Press Kit

Digital Twin & Adaptive Management Systems in Deep Sea Mining

Limitations and the Risk of Self-Regulation

Exclusive Story

In an exclusive for Cook Islands News, journalist Rachel Reeves covers the recent release of this report at the Deep Ocean Symposium. Her article delves into our findings on the impacts associated with using digital twin technology and adaptive management systems in deep sea mining. It also highlights calls for a moratorium to prevent harmful deep sea mining practices.

Press Release

View the official release here

Factsheet

The Context

Even in 2024 the deep sea remains largely a mystery. There is still much unknown about deep sea ecosystems and their vital roles in nutrient cycling and carbon sequestration. We also don't yet understand how important their relationships are to marine species we are more familiar with. Science is just starting to get a handle on the roles that deep sea ecosystems play in ocean processes that are important for balancing our planet's systems, especially in the face of climate change.

Deep sea mining (DSM) is an unprecedented industry with no commercial operations anywhere in the world. While there is much uncertainty about its impacts, the scientific consensus predicts these would be severe, long term, and potentially irreversible in human time frames[i]. Research suggests it will be decades before enough is known to understand the cascading environmental consequences of DSM, let alone if and how these might be addressed[ii].

Driven by its precarious financial circumstances, The Metals Company (TMC) is in a desperate hurry to mine within the next two years[iii]. In order to do so, TMC proposes to bypass responsible environmental management informed by sound science. It intends to replace this with Digital Twin Artificial Intelligence incorporated into an Adaptive Management Approach.

Digital Twin Technology – not yet intelligent enough

A Digital Twin (DT) is an unproven, novel form of Artificial Intelligence that aims to provide a virtual representation of an object, resource extraction project, or manufacturing operation based on real time data. While the technology is still in development, researchers are also investigating the possibility of DTs for natural systems such as the Ocean. The more complex the system a DT aims to represent, the greater are the challenges to overcome. Like all AI, DTs can only be as accurate as the information inputted. Some researchers believe that DTs may never be able to replicate dynamic and complex environments like the ocean in any meaningful way, nor accurately monitor the wide-ranging environmental impacts predicted to result from DSM.

DT has become a “buzz word” often incorrectly applied to any computer model that provides a static simulation or replica - more correctly termed digital shadows. Accurate monitoring of DSM induced ecological changes, will demand a level of technological sophistication, interdisciplinary cooperation, and deep ocean science that is decades away. In the meantime, DTs might be useful for tracking operational performance, equipment integrity and some other easy to measure parameters. It is not a proxy for responsible environmental management.

Adaptive Management in DSM – Learning by Destroying

TMC is in a rush to begin commercial mining before the impacts of this industry is understood. TMC argues it will develop an Adaptive Management System (AMS) and that its DT will be a core component [iv].

Adaptive management was developed as an iterative ‘Learning by Doing’ process aimed at allowing environmental and resource managers to continuously improve conservation outcomes over time. It has provided a management framework in areas such as fisheries, community forestry, waterfowl protection, grazing land restoration.

Adaptive Management is not an appropriate environmental management approach for the rapid, wide ranging and long-term impacts predicted for DSM, nor its potentially irreversible damage to seabed ecology and ocean chemistry. Any learning that may occur will be at the expense of deep sea ecosystems and far too late to protect ocean and planetary health.

In effect adaptive management would render the world’s deep oceans – the common heritage of humankind – the living experimental laboratory of DSM companies.

Digital Twins and Adaptive Management Systems Equal a Regulatory free-for-all

The application of AMS and DT to DSM would offer this unprecedented industry the opportunity to mine world oceans under a facade of cautious environmental management. It would mask the paucity of knowledge about deep sea ecosystems, the broader roles these play in stabilising planetary systems, and the likely cascade of impacts DSM would create.

No independent oversight, regulation, or industry standards exist for the deployment of DTs, or what parameters they should measure, the transparency of data collected and who the data will be shared with.

There is also no agreement about what the goals of adaptive management for DSM should be. For example: what is ‘effective protection’ of the marine environment? How is ‘serious harm’ to the marine environment defined, including from the cumulative impacts of DSM? What are the ‘acceptable’ levels of impact, and who determines these and on what basis?

This leaves it to the very companies who have staked their financial interests in DSM to make these critical decisions.

Proceeding with DSM under the smokescreen offered by Adaptive Management and DTs would facilitate a regulatory free-for-all. It would provide free rein to DSM companies to rapidly destroy one of the planet's few remaining intact ecoregions - recognised by international law as the common heritage of humankind.

