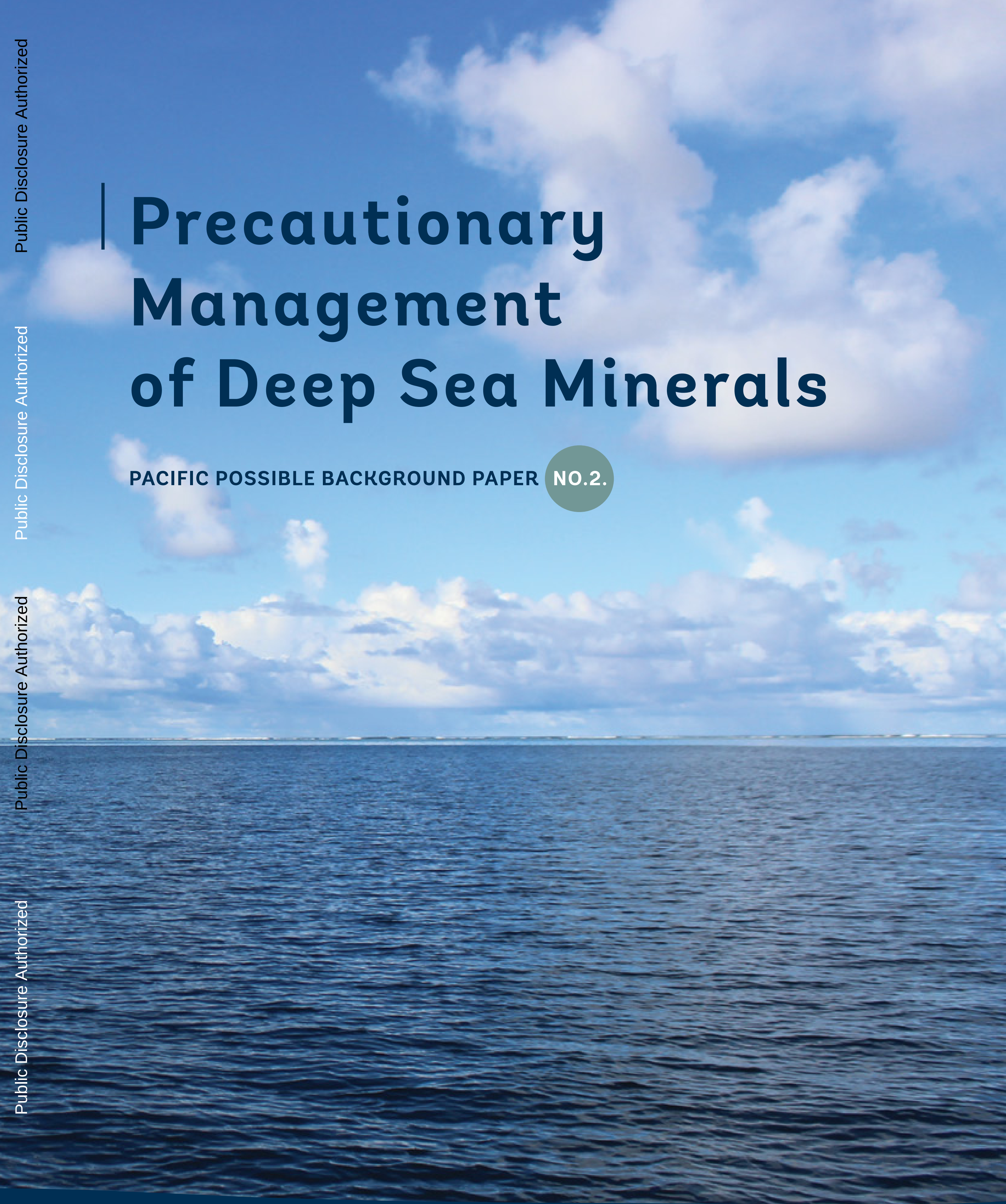

Precautionary Management of Deep Sea Minerals

PACIFIC POSSIBLE BACKGROUND PAPER NO.2.

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Pacific Island countries face unique development challenges. They are far away from major markets, often with small populations spread across many islands and vast distances, and are at the forefront of climate change and its impacts. Because of this, much research has focused on the challenges and constraints faced by Pacific Island countries, and finding ways to respond to these.

This paper is one part of the Pacific Possible series, which takes a positive focus, looking at genuinely transformative opportunities that exist for Pacific Island countries over the next 25 years and identifies the region's biggest challenges that require urgent action.

Realizing these opportunities will often require collaboration not only between Pacific Island Governments, but also with neighbouring countries on the Pacific Rim. The findings presented in Pacific Possible will provide governments and policy-makers with specific insights into what each area could mean for the economy, for employment, for government income and spending.

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Pacific Possible

Precautionary Management of Deep Sea Minerals

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Abbreviations / Glossary

'the Area'	The seafloor beyond national jurisdiction, managed by the ISA
CCFZ	Clarion Clipperton Fracture Zone, nodule-rich stretch of seabed in 'the Area', the site of most ISA contractor interest
CFC	Cobalt-rich ferromanganese crusts
COMRA	China Ocean Mineral Resources Research and Development Association
CRC	Cobalt-rich crusts, one of the three types of DSM deposits of current commercial interest
DSM	Deep sea minerals (namely minerals found within: CRC, nodules, or SMS)
EEZ	Exclusive Economic Zone, a State's marine area of national jurisdiction, where the State holds sovereign rights over the resources
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EU	European Union
FSM	Federated States of Micronesia
IMF	International Monetary Fund
ISA	International Seabed Authority
NM	Nautical mile (=1.852 kilometers)
Nautilus	Nautilus Minerals Inc. (Canadian publicly-listed DSM exploration company)
Nodules	Manganese or polymetallic nodules, one of the three types of DSM deposits of current commercial interest
PFTAC	Pacific Financial Technical Assistance Centre
PIC	Pacific Island country
PMN	Polymetallic manganese nodule
PNG	Papua New Guinea
REE	Rare earth element
RMI	Republic of Marshall Islands
SMS	Seafloor massive sulphides, one of the three types of DSM deposits of current commercial interest
SPC	Pacific Community, regional intergovernmental technical assistance agency
UNCLOS	The 1982 United Nations Convention on the Law of the Sea (in force from 1994), to which all Pacific Island countries are signatory

Acknowledgements

Michael Stanley (Lead Mining Specialist, GEEDR, World Bank) and Tijen Arin (Senior Environmental Economist, GEN2B, World Bank) led the preparation of the background report on deep sea mining. The report benefited from inputs by Daniele La Porta (Senior Mining Specialist, GEEDR, World Bank), Bryan Land (Lead Oil and Gas Specialist, GEEX2, World Bank), Victor Mosoti (Senior Counsel, LEGEN, World Bank), Sefton Darby (Consultant, GEEDR, World Bank), and Hannah Lily (Consultant, GEEDR, World Bank).

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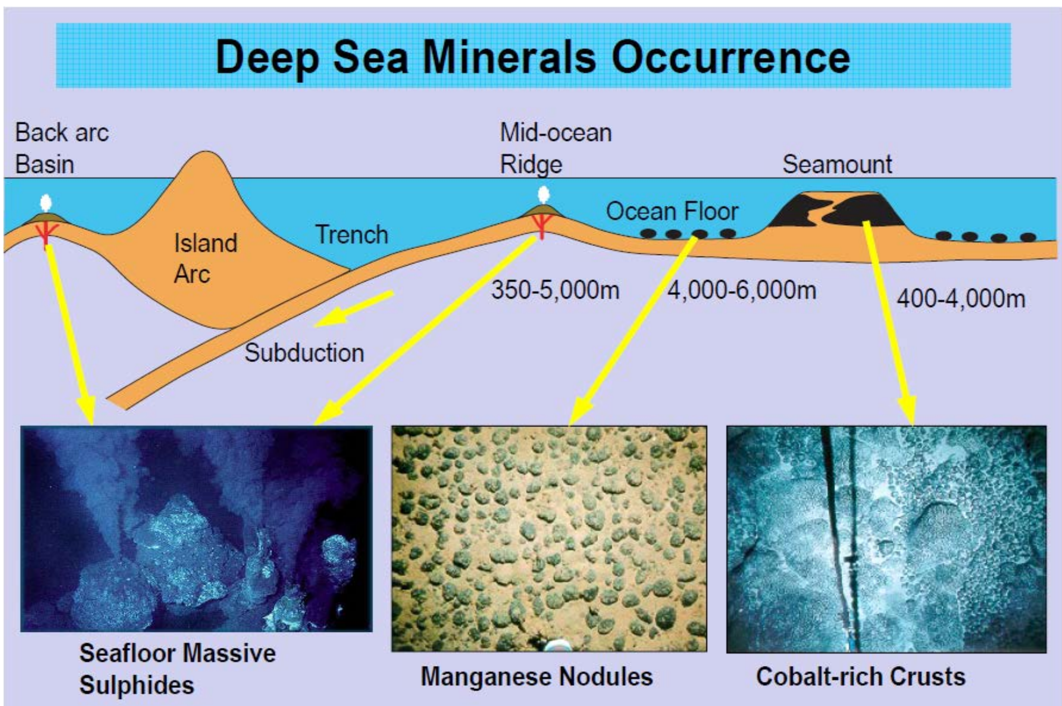
Executive Summary

Background and Motivation

Driven by Pacific Island countries' (PICs) limited growth opportunities, the relatively high grade of deep sea minerals (DSM) including rare earth elements, and technological advances, deep sea mining has emerged as a new industry in the Pacific. The Pacific Island countries (PICs) face unique development challenges. Their small size, distance to major markets and disperse populations make economic growth difficult. However, increasingly, their oceans are being seen as a resource for growth. Since as early as the 1970s exploration of the deeper sea floor has indicated that metallic minerals could be spread across large sections of the Pacific region, leading to a very new industry characterized as "deep sea mining". To date, three main kinds of deep sea minerals have been identified across the Pacific region:

Figure ES1. DSM Occurrence



Source: SPC

- **Seafloor massive sulphides (SMS)** are commonly found at depths between 350 and 5,000 meters. SMS deposits form in the deep ocean around submarine volcanic arcs, where hydrothermal vents exhale sulphide-rich mineralizing fluids into the ocean. They contain high concentrations of iron, copper, zinc, gold, silver, manganese, nickel and cobalt. SMS deposits have been identified in the exclusive economic zones (EEZs) waters of Fiji, PNG, Solomon Islands, Tonga and Vanuatu.

- **Polymetallic manganese nodules** (PMN) most often occur at great depths (3,500 – 6,000m). These nodules can contain manganese and limited amounts of cobalt, copper, iron, lead, manganese, nickel, zinc, and rare earth elements. They are known to occur in the EEZs of the Cook Islands and Kiribati, and to a lesser extent, of Niue and Tuvalu.
- **Cobalt-rich ferromanganese crusts** (CFC) are commonly found in a range of 800-2,500m of depth. They can contain cobalt, nickel, manganese and copper, as well as other minerals including precious metals (platinum) and rare earth elements. They are known to occur in the EEZs of Kiribati, the Marshall Islands, the Federated States of Micronesia, Niue, Palau, Samoa and Tuvalu.

To date, Fiji, Papua New Guinea, Solomon Islands, Tonga and Vanuatu have granted deep sea mining exploration permits, and the Cook Islands is part-way through a minerals exploration tender process. PNG is currently the only country in the Pacific region to have granted a license to mine, through the Solwara 1 Project, an action that reflects PNG's greater familiarity with mining and systems in place for regulatory and contractual oversight. However, there are strong challenges over this emerging industry given weak regulatory and institutional capacities and patchy traditions of transparency and stakeholder consultation, substantial uncertainties about the economic potential of DSM, and the limited understanding of the environmental and social risks associated with DSM mining. This is an unusual situation for governments and industry alike, where the underlying data used to model costs and benefits is limited to scarce observations for which connectivity to the surrounding environment is not well understood. And, it is proposed at great depths where regulatory monitoring is exceptionally difficult.

This report does not advocate deep sea mining; rather, it takes stock of the existing information around deep sea mining decision making and the regulatory and institutional capacities necessary for positive outcomes. As such, the report summarizes the knowns and unknowns, frames the need to apply the Precautionary Approach, and identifies professional and institutional capacity building needs.

Some Knowns, Many Unknowns

While the potential revenue for countries with deep sea minerals may be sizeable in some cases, the costs and risks involved remain unclear. Core to understanding the economic potential of DSM mining is to first determine the in-situ value of the mineral endowment in consideration of prevailing markets and the technologies available to exploit them. From this endowment it is then necessary to deduct the capital and operating costs and risk-adjusted private returns associated with investing in the location, appraisal and exploitation of DSM deposits. Third, there is need to consider how costs attributable to social and environmental impacts are treated, for purposes of weighing the net private and public benefits of DSM mining, while taking into account the public cost of environmental impacts. Moreover, a high level of uncertainty must be affixed to each of the three factors highlighted above, to better inform the design of regulatory mechanisms through which risks would then be allocated among private and public actors. This entire system of cost accounting and assignment of risks is far from fully developed, and thus informed decision making remains very unclear.

Table ES1. State of definition and earliest commerciality of DSM

	Seafloor massive sulphides		Manganese nodules		Cobalt-rich crusts	
	Stage of Definition	Earliest commerciality	Stage of Definition	Earliest commerciality	Stage of Definition	Earliest commerciality
Fiji	Early exploration	2030s				
Kiribati			Prospecting	N/A	Prospecting	N/A
RMI					Early exploration	2040s
FSM					Prospecting	N/A
Palau					Prospecting	N/A
PNG	Advanced exploration	2020s				
Samoa						
Solomon Islands	Early exploration	2030s				
Tonga	Early exploration	2020s- 2030s				
Tuvalu			Prospecting	N/A	Prospecting	N/A
Vanuatu	Early exploration	2030s				

Source: Authors' estimates and SPC (2016a)

Environmental Risks

Knowledge on the environmental risks of DSM mining is limited at best, because deep sea ecosystems and their links with pelagic and coastal ecosystems are poorly understood, and in the absence of any exploitation to date, there are no real-life data on how mining might influence these ecosystems and the services they provide. Under these circumstances, expectations on the impacts are based on modelling exercises and baseline scientific research carried out during exploration efforts, notably for Solwara 1 in Papua New Guinea (PNG), which the Pacific Community under the European Union DSM Project synthesized in layman terms. Of the different stages in DSM mining, which progresses from prospecting through to exploration and on to exploitation should the resource be commercially viable; it is the exploitation stage that is expected to have severe and potentially permanent impact on ecosystems. Impacts of exploitation activities on the host PIC environment are expected to be mainly in the marine domain as most processing is envisaged to take place in other countries with established supply-chain integration. As such, offshore ecosystem impacts from exploitation would be due to:

(i) Seafloor operations to remove mineralised material,

(ii) Operational plume and sediment resuspension at the seafloor by machines;

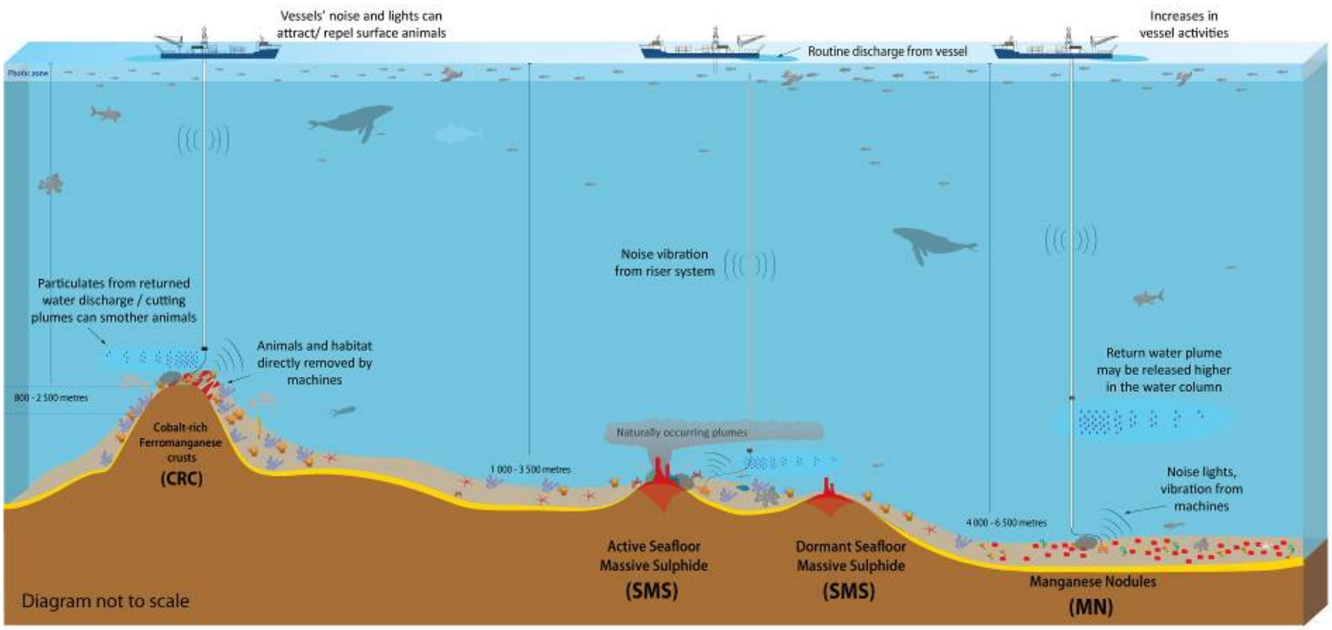
(iii) Returned seawater plume;

(iv) Standard vessel operation and discharges; and

(v) Accidental, non-routine incidents.

The approximate annual direct footprint of seafloor operations varies significantly between mineral types, ranging from less than 0.4km^2 in the case of SMS to 100-300km^2 in the case of CRCs. The indirect impact can be large ranging from less than 10km^2 in the case of SMS to 1,500 – 6,000km^2 in the case of PMN. Reviewers and stakeholders have paid particular attention to potential irreversible impacts on seafloor ecosystems from mineral removal and operational plumes and on the marine food chain, including possibly up to economically significant tuna, from operational, dewatering and, possibly, accidentally released toxic plumes. Disclosure of some critical new studies on some of these topics commissioned by Nautilus, the company promoting Solwara 1, and by the PNG government of the independent review of the Environmental Impact Statement, which informed its decision to grant an environmental permit would help answer some of these issues in the public's mind.

Figure ES2. Graphic Representation of Mining Operations on Different DSM Types and Associated Key Sources of Offshore Environmental Impact



Source: SPC

Social Risks

Stakeholder concerns are based upon the many unknowns related to DSM mining impacts, recognizing the many social challenges that have resulted from prior experience with terrestrial mining globally and in some of the PICs. The concerns expressed by coastal communities and non-governmental organizations may be grouped in five interrelated categories:

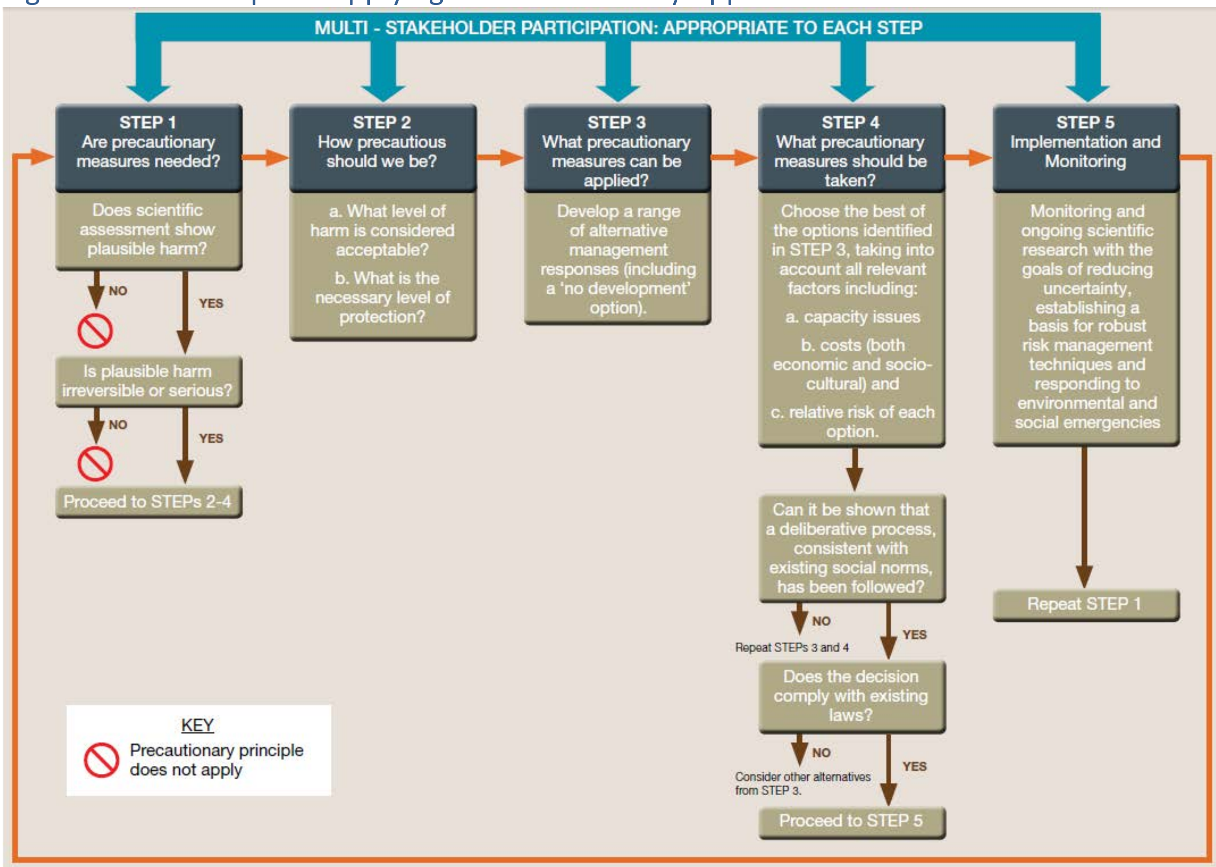
- Potential impact on livelihoods, especially of vulnerable groups through pollution, limited access to traditional fishing grounds, or reduced tourism;
- Weak capacity within the governments to ensure strong sector governance, leaving open the opportunity for inadequate revenue management and local communities not receiving their commensurate share of benefits which include revenues and compensation for damages they may incur from DSM mining projects;
- Limited employment and other economic opportunities due to the offshore nature of the mining operations and plans to process the recovered minerals in other countries;
- Impact on customs and spiritual associations which reflect the large role that the vast Pacific Ocean plays in the everyday lives of the Pacific islanders;
- Limited ability to express concerns and influence decision making on DSM mining proposals as legislation may not embed comprehensive public consultations.

