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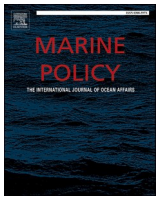

A precautionary tale: Exploring the risks of deep-sea mining

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ABSTRACT

Since the 1970 s, scientists and entrepreneurs have been seeking new opportunities to mine by exploring the deep sea as a viable option. Deep-sea mining was soon seen as an alternative to terrestrial mining, especially for precious materials needed for technology. The International Seabed Authority (ISA) has been tasked with the mandate to govern deep-sea mining within the high seas, including providing exploration permits to countries, as well as eventual exploitation contracts, once such activities commence within the next decade. In this exploratory study, we analyze the levels of international cooperation and other indicators of the 21 countries that have been given permits by the ISA to explore areas for deep-sea mining in the high seas. By examining whether these countries have ratified the 17 major international sea; illegal, unreported, and unregulated fishing; climate; and transnational organized crime conventions; providing a case study of worst performing countries in terms of their ratification status of such conventions; as well as examining the performance of these 21 countries on 18 global risk indicators, this paper finds that, overall, there is lack of commitment among these countries with their international obligations, while they rank moderate-to-high on the 18 global risk indicators. These findings should be a warning sign to the international community, as well as ISA that is responsible for issuing permits for deep-sea mining.

1. Introduction

Deep-sea mining, which is the process of mining precious metals from below the deep seafloor, is a relatively new industry. This industry is thought to be profitable and alluring, because the metals in the deep sea can be used in batteries for electronics. There are three types of valuable metal deposits located within the deep sea, and these include polymetallic nodules, cobalt crusts, and seafloor massive sulfides [11,14]. Each of these deposits are rich in cobalt, copper, manganese, nickel, and other metals, which are frequently used in batteries for electronics [14,6]. These metals are mined using a three-phase process: prospecting, exploration, and exploitation [10]. To date, there has been no exploitation of the deep sea [9].

Discovered in the late 1950 s, the deep-sea was seen to contain an endless supply of valuable metals that would one day lead to the end of terrestrial mining [5,6]. Throughout the 1970 s, ships were deployed to the Pacific Ocean in hopes of finding ways to extract the battery metals from the seabed [5,6]. However, due to a lack of technology with the ability to extract the metals from the seafloor, deep-sea mining became impossible at that time [5,6].

Today, deep-sea mining has gained a renewed interest, and it can take place in either coastal countries' exclusive economic zones (EEZs) or in the International Seabed Authority's Area [1,3]. In EEZs, current deep-sea mining explorations take place in Papua New Guinea, Fiji, The Cook Islands, and Nauru. Mining in the high seas is under the jurisdiction of the International Seabed Authority.[1]

1.1. Impacts of deep-sea mining

1.1.1. Environmental costs

Deep-sea mining does not come without potentially devastating environmental risks [7,11,13,18,2]. There are thousands of species that are threatened by the disruption deep-sea mining will bring to their ecosystem [13,18,2]. While there has been some work to protect ecosystems in the deep sea, scientist still do not know the full impact of deep-sea mining on the environment [7,11,12,13,18,2].

Mining operations can have an impact not only on the deep sea, but the ocean in general [7,11,13]. Mining equipment is loud, disruptive on

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[1] For maps of deep-sea mining exploration areas, see Appendix 3, and for a detailed description about the International Seabed Authority and its operational procedures, see Appendix 4.

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the surface of the ocean floor and the top surface of the ocean, and it gives off heavy light pollution [7,11]. Additionally, mining equipment often stirs up sediments that can dislocate animals or create clouds of dust [11,12]. When this dust settles, it can harm and possibly kill filter-feeders at the bottom of the ocean that rely on clean water flow [11,12]. According to Greenpeace International [7], fish stocks will be endangered by the disruption on the surface of the ocean. Furthermore, the burden will fall on communities, which are disproportionately in the global south, that rely on fish stocks for economic means or for food [7]. Lastly, deep-sea mining can release carbon that is normally absorbed by the sea into the atmosphere [7].

In addition to biological impacts, deep-sea mining can significantly affect the chemical composition of the deep sea [11]. This is because extracting manganese can release toxic metals into the marine environment. Additionally, because metal extraction happens vertically, deep sea water is extracted along with the minerals and is often discharged either along the way or at the top of the ocean [11,12]. The composition of this water can be different than that at the surface, and this can be disruptive to the ecosystem on the ocean surface (Koschinksy et al., 2018).

To combat threats to ecosystems, scientists have developed deep-sea restoration projects [18,2]. For example, species, like cold water corals, are taken out of the deep-sea environment, placed in labs where they grow, and then reintroduced to the seafloor [2]. While experiments have shown that, after three years of post-reintroduction, 76% of corals survived [2], scientists do not know how successful large-scale restorations would be [18,2]. Barbier et al. [2] point out that current knowledge is not promising, calling on research that was done on freshwater restoration. Four decades after freshwater restoration, ecosystems do not recover the full biodiversity as they had before disruption [2]. Another study with similar results was conducted in the Peru Basin [11]. The study removed manganese sediments, as a commercial deep-sea mining company would, to understand the environmental cost (Koschinksy et al., 2018). They found that mining caused permanent damage to the habitat [11]. Furthermore, costs for restoration can be very expensive. One estimate suggests that it would cost 75 million USD to restore one hectare of seabed in the Darwin Mounds in the Northeast Atlantic [2]. Overall, the environmental cost of deep-sea mining is not small, and it can be drastic if deep-sea mining begins before we truly understand its impact on the ocean.

1.1.2. Social costs

Roche and Bice (2013) argue that the social costs of deep-sea mining will be very similar to the social costs of terrestrial mining. Social impacts of mining highly depend on the location and how long the project is expected to last (Roche & Bice, 2013). While there are uncertainties surrounding the social costs of deep-sea mining due to the fact that deep sea mining is yet to occur, some researchers have begun assessing both the potential costs and the benefits. In terms of costs, some argue that developing nations can: (a) see their economies be taken over by foreign corporations of the countries that received the permits to mine within their EEZs; (b) experience increased demands on infrastructure, such as ports, causing strain to these nations; and (c) witness potential displacement of local fishers (Roche & Bice, 2013). Additionally, a cost-benefit analysis conducted by the European Parliament Research Service concluded that while deep-sea mining is foreseen to generate fewer economic opportunities and jobs, it is likely to have substantial impacts on these communities, especially if "fish stocks are affected or if land-based processing practices of mining-related activities are not controlled" ([17], p. 55). Koschinsky et al. [11] warn that this does not take into account the fact that plumes of sediment from the deep-sea can travel far beyond the deep-sea mining site, impacting fishing by polluting the environment of the fish. Others suggest that the social costs of deep-sea mining can be situational: for example, a cost-benefit analysis conducted by Wakefield and Myers [19] found that allowing for deep-sea mining for sulfide deposits in Papua New Guinea and manganese modules in Cook Islands has the potential to improve the well-being of the people in these nations, nevertheless the same cannot be concluded for cobalt mining in the Marshall Islands, as such activity is not likely to improve the well-being of the communities in this nation.

