Impossible Metals Myth-Busting and Frequently Asked Questions (FAQ) for website

V2.3 (Last Update October 7, 2025)

Please contact our team if you have any questions that aren't covered here or would like to discuss your questions or feedback with Impossible Metals.

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Mythbusting False and Misleading Statements About Deep Sea Mining (DSM)

Deep sea mining is an emerging industry that has sparked significant excitement, speculation, and concern. Like any emerging industry, this can lead to misconceptions or confusion, and even in some cases misleading or false statements. Impossible Metals is committed to evidence-based, environmentally responsible, and transparent operations, and therefore we have published substantial information on the expected impacts—positive and negative—of deep sea mining, and how our approach differs. However, certain myths persist and are unfortunately repeated by some organizations, particularly those with a stated goal of stopping all deep sea mining. Our planet, economy, and security requires a critical minerals policy that is based in science, and the data clearly show that selective harvesting of seabed minerals will be the lowest cost, lowest environmental impact, and lowest time path to a secure critical minerals supply chain. In the past, a number of well-meaning organizations opposed nuclear power, and we lost 20 years of innovation in a technology that is now recognized as critical to producing clean, reliable, baseload energy.

This section of our extensive FAQ will address common myths on deep sea mining. We have had productive dialogues and exchanges with the majority of the non-government organisations (NGOs) and marine scientists engaged in deep sea mining issues, and welcome other organizations to engage with us to strengthen the scientific foundation of this new industry. Regardless of the source, we take feedback constructively in line with our value of encouraging sharing and respecting all perspectives.

Impossible Metals commits that we will only mine if we are satisfied that our Environmental Impact Statements (EIS) show there will be no material, long-lasting impacts on the marine habitat or other uses of the ocean. (fishing, transportation, recreation, submarine cables, etc.)

Myth #1: Very little is known about the deep seabed.

It is an ‘old saw’ that we know less about the deep sea than the moon. While that may have been true in 1969, the last few decades have seen tremendous amounts of data collection and scientific research on the environmental conditions of the sea floor—much of it enabled by the interest in seabed mining.

The comprehensive Environmental Impact Assessment (EIA) studies conducted within a specific mining area for planned mining operations provide a detailed understanding of the environment, enabling us to predict potential impacts and subsequently inform regulators' decisions on whether to issue exploitation permits. Several have been already completed in licensed areas of the Clarion-Clipperton Zone, for example.

As there has been exploration activities in the deep sea and abyssal plains for decades, there is actually a tremendous amount of raw data. The problem is that there has been limited funding to process and structure this data — and substantial funding only will become available when commercial activity is permitted.

The International Seabed Authority (ISA) DeepData Database contains data collected from mining contractors since the early 2000s. At the time of writing, this includes:

- Number of scientific cruises: 148
- Total Samples: 759,628
- Total Bio Samples: 150,920
- Total Geo Samples: 608,708

Globally, several programs are combining data to provide a better understanding of our oceans.

- Seabed 2030 aims to map the entire ocean floor by 2030.
- The World Ocean Database hosts the world's largest database of data about the ocean water column (temperature, salinity, oxygen, nutrients, etc., by location & depth).
- The Ocean Biodiversity System hosts open-access data on marine biodiversity, connecting 500 institutions from 56 countries.

For more details, see our blog post: Data from the Deep Seabed: What Do We Know?

Myth #2: Deep sea mining threatens our planet's largest carbon sink.

Some have argued that because the ocean is the largest carbon reservoir on Earth, holding significantly more carbon than the atmosphere or terrestrial biosphere, deep sea mining would release carbon.

However, the reality is that less than 1% of the CO^2 sequestered in the ocean's upper layers reaches the deep sea floor annually. As the carbon-based organic matter sinks to the bottom of the ocean, much of it is processed before reaching the ocean floor. Due to lower productivity and reduced input of organic matter, deep-sea sediments have an overall low organic carbon content of approximately 0.05% of the dry weight of the sediment. Nodules do not sequester CO^2 and do not contain a meaningful amount of carbon. Sediment disturbed by the collector vehicle has no pathway to the atmosphere. Local sediment disturbance has shown not to rise more than a few meters, many meters away from phytoplankton, which need light for photosynthesis. Impossible Metals has no riser system with a mid-column discharge plume, so this will not impact phytoplankton photosynthesis.

Any possible carbon sink impacts will be confirmed by scientists as part of the Environmental Impact Assessment (EIA) before permission is granted to start mining. See more details in the ISA Fact-check 2024/1 – The carbon cycle in the Area.

Myth #3: The deep ocean has a similar amount of life as the shallow ocean.

Often, we see images of the shallow ocean alongside calls for a moratorium on deep sea mining. The implicit message is that the deep ocean has a similar amount of life. While the lack of light or life in the deep sea makes pictures a relatively uninteresting complement to articles or fundraising appeals, this is like using a picture of the rainforest to illustrate the desert.

The deep ocean receives no sunlight, has no plant life (flora), and the vast majority of life is microscopic (e.g. bacteria). Every few kilometres or miles, megafauna (life bigger than 1cm) is present, but it is very rare. The deepest diving marine mammal is the Cuvier's beaked whale, which can dive to a depth of nearly 3,000 meters (9,816 feet) according to Whale Scientists. This is well above depths of 4-6km (2.5 to 4 miles), where deep sea mining for nodules will occur. Our Eureka Collection System uses AI to avoid disturbing megafauna and is programmable to leave any percentage of the nodules undisturbed. The Eureka Collection System is initially set to leave 60% of the nodules undisturbed but can be adjusted to meet changing requirements.

Below are two videos of the actual seabed recorded with remotely operated vehicles (ROVs).

From the BGR (German) area of the ClarionClipperton Zone (CCZ)

The Nodule Field in the BGR License Area in the Clarion-Clipperton Zone (CCZ) >

From the Moana Minerals area of the Cook Islands EEZ

Nodule fields of the Cook Islands - Short Version >

Myth #4: Deep sea mining causes significant and irreversible damage.

Opponents of deep sea mining argue that it will damage a pristine environment in an irreversible way. This belief does not account for the impacts of existing mining sources or the opportunity to minimize mining impacts through technology.

All mining removes natural resources from a location, but it has been pursued throughout human history as an indispensable part of economic production. Historically, mining has had a profound and multifaceted impact on civilization, shaping economic growth, technological progress, and infrastructure, while also contributing to environmental degradation, social conflict, and geopolitical tensions. Without mining, there would be no civilization and no technology.

As demand for critical metals increases due to the energy transition, vital infrastructure requirements, digital transformation, and defense resilience, the question becomes: *where* should mining take place?

We believe it should come from places with the least amount of biomass, where the vast majority of life is microscopic, and no humans are living close to the mine. This is the ocean's abyssal plains, which are located between 4,000 (2.5 miles) and 6,000 (4 miles) meters deep. Currently, ~75% of nickel is mined in rainforests, and 75% of cobalt mining originates from the Democratic Republic of the Congo (DRC), with significant environmental and social impacts, including human rights abuses.

Technological innovation can also mitigate the impacts. Impossible Metals' approach focuses on creating the most environmentally responsible form of mining. Far from creating irreversible damage, this approach maintains existing ecosystems—something never before achieved in mining. See FAQ B.6 What is Impossible Metals' plan to protect the marine environment? for more information on what that entails. Deep sea mining can be the lowest-cost and lowest-impact source of critical minerals, enabling policies to stop sourcing minerals from rainforests or locations that use child labor.

Myth #5: Deep sea mining is economically risky.

Because deep sea mining involves such incredible technology, capable of operating in one of the universe's most demanding environments, some assume that it will be economically risky. And it is true that all first-of-their-kind projects employ more risks than established industries. However, the rising demand for critical minerals and the surprisingly low costs of deep sea mining—particularly with Impossible Metals' innovations—make it a potentially significant new industry.

The demand for critical metals is enormous and growing. In 2025, the total market for nickel, copper, cobalt, and manganese is approximately $450 billion per year, and is projected to reach $650 billion by 2030.

The cost to mine and process nickel using Impossible Metals technology is expected to be approximately 10x less expensive than the average land-based mine in 2024. For more details on why costs are so low, please see this blog post: Why Will Deep Sea Mining Be Less Expensive Than Traditional Land-Based Mining?

In our latest concept economic model (v6), we demonstrate how 'Project 1' will collect 6.7 million metric tonnes of nodules per year, generating $4 billion in revenue and a net profit of $1 billion per year. This is while leaving undisturbed 30% of the nodules by mass (60% by quantity, selecting the largest nodules).

Myth #6: Countries representing millions globally are against deep sea mining.

A number of countries are listed as having signed up for a moratorium, pause, or ban. It primarily signifies that:

- Legal structures should be in place to properly regulate deep-sea mining and
- Deep-sea mining should only occur if it can be managed in a way that ensures effective protection of the marine environment.

These principles align with the purpose of the approval processes established by regulators such as the International Seabed Authority (ISA) and other national regulators, including the Cook Islands Seabed Minerals Authority (SBMA) and the Bureau of Ocean Energy Management (BOEM).

A key component of the regulatory process is the Environmental Impact Assessment (EIA), which must be approved by the regulator before any mining can commence. The EIA documents the potential impacts of a particular mining project in a particular location, and outlines prevention and mitigation measures. Based on this assessment, the ISA determines whether the net impact is acceptable and whether mining can proceed.

The similarity in the purpose of moratoriums and approval processes gives the impression that jurisdictions are saying “no” to DSM. **However, this isn’t entirely accurate.** Essentially, signing onto a moratorium means supporting the completion of a robust mining code—something these countries are already doing, and a goal that Impossible Metals shares.

To date, 40 countries have adopted national legislation for deep sea mining and are listed in the ISA database.

See more in our blog post: What Does It Mean to Support a Deep-Sea Mining Moratorium?

Myth #7: Deep sea mining could harm vital fisheries.
Communities with long traditions and deep economic ties to fishing are understandably concerned about potential impacts on fish. Fortunately, deep sea mining takes place miles away from fish, and has been shown to avoid impacts that could disturb fish—especially with Impossible Metals’ approach.

Fisheries stocks are not present on the deep ocean abyssal plains where we find polymetallic nodules. Local sediment disturbance has been shown not to rise more than a few meters, many kilometers (or miles) away from phytoplankton (food for fish), which need light for photosynthesis. Impossible Metals has no riser system with a midwater discharge plume, so this will not impact phytoplankton photosynthesis.

Potential fisheries impacts will be confirmed by scientists as part of the Environmental Impact Assessment (EIA) before permission is granted to start mining.

See more details in the ISA Fact-check 2024/2 – Status of fishing activities in the Area.

Myth #8: Deep sea mining will not replace terrestrial mining.

Recently, most of Australia's nickel mines have been placed into care and maintenance, due to low nickel prices and competition from Chinese-operated mines in Indonesia. The extra supply of Indonesian low-cost nickel caused the global prices to decrease, resulting in high-cost Australian mines becoming uneconomical.

When low-cost deep sea minerals come to market, this new supply will cause the global nickel price to decrease further. In addition to the high-cost producers, the mid-cost producers will also become uneconomical and will close. As a result, deep sea mining will start to replace terrestrial mining, although it will never replace it 100%. It will also make it very unlikely that new terrestrial mines will open.

Policy can also make a difference. In the U.S., for example, the Uyghur Forced Labor Prevention Act has made significant strides in prohibiting the importation of goods into the United States manufactured wholly or in part with forced labor in the People's Republic of China. If more countries had secure domestic supplies of critical minerals, it would strengthen their ability to take similarly aggressive action against goods manufactured with minerals mined with forced labor or from rainforests.

Myth #9: There is no regulation of deep sea mining.

While not every jurisdiction has completed their final regulations for full scale commercial mining, deep sea mining has been regulated for decades. No commercial seabed mining has happened yet, precisely because of these regulations, which prohibit deep sea mining without a license.

The International Seabed Authority (ISA) adopted the exploration regulations for polymetallic nodules on July 13, 2000. Since then, 31 exploration licenses have been awarded. A draft set of regulations governing commercial extraction has also been under discussion at the ISA since 2011, when Fiji requested the ISA to prepare a work plan for adopting the extraction mining code, with iterative revisions released (e.g., 2015, 2017, 2018, 2019, 2024). The ISA has undoubtedly been delayed by motivated opponents hoping to stop all deep sea mining, but the issues are well understood and the ISA could finish their commercial mining regulations within a year.

Other nations, including the Cook Islands, Japan, Mexico, Norway, Papua New Guinea, Saudi Arabia, Sweden, and the U.S. , have already completed exploration and/or commercial mining regulations. These regulations allow for mining in domestic Exclusive Economic Zones, generally within 322km (200 miles) of their shoreline. In the case of the U.S., domestic law also permits U.S. companies to apply for mining licenses in international waters; two such licenses were issued several decades ago and remain active.

Myth #10: Deep sea mining endangers cultural connections to the oceans.

Many coastal communities have strong cultural and historic ties to the oceans. Respecting these connections while benefiting from marine resources is something that many industries must manage, from fishing to tourism, from shipping to offshore oil and gas.

Deep sea mining activities must be respectful of cultural heritage through engagement with any and all communities that are geographically linked to the resource areas where mineral harvesting is taking place. All deep sea mining will detect tangible cultural heritage (e.g. a ship wreck) and should avoid disturbing the wreckage. The draft ISA mining code, for example, contains a section specifically devoted to regulating these issues.

Because the ecological forces that lead to the development of seabed mineral resources like polymetallic nodules only occur at depth, deep sea mining of polymetallic nodules will be a hundred or more miles (~160km) away from any land mass, at depths of between 2.5 and 4 miles (4-6km). International waters are typically thousands of miles or kilometers away from any habitable landmass.

Every day, land-based mining results in immediate and devastating consequences by displacing communities, destroying ecosystems, and violating the human rights of Indigenous peoples who have lived in harmony with these lands for generations. These impacts are direct, visible, and culturally irreparable. Deep-sea mining offers the opportunity to replace those mines with sources in distant, uninhabited parts of the ocean's abyssal plains that lack the immediate cultural and human toll that we see on land. Protecting living cultures and human dignity must take priority. See more on the blog post: Illegal Land-Based Mining Consequences and How Deep Sea Minerals Can Help.

Myth #11: Eureka III generates 23,000 times the rate of natural sedimentation.

Some have argued that the natural sedimentation rate of the ocean is only of the order of 1-2 mm/thousand years, to imply that any sediment disturbance in the deep sea is unnatural. However, this is factually inaccurate. This number ignores benthic storms and seismic activity on the seabed floor, which significantly increase the sediment rate. Hence, we will not generate 23,000 times the rate of natural sedimentation.

The exact amount of sediment disturbance for each mining project will be confirmed by scientists as part of the Environmental Impact Assessment (EIA) before permission is granted to start mining. The sedimentation rate will depend on the particular sediment composition in an individual site and the technology used, but it is established that the Eureka Collection System generates a fraction of the sediment disturbance compared to the dredging/riser technology developed by the other DSM companies.

Myth #12: Impossible Metals AI computer vision will not work.