Given the Risks, Apply the Precautionary Approach

Because DSM mining carries risks of causing irreversible damage to the environment and harm to the public, it is recommended that decision making on DSM exploitation proposals follow the Precautionary Approach. In other words, project proponents should take cost-effective measures to minimize environmental impacts even when there is no scientific certainty on the level and nature of the risk and the impact.[1] SPC has laid out an iterative and continuous process of five steps in applying the Precautionary Approach to DSM mining (Figure ES3). In this process, if environmental assessment of a proposed project indicates irreversible damage (Step 1), policy makers are to proceed to determining the level of harm that is acceptable and what level of protection is necessary (Step 2). These questions require extensive stakeholder consultations, analysis of benefits and cost, including of difficult-to-measure potential losses of ecosystem services, determination of how the benefits and costs would be distributed among the different segments of the society. The answers define possible precautionary measure applicable to the project (Step 3). Six options ranging from 'no development' to 'adaptive management' are available to decision makers. Next, regulators in consultation with stakeholder and in conformity with existing laws, choose the best option, taking into account factors including capacity issues, costs, and relative risk of each option (Step 4). Here again, cost benefit analysis has an important role to play. Regardless of the options chosen, but especially when the project goes ahead, the monitoring and scientific research continues to reduce uncertainties and risks (Step 5), which leads back to the original question on the existence of plausible harm. Throughout the process, transparency and participation of a range of stakeholders, including potentially affected communities, is considered fundamental.

[1] Principle 15 of the 1992 Rio Declaration states: "In order to protect the environment, the Precautionary Approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Figure ES3: Five steps for applying the Precautionary Approach



Source: SPC

Sound economic analysis is critical for evaluating trade-offs and different options; it needs to incorporate loss of ecosystem services, including those related to existence, cultural and spiritual values, and take into account cumulative effects of subsequent explorations in the general geographical area. The cost benefit analyses commission by SPC for the proposed projects in PNG (SMS,-Solwara 1) and Cook Islands (PMN) estimated the net present values of economic benefits at $83million (2-year project) and $494million (20-year project), respectively. However, these estimates incorporate only few of the possible environmental and social risks and that with methodological limitations. In particular, they reflect stakeholders' key concerns about possible impacts on the marine food chain, fisheries, and health of communities of accidental spills of toxic minerals and return water due to a break in the riser, and of plumes generated by the mining operations. The study assumed, without sound independent evidence, that operational technology would eliminate these risks. Given the deep uncertainty around a number of variables affecting the costs and benefits of a DSM mining project, and in particular, the risk of damage to ecosystem services, the scenario analysis approach, rather than the conventional approach that makes upfront assumptions on the point values and probability distribution, should be preferred in economic cost benefit analyses of DSM mining proposals.

Precautionary Approach as Part of Good Governance

As in terrestrial mining, public sector governance is paramount in determining the extent to which DSM exploitation is economically, politically, socially, and environmentally viable. Critical elements of strong sector governance include:

- Good management to ensure efficient and effective exploitation under strong social and environmental performance.
- Good tax design to ensure appropriate government revenue and adequate incentives for investors.
- Good revenue administration to ensure revenue is collected.
- Good public expenditure management to ensure volatile and temporary natural resource revenue translates to permanent benefits for the nation and to manage the risk that resource wealth poses to the wider economy.

GAP analysis points to significant regulatory and institutional weaknesses at the country level despite recent progress. Good governance and the Precautionary Approach require strong regulations and institutions having the technical capacity to ensure regulatory compliance and associated monitoring and reporting. Under the SPC-EU DSM Project, SPC prepared draft policies, laws and model frameworks to guide the economic, environmental and social regulations; bringing greater alignment of individual country frameworks to other PICs in the region. A number of PICs have either developed, or are in the process of developing, country-specific robust policies and legislation; whereas technical professional capacity available within governing institutions designated to implement these regulations is nonexistent to inadequate in most PICs and more partially adequate in a few.

Recommendations

Cost and small population sizes will limit most individual PICs' ability to adequately manage DSM mining; regional cooperation would help. For any PIC considering to derive economic benefits from DSM mining in its EEZ in a fiscally, environmentally and socially responsible manner following the Precautionary Approach, the cost of regulatory monitoring and enforcement is high. Meeting the demands for specialized expertise and equipment is a significant challenge for most PICs given limited national budgets and prior experience in regulating the mining sector. Recognizing these challenges, PICs have expressed growing interest towards formalized regional cooperation in supporting the regulation of DSM, building on the ongoing current collaboration under the auspices of the SPC-EU DSM Project and inspired by the existing regional cooperation in fisheries management.

Currently, the PICs cooperate with SPC on general regulatory functions; however, PIC governments carry out all specific project-related measures, including scoping, reviewing and approving environmental and social assessments; selecting an appropriate Precautionary Approach option (including possibly ‘no development’); supervising and enforcing the selected option, and ensuring full regulatory compliance on mining. However, given their current capacity deficiencies and available resources to improve sector governance, most PICs are not in a position to perform most of the project-specific regulatory functions. SPC has provided technical assistance to national regulators in some areas, specifically in regard to providing technical and legal advice on the pros and cons of each option, while the decision of the appropriate Precautionary Approach option rests with sovereign states.

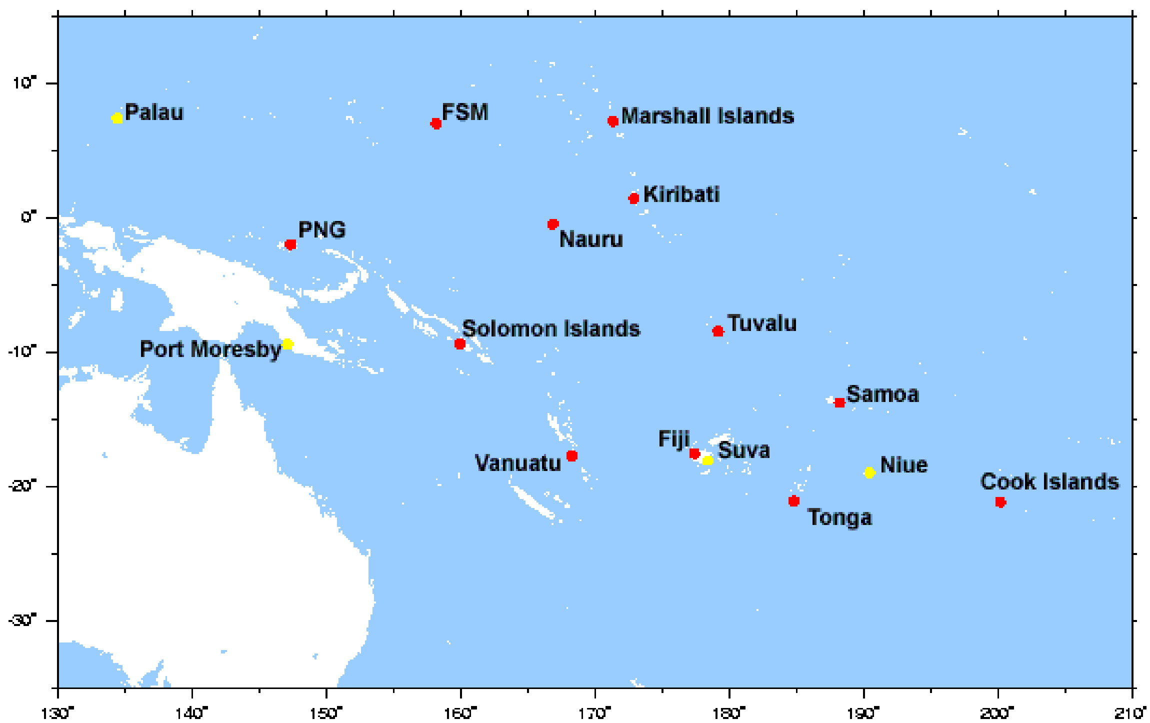
Going forward, two modes of regional cooperation have been identified, namely one that involves a ‘regional technical service provider” and another that is based on a “regional regulator”. In the former scenario, the regional technical service provider would expand on SPC’s current areas of support. Specifically, it would manage/supervise all technical activities and provide technical advice to the national authorities on regulatory matters, such as choice of the appropriate Precautionary Approach option, on enforcement decisions in case of transgressions in the chosen option; however, the decision making authority on these questions would rest with PIC national governments. In the second scenario, a regional regulatory body would not only provide technical support to regulators, but PIC governments would also delegate to the SPC the authority to make and implement decisions on enforcement matters and lead the process of choosing a Precautionary Approach option. The choice will rest with the PICs and may evolve over time.

While the establishment of a regional body, whether a technical service provider or regulator, would be much more efficient and effective, than individual PICs building up regulatory capacity, a critical question concerns the appropriate level and source of funding. It would seem practical and consistent with the polluter pays principle to suggest that the regional body be funded by companies licensed to carry out prospecting and to larger degree by companies licensed for exploration and exploitation. The “taxing” of companies at the exploration stage makes sense given that a large number of critical regulatory functions, including the social and environmental assessments and decisions on the Precautionary Approach option take place during the exploration phase.

Introduction

Since the early 1970s, exploration of the deeper sea floor has produced indications of wide-spread metallic mineral commodities, spread across large sections of the Pacific region in association with the "ring of fire" tectonic plates. Similar resource potential has also been indicated for offshore eastern African countries, in South Asia along the eastern Indian continent; in the Atlantic Ocean; and even western continental North America. What has emerged is a proposed set of mining extraction operations that represent a very new type of industry, characterized as deep sea minerals (DSM) mining by virtue of the great depths at which these minerals occur. By definition, DSM occur in the deeper-water (400 – 6,000 meters) where minerals are deposited by natural processes as iron-manganese (or ferromanganese) nodules and crusts, massive sulphide, phosphates, and metalliferous sediments.

Map 1: Pacific Island Countries (PICs)



While DSM has been pursued to varying degrees over the last few decades, the commodity super-cycle (circa 2005 – 2013) catalyzed new interest by financiers and mining companies to back ventures, and this has advanced application of (pre-) commercial-scale technologies. High metallic concentrations within these deposits have led to strong investor interest within the private and public sector. In response to suggestions of large potential revenue streams, many nations have granted exploration permits while regulatory and institutional capacities are weak and environmental / social impacts are still yet to be fully understood. There are material information gaps, for which economic / environmental / social impacts remain uncertain and that carry an element of risk into these development schemes. This report signals a need for governments to prepare for the inevitable arrival of seabed mining and in doing so, echoes Pacific Leaders who adopted the Madang Guidelines in 1999 SOPAC (1999). Any government going forward with DSM needs to have (a) a better understanding of the ecological situation including the impacts to highly sensitive ecological areas, such as fish spawning grounds, up front so as to avoid catastrophic ecosystem damage; (b) ensured good sector governance through strengthening of laws and policies, regulatory and administrative capacities, revenues management and accountability of decision makers; and (c) introduced and implemented effective environmental safeguards. That stakeholders are concerned that impacts on livelihoods and marine biodiversity should not overwhelm any potential economic benefits, is a required precautionary approach.

That DSM mining has unknown associated risks is a source of concern. Large-scale mining on land has a long and mixed history of contributing towards positive development outcomes, and resource-rich / resource-dependent nations in particular have struggled to leverage natural resource development towards broader economic diversification and sustained growth. Resource development undertaken today will impact a nation for generations to come, and the need for good sector governance, strong institutions and highly skilled professionals to develop and implement sound policies, laws and regulatory oversight is paramount to deriving lasting benefits.

While there is a common understanding that Pacific Island Countries are facing DSM exploration and production decisions today; what role the Bank should take, in offering policy guidance and/or technical assistance across financial management, regulatory oversight capacity and other contractual compliance measures has not been defined. The Bank is not taking a position on DSM, but rather recognizes that a comprehensive stock-taking of the issues will inform Pacific Island Countries (PICs) of the information gaps that need to be addressed for informed decisions, and institutional and professional capacities that must be built to ensure sustainable outcomes. In assisting governments with land-based mining, the World Bank undertakes sector governance assessments to: (a) ensure appropriate and adequate content of policies, laws and regulations to manage the varied demands and impacts associated with the sector, (b) create the capacity for effective development, implementation, monitoring and enforcement of rules that ensure effective monitoring and enforcement of policies, laws and regulations; and (c) clarify roles and responsibilities of decision-makers to ensure accountability through transparent and non-discretionary processes that are inclusive of a broad set of stakeholder views and reinforced by codes of acceptable conduct.

While there have been qualitative descriptors of DSM potential, quantitative estimates of the potential, *in-situ* resource value remain restricted to just 2-3 prospects that have advanced to the feasibility stage, reflecting the industry's limited progress towards feasibility. Pacific Island governments face a complex array of technical challenges. Appropriate fiscal regimes to deliver equitable Government ‘take’, steps to manage those funds sustainably, and the full economic impact of DSM are untested. Core to understanding this potential (financial and economic) is to have sound estimates of the *in-situ* value of these deposits, some estimates of the capital and operating costs for production and full payment of taxes and royalties, factoring in the cost of meeting the full contractual and regulatory compliance necessary to keep a license holding in good standing. As is the case for environmental and social impacts, the appropriate fiscal regime and economic benefit to DSM is not clearly understood, although progress has been made in a few specific project cases, such as Solwara 1.

Many foundational actions and analyses have begun. The Pacific Community (SPC), with support from the European Union, has mobilized leading specialists to prepare draft policies and laws, model frameworks to guide economic, environmental, social performance, regulations to improve contractual and regulatory compliance, and assess institutional needs. Workshops, public consultations, learning events, and other stakeholder input processes have been undertaken. And estimates of cost / benefit have begun using indicative costs and assumed fiscal regimes. In all, what has been accomplished by the SPC is commendable, given the multitude of challenges, diversity of views on DSM, and geography encompassed by sector activity. The Commonwealth Secretariat has provided legal and economic policy advice, including the Cook Islands Seabed Minerals Act 2009, which has served as a benchmark for other states, and assisted Kiribati by funding a DSM Adviser to be based with the Ministry of Fisheries and Marine Resource Development. The International Monetary Fund (IMF), through its regional Pacific Financial Technical Assistance Centre (PFTAC) has provided assistance to Tonga and Cook Islands on (i) developing a fiscal policy for raising DSM revenue, and (ii) drafting relevant taxation and royalty regime laws. The IMF PFTAC and the SPC EU DSM Project also collaborated to develop a 'Regional Financial Framework' for DSM in the region (SPC, 2016c.)

Common to the above experiences is a reported (a) significant capacity deficiency on collection and dissemination of geological data and mineral resource information; (b) DSM national policies and laws that vary to some extent from one nation to the next and remain largely untested; (c) fiscal frameworks for DSM that are either direct extensions or derivatives of terrestrial mining frameworks, whose risk profiles and underlying assumptions are materially different, (d) weak understanding of the appropriate environmental framework given the deep marine environment, (e) near total neglect of the social policies necessary for DSM to ensure adequate / commensurate benefit sharing, and (f) institutional weakness across licensing, regulatory compliance monitoring, and revenues management. Most importantly, the majority of nations for which DSM is a potential industry have no previous experience in overseeing large-scale terrestrial mining sector activities.

Under these circumstances there is need for caution, giving special attention to protecting the marine environment and the people who value it. A sound precautionary approach, which does not preclude the option of 'no development' is needed to avoid or minimize temporary or lasting harm to the environment, to the people and to the economy. This forms the starting point for this document -- application of the Precautionary Principle for DSM, and the gaps that currently exist that could impede informed decision making.[2]

Background

What is Deep Sea Mining?

There is some confusion as to what actually constitutes 'deep sea mining' and a variety of definitions exist according to which the cut offs between 'near shore mining' and 'deep sea mining' are set at different depths. Those different definitions are typically shaped by:

- Whether specialized equipment is required due to the pressures that are encountered at depth, or whether more conventional technology (i.e. dredging) can be used;
- Whether it is occurring at a depth at which sunlight is still present (the photic zone) and the kind of corals, fish and other sea life that exist at different depths;
- Whether it is likely to interact with other resource uses such as traditional, and potential future fishing.

These factors are variable and imprecise – sunlight penetration is heavily influenced by the turbidity of the water; different countries have different limits and practices around bottom trawling fishing; some marine mammals can range from the surface to more than 2,000m of depth in their diving. Near shore mining already exists and typically focuses on sand, gravel, coral, alluvial precious metals and stones and normally uses trailing suction dredge technology. This is commonly used to extract building materials and as part of land reclamation projects. Near shore precious stone mining includes operations such as De Beers Marine's diamond mining off the coast of Namibia. There are also some examples of near shore mineral sands (e.g. iron sands) operations.

Maritime Zones and the Jurisdictional Limits of DSM Activities

Deep sea mineral deposits occur in various Maritime Zones. Maritime Zones are defined and described the United Nations Convention on the Law of the Sea (UNCLOS). UNCLOS is the primary legal instrument for the governance of the world's oceans and seas. It sets out the rules governing all uses of the oceans and their resources. Maritime Zones are described in Articles 1, 3, 33, 55, 57, 76, and 86. Information in these provisions are summarized below.

Baselines

In order for States to determine and measure the maritime zones applicable to their territories, States start by determining their baselines. As specified in Article 14, a coastal State may determine its baselines in accordance with any of the methods mentioned in Articles 7-13 of UNCLOS. Once a

[2] During the preparation of this document, PNG was reported to be adopting the Precautionary Approach, subsequent adoption of this approach has not been confirmed.

coastal State has determined its baselines, it must make those baselines publicly known in charts or lists of geographical coordinates and deposit a copy of each such chart or list with the Secretary-General of the United Nations, in terms of Article 16(2).

Territorial Sea

As stated in Article 3 of UNCLOS, the breadth of a coastal State's territorial sea is up to a limit not exceeding 12 nautical miles, measured from its baselines.

Contiguous Zone

The contiguous zone is the area 'contiguous' to the coastal State's territorial sea, which may not extend beyond 24 nautical miles from the baselines from which the breadth of the territorial sea is measured, according to Article 33 of the UNCLOS.

Exclusive Economic Zone

The Exclusive Economic Zone (EEZ) is an area beyond and adjacent to the territorial sea, which in addition shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

The total area of EEZs controlled by Pacific Island Countries and Territories is 27.8 million km^2 (compared with a land area of about 531,000 km^2 - a ratio of 52:1.) (Map 2). Additionally, the area of Extended Continental Shelf (ECS) represents an additional 2.0 million km^2, over which coastal states exercise jurisdictional rights over mineral resources.

Continental Shelf

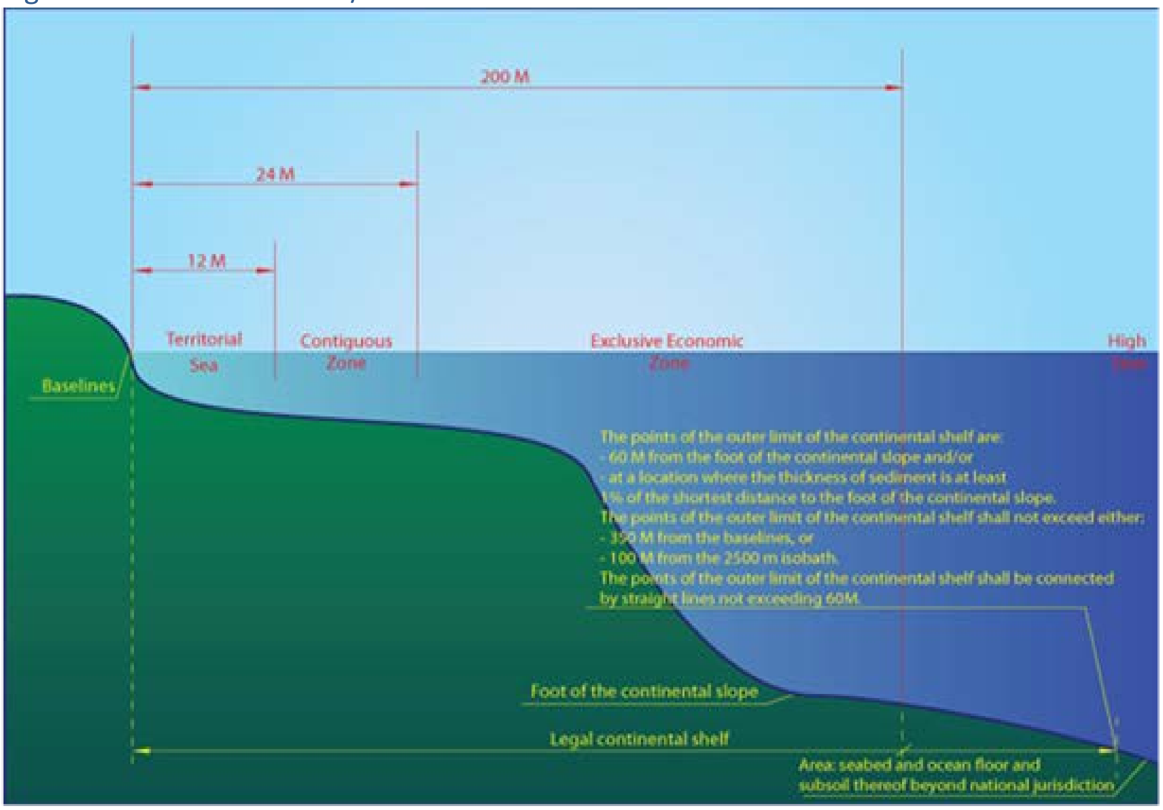
According to the Commission on the Limits of the Continental Shelf, the Continental Shelf of a coastal State comprises the submerged prolongation of the land territory of the coastal State - the seabed and subsoil of the submarine areas that extend beyond the coastal State's territorial sea to the outer edge of the continental margin, or to a distance of 200 nautical miles where the outer edge of the continental margin does not extend up to that distance. The continental margin consists of the seabed and subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof.

The "Area"

The "Area" is defined in Article 1 of UNCLOS as the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction. The Area and its resources are the "common heritage of mankind" as stated in Article 136 of UNCLOS. All rights in the resources of the Area are vested in "mankind as a whole". It is the International Seabed Authority (ISA) which is authorized to act on behalf of mankind in respect of the Area.