It is important to acknowledge that *'social cost'* does not inherently imply a negative connotation. Terrestrial mining has benefitted, in some capacity, developing countries by boosting education and healthcare access and quality, by allowing community members to participate in the economy by owning better homes or opening businesses, and by affording opportunities for women to get involved (Roche & Bice, 2013). Deep-sea mining may have similar impacts. For example, Wakefield and Meyers (2018) predicted that deep-sea mining on the Cook Islands would lead to 150 jobs for 20 years. While this number may appear small, when taking into account how small the Cook Island's workforce is, 150 jobs is actually a 2% increase in employment (Wakefield & Meyers, 2018). All social implications as they apply to deep-sea mining are yet to be seen, but these need to be taken into consideration before deep-sea mining exploration actually begins [8,4].

As it can be seen, deep-sea mining comes with some known environmental and social impacts [7,11,2], however, studies on the risks associated with deep-sea mining remain scarce. This paper fills one gap in this research by focusing on examining data on 21 countries that have been given mining exploration permits by the International Seabed Authority (see Appendix 1 for a list of these countries). The risks are assessed in terms of their international commitments through the ratification/signing of international treaties, as well as through their performance on various risk indices. This paper argues that the overall lack of good-faith commitment through clear demonstration of ratification of relevant international treaties, in combination with various performance indices of risk (as assessed by third parties, such as the World Bank), should be a warning sign and be taken into consideration when issuing permits for deep-sea mining.

2. Researh methods

To achieve the goal outlined above, this research collected data on all 21 nations that have a contract with the ISA. The data were separated into two subcategories: commitments to UN and other International Conventions; and Other Risk Indicators. The following section will lay out the conventions and other indicators for which data were collected, summarized, and analyzed in this research.

2.1. Data and their sources

2.1.1. United Nations treaties

We chose United Nations treaties to show the normative adherence to international law by the deep-sea mining nations. Treaties analyzed were chosen based on their relevance to deep-sea mining. The treaties are broken up into several subcategories including: sea-related conventions; illegal, unreported, and unregulated fishing-related conventions; climate-related conventions; and transnational organized crime-related conventions. We chose these types of treaties as they either relate to the environment or to crime. This serves as an indicator of adherence to international law and normative practices. The UN Convention data was pulled directly from the United Nations (https://treaties.un.org). A list of all the treaties can be found in Appendix 2. For each convention, each country was scored in terms of their ratification status of the relevant convention (i.e. 0= did not ratify; 1= ratified).

2.1.2. Transparency International corruption perception index 2020

Data on the Corruption Perception Index (CPI) was developed by Transparency International (https://www.transparency.org/en/cpi/2020). CPI ranks the levels of perceived public sector corruption as perceived by experts and business people. Transparency International collects data from 13 sources on various measures to build this index.

Rated on a scale from '0' to '100', a country with a lower score is perceived to be more corrupt.

2.1.3. World Bank ease of doing business score 2020

The World Bank Doing Business Score measures the regulation on local businesses (https://www.worldbank.org/en/businessready). The 'doing business' score calculates the difference between each economy from the best regulatory performance observed across all economies in the doing business sample since 2005. A score of '0' represents the lowest performance, and '100' represents the best performance. A score of 75 Indicates that an economy was 25 percentage points away from the best regulatory performance of all time.

2.1.4. Major money laundering countries 2020

The list of Major Money Laundering Countries is published by the United States Department of State (https://www.state.gov/2021-incsr-volume-ii-money-laundering-as-submitted-to-congress/). The Department reviews 200 jurisdictions including their financial institutions; steps taken to address financial crimes; and jurisdiction's vulnerability to money laundering. The major money laundering countries are divided into three categories coded as follows: primary concern =3; concern =2; monitored =1. Countries that are not considered as a major money laundering country were coded as '0'.

2.1.5. World Justice Project rule of law index 2021

Next, data from World Justice Project was extracted to be used as a measure of rule of law. The World Justice Project calculates the countries' index by conducting household and expert surveys. Data on this measure was available for a total of 139 countries (https://eprints.ugd.edu.mk/29196/1/WJP-INDEX-21.pdf). The organization surveys eight factors: 'constraints of government powers', 'absence of corruption', 'open government', 'fundamental rights', 'order and security', 'regulatory enforcement', 'civil justice', and 'criminal justice'. Scores range from '0' to '1', and indicate that rule of law is stronger in nations with higher scores on this index.

2.1.6. Human freedom index 2021

The Cato Institute conducts research regarding freedom and produces the annual Human Freedom Index (https://www.cato.org/human-freedom-index/2021). The Index covers 162 countries and jurisdictions. The Human Freedom index is comprised of numerous subindices, however, for the purpose of this paper, we only extracted data on the following: 'rule of law', 'disappearances', 'conflict and terrorism', 'size of government' (access to funds), 'legal system and property rights', 'freedom to trade internationally', 'labor market regulations', and 'business regulations.' These scores are rated from '0' to '10', where '10' means more freedom.

2.1.7. World governance indicators 2021

The World Governance Indicator, compiled by the World Bank, is comprised of six indicators. These six indicators are aggregated data compiled from surveys of households and firms, commercial business information providers, nongovernmental organizations like Freedom House and others, and public sector organizations (World Bank, 2020). The data is collected on these six indicators, aggregated, and rescaled to –2.5–2.5 with higher scores indicating better performance. The first indicator, 'voice and accountability', measures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, of association, and media. The second indicator is 'political stability and absence of violence/terrorism'. This indicator captures the perceived likelihood that the government will be destabilized or overthrown by violent or unconstitutional means. The indicator 'government effectiveness' is the third one selected. This captures the perceptions of the quality of public services, civil service, and the degree of independence of these services from political pressure. The indicator 'regulatory quality' is operationalized by capturing the perceptions of the ability of government to formulate and implement sound policies and regulations that permit and promote private sector development. The indicator 'rule of law' captures the perceptions of the extent to which agents have confidence in and abide by the rules of society, in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violent. Lastly, the indicator 'control of corruption' captures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption and well as "capture" of the state by elites and private interests. These indicators are captured using a percentile rank comparative to other nations (https://www.worldbank.org/en/publication/worldwide-governance-indicators/interactive-data-access).