The AI machine/computer vision is looking for three things. The seabed, nodules, and anything else. We assume anything else is life that we want to avoid disturbing. Hence, we do not need to train the AI, nor do we need to have seen life before encountering it. As there is no light at these depths, we control the illumination with our own lights, which significantly simplifies the computer vision complexity.

Some local sediment disturbance will occur when the nodule is picked. The cameras identify the location of the nodule in front of the vehicle. The nodule's location is tracked relative to the robot through precise tracking of the vehicle position. With the nodule out of sight from the camera, because the robot's position is precisely tracked, the nodule's location is understood, enabling the arm to pick it up even without our system seeing it at the same time. With the nodule under the vehicle, the arm picks it, and any disturbed sediment is well behind the camera. Additionally, the vehicle will travel primarily into any existing current. Between the vehicle's motion and the surrounding currents, any sediment distributed under the vehicle will remain behind it.

Myth #13: Recycling, substitution, or demand reduction can replace the need for deep sea minerals.

The International Energy Agency forecasts that the secondary supply of batteries and the reuse of nickel will represent just 3% of total demand in 2030 and 10% in 2040. There just is not enough material in circulation for recycling to move the needle in the next 25 years. To help close the demand gap, mining for new metals will still be essential.

Substitutions come with severe compromises, such as reduced driving range.

Without new mineral sources, the only remaining option would be a diminished economy—families having one less car or turning off the air conditioner, or denying developing countries access to economic growth and the greater carbon intensity it brings.

Myth #14: Dark Oxygen is a reason to oppose deep sea mining

Groups opposed to deep sea mining heavily amplified the topic of dark oxygen based on a single paper. Other studies report conflicting results — for example, Paper Says Dark Oxygen Production Thermodynamically Impossible.

For more information, see question B.18.

Myth #15: The China problem for critical metals is exclusively about mineral processing

The “China problem” is that China’s overwhelming dominance in mining, mineral processing, and the manufacturing of critical metals gives it the power to disrupt or control access for the rest of the world, creating dependency risks for the energy transition, AI data centers, and defense.

China holds a dominant position in the mineral processing of critical metals; however, an increasing number of countries are restricting the export of ore, requiring that mineral processing occur within their own borders. For example, a ban prohibiting all nickel ore exports took effect in 2014 in Indonesia. As a result, China has stepped up financing and control of foreign mines, resulting in 75% of Indonesia’s nickel refining/smelting capacity as of 2023.

China now controls a vast number of mines in Africa and Indonesia, not just the mineral processing.

Myth 16: There are health risks associated with the natural radioactivity of nodules

A scientific paper shows that there are no fundamental health risks associated with the natural radioactivity of nodules. Please refer to Question B.19 for more information.

A. Market for Deep Sea Critical Minerals

A.1 Why do we need more critical minerals than what we mine on land today?

The demand for nickel, cobalt, copper, and manganese, materials crucial for producing advanced technologies in defense, energy, and infrastructure, has skyrocketed. Projections from the World Bank indicate that demand for these metals will increase by 500% by 2050, raising concerns about their availability and sustainability on a global scale. Without deep-sea minerals, 388 new mines must be built by 2030 to provide the necessary minerals to meet this demand.

A.2 Can recycling replace the need for deep sea minerals?

Recycling can be a part of the solution, as metals are highly reusable, but it is insufficient. A new electric vehicle (EV) won't be scrapped for 10 to 15 years. Its battery pack, while no longer able to power a vehicle, can last 15 to 20 years and may find a second life by storing wind or solar energy before being recycled. The International Energy Agency forecasts that the secondary supply of batteries and the reuse of nickel will represent just 3% of total demand in 2030 and 10% in 2040. To help close the demand gap, mining for new metals will still be essential.

A.3 Can reducing demand replace the need for metal mining?

Proposals to reduce demand fall into two categories:

The first category is to reduce demand by reducing car dependence in wealthy nations, which sounds doable in theory but can have significant implications for GDP and the economy. For example, in the U.S., that could require the migration of 50% to 75% of the population from rural and low-density communities to medium-density communities to take advantage of cycling, biking, walking, and mass transit. This migration would impact hundreds of millions of Americans and require significant policy, urban, infrastructure, and transportation changes that could take decades to implement and bring their own challenges.

The second proposed solution would limit access to modern technology like air conditioning (AC) and electric vehicles (EVs) in developing countries like India and in Africa. While climate change affects the entire planet, poorer countries are more severely affected, and their need for AC to reduce heat stroke and improve daily life is already significant. When Harvard China Project researchers modeled future air conditioning demand, they found an enormous gap between current AC capacity (2.8 billion people live in the hottest parts of the world, but only 8% of them have home AC) and the AC capacity needed by 2050 to save lives. In addition, a World

Bank study of 20 developing countries found that EVs would be an economic and environmental win for more than half of those countries. While it is essential to dig into how to reduce the overall demand for critical metals to attain net-zero goals, it's clear that the solution needs to be more practical and humane.

A.4 Will new battery chemistries eliminate the need for deep sea minerals?

While new battery chemistries are emerging, nickel and cobalt are likely to remain important for longer-range EVs and many non-battery uses.
Nickel and cobalt are used in many but not all battery chemistries. Today, they are mainly used in lithium, nickel, manganese, cobalt oxides (NMC), and lithium nickel, cobalt, aluminum, and oxides (NCA). Lithium iron phosphate batteries (LFP) are popular in China and do not use nickel or cobalt. However, LFP batteries are also significantly heavier, resulting in less range in an EV. Manganese-rich NMC could be a cheap alternative to LFP/LMFP, avoiding dependency on Chinese supply chains without sacrificing range. Cheaper, sustainably mined Cobalt from deep sea minerals would make high-voltage mid-nickel NMC an additional alternative. Nickel and cobalt are also used in many non-battery energy transition applications, including solar, wind, and nuclear power.

External industry analysts, such as Roland Berger, Benchmark Mineral Intelligence, etc., forecast that L(M)FP will account for around 35% of North American EV batteries in 2030. North American EVs will also use nickel-based (NMC) and iron-based (LFP) batteries. LFP is better for small pack sizes and cheaper vehicles, which are very popular in China. NMC has higher energy density and is best for long-range vehicles with bigger pack sizes.

LFP is primarily a Chinese technology today, so North America has no volume manufacturing. If you buy a car with Chinese batteries, you do not qualify for the Inflation Reduction Act (IRA)'s $7,500 tax rebate because they contain materials from a "foreign entity of concern." For example, the lowest-cost Model 3 Teslas, which use LFP batteries currently do not qualify for the credit,but the long-range vehicles do qualify, making them cheaper on an after-tax basis than the LFP-based vehicles and offering almost 100 more miles of range. LFP also has a very low recycling value. NMC has large recycling values; if you factor in the end-of-life recycling value, NMC is cost-competitive.

Finally, while additional battery chemistries are being developed today, some of which will not require nickel and cobalt, they are unlikely to make a significant impact on climate goals in the next one to two decades. It typically takes 20 years after a new battery chemistry is invented before a Western automotive manufacturer deploys it at scale. Western automotive manufacturers need many years of samples from the volume production factory before the battery cells will be qualified.

For more details, see our blog post, "Inconvenient Facts About LFP Batteries."

A.5 How long does it take for a land-based mineral deposit to get into production?

According to S&P Global, mining companies take an average of 23 years from discovery to production; in the US, it's 29 years.

A.6 Can deep sea minerals be cost-competitive with land-based mining?

Deep sea minerals will significantly lower recovery costs compared to new land-based mines. Given the high ore grade, four metals in one ore, and low infrastructure costs, deep sea minerals extracted from polymetallic nodules will be the lowest cost of all forms of mining. In addition, the ocean seabed is the world's largest source of nickel, cobalt, and manganese, and selective harvesting will have the lowest environmental impact. For more details, see this blog post, "Why Will Deep Sea Mining Be Less Expensive Than Traditional Land-Based Mining?"

A.7 Will selective deep-sea mining match the production rate of land mining?

Yes. The known reserves of Ni, Co, and Mn in the ocean are between 3x and 10x the known reserves on land. Our parallel fleet of underwater robots can collect substantial amounts of critical materials, and replication of a single project can increase productivity.

A.8 Is deep sea mining economically viable compared to low-cost land-based nickel production?

Yes, We estimate that our system will be 15x lower cost than the average nickel mine in 2024. See this blog post to learn more.

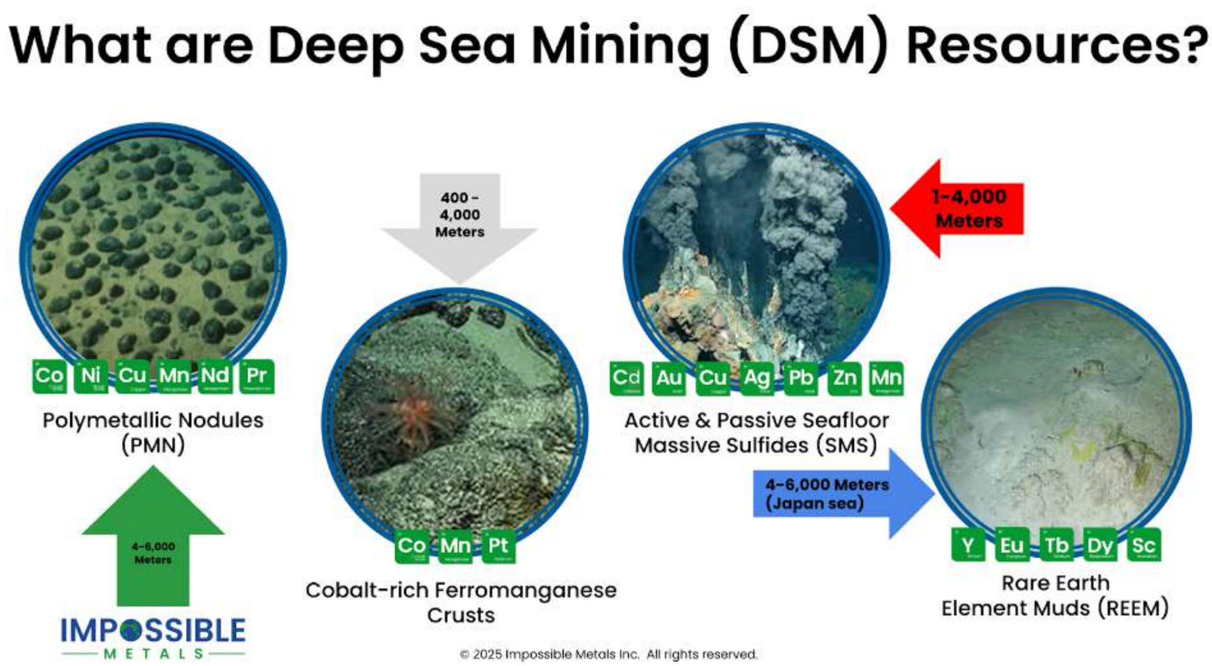
A.9 Will deep sea minerals replace new land-based mines?

Yes. Existing land-based mines will continue to operate, but new land-based mines will not open after deep sea minerals ramp into production. This is because of the cost advantages of extracting deep sea minerals, the size of the resource, and the lower Environmental, Social, and Governance (ESG) impacts.

A.10 What are the different types of deep sea minerals?

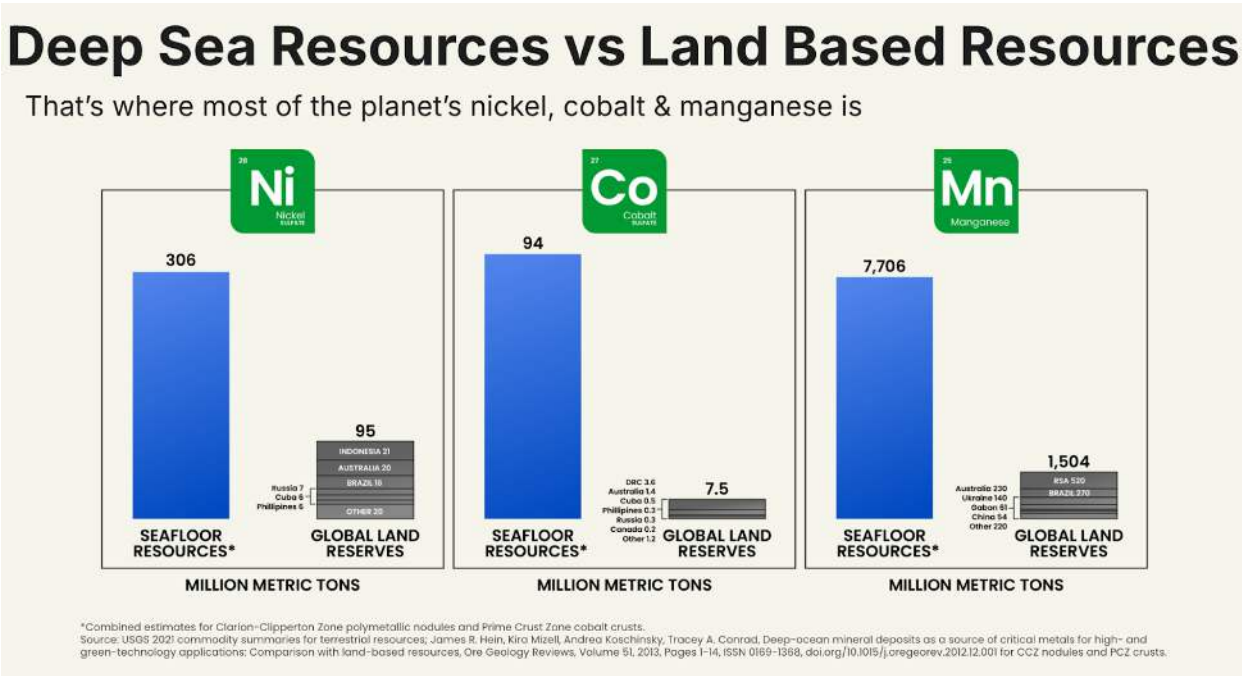
There are four potential sources of deep sea minerals: polymetallic nodules, cobalt-rich ferromanganese crusts, seafloor massive sulfides, and rare earth element muds.

Polymetallic Nodules (PMN) contain nickel, cobalt, copper, and manganese. These potato-sized rocks are found on the abyssal plains lying on the seabed sediment. They do not require cutting, blasting, or tunneling. This is the exclusive focus of Impossible Metals. Cobalt-rich Ferromanganese Crusts (CFC) mainly contain cobalt. They form on sediment-free rock surfaces around oceanic seamounts, ocean plateaus, and other elevated features. Seafloor Massive Sulfides (SMS) mainly contain copper, lead, zinc, and some gold and silver. They appear on and within the seafloor when mineralized water discharges from a hydrothermal vent. The hot, mineral-rich water precipitates and condenses when it meets cold seawater. Most proposed mining is focused on extinct hydrothermal vents. Rare Earth Element Muds (REEM) mainly contain rare earth elements in the seabed sediment.