States may also sponsor DSM exploration and exploitation activities in the Area. The Cook Islands, Kiribati, Tonga, and Nauru all act as Sponsoring States for exploration activities in the Clarion Clipperton Fracture Zone.[3]

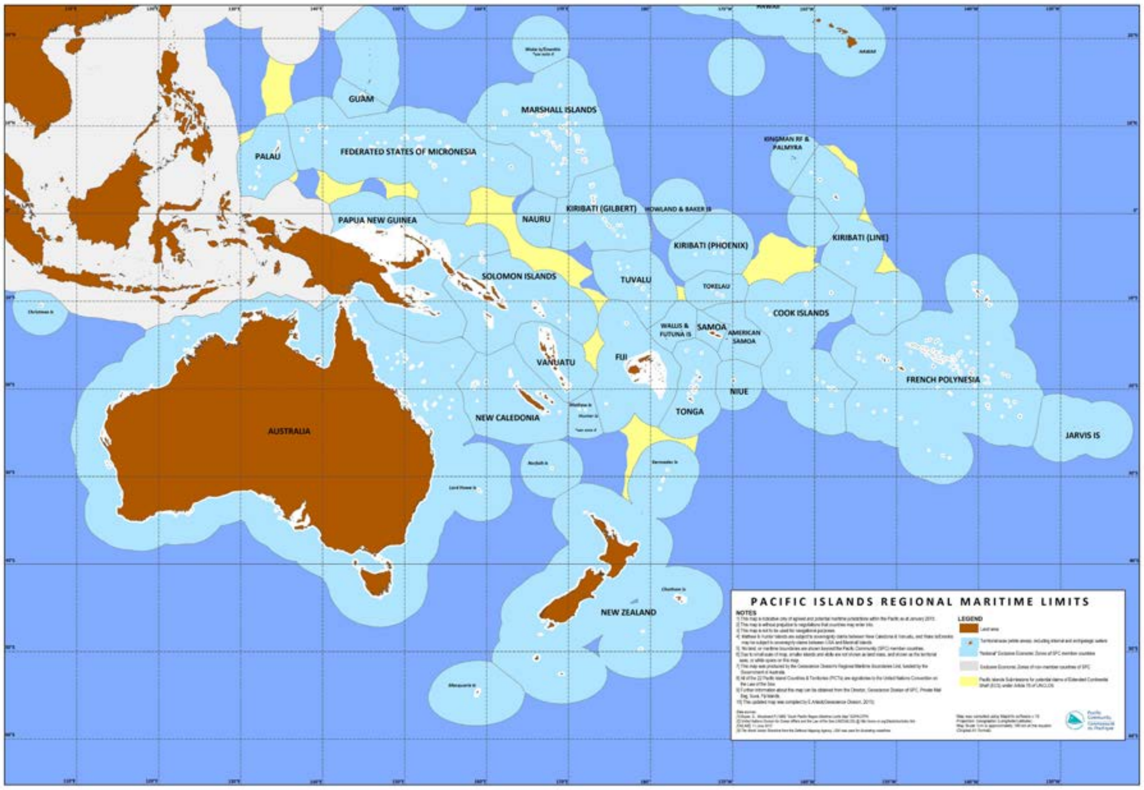
Figure 1. Continental shelf / EEZ vs. The Area



(Source: Commission on the Limits of the Continental Shelf
http://www.un.org/depts/los/clcs_new/marinezones.jpg)

[3] For more information see https://www.isa.org.jm/

Map 2. EEZ of Pacific Island Countries and Territories



Source: SPC, 2016

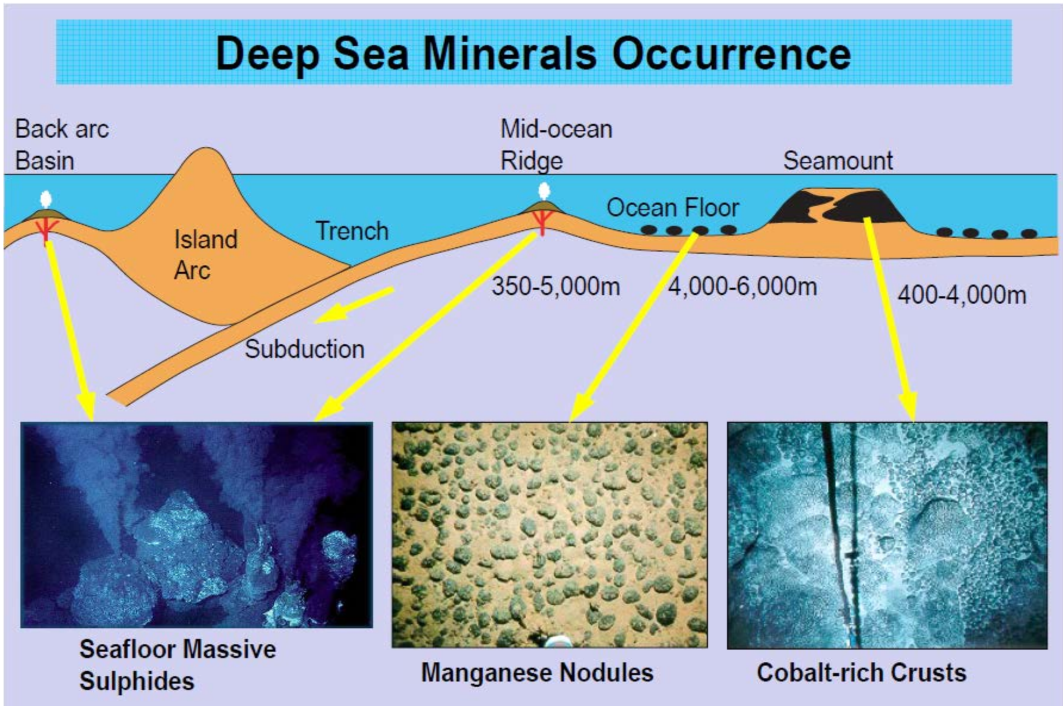
Deep Sea Mineral Deposits in the Pacific Island EEZs

To date, three main kinds of deep sea mineral deposit types have been identified within the national jurisdiction of several Pacific island countries (SPC, 2013b):

- **Seafloor massive sulphides** (SMS) are found at hydro-thermal vents (both active as well as inactive volcanic vents) on the seafloor at 1,500-5,000m depth which precipitate out concentrated minerals, including copper, iron, zinc, silver, and gold. This resource is under development in Nautilus Mineral's Solwara-1 project in PNG (see Chapter 3). Some PICs known to have SMS occurrences are Fiji, PNG, the Solomon Islands, Tonga and Vanuatu
- **Polymetallic manganese nodules (PMN)** – often occurring at great depths (4,000 – 6,000m), these nodules can contain a mix of cobalt, copper, iron, lead, manganese, nickel and zinc. These are the kind of resources prospected for in the Clarion Clipperton Fracture Zone (CCFZ) and they are known to occur in the waters of the Cook Islands and Kiribati, and to a lesser extent in Niue and Tuvalu.
- **Cobalt manganese crusts** – which can contain other minerals including precious metals (platinum) and Rare Earth Elements (REE). They are found in a range of 400-4,000m of

depth and are known to occur in Kiribati, the Marshall Islands, the Federated States of Micronesia, Niue, Palau, Samoa and Tuvalu (Figure 2).

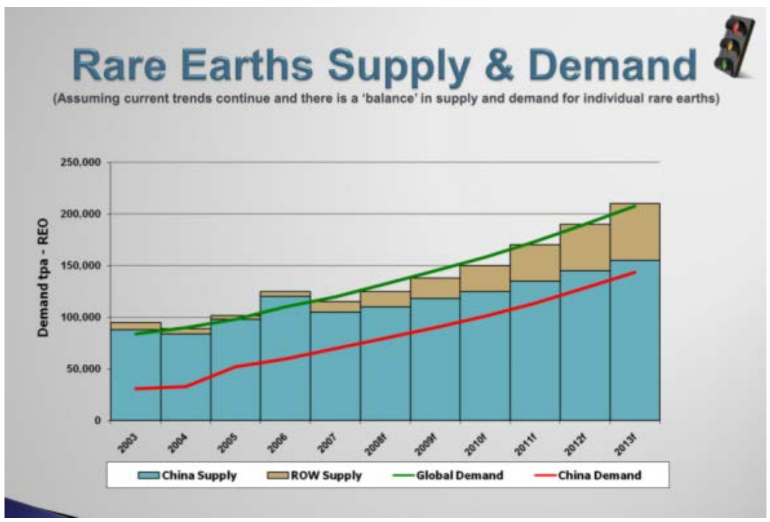
Figure 2. Deep Sea Minerals Occurrence



Source: SPC

Box 1. DSM: the New Frontier for Rare Earth Elements?

An important aspect that gives the rationale for DSM exploration/exploitation some more nuance is that these deposits are polymetallic and may contain rare earth elements (REEs). REEs are considered strategic minerals and an important component in new technologies, especially within the clean energy, military, and consumer electronics sectors. As these sectors continue to grow and diversify so will the demand for REEs however, despite this growing demand, there is a lack of security in the supply chain. In 2011, over 95% of global REE supply originated from China. China is also has the largest demand for REEs, at 65% of total. The US is the next largest consumer, at 15% of total demand. Reduction in exports from China in 2010 created large instability in the REEs market which led other countries to look for alternative sources (Hatch, 2012). As REEs occur with other minerals reserves are either in small or low-concentration deposits. This makes specific mining for REEs challenging with the number of readily mineable REE deposits small increasing the attractiveness of DSM and its strategic relevance even more accentuated.



Source: Global Commodities 2015

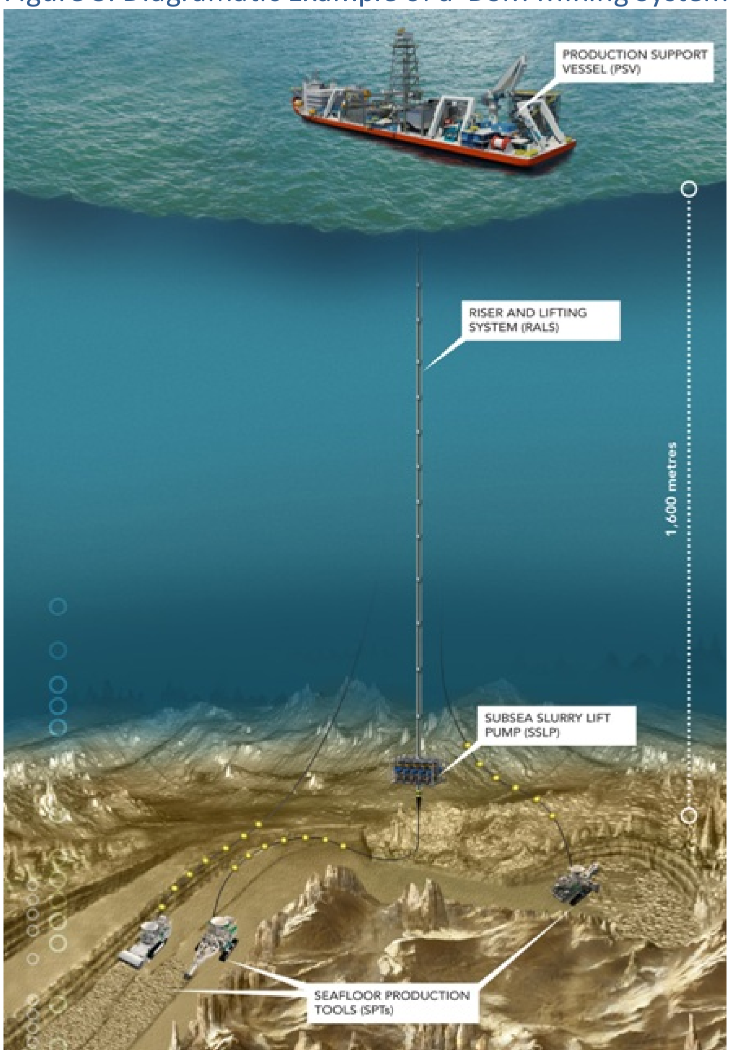
Rare earth elements have several industrial uses worldwide but are primarily used in the electronics and electrical fields such as rechargeable batteries, computer memory, cell phones, DVDs, magnets, car catalytic converters, fluorescent lighting, and several other instruments. The worldwide demand for these electronic devices and instruments has quadrupled and will continue to grow. Additional supplies of REEs will be needed to meet this demands. There are several industries such as petroleum refining, glass polishing, chemical catalysts, metallurgy, catalytic converters, permanent magnets production, television and monitors, etc. where these rare earth elements are also needed in abundance. REEs are essential for manufacturing rechargeable batteries which are used to power up several electrical and electronic devices, digital cameras, computers, laptops, hybrid vehicles and electric vehicles.

Source: SPC

DSM Mining Technology

Technological breakthroughs towards commercial DSM mining should be expected; most likely in the waters of Papua New Guinea, Tonga, Solomon Islands, Fiji, Vanuatu, New Zealand and Japan. Governments, principally Russia, China, Korea, India, Japan, are also supporting detailed geodetic / geological surveys to assess mineral resource endowment, seeking to understand the commercial viability of these resources viz. ongoing investor interest and current supply / demand trends. These programs will yield a first descriptor of the inventory of potentially recoverable minerals using current technologies and prevailing prices (the gross value, in-situ).

Figure 3. Diagramatic Example of a DSM Mining System



Source: www.Nautilus.com

The technology for extraction varies somewhat from project to project, depending on a variety of deposit and seafloor characteristics. Some projects propose to use submersible suction dragged and positioned by surface ships; others propose to use seabed 'crawlers' (i.e. that could move themselves rather than be positioned only by the ship) that would suction up the material on the seabed, or cut through and grind material on the seabed to then be transported to the surface through a separate suction system or crawler.

Deep sea engineering is of course not a new or unknown technology - dredging, marine cable laying and the offshore oil industry have all worked on various technologies that feed into the technology that is proposed for seabed mining, and indeed a number of companies in this area (e.g. Boskalis, Royal IHC, KIOST, JOGMEC) are investigating and have interests in seabed mining ventures. It should be noted, however, that the process of DSM mining has been estimated by various specialists to have widely varying environmental impacts, including in some cases irreversible damage to the marine ecosystem as detailed in SPC (2016b) and summarized in Annex 1. DSM mining is of a completely different nature, magnitude and severity than any other deep sea engineering activities carried out so far.

Drivers of Deep Sea Mining

Factors that make seabed mining unique and which are driving investment and interest in these areas are:

- The long-term decline of the grade of many onshore minerals compared to relatively untouched and high-grade seabed deposits.
- Lack of fixed capital and infrastructure: while much of the capital cost in accessing terrestrial mines is fixed in the form of roads, trenches, pits and drives (tunnels) to access resources; the capital investment in seabed mining is mobile, with the primary advantages being that it can be removed in advance of extreme natural events; should a project encounter political or social barriers or disruptions; or when a resource is exhausted.
- Terrestrial mines are increasingly constrained by proximity to settlements and communities as well as areas with high environmental values.
- The ability to ship mined materials directly to markets can obviate the need for expensive infrastructure development such as roads, railways and export ports that is often a major cost in terrestrial mining.
- Average mine life for Solwara 1 is expected to be around 2-3 years, similar to some terrestrial artisanal and small scale mines, but very different from the longer term large mines which often exceed 35 years. However, if a series of deposits are mined sequentially the overall “mine life” could be long.
- One important attraction of DSM deposits is the higher grade compared to equivalent land resources which translates into a higher value per ton of ore produced. Another important aspect that gives the rationale for DSM exploration/exploitation some more nuance is that these deposits are polymetallic and contain Rare Earth Elements (REEs) (Box 1).

Box 2. Deep Sea Mining Cycle: from Prospecting to Exploitation

Prospecting -- the search for DSM deposits within designated license and/or national areas including estimation of the composition, size and distribution of deposits and their economic values, without any exclusive rights.

Exploration -- searching for and measurement (grade and tonnage) of deposits of DSM (either in the Area or within national jurisdictions) with exclusive rights; and the analysis of such deposits, the use and testing of recovery systems and equipment, processing facilities and transportation systems, and the carrying out of studies for the environmental, social, technical, economic, commercial and other appropriate factors that must be taken into account in exploitation.

Exploitation- the recovery for commercial purposes of DSM from the seabed (either in the Area or within national jurisdiction), and the extraction of minerals, including the construction and operation of mining, processing and transportation systems, for the production and marketing of minerals, intermediate processed products or metals.

Ongoing and Proposed DSM Projects in the Pacific Islands

As detailed in Table 1 below, Fiji, Papua New Guinea, the Solomon Islands, Tonga and Vanuatu have granted DSM exploration permits. PNG is the only country to have granted a license to mine so far, for the Solwara 1 Project.

Table 1. DSM Engagement by Country (Status as of June 2016)

Country	DSM Engagement
Cook Islands	Abundant manganese nodule occurrence, with high cobalt content, has been identified within the Cook islands EEZ. There is strong political will to attract DSM investment; however, an international invitation to tender for exploration in the EEZ in 2015 did not yield any applications. Cook Islands lodged an application with the ISA in December 2013, for an exploration contract for nodules in 'the Area', in partnership with GSR.
Federated States of Micronesia	FSM's EEZ is considered to have CRC potential, and some indicators of possible SMS deposits. FSM has had initial discussions with an exploration company interested in SMS (but the Government is unable to issue licences within the EEZ until relevant laws are enacted). There is strong political will to attract DSM investment, to cover budget shortfalls anticipated by the end of US compact in 2023.
Fiji	Hydrothermal vents with SMS potential have been identified in Fiji's EEZ (both in the Lau and North Fiji Basin areas). Exploration licences have been issued by the Government within Fiji's EEZ to KIOST and Nautilus. Fiji has also expressed interest in sponsoring activity in 'the Area', and has met with Lockheed in that regard.
Kiribati	The largest EEZ in the region, with nodule and CRC potential. No DSM licences yet issued in the EEZ. A Kiribati State company, 'Marawa Research and Exploration Ltd' holds an ISA contract for nodule exploration in the CCFZ. DeepGreen prepared and funded Kiribati's application in return for an off-take agreement. The EEZ borders the nodule-rich CCFZ – in 'the Area', currently the subject of 12 ISA exploration contracts. (Raising a possible opportunity for Kiribati to offer 'local services' e.g. refueling and other supplies for vessels.)
Marshall Islands	Seamounts in the western part of RMI's EEZ have significant CRC potential. Japan, Russia and China have recently taken ISA exploration contracts for CRC in sites close to RMI's and

Country	DSM Engagement
	FSM's EEZ. RMI has not been approached by any DSM companies, and has not issued any DSM licences.
Nauru	No data has been collected on the potential of seabed minerals within Nauru's EEZ. A local company, Nauru Offshore Resources Inc (NORI) holds an ISA contract for nodule exploration in the CCFZ. DeepGreen prepared and funded the application in return for an offtake agreement, and sits on the Board of Directors.
Niue	Surveys of Niue's EEZ suggest little promise of nodule potential but more encouraging CRC potential. Further surveys are required for better assessment.
Palau	Surveys confirm the occurrence of CRC and phosphate, as well as indications of SMS. Nodule potential is also possible. Further surveys are required for better assessment. In 2013 the President proposed that the entire EEZ should be a 'no-take' marine protected area.
Papua New Guinea	PNG's EEZ contains SMS with high-grade copper, gold and silver. In January 2011 PNG granted a world-first lease to Nautilus[4] to carry out DSM mining within its EEZ: the Solwara 1 Project in the Bismarck Sea. Although a dispute with Government and challenges in raising capital had stalled Nautilus' progress, mining is now slated to commence in 2018. The SPC Cost-Benefit Analysis (CBA) report estimates raising US$80m from one DSM project from taxes and royalties. A number of SMS deposits in the Nautilus licence area in PNG are expected to be further assessed and ready to be mined by 2020.
Samoa	Samoa's EEZ is small, prospecting to date has not discovered promising nodule deposits, and the EEZ's geologically-young seamounts do not suggest positive CRC potential. Samoa has expressed interest in DSM activities in 'the Area', and held discussions in 2013 with COMRA.
Solomon Islands	EEZ contains significant SMS deposits. Ninety DSM exploration licenses issued by the Government to Nautilus and Neptune. Exploration activities are ongoing. Applications for DSM mining from Neptune Minerals were received by Government in late 2013.
Tonga	EEZ contains significant SMS deposits (in the Lau Basin). Granted licenses for exploration within its EEZ to three companies (Nautilus, KIOST and Neptune), whose findings are commercially attractive. 2011 Government sponsored a Nautilus subsidiary (Tonga Offshore Minerals Ltd) to obtain an exploration contract to explore the CCFZ in 'the Area' for nodules
Tuvalu	Prospecting results show nodules and CRC, but lower abundance and grade than in other PICs' EEZs. Expressed interest in sponsoring DSM activity in 'the Area', and has met with one DSM company.
Vanuatu	EEZ contains SMS deposits. More than 150 DSM exploration licenses have been granted within the EEZ to Nautilus and Neptune.

Source: SPC, 2016

[4] Nautilus Minerals is by far and away the dominant commercial player in seabed minerals exploration and development in the South Pacific, holding approximately 423,000km2 of exploration tenements (either under application or awarded) in Fiji, New Zealand, PNG, the Solomon Islands, Tonga and Vanuatu, as well as in the CCFZ via its subsidiary Tonga Offshore Mining Limited. Active exploration, however, appears to be currently limited to PNG and the Solomon Islands. It is also the company closest to the development of a producing deep sea mine with its Solwara-1 project in Papua New Guinea. Nautilus Mineral is publicly listed on the Toronto Stock Exchange (TSX), its three largest shareholders are MB Holdings (Oman), Metalloinvest Holding Limited (Cyprus), and Anglo-American PLC.
See http://www.nautilusminerals.com/IRM/content/default.aspx

Chapter 1. Some Knowns but Many Unknowns about DSM

Deep Seabed Resource Potential at a Glance

Core to understanding the economic potential of DSM is to first determine the in-situ value of minerals given the technologies available to exploit them, second to deduct from the in-situ value of minerals the capital and operating costs and risk-adjusted private returns associated with investing in the location, appraisal and exploitation of DSM deposits and third consider how any costs attributable to social and environmental impacts are treated, for purposes of weighing the net private and public benefits of DSM, taking into account the public cost of environmental impacts.

A high level of uncertainty is connected with each of the three factors highlighted above and the regulatory mechanisms through which risks are allocated among private and public actors are far from fully developed. Having said that, it must be recognized that a number of PICs either have developed or are in the process of developing robust policy, legislation or both in place with the assistance of the SPC-EU DSM Project and other partners. Any assessment of the overall cost/benefit of proceeding with DSM, therefore, faces a set of challenges that is perhaps an order of magnitude greater than typically encountered in the case of terrestrial mining.

To date there have been rather few comprehensive evaluations of the financial cost/benefit of DSM mining, other than those contained in project specific submissions by project sponsors to regulators and financial institutions. Recently, a study has been completed on behalf of the SPC, which undertook an economic and financial cost/benefit assessment of a hypothetical mining operation for each of the three main deposit types found in the Pacific in deep water.

Seafloor Massive Sulphide Resources

Based on current knowledge, out of the more than 200 sites of hydrothermal mineralization currently known, only about 10 deposits are currently considered likely to have sufficient size and grade to be of commercial interest for DSM mining. SMS deposit areas are small (e.g. generally between 0.1-10 $km^2$of seafloor surface area), but made viable through the high concentration of metals (clusters of richly mineralized chimneys).

Table 2. Seafloor Massive Sulphide Resources

	PNG	Fiji	Solomon Is	Vanuatu	Tonga
Stage of Definition	Advanced Exploration	Early Exploration	Early Exploration	Early Exploration	Early Exploration
Earliest Commerciality	2020s*	2030s	2030s	2030s	2020s-2030s
Deposit Value pa	$19.2 million				
5 x deposit[5]	$72 million				
GDP 2013/14	$16,900 million	$4,500 million	$1,200 million	$800 million	$400 million

Notes:

Stage of Definition: Prospecting results in identification of occurrences of target deposits: Early exploration leads to identification of potentially commercial deposits from among occurrences. Advanced exploration establishes size, grade and mineability of specific deposits.

Earliest commerciality: Classified by likely decade in which first commercial projects will take place with duration of exploration, technology and markets being principal drivers.

Deposit Value pa: The estimate of value addition per annum associated with a single specific hypothetical mine – in the case of SMS this is Solwara 1 in PNG, in the case of manganese nodules this is a hypothetical mine operated in the richest known and measured nodule zone. Estimates are from SPC, 2016a.