2.2. Analytical strategy: descriptive statistics and hypothesis testing

Considering the primarily exploratory nature of this research, the analyses provided in the section below are primarily descriptive and provide summary statistics on the ratification status of the 17 UN conventions and the additional 18 risk indices compiled through the sources discussed above. Additional analyses are performed to compare these 21 countries on all indicators by stratifying these countries into developed and developing nations as per the United Nations World Economic Situation and Prospects (2023) classification. For dichotomous outcome variables (which are essentially the indicators of ratification status for relevant UN conventions), the comparisons between these countries are made by conducting a Chi-square test. For the remaining outcome variables that measured indicators of risk (all of which were continuous), we used an independent samples T-test to make the comparisons. The results of these analyses are discussed in the results.

3. Results

3.1. Ratification of major international conventions

For the purposes of this research and its scope, we have identified a total of 17 international conventions. These fell into four different groupings, including sea conventions (n=5), IUU-fishing related conventions (N=3), climate conventions (n=4), and transnational organized crime-related (TOC) conventions (n=5). The 21 countries that have been given permission for deep-sea mining have performed relatively differently in terms of their commitment to these conventions. Of the 17 conventions, only five (5), i.e. approximately 29% of the conventions examined were ratified by all the countries. These included UNCLOS, PCA, UN MP, UNTOC, and UNCAC (an explanation of these abbreviations can be found in Appendix 2). Of these, one was a sea-related convention, two were climate-related conventions, and two were TOC-related conventions. None of the IUU-fishing-related conventions were ratified by all of the countries examined.

Moreover, certain conventions, such as SUA, UNCCRS, ILO WIF, and ICPIRCO, were only ratified by less than 30% of the countries, with the worst performing of these being ICPIRCO (a TOC-related convention), which was only ratified by 9.5% of the countries. ILO WIF was only ratified by 14.3% of the countries.

On average, comparing the average ratification percent by convention category, the worst commitments were to IUU fishing-related conventions (with an average of 39.67% of the countries having ratified them), followed by sea conventions (with an average of 62.88% of the countries having ratified them). Both conventions are sea-related, unlike the climate and TOC-related conventions. A summary of the ratification status of these 17 conventions is provided in Table 1. Additionally, Table 2 lists the 21 countries and the 17 conventions, detailing each country's ratification status as they relate to these conventions.

Table 1
Summary Statistics on the Percent of the 21 Countries who Ratified Major International Conventions.

Convention	% Ratified	% Did Not Ratify
Sea Conventions		
UNCLOS	100	0
SUA	28.6	71.4
SOLAS	81	19
UNCCRS	23.8	76.2
ILOMLC	81	19
IUU Fishing Conventions[a]		
FAOCA	47.6	52.4
PSMA	57.1	42.9
ILO WIF	14.3	85.7
Climate Conventions		
CITES	85.7	14.3
PCA	100	0
UN CMS	57.1	42.9
UN MP	100	0
TOC Conventions[b]		
UNTOC	100	0
UNCPS	85.7	14.3
UNCAC	100	0
UNTIP	90.5	9.5
ICPIRCO	9.5	90.5

[3]For a full list of conventions, please refer to Appendix 2.
[a] IUU- Illegal, Unreported, and Unregulated Fishing
[b] TOC- Transnational Organized Crime

3.2. Performance on various indicators

Table 3 provides summary statistics on performance indicators for various indices broken into three groupings: World Bank Governance Indicators; Human Freedom Index Indicators; and Other Indicators. Based on the six World Bank Governance Indicators examined, for which data were available on 20 out of 21 countries (except for 'political stability and absence of violence'), the overall performance of these countries was relatively low as measured by the mean scores. The countries performed poorest on 'voice and accountability' (mean=0.42) relative to the remaining indicators examined, and best on 'government effectiveness' (mean=0.65), again relative to the remaining indicators. On average, however, the countries performed poorly on these indicators.

On the eight Human Freedom Index Indicators, where higher scores indicate better performance, countries performed significantly better on some indicators than others. Of the maximum score of "10", the average performance of the countries on 'disappearance, conflicts, and terrorism' indicator was 9.41, the only highest indicator of the eight. Poor performances were recorded on indicators of 'rule of law', 'size of government', 'legal system and property rights', 'labor market regulations.' The average score on other important indicators, including the overall 'human freedom index', 'freedom to trade internationally', and 'business regulations' was between '7' and '8', reflecting moderate performance on these indicators.

Lastly, other indicators were assessed through their 'Corruption Perception Index', 'doing business', 'World Justice Project Rule of Law Index', and 'major money laundering country' scores. The results showed that countries performed moderately on their 'Corruption Perception Index' with an average score of 64.86 (with the score of '100' being the best). However, a minimum score of '30' shows that among the 21 countries, there were those that performed relatively poorly on this indicator. The countries performed better on the "Doing Business" score, averaging a score of 73.76 on this indicator. The countries performed

Table 2
Major International Conventions and the Ratification Status of These Conventions for the 21 Mining Countries.

	SEA CONVENTIONS					IUU Fishing CONVENTIONS			CLIMATE CONVENTIONS				Transnational Organized Crime CONVENTIONS				
COUNTRY	UNCLOS	SUA	SOLAS	UNCCRS	ILOMLC	FAOCA	PSMA	ILOWIF	CITES	PCA	UNCMS	UNMP	UNTOC	UNCPS	UNCAC	UNTIP	ICPIRCO
Belgium	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
Brazil	✓		✓		✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	
Bulgaria	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
China	✓	✓	✓		✓				✓	✓		✓	✓	✓	✓	✓	
Cook Islands	✓				✓	✓				✓	✓	✓	✓		✓		
Cuba	✓		✓				✓		✓	✓	✓	✓	✓	✓	✓	✓	
Czech Republic	✓		✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	
France	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Germany	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
India	✓		✓		✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Jamaica	✓		✓		✓				✓	✓		✓	✓	✓	✓	✓	
Japan	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	
Kiribati	✓		✓		✓					✓		✓	✓		✓	✓	
Nauru	✓									✓		✓	✓		✓	✓	
Poland	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Russian Federation	✓			✓	✓		✓		✓	✓		✓	✓	✓	✓	✓	
Singapore	✓		✓		✓				✓	✓		✓	✓	✓	✓	✓	
Slovakia	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
South Korea	✓		✓		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	
Tonga	✓		✓				✓		✓	✓		✓	✓	✓	✓		
United Kingdom	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 3
Descriptive Statistics on Various Indicator Scores for the 21 Countries.