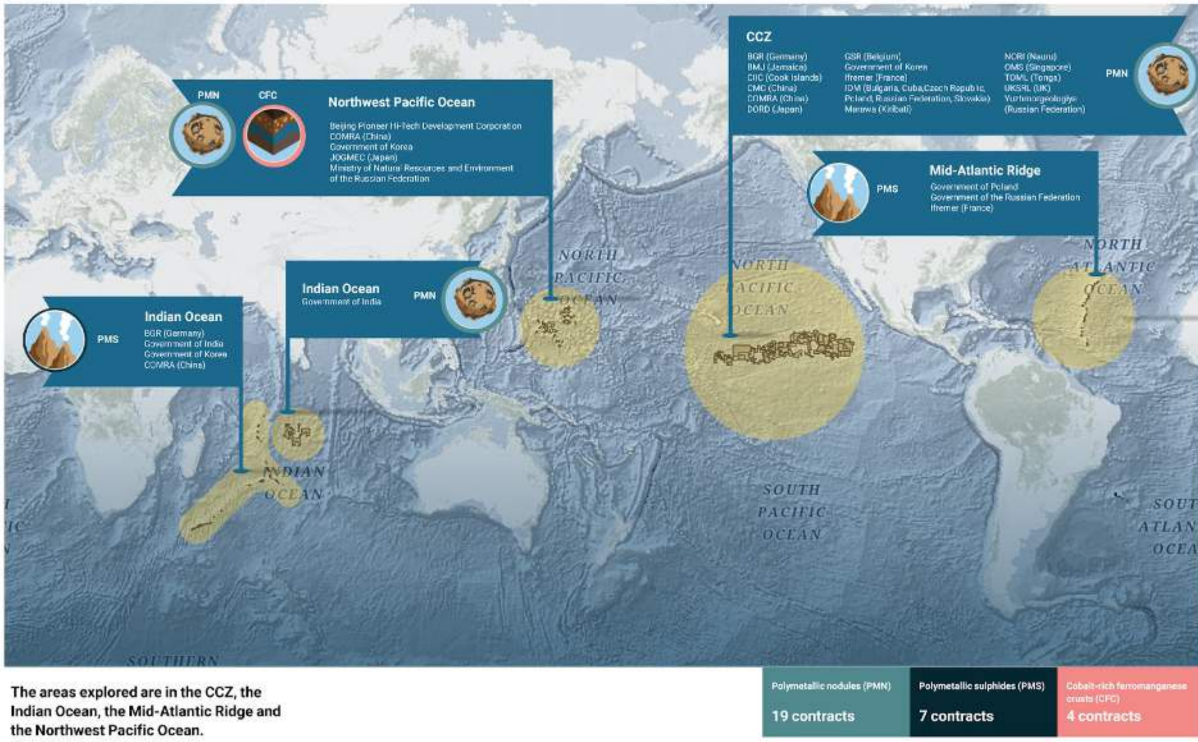
A.11 How significant are the reserves for deep sea minerals vs land-based reserves?

71% of our planet's surface area is oceans, and only 29% is land. We have mined on land since the Bronze Age, so the world's oceans contain significantly more nickel, cobalt, and manganese reserves.

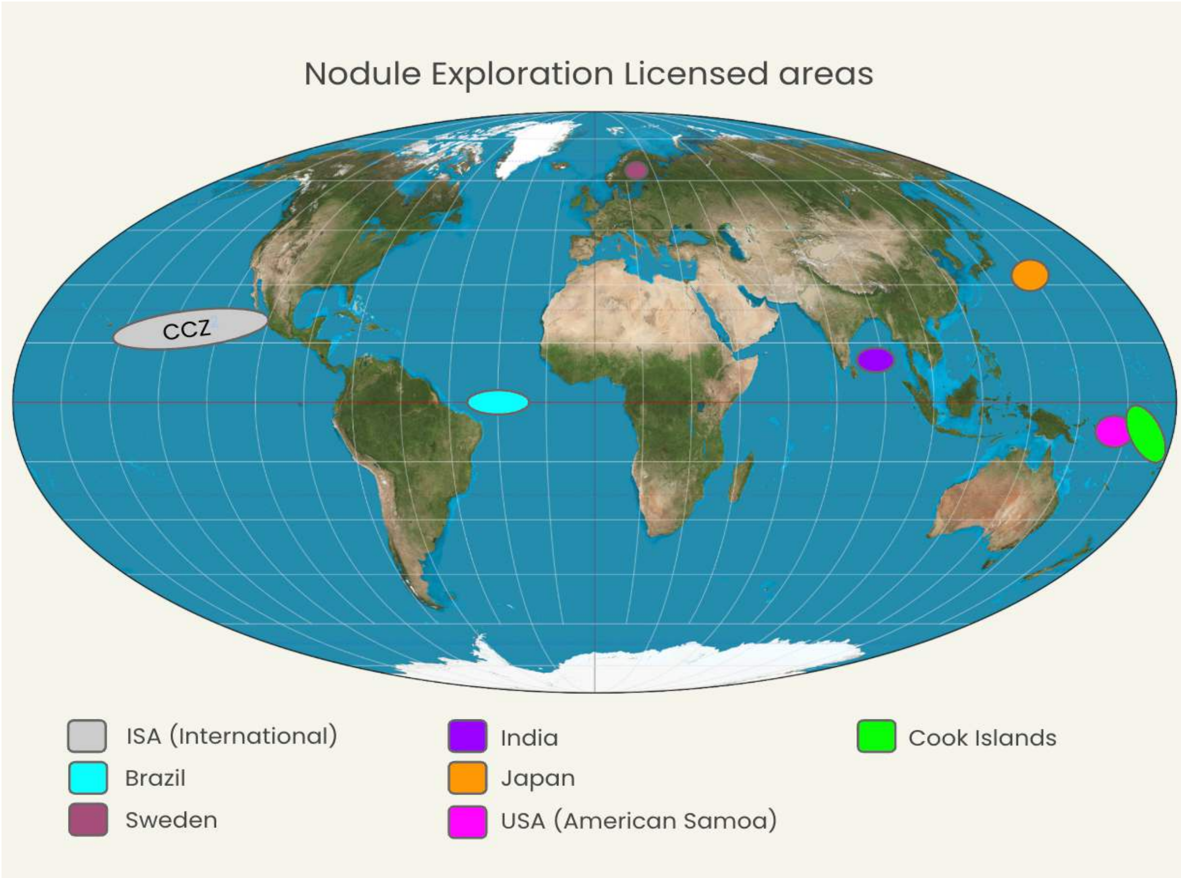


A.12 Where are deep sea minerals found?

All of the world's oceans contain deep sea minerals. The international seabed area, under ISA jurisdiction, has issued exploration licenses in the Clarion-Clipperton Zone (CCZ), the Indian Ocean, the Mid-Atlantic Ridge, and the Pacific Ocean.



Many countries contain deep sea minerals within their EEZs, such as the Cook Islands, Norway, Japan, Sweden, India, the Kingdom of Saudi Arabia, American Samoa, Papua New Guinea, Chile, the United States, Brazil, and China. See countries developing subsea minerals in their EEZs.

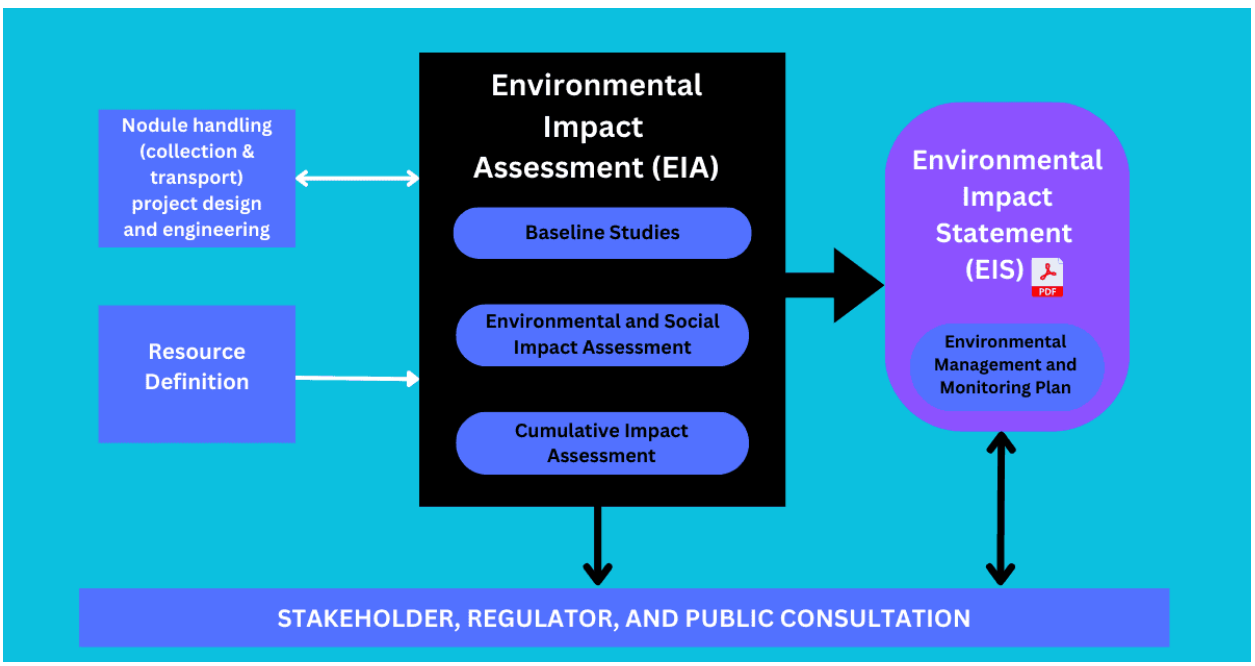

Nodule Exploration Licensed areas
CCZ
ISA (International)
Brazil
Sweden
India
Japan
USA (American Samoa)
Cook Islands

B. Environmental and Social Responsibility for Deep Sea Mining

B.1 How do we know what the environmental and social impacts will be from deep sea mining?

That is the purpose of the Environmental Impact Assessment (EIA), which must be conducted before any mining is approved. This work typically takes 3-5 years and is performed under an exploration license that does not allow commercial mining. The cost is typically around $30–80M USD and requires many baseline studies with hundreds of scientists. All this data is made public. A regulator will decide if deep sea mining can start commercial operations only after the impacts are known.

For more details on the EIA, see this blog post.



B.2 How much of the seabed will likely be mined in the next 30 years?

There are 22 exploration-licensed areas for nodules. Let's assume all areas go into production and no new areas are added. The average size of each licensed area is 75,000 sq km. Only 50% of that area is mined due to sea slopes, leaving marine protected areas. So the impacted area is approximately 22 * 75,000 * 50% = 825,500 sq km over 30 years. The total surface area of the world's oceans is approximately 361 million square kilometers. So deep sea mining for nodules will likely be just 0.23% of the world's oceans after 30 years.

In the case of Impossible Metals, we have committed to leave 30% of the nodules undisturbed by weight which is 60% by numbers, so the number would reduce to 577,850 sq km. or 0.16% of the world's oceans.

Every year, 1.4% of the ocean is impacted by trawling fishing, according to a paper published in nature.

B.3 Will carbon stored in the ocean be released into the atmosphere and have an impact due to deep sea mining?

No. Although the ocean is the largest carbon reservoir on Earth, holding significantly more carbon than the atmosphere or terrestrial biosphere, sequestering about 25% of the annual anthropogenic CO^2 emissions released into the atmosphere.

Less than 1% of the CO^2 sequestered in the ocean's upper layers reaches the deep sea floor annually. As the carbon-based organic matter sinks to the bottom of the ocean, much of it is processed before reaching the ocean floor. Due to lower productivity and reduced input of organic matter, deep-sea sediments have an overall low organic carbon content of approximately 0.05% of the dry weight of the sediment. Nodules do not sequester CO^2 and do not contain a meaningful amount of carbon. Sediment disturbed by the collector vehicle has no pathway to the atmosphere. Local sediment disturbance has shown not to rise more than a few meters, many meters away from phytoplankton, which need light for photosynthesis. Impossible Metals has no riser system with a discharge plume, so this will not impact phytoplankton photosynthesis.

Impossible Metals has committed to carbon neutrality, so we will either offset any emissions from the ships, charging of the underwater robotics, and metal refining, or use new technology to eliminate these emissions.

See more details in the ISA Fact-check 2024/1 – The carbon cycle in the Area.

B.4 Will fishing be materially impacted by deep sea mining?

No. 90% of global fishing activities are carried out within Exclusive Economic Zones (EEZ) and Extended Continental Shelf (ECS). Most deep sea mining exploration is in areas beyond national jurisdiction (‘area’), although the Cook Islands and India will have deep sea mining within their EEZ. Local sediment disturbance has been shown not to rise more than a few meters, many meters away from phytoplankton (food for fish), which needs light for photosynthesis. Impossible Metals has no riser system with a mid-water discharge plume, so this will not impact phytoplankton photosynthesis.

See more details in the ISA Fact-check 2024/2 – Status of fishing activities in the Area.

B.5 What are the environmental concerns related to deep sea mining?

There are a few categories of concerns about the potential impacts of deep sea mining. Impossible Metals’ approach from our founding has focused on removing or minimizing these concerns to create the most environmentally responsible form of mining.

1. **Loss of Biodiversity**: Identifying new species during deep sea exploration is common. These creatures may hold unknown discoveries for science or medicine, and there is concern that deep sea mining could result in their loss before we know they exist. Although “protected areas” (the ISA calls them “areas of particular environmental interest” [APEIs]) are left as non-mining areas, these protected areas are significantly distant from the mining areas, so the biodiversity in these areas differs from the mining areas.
2. **Sediment Disturbance & Pollution**: Deep sea mining may disturb sediment, which can have various impacts, such as:
    a. Disturbance of animals that live in the sediment. These are typically small (or very small) creatures that spend all or part of their lifecycle under the upper layers of the very fine deep sea sediments.
    b. When sediment is disturbed, it sinks to the seafloor, which can smother animals that cannot move out of the way, like deep sea corals.

    c. Increasing toxicity in the water can harm marine organisms and bioaccumulate/magnify. This could impact fish food sources.
    d. Potential for release of stored carbon in sediment.
3. **Noise & Vibration Disturbance**: Equipment used in the ocean may have sounds or vibrations associated with them, from the motors running dynamic positioning (DP) systems to keep ships in place to electromagnetic waves from various monitoring or communication systems. Plenty of sea creatures use particular wavelengths to communicate, like whales. Noise and vibration from deep sea mining have the potential to impact this communication, which could result in changing behaviors or migratory pathways.
4. **Light Disturbance**: The abyssal plains where nodules form are very deep (4-6 km) and, therefore, very dark. There is concern that the introduction of light sources could impact sea creatures.
5. **Loss of Hard Surface**: Polymetallic nodules often represent the only hard surface in these abyssal ecosystems, where the rest of the seafloor is composed of very fine sediment. Some animals attach to the nodules, like deep-sea corals and sponges. Other animals use the nodules to move around, similar to how it takes less energy for a person to walk on a sidewalk than on soft sand.
6. **Emission of Greenhouse Gasses:** Management of emissions will be a key task for the deep sea mining industry. Ship fuel will account for a significant proportion of emissions, providing energy for ship movement and the variety of tasks the ship will perform. This includes ship dynamic positioning (DP) and the riser system in a traditional architecture.

B.6 What is Impossible Metals' plan to protect the marine environment?