---

[i] A. Chin and K. Hari, 2020 “Predicting the impacts of mining of deep sea polymetallic nodules in the Pacific Ocean: A Review of Scientific Literature,” Deep Sea Mining Campaign and MiningWatch Canada https://dsm-campaign. org/deep-sea-nodule-mining-danger-to-pacific-ocean-and-island-nations/

[ii] Amon D et al, 2022, Assessment of scientific gaps related to the effective environmental management of deep-seabed mining. *March 2022, Marine Policy* 138 (30) https://www.researchgate.net/publication/358958506_Assessment_of_scientific_gaps_related_to_the_effective_environmental_ management_of_deep-seabed_mining

[iii] Deep Sea Mining Campaign press release, 2 April 2024, “The Metals Company under huge financial pressure”. https://dsm-campaign.org/the-metals-company-under-huge-financial-pressure/

[iv] The Metals Company, Press Release, July 12 2022, https://investors.metals.co/news-releases/news-release-details/metals-company-contracts-csiro-led-consortium-pioneer-ecosystem

Biography - Dr Helen Rosenbaum

Dr. Helen Rosenbaum is co-founder of the Deep Sea Mining Campaign and is its Research Coordinator. Helen holds a doctorate in Medical Science, has worked as a marine toxicologist and in the development of coastal zone policy in Australia. She also has 30 years’ experience in environmental and human rights advocacy and in community development in the Pacific region. Over the past 12 years the DSMC has undertaken science based advocacy in solidarity with civil society organisations, scientists and citizens around the world who are concerned about the likely impacts of deep sea mining on ecosystems and island and coastal communities. They have produced several evidence based reports and the video Blue Peril presented for the first time the results of modelling independent of mining companies showing the spread of pollution and the extent of seafloor destruction for actual exploration licence areas in the Pacific Ocean.

Quotes from Dr Rosenbaum

Technological Immaturity:

"Digital Twin technology, for the foreseeable future, lacks the sophistication to monitor the complex dynamics of deep sea ecosystems. Although yet to be applied to deep sea mining , the technology would be able to do little more than track aspects of equipment performance

and monitor a few readily measured, but not necessarily relevant environmental parameters. It is not a replacement for robust environmental management informed by sound science*."*

"Given the extreme and unknown conditions of the deep sea, Digital Twin models cannot yet accurately predict or monitor ecological changes. This leaves a dangerous gap in the ability to prevent significant damage.

Digital Twins or Digital Shadows? The Distinction Matters:

“While the term 'Digital Twin' is often thrown around, what we're really seeing in discussions about deep sea mining are Digital Shadows — basic computer models that only mimic certain conditions. These are not true Digital Twins, which require far more advanced technology and deep sea science to effectively model the complex ecological impacts of mining.”

“The distinction matters because calling these basic models 'Digital Twins' misleads us into thinking we can properly monitor and mitigate the ecological damage caused by deep sea mining. The reality is, we're decades away from having the technology needed for that level of oversight. Until then, these so-called Digital Twins can only offer limited insights — tracking equipment performance, not the intricate and often irreversible changes in the deep sea environment.”

Self-Regulation Risks:

"Relying on DSM companies to regulate themselves, with an immature technology embedded in an inappropriate environmental management framework sounds a death knell for ocean and planetary health. If the companies with skin in the game set the ground rules, how can we trust that the environmental data measured would meaningfully reflect damage to ecosystems, or that it would be accurately measured or shared for transparency and accountability including with independent scientists and civil society.”

"The lack of mandatory standards leaves room for companies to decide what environmental impacts are deemed acceptable, likely leading to significant irreversible ecological damage."

“Is using Adaptive Management learning by destroying?”

Environmental Consequences:

"Science is just starting to show that deep sea ecosystems play a vital role in carbon sequestration and nutrient cycling. Mining these areas could disrupt these processes, worsening the climate and biodiversity crises."

"Our report titled “Predicting the impacts of mining deep sea polymetallic nodules in the Pacific Ocean” highlights that the impacts of DSM could be irreversible, particularly because deep sea ecosystems recover very slowly, if at all. Once disturbed, the damage may persist for decades or centuries."

Scientific Knowledge Gaps:

"Our understanding of deep sea ecosystems is still in its infancy. Critical knowledge gaps exist around how these ecosystems function, their role in global environmental processes, and how they would respond to mining activities. We are sure that the destruction would be significant."

"It will likely take decades of dedicated research to fully understand the implications of DSM. Rushing to mine the deep is reckless and will lead to unfathomable environmental disaster."

Call for a Moratorium:

"The report urges governments to adopt an immediate moratorium on deep sea mining. Until we close knowledge gaps and develop the necessary technology and regulatory frameworks, proceeding with DSM would be premature and dangerous."

Multimedia

1. Digital Twin Report (web version - contact communications@dsm-campaign.org if you want a print copy)
2. Blue Peril - A visual investigation into deep sea mining in the Pacific Ocean

Frequently Asked Questions

1. **What is deep sea mining?**

   Deep sea mining aims to extract minerals from the ocean floor. In the Pacific Ocean there is a frenzy of interest in mining polymetallic nodules - small rocks containing minerals such as cobalt, nickel and manganese. To date only exploration and test mining has occurred. The science about deep sea ecosystems and the impacts of mining on them is only just emerging, but it indicates that commercial mining would threaten deep sea systems vital for planetary health. The environmental risks far outweigh potential benefits.