WORLD BANK GOVERNANCE INDICATOR	N	Mean	Median	Std. Dev	Min	Max
Voice and Accountability	20	0.42	0.63	0.88	-1.65	1.38
Political Stability and Absence of Violence	21	0.50	0.59	0.62	-0.86	1.47
Government Effectiveness	20	0.65	0.48	0.74	-0.45	1.47
Regulatory Quality	20	0.53	0.65	0.93	-1.50	2.21
Rule of Law	20	0.58	0.61	0.83	-0.76	1.88
Control of Corruption	20	0.50	0.45	0.89	-0.91	2.15
HUMAN FREEDOM INDEX INDICATOR	**N**	**Mean**	**Median**	**Std. Dev**	**Min**	**Max**
Human Freedom Index (overall)	16	7.70	8.00	0.83	6.07	8.52
Rule of Law	16	6.33	6.55	1.52	4.00	8.30
Disappearance, Conflicts, and Terrorism	16	9.41	9.75	0.91	7.00	10.00
Size of Government	16	6.32	6.50	1.00	4.80	8.50
Legal System and Property Rights	16	6.26	6.35	0.99	4.70	7.70
Freedom to Trade Internationally	16	7.83	8.25	0.95	5.70	9.40
Labor Market Regulations	16	6.83	7.15	1.20	4.50	8.20
Business Regulations	16	7.29	7.05	1.18	4.60	9.30
OTHER INDICATORS	**N**	**Mean**	**Median**	**Std. Dev**	**Min**	**Max**
Corruption Perception Index	21	64.86	61	22.80	30.00	99.00
Doing Business	18	73.76	76.35	9.67	46.90	86.20
World Justice Project Rule of Law Index	16	0.66	0.69	0.13	0.46	0.84
Major Money Laundering Country	21	-	2.00	0.87	0.00	3.00

Note: *Data on Cook Islands were missing for all World Bank Governance Indicators (WBGI), except for "political stability and absence of violence". Higher values on WBGI indicate better outcomes. Data on Human Freedom Indicators were missing for Tonga, Nauru, Kiribati, Cook Islands, and Cuba. Higher values for HFI indicate better outcomes. Higher scores on the World Justice Project Rule of Law Index and World Bank Doing Business Score indicate better outcomes. The lower the country's Corruption Perception Index, the more corrupt it is perceived to be. Major Money Laundering Country was coded as 3=primary concern; 2=concern; 1=monitored; 0=not listed.

moderately on the 'World Justice Project Rule of Law Index', collectively receiving a score of 0.66 (out of '1') on this indicator. The minimum score on this indicator was '0.46', showing that the list of 21 countries contains poor performing ones on this index. Lastly, the median score on the 'major money laundering country' was '2', indicating that the significant majority of the countries were listed as 'of concern' on this indicator. A maximum score of '3', which some countries received, shows that among these countries are also those that are of 'primary concern' for money laundering.

3.3. Comparing developing and developed countries

Of the 21 countries with permits to explore the deep sea, 11 were developing countries, and the remaining were developed. The results of the Chi-Square test show statistically significant differences between these countries on the ratification of eight out of 17 international conventions and treaties. Specifically, there were statistically significant differences on the ratification of two out of the four sea conventions (SUA: $\chi^2(1) = 4.30, p < .05$; UNCCRS : $\chi^2(1) = 2.70, p < .10$), and statistically significant differences on all three IUU fishing conventions (FAOCA: $\chi^2(1) = 8.03, p < .01$; PSMA: $\chi^2(1) = 8.42, p < .01$; ILO WIF: $\chi^2(1) = 3.86, p < .05$). For the climate conventions, statistically significant differences were found on two out of the four (CITES: $\chi^2(1) = 3.18$, $p < 10$; UN CMS : $\chi^2(1) = 4.07, p < 96$). Lastly, statistically significant differences were found between the developing and developed countries

Table 4
Differences Between the 21 Countries That Received Permits for Deep-Sea Mining on Various Performance Indicators.

	Developed Countries		*Developing Countries*			
WORLD BANK GOVERNANCE INDICATOR	M	SD	M	SD	t	Effect Size
Voice and Accountability	0.95	0.33	-0.11	0.95	3.33**	0.28
Political Stability and Absence of Violence	0.63	0.21	0.38	0.83	0.91	
Government Effectiveness	0.99	0.54	0.31	0.78	2.26*	0.34
Regulatory Quality	1.14	0.33	-0.09	0.93	3.94***	0.24
Rule of Law	1.07	0.53	0.09	0.79	3.21**	0.29
Control of Corruption	0.98	0.67	0.001	0.83	2.89**	0.31
HUMAN FREEDOM INDEX INDICATOR						
Human Freedom Index (overall)	8.19	0.27	6.88	0.81	4.8***	0.20
Rule of Law	7.1	0.99	5.03	1.39	3.49	0.27
Disappearance, Conflicts, and Terrorism	9.85	0.24	8.68	1.16	3.13**	0.29
Size of Government	6	0.73	6.85	1.22	-1.76	0.33
Legal System and Property Rights	6.71	0.58	5.52	1.12	2.84*	0.31
Freedom to Trade Internationally	8.28	0.2	7.07	1.24	3.09**	0.29
Labor Market Regulations	7.13	1.08	6.32	1.31	1.35	
Business Regulations	7.65	0.78	6.68	1.53	1.69	
OTHER INDICATORS						
Corruption Perception Index	64	12.88	46.57	17.78	2.35**	0.33
Doing Business	77.73	3.74	68.8	12.58	2.14**	0.34
World Justice Project Rule of Law Index	0.72	0.09	0.55	0.12	3.38***	0.28
Major Money Laundering Country	2.4	0.52	2	1.1	1.05	

Note: *p<.05; **p<.01; ***p<.001. World Bank Indicator scores range from −2.5–2.5. Lower scores indicate poor performance. Human Freedom Index Indicator scores range from 0 to 10. Lower scores indicate poor performance. Corruption Perception Index ranges from 0 to 100. Lower scores indicate higher rank on corruption. 'Doing business' indicator scores range from 0 to 100, with the lower score indicating low performance. World Justice Project rule of law index scores range from 0 to 1, with the lower score indicating poorer performance. 'Major money laundering country' indicator scores range from 0 to 3, with the higher score denoting 'significant concern'.

on their ratification status for one out of the five TOC conventions (UNCPS: $\chi^2(1) = 3.18, p < .10$). In all these cases, the developing countries that received permits for deep-sea mining were significantly less likely to ratify these major international conventions than the developed countries.