Impossible Metals was explicitly founded to address the environmental concerns surrounding deep sea mining of polymetallic nodules, so here's how we address each of the concerns listed in the previous answer:

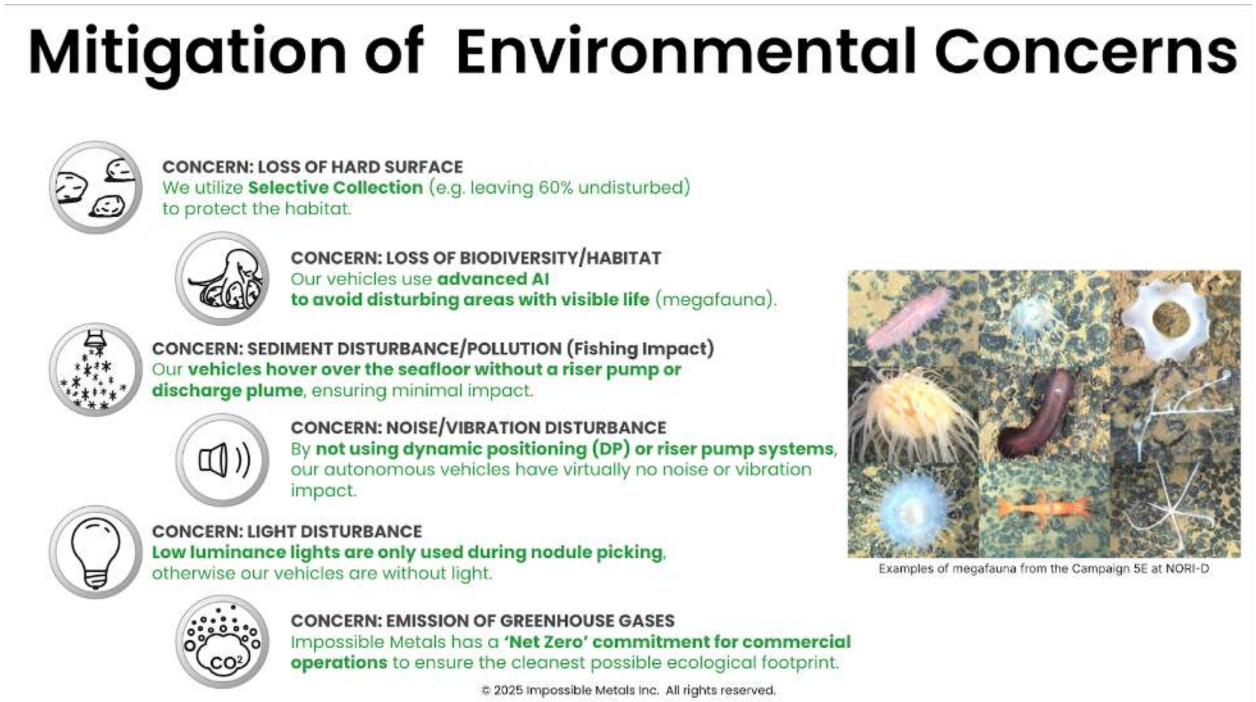
1. **Loss of Biodiversity**: By avoiding picking up visible life (megafauna) and leaving behind a percentage of nodules, our system minimizes the potential for destruction of animals for their own sake, for the ecosystem, and for any potential human uses.
2. **Sediment Disturbance & Pollution**: Our underwater robots—formally known as Autonomous Underwater Vehicles (AUVs)—have a variety of features that minimize sediment disturbance:

    a. Our AUVs hover over the seafloor so they do not disturb sediment from landing or driving over the seafloor.
    b. The buoyancy engine makes the robot positively buoyant while it hovers over the seafloor, meaning thrusters push upward, not downward into the sediment.
    c. Robotic arms/claws pick up nodules individually, minimizing sediment pickup.
    d. The AUVs move up and down the water column avoiding the need for a riser pump system and its discharge plume.

3. **Noise & Vibration Disturbance**: Our sound emissions are relatively low. Most sound subsea will come from the acoustic communication system, subsea thrusters, and buoyancy pumps. The surface sound will be from the ship and the launch and recovery operations of the underwater robot. As part of our equipment's environmental design basis, we have aimed to generate minimal sound. In particular, we have aimed for minimal sound compared to dredge-based equipment. Substantial sound comes from DP {Dynamic Positioning) ships and the riser system. We do not require DP or risers. Our sound profile is small compared to other technologies.
4. **Light Disturbance**: Today, we use visible white light. We are working with marine scientists to determine the best wavelength (color) to have the least impact. In production, we may reduce the light power by using more sensitive sensors in our cameras. We will work with scientists to measure the effect on the marine ecosystem.
5. **Loss of Hard Surface**: Selective harvesting allows us to leave behind a percentage and/or pattern of nodules that maintain the ecosystem's hard surface and avoid nodules with attached visible life (megafauna). Our current economic models assume we will leave 20% of nodules behind, but this estimate will be refined through study and discussion with scientists.
6. **Emission of greenhouse gasses:** Our plan for producing responsible metals includes a commitment to carbon neutrality. This means we will minimize emissions as much as possible and use carbon offsets for any remaining impacts. We report annually on our environmental impact. Our selective harvesting system design minimizes emissions in the following ways:
    a. AUVs are electric, and we are investigating renewable energy sources for battery charging

b. No riser pump, ship-to-ship transfer, or onboard separation of nodules from sediment and water

c. We are working on a launch and recovery system that does not require our ships to have dynamic positioning.



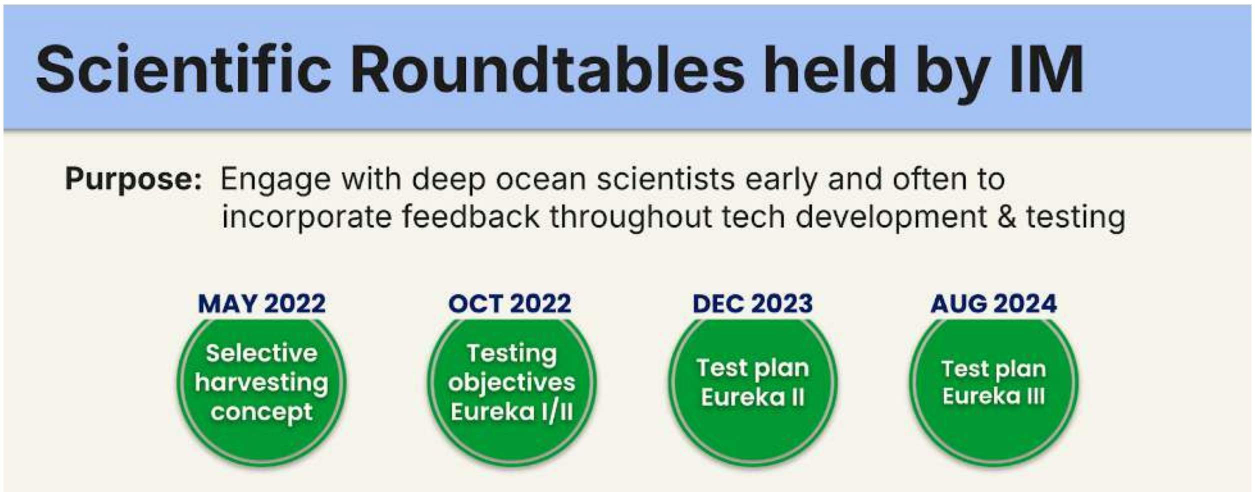
B.7 How will Impossible Metals prove selective harvesting has a lower environmental impact than competing technologies?

The only way we can prove our impact level is to collect nodules from the seafloor, so that is what we will do. We will carry out a test where our robot picks up nodules, typically called “component testing” or “test mining,” depending on scope. During this test, there will be a wide range of environmental monitoring to characterize the environmental impact, including sediment monitoring and a photomosaic with detailed imagery before and after the test. Before the test, sediment modeling will be carried out to estimate the sediment disturbance. Impossible Metals is committed to transparency about all modeling and monitoring results.

Impossible Metals is collaborating with BGR to test our hovering selective harvesting robot for collecting critical metals from the seabed. See the press release.

B.8 How does Impossible Metals work with marine scientists?

Impossible Metals started engaging with marine scientists early in our company's history, with initial discussions about selective harvesting in April and May 2022. Since then, we have continued to engage scientists to discuss vehicle testing and monitoring and will continue to carry out this engagement as we develop our technology. Additionally, we will leverage the expertise of marine scientists to monitor the environmental impacts of selective harvesting during testing. See the roundtable summaries.



B.9 What are the standards that Impossible Metals has committed to following for responsible metals sourcing?

- Protects safety and human rights.
- Are carbon neutral.
- Maximizes the potential for recycling and circularity.
- Eliminates toxic waste.
- Avoids widespread habitat destruction.
- Avoids water scarcity.
- Avoids loss of biodiversity.
- Avoids displacing Indigenous people or communities.

B.10 What data has Impossible Metals published?

Impossible Metals has published the following data to its public data folder:

- ESG Annual Reports
- Eureka I Demo Days May 17-18, 2023
- Eureka II Demo Days Nov 12-13 2024

- Eureka III BGR test in CCZ
- MediaKit
- Ocean Deployment - Public Data
- Public Presentations
- Scientific Engagement Round Table Reports
- Techno Economic Analysis (TEA)

B.11 What is Impossible Metal's commitment to the UN Sustainable Development Goals (SDGs)?

- SDG Goal 5 – Achieve Gender Equality and Empower All Women and Girls.
- SDG Goal 6 – Clean Water and Sanitation.
- SDG Goal 7 – Affordable and Clean Energy.
- SDG Goal 9 – Innovation, Industry and Infrastructure.
- SDG Goal 12 – Responsible Consumption & Production.
- SDG Goal 13 – Climate Action.
- SDG Goal 14 – Life Below Water.
- SDG Goal 15 – Life on Land.

B.12 Do we know enough about the deep ocean to start deep sea mining?

If you were to point to a random point in the deep ocean, we likely would need more information to start mining there. However, the areas proposed for deep sea mining are some of the best-explored areas of abyssal plains in the world. In international waters, at least three years of environmental baseline information must be collected, characterizing biodiversity and the ecosystem, the physical and chemical characteristics of the water and sediment, and their interactions. Some exploration permit holders have been doing baseline studies for over 20 years! For more on this topic, check out our blog, "Data from the Deep Seabed - What Do We Know?"

B.13 What are the most significant human impacts on ocean life?

Currently, deep sea mining is not occurring. Existing industries that impact ocean life are fishing (particularly bottom trawling), oil and gas, offshore wind, and shipping. Bottom trawling is of particular concern as it scrapes the ocean floor, destroying and disrupting habitats and ecosystems. Bottom trawlers catch 26 percent of the total global marine fisheries catch.

Additionally, many industries contribute to the global issue of climate change, which impacts the ocean through warming, deoxygenation, and ocean acidification.

B.14 What are the environmental & social impacts of land-based mining for nickel?

Land-based nickel mining has significant environmental impacts, with the severity varying based on the regulatory frameworks in different jurisdictions. Indonesia and the Philippines produced 58.2% of the world's nickel in 2022, largely from deposits located beneath rainforest ecosystems. In addition to environmental destruction, poor social protections put local communities at risk, including Indigenous communities, which have the right to free, prior, informed consent under the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Watch a video about Indonesian nickel mining (BBC News)

Watch a video about Philippines nickel mining (FRANCE 24)

B.15 What are the environmental & social impacts of land-based mining for cobalt?

The Democratic Republic of the Congo (DRC) supplies an overwhelming 68% of the world's cobalt and has half of global land reserves, so the significant impacts in the DRC are especially notable. Amnesty International reports that cobalt (and copper) mining in the DRC has led to *"the forced eviction of entire communities and grievous human rights abuses including sexual assault, arson, and beatings."* Additionally, it is well-documented that DRC mines use child labour. The US Department of Labor states that, "*While mining is on the DRC's list of hazardous activities for which children's work is forbidden, the majority of cobalt mining in the DRC is done informally, where monitoring and enforcement are poor."* These social issues in the DRC are compounded by environmental hazards, such as deforestation, toxic tailings, and soil erosion/degradation that further threaten human health and wellness.

To learn more, check out "Cobalt Red", a book by Siddharth Kara.

B.16 What is Impossible Metals' stance on calls for a deep sea mining moratorium, pause or ban?

We want the environmental bar to be set high and for the industry to innovate to reach it. A ban would stop innovation and remove significant funding for scientific research. It is well established that we will need a lot of critical minerals for the energy transition away from fossil fuels (e.g. IEA, World Bank Group). Deep sea mining represents an opportunity for environmentally and socially responsible access to these resources. Consumer demand for responsibly sourced materials is rising, so we should define what that looks like and empower the innovators to do their work. We also feel that a holistic approach to critical minerals is required. A deep sea mining moratorium, pause, or ban would only result in more land-based mining impacts and will make it impossible to achieve Net-Zero by 2050.

B.17 NGOs cite that many countries and companies have signed up for a moratorium, pause, or ban. What is Impossible Metals' view on this?

A number of countries are listed as having signed up for a moratorium, pause, or ban. Although these countries may have made public statements, the vast majority have not passed legislation. In fact, these countries have signed UNCLOS, which legally commits them to deep sea mining regulated by the ISA. Some of these countries have sponsored exploration applications. If they legally supported a moratorium, pause, or ban, they would be in violation of their legal obligations and could lose their exploration areas.

A number of companies are listed as having signed up for a moratorium, pause, or ban. The wording says, “Before any potential deep seabed mining occurs, it needs to be clearly demonstrated that such activities can be managed in a way that ensures the effective protection of the marine environment.” This is the purpose of the Environmental Impact Assessment (EIA), which must be approved by the regulator before any mining can start. After a regulator approves an exploitation application, the EIA will provide for protecting the marine environment. So, any companies that have signed the moratorium will be free to purchase deep sea minerals. Also see this blog post for more information.

B.18 What is your view on the dark oxygen paper?

We are well aware of this. In fact, Andrew Sweetman, the lead author of the paper, participates in our scientific roundtables, where we regularly engage with the scientific community and they provide input on our approach. The topic of dark oxygen was heavily amplified a year ago by groups opposed to deep sea mining, based on a single paper.

It is potential discoveries like this one that really highlight the regulatory value of the Impossible Metals approach with our Eureka collection system. Our ability to leave undisturbed high proportions of nodules, which maintain all functions of the ecosystem, including dark oxygen, if proven to be true.

There are several scientific rebuttals and critiques to the dark oxygen paper:

- Critical Review of the Article: “Evidence of Dark Oxygen Production at the Abyssal Seafloor” by Sweetman et al. in Nat. Geosci. 1–3 (2024)
- Rebuttal of Sweetman, A.K., Smith, A.J., de Jonge, D.S.W. et al. Evidence of dark oxygen production at the abyssal seafloor. Nat. Geosci. (2024)
- Extraordinary claims require extraordinary evidence: evaluating nodule-associated dark oxygen production

B.19 What is the radiation exposure of polymetallic nodules?