2. **What is Digital Twin technology and can it monitor the environmental impacts of DSM?**

   a. Digital Twin (DT) is AI technology that aims to create virtual models of real-world objects, manufacturing processes, resource extraction operations, or large scale environments. While promoted as ‘cutting edge’, the capability of DTs remains limited, especially for challenging applications like environmental monitoring in dynamic natural habitats - such as the ocean. For

the foreseeable future, DTs will be largely used to maintain equipment and supply chains and troubleshoot operational problems. Monitoring complex DSM-induced ecological changes, require levels of technological sophistication, collaboration, and deep sea science that is still decades away.

What is the difference between a Digital Twin and Digital Shadow?

Digital Twin has become a “buzzword” often misapplied to more basic computer models that provide only static simulations, known as Digital Shadows. The key difference between a DT and a digital shadow is the real-time dynamic flow of data – from the physical to the digital and back again. As highlighted above, knowledge and technology gaps place DTs capable of monitoring wide ranging DSM impacts as a long term goal.

3. **What is Adaptive Management and can it address the impacts of DSM?**

Adaptive Management is an environmental management approach that attempts to improve conservation outcomes over time based on new monitoring data. Often described as ’learning by doing’, it was designed to develop effective conservation strategies for natural resource management eg. in fisheries, forestry, wetland restoration or farmland rehabilitation. Adaptive management is entirely inappropriate to address the rapid, wide ranging and long-term impacts expected for DSM. Any learning that may be gleaned will not occur in time to protect ocean ecosystems and planetary health.

4. **Why are there concerns about using Digital Twin technology and Adaptive Management in deep sea mining?**

    a. There are no regulations or agreed industry standards covering the deployment of DTs in DSM, what parameters they should measure to provide an accurate picture of environmental impacts, the transparency of the data collected by companies, and who the data will be shared with.
    b. There is also no agreement about what the goals of adaptive management for DSM should be. For example: what is ‘effective protection’ of the marine environment? How is ‘serious harm’ to the marine environment defined, including from the cumulative impacts of DSM? What are the ‘acceptable’ levels of impact, and who determines these and on what basis?
    c. The application of Adaptive Management and DTs to DSM would offer this unprecedented industry the opportunity to mine world oceans under a facade of cautious environmental management while it rapidly destroys one of the planet's few remaining intact ecoregions for short term financial gain. It would facilitate a regulatory free-for-all whereby the mining companies set the criteria for environmental management.

5. **Why does TMC want to use DT technology and Adaptive Management?**

TMC is in a rush to begin commercial mining before the impacts of this industry is understood. It plans to bypass responsible environmental management informed by sound science. TMC intends to replace this with a DT incorporated into an Adaptive Management Approach.

In effect this would provide TMC with a regulatory ‘free-pass'. TMC is asking society to overlook its direct financial interest and to trust it to self–monitor and to self-regulate: ie. to determine which environmental variables to measure, how much harm to the marine environment is acceptable, how it will respond to unacceptable impacts, and whether it will allow public access to information about the damage its causes.

6. **What risks does deep sea mining pose to ocean ecosystems?**

   Deep sea mining risks disrupting ecosystems vital for biodiversity, carbon storage, and nutrient cycling. Disturbing these habitats could result in long-term, potentially irreversible damage, undermining ocean health and ecosystem resilience.

7. **How could deep sea mining affect the climate crisis?**

   Deep sea ecosystems play a crucial role in storing carbon, helping to regulate climate. Disrupting these ecosystems through mining could release carbon, amplify ocean acidification, and weaken the ocean’s climate-moderating functions.

8. **Why does the report recommend a moratorium on deep sea mining?**

   The report calls for a moratorium because of the considerable knowledge gaps, technological limitations, and absence of effective oversight, which together make deep sea mining highly risky and likely to cause irreversible harm to marine ecosystems.

9. **How does this report fit with global calls to pause deep sea mining?**

   The report aligns with a global call by at least 32 countries for a moratorium or ban. Until scientific standards, protective regulations, and monitoring technologies are established, advancing deep sea mining is a dangerous step for the health of the ocean, already on the brink due to other stressors such as climate change, pollution and overfishing.

10. **What specific minerals are targeted in deep sea mining, and why are they considered valuable?**

    Minerals like cobalt, nickel, and manganese are found in deep sea polymetallic nodules. Often described by the U.S. and China as "critical minerals," these resources are primarily valued for strategic uses, especially in defence and weaponry. Although these minerals are promoted as essential for “green” energy, renewable energy technology is rapidly evolving away from using them. Rather than supporting sustainability, deep sea mining would more likely serve military interests.

11. **Is the impact of deep sea mining less than land-based mining?**

    Deep sea mining is not a sustainable alternative to land-based mining. It poses a potentially higher risk by disturbing fragile ecosystems that play a role in global climate regulation. The scale of deep sea mining could exceed land mining’s impact over time, threatening biodiversity and ecosystem services. TMC itself admits in filings with the US securities exchange commission that it can’t guarantee that DSM will have less environmental impact than mining on land. Opening the ocean to

mining won't reduce land-based mining operations; instead, it would amplify environmental and social harms across both land and sea.

12. What is the alternative to deep sea mining?

The only sustainable alternative is shifting to a circular economy that maximises recycling and re-use. Only a minute fraction of the batteries and electronics discarded annually worldwide is currently recycled.