For the assessment of the differences between these countries on 18 different performance indicators, we ran independent samples T-tests. The results are summarized in Table 4. On all but five risk indicators, the differences between these countries were statistically significant, with developing countries that have received permits for deep-sea mining, performing significantly poorly when compared to developed countries.

3.4. Case studies on worst performing countries

The section below examined, in more detail, the performance of the three countries that scored lowest on most of the indicators discussed earlier. These are China, Russian Federation, and Brazil. Table 5 details the performance scores of these countries.

In terms of their performance on World Bank Governance Indicators, China ranked lowest on the 'voice and accountability' indicator, followed by Russia and Brazil. The Russian Federation performed worse on indicators of 'political stability and absence of violence', 'rule of law', 'control of corruption', and 'regulatory quality', surpassing China and Brazil. In terms of 'government effectiveness', Brazil was the worst performer compared to the three countries examined.

The countries performed below the global mean on all eight Human Freedom Index Indicators examined, with all the countries receiving a score below a '5' for 'rule of law', and a score of '5' or below on the indicator 'legal system and property rights'. Brazil also performed below a score of '5' on two additional indicators, including 'labor market regulations' and 'business regulations.'

All three countries are classified as major money laundering countries by the U.S. Department of State. These countries also scored below the global mean (of.66) on the 'World Justice Rule of Law Index', and remain high on the 'Corruption Perception Index' rankings. Unlike other indicators, China and the Russian Federation fell within the brackets of the best regulatory performance when it comes to the 'Doing Business' scores, earning a score of 77.90 and 78.20, respectively. Brazil, however, remained low on this indicator with a score of 59.10.

Table 5
Performance Scores of China, Russian Federation, and Brazil on Various Indicators.

WORLD BANK GOVERNANCE INDICATOR	CHINA	RUSSIAN FEDERATION	BRAZIL
Voice and Accountability	-1.65	-1.08	.26
Political Stability and Absence of Violence	-.29	-.73	-.42
Government Effectiveness	.65	.03	-.45
Regulatory Quality	-.08	-.44	-.16
Rule of Law	-.06	-.76	-.18
Control of Corruption	-.07	-.91	-.34
HUMAN FREEDOM INDEX INDICATOR			
Human Freedom Index (overall)	6.07	6.31	6.83
Rule of Law	4.40	4.00	4.40
Disappearance, Conflicts, and Terrorism	8.20	7.00	9.50
Size of Government	4.80	6.40	6.90
Legal System and Property Rights	4.90	4.70	5.00
Freedom to Trade Internationally	6.50	6.90	6.80
Labor Market Regulations	5.50	5.90	4.50
Business Regulations	6.60	6.00	4.60
OTHER INDICATORS			
Corruption Perception Index	42	30	38
Doing Business	77.90	78.20	59.10
World Justice Project Rule of Law Index	.47	.46	.50
Major Money Laundering Country	3	3	3

As far as the countries' commitment to international conventions is concerned, China has ratified 11 out of the 17; Russia −12; and Brazil −13. The majority of the treaties ratified by these countries overlapped, and their ratification decisions converged as they pertain to UNCLOS, UNCAC, UNMP, ILOMLC, PCA, UNTIP, CITES, UNCPS, UNTOC. In terms of the remaining treaties, countries diverged when it came to SUA, which was only ratified by China; UNCCRS and PSMA, which were only ratified by the Russian Federation; UNCMS and FAOCA, which were only ratified by Brazil (Fig. 1).

3.5. Discussion and conclusion

This study sought to provide a risk assessment for countries that have been given permits by the International Seabed Authority for deep-sea mining. To carry out the exploratory analyses, this research compiled 17 UN treaties and other international agreements, as well as 18 different indicators of risk, such as those compiled by the World Bank. As shown in Table 1, overall, this research found that countries vary in their adherence to relevant international treaties, with IUU fishing-related, some sea-related, and a TOC-related conventions having the lowest ratification rates. Furthermore, nations also varied in their levels of perceived corruption. While most nations performed moderately, some scored well below the remaining countries. In terms of rule of law, the average score for the 21 mining countries was 0.66, however, there were some outliers well below this average. Additionally, many countries were designated on the U.S. Department of State's as major money laundering countries.

While primarily descriptive in its design, this study also sought to explore whether there were statistically significant differences between the 21 countries that received permits for deep-sea mining exploration on their ratification status for the 17 conventions and treaties, and their performance on 18 different risk indicators. Significant differences were found between these countries on their ratification status of 8 out of 17 conventions, and 13 out of 18 performance indicators. In both cases, these countries performed significantly poorly on 47% of the conventions 72% of the performance indicators. From these findings, it was evident that the developing countries that were granted permits were significantly less likely to adhere to global regulatory mechanisms than developed countries, albeit, in many of these indicators, the average scores were relatively low for all 21 countries. Future research can expand on these studies to explore whether these assumptions are true when comparing these 21 countries to a broader set of potential candidate countries that will likely express interest in deep-sea mining in the future.

In an attempt to better understand the risks associated with the worst performing countries, this research extracted data on three case study countries, which included China, the Russian Federation, and Brazil. All three countries ranked lower than the averages of the 21 countries examined on all the World Bank Governance Indicators, with China and Russia performing worse on some indicators than Brazil. These countries also performed below average (of the 21 countries combined) on the Human Freedom Index indicators. Importantly, these countries ranked high on the corruption and the rule of law indices, however, China and Russia earned among the highest ranks when it came to the 'doing business' World Bank scores. This pattern is alarming, as it is indicative of the potential of these countries' willingness to disregard laws while engaging in business opportunities. Not surprisingly, such a pattern has already been established by the literature examining illegal, unreported, and unregulated fishing carried out in both coastal countries' EEZs and the high seas [16,15]. Therefore, poor performance of these countries on such important indices should be a warning sign for the International Seabed Authority, and a factor that should be taken into account when making future mining authorization decisions for these countries.