The Federal Institute for Geosciences and Natural Resources (BGR), in collaboration with external experts, has assessed potential health risks associated with the natural radioactivity of polymetallic nodules. According to the EU Radiation Protection Act, it is the effective body dose under realistic working conditions, rather than the activity concentration, that is decisive for assessing the actual risks posed by natural radionuclides in polymetallic nodules. The new investigations show that there are no fundamental health risks associated with the natural radioactivity of nodules.

For more details, please see this paper published in Nature: Estimations of effective doses received from naturally occurring radioactivity in polymetallic nodules from the deep sea.

C. Deep Sea Mining Regulations

C.1 Is deep sea mining happening right now?

The exploration phase of collecting deep-sea minerals has begun. So far, no commercial collection has taken place in the deep sea. To date, approximately 40 exploration licenses have been awarded: 31 by the International Seabed Authority (ISA) and the remainder by different governments within their exclusive economic zones (EEZ). There are 22 exploration resource areas for nodules: 19 from the ISA and 3 from the Cook Islands.

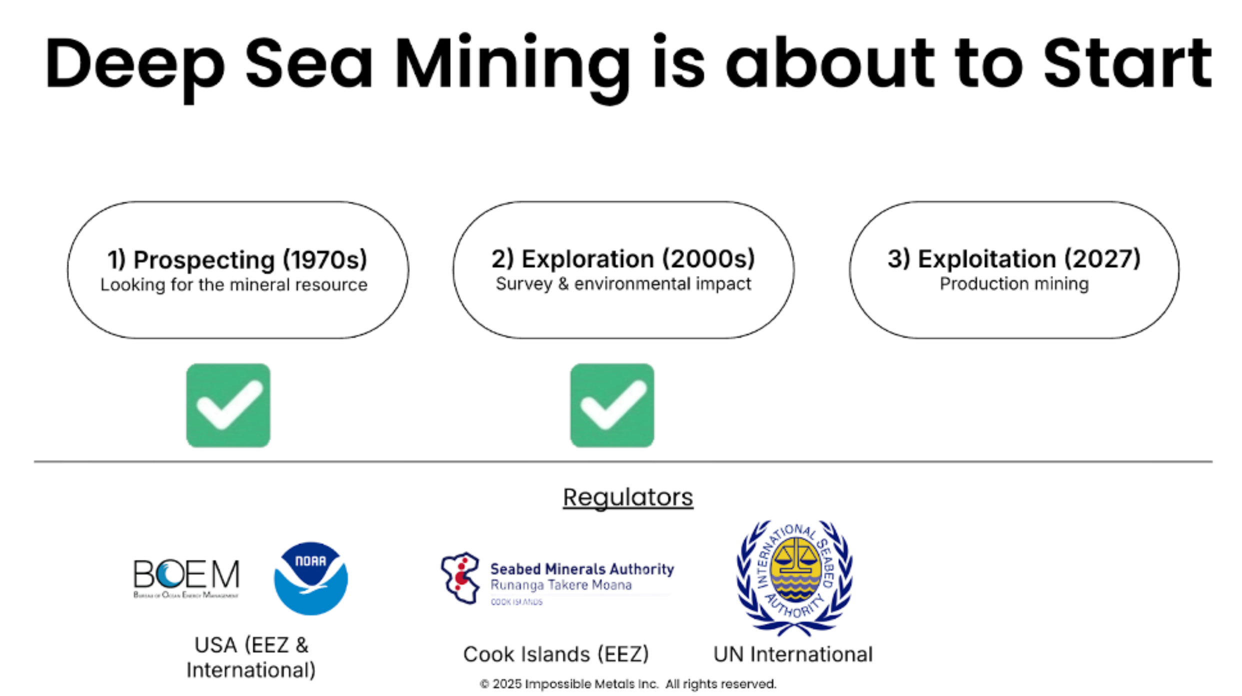
C.2 Who regulates deep sea minerals?

Individual countries govern the deep sea minerals within their EEZs. In international waters, deep sea minerals are governed by the United Nations (UN) through the "United Nations Convention Law Of the Sea (UNCLOS)." 169 countries, including the European Union, are signatories of UNCLOS. UNCLOS is controlled and enforced by the International Seabed Authority (ISA), an autonomous organization within the United Nations common system. For more details, please see the blog post "Current Status of Deep Sea Mining Regulations."

C.3 What is the current status of deep sea mining regulations?

Exploration regulations have been in force for many years. Exploration includes analyzing deposits, testing systems, and equipment, and completing environmental baseline, scientific, technical, and economic studies; no commercial activity is permitted under exploration.

Exploitation (commercial mining) regulations have been under development for many years. The ISA has stated that the exploitation regulations will be adopted in 2025. Multiple countries, including the Cook Islands, have awarded exploration licenses within their exclusive economic zones. For more details, please see the blog post "Current Status of Deep Sea Mining Regulations."



C.4 Does a comprehensive baseline have to exhaustively measure every ecosystem component and solve every aspect of ocean science? If so, how can this be achieved in 3–5 years?

No. No single baseline for any development project can hope to solve ocean science and answer every question. A baseline project is not an unbounded ocean research exercise. The scope of a baseline project is defined by an EIA Scoping Study that identifies the parameters essential to assessing impacts and that directly connect to monitoring key indicators. However, there is an interface between a baseline project and regional and global ocean science objectives. By aggregating results across several individual baseline projects using consistent methods, regional assessments are made, and by integrating across information sources, the knowledge of global ocean science is improved. Publishing the objective findings of baseline studies is a key global knowledge enhancement process.

C.5 How are nodule-rich areas mapped and identified?

Nodule-rich areas are mapped and identified as part of the mining prospecting and exploration phase (not our focus). A traditional AUV with wideband sonar and box core samples performs the mapping. The essential data is nodule abundance measured in kg per square meter and metal grade. The metal grade is by collecting multiple box core samples and sending the nodules to the lab to measure the ore grade. Multiple NI-43-101 resource estimations have been completed for deep-sea minerals. The resource estimations are much more complex on land as the resource is three-dimensional compared to two-dimensional on the seabed. Holes are drilled, and an estimate of the three-dimensional resources is calculated.

C.6 How much does it cost, and how long does it take to run the Environmental Impact Assessment (EIA) program for deep sea mining?

Collecting and analyzing the data and writing the Environmental Imspact Statement (EIS) report typically take three to five years. This is the primary purpose of the exploration license, which typically costs around $30–80M.

C.7 Do stakeholders and the public get a say in the EIA?

Yes. Stakeholders are engaged throughout the EIA process. EIS submission typically involves a public consultation period during which any parties can provide comments registered by the regulator and proponent and require assessment.

C.8 What else does an EIS (Environmental Impact Statement) contain?

Additional elements of an EIS include stakeholder consultation outcomes, Environmental Management and Monitoring Plans, closure plans, and adaptive management measures. An EIS typically assesses project alternatives and states the no-development case. A level of Cumulative Impact Assessment (CIA) is typically required.

For more details on the EIA, see this blog post.

C.9 If EIAs are paid for or authored by the proponent, can they be objective and trusted?

Yes. Environmental Impact Assessment (EIA) is a branch of environmental science performed by objective professionals with the necessary qualifications and experience. Given the oversight in modern EIA practice, project approvals do not benefit from poor-quality EIAs or overt client advocacy. EIA specialists do not engage in client advocacy. Furthermore, independent reviews, panels, committees, and hearings are standard practices in EIA.

C.10 Once an EIA is submitted, is the regulatory body forced to award an environmental permit?

No. The award of an environmental permit is contingent on a variety of factors. These include the comments from the public consultation period, independent reviews, and regulators' internal assessment processes.

C.11 Can a contractor do whatever they want if an environmental permit is awarded?
No. The permitting process involves setting a range of conditions. Permit conditions can include a range of measures, including additional studies, revised modeling, additional monitoring requirements, etc. Regular reporting and independent monitoring are also part of the checks and balances applied.

C.12 Does approval require consensus?
No. EIS does not seek consensus among all parties, and the award of an environmental permit does not require a response to every public comment on every topic.

C.13 When do you expect exploitation contracts to be awarded?

Exploitation regulations are in the final stages of being adopted by multiple regulators. It is anticipated that the earliest date an exploitation contract could be awarded and production mining started is 2027.

C.14 Why has the United States not ratified UNCLOS?

169 countries, plus the European Union, have ratified UNCLOS. This represents 7.5 billion people (93%) of the world's population. In the United States, there has been a vigorous debate over the treaty's ratification, with criticism primarily coming from political conservatives who raised concerns about the Convention's impact on U.S. sovereignty.See more details in the 60 minutes TV program from March 2024.

C.15 Will there be a royalty for deep sea mining?

Yes. All mining typically has a royalty, paid for access to the resource. The ISA Finance Committee is working on equitable finance sharing from deep seabed mining. This is likely to result in a royalty. See the blog post "For All Mankind: How Deep Sea Minerals Could Pay Children in Africa to Go to School Instead of Mining" for more information.

C.16 What deep sea mining legislation has been passed?

- US Outer Continental Shelf (OCS) Lands Act, 1953
- US Deep Seabed Hard Mineral Resources Act (DSHMRA), 1980
- International UNCLOS, 1982
- India Offshore (Development and Regulation) Areas Mineral Act, 2002
- Cook Islands, Seabed Minerals Act, 2019

D. Impossible Metals Technology

See a video walkthrough of Eureka II here:

Eureka II Walkthrough tour by Jason Gillham our CTO/COO & Co-Founder

D.1 How is Impossible Metals technology different from others?

Impossible Metals leverages advanced autonomous robotics and AI to conduct selective deep-sea mineral collection with minimal environmental impact. At the core of our system is the Buoyancy Engine, which enables dynamic control of vertical position and achieves true neutral buoyancy. This eliminates the need for downward thrusters that disturb sediment and marine life. The Buoyancy Engine powers the Eureka Collection System, our robotics architecture for low-impact deep-sea operations.

Built on that foundation, the Eureka Collection System is a scalable fleet of autonomous underwater robots designed to collect nodules individually, without direct contact with the seafloor. This system sets a new technical standard for environmentally selective mineral access in the deep ocean."

A list of deep sea dredging tractors + Eureka II AUV is here.

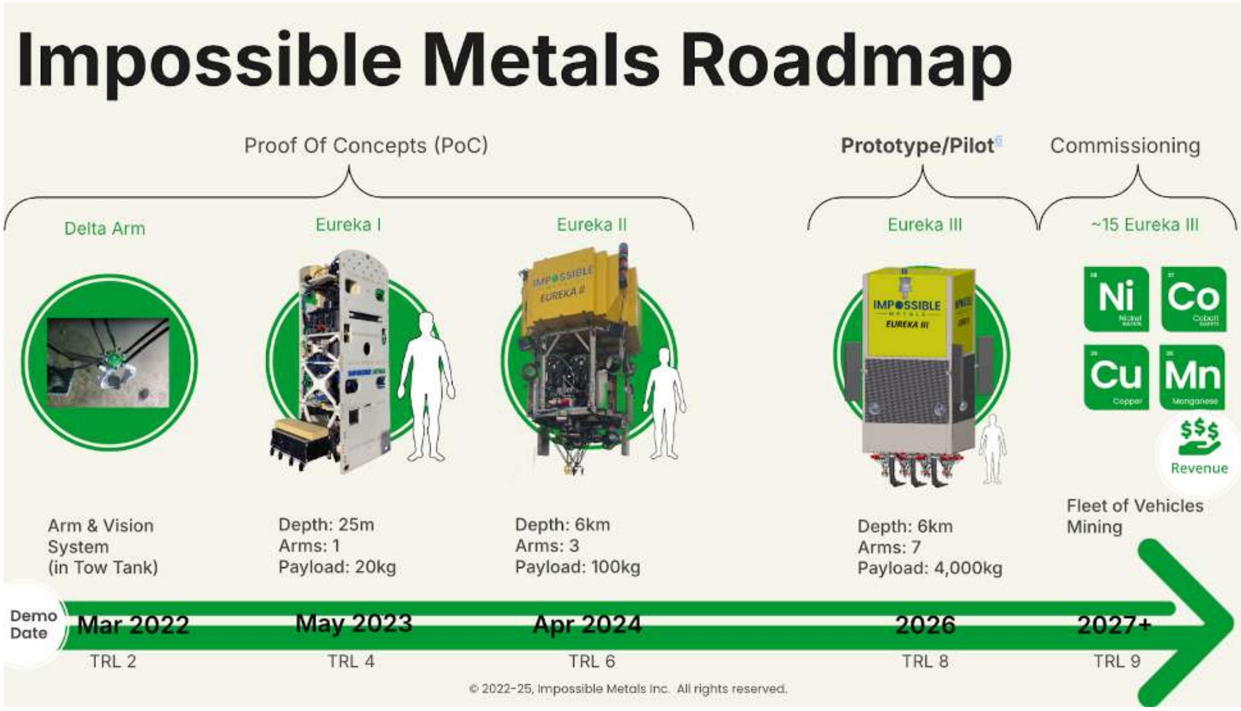
See this video: Compare Impossible Metals vs Conventional Dredging for Deep Sea Mining

D.2 What technical risks do Impossible Metals still have to mitigate?

Our primary technical risks include ensuring the durability and resilience of our robots in harsh underwater conditions, refining our AI algorithms for optimal target identification and resource recovery, and maintaining reliable communication systems between our robots and surface operations. We are actively working on mitigating these risks through rigorous testing, continuous improvement, and strategic partnerships with leading technology providers.

D.3 When will your technology be ready for commercial mining operations?

Our technology will be ready for commercial mining operations by 2027. As of mid-2025, we are in the final stages of testing and validation, ensuring our systems meet all performance requirements. We also engage with potential customers to align our development with market needs and expectations. We have also completed the design of Eureka III, the full-size production system.



D.4 How do you scale to high rates of production?

D.4 has moved to Section I.

D.5 How reliable will your technology be?

Reliability is a cornerstone of our technology development. Our robots are designed with multiple fail-safes, redundancy systems, and real-time monitoring capabilities to ensure consistent performance in various underwater conditions. We conduct extensive testing under simulated and real-world conditions to validate the reliability and durability of our systems.

See also this blog post: Prioritizing Reliability: Reducing the Mean Time Between Failures.

D.6 How do you deal with the complexity of your technology?

We address the complexity of our technology through a modular design approach, enabling easy maintenance and upgrades. Our interdisciplinary team of experts continuously collaborates to integrate cutting-edge robotics, AI, and marine engineering advancements.

D.7 How is the robot (AUV) controlled?

A mission plan is uploaded to each robot before deployment. The robot is fully autonomous and completes the mission plan based on sensors and programming. The robot's progress is monitored through an acoustic modem (USBL) that tracks the robot's position and provides low bandwidth status information. The fleet management software on the surface will automatically send essential speed and course adjustment information to the robots in the water to support synchronization of the robotic vehicle launch and recovery. Additionally, the operator on the surface vessel can provide override commands when required.

D.8 Why is your underwater nodule collection robot untethered?

To allow many robots to operate in parallel, we need to eliminate the need to manage a tether (cable) to each of the robots. Each robot is battery-powered.

D.9 What are the size ranges of nodules that the underwater robot's robotic arms pick up?

D.9 has moved to Section I.