*5 x deposit: Five times the Deposit Value pa *Status of Solwara 1 is reported elsewhere in the document*

GDP 2013/14: Current USD GDP according to World Bank (2014), UN, or national sources – rounded to the nearest US$100 million

Source: Authors' estimates and SPC (2016a)

Manganese Nodule Resources

While the nodules can be found in many regions of the world's oceans, there are four primary locations with densities high enough for potential commercial extraction: (1) the Clarion Clipperton Zone, (2) the Peru basin, (3) the Penrhyn basin in the Cook Islands, and (4) the Indian Ocean. With respect to density, the commonly accepted cut-off in nodule density for commercial mining is approximately 5 kg/m^2. While highly variable, nodule density within the Cook Islands EEZ ranges from 5 kg/ m^2 to more than 50kg /m^2.

Table 3. Manganese Nodule Resources

	Cook Islands	Kiribati	Niue	Tuvalu
Stage of Definition	Early Exploration	Prospecting	Prospecting	Prospecting
Earliest Commerciality	2030s	N/A	N/A	N/A
Deposit Value pa	$43 million			
5 x deposit	$161 million			
GDP 2013/14	$330 million	$200 million	<$100 million	<$100 million

Source: Authors' estimates and SPC (2016a)

[5] This estimate reflects a 25-year window going forward. It is a reasonable estimate given the number of prospective areas within the blocks under investigation; but would be subject to compliance with the precautionary approach.

Cobalt Rich Crust Resources

While the crusts cover approximately 2% of the ocean floor, the Central Pacific region, particularly the EEZs around Johnston Island, Hawaii, RMI, the Federated States of Micronesia, and international waters in the mid-Pacific offer the greatest potential for crust mining because of their thickness, exposure and metal grades.

Table 4. Cobalt Rich Crust Resources

	Marshall Islands	**FSM**	**Palau**	**Kiribati**	**Tuvalu**
Stage of Definition	Early Exploration	Prospecting	Prospecting	Prospecting	Prospecting
Earliest Commerciality	2040s	N/A	N/A	N/A	N/A
Deposit Value pa					
5 x deposit					
GDP 2013/14	$200 million	$300 million	$300 million	$200 million	<$100 million

Source: Authors' estimates and SPC (2016a)

The Importance of Industry Learning and Cost

Perhaps the core key challenges to DSM mining is that it is an industry in its infancy. As such, what is proposed today in terms of the size of an operation and associated technology is a starting point on a path that would certainly evolve through time as significant learning occurs. Present performance is not indicative of future performance. The underlying costs for DSM are projected and have yet to be verified empirically through many actual mining operations. Currently proposed technologies to harvest the mineral resource may be less profitable in the earliest years but would yield significant information upon which the industry would then innovate and improve. And, there is a need to differentiate between different types of mining on the seafloor (from various technologies) that may become as diverse as that which exists in terrestrial mining.[6] In this report, and more broadly, speculating on the cost structure and profitability of DSM mining at this stage may not be a terribly fruitful exercise, nor is putting any numbers on the potential financial, and fiscal revenues that could be generated.

Need for Cost Models

For government planning purposes, there is need to better understand costs and potential revenues. What is currently available are some indicative costs that have emerged from a limited number of proposed operations, using current market conditions and initial design of new DSM technologies. For long-range planning purposes by governments, cost models are needed to allow better understanding of the costs associated to mining each type of deposit and the economic returns expected to be generated. In addition, these costs would influence the definition of the

[6] For DSM cost models may vary according to: (a) SMS; (b) metallic nodules; and (c) Cobalt-rich ferromanganese crust.

fiscal regimes for DSM mining in the PICs. Given few DSM mining experiences on which to draw, the information to be used to create a cost model might include current literature, company technical reports and interviews with exploration companies. In preparing this report, consideration has been given to the major steps towards preparing such cost models in support of long-range planning; and are thought to include:

a. Evaluate current literature, company's reports and conduct interviews with exploration companies to assess indicated or measured reserves (depending on the data available) for one of each of the three types of known deposits within the PIC countries;

b. Assess size and grade of expected deposits and associated capital and operating costs (by deposit type);

c. Simulate many times expected changes to the size of the operations, recoveries, costs, market conditions and varying fiscal regimes;

d. Arrive at curves that describe associated costs and benefits (including but not limited to revenue), and the distribution of these benefits geographically and across time in order to inform long-range planning of DSM mining by governments.

Cost Benchmarks that Change in Time

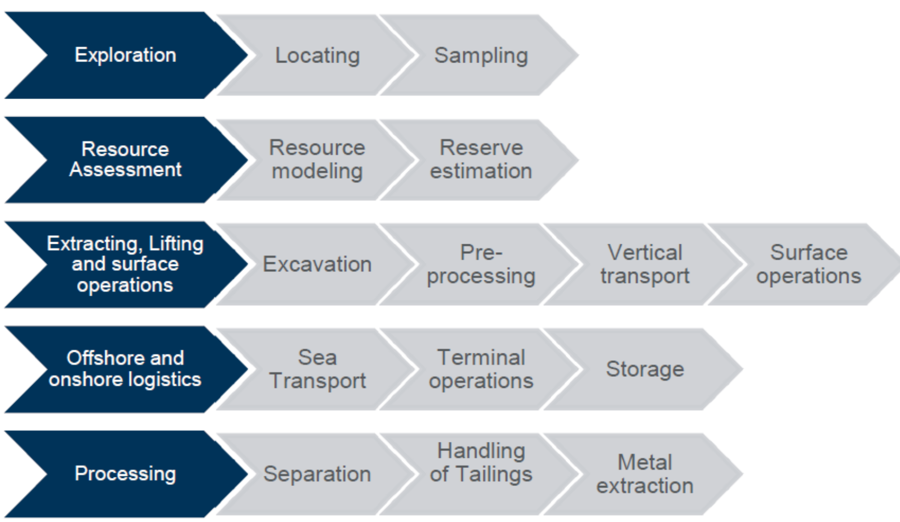
In terrestrial mining, each new operation is often compared using global benchmarks of capital and operating costs that come from an extensive pool of ongoing and past operations. These comparators often vary by commodity type and by the broad geological characteristics used to classify a mineral occurrence according to a particular "deposit model". Setting aside these differences, the end result is a set of benchmark costs that reflect learning in a multitude of geological and political / economic environments – and within an industry that is ever innovating. Indeed, one measure of the global mining industry is the ability of companies to deploy large amounts of capital into technology suites, pilot and learn, and then improve through further innovation. This ability to deploy capital in order to learn has propelled the industry towards improvements across (a) exploration / exploitation technologies, (b) mining and metallurgical productivity, (c) de-risking exposure to uncertainties and use of structured financing, and (d) improved information collection / management / dissemination regarding costs and the distribution of benefits.

By definition, key to learning is time. Some improvements require up to a decade initially, before rapid acceleration in technological innovation that will lead to improved resource efficiency, larger resource rents to be shared, and arriving at the appropriate fiscal policy to guide the allocation of those rents. Indeed, one indicator of the degree to which the industry is learning is the rate of technology switching seen in recapitalization of operations.[7] And in this regard, learning comes

[7] A good example of technology switching is seen in the global copper industry that moved from smaller higher-grade deposits to bulk tonnage operations using advanced mining technologies that significantly reduced costs. Concurrently, advances in metallurgical processing led to the mining of new mineralogies that previously had been considered waste. The industry is ever-learning and improving the deployment of technologies, thus improving the commercial viability of operations.

with risk and losses. Mining companies require an acceptable return to their capital over time, in order to endure strong commodity cyclicity and associated profit and losses that may partially result from inefficiencies and technological weaknesses. So, what may appear an excessively high return on capital in one period may be recovering losses or low returns in the past or future, driven in part by the deployment of new technologies. And so fiscal policy is also underpinned by a recognition of the need to incentivize the industry to continue to innovate, which is effectively years of industry learning.

While projections of potential revenue streams and economic linkages from DSM are difficult to predict now, there are some guiding principles that can be adopted going forward. To ensure that governments and communities receive the resource rents and other associated benefits they are due, there is need to ensure that the processes by which contracts are awarded are competitive and transparent; and backed by a regular comprehensive audit function. Moreover, the capture of economic rent from DSM mining should be focused beyond direct payments alone (taxes, royalties, fees etc.), towards indirect / induced economic linkages which come from strengthening interrelationships with other activities on the landscape. This broadening of perspective recognizes the need for DSM mining to be a driver of "local content" from the outset. And so, while present DSM performance may not be indicative of future performance, ensuring local content guides the overall industry.



Source: ECORYS, 2014

Figure 2-2 Typical Deep-sea Minerals Mining Value Chain

Environmental Impacts and Risks[8]

Ecosystems and biodiversity at the depths in question and their links with coastal or pelagic ecosystems are poorly understood and documented. Furthermore, because no exploitation has taken place to date, there is no real-life data on how it might influence these ecosystems and the services they provide. Consequently, discussions have not been informed by experience but rather by expectations, experiences with terrestrial mines, and models.[9]

Reports prepared under the SPC EU EDF 10 Deep Sea Minerals Project (SPC, 2013a- c; SPC, 2016b) lay out expected impacts by type of deposit and associated mining technologies, and by project stage. In summary, "prospecting is expected to have very minimal environmental impact" since "most prospecting studies that are conducted are remote sensing (e.g., ship based or towed sensors) with a few seafloor samples taken to confirm data interpretation. Exploration is expected to have minimal to moderate environmental impact. Many exploration techniques leave no lasting impact on the seafloor, with the exception of drilling, dredging, and test mining. Any test mining activities conducted under an exploration permit – whether at a reduced scale or not, will have impacts, though on a smaller areal scale." Impacts of exploitation "are expected to be severe at the mine site, and potentially permanent." The significant differences in geological settings and physical and biological characteristics among the three types of deep sea mineral deposits lead to differences in the mining methods and the management of their impacts." (SPC, 2016b). In addition to extraction, disposal from the mining vessel of solid and hazardous wastes, overburden, separated seawater, and tailings may cause environmental impacts (SPC, 2016b). Annex 3 presents in detail possible environmental impacts by mine type.

Processing of materials mined to recover metals will also cause environmental impacts; however, it is generally expected that no processing will take place in any of the PICs.[10] Furthermore, compared to terrestrial mining, DSM will not have any ancillary impact on the environment, such as through road construction. Conversely, however, one cannot ignore the environmental risks involved with shipping activities.

On the other hand, concern has been expressed that DSM mining and related activities may impact other economic resources. This includes off-shore and coastal fisheries through destruction of ocean floor habitats at the mining site, sediment and discharge water plumes, noise, and pollution through accidental skills and leakages. Two factors seem to be instrumental: the nature of the minerals mined, i.e. massive sulphide minerals v. manganese nodules, and the technology being

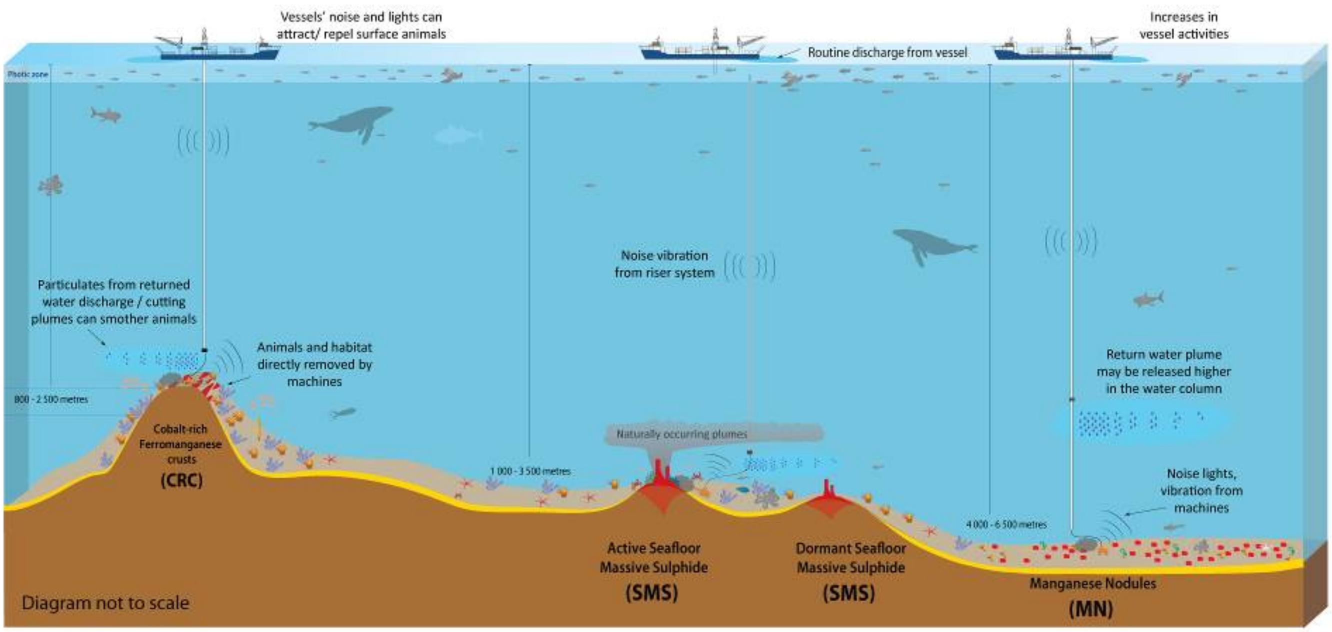
[8] Chapter 2 presents a discussion on costs and benefits of DSM operations and on deep sea and marine ecosystem services.

[9] The lack of factual data has also impacted regulatory decisions by the International Seabed Authority (ISA) which is currently in the process of drafting a Regulatory Framework for Mineral Exploitation in the Area (ISA, 2015), and regulators in otherwise high-capacity bureaucracies such as that of New Zealand's.

[10] There may be some processing stages, including initial separation and concentration that take place either on the mine vessel or at a shore-based facility but smelting and refining to obtain metals requires scale and reliable cost-effective access to other raw materials, water and power.

used. “Dredging” of areas where manganese nodules are found seems to have been entirely devastating. However, long term impacts of DSM on fisheries is very poorly understood. Nautilus reported to have commissioned a study modelling the impact of a possible break of the riser as part of the Solwara 1 Project Environmental Impact Assessment. Under the SPC EU DSM Project, SPC has commissioned a similar study. Increased vessel traffic, no matter what form it takes, will always represent an environmental risk and impact, and may also negatively impact tourism, e.g. whale watching and transportation, as well as scientific exploration. While the impacts of individual DSM mining projects have been the focus of impact assessment to date, the cumulative impacts of DSM mining have hardly begun to be assessed. Is therefore fortunate that SPC, with EU support, will commission an independent assessment of the potential impacts of DSM mining on Pacific Island fisheries. The six-month desk study will cover potential impacts from all types of DSM mining including both exploration and exploitation on all types of commercial artisanal and subsistence fisheries resources that exist in the EEZs of the 15 Pacific states assisted by the SPC-EU DSM Project.

Figure 4. Graphic Representation of Mining Operations on Different DSM Types and Associated Key Sources of Offshore Environmental Impact



Source: SPC

Social Impacts and Risks

Stakeholder concerns are influenced by the many unknowns related to DSM mining as well as prior experiences with terrestrial mining [11] The concerns expressed by communities and non-

[11] Terrestrial mining has a long history in PNG, Solomon Islands and Fiji, and was also once the main economic activity in Nauru. Other PICs by comparison have seen little or no mining aside from low intensity recovery of sand, stone, coral and other minerals for construction and other uses.

governmental organizations (Rosenbaum, 2011; SPC, 2014; Blue Ocean Law & PANG, 2016) may be broadly grouped under the following five broad, interrelated categories: [12]

- **Impact on livelihoods.** This concern is about the impact DSM mining may have on fisheries, and on tourism. Regarding fisheries, communities depend on employment in commercial fishing or on coastal fishing, worry that noise and pollution caused by the mining operations and accidental toxic spills would harm the resource[13] and impact the health of coastal communities whose diet consists largely of fish. Communities are also concerned that their access to traditional fishing grounds may be restricted when certain areas are assigned to DSM mining, even when the DSM legislation recognizes customary user rights.) Furthermore, tourism which contributes to local economies may suffer from pollution and impact on unique cultural practices that draw tourists. Concern has been expressed that the livelihoods of vulnerable groups, including indigenous groups (Box 3), women and children is most at risk.

- **Getting a share of the benefits / revenue management by government**. There is a concern that weak governance would result in poor management of revenues from DSM mining operations, and that communities would not receive a fair share of the revenues or compensation for damages they may incur from DSM mining projects.

- **Limited employment and other economic opportunities.** Communities are also concerned that the technology intensive nature of DSM mining and processing of minerals being planned in other countries will significantly limit employment opportunities for local DSM mining operations.

- **Impact on customs, spiritual values.** Various sources documenting the reaction of the public in the PICs to DSM speak of a spiritual association or identification with the Pacific Ocean which is vast compared the territories of the islands[14] and plays a significant role in the livelihoods and daily lives of most communities. This connection manifests itself in some cultural practices, such as shark calling[15] practiced by some local communities in PNG's New Ireland Province, which they fear would be affected by the noise, vessel traffic and pollution caused by DSM mining.[16]

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[12] This section draws largely on Rosenbaum (2011), SPC (2014) and Blue Ocean Law & PANG (2016).

[13] Blue Ocean Law & PANG (2016) report of some coastal communities in PNG observing fish deaths and linking them to Solwara 1 exploration activities.

[14] To highlight this, some suggest that the PICs should be called "big ocean states" rather than "small island states" which is how the PICs are sometimes referred too.

[15] Sharkcalling is practiced in the Bismarck Archipelago of Papua New Guinea. It involves religious rituals followed by luring a shark to one's canoe in the open sea and catching it with the help of a noose. The practice is closely tied to the local indigenous communities' creation story. Source: http://www.huffingtonpost.com/2012/08/26/shark-callers-photos_n_1828134.html

[16] Blue Ocean Law and PANG (2016) report of local community claims that exploration drilling related to Solwara I have led to decreased shark catches.

- **Adequacy of consultations**. Concern has been expressed that consultations with local communities on DSM policy and legislation in general have not been adequate. In the case of Solwara 1, while the company has carried out a large number of consultation events, critics have pointed out lack of sufficient advance notice, narrow outreach, and insufficient focus on eliciting communities' concerns. Critics have also voiced concern that new / draft DSM mining legislation in some countries does not embed processes through which communities may participate in decision making on DSM management.

Box 3. Diverging Views on the Applicability of the Concepts of "Indigenous Peoples" and the "Right to Free, Prior, and Informed Consent"

Some civil society organizations, such as Blue Ocean Law and the Pacific Network on Globalization (PANG) have argued that PIC governments and partner regional organizations need to take into account the concerns and interests of Indigenous Peoples in the Pacific Island countries. They also argued that Indigenous Peoples' "right to free, prior, and informed consent" (FPIC) when developing DSM related policies needs to be respected. Not doing so would violate Indigenous Peoples' "rights to land, culture and their resources."[17]

There is no universal definition of the term "Indigenous Peoples". The prevailing view even among Indigenous Peoples themselves is that no such definition is necessary. The term generally refers to people whose identities are inextricably linked to the lands on which they live and the natural resources on which they depend, who have historical continuity or association with a given region or area prior to colonization or annexation, who have continued to maintain distinct political, legal, economic, social and cultural institutions different from the dominant society, and who identify themselves as Indigenous Peoples.

A number of international legal instruments recognize the rights of Indigenous Peoples. These legal instruments include the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), which was adopted in 2007 as well as the International Labor Organization's Convention No.169 (ILO 169) Concerning Indigenous People and Tribal Peoples in Independent Countries. A number of international financial institutions also have policies that require them to assess the positive and adverse effects on Indigenous Peoples of projects proposed for their financing. These institutions include the World Bank with its Operational Policy on Indigenous Peoples (OP 4.10), the International Finance Corporation with its Performance Standard on Indigenous Peoples (PS 7) and the Asian Development Bank Safeguard Policy Statement.

Both the UNDRIP and ILO 169 recognize the rights of Indigenous Peoples to free, prior, and informed consent (FPIC) for any development project affecting their lands and territories. When the Bank's Indigenous Peoples policy was approved in May 2005, UNDRIP had not been adopted. Instead of FPIC, the Bank's policy on Indigenous Peoples requires that for all projects proposed for financing by the World Bank and affecting Indigenous Peoples, the borrower engages in a process of free, prior, and informed consultation with Indigenous Peoples, leading to their broad community support for the project. The Bank's newly approved Environmental and Social Framework includes a new Standard on Indigenous Peoples,

[17] Source: Statements made by PANG Representative at the April 26, 2016 stakeholder consultation workshop in Suva, Fiji on the draft version of the present report, Blue Ocean Law and PANG (2016), and "The regional initiative submitted by PANG for consideration to the Pacific Leaders through the Framework for Pacific Regionalism 2016" as reported in SPC-EU DSM Project (2016).

which now embraces the concept of FPIC. The Bank follows a process laid out in this Policy Framework to determine the groups that would be treated as IPs.

The basic principles of FPIC are to ensure that Indigenous Peoples are not coerced or intimidated, that their consent is sought and freely given prior to the authorization or start of any activities, that they have full information about the scope and impacts of any proposed developments, and that ultimately their choices to give or withhold consent are respected.

The situation of Indigenous Peoples varies from region to region and from country to country. For instance, the SPC contends that "in a Pacific context, the concept of 'indigenous people' as presented above can only, with difficulty, be applied to most Pacific Islands and societies. Firstly, because the vast majority of island population can claim to be indigenous. Secondly, because the political efforts to ensure unity and solidarity amongst different ethnic groups of the same population call for broad uniformity and not fragmentation. Thirdly, because island communities play a key role in the social and political governance systems in place across the Pacific nations which do not require the need to segregate nor discriminate groups of the same population." Furthermore, SPC argues that "the implementation of the FPIC concept in a DSM context is haltered by several legal issues including: (i) The general inadequacy and the lack of recognition of the FPIC concept in the Pacific context where Pacific Leaders support traditional forms of Pacific Island governance; (ii) the fact that FPIC applies to a particular community, which land, property or resources will be affected by Government decision. In fact, most of the legislation already in place in P-ACP States, DSM are vested in the State/Crown and not in communities; and (iii) the legal status of the FPIC principle has not acquired the status of customary international law".[18]

SPC emphasizes that "conscious of the potential impacts that the DSM industry could cause to PICs and to some communities, has been steadily emphasizing (SPC-EU DSM Project, 2016, p.32) the need to engage and consult with local communities and civil society in general, defending the need for government to (i) adopt an inclusive participatory approach to make sure that island populations and traditional leaders have access to the relevant information as well as the right to express their concerns, and (ii) take all concerns into consideration in making any decisions.

[18] Authors' communication with SPC.