Research findings suggest the International Seabed Authority create a legal framework for deep-sea exploitation to communicate the expectation that the countries have the added responsibility to adhere to

Fig. 1. Network Graphs of China, Russian Federation, and Brazil and Their Links to the UN Convention They Have Ratified.

regulatory mechanisms designed to protect the commons, or the resources that are commonly shared by all. Moreover, within that framework, this research recommends that the ISA account for potential risks associated with countries' adherence to international law. All of the indicators within this study were chosen based on the assumption that past behavior is a good predictor of future behavior. The ISA should consider whether or not permit countries adhere to international norms through the ratification of treaties, whether or not they violate those treaties, and how they perform domestically on adherence to rule of law and corruption. It is important for the ISA to consider the risks associated with each permit country due to the novelty of deep-sea mining. It is too early to predict the major environmental consequences of deep-sea mining endeavor, and the global community must be able to trust those who are permitted for deep-sea mining that they will take precautionary measures to ensure that an activity with a potential negative impact on the environment is well-regulated and monitored. If mechanisms are not set to prevent potential exploitation of natural resources, the countries that have shown disregard for law and international regulatory mechanisms, specifically those examined in this study, will have little incentive to act responsibly. This can lead to potential devastating environmental impacts. Third, in agreement with Willaert [20], this research recommends that the permit area for exploitation be much smaller than the permit area for exploration. Again, without knowing the environmental and social costs of deep-sea mining, activities should be limited to only areas necessary for extraction.

In conclusion, this study provided a risk assessment of the 21 countries permitted for deep-sea mining by the International Seabed Authority based on measures of corruption, money laundering, and adherence to international treaties. While countries varied on their scores, some states scored significantly lower than the rest. As deep-sea mining exploitation draws closer over the next decade, the International Seabed Authority should consider all risks when giving permits for deep-sea mining, as the environmental and social impacts may be higher than anticipated, and the potential of these countries' infringements of the regulatory mechanisms put in place to monitor their activities remains high.

CRediT authorship contribution statement

Gohar A. Petrossian: Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Jess Lettieri:** Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Data availability

Data will be made available on request.

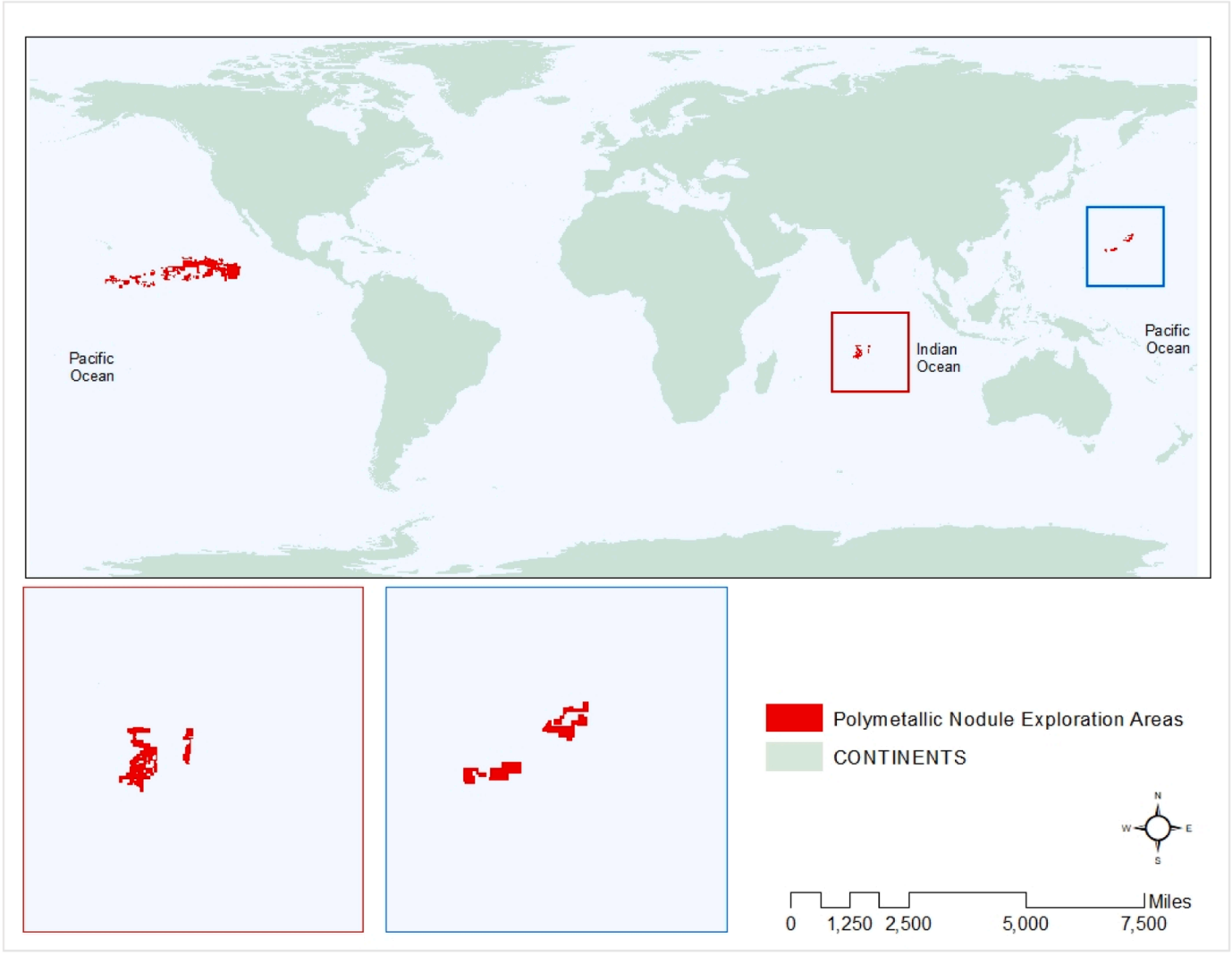
Appendix 1. List of countries with ISA permits

Countries with ISA Permits	
Belgium	Japan
Brazil	Kiribati
Bulgaria	Nauru
China	Poland
The Cook Islands	Russian Federation
Cuba	Singapore
Czech Republic	Slovakia
France	South Korea
Germany	Tonga
India	United Kingdom
Jamaica	