D.10 How does the underwater robot maintain its position and orientation on the ocean floor? What technologies facilitate the underwater robot's underwater navigation and mapping?

The underwater robot incorporates several standard environmental awareness sensors, such as DVL (Doppler Velocity Log), pressure sensors, USBL (ultra-short baseline), and Stereo Cameras, which are fed into the INS (inertial navigation system), where the information is fused to develop a state estimation for the AUV. As multiple AUVs begin to operate concurrently, a dynamic LBL (Long BaseLine) positioning approach will also be employed.

More information about subsea positioning

The state estimation accuracy for the AUV will be highest at the seafloor, where it is in proximity to other AUVs that have maintained a high accuracy, and near the surface, where it is close to the surface vessel-based USBL. When at the surface, the position will be based almost exclusively on USBL. When at the seafloor, the dynamic LBL combined with DVL and vision tracking of the seafloor will dominate. The stereo cameras on the front of the AUV map out the locations of any nodules and any macro life for the arm control algorithms to determine how to handle them.

D.11 How does the underwater robot adapt to changing seabed topography during its mission?

As the underwater robot travels through the mission, it adjusts the operating mode from having a desired depth while it travels down through the water, and then, as the acoustic sensors and optical sensors begin to observe the seafloor, the vehicle autonomously transitions to altitude control. Altitude control will be active while collecting nodules. The vertical thrusters adjust the force they exert to maintain the set altitude for the AUV over the seafloor. As nodules are collected, the buoyancy engines on board the AUV pump water out of the tanks to maintain the same small desired downward force from the vertical thrusters.

The seafloor's typography, where we will collect nodules, gradually changes, and the vehicle travels relatively slowly. A forward-looking sonar provides feedback to the system for topography changes that are too much for the vertical thrusters to manage.

D.12 How will multiple underwater robots coordinate to avoid overlapping or interfering with each other's missions and paths?

Each underwater robot will be provided with a mission as part of pre-launch communications. Through the ship-based USBL and seafloor dynamic LBL positioning, the robot will move to the desired target starting location. At the start and end of each path, the robot will perform a small visual survey. When arriving at the start of a run, the robot will survey the area briefly to ensure that the positional alignment of the new path is correctly positioned relative to the start or end of the robot from past paths. It will use the distinctive pattern of nodules in the survey as a fingerprint to understand any centimeter-level misalignments that the navigation system is experiencing relative to the navigation system from other robot trips to the same location.

D.13 What is the typical operational lifespan of the underwater robot?

D.13 has moved to Section I.

D.14 What factors influence the lifespan of an underwater robot, and how can it be extended?

D.14 has moved to Section I.

D.15 How is the mission assigned to the underwater robot?

Before deployment, the mission is wirelessly uploaded via WiFi to the underwater robot while on deck. During operation, deviations from this initial plan can be uploaded to the robot via the acoustic link. The plan that is initially uploaded and the following deviations are provided by the master software, which is constantly developing updated operational optimization.

D.16 What is the efficiency of the underwater robot's collecting system?
D.16 has moved to Section I.

D.17 How are the underwater robot's lithium-ion batteries recharged? What is the power source?

Today, we use a diesel generator to recharge the batteries. In our economic model, we capture the carbon from the diesel generator or pay for carbon offsetting. In the long term, we will look for a renewable power source, such as waves, wind, etc.

D.18 How will the underwater robot respond to emergencies or system failures?

The response of the underwater robot depends on the nature of the emergency or failure. Awareness of emergencies and failures external to the individual robot will be communicated acoustically through the USBL, and the updated desired behavior of the robot will react accordingly. For example, suppose the surface vessel becomes unavailable due to incoming weather conditions or an onboard emergency such as a fire. In that case, the communication signal will be sent to the robot to change its course or hold in place until the weather has passed or operations can be resumed in extreme cases with the second ship in the operations.

For small internal failures to the robot, such as loss of connection to certain computers or components, an isolated power reset will occur to re-establish the connection. If the error persists, the mission will abort. Other small failures, for example, could be a break to an arm, and in these cases, the robot is expected to complete the mission and have the damage repaired at the surface.

Each vehicle has a high degree of redundancy, and there are limited single points of failure. An example of a failure that will result in an aborted mission and an emergency ascent is if a leak detection sensor is triggered.

A final active emergency response if the robot is not rising to the surface due to loss of power to achieve this or for any other reason, it will release the load in the hopper; actively attempted if control electronics and power are available or triggered passively using a time delay corrosion fuse that will release the load after approximately 1.5 weeks have passed.

In all cases, a locating beacon on a separate power supply will ping to inform the surface ship of its position if the beacon loses communication with the rest of the vehicle.

See also D.32 How long can the robots remain underwater to deal with weather and emergencies?

D.19 Are there any specialized tools or equipment for the maintenance of the underwater robot?

While no substantially specialized tools are required for maintaining the underwater robots, while onboard the vessel, it is impossible to travel to the hardware store to pick up what is needed, so a complete set of required tools and redundancies will be available on the vessel.

D.20 Are there any limitations to the large-scale deployment of underwater robots?
No, the limitation of our operations is the rate at which the underwater robots are lifted onto the vessels. By increasing the number of vessels concurrently operating, the number of underwater robots doesn't have limitations.

D.21 What is the data storage capacity of the underwater robot?

Many terabytes of storage will be available onboard the underwater robots, providing more data storage capacity than is required. Additionally, redundancy will be in place to protect against corrupted drive failures.

D.22 What communication protocols enable data exchange between the underwater robot and its mothership/operating center?

An acoustic link (USBL) transmits basic telemetry and status information between the underwater robots and the surface ship. Due to the low bandwidth of the acoustic link, we are limited in terms of what data is transmitted while the robots are submerged. Once a robot has surfaced as part of its on-deck servicing, the onboard data is transferred off the robot and into the on-ship data center. Data is exchanged between the ship and the cloud-based servers via TCP/IP connection over satellite. Lastly, upon arriving back at port, any data that has not been wirelessly transmitted into the data center is physically connected and transferred into the data center. A prioritization scheme will be developed to transfer the most critical information first.

D.23 What recovery protocols are in place if the underwater robot loses communication with the operating center?

The mission is downloaded to the underwater robot at the start of the mission. We don't need real-time communication. In an emergency, the robot will go to the surface and use WiFi or satellite communication to communicate with the operating center.

D.24 What will the effect of temperature and salinity be on the underwater robot?

Temperature and salinity at the depths at which we operate are very consistent. This impacts the index of refraction for our optical and acoustic systems, and variation in these values at the depth and through the water column is compensated for during operation.

D.25 How do harsh marine weather conditions affect the reliability and efficiency of underwater robot deployment and recovery operations?

A common practice for docking autonomous underwater vehicles is securing them below the water's surface so surface waves do not impact them and changing weather conditions. We are using this approach for the underwater robot's recovery operations.

Our techno-economic models assume 40 days a year when we are in a ‘weather hold’ condition and cannot operate.

D.26 How does the underwater robot withstand extreme ocean pressures?

We design for this using pressure vessels to protect the components and, in other cases, oil-compensate when the internal electronics are pressure tolerant but need to be isolated from the seawater. These are both common techniques for design in underwater robots.

D.27 How does the underwater robot's design and propulsion system handle strong ocean currents?

From the extensive exploration data, we know that there are very few currents in the deep ocean. We have thrusters and control surfaces for navigating the underwater robot in the water column. Also, in the mission control software, we receive the sensor data in real-time via USBL and update the mission parameters.

D.28 What is the accuracy and resolution of the vision system?

At the altitude of 1 meter where we are currently operating, the resolution ranges from 1.25 mm to 0.38 mm on the seafloor, depending on which camera and where in the camera field of view is being considered. The goal for the vision system is to detect life larger than 1 mm with 95% accuracy.

D.29 How does the underwater robot vision system adapt to underwater environments such as turbid water, varying seabed types, etc?

The nodule location is a consistent environment with a flat seabed and clear water. The underwater robot does not need to adapt to different environments autonomously. The size and shape of the nodules can vary from one region with nodules to another, and the algorithms for these new environments will need to be adapted. Still, this adaptation takes place at the development level, not in the autonomous behavior of the underwater robot.

D.30 Won't local sediment disturbance obscure the vision system from identifying nodules and life on the nodules?

The design of the robotic arms, the claw, the arm's movement, and the claw's position on the nodule are optimized to minimize local sediment disturbance. Even so, some local sediment disturbance can occur when the nodule is picked. The cameras identify the location of the nodule in front of the vehicle. The nodule's location is tracked relative to the robot through precise tracking of the vehicle position. Even with the nodule out of sight from the camera, because the robot's position is precisely tracked, the nodule's location is understood, enabling the arm to pick it. With the nodule under the vehicle, the arm picks it, and any disturbed sediment is well behind the camera. Additionally, the vehicle will travel primarily into any current that exists. Between the vehicle motion and the surrounding currents, any sediment distributed under the vehicle will remain behind the vehicle.

D.31 How can you scale to millions of tons of nodules?

D.31 has moved to Section I.

E. Transport Vessels

E.1 How is the payload secured and stabilized on the ship once off-loaded from the AUV?

Nodules are offloaded from the AUVs into storage onboard the vessel. The current economic models assume the use of bulk ore transport vessels. We continue to explore alternative novel methods, such as containerizing the nodules onboard the vessel. This method could eliminate vessel stability concerns related to liquefaction of the load. This also provides economic benefits, increasing the number of ports where the nodules can be transported.

E.2 Are there backup systems for critical functions?

Yes, a minimum of two vessels operate in the field, and while one is transiting to port, the other is servicing the robots. This inherently provides a level of redundancy if critical systems for one of the vessels take one ship out of operation. Additionally, parallel operations on each vessel are planned, with 36 launch and recovery systems on board each vessel and parallel materials handling equipment on each vessel, eliminating single points of failure.

E.3 Are there any alternative or renewable energy sources to power the vessels?

We hope so, and our architecture and commercial model for the vessels enable us to use the best available technology. People are working on batteries, Hydrogen, and Ammonia energy systems for ships. Others are working to capture the carbon from the engines. We will adopt the best technology that is available.

E.4 Do you require dynamic positioning (DP) vessels?
Our current expectation is that some level of DP may be needed, and we continue to reduce this requirement with a target to minimize the use of this capability and ideally eliminate the need for installation of this capability. Our smart launch and recovery system (SLARS) has been designed with self-mobility of the hook to engage with the AUVs at a distance from the ship, enabling the potential for minimal use and capability of the ship's DP, and potentially the elimination of this functionality altogether.

E.5 Does Impossible Metals architecture require a production support vessel?

No. We avoid the cost and complexity of a production support vessel (PSV). Impossible Metals retrofits our smart launch and recovery system (SLARS) to the transport vessels. This has a massive saving in costs.

E.6 Does Impossible Metals require a ship-to-ship transfer in the ocean?

No. As we do not require a production support vessel (PSV) we do not need to do the following transfers to the Shuttle Transport And Resupply Ship (STARS):

- Transfer of nodules from the PSV
- Transfer of fuel to the PSV
- Transport of equipment, and provisions to the PSV
- Transfer of personnel to and from the PSV per crew rotation.

This will be very expensive, and there are safety concerns. It will also reduce the number of days a year the mining operation can operate.

For more details, see STARS; the missing link in dsm supply chain.

E.7 How many days a year do you expect to be collecting?

E.7 has moved to Section I.

F. Impossible Metals Company

F.1 When was Impossible Metals incorporated?

Impossible Metals was incorporated in 2020 as a Delaware B Corporation, a public benefits corporation ("B Corp").

F.2 What is Impossible Metals' public benefit?

The corporation's specific public benefit purpose is to deliver responsibly mined and processed battery metals to the market in a manner that promotes sustainability, transparency, and accountability and to render a public benefit by accelerating the world's transition to sustainable energy to mitigate the climate crisis.

F.3 What is Impossible Metals' vision?

Accelerating clean energy by delivering the most sustainable critical metals.

F.4 What is Impossible Metals' mission?

To harvest and process critical metals from the seabed while protecting the environment.

F.5 What are Impossible Metals' Core Values?

1. Planet comes first: environment and people before profit.
2. We are determined, striving to make the impossible possible.
3. We encourage, share and respect all perspectives.
4. We move fast, separating what must be done now from what can be improved later.
5. We embrace and learn from every success and failure.
6. We act as owners, managing resources responsibility and efficiently.

F.6 How much seed funding has Impossible Metals raised to date?

Around $15M. We closed our seed round in May 2022 of $10M and pre-seed round of $2M in September 2021.We have also received government grants and additional investor funding.

F.7 Who are Impossible Metals' investors?

Chalet, Y Combinator, Justin Hamilton, and many smaller funds and individuals.

More details: https://impossiblemetals.com/about/partners/

F.8 Where is Impossible Metals based?

HQ: San Jose, CA, USA

Research and development centre: Collingwood, ON, Canada

F.9 Who are the leadership and board members of Impossible Metals?

See the leadership team here.

See the board members here.

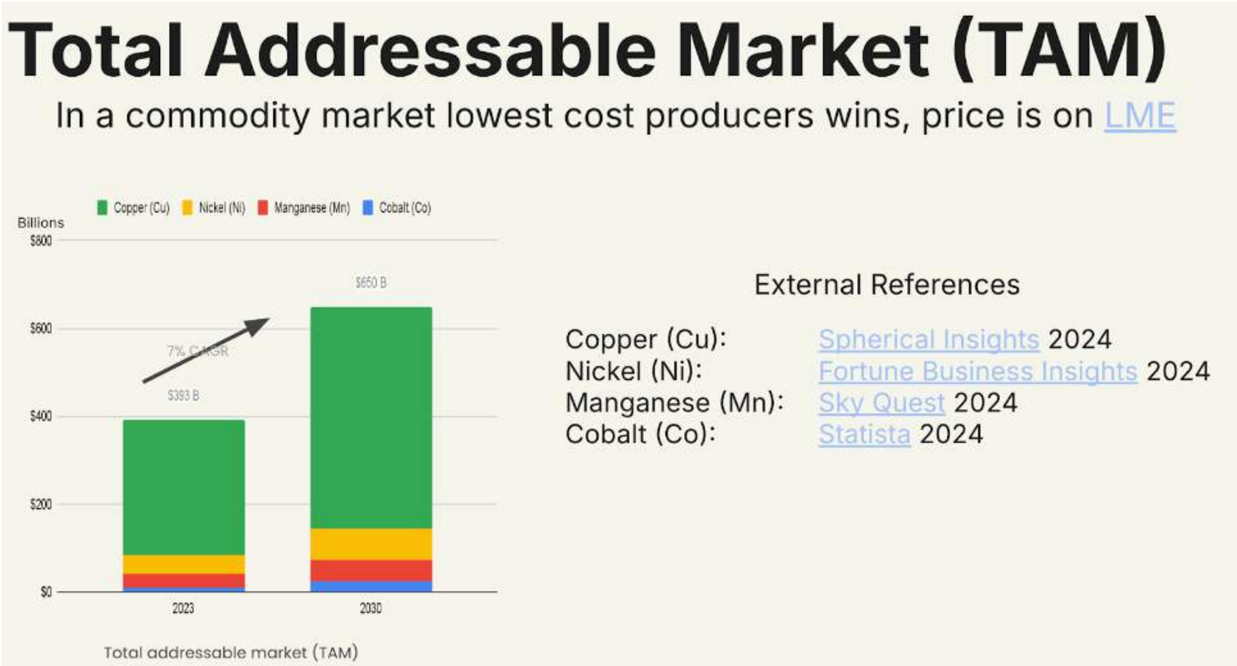
F.10 What is Impossible Metals' business model?