Chapter 2. Given the Risks: Apply the Precautionary Approach

Definition of the Precautionary Approach

Principle 15 of the 1992 Rio Declaration states: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[19] In fact, as shown in the previous chapter, risks exist not only in terms of environmental impacts, but also in social, economic and fiscal matters. Therefore, a broader definition in the context of risk management may be applied. "The precautionary principle or precautionary approach to risk management states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is not harmful, the burden of proof that it is not harmful falls on those taking an action."[20] The overwhelming uncertainty regarding social, environmental, economic and fiscal impacts warrants the application by policy makers and regulators of the Precautionary Approach to DSM operations.

In general, the mining industry appears ready to embrace the principle of Precautionary Approach. The International Marine Minerals Society's Code for Environmental Management for Marine Mining (ISA, 2010) which was adopted by ISA in 2010 calls for "the use of appropriate risk management strategies and the precautionary approach to guide exploration, extraction, waste disposal and closure, and to identify environmental risks, their possible consequences, and their probabilities of occurrence." Specifically mining companies ought to "adopt the precautionary approach in managing identified environmental risks."

The Process of Applying the Precautionary Approach and Key Supporting Elements

SPC has laid out the five steps in applying the Precautionary Approach to DSM mining (Figure 5). The process is an ongoing and iterative one in that completion of Step 5 leads back to Step 1 in order to reevaluate the likely harm and the necessary approaches. The process is managed by a regulatory authority with strong stakeholder participation.[21]

Stakeholder Participation

Stakeholder participation is fundamental to the satisfactory application of the precautionary approach, as it is to the mitigation of negative impacts caused by any investment projects. The IFC Performance Standard 1 defines stakeholder engagement as an ongoing process that may involve, in varying degrees, the following elements: stakeholder analysis and planning, disclosure and

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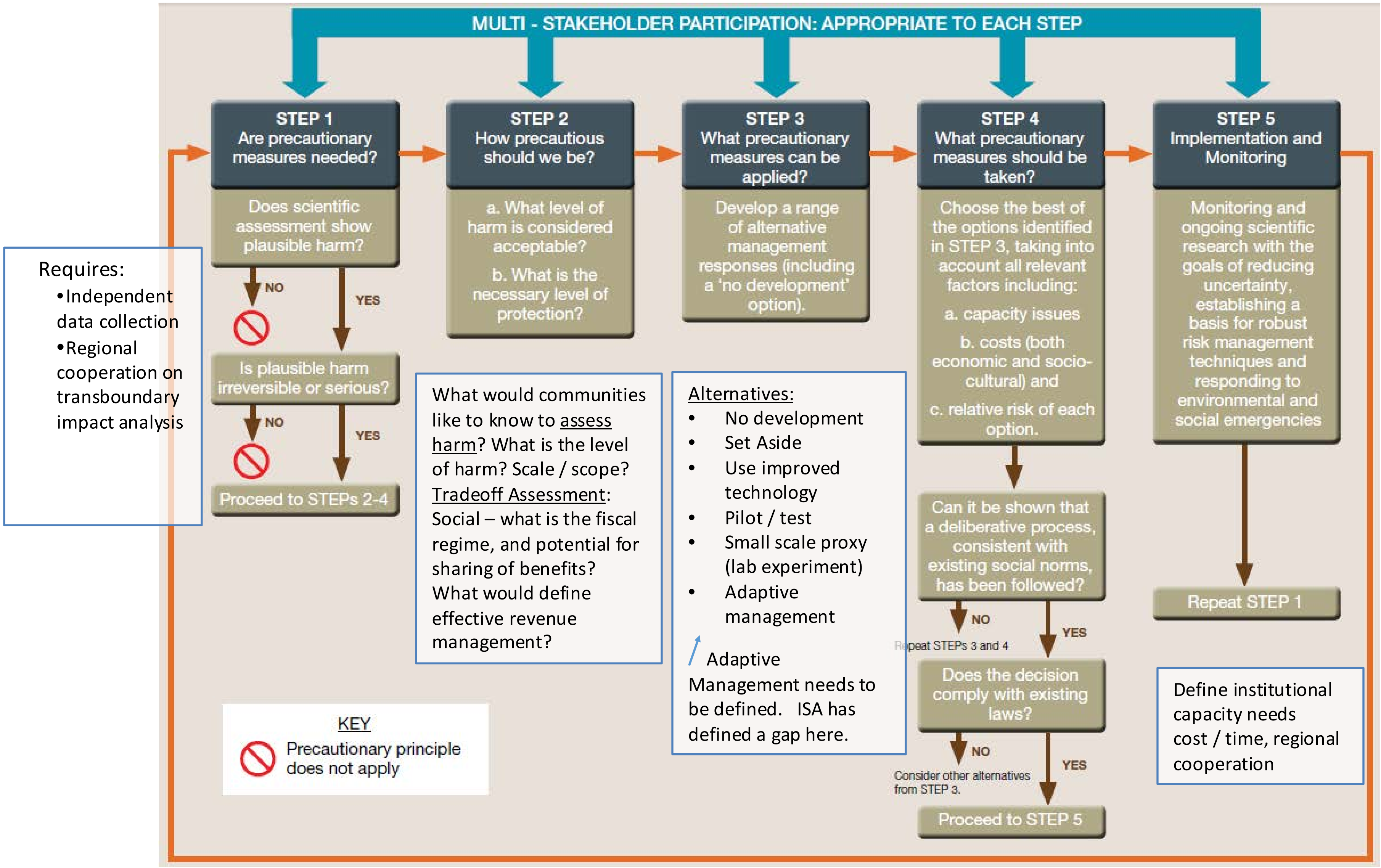
[19] http://www.unep.org/documents.multilingual/default.asp?documentid=78&articleid=1163
[20] www.wikipedia.com, accessed on 2 November 2015
[21] Elements of this process may already be embedded in the legislation of some PICs.

dissemination of information, consultation and participation, grievance mechanism, and ongoing reporting to Affected Communities (Annex 2).

Figure 5. Five Steps for applying the Precautionary Approach



Source: SPC with authors' additions

Step 1. Are precautionary measures needed?

In the first step, policy makers determine whether there is scientific evidence pointing at plausible harms and if so, whether the plausible harm is irreversible or serious. If the answer is positive, then the precautionary approach should be applied. As discussed in the previous section, some exploration activities and most exploitation activities are likely to cause irreversible or serious harm.

Step 2. Degree of precaution needed

The level of precaution needed depends on the level of harm that is considered acceptable and the level of protection that is considered necessary. Both of these questions are not only crucial but also challenging to answer, mainly due to the dearth of data on the current status ("baseline") of the marine ecosystem and the services it provides, and on the changes that are likely to occur ("impact") as a result of the DSM mining project.

International law[22] requires an environmental impact assessment (EIA) for serious harm to the marine environment. Therefore, some exploration and all exploitation activities will require an EIA. For most prospecting and some exploration activities, a less comprehensive environmental assessment (EA) will be required. In all cases, the assessment will cover not only the impacts on the physical (marine and possibly coastal) environment, but also the social, economic and cultural dimensions of the human environment. The assessment will document the baseline situation and assess the likely impact of the proposed intervention. Furthermore, the EA/EIA will devise an environmental management plan, which also outlines the monitoring requirements and specifies the roles of all involved as well as the associated costs. [23] The cost of implementing the EMP will be covered by the DSM developer.

[22] UNCLOS Article 206; Convention on Biological Diversity Article 14; Noumea Convention Article 16.
[23] In some jurisdictions, submission of an EMP and EIA is not required to be simultaneous. As the Nautilus sustainability manager commented in her written comments dated May 16, 2016, "[q]uite often the EMP has management commitment that reflect detailed engineering designs, and as such often are written after the EIS, when project design is finalized to the level of detail required to prescribe the engineering designs behind specific commitments, and details such as where the monitoring stations will be located, how frequently they will be monitored etc.".

Box 4. What type of information is needed to determine acceptable harm?

Research exploring the acceptability of DSM mining to Australian stakeholders found that stakeholders were primarily concerned about the potential environmental impact of DSM mining and highlighted the lack of baseline data "from which [they] rigorously evaluate the relative costs and benefits of seafloor mining activities." In particular, stakeholders were interested in i) information on the nature and location of the proposed activity to evaluate potential impact on the marine habitats or other natural resources that were highly valued; ii) the environmental impacts and in particular, the scale and scope of the impacts as compared with the effects of human interventions in other significant endangered eco-systems, such as the Amazon; iii) the costs and benefits associated with the proposed DSM project, including not only environmental but also social and economic impacts; iv) how the industry would be regulated, and in particular how stakeholder and community consultation would be carried out; and (v) how independent and transparent the information shared would be.

Source: Mason et al., 2010

Trade-offs: Need for sound cost - benefit analysis

Like any major investment project, a detailed economic cost-benefit analysis should be undertaken for proposed DSM mining projects following established methodologies, which are presented in WBI (2001) among others and considering issues specific to DSM-mining:

- The cost benefit analysis should establish the current conditions ("the baseline"), the project scenario, and a counterfactual without project scenario. Expected changes to the baseline under the project should be compared with expected changes if the project is not undertaken.
- The perspective of the analysis should be that of the society of the host country, including government and citizens, although, given cross-boundary environmental effects, a supplemental analysis from a regional perspective would also be useful. Additionally, the global community/humankind stands to benefit and lose from the impacts of DSM mining. For the latter, examples for benefits may be increased availability of minerals including rare earth and increased knowledge of deep sea ecosystems gained as part of environmental assessments and monitoring associated with DSM mining projects. A prime example for losses would be the environmental externalities (see below), in particular of deep sea ecosystems which may have significant existence and option value (scientific, genetic, pharmaceutical) to them (Box 6). Such values may have implications for channeling funds to conservation efforts (Barbier et al, 2014).
- The analysis undertaken by the government should take into account not only a single project but the *cumulative effects* of existing and planned projects within the subject country's EEZ and neighboring EEZs, whether or not they are implemented by the same company or exploit the same mineral type.[24]

[24] Ocean Foundation (2015) criticized the cost benefit analysis for the Solwara 1 (Earth Economics, 2015) for not considering the cumulative impact of the planned Solwara 2-12 projects, for which the company has exploration licenses.

- The analysis should be comprehensive and strive to capture in monetary terms all costs and benefits to different sections of the society (Table 5). Focusing on the immediate mining site alone, which may be small, would miss a significant number of environmental externalities that would affect humans (see below and Box 3).
- *Government revenues* are often straightforward to estimate based on the company's projections on revenues and capital and O&M costs. Nevertheless, such projections should be subjected to rigorous sensitivity analyses to account for risks and uncertainties in costs due to the as yet commercially untested nature of extraction technologies, and unexpected weather patterns, and in revenues due to commodity price fluctuations, taking into account the specific contractual arrangements between the government and the company.
- *Environmental externalities.* DSM mining may lead to a variety of negative environmental externalities, as presented in detail in Annex 1, which must be included in the economic analysis. Externalities may occur offshore and onshore. Special consideration would be given to offshore impacts, which may be on the seabed, and flora and fauna, on water quality and fauna living along the water column. These costs accrue through changes in the services that the impacted marine ecosystems provide. Such services are classified as provisioning, regulating, cultural and supporting services (Millennium Ecosystem Assessment, 2005). The economic cost benefit analysis for a DSM mining project should analyze and, ideally, quantify the changes in the services likely to be caused by the project.
- There is a significant amount of unknowns about the marine organisms, ecosystems and processes that DSM mining may impact, as well as the services they provide to human societies, the nature and level of the impacts, and how the impacts may change the services. Therefore, it is extremely difficult to evaluate these services even qualitatively, let alone quantitatively, as evidenced by the economic cost benefit analysis that SPC commissioned (SPC, 2016a) (see below).
- *Distributional analysis.* Like most investment projects, DSM mining projects would impact different segments of the host society differently, potentially leading to winners and losers. A distributional analysis would identify the winners and losers together with the associated gains and losses, allowing the government and project proponent to determine the ways and amount of compensation of the losers, should the project go ahead.

Box 5. New Zealand Experience with Ecosystem Impact Assessment

In New Zealand, in its application for an exploration license, Chatham Rock Phosphate (CRP) contended that while the benthic ecosystems in the proposed mining area would be destroyed, (i) they weren't that unusual; (ii) were not crucial ecosystems for commercial fish species; and (iii) that the overall area that would be lost would be a miniscule proportion of the New Zealand's EEZ. The evidence presented by those opposing the project focused partly on (i) the uniqueness of those benthic environments; and (ii) their role, i.e. ecosystem services, for various fish species. CRP's inability to counter that evidence or to advance an argument beyond 'it's only a small area' contributed to the rejection of their application.

Source: Authors' communication with former members of the New Zealand regulatory office.

Table 5. Potential Costs and Benefits of DSM Operations to the Host Country

<table>
<tr><th>Stakeholder</th><th>Costs</th><th>Benefits</th></tr>
<tr><td rowspan="3">Government*</td><td>Cost of developing a national policy and regulatory framework prorated to project</td><td>Royalty and tax revenues</td></tr>
<tr><td>Administrative costs of monitoring, enforcing and reporting on the mine operation. **</td><td>Any direct revenues as direct participant in investment</td></tr>
<tr><td>Any capital and operational costs as direct participant in investment</td><td></td></tr>
<tr><td rowspan="5">Citizens and Communities</td><td>Reduction in services provided by deep sea ecosystems, including provisioning, regulating, cultural and supporting services, due to mineral extraction.</td><td>Income derived by host-country nationals from employment by project company</td></tr>
<tr><td rowspan="3">Reduction in services provided by other marine eco-systems, notably:
Provisioning: Loss of income from off-shore or coastal fisheries and tourism due to regular DSM mining activities and their impact on the environment.
Cultural: Loss of cultural or spiritual value associated with pristine ocean, sense of ownership of/identification with the ocean and its resources</td><td>Value added due to secondary economic activities supporting the DSM mining project</td></tr>
<tr><td>Human and physical capital enhancements due to investments by government from tax & royalty revenues or by company in education, health and infrastructure.</td></tr>
<tr><td>Increased knowledge of deep sea ecosystems and geology obtained through regular monitoring data collection during DSM project</td></tr>
<tr><td>Damage to property, resources, and livelihoods caused by accidental spill of hazardous materials such as oil, and other accidents involving the DSM mining vessel.</td><td></td></tr>
<tr><td></td><td>Reduction in well-being of one or more sections of the society caused by dependency on payments from government, temporary nature of mining employment, or disruption to social fabric due to influx of foreign workers.</td><td></td></tr>
</table>

*This table assumes that the main company is not based in the host country and pays the government royalties and or taxes for the resource. If the company is incorporated in the host country, its revenues net of its capital and operating and maintenance costs enters in the CB analysis, while taxes and royalties it pays to the government, which are transfers, do not.

** Including cost of staff time, monitoring data, and independent reviews. Some of these costs will be borne by the company per the polluter pays principle.

Source: Authors and SPC, 2016a.

Cost-Benefit Analysis Commissioned by SPC

SPC has commissioned a preliminary economic cost-benefit analysis of DSM mining in the Pacific Island region. The analysis carried out for three mineral deposits thought to have a high potential for economic viability: (a) seafloor massive sulphide deposits in Papua New Guinea (PNG); (b) Polymetallic Manganese Nodules in the Cook islands; and Ferromanganese Cobalt-rich crusts in the Republic of Marshall Islands. The mining scenario analyzed for (a) reflects the planned Solwara 1 operation, while those for (b) and (c) are more hypothetical albeit realistic, based on potential operations in these countries. As summarized in Table 6, the analyses led to the following conclusions: First, in the case of massive sulphide deposits in PNG, benefits significantly outweigh the costs by $82.7 million (refer to Chapter 3 for more details). Second, in the case of the Cook Islands, where four metals would be recovered, the miner owns the operation, and the processing facility would be overseas, net benefits would reach some USD467million, largely due to the high grades of manganese and other minerals in the nodules. Third, crust mining in the Marshall Islands would not be economically feasible under the constructed scenarios (SPC, 2016a).

Table 6. Economic Costs and Benefits Estimated (in millions USD, 2015)

Country	Resource	Cost	Benefit	Net Benefit
PNG	Cu, Zn, Au	0.64	83.30	71.90
Cook Islands	Manganese nodules	9.60	494.00	467.00
Marshall Islands	Cobalt crusts	7.30	39.00*	0.00

* The project is not commercially feasible. Royalty payments are the only benefit.
Source: SPC, 2016a.

The economic cost-benefit analyses generally followed the principles of good practice listed above. Specifically, they compared project impacts with the counterfactual, attempted to cover a number of environmental externalities (see below), differentiated cost and benefits by stakeholder, and used the host society as the unit of accounting for benefit and cost accrual. They also included 'regional economic impact analyses' to consider distributional impacts or cumulative impacts. On the other hand, they did not consider impacts on the nations of neighboring EEZs, which may suffer some of the environmental impacts. Furthermore, the analyses were focused on single projects, thus failing to consider the likely cumulative impacts of planned series of projects in the same general area.

The authors made a reasoned attempt at analyzing and quantifying some of the possible environmental externalities. Of the possible impacts identified in SPC (2016b) and summarized in Annex 1, they covered to a large extent (1) seafloor operations to remove mineralized materials, (2) operational plume and sediment resuspension at the seafloor by machines, and (3) returned seawater plume under the headings of 'mining related disruptions provided by deep seabed communities' and 'surface water quality impacts due to discharge of nutrient rich water'. They also partially evaluated the impact of accidental, non-routine incidents by focusing on oil spills.

Table 7. Potential Impacts of a DSM Mining Project on Marine Ecosystems

Causes of impact*	Effects*	Assessed by SPC (2016a)?
(1) Seafloor operations to remove mineralized material	Removal of seabed chimney structures / nodules / crust and of associated organisms. Lights on machines may blind some organisms, and interference with bioluminescent communication. Noise and vibration may mask mammal communication / prey detection and predator avoidance.	Partially with focus on seabed ecosystems. See text for methodological concerns.
(2) Operational plume and sediment resuspension at the seafloor by machines	Smothering of seabed organism and hard substrates, choking of motile organisms and suspension feeders, clogging of filtering apparatus of pelagic organisms; damage to ability of larvae to feed in the water column or to settle on substrates. Metals in plumes may become toxic and bioavailable.	
(3) Returned seawater plume	If released in the surface waters, plume could reduce plankton growth, overstimulate primary production, increase heavy metal burdens, reduce water clarity, affecting visual predators, lead to toxicity and bioaccumulation of metals. Plumes could reach kilometres to up to tens of kilometres from the mine site. Plumes will have a gradient of impact, reducing with distance from the discharge location.	Partially, see text below.
(4) Standard vessel operation and discharges	Water pollution from ballast water, treated sewage, grey water, food waste, highly salinated water. Paints on the vessel may be toxic to marine organisms. Noise and vibrations may impede marine mammals' communication and navigation.	No
(5) Accidental, non-routine incidents	Spills of recovered materials, oil leaks from vessel, leaks from the lifting system may impacts water quality and fauna vertically along the water column and horizontally.	Only oil spills.

Source: Adapted from SPC, 2016b

While the approach followed by SPC (2016a) represents an improvement over an earlier attempt by Earth Economics (2015), there are methodological and coverage related concerns with this analysis too, which in part point to the difficulty of quantifying impacts which have not or are just beginning to be studied:

- *Arbitrary and unsubstantiated evaluation of the disruptions to the services provided by deep seabed communities*. The authors first catalogued the services provided by the deep seabed communities at each of the mines. Second, they assessed the magnitude of the baseline services by assigning each service a level from 1 to 3 relative to service provided by the forest and wetland habitats. For example, they assigned "1" to the provisioning service of 'utilization of genetic resources from deep sea vent areas. Third, they evaluated the project related changes by assigning a value between -3 (negative impact perceived by most host country residents) and +3 (large positive impact perceived by most country residents) and conclude a level of composite service loss. The values assigned in values in steps two and three appear rather arbitrary in the absence of any references to relevant scientific work.

- *Questionable application of the habitat equivalency analysis (HEA).* The authors quantified the monetary value of the above service losses on the basis of the total value of services provided by wetlands, using HEA. A key concern with this approach is the validity of comparing deep seabed habitats with wetland habitats, given that preference for compensation with the same services as were injured (Dunford, 2004). At the same time, literature on deep sea ecosystems already includes some studies on willingness to pay for deep sea ecosystem conservation (Box 6); so, one wonders if similar valuation studies on proposed DSM mining sites or at least a benefit transfer of the results from existing studies might not be more suitable and worth attempting.

Box 6. Valuation of Deep Sea Ecosystems

- A 2007 study (Wattage et al., 2011) revealed that the public in Ireland is willing to pay up to €10 ($14) per person to protect deep-sea corals from trawling so that the corals can provide raw materials for the biomedical industry, essential fish habitats and carbon sinks.
- Visitors and residents in the Azores, an Atlantic archipelago about 1,500 kilometres west of Portugal, expressed a willingness to pay €405–605 per person (Ressurreição et al, 2011) to prevent 10–25% reductions in marine species richness in open waters, including the deep sea.
- In Scotland, survey (Jobstvogt et al, 2014) respondents were willing to pay £70 ($115) to £77 each to promote maximum deep-sea biodiversity conservation and develop new medicinal products from deep-sea.

Source: Barbier et al.,2014

- *Questionable estimation of the cost of ecosystem service damage due to accidental oil spills*. The external cost of accidental oil spills is approximated by the annual premiums for accidental oil spill compensation insurance policies. However, these policies would only compensate claimants for financial losses. The authors therefore estimate the cost to the host society of losing other ecosystem services due to oil spills separately by multiplying the expected oil spill amount by $24,000, a figure reported in Kontavas and Psaraftis (2010). The applicability of this damage figure is based on the multiplication of a global average financial damage figure estimated a long time ago with an arbitrary factor of 1.5, which Kontavas and Psaraftis (2010) themselves question.

- *Omitted possible impacts*. The analysis does not cover concerns voiced in several publications (Steiner, 2009; Rosenbaum 2011; Deep Sea Mining Campaign 2012 and 2015) including the impact of the marine food chain, fisheries, and health of communities of accidental spills of toxic minerals and return water due to a break in the riser, and of plumes generated by the mining operations, as well as possible vessel accidents. A characterization of the services provided by pelagic ecosystems, as the authors did for the benthic area, would help analyze these possible impacts.

In sum, while the cost benefit analysis indicates that some cases of DSM mining has high revenue potential for host countries, the cost of potential losses due to environmental externalities cannot be reliably estimated in the current limited state of knowledge. This points to a need for more research on how marine ecosystem services may be impacted by DSM mining and the economic value of changes in such services.

Box 7. Spatial Identification of Eco-system Service Values

Public participation/participatory Geographical Information Systems (GIS) and Social Values for Ecosystem Services Mapping are approaches that have evolved in the past decade and have been used to explicitly identify and map a range of ecosystem services associated with a geographical area. Participants, who can range from lay people to stakeholders to experts, identify spatially explicit direct and indirect benefits from ecosystems that contribute to human well-being and may also include an assessment of the relative importance of the services provided. The application of the methods has ranged from terrestrial landscapes to marine landscapes, such as the Channel Islands off the coast of California.

Source: Brown and Fagerholm, 2015; Van Riper and Kyle, 2014.

Step 3. What precautionary measures can be applied?