Appendix 2. List of UN conventions and their abbreviations

List of UN Conventions & their Abbreviations	
Abbreviation	Convention
Sea-Related Conventions	
UNCLOS	United Nations Convention on the Law of the Sea
SUA	Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation
SOLAS	International Convention for the Safety of Life at Sea
UNCCRS	United Nations Convention on Conditions for Registration of Ships
ILOMLC	International Labor Organization Maritime Labor Convention
IUU Fishing-Related Conventions	
FAOCA	Food and Agriculture Organization Compliance Agreement
PSMA	Food and Agriculture Organization Port State Measures Agreement
ILO WIF	International Labor Organization Work in Fishing
Climate-Related Conventions	
CITES	Convention on International Trade in Endangered Species
PCA	Paris Climate Agreement
UN CMS	Convention on the Conservation of Migratory Species of Wild Animals
UN MP	The Montreal Protocol on Substances that Deplete the Ozone
Conventions Against Transnational Organized Crimes	
UNTOC	United Nations Convention Against Transnational Organized Crime
UNCPS	United Nations Convention on Psychotropic Substances
UNCAC	United Nations Convention Against Corruption
UNTIP	United Nations Trafficking in Persons
ICPIRCO	International Convention on the Mutual Administrative Assistance for the Prevention, Investigation, and Repression of Customs Offenses

Appendix 3. Deep sea mining exploration areas



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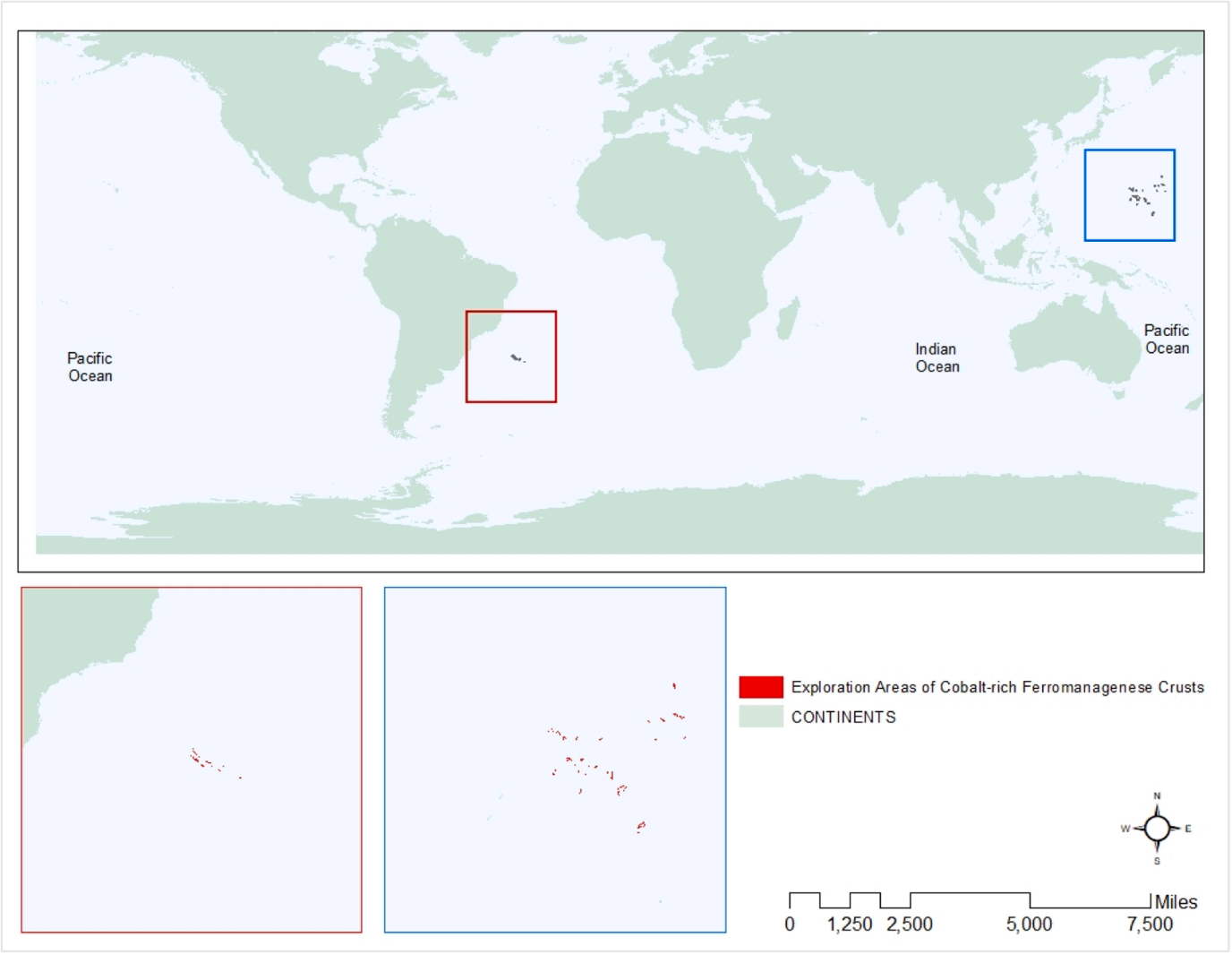