Impossible Metals intends to partner with companies that hold deep-sea mineral exploration areas, leverage third parties to process (refine) the metals and sell the resulting offtake. In the longer term, Impossible Metals intends to apply for its own exploration areas.

F.11 What is the total available market (TAM) for Impossible Metals?

Polymetallic nodules contain four metals (nickel, cobalt, copper, manganese). The TAM for the four metals in 2023 was $393B per year, and will be $650B in 2030. The market is growing at a compound annual growth rate (CAGR) of over 7%. External references:

Copper (Cu):	Spherical Insights 2024
Nickel (Ni):	Fortune Business Insights 2024
Manganese (Mn):	Sky Quest 2024
Cobalt (Co):	Statista 2024



F.12 What happened to the mineral processing team?

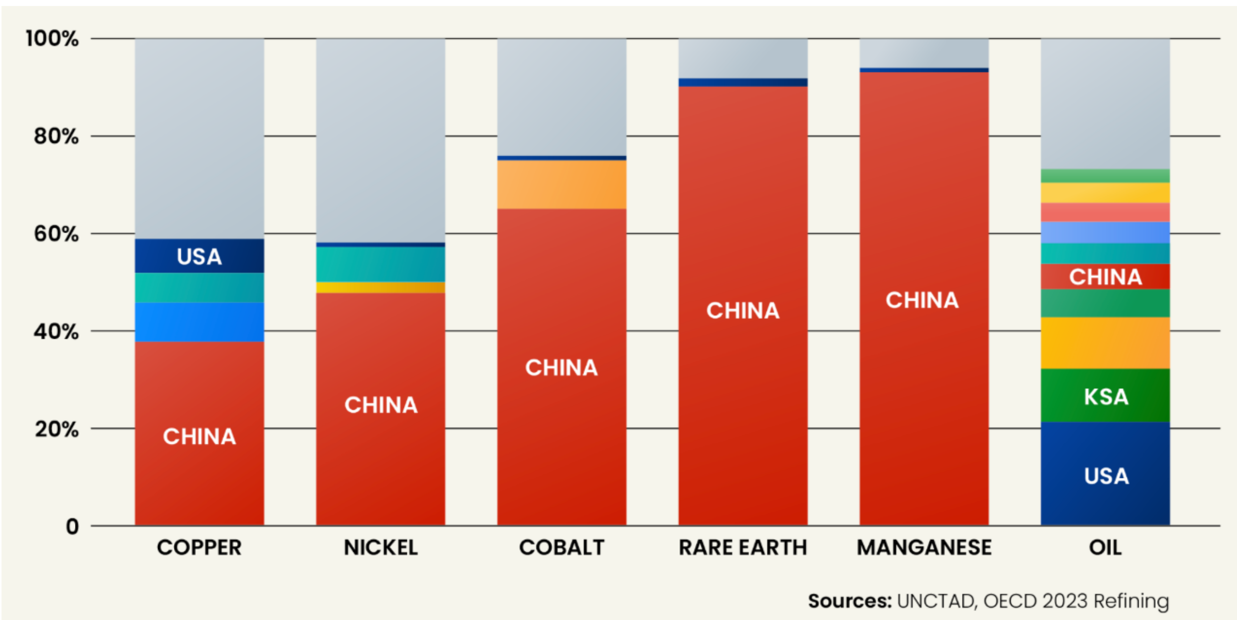
In April 2024, this team was spun out into a new company called Viridian Biometals. Impossible Metals maintains a minority holding in Viridian Biometals.

G. Impossible Metals Competitors

G.1 Who are Impossible Metals competitors?

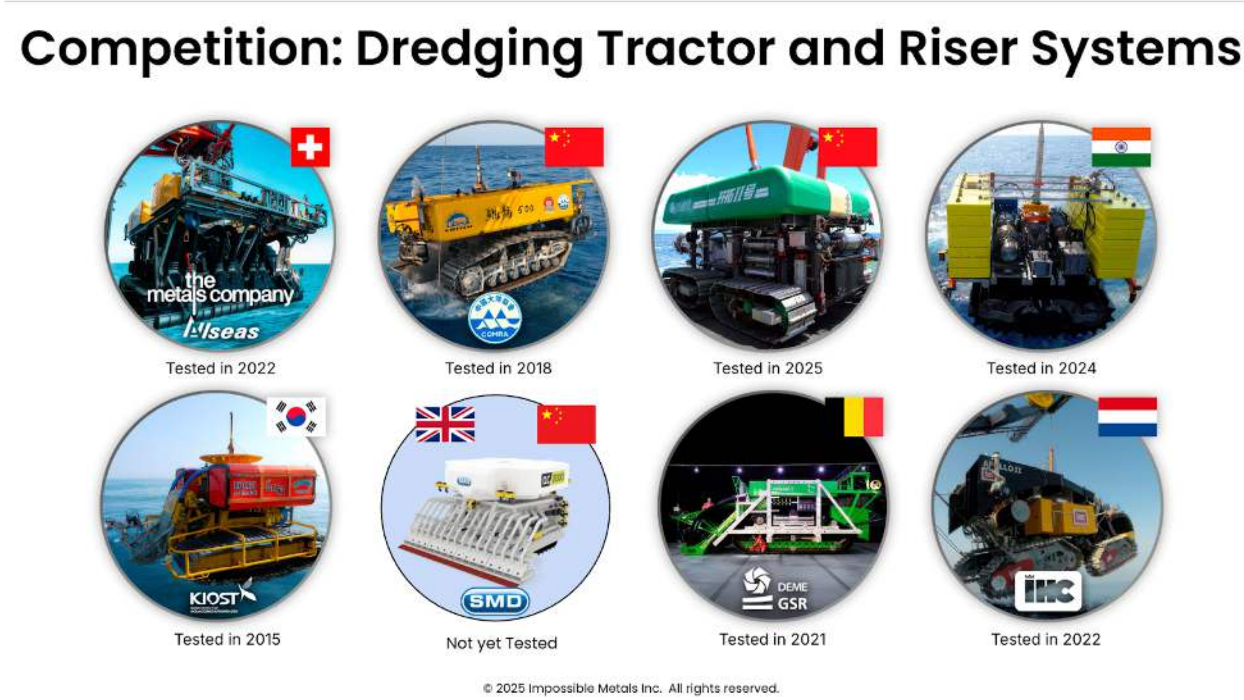
Impossible Metals has competition from land- and ocean-based mining companies for nickel, cobalt, copper, and manganese.

G.2 Which countries control land-based mining for critical metals?



G.3 Who makes competing dredging tractor and riser systems?

A list of deep sea dredging tractors + Eureka II AUV is here.



See this video: Compare Impossible Metals vs Conventional Dredging for Deep Sea Mining

G.4 What technical risks do competing dredging tractor and riser systems still have to mitigate?

A number of companies have conducted dredging tractor and riser system deep sea trials; however, the ship-to-ship transfer of the nodules has not been tested. The ship-to-ship transfer of the nodules in the ocean is complex and will likely require very specialized transport ships, including dynamic positioning (DP) and dewatering technology. This article includes more details on this topic.

G.5 How does the cost of Impossible Metals technology compare to dredging technology?

G.5 has moved to Section I.

G.6 Why do we refer to our competitors as using dredging tractors with riser pumps?

The U.S. Army Corps of Engineers defines dredging as “A dredge is a machine that scoops or suctions sediment from the bottom of waterways...” ≈

Although companies are using the ‘Coanda effect’, it is still dredging. The leading dredging companies have built polymetallic nodules collection systems. e.g. All Seas, DEME/GSR, Royal IHC, etc. Dredging tractors for deep sea mining were first described in a 1965 patent 3,456,371.

G.7 How do you compare on scaling with your competitors?

G.7 has moved to Section I.

G.8 How do you compare to The Metals Company (TMC)?

TMC vs Impossible Metals

	Founded	HQ	Capital Efficiency (raised)	Public	Resource Areas	Collection Technology	Environmental Impact
The Metals Company (TMC)	2011	Canada	$600M	Yes (~$3.5B) NASDAQ	Own (Sponsorship: Nauru, Tonga)	Partner (Allseas)	Medium (Dredging & Riser)
Impossible Metals (IM)	2020	USA	$15M	2025: Series A 2029: IPO	Partner	Own (Patents) ⅓ the cost	Low (Selective Harvest)

H. Mineral Processing of Polymetallic Nodules

H.1 How do you process (refine) nodules into high-purity metals?

Mineral processing is the process of separating commercially valuable minerals from their ores. The first step is called comminution, which involves reducing solid materials from one average particle size to a smaller average particle size, typically through crushing or grinding. The next step is either Pyrometallurgy (the use of heat) or Hydrometallurgy (the use of acid) to separate the valuable metals from the ore. A novel technology using living bacteria to separate metals from ore is in development. One example is Viridian Biometals, which spun out of Impossible Metals.

It has been demonstrated that existing pyrometallurgy and/or hydrometallurgy processes can be used to process nodules. Typically, existing mineral processing plants require modifications to extract multiple metals from the nodules.

H.2 What should be the strategy for mineral processing of the nodules?

Impossible Metals plans to outsource the mineral processing of the nodules. We will pay a fee for each ton of nodules that are refined into high-purity nickel, cobalt, copper, manganese, and possibly rare earth elements. We see three phases:

1. Create a strategic stockpile of nodules in the US to stimulate processing investments.
2. Upgrade existing nickel processing facilities in friendly nations, such as Japan, Australia, and Canada, to process nodules. Efficiency is likely to be around 75%.
3. Build bespoke nodule processing facilities in the US and friendly nations, such as Canada. Efficiency is likely to be around 95%.

H.3 What testing has been done to refine nodules?

The Japanese company Pacific Metals (PAMCO) has processed over 2,000 tons of nodules. Other companies, such as SGS and Hatch, have also developed flow sheets.

<Embedded Webinar by SGS on mineral processing of nodules>
https://youtube.com/watch?v=ajfbHNnrV9U

H.4 What are your requirements for future refining facilities in North America?

Ideally, these facilities will be collocated with deep-water ports, avoiding the need for land transfer of the nodules. The location would ideally have access to low-cost, really clean energy and be geographically close to the customers for the metals.

I. Techno-Economic Analysis (TEA)

I.1 How do you scale to high rates of production?
Our latest economic model is v6. Each Eureka IV, our planned production-scale underwater robot, will be able to deliver 12 dry metric tonnes of nodules to the transport ship every 4.3 hours. The same vehicle performs over 5.5 trips per day to deliver an average of 66 metric tons to the transport ship. 100 Eureka IV robots operating in parallel would harvest 6,600 tons per day. No fundamental limit exists on how many underwater robots and transport ships are deployed. We anticipate a volume production per location of around 6.8 million dry tons of nodules annually.

I.2 What are the size ranges of nodules that the underwater robot's robotic arms pick up?
The current end effector and internal nodule conveyor can accommodate a wide range of nodule sizes from 2 cm to 11 cm diameter. Refinement to the end effector design and conveyor for the production system will be customized to the nodule distribution in the field of operation. Our current v6 concept economic model assumes targeting the largest nodules in the field picking nodules 6.5 cm diameter and larger. An average nodule collection diameter of 8 cm is assumed based on available size distribution data.

I.3 What is the typical operational lifespan of the underwater robot?
Our current economic model is v6. In our economics, we model a 25-year effective life for the underwater robots. Underwater vehicles, when maintained, can last well beyond 25 years. The JASON ROV, launched in 1988, is a good example of this. We will spend about 10% of the total CAPEX each year on the maintenance of our equipment. This high degree of maintenance ensures that continued operation is similar to an airplane.

I.4 What factors influence the lifespan of an underwater robot, and how can it be extended?

The main factors that influence underwater robots in general are maintenance management for:

- Corrosion: Low-corrosion materials and sacrificial anodes are used and replaced as needed.
- Biofouling: The ongoing maintenance will include a maintenance schedule for clearing acoustic and optical surfaces to prevent biofouling build-up.

- Moving component wear and tear: The primary cost factor for maintenance is rebuilding components due to wear and tear or in the event of failure, and we've incorporated it into the economic model. (Learn more about analysis in this blog post.)
- Electronics failure: In the event of a complete loss of power or control, the robot will always remain positively buoyant and float to the surface.

Since we are operating a large fleet of underwater robots, we can collect performance and required maintenance data on a statistically significant scale and employ maintenance insights based on this information.

See also this blog post: Prioritizing Reliability: Reducing the Mean Time Between Failures.

I.5 How long does each collection mission take?

Eureka III delivers four dry metric tons of nodules every 4 hours. Eureka III delivers 4 dry metric tons. Each Eureka IV will deliver 12 metric tons. The breakdown of the mission time for Eureka III is as follows:

1. Launch Eureka from the transport vessel to the ocean: 2 minutes
2. Dive Eureka to the seabed at 5km depth: 70 minutes (~1.2 meters per second)
3. Harvest nodules to fill Eureka payload: 60 minutes
4. Rise Eureka up the 5km water column: 70 minutes (~1.2 meters per second)
5. Recovery of Eureka from the ocean to the transport vessel using our Smart Launch and Recovery System (SLARS): 5 minutes
6. In parallel on the vessel: 25 minutes
    a. Unload the Eureka payload of nodules to the transport vessel
    b. Swap the Eureka battery for a fully charged new battery pack
    c. Fill the buoyancy tanks for the next mission
    d. Eureka vehicle maintenance
    e. Download of mission data
    f. Upload of the next mission

Total = 232 minutes or ~4 hours. So in 24 hours, 6 missions can be executed per Eureka III. Please also see Question **I.1 How do you scale to high production rates?**

I.6 How can you scale to millions of tons of nodules?

Each Eureka IV robot has approximately 12 arms with a 12-metric-ton payload. The Eureka IV can be reused every 3 hours. So, in 24 hours, 8 missions can be completed, delivering 8 * 12 = 96 metric tons per 24 hours. A fleet of 200 Eureka IV robots can deliver 19,200 metric tons per 24 hours using 4 vessels, which translates to 6 million metric tons per year, assuming ~312 production days a year. (Assuming around 53 days a year when a weather hold is in operation.)

I.7 How many days a year do you expect to be collecting?

As we do not have any tethers and have a smart launch and recovery system, we can operate in a much wider range of sea states. V6 of our economic model assumes we can operate for 325 days a year.

I.8 How does the cost of Impossible Metals technology compare to dredging technology?