Six alternative management responses that have been identified:

1) ***No development.*** This option was chosen by the New Zealand Environmental Protection Agency ("NZ EPA") in declining two license applications for exploiting phosphate deposits on the grounds that the environmental risks outweigh the economic benefits of the proposed projects and "could not be mitigated by any set of conditions or adaptive management regime that might be reasonably imposed." (NZ EPA, 2015) [25]. It is noteworthy that the resources in question were not DSM, and were shallow and known. Nevertheless, the NZ EPA considered the associated environmental risks excessive, suggesting that a DSM mining project with larger uncertainties may face equal or more substantial scrutiny.
2) ***Set-asides.*** This option entails setting aside, before any test mining or exploitation occurs, and protecting one or more reserve areas that are representative of the habitat that will be impacted, also taking into account the possible transboundary nature of some ecosystems (SPC, 2016b). The Environmental Management Plan for the Clarion-Clipperton Zone in the Area provides for nine such areas termed "areas of particular environmental interest" (ISA, 2011). The PNG Solwara 1 Project also plans to use a set aside as a reserve and as a source of fauna specimen with which to rehabilitate the project impact zone after the mining operation is completed (Coffey Natural Systems, 2008).
3) ***Use technological innovation to minimize impacts***, such as reduction of the footprint of sediment plumes or elimination or mitigate sediment compaction (SPC, 2016b), through the design of riser

[25] http://www.epa.govt.nz/news/epa-media-releases/Pages/EPA-refuses-marine-consent-application-by-CRP.aspx. Accessed on 4 November 2015.

Specifically, in the case of the proposal to mine phosphate nodules on the Chatham Rise, the NZ EPA "concluded that mining would cause significant and permanent adverse effects on the existing benthic environment on the Chatham Rise" and was "left with a lack of certainty about the receiving environment and the adverse effects of the proposal on the environment and existing interests." Furthermore, the EPA "found that the destructive effects of the extraction process, coupled with the potentially significant impact of the deposition of sediment on areas adjacent to the mining blocks and on the wider marine ecosystem, could not be mitigated by any set of conditions or adaptive management regime that might be reasonably imposed."

and pump systems and seafloor crawlers / vehicles. The approved EIA may include an obligation to minimize impacts that are understood and can be anticipated or modeled.

4) ***Stage a mining proxy,*** namely an experiment that replicates a DSM operation on an ongoing basis but much smaller scale, in order to gather information on the impacts of DSM. Such a proxy would require creating environmental impacts, and the amount of useful data produced over a long period of time is unknown.

5) ***Pilot or trial mining* on a small scale**, although unlikely to be undertaken due to high cost relative to scale, this scenario proposes, as part of a staged program, rather than immediately authorising commercial-scale activity (SPC, 2016b). Such pilot mining would be accompanied by extensive monitoring before and during the pilot of the mining sites, surrounding areas and control areas. The results of such monitoring would allow regulators to halt or substantially change plans for the main mining project. The advantage of a trial approach over initiating a full scale DSM project right away is the ability to limit the damage to a small area, should one occur. A critical question involves the parameters and length of monitoring.

6) ***Adaptive management*** is defined an iterative process of robust decision making in the face of uncertainty using monitoring results which help reduce the uncertainty. In a DSM project extensive monitoring would be carried out before and during the project of the mining sites, surrounding areas and control areas. Monitoring results would lead to amending or improving the plan of work, including methods of mitigation, in cases where new information requires changes in approach. Complete cancellation of the mining project is also not ruled out, as a result of observed results or regulatory non-compliance..[26]

Step 4. What precautionary measure should be taken?

SPC and NIWA (2016) posits that the best option is to be chosen in the light of (i) capacity issues; (ii) economic and socio-cultural costs; and (iii) relative risk, and following a deliberative approach consistent with existing social norms and existing laws. Options (ii) and (iii) will be largely determined on a case by case manner. However, some general observations on capacity and regulatory issues that will impact the choice can already be made:

- ***Each of the options requires strong technical capacity on the part of the PIC regulator*** to evaluate the proposed DSM project, including the proposed technology, potential impacts, and mitigation measures. Set-asides require the ability to judge the appropriateness of the proposed areas. Requiring technological innovations necessitates a sound understanding of impacts and available

[26] The International Marine Minerals Society's Code for Environmental Management for Marine Mining (ISA, 2010) calls for adaptive management under the section heading Integrated Environmental Management: "2. Periodically review and update the environmental management system in a structured, iterative process that involves the local or affected community, to ensure that the system remains up-to-date, effective and relevant to the company's evolving needs, improvements in best environmental practices, and to changing community values and expectations." (p.12)

technologies. Mining proxy, trial mining, and adaptive management will require intensive monitoring, which the regulator would need to verify and evaluate to decide on the next step.

- ***Investors' unwillingness to finance may make some options impractical.*** In the case of a mining proxy, it is not clear how such an experiment would be financed since no commercial organization would likely be interested in an investment that did not offer the possibility of yielding any returns. Similarly, in the case of pilot/trial mining or adaptive management, it is very difficult for a company to make an internal or external investment case if there is a reasonable chance they might be prohibited from mining some of the resource. [27] This is particularly the case at this very early stage of the industry where many of the major players are single project investment vehicles – i.e. they exist to develop one major resource, and unlike traditional multinational mining companies they cannot offset the high risk of new development against existing producing assets. On the other hand, one aspect of DSM that mitigates commercial risk is the ability to move equipment and vessels to new resources and areas.

- ***Cost of monitoring.*** The cost of monitoring, which would be borne by the investor, would be high in all five options, but especially in adaptive management.

- ***Regulatory clarity will be needed.*** In the case of trial mining, regulatory clarity is needed as to the grounds on which mining, which has been preceded by pilot or trial operations, could nonetheless be rejected. Similar clarity is needed in the case of adaptive management. Moreover, there is a general lack of definition of the terms of adaptive management in DSM. Hence, the need for "a regulation that better defines adaptive management" is identified as a high level issue by the International Seabed Authority in its draft regulatory framework for mineral exploitation in the Area (ISA, 2015).[28, 29]

- ***Lack of baseline data.*** The New Zealand experience highlighted the difficulty for a company to incorporate adaptive management into a DSM license application in the absence of baseline data.

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[27] This is different from the common situation governing events that could require terrestrial mining to be halted, such as mine or damn collapses, pollution events and serious safety breaches. In these cases the legal obligations are well understood in advance and such incidents relate to well understood baselines and standards.

[28] Under "Commentary / Suggested Content" it notes:

"All actors to adopt an adaptive management approach to exploitation activities. Adaptive management may include:-

- The permitting of exploitation operations to proceed on a smaller scale or for shorter defined periods of time in order to assess impacts on the environment and on human health and safety;
- The duration of any approval of an EMP;
- The frequency of review periods to be imposed by the Authority; and
- Additional reporting obligations under an EMP.
- Note: this approach should be balanced with the commercial (economic) viability of operations

[29] Among next steps in the regulatory framework development, the ISA document lists elaboration with interested parties through a working group and collaboration with the New Zealand Government given its recent regulatory development and marine consent experience.

Step 5. Implementation and Monitoring

All options will require ongoing data collection including through scientific research on DSM and the ecosystems it may impact. In the “no-development” option, if the decision rejecting an operation was made “for the time being, until more information on the risks become available”, there is a need to continue collecting and assessing data on the risk elements. In the five “development options”, monitoring would be part of a project environmental management plan based on impacts and risks identified in the EIA. Impact monitoring would cover the project areas and similar non-project areas to control for confounding factors. It will also be important not to limit monitoring to the EEZ where a project is located as impacts may be transboundary or even extend into the Area. In such cases, the regulator needs to coordinate with the regulators of the neighboring EEZ or the ISA. Moreover, in the case of projects in the same general area, cumulative impacts need to be considered. Finally, in the set-asides option, the ecosystems in such sites need to be monitored to ensure that they are not impacted by the DSM operation. The project proponent should be responsible for funding the implementation of this monitoring plan. The regulator, in addition to supervising implementation, must verify the data through independent monitoring, and compile and analyze the data with a view to identifying potential needs for amending the environmental management plan. This is particularly true under adaptive management. Monitoring should focus not only on environmental aspects, but also encompass impacts on livelihoods, other social aspects and cultural values. The regulator must manage an effective grievance mechanism.

Data gathered through the above processes will inform the regulator on the appropriateness of the current option. For example, in case serious social or environmental risks emerge or the operator transgresses the license conditions, the regulator may cancel the operation. The regulator will also decide whether or not to convert a mining proxy or a pilot/trial to a full-scale operation (Table 10.)

Table 8. DSM Environmental and Social Management Requirements as per WBG Safeguards Policies and Performance Standards, UNCLOS, and ISA Mining Code

<table>
<tr><th>World Bank Safeguards</th><th>IFC Performance Standards</th><th>UNCLOS</th><th>ISA Mining Code*</th></tr>
<tr>
<td>Environmental (OP 4.01, OP 4.04, EHS Guidelines)

(i) Impacts on terrestrial and marine biodiversity; (ii) water quality, use and discharge; (iii) noise and vibrations; (iv) sedimentation; (v) worker health and safety.

Instruments: Environmental Assessment (EA) + environmental management plan (EMP) for nearly all types of projects. Environmental Impact Assessment (EIA) + EMP for serious or irreversible impacts. Stakeholder consultations (2X for EIA). Public disclosure.

Social (OP 4.01, potentially OP 4.10)
(i) Equitable benefit sharing schemes (possibly including technology transfer concerns?); (ii) Public participation and engagement, including free, prior and informed consultations for certain communities; (iii) Livelihoods impacts on other users, especially fishing communities and tourism service providers

Instruments: Social Assessment; Grievance mechanism

International (OP 7.50, OP 7.60)
Transboundary impacts – on water quality; (ii) Maritime boundaries – not all maritime boundaries have been delimited and disputes abound.</td>
<td>Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

• Methodological approach to identify and manage environmental and social risks and impacts in a structured way on an ongoing basis.

• Mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/offset for risks and impacts

• Grievance from Affected Communities and external communications from other stakeholders to be responded to and managed appropriately

• Adequate engagement with Affected Communities throughout the project cycle; relevant environmental and social information to be disclosed and disseminated.</td>
<td>• Provides for regulation of all ocean space, access to the seas, navigation, protection and preservation of the marine environment, settlement of disputes.
• Sets out the legal framework for exploration and exploitation of the deep seabed.
• Establishes the EEZ measuring up to 200 nm.
• Grants <u>all</u> coastal states have a right to engage in exploration and exploitation of the seabed and subsoil within their national jurisdictions.</td>
<td>• Governs DSM in the Area together with legislation by sponsoring sovereign states.
• Bound by UNCLOS
• Three sets of regulations for exploration (one each for nodules, sulphides and cobalt):
• Regulatory framework for exploitation under development.</td>
</tr>
</table>

* Currently encompasses three sets of regulations on prospecting and exploration of i) SMS, ii) PMN, and iii) cobalt rich crusts in the Area. Regulations on exploitation of deep sea minerals are currently under development.

Chapter 3. The Case of the Solwara 1 Project[30] [31]

Being the first DSM mining project in the Pacific to have been granted an exploitation license, the Nautilus Solwara 1 project in Papua New Guinea (PNG) could move into production in a few years if the mining company is able to mobilize the necessary capital to complete the build and deployment of the project's seafloor production system.[32] Solwara 1's successes and failures have and will continue to shape the wider global DSM mining industry.

The project envisages extracting high-grade seafloor massive sulphide deposits from an area of 0.11km2 at a depth of approximately 1,600m around 30km off the coast in the Bismarck Sea. The project is very close to an existing and active seabed volcano - North Su - with resulting sediment plume activity. Solwara 1 is the first of 12 Nautilus projects in the Bismarck Sea with exploration licenses.[33] Environmental permits were granted in 2009 and a mining lease in 2011. The project will use three large seafloor production tools (large tracked cutting and collecting machines) to mine material that will then be pumped in slurry form to a surface vessel (Figure 5.)

As outlined in the Environmental Impact Statement (EIS) (Coffey Natural Systems, 2008), the Solwara 1 resource is a seafloor massive sulphide (SMS) deposit in a water depth of between 1,500 to 1,700 meters. Five mineralised bodies contribute to the estimated 2.6Mt of mineral resource. The resource sits on the surface of the seafloor and is covered with a thin layer of unconsolidated sediment of varying thickness. The terrain can be quite steep, with localised gradients of up to 30 degrees.

The three main tasks in the mine operation on the seafloor at Solwara 1 are sediment removal, material cutting and stockpiling and collection of fragmented mined material. On completion of these activities, the mined material is to be pumped via the Subsea Slurry Lift Pump to the Production Support Vessel at the surface. The detailed description of the proposed Solwara 1 development was provided in Chapter 5 of the EIS and remains largely unchanged, including the areas to be mined. As outlined to the PNG Department of Environment and Conservation in the letter dated June 2010, the original EIS included a single seafloor mining tool which was to carry out sediment removal, and mined material cutting and collection. However, as a result of mine methodology optimisation, a revised mine plan has been developed, which involves the use of three seafloor production tools, consisting of an auxiliary cutter, a

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[30] The information contained in this section draws on documents available on the website of Nautilus Co. and the authors' exchanges with Renee Grogan, Nautilus's Sustianability Manager, by phone and email in June 2016.

[31] Annex 4 presents summary information on Cook Islands manganese nodules

[32] In 2016, Nautilus Minerals Inc. indicated that it requires significant additional funding in order to complete the build and deployment of the seafloor production system to be utilized at the Solwara 1 Project. http://www.nautilusminerals.com/irm/PDF/1818/NautilusobtainsbridgefinancingandrestructuresSolwara1Projectdelivery

[33] Nautilus Minerals holds explorations licenses on approximately 420,000km2 of the ocean floor in the western Pacific, including in PNG, the Solomon Islands, Fiji, Vanuatu and Tonga, as well as in the Area in the eastern Pacific.

bulk cutter, and collecting machine. These three machines will feed the subsea slurry lift pump which will transfer the mined slurry to the production support vessel, as outlined in the original EIS.

Cost Benefit Analysis

Economic costs and Benefis

The economic cost benefit analysis commissioned by SPC (SPC, 2016a) concludes that the benefits of DSM mining in PNG far outweighs the costs (Table 8). The report also notes that the total monetized social costs[34] represent a small portion of the monetized social benefits, ultimately having very little impact on the overall results. The report notes that the following factors contributed to the above findings:

- The remote location of the mine site from populated areas (30-40km offshore) when compared to land-based mining that often disrupts and/or displaces local communities;
- The small footprint of the mine site (0.11 km^2) as it relates to the potential for long-term environmental impacts and permanent loss of biodiversity;
- The advances in technological improvements of SMS mining equipment and processing, allowing for efficiency gains and reduced costs of operation;
- PNG's extensive experience in the extractive sector with several "world class" mines that produce from some of the most significant deposits of land-based gold, silver and copper in the world has allowed it to draw on its experience to write effective frameworks and policies adapted for DSM mining and make the development of these deep sea mineral deposits more likely to be accepted by the people of PNG; and
- Nautilus' commitment to discourage immigration through its employment policy and its commitment to providing assistance to local communities in the form of social programs.

Table 9: Expected Net benefits in PNG Mining Scenario (in million USD)*.

Category	Present Value
Government revenue	83.30
Unplanned spills and grounding	-0.03
Replacing lost environmental services	-0.61
Mean net social benefits	82.70
Benefit – cost ratio	124

Source: SPC, 2016a. *Mine life of two years

The above estimates should be considered with some caution as the many uncertainties regarding the environmental and social costs associated with DSM mining are still one of the largest unknowns being carried forward. As discussed in detail in Chapter 2, the cost benefit analysis has methodological and coverage issues with regard to such costs. Another aspect is that although the Solwara 1 project is well advanced from the exploration point of view, the feasibility study was under preparation at the time of

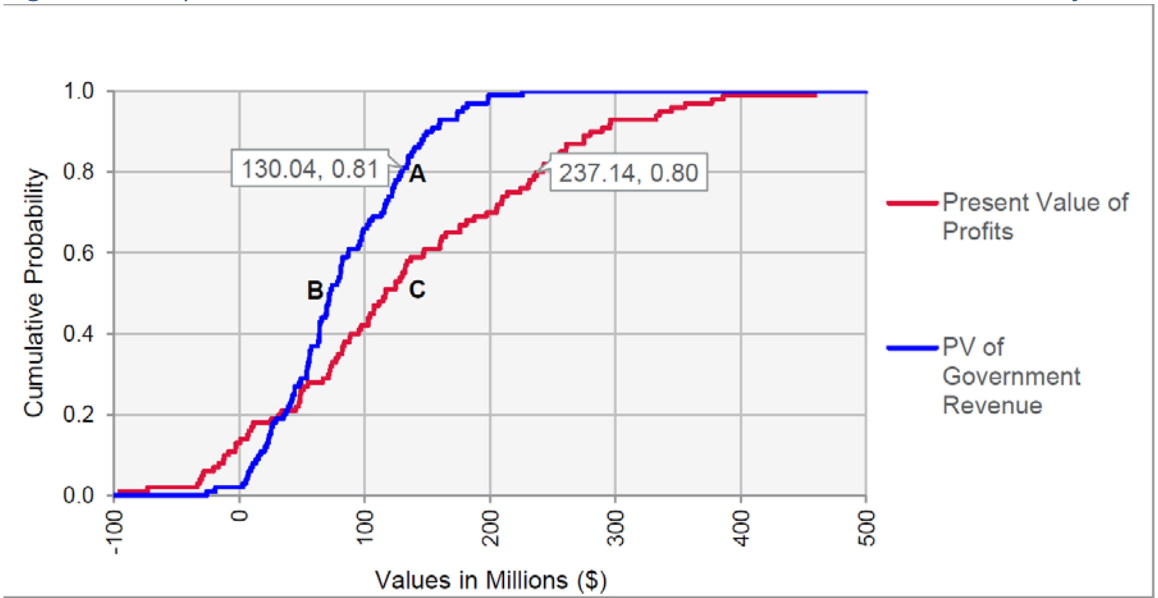
[34] SPC (2016a) uses the terms "social" to refer to "economic" benefits and costs.

writing of this report, and it was recognized at that time that pending additional drilling and reserve estimates could change the cost and benefit estimates.

Government Interest in Solwara 1

There was an extended legal dispute with the PNG Government regarding its participation in the project which was resolved in 2014 when the government agreed to buy a 15% share in the project for US$120 million, with options for purchasing a further 15% currently being considered. There are distinct advantages and disadvantages to the direct interest that the government has in the project. The most obvious advantage is that a direct stake in the project might allow the government to compensate for the reduced (compared to traditional mines) onshore benefits from the project. The disadvantages are that it shares in the commercial risk, and there is some concern that it might compromise the government's regulation of the project.

Figure 6. Comparison of Nautilus Profit and Government Revenue in Solwara 1 Project Scenario.



Source: SPC (2016)

The cost benefit analysis identifies payments made to the PNG government as the primary benefit of DSM mining from the perspective of the PNG citizens. With the exception of monitoring and regulatory costs, considered small, all other revenues would be available to the PNG government. The current Mining Act is being revised to address DSM mining activities. In addition, Nautilus has also established a Community Development Fund, where approximately $0.75 (USD) per ton of ore mined will be placed into a fund used to support health and education projects in other PNG provinces.

Environmental Impact Assessment[35]

Process. In compliance with the PNG Environment Act 2000, in 2008, Nautilus issued an environmental impact statement (EIS) based on oceanography, biology, chemistry, water quality and sedimentation rate studies in the Bismarck Sea during from 2006 and 2008 (Coffey Natural Systems, 2008).[36] The EIS consisted of an executive summary, a main report (Volume A) and 15 appendices (Volume B) with supporting studies (Annex 3).[37] More than 34 independent studies were published by scientists who have worked on the Solwara 1, South Su, and North Su sites, the three areas that comprise the mining lease for the Solwara 1 Project (Annex 3), mainly focusing on baseline characterization. The EIS states that "… consultations with governments, regional communities in East New Britain and New Ireland Provinces, and offshore resource users have been followed throughout to ensure awareness of the fundamentals of the Project, particularly those that differentiate it from other projects, and to promote the forum for raising and receiving responses to concerns and developing strategies to minimize any impacts."[38]

Steiner (2009) conducted an independent review of the EIS at the request of the *Bismarck-Solomon Seas Indigenous Peoples Council*. However, at the time of his review Volume B had not been made available to the public, which prevented him from reviewing the supporting studies and led him to judge the EIS as "not fit-to-purpose", as "[m]any risk contingencies are poorly analyzed, some are not analyzed at all, and many of the baseline studies necessary to understand potential impacts have yet to be completed".[39] The Government of PNG reportedly also commissioned an independent review of the EIS; however, as of the writing of this report it had not been made publicly available. In 2009, the Government, under the Environment Act 2000 issued an environmental permit[40] to carry out the Solwara 1 project for a term of 25 years, pending the preparation of an Environmental Management and Monitoring Plan (EMMP) (see below). Criticism of the EIS process centered on transparency. It was noted that procedural requirements regarding public consultations were not followed and the independent review of the EIS commissioned by the Government has not been disclosed (Rosenbaum, 2011.)

Content. The EIS (Environmental Impact Statement, Coffey Natural Systems 2008) discusses likely impacts of Solwara 1 and presents mitigation measures. Annex 1 of the present report summarizes the offshore impacts and proposed mitigation measures applying the framework developed by SPC (2016b). Among the key points, the EIS recognizes that the seafloor operations "will directly remove seafloor substrate, including active and inactive areas, causing loss of habitat and associated animals"[41]. The mitigation

[35] Chapter 1 and Annex 1 discuss the environmental impacts of DSM mining, including of seabed massive sulphides.
[36] According to the PNG Environment Act (2000) section 51, the term "Environmental Impact Statement (EIS)" refers to a report, while "Environmental Impact Assessment" refers to a process encompassing (a) submission of an inception report which set out the proposed issues to be covered in the EIS; (b) submission of an EIS which sets out the environmental impacts which are likely to result from the carrying out of the activity; (c) assessment and public review of the EIS; and (d) acceptance of the EIS by the Director of Environment.
[37] http://www.nautilusminerals.com/irm/content/environment-reports2.aspx?RID=413
[38] EIS, Executive Summary, p. 15.
[39] After making Volume B with the background studies available to the public, Nautilus unsuccesfully invited Dr. Steiner to conduct another review. (Authors' communication with Nautilus in June 2016.)
[40] The permit is available to the public upon request from CEPA.
[41] Environmental Impact Statement, Coffey Natural Systems, 2008 (p.26)

measures proposed include "protection (from current mining) of a nearby reference area at South Su, the retention of temporary unmined refuge areas within Solwara 1, and the enhancement of recolonisation by translocation of animal communities from areas about to be mined to areas where mining is complete" [42]. Critics of these proposals have pointed to incomplete understanding of the species composition in the mining site and the reserve site, especially regarding meiofauna, and the untested nature of the proposed measures (Rosenbaum, 2011; IUCN Pacific Center for Environmental Governance, authors' communication). With regard to plumes and sediments generated at the mine site and by the returned seawater, the EIS points to limited impact, in particular due to release of the returned seawater at the bottom of the sea. Critics have pointed out that impact on South Su could not be excluded and also warned of toxic impact of both types of plumes on the food chain in the ocean, including on fisheries which could have public health impacts for the coastal communities and lead to commercial losses in the case of tune fisheries (Rosenbaum, 2011; Deep Sea Mining Campaign, 2012). According to Nautilus, the new studies it has commissioned rule out such impacts. However, these studies have not been disclosed to the public yet.[43]

Additional Studies. Nautilus commissioned a number of scientific studies in 2015 in order to consolidate its understanding of the baseline environment at Solwara 1, and in response to continued concerns raised by stakeholders, primarily at the community level in the provinces of Papua New Guinea. These studies are carried out by a team of external scientists and, as per information provided by Nautilus in June 2016 (authors' communication), were to be finalized in late 2016: [44]

- Comprehensive analysis of the existing seafloor noise, and an assessment of the likely impacts to all marine fauna as a result of project operations;
- Baseline study of the heavy metals concentrations in existing fish stocks (using fish tissue analysis) in the Manus region (at the Project site, and along coastlines);
- Baseline study of the health and function of existing coral reef systems in the East New Britain and New Ireland provinces;

[42] Environmental Impact Statement, Coffey Natural Systems, 2008 (p.29)

[43] As of January 19, 2017, neither of two Nautilus websites "http://www.nautilusminerals.com/irm/content/environment-reports2.aspx?RID=413" and http://cares.nautilusminerals.com/irm/content/solwara-1-project.aspx?RID=339" featured such studies.

[44] Nautilus informed the authors that in 2015 it commissioned Earth Economics to conduct a comprehensive compliance audit of the proposed Solwara 1 project against environmental and social performance standards, as well as environmental, health and safety guidelines used by organizations within the World Bank Group. The audit reviewed the Solwara 1 Project against the International Finance Corporation (IFC) Performance Standards on Environmental and Social Sustainability (2012); the IFC Environmental, Health and Safety Guidelines for Mining (2007), for Offshore Oil and Gas Development (2007); and for Shipping (2007); and the World Bank Environmental and Social Framework (2015 – second draft for consultation). The audit found that Nautilus either meets, or has documented plans to meet before mining commences, all applicable IFC performance standards and guidelines as well as World Bank standards. The audit also indicated that in some areas Nautilus has set a higher bar than IFC guidelines, and has established examples of good industry practice that may further improve industry standards in future. Nautilus aims to have the Solwara 1 Project reassessed following commencement of mining to confirm ongoing compliance throughout operations with these extremely rigorous voluntary standards (Authors' communication with Nautilus.)

- Further comprehensive water quality and sedimentation data collection to provide long term baseline data that adequately captures the variability of the site, due to the influence of hydrothermal activities and the active North Su volcano.

A subsequent study of impacts on fisheries. The Solwara 1 EIS (Appendices 10, 11, 12 and 13) contains information about the Solwara 1 Project that is relevant to the fisheries industry. In addition to these data, Nautilus has updated its sediment plume modelling to reflect updated baseline information on the naturally occurring sedimentation processes (associated with the North Su volcano), as well as some amendments to the project design, engineering, and mine design. This updated modelling was to be finalized and made public by late 2016.[45] Nautilus remains confident that it will have no impact on fisheries industries or any nearshore environments, including coral reefs (Author's communication with Nautilus in June 2016).

*Preparation of the EMMP***.** The Solwara 1 Project Environment Permit requires the development of an Environmental Management and Monitoring Plan (EMMP) by Nautilus, for approval by the Conservation and Environmental Protection Authority (CEPA) prior to the commencement of mining. The Permit required that the EMMP include 12 sub-plans[46] and a risk assessment. Nautilus commenced the process of EMMP drafting with a workshop in 2011 at which 15 independent scientists and five PNG government representatives met to discuss the potential management strategies that should be considered for the Solwara 1 Project. This workshop was the beginning of a long history of stakeholder engagement, in which Nautilus canvassed the views of independent experts in order to propose a set of management strategies that most effectively implemented adaptive management strategies and the precautionary principle (authors' communication with Nautilus).

The EMMP and 12 supporting Sub-Plans as of June 2016 remained in draft, and were being finalized through a formal process of engagement with CEPA, the National Fisheries Authority, the National Maritime Safety Authority, and the Minerals Resource Authority in PNG. Once the plans are finalized they will be subject to independent expert review, a process that is commissioned and owned by CEPA in order to maintain transparency and independence. Following this process (and subject to any required amendments), the documents will be accepted by CEPA for the formal review and approval process (authors' communication with Nautilus, 2016).

Once the EMMP and sub-plans are approved, Nautilus may commence mining. During mining, environmental monitoring will occur as part of all operational activities, as outlined in the Monitoring Plan (a sub-plan to the EMMP). The environmental monitoring reports generated as part of operational monitoring will be made publicly available throughout the Solwara 1 Project life, and will be independently

[45] As of January 19, 2017, neither of two Nautilus websites "http://www.nautilusminerals.com/irm/content/environment-reports2.aspx?RID=413" and http://cares.nautilusminerals.com/irm/content/solwara-1-project.aspx?RID=339" featured such studies.

[46] These sub-plans are on: (1) air quality and dust management, (2) stockpile and acid drainage management, (3) offshore sediment management, (4) noise and vibration management, (5) water quality management, (6) waste management, (7) lighting management, (8) marine mammal and turtle management, (9) introduced species management, (10) benthic ecology management, (11) emergency spill contingency, and (12) emergency response.

audited by a scientific expert appointed in consultation with CEPA and the Provincial Governments of Papua New Guinea. Further, Nautilus will use the environmental monitoring data to update the EMMP and 12 sub-plans every six months during operations, to formally capture adaptive management processes. These updated documents will be formally submitted to CEPA every 6 months during operations, in line with the requirements of the Environment Permit.

Critics of the EIS principally cited insufficient treatment of damage to highly valuable endemic benthic[47] fauna, for which discovery of additional species is possible; impact on pelagic (water column) fauna; risks of leakage from the riser or discharge pipes and of spills from the Mining Support Vessel, shuttle barges to Rabaul or ore freighters from Rabaul; vertical and horizontal currents transporting sediment plumes and pollutants shorewards and into contact with marine food chains; impact on fisheries and other livelihoods; and cumulative impacts. (Steiner, 2009; Ocean Foundation, 2015).

Lessons learnt to date[48]

- The importance of timely publishing of documents cannot be overstated. While Nautilus has a strong history of transparency and data sharing, the internal review process can be time consuming, and it is important to balance the processes of transparent data-sharing and rigorous data review.
- Nautilus acknowledges the benefit of the independent external review process, and welcomes the opportunity for those reviews to be made public, to further enhance the transparency of the process.
- The benefits of engaging with external stakeholders, and in particular regulators, throughout the permitting and operations phases cannot be overstated. Engaging with government agencies includes regulatory bodies (such as CEPA) but also with other interested parties such as the provincial governments, and agencies such as the National Fisheries Authority, to ensure that all government stakeholders are recognised and able to provide timely feedback and input to the project.

The process for protecting set-asides or reserve areas, after mining is complete, remains an outstanding issue, that may warrant further discussion. At present, the Solwara 1 set-aside, the “South Su” area, is protected by Nautilus’ commitment to maintain it as a reserve area (in the Solwara 1 EIS), and the fact the Regulator must authorise any significant changes from the approved mine plan. It is also protected from parallel exploitation by another company as it is located on the Solwara 1 mining lease and therefore cannot be accessed by any other resource company. However, at the conclusion of mining and relinquishment of the Solwara 1 lease, an alternative protection method (such as a Marine Protected Area) may warrant consideration.

[47] The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers.(source: Wikipedia.com)
[48] Based on the authors’ communication with with Renee Grogan, Sustainability Manager, Nautilus Minerals in June 2016.

Chapter 4. Establishing DSM Sector Governance

Need for Long-range DSM Sector Planning

The economic contribution from mining is highly varied across countries, and negative outcomes have resulted from governments failing to convert mineral endowment into sustained forms of sustained economic activity. The quality of mining sector governance is paramount in this regard.[49] In summarizing lessons learned for mining resource rich nations, the IMF notes that key requirements that strengthen sector governance include:

- Good management to ensure efficient and effective exploitation;
- Good tax design to ensure appropriate government revenue and adequate incentives for investors;
- Good revenue administration to ensure that revenue is collected in practice; and
- Good public expenditure management to ensure that volatile and temporary natural resource revenue translates to permanent benefits for the nation and to manage the risk resource wealth poses to the wider economy.

There is a global experience that modest mining revenues that are well managed lead to larger development outcomes, than larger revenue streams that are poorly managed. At the core of this challenge is that few countries have a comprehensive governance strategy for effective natural resource management, owing to a fragmentation of stakeholder views limited by incomplete information (gaps) regarding the underlying resource endowment.

There is a growing recognition that public sector governance may well be the key determinant of the extent to which any one mine is economically, politically, socially, and environmentally viable. Where governance is weak or incomplete, instability and lack of predictability too often prevail and result in conditions of heightened risk and uncertainty for all. Mining investors require stability / predictability of financial and economic policies, and a transparent non-discretionary implementation of laws and regulations. Given an array of technical, commercial, and political risks; mining is high-risk / high-reward and financial gains and losses are both highly volatile and cyclical. Moreover, environmental / social / economic performance standards have become a core prerequisite for achieving sustainable outcomes, together with new demands regarding “shared value” that leverage mining investments to align with public sector development plans and ensure sharing of benefits with those most affected by mineral industries.

This interdependence between public sector performance and private sector risk is well known to investors. A 2015 World Bank compendium of industry perspectives and outlooks underscore the challenges facing the mining sector within emerging economies:

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[49] At a general level, many conceive of mineral sector governance as a series of questions: *what the basic rules are that guide activities within a specified society; how these rules are implemented, monitored, and enforced; and who determines the rules and how this authority is conferred and employed?*

- Governance. Following the financial crisis of 2008, the mining industry is emphasizing a need for good sector governance in order to access scarce investment capital. Those nations offering higher levels of sector governance offer greater stability / predictability to investors.
- Social License to operate. Earning the social license to operate through inclusive growth processes and increased benefits sharing is essential. This requires improved revenue mobilization and tax administration by the public sector. As a part of this challenge, there is a need for increased "shared Value" to address the underlying root causes of community concerns and unlocks economic opportunities for companies in the extractives sector. Key opportunities include (a) the sharing of mutually beneficial infrastructure, (b) policies for local content to improve local workforce, suppliers and community health, and (c) creating the enabling environment for local cluster development, local infrastructure networks, and playing an active role in regional & community development. Shared value initiatives align private and public sector investments towards common goals.
- Integrated landscape management**.** Over the past decade there has been an increased appreciation of the importance of integrated spatial / temporal planning, recognizing that mines exist within complex landscapes having many other complementary and non-complementary uses. Moreover, the intersection of mining and its associated infrastructure with water and forest resources is a leading source of negative impact, and an area where integrated management can help to address the impacts of climate change.

Deep Sea Mining, like surface mining, has a number of unique characteristics that influence fiscal policy design and tax design and administration. These include:

- Mineral resources are a valuable nonrenewable national asset, and governments expend much capital to assess the total resource endowment to understand (a) the full resource potential and (b) how any one mine development is impacting the depletion of this national asset.
- The profitability of a mining operation can vary significantly with changes in commodity prices, production costs, and fiscal policy.
- The industry has long been characterized as high risk / high reward, requiring large capital investments backed by strong technological expertise.
- In lower-income countries most of the natural resources produced are exported, and most of the high-value equipment and services used for natural resource operations are imported.
- Natural resource companies often operate under distinctive risk-sharing commercial arrangements.
- Transfer of ownership of interests in natural resource operations is common.
- Natural resources present exceptional challenges to governance and transparency.

Need for Quantitative Resource Assessment

However, Deep Sea Mining carries a one unique characteristic – an inability by PIC governments to conduct a resource assessment of the broader mineral endowment in order to inform on the design of an appropriate fiscal policy, and understanding of economic potential. The current understanding of resource potential comes from a very small number of blocks (1-2) for which Bankable Feasibility Studies have been submitted and are available. It is not known where these first deposits are located upon the full spectrum of possible deposit sizes and qualities, and thus the potential size of the next "discovery" and the corresponding potential economic contribution.

The resulting information gaps extend physically across an area much larger than the proposed mining operation itself, and the provision of information to address these gaps may have to come from a partnership with those companies exploring the seafloor itself. Application of the Precautionary Approach for mitigating and managing environmental / social impacts may be useful in this regard, serving as a framework for approaching the economic resource potential – in that different options under the Precautionary Approach could include alternative incentives and obligations for the company to provide such data.

Need for DSM -Driven Local Content

Decades of practical experience in capturing the economic impacts & linkages of mining highlight the existence of limited spillover effects in developing countries. Mining enclaves having few local linkages, result from the use of specialized input, often at the high end of the technology spectrum, sourced through globally integrated supply chains or global value chains. This is a DSM challenge given technology-intensive methodologies from a concentration of suppliers, many of whom may more commonly service offshore hydrocarbon exploration and development.

Policy interventions to strengthen economic linkages often taken the form of local content requirements, local ownership requirements, local processing standards, local hiring of staff, compulsory corporate social responsibility (CSR) programs, mandatory local content reporting requirements and supplier development programs among other (Hirschman, 1958, Kokko, 1994; UNCTAD, 2001; and Alfaro et al., 2010). Today, ninety-percent of all resource rich countries have policies or regulations related to promoting local content from extractive industry FDI, ranging from harder, and targeted requirements to softer approaches (Dobbs et al., 2014). Although these policies were designed to correct for enclave development, their application has achieved mixed results.

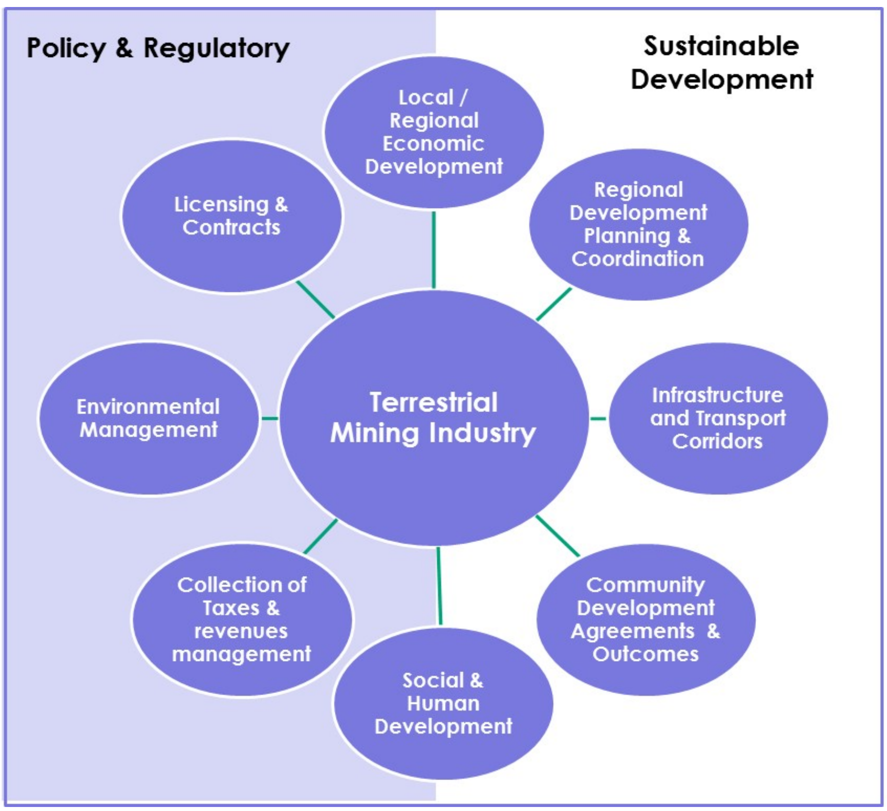
In approaching DSM mining, some useful lessons can be learned from the experience of other countries, policies and implementing tools aimed at developing productive linkages are context-specific – again aligned with the foundational premise of achieving "shared-value" combing the lessons of Porter et al. (2013) and the World Bank (2016).

- What types of DSM policies can be used to guide investment while increasing local linkages in PIC's? Do they differ across the region?
- What are the costs and benefits of introducing such policies, and how can this best be determined for potential DSM investors, PIC governments, and the society as a whole?
- How can the implementation of such policies be measured and monitored and the national level and through regional cooperation?

- What kind of technological and knowledge spillovers are more easily transferred to the PIC's? How would they be measured?
- What exactly is "shared-value" in the context of DSM in PIC's?

PIC governments will want to catalyze their position as owner of the mineral resources to leverage new collaborative partnerships around shared-value by aligning private sector DSM investments and public sector investments targeting poverty reduction and increased shared prosperity. Creating "shared value" within PIC's goes well beyond contractual / regulatory compliance challenges within PICs towards developing strategies for that deliver tangible social benefits. Figure 7 below was created by the World Bank to depict several interrelated issues around shared value and sustainable development for mining. As applied to DSM, PIC governments would want to move beyond narrow definitions of policy and regulatory compliance (on the left side of the diagram), towards the strengthening of economic linkages (local content) through integrated planning, benefits that target community, and the sharing of infrastructure (which for DSM might relate to marine infrastructure and information technology systems to improve connectivity).

Figure 7. Interrelated Issues around Shared Value and Sustainable Development for Mining



Source: Authors

And, in approaching DSM it is equally important to understand what potential investors might need / want from governments. While no survey has been taken of potential DSM investors, the World Bank for many years did conduct surveys of terrestrial mining companies in emerging economies. Table 10 below underscores the key elements of predictability, stability, and consistency of policy and decision making processes. Any poor practices that erode the enforcement of a competitive, transparent non-discretionary regime – serve to directly erode the viability of the investment, and PIC governments will want to safeguard against poor practices.

Table 10. The Key Elements of Predictability, Stability, and Consistency of Policy and Decision Making Processes for Extractive Industry Investments

Investment Decision Criteria	***What Government Needs to Do***
Geological Potential / Resource Certainty	Geological Survey providing basic geo-data and undertaking mineral resource assessment
Profitability of Potential operations – competitive fiscal regime, realistic foreign exchange controls	Investment laws
Security of Tenure – clear, non-discretionary mining rights and title for permitting	Mining cadastre
Consistency of Mineral Policy – clarity of roles & responsibility, stability of exploration / exploitation terms and conditions, mineral ownership (resource nationalism)	Mineral policy Tax legislation
Stability of Legislation –predictable environmental / social obligations, non-discretionary transparent regulatory environment	Clear, consistent mining, environmental, social, and tax regulations
Availability of Infrastructure	Public Private Partnerships

Souce: What Investors Want, World Bank 2002

Need to Grow Industry

The mining industry in a new country is often stimulated by one exceptionally large or rich discovery. In the context of DSM, this might be a particular PIC licensing a single operation and the industry using that opportunity to "learn" how to better optimize production technologies and exploration to improve operational efficiencies. A second operation might then be begun, and one-by-one clusters of mining operations emerge. As such, the economic impact of DSM ten-to-fifteen years into the future could be more robust, making modelling of potential revenue streams all the more difficult absent a sense of the rate of learning associated with DSM.

Likewise, it is the experience in many countries having undergone World Bank supported reforms that governance also improves in incremental stages and the rate of improvement of sector governance ten-to-fifteen years into the future could also be appreciably different (most often improving in non-linear fashion). This learning by industry and government alike leads to some conceptual curves used by the World Bank to convey that reforms and concurrent sector activity (exploration and exploitation) take time to germinate, but once having achieved initial levels of efficiencies, can have marked further improvements thereafter (see Figure 8). It is not known if DSM would replicate the experience of terrestrial mining, only that incremental rates of increase through learning should be expected.

Figure 8. Trends in Mining Sector Growth, Time Required for Reforms to be Reflected in Long Term Investments and Sector Growth

Source: Authors

In summary, DSM will be an industry that undergoes learning, recognizing that the process has begun and there is need to signal / prepare governments for this process. The challenge is to systematically build capacity to (a) collect new data that informs upon the ecological situation, (b) where potential problems lie, (c) how to address administrative and fiscal management deficiencies of government, including policy and regulatory development, and (d) introduce effective environmental safeguards. And in this regard, time is not always on a government's side.

Fiscal Considerations

As with terrestrial mineral deposits, a commercial company will want to proceed with mining at sea when there is the prospect that the value of minerals produced will exceed the costs of finding and exploiting those minerals at least enough to cover the costs of capital invested. However, unlike terrestrial mineral deposits far less is known about the costs of finding and exploiting deep seabed deposits. Nor have enough data been collected to know the economics of the "average" deep seabed deposit or to predict the frequency of above and below average deposits. This is a challenge for both the investor and the Government, which hopes to capture a portion of any profits made.

The repercussions of these unknowns for the design of a fiscal regime may be summarized as follows:

- It will be especially hard to determine in advance how profitable mining will be, at least in the initial stages of development of DSM. Fiscal terms fixed in advance could turn out to be entirely unbalanced, favoring one side or the other far too much. Indeed, if terms were left to negotiation, the high level of uncertainty and risks borne by the investor would likely lead to the Government having to make large concessions to secure any investment. If, later on, it turned out that mining could in fact be done very profitably, the Government would not be in a position to share in those benefits, except by reneging on the agreement and changing terms in its favor. This problem, which is encountered in terrestrial mining as well, will be especially acute for DSM until the sector has matured.

- These circumstances would tend to favor flexible fiscal regimes, in which the share in profits obtained by the investor and the Government would vary in proportion to the level of profits made (ex-post). This means that if profitability turns out to be greater than thought at the time of the investment, the upside would be shared and not benefit the mining company alone.

- In its purest form, a resource rent tax, such flexibility will, however, tend to mean that fiscal receipts will be back-end loaded to allow investment recovery to take place first. In addition, by linking fiscal receipts so closely to profitability, revenue flows would be more likely to match the highly cyclical and volatile nature of mineral commodity markets. Whereas a large and diversified economy could probably absorb erratic revenues from mining, that will not be the case in small mineral-dependent economies.

- Some governments in the region may see DSM as an opportunity to generate windfall revenue, even as early as when awarding rights to explore for exploit deep seabed minerals, through a system of cash bonus bidding, such as is commonly used in the oil industry. However, this is unlikely to be a viable approach so long as commercial risks remain very high and only a small field of players exist.

- Similarly, some governments may wish to participate financially in DSM, to gain direct access to profits. However, it should be recognized that such equity participation would be placing public funds in the riskiest of all mining ventures. Governments could be better off limiting or eliminating downside risks, while retaining an opportunity to participate in any upside through a resource rent tax.

- There will undoubtedly be considerable pressure on Governments to offer fiscal incentives to investors in DSM on the grounds of the high risk and the "pioneer" character of DSM projects. Fiscal incentives are only justifiable if the counter-factual is no investment at all or if the incentives generate non-fiscal benefits (i.e. additional jobs, additional infrastructure) that justify the tax revenue foregone. Because of the new nature of DSM, Governments may be poorly placed to assess the counter-factual and unless incentive systems are very well defined and monitored, they can be open to abuse, denying Governments badly needed revenues.

- There is also likely to be pressure from investors to receive fiscal stabilization assurance for the same reason that DSM projects are high risk and the investor is acting as a pioneer. Companies will want to protect themselves from any temptation the Government may later have to renege on the fiscal terms to the disadvantage of the company. Care should be taken to limit the application of such stability assurances in terms of both duration and scope.

Chapter 5. Regulatory and Institutional Gap Analysis

The management of DSM mining in a fiscally, environmentally, and socially responsible manner in line with the Precautionary Approach requires a sophisticated regulatory regime and highly specialized technical expertise. This chapter reviews the existence of legislation to regulate the DSM industry and the institutional capacity to implement it, in the PICs. An in-depth review of the content of the legislation or the national consultative process by which each PIC adopts such legislation, however, is beyond the scope of this study.

Regulatory framework. As of June 2016, of the fifteen PICs five, namely Cook Islands, Fiji, Nauru, Tonga and Tuvalu had legislation in place that covered DSM specific issues. In six countries, namely FSM, Kiribati, Republic of Marshall Islands, Niue, Solomon Islands, and Vanuatu, draft DSM legislation prepared under the SPC-EU DSM project was at various stages of processing for enactment. Separately, in Papua New Guinea, a review of the mining laws and the national minerals policy currently is in progress and will result in the revision of the mining laws to include DSM. In Vanuatu, a DSM policy has been completed and submitted to cabinet for adoption. A new DSM law is drafted by SPC (Table 9). [50] A number of regional frameworks (i.e. legislative and regulatory framework; financial framework; environmental framework; and scientific research guidelines) have been prepared by the SPC-EU DSM Project for information and use by PICs as a guide to develop similar national frameworks.

The SPC has laid out the main elements of a regulatory regime that embodies and supports the application of the Precautionary Approach in dealing with the environmental and social impacts and risks of DSM (SPC, ND; SPC, 2016b). Whether a self-standing DSM legislation or as part of a more general existing legislation on mining, the legislation and associated regulations would need to clearly define i) the requirements for assessing and documenting the environmental and social impacts and risks associated with the proposed DSM project, at each stage of the project, including prospecting, exploration, exploitation, closing, and post-exploitation; ii) monitoring and compliance requirements, and iii) transparent and enforceable procedures, including public participation, at each step, and a grievance mechanism. As such, the proposed regulatory regime is in line with the key requirements of UNCLOS and the World Bank Group Safeguards Policies and Standards summarized in Table 10.

Institutional capacity. Specialized technical capacity of government personnel dealing with DSM issues is limited at best in most PICs (Table 9). While no systemic analysis of environmental management capacity with regard to DSM has been carried out, it is likely also very limited in most countries. Under the SPC-EU DSM Project, SPC facilitated the establishment of national offshore minerals committees, which are tasked with facilitating and/or reviewing of DSM policy and laws and conducting awareness programs, among others. To address technical capacity shortages, the said project also sponsored training workshops, internships, conference attendance, and short-term attachments. However, the sustainability

[50] Bol&PANG (2016) maintains that in some PICs DSM legislation drafted with support from the SPC is inadequate in terms of coverage of provision on indigenous or human rights and environmental protection, and that the national review process has lacked in community consultation.

of the capacity thus built is questionable as qualified and experienced professionals tend to join the private sector and regional organizations or migrate to countries such as Australia and New Zealand.[51]

[51] The continuation of these capacity building programmes is uncertain with the ending of the SPC-EU DSM Project on 31st Dec 2016.

Table 11. Status of Regulatory Capacity by Country*

Country	In-Country Capacity	Status of DSM Law and Policy	Areas in Need of Strengthening
Cook Islands	Despite no commercially-generated income from DSM yet, Cook Islands has an established Seabed Minerals Authority, reporting to the Minister of Finance and comprising a Seabed Minerals Commissioner, a Legal Advisor, and a Natural Resources Advisor (funded by Commonwealth Secretariat). Government also includes two trained GIS specialists, and a Secretary of Finance with significant international experience of raising and managing extractive industry revenue. SPC-EU DSM Project is currently reviewing the Cook Islands Tender Process.	A Seabed Minerals Act 2009, Income Tax Amendment (Seabed Minerals) Act 2012, Seabed Minerals (Royalties) Regulations 2013, and Seabed Minerals Policy 2014, Seabed Minerals (Prospecting and Exploration) Regulations 2015 are all in place. A draft law to establish a sovereign wealth fund for DSM revenue is under consultation. A letter of agreement is in place with GSR for a joint venture application for ISA contract, under Cook Islands sponsorship.	• Review of Seabed Minerals Act, and/or Environment Act with full prior environmental impact assessment before any DSM exploration license • Environmental Permitting (Seabed Minerals) Regulations, under the Env. Act • Tender process guidelines • Running a tender process • Negotiating the terms of a joint venture for exploration in 'the Area', with GSR. • An Act to cover the Cook Islands sponsorship of DSM activities in 'the Area'.
FSM	FSM has no minerals or other extractive industry experience, no technical personnel or regulatory infrastructure within Government. The Ministry of Resources and Development has been designated the lead agency for DSM issues, but has no in-house expertise. Assistant Attorney-General has received DSM law training.	A draft Seabed Mining Bill (and Explanatory Guide), prepared in partnership with SPC, was due for submission to Congress in 2016. Consultations in each of the four States were undertaken in 2014 and 2015.	o Capacity-building within Government o Development of a regulatory authority – personnel and infrastructure capacity-building o National DSM Policy o DSM licensing Regulations, including model licenses and agreements o DSM environmental permitting guidance / regulations o Economic planning assistance o Fiscal policy and law assistance o Additional DSM prospecting / exploration within national jurisdiction
Fiji	Fiji has some institutional structure and capacity from its (small-scale) onland mineral industry. The former Director of Mineral Resources (now Permanent Secretary of the Ministry of Lands and Mineral Resources) is apprised of DSM issues, and 1 junior Law Officer has received DSM law training. Fiji, via Foreign Affairs (UN Office), have historically been very active at the ISA, and this continues to date with: Fiji holding a place on the ISA Council, a Fijian nominee being a	In 2013 Fiji passed an International Seabed Minerals Management Decree (to cover future sponsorship of DSM activities in 'the Area') with SPC's assistance. With regards to the EEZ: a draft Minerals Exploration and Exploitation Bill 2006 has been under review for 7+ years, but does not cover DSM. DSM licences have been issued using the Mining Act 1978, which was amended in 2010 to include the seafloor within its scope (but which does	o Capacity-building within Government o Updating and publication of Offshore Minerals Policy o Public consultation / awareness-raising, including traditional leaders and landowners. o Review and finalization of the Minerals Bill, incorporating DSM provisions (or a separate DSM law) o DSM licensing Regulations, including model licenses and agreements.

Country	In-Country Capacity	Status of DSM Law and Policy	Areas in Need of Strengthening
	member (and former Chair) of the ISA's LTC, and Fijians hired as senior ISA Secretariat staff.	not otherwise cover DSM). A draft DSM Policy exists.	o DSM environmental permitting guidance / regulations. o Economic planning, and fiscal policy and law.
Kiribati	There is a Government minerals unit staffed by junior officers, but experience and infrastructure is lacking. A senior officer and a junior officer are appraised on DSM issues. There may be in-country financial management knowhow garnered from Kiribati's phosphates fund. It is unclear how Kiribati will perform the exploration and other requirements of their ISA contract, which will require significant financial and technical capabilities. Some national awareness-raising has been conducted (e.g. a Government radio phone-in on DSM).	A cross-Ministerial National Offshore Management Committee has been established to progress DSM matters. A DSM policy has been drafted, and was due for national consultation in 2016. Draft DSM Bill and Explanatory Guide prepared in partnership with SPC, is due for submission to Cabinet in 2015. A Mineral Development Licensing Ordinance 1977 provides a framework that can be used for a DSM regulatory regime, but would require additional regulations – and sets a 2% royalty rate that should be re-examined. A national law is required for the management of DSM activity under Kiribati sponsorship in 'the Area'.	• National law to cover Kiribati sponsorship of DSM activities in 'the Area'. • Review / replace 1977 Mineral Development Licensing Ordinance • DSM licensing Regulations, including model licenses and agreements. • Development of a regulatory authority – personnel and infrastructure capacity-building. • Review of environment laws and assistance with developing a regime for DSM environmental management • Economic planning assistance. • Fiscal policy and law assistance. • Technical support and advice for implementation and management of ISA contract and related loan and off-take agreements. • Additional DSM prospecting / exploration in national jurisdiction
Marshall Islands	RMI has no minerals or other extractive industry experience, no technical personnel or regulatory infrastructure within Government. Interim Seabed Minerals Board established in October 2014. Marine Resources Authority appears reluctant to expand its (currently fishery-focussed) remit to include DSM, and Resources and Development – which has been designated the lead Ministry – is under-resourced and slow-moving on DSM issues. Two assistant Attorney-General officers have received DSM law training.	A draft Seabed Mining Bill and Explanatory Guide prepared in partnership with SPC is with the AG's Office, was due for submission to Congress in 2016. Draft DSM Policy prepared by SPC is currently under review. National consultations were held in Majuro and Ebeye in April 2015, second round of consultations was held in October 2015. A session on DSM was held with the new parliament in the 1st week of March 2016 to briefing the Members of Parliament on the recent DSM work in RMI and the status of the DSM Policy and Bill.	• Capacity-building within Government • Development of a regulatory authority – personnel and infrastructure capacity-building. • DSM Licensing Regulations, including model licenses and agreements. • DSM environmental permitting guidance / regulations. • Economic planning assistance. • Fiscal policy and law assistance.

Country	In-Country Capacity	Status of DSM Law and Policy	Areas in Need of Strengthening
Nauru	Nauru has no technical personnel, Ministry or regulatory infrastructure relevant to DSM, and limited legal capacity within Government. Two Attorney-General's officers have received DSM law training.	No relevant policy in place. Draft DSM Bill and Explanatory Guide prepared in partnership with SPC and was submitted to Parliament in September 2015. The DSM Act was passed by Parliament in October 2015.	• Development of a regulatory capacity • Technical support and advice for implementation and management of ISA contract and related loan and offtake agreements. • Economic planning assistance • DSM prospecting / exploration within its EEZ.
Niue	As may be expected from a country with a population of just 1200: very limited access to technical personnel or infrastructure, no minerals experience or relevant Ministry. One Crown Law's officer has received DSM law training.	A draft Bill for the national regulation of DSM mining, and licensing Regulations, prepared by SPC, are with Crown Law.	o Securing further survey work in the EEZ o Finalization of policy and law o Economic planning. o Fiscal policy and law o Additional DSM prospecting / exploration within its EEZ
Palau	The Palau Government has an established task-force for offshore petroleum (although has no oil/gas projects), and strong Fisheries management. But no minerals authority or personnel.	No DSM policy or law, but in 2012 Palau enacted a full suite of policy and legislation for petroleum, with the support of the World Bank.	o Review of petroleum laws and amendment, or additional laws to extend the regime to cover DSM. o Economic planning, particularly with regards declaration of EEZ as no-take zone
Papua New Guinea	PNG has several onland metal mines and a well-resourced Ministry of Mineral Policy and Geohazards Management, and Mineral Resources Authority – who are also responsible for DSM. PNG however has a history of civil conflict, environmental degradation, and poor revenue management associated with its mining industry. Civil society groups complain of lack of consultation (although Nautilus records having met with 20,000 community members) and there are local campaigns opposing Solwara 1. PNG has recently become an EITI candidate country.	The Nautilus DSM mining lease was issued under existing mining laws, amended only to extend the definition of 'land' to include the seabed. The same fiscal regime as applies to onland minerals has been applied to Solwara 1 (and PNG exercised their right to take a 15% equity share in the project). Review of the mining laws in progress. The revised instruments include DSM. National offshore minerals policy under review.	o Public consultation / awareness-raising, including traditional leaders and landowners. o Complete review of mining laws. o Incorporating DSM provisions (or a separate DSM law) into mining laws. o Fiscal policy for DSM, and DSM tax / royalty laws. o DSM licensing Regulations, including model licenses and agreements. o DSM environmental permitting guidance / regulations. o Work towards EITI compliance. o Economic planning. o Engaging with the ISA, and seeking partnership opportunities for DSM activities in 'the Area'. o Advice in obtaining further downstream benefits from DSM – e.g. refinery work in-country
Samoa	The Ministry of Natural Resources and Environment, and AG's Office, appear reasonably well-informed and well-resourced,	No policy or law in place. Samoa has yet to make a firm policy decision on whether to	o A national DSM strategy and policy.

Country	In-Country Capacity	Status of DSM Law and Policy	Areas in Need of Strengthening
	although Government has not much engaged with DSM issues to date.	engage in DSM activities (including in 'the Area').	o Engagement with the ISA, and finding partnership opportunities for DSM activities in 'the Area'.
Solomon Islands	Despite on-land gold-mining, and a Ministry of Mines, Energy and Rural Electrification, capacity to progress DSM matters in the Solomon Islands is slow. With the support of the SPC-EU DSM Project, some community-level information-sharing by a joint Government, NGOs and industry initiative, in Temotu province in 2014, and a Youth Debate on DSM in 2015.. EITI-candidate country	Review of existing mining policy, law and Government structures with World Bank support draft Mineral Resources Authority Act, due for enactment mid-2013, has yet to be passed Draft DSM Policy prepared in partnership with SPC and submitted in January 2015. Recent discussion between SPC, the World Bank and the Government regarding collaboration on the review of the Minerals Policy and Mines and Minerals Act to include DSM.	o Enactment of the Mineral Resources Authority Act o Establishment of the new Mineral Resources Authority o Review of the Minerals and Mining Act, incorporating DSM provisions (or prepare a separate DSM law) o DSM licensing Regulations, including model licenses and agreements. o DSM environmental permitting guidance / regulations. o Economic planning. o Fiscal policy and law. o Work towards EITI compliance. o Public consultation / awareness-raising, including traditional leaders and landowners.
Tonga	Regulatory expertise and infrastructure for minerals licensing and environmental permitting is very limited The Ministry of Finance is more advanced with regards to fiscal policy and laws DSM companies with interest in the EEZ have requested new DSM-specific laws and regulatory processes in order to move to mining phase. Tonga recently raised its exploration fees, increasing its annual exploration income from $20k to $3m	Seabed Minerals Act 2014 DSM licensing Regulations in progress, National DSM Policy in progress IMF provided DSM fiscal policy and legislation assistance. Discussions are ongoing with SPC on the drafting of the DSM fiscal legislation in 2016.	o Public and industry consultation on the draft DSM policy and law o Amendment and finalization of DSM policy and regulations o Government capacity-building o Establishment of regulatory authority and other institutions envisaged in the DSM policy and law o TA for implementation and management of ISA contract and related loan and off-take agreements o Advice in obtaining further downstream benefits from DSM – e.g. refinery work in-country.
Tuvalu	Capacity for progressing DSM matters is limited, but the Ministry of Natural Resources and government well-informed One Attorney General's officer has received DSM law training	Seabed Minerals Bill 2014 DSM licensing Regulations and DSM Policy in progress	o Continued pursuit of commercial partnership opportunities for DSM activities in 'the Area' o Finalization of DSM policy and regulations o Economic planning o Fiscal policy and law

Country	In-Country Capacity	Status of DSM Law and Policy	Areas in Need of Strengthening
			o Additional DSM prospecting / exploration within its EEZ
Vanuatu	Capacity within the Department of Geology, Mines and Water Resources, but staffing is limited and training is required.	Public consultations on th draft DSM policy completed and it has been finalized and submitted to cabinet. New DSM law, or significant amendment to the Minerals and Mining Act 1986 required for a comprehensive national DSM regulatory regime. At the request of the government SPC is currently drafting the DSM Bill.	o Public consultation / awareness-raising, including traditional leaders and landowners o Review of the Minerals and Mining Act, to incorporate DSM provisions (or prepare a separate DSM law) o DSM licensing Regulations, including model licenses and agreements o DSM environmental permitting guidance / regulations o Economic planning, Fiscal policy and law o EITI candidacy (or equivalent initiative for DSM)

*This table reflects the status as of June 2016.
Source: Authors and SPC

Table 12 presents a qualitative assessment of the need for specialized expertise and equipment for the specific regulatory functions with regards to environmental and social risk management that PIC governments would need to carry out under the Precautionary Approach. The assessment takes into account the level of information and analysis needed for each action. The majority of these functions require specialized expertise and equipment, as indicated by the red highlights.

Table 12. Institutional capacity needs for DSM management

<table>
<tr><th>No development</th><th>Set asides</th><th>Use technological innovation to minimize impacts</th><th>Mining Proxy</th><th>Pilot or trial mining on small scale</th><th>Adaptive management</th></tr>
<tr><td rowspan="10">If decision is made “for the time being, until more information on the risks become available”, then there is a need to continue to collect and assess data on the risk elements</td><td>Selection and demarcation</td><td>Define limits on impacts</td><td></td><td></td><td></td></tr>
<tr><td>Monitoring impact on set-asides</td><td>Evaluate whether appropriate technologies are deployed.</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Supervision and independent verification of company’s monitoring activities</td></tr>
<tr><td colspan="5">Monitoring of transboundary effects</td></tr>
<tr><td colspan="5">Continued public consultations, incl. grievance mechanism</td></tr>
<tr><td colspan="5">Monitoring data compilation, analysis and interpretation</td></tr>
<tr><td colspan="5">Enforcement in case of transgressions against license (EIA) conditions</td></tr>
<tr><td colspan="5">Decision to cancel operation in case of significant risk or impact</td></tr>
<tr><td colspan="5">Emergency preparedness and response</td></tr>
<tr><td colspan="5">Coordinating with ISA on regulatory development and management of DSM operations whose impact span across the boundaries between EEZs and The Area</td></tr>
</table>

Yellow indicates moderate capacity need.

Orange orange indicates high calacity need.

Source: Authors’ assessment

Costs. The administrative costs of adequate regulation of DSM mining operations are high. SPC (2016a) estimates the annual recurrent expenditures for monitoring and reporting on a single DSM mining activity in PNG at US$205, 000, as detailed in Table 14. The estimates provide a useful ballpark figure, while one must keep in mind the large variation among the PICs in terms of key cost determinants, including the extent of DSM resources, their distances from the capital city, and general wage levels.

Table 13. Estimated Administrative Costs of Regulating a DSM Mining Activity in PNG

Cost item	Amount (US$)	Details
Annual recurrent expenditures		
Monitoring and reporting of DSM activity associated with a single mining operation	$120,000	Six full-time equivalent workers to provide constant monitoring of DSM mining activities (e.g. production support vessel on-board monitoring)[52]. Semi-skilled positions priced just above the median income for PNG. Including salaries, benefits and overhead.
Collection and distribution of DSM related payments	$50,000	One full-time equivalent[53] with a salary bracket in the top 10% of income distribution. Including salaries, benefits and overhead.
Contract Administration	$35,000	One full-time equivalent. Including salaries, benefits and overhead.[54]

Source: SPC, 2016a

DSM Management in the Area

The International Seabed Authority ("ISA" or "the Authority") administers the Area in accordance with the 1992 United Nations Convention on the Law of the Sea (UNCLOS) and its 1994 Implementing Agreement relating to the deep seabed mining. Within this general legal framework, ISA issues rules, regulations and procedures, the totality of which is referred to as the "Mining Code".

ISA has Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area (adopted 13 July 2000) which was later updated and adopted 25 July 2013; the Regulations on Prospecting and Exploration for Polymetallic Sulphides in the Area (adopted 7 May 2010) and the Regulations on Prospecting and Exploration for Cobalt-Rich Crusts (adopted 27 July 2012).[55] In 2011, the Authority's Legal and Technical Commission issued an environmental management plan for the Clarion-Clipperton Zone (ISA, 2011).

The Authority is in the process of developing regulations on exploitation of mineral resources in the Area. In July 2015, the Authority issued a working draft of exploitation regulations for comments until Novermber 25, 2016. Key issues of discussion during the drafting of the regulations concern dispute resolution, data and information management, communications and engagement of stakheolders, and

[52] Assuming mining is a 24/300 operation and allowing for 30% of a monitors time to be spent on administrative duties and travel, 6 workers are required to ensure 100% at-sea coverage. Lower at-sea coverage requirements would reduce the number of staff neded.

[53] Even without onshore processing, DSM mining would be a large part of the economy. This is a fairly skilled employee who makes sure payments are received in a timely manner and funds are dispersed to coastal residents in a manner consistent with laws and policies. It is envisioned as a full-time position with a salary bracket in the top 10% of income distributions.

[54] This position would be considered entry-level in the U.S. and requires an employee who would be responsible for monitoring contractor performance for compliance with applicable laws, delivery schedules, payment provisions, inspections, contract and date reporting requirements. Salary is based on similar job posted by the U.S. government for a contract administrator for the Department of Defense (https://www.usajobs.gov/GetJob/ViewDetails/412169800 Accessed August 7, 2015.

[55] https://www.isa.org.jm/mining-code/Regulations. Accessed on November 2, 2015.

enforcement and liability challenges for environmental regulation of deep sea mining. The ISA has issued a discussion paper on each of these topics.[56]

[56] https://www.isa.org.jm/legal-instruments/ongoing-development-regulations-exploitation-mineral-resources-area. Accessed on January 24, 2017.

Chapter 6. Some Concluding Thoughts on Where Regional Cooperation needs to be strengthened

For any Pacific Island country that is considering to derive economic benefits from deep sea minerals in its EEZ in a fiscally, environmentally, and socially responsible manner following the Precautionary Approach, the cost of regulatory measures is high. Meeting the demands for specialized expertise and equipment is a significant challenge for most PICs given limited national budgets and populations. Recognizing these challenges, PICs have voiced growing interest in formalized regional cooperation in regulating DSM building on the ongoing current collaboration under the auspices of the SPC-EU DSM Project ("Current Situation") and following the existing regional cooperation arrangements for the management of fisheries (Box 6).

Box 8. Existing Regional Modes of Cooperation for managing the Resources of the Pacific

- The **Framework for a Pacific Oceanscape** (2010) is a framework for policy implementation to better understand and conserve the Pacific Ocean in support of the Pacific Plan's (2005) key objective of ensuring the health of the Pacific Ocean and the fisheries resources it supports. The Pacific Islands Forum Secretariat houses an Oceanscape Unit responsible for monitoring implementation of the Framework while the Pacific Islands Fisheries Agency provides direct oceanic (tuna) fisheries management, development and compliance services to the Forum's member countries. The Pacific Community provides coastal fisheries science, management and development services to its members, together with the oceanic scientific research.
- The **Nauru Agreement** Concerning Cooperation in the Management of Fisheries of Common Interest (" The Nauru Agreement") signed in 1982 by 8 PICs, namely the Federated States of Micronesia, Kiribati, the Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands and Tuvalu, who collectively control 25–30% of the world's tuna supply and approximately 60% of the western and central Pacific tuna supply. The 'Parties to the 'Nauru Agreement' (PNA) aim to improve regional conservation measures and financial returns from foreign vessels operating within their EEZs. To this end, the PNA have developed a vessel day scheme as a specific system for collective action to manage the shared purse seine fishery within their waters, which is administered by the PNA Office based in Majuro.