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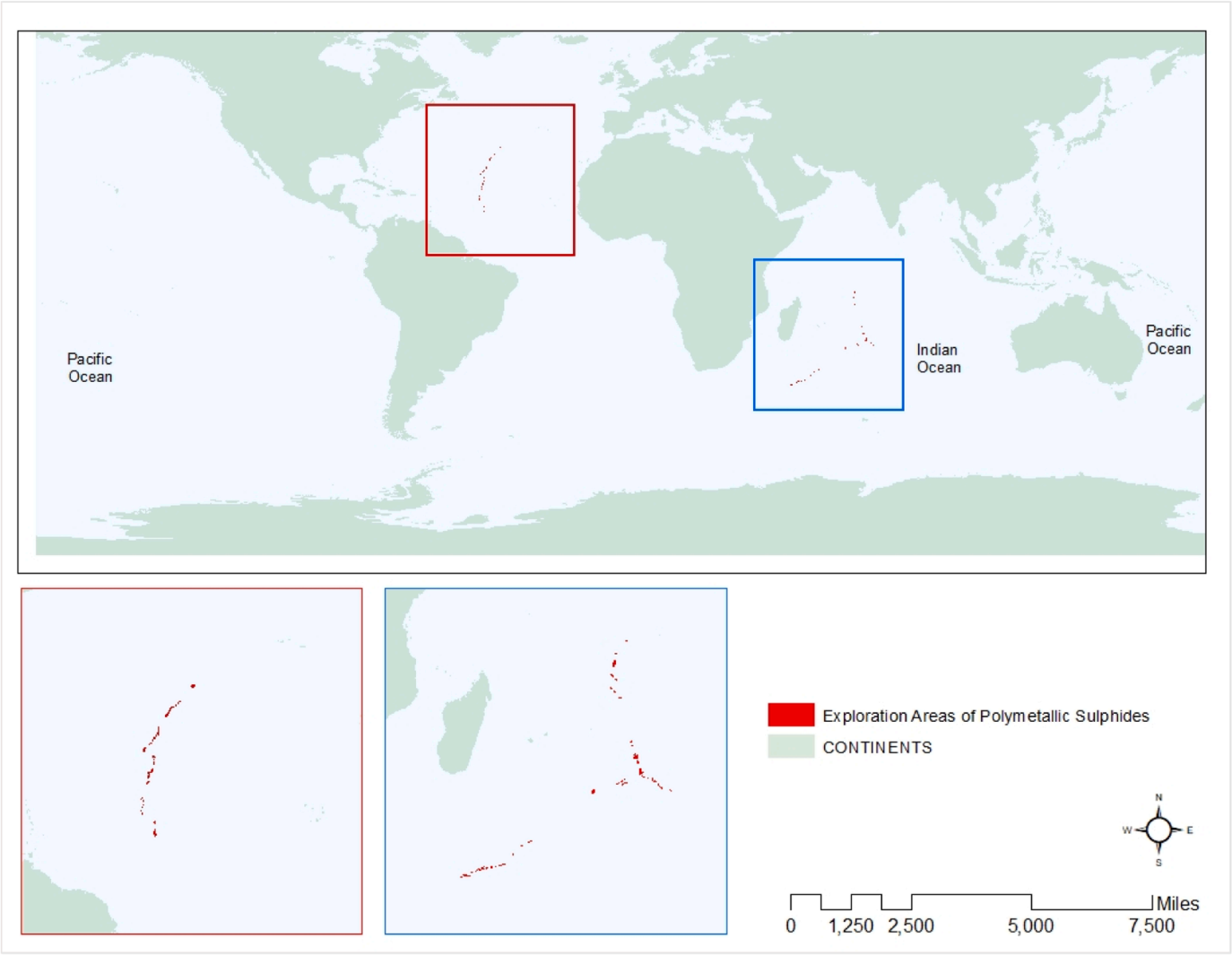

Appendix 4

The International Seabed Authority

Established in 1994, The International Seabed Authority (ISA) is the intergovernmental agency that controls areas for international deep-sea mining for the purpose of managing resources on behalf of mankind [1,20]. The ocean that is suitable for deep-sea mining controlled by the ISA is known as the "Area" [1,20]. This area includes the Clipperton Fracture Zone (CCFZ) which is a focus for deep-sea mining exploration [1,20].

The legal framework establishing the ISA can be found in the United Nations Convention on the Law of the Sea (UNCLOS) [1,20]. The authority is comprised of three branches: the Secretariat, the Assembly, and the Council [9]. Located in Jamaica, the Secretariat is run by the Chief officer of the ISA- the Secretariat General. This branch is responsible for producing reports for decision-makers, providing translation services to other branches, organizing working groups and seminars, and ensuring compliance with plans of work for exploration. The Assembly is the policy making branch of the ISA and is made up of all parties to UNCLOS. This branch has the power to elect members of the Council and the Secretary-General, negotiate and set budgets, and approve policy. Finally, The Council is elected by the Assembly and is made up of 36 representatives from various countries [9].

The two important subsidiary organs of the ISA are the Legal and Technical Commission, and the Finance Committee. For the purpose of this paper, we will focus on the former. The Legal and Technical Commission is made up of 30 members that are elected by the Council for terms of five years. This organ is responsible for the approval of plans of work, supervision in exploration, development of environmental management plans, and approval of Area procedures. This organ is responsible for the Mining Code [9] which establishes rules that States or private companies must follow when exploring the Seabed. This Code also sets up necessary precautions to protect the environment during exploration [1,20]. States and companies are required to take precautionary measures, cooperate with the ISA in implementing environmental safety programs, and notify the ISA of any environmental incidents while exploring so that the ISA can take Emergency Measures [1]. It should be noted that the Mining Code, in its current state, only establishes rules and regulations for DSM exploration, therefore, procedures for deep sea mining exploitation exists only as a draft of regulations

to come [9,20].

Getting a permit in the ISA

The ISA has specific regulation requirements needed to be approved for an exploration contract [1]. For example, contractors must be able to provide a description of the project and their financial capabilities in case of environmental incidents [1]. When applying for a contract, contractors should have a general schedule of proposed exploration as well as an assessment of the environmental impact from the proposed contract [1]. To date, the ISA has approved 30 contracts with 22 countries. These contracts are 15-year permits to explore in the Area [9]. Note that while exploration permits cover a large area of seabed, exploitation permits are drafted to cover a smaller, specific, area of seabed for 30 year contracts [20].

Who can apply for a permit?

Typically, nations apply for contracts with the ISA, however, private companies are allowed contracts if they are sponsored by a governmental party to UNCLOS [7]. Greenpeace International [7] notes a concerning trend where corporations, which are located far from the deep-sea mining locations, are using Pacific Island nations as sponsors for exploration. It is important to note that these corporations can have both ISA contracts and permits within the national jurisdiction of nations.

It should be stated that only parties to the UN Law of the Sea can obtain a permit for deep sea mining within the Area [20]. The United States is not party to the Law of the Sea, which means that the United States government cannot obtain permits for the Area [20]. However, this does not mean that U.S. companies cannot apply for a permit [7,20]. If a company has a subsidiary located in a state that has ratified the UNCLOS, they are able to apply for a permit for deep-sea mining, with the sponsorship of that state [7,20]. This has produced legal loopholes [7,20]. For example, Lockheed, a prominent weapons company based in the United States, is one of four major companies that has permits for deep-sea mining [7,20]. Lockheed, however, has a subsidiary in the United Kingdom [7,20] through which the company has been able to obtain a permit to mine within the Area [7,20]. This shows that while a country may miss out on the opportunity to mine, multinational companies, particularly from the global north, can easily find loopholes [7,20].

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