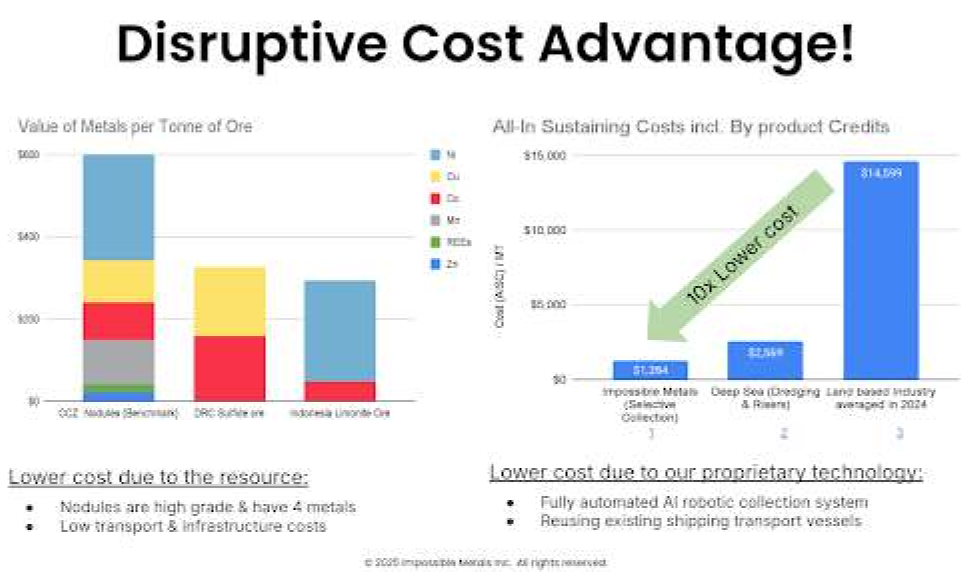
We expect Impossible Metals' approach to be the lowest-cost method for deep-sea mining. A fleet of robots has three primary economic benefits compared to dredge and riser-based systems.

The first is the improved economics for a fully operating system. This is achieved through reduced capital expenses (CapEx) by eliminating the need for a dedicated surface production vessel to support

equipment such as a riser system. With the Impossible Metals approach, the transport ships pull the robots from the water, collecting the ore without needing ship-to-ship ore transfer.
The second benefit is the ability to scale the system through the incremental addition of CapEx. A small-scale operation can become operational with a relatively modest initial capital investment. As additional capital is invested, the fleet of robots and, thus, the material throughput can be scaled.

The third economic benefit is the lack of single points of failure. While there are increased points of failure with the fleet of robots, there are no single points of failure, ensuring that the selective harvesting architecture remains operational through these failures.

We estimate our costs for a production-scale operation will be about ½ ~~¼~~ less costly than the cost of a dredging tractor with a riser system for the same rate of production.



I.9 How do you compare on scaling with your competitors?

Fleet Production Scaling

Collector	Number of Collectors	Riser & Dewatering Systems	Production Support Vessel	Other Vessels Types	Days a year of Production	Annual Production Rate (wet tonne million)
Eureka III (Impossible Metals 4MT)	97	0	0	2 x Bulk carriers	325	1.5
Eureka III (Impossible Metals 4MT)	194	0	0	4 x Bulk carriers	325	3
Hidden Gem[1] 15m collector (The Metals Company)	1	1	1	2 x Bulk carriers 1 x Transport Nodules 1x Transport Waste 1x Transport Fuel 1x Transport crew & supplies	193	1.5
Hidden Gem[1] 2x15m collector (The Metals Company)	2	1 (Upgraded)	1 (130 people)	4 x Bulk carriers 1 x Transport Nodules 1x Transport Waste 1x Transport Fuel 1x Transport crew & supplies	193	3

[1] TMC PFS 8/4/2025

Deep Sea Mining & Other Industry Glossary

Abyssal plains = underwater plain on the deep ocean floor, usually found at depths between 3,000 and 6,000 meters.

Areas Beyond National Jurisdiction (ABNJ) = The formal term for the international seabed, beyond any country's borders otherwise known as the 'Area' or the high seas.

AUV (Autonomous underwater vehicle) = self-guided underwater robots used for exploration, mapping, and, in the case of Impossible Metals, the selective harvesting of polymetallic nodules. These vehicles are battery-operated and operate without tethers, utilizing onboard sensors and AI to navigate and make collection decisions in real-time. They are central to minimizing environmental impact by avoiding direct contact with sediment or marine life.

BBNJ (Biodiversity Beyond National Jurisdiction) Treaty = also known as the High Seas Treaty or the Global Ocean Treaty, is a landmark international, legally binding instrument adopted by the United Nations on June 19, 2023. It aims to ensure the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction.

Biodiversity = biological diversity among and within plant and animal species in an environment.

Bulk carrier or bulker vessel = merchant ship specially designed to transport unpackaged bulk cargo such as nodules.

Bureau of Ocean Energy Management (BOEM) = a U.S. federal agency under the Department of the Interior that oversees the leasing and development of offshore energy and mineral resources on the Outer Continental Shelf. BOEM ensures that activities such as offshore oil, gas, wind, and mineral extraction are conducted responsibly, balancing energy needs with environmental protection.

CAGR (compound annual growth rate) = business, economics and investing term representing the mean annualized growth rate for compounding values over a given time period.

CCZ (Clarion-Clipperton Zone) = large area in the Pacific Ocean from Hawaii to Mexico.

Container ship or box ship = cargo ship that carries all of its load in truck-size intermodal containers.

Contractor = is a company, consortium, or state entity that has been officially licensed to explore or exploit mineral resources on the deep ocean floor, particularly in areas regulated by the International Seabed Authority (ISA) or within a country's Exclusive Economic Zone (EEZ).

CFC (Cobalt-rich Ferromanganese Crusts) = ‘Crusts’ which form on sediment-free rock surfaces around oceanic seamounts, ocean plateaus, and other elevated features.

Critical Minerals or Metals (CM) = Copper, nickel, and cobalt which are essential components in many of today's rapidly growing clean energy applications. Many governments maintain a list of critical minerals.

Deep Sea Mining (DSM) = Collection of ore from the ocean.

Deep Seabed Hard Mineral Resources Act (DSHMRA) = is a U.S. federal law passed in 1980 that establishes an legal framework for U.S. entities to explore for and recover hard mineral resources—specifically polymetallic nodules enriched in manganese, nickel, copper, and cobalt—from areas beyond national jurisdiction (the "Area")

Department of the Interior (DOI) = a U.S. federal executive department responsible for managing the nation’s natural resources, public lands, and cultural heritage. It oversees agencies such as the National Park Service, Bureau of Land Management, and Bureau of Ocean Energy Management, playing a key role in conservation, energy development, and stewardship of federal lands and waters.

Dredging = bulk collection method involves machines that drag, vacuum, or scrape the seabed to collect polymetallic nodules and other mineral resources. This process typically involves disturbing large areas of sediment, which can create plumes, displace marine life, and damage sensitive ecosystems.

DP (Dynamic Positioning) = computer-controlled system to automatically maintain a vessel's position and heading by using its own propellers and thrusters.

DSM (Deep Sea Mining) = process of extracting minerals from the deep sea..

ECS (Extended Continental Shelf) = area of the ocean which is part of a continental shelf that extends more than 200 nautical miles from the coast.

EEZ (Exclusive Economic Zone) = area of the ocean, generally extending 200 nautical miles beyond a nation's territorial sea, within which a coastal nation has jurisdiction over both living and nonliving resources.

EIA (Environmental Impact Assessment) = series of baseline and technical studies, modeling, and analysis that aims to understand the receiving environment, the nature, and scale of impacts, identify mitigations, consult and liaise with regulators and stakeholders, interface engineering design and mine planning with environmental risks, assess optionality and weigh various alternatives. An EIA provides a formalized and transparent impact assessment that outlines how project pressures cause effects, how those effects work individually or in concert to cause impacts, and predicts the consequences of impacts in terms of their expected magnitude and duration.

EIS (Environmental Impact Statement) = tool for decision-making. It describes the positive and negative environmental effects of a proposed action.

EMMP (Environmental Management and Monitoring Plan) = is a comprehensive plan that outlines how a mining contractor will protect the marine environment before, during, and after deep sea mining operations. It is mandatory for any contractor applying for an exploitation license from the International Seabed Authority (ISA) or from a national government.

Eureka I, II, III. IV = Underwater robots (more formally called autonomous underwater vehicles, or AUVs) designed by Impossible metals for selective harvesting of polymetallic nodules from the ocean floor.

Eureka Collection System = The complete system for commercial mining of polymetallic nodules designed by Impossible Metals. This consists of the Eureka AUVs, SLARS, Vessel based media handling, Charing and battery swapping, Mainetance.

EV (electric vehicle) = vehicle that uses one or more electric motors for propulsion.

Exploitation license = a formal legal authorization that allows an entity to begin commercial extraction of mineral resources from the deep seabed. It follows an exploration license and is issued only when the contractor meets strict technical, financial, and environmental criteria. Also known as a ‘recovery permit’

Exploration License: a formal legal authorization that grants a company or government entity to

- Conduct geological, biological, and environmental surveys
- Collect small quantities of mineral samples
- Evaluate commercial mining potential & define the resource size & economic potential
- Develop an environmental baseline
- Design an Environmental Management and Monitoring Plan (EMMP)

It does not allow commercial-scale mining. That requires a separate exploitation license or recovery permit.

ISA (International Seabed Authority) = autonomous international organization that organizes and controls all mineral-resources-related activities in the Area for the benefit of humankind.

LARS (launch and recovery system) = a device that helps safely launch and recover autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) from a ship.

L(M)FP (Iron, manganese, phosphorus) = battery chemistry cathode

Megafauna = animals of a given area that can be seen with the unaided eye.

Mineral Reserve = is the economically mineable portion of a measured or indicated resource. Determined after applying modifying factors: mining, processing, economic, legal, environmental, and social considerations.The data is supported by feasibility studies showing profitability.

Subcategories (increasing confidence):

- Probable Reserve → based on Indicated (and sometimes Measured) Resources.
- Proven Reserve → highest confidence, based on Measured Resources and full economic feasibility.

Mineral Resource = s a concentration of minerals in the Earth's crust or surface with reasonable prospects for eventual economic extraction. It is Identified and estimated through geological evidence, sampling, and testing. It is not yet proven to be economically mineable.

Subcategories (increasing confidence):

- Inferred Resource → lowest confidence, based on limited data.
- Indicated Resource → more sampling, better confidence.
- Measured Resource → highest confidence in geology and grade continuity.

NCA (nickel, cobalt, aluminum) = battery chemistry cathode

NMC (nickel, manganese, cobalt) = battery chemistry cathode

National Oceanic and Atmospheric Administration (NOAA) = a U.S. federal agency within the Department of Commerce focused on understanding and managing the nation's oceans, weather, climate, and coastal resources. NOAA conducts research, provides forecasts, monitors environmental conditions, and supports marine conservation to protect ecosystems and public safety. They also regulate DSM in 'the Area' under the Deep Seabed Hard Mineral Resources Act (DSHMRA).

Outer Continental Shelf Lands Act (OCSLA) = a U.S. law enacted in 1953 that governs the exploration and development of offshore mineral and energy resources, including oil, gas, and renewable energy, on the Outer Continental Shelf (OCS). It authorizes the federal government, primarily through the Department of the Interior, to lease areas of the OCS, regulate activities, and ensure environmental protection and resource conservation during offshore operations.

PMN (Polymetallic Nodules) = 'nodules' also known as manganese nodules, are mineral concretions on the ocean floor that contain valuable metals. See Wikipedia.

Prospecting = in mining is the first stage of the mineral resource discovery process. It involves searching for evidence of valuable minerals or metals in a specific area, usually through preliminary surveys and testing, before any drilling, excavation, or large-scale operations begin.

PSV (Production Support Vessel) = large surface ship that serves as the central facility for deep sea mining operations. PSVs are typically modified from dynamically positioned drillships used in the oil and gas industry. Their primary functions are to:

- Collect, gather, lift, and temporarily store polymetallic nodules
- Store, maintain and control the dredging tractor and riser system
- Dewater the nodules
- Provide power, control, and guidance to the subsea collector
- House the crew that monitors and runs the operations

The temporary storage of nodules only has capacity for a few days of storage. When full, a Shuttle Transport And Resupply Ship (STARS) is required to transfer the nodules to port.

Note: Impossible Metals does need PSV.

Regulator = a governmental or intergovernmental authority responsible for creating and enforcing the rules that govern mineral activities in the ocean, especially in areas beyond national jurisdiction. These regulators ensure that mining is done responsibly, sustainably, and legally, balancing economic interests with environmental protection. E.g. ISA, BOEM, NOAA, SBMA.

REEM (Rare Earth Element Muds) = 'Muds' mainly contain rare earth elements in the seabed sediment.

ROV (Remotely Operated Vehicle) = free-swimming submersible craft used to perform underwater observation, inspection and physical tasks. The vehicle is tethered to the vessel.

SBMA (Seabed Minerals Authority) = is the national regulatory agency of the Cook Islands responsible for managing, regulating, and monitoring activities related to the exploration and potential exploitation of seabed minerals in the country's Exclusive Economic Zone (EEZ)—one of the largest in the world.

Selective Collecting = Rather than scooping or vacuuming everything in sight, Eureka underwater robots identify and pick up individual nodules while avoiding sensitive habitats, visible organisms, or sediment. This approach minimizes disruption and improves sustainability.

Sediment Disturbance = This occurs when mining activities disturb the ocean floor, creating small sediment disturbance.

Sediment Plume = Large cloud of disturbed seabed sediment from deep sea mining operations. Impossible Metals' AUVs hover above the seafloor, avoiding direct contact and significantly reducing this impact compared to traditional dredging and do not create enough sediment disturbance to form a plume.

SLARS (Smart Launching and Recovery System) = Impossible Metals technology which allows full autonomous operations of the LARS with a vessel without DP and in a wide range of sea states.

SMS (Seafloor Massive Sulfides) = 'Vents' appear on and within the seafloor when mineralized water discharges from a hydrothermal vent.

STARS (Shuttle Transport And Resupply Ship) = specialized ships with DP used to supply the mining Production Support Vessel (PSV). Key tasks performed are:

- Transfer of nodules from the PSV
- Transport of those nodules to the processing facility
- Transport of equipment, fuel and provisions to the PSV
- Transfer of personnel to and from the PSV per crew rotas

Note Impossible Metals does not need STARS.

TAM (Total addressable market) = metric that estimates the maximum revenue potential for a product or service if it were to capture 100% of a market.

Tailings: Waste materials from mineral processing, sometimes discharged into the ocean.

“Two-year rule” at the ISA = is a provision from the 1994 Implementation Agreement to the UN Convention on the Law of the Sea (UNCLOS) that requires the ISA to finalize deep-sea mining exploitation regulations within two years of a request by a member state whose national intends to apply for a license to mine the seabed. After Nauru invoked the rule in 2021, the ISA missed the July 2023 deadline to establish a regulatory framework (mining code). This now allows any ISA contractor to submit an exploration application to the ISA. The ISA Council must then "consider and provisionally approve" the plan of work in the application because the two year rule was triggered in 2021.

UNCLOS (United Nations Convention on the Law of the Sea) = established a comprehensive international legal framework to govern activities related to the global oceans.

USBL (ultra-short baseline) = method of underwater acoustic positioning and wireless communication as GPS and WiFi do not work underwater.