physical objects’ (for example, ports, ships, deep-sea mining equipment) and a metaphorical ‘addiction’ to resource extraction (Brent et al. 2019: 3). In other words, for those who work

DSM into the blue economy narrative, the seabed becomes a key geographical site for capital's ongoing expansion.

Yet for all the spatially centred critiques that it provokes, deep-sea mining also invites us to think about the (geo)political effects of its unique *temporalities*. As Childs argues, temporal dimensions 'may be projected forwards; DSM's target metals and minerals have been constructed both historically and currently as 'resources of the future', global finance is courted by corporate pronouncements of DSM's 'resource potential', 'waste' from the extractive process is included in predictions of environmental impact and so forth. But the temporal also engages with the geological time of deep-sea topographical formation; for example, where hydrothermal vents form at very different speeds to deep-sea polymetallic nodules, or where the status of resources can be either materially altered by physical forces such as volcanism or through discursive shifts inspired by (human) knowledge production and commodification' (Childs 2018: 2). *Time* and *space* then, are vital parts to critically consider in understanding the politics of DSM.

Yet it is also vital to consider DSM as *social*. A geopolitical approach critiques the oft-understood domain of DSM as largely asocial (its industry proponents often describe it as having 'no human impact'). To date, there have been very few ethnographic studies of those affected by or invested in the activity (yet see Carver 2019). Childs has sought to partially address this gap by analysing the emotional and affectual aspects of DSM upon communities in Papua New Guinea (PNG) situated closest to the world's first commercial DSM licence. Using a range of participatory methods and creative practices, including drawing, sculpture and participatory theatre, these small-island communities sought to find an alternative vocabulary for making the seabed visible to deep-sea mining actors including the corporation, the PNG state and activist groups at local, national and global scales (Childs 2019b). Building on earlier sections of the chapter – research on DSM is not only scientific but understanding the assemblage of the issue involves engaging with legal analysis, interviews and as demonstrated here, more novel methodologies. Indeed, creative practices, in particular, emerge as particular 'submerged perspectives' that seek to 'pierce through the entanglements of power' associated with blue growth and proclamations of 'sustainable' deep-sea mining and which seek to 'differently organize the meanings of social and political life' (Gomez-Barris 2017: 11 in Childs 2019b: 7). In other words, they make possible a greater understanding of geopolitics in the context of DSM.

There is also a need to understand the political possibilities enabled by the deep-sea's unique materialities, not least in terms of the ways that these prefigure the legitimizing strategies of certain human actors to mine the seabed. For example, the Deep-Sea Mining Corporation frames DSM activity in a way quite specific to the deep-sea environments in which it operates. By engaging with the matter or materiality of deep-sea mining (for example, the violence and unruliness of its associated volcanism, and the temporalities of sulphide 'chimneys'), the DSM industry is able to position itself as a more sustainable version of mining than its terrestrial equivalent (Childs 2019a), geopolitically legitimizing itself. Understanding geopolitical 'positioning' then, of this multinational and complex industry and its physical materialities are an important part of any seabed mining assemblage.

Finally, connecting studies of deep-sea mining to a broader turn in the social sciences towards 'critical ocean studies' (DeLoughrey 2019) seems essential to understanding its place in the politics of the Anthropocene. This means taking the geophysical processes of the seabed and deep-water column as well as a broadened cast of political actors (including spirits and deep-sea fauna) seriously in understanding how DSM's politics is wrought. Such an approach can draw upon work that has urged us to think 'with' the ocean (Steinberg and Peters 2015; Peters and Steinberg 2019) and the still hidden postcolonial histories that it reproduces (DeLoughrey 2017).

Endings, and beginnings

This chapter has been ambitious in scope, assembling together a collection of perspectives and knowledges about seabed and more specifically deep-sea mining. Unlike other publications on the seabed – *which have tended to focus solely on single issues* – this chapter has deployed the post-structural theory of 'assemblage' – as a mode of bringing together disparate parts, territorializing them into one coherent whole – a multipart, complex and varied discussion of the issue of seabed mining. Each 'part' of the chapter – on definitions, legal dimensions, ecosystems services and values, to science communication and geopolitics – has aimed to demonstrate that DSM cannot be understood through only one approach, but requires a *conversation* and *collaboration* across fields of knowledge and academic disciplines, and across the many approaches of those disciplines (from quantitative modelling, to qualitative interview data to scientific findings).

Taking an ‘assemblage’ approach has enabled a chapter that pays attention not to one ‘master narrative’ of mining, but rather the many parts that constitute this global, underwater development. Demonstrating the potential of assemblage, it has enabled the authors here to identify often overlooked or previously unrecognized dimensions of the issue. Indeed, assemblage theory encourages scholars to be critical in thinking through the many parts that make a ‘whole’ (whether they seem immediately important or not) which come together to form an understanding of an issue. It permits also, “an alternative account” (Ong and Collier 2009, 562), one rich in its diversity and attention to heterogenous elements (in this case, law, geopolitics, science, governance, management) showing how they interrelate.

Yet also crucial to assemblage is the acknowledgement, as noted at the start of the chapter, that any assemblage is always open, and could ‘deterritorialise’ and change in future as new parts are added or detracted. This chapter has ‘held together’ a set of ‘parts’ concerning arising at one moment in time. In this sense, this chapter provides a certain sort of conclusion for how to think about and understand seabed mining. But the chapter also, with the knowledge that assemblages change and evolve – and that seabed assemblages, in particular, are a terrain of flux (physically, legally, and beyond) – argues that this is just the beginning. Future studies of this emergent assemblage will be necessary in the future, and we hope they may take inspiration from our approach here.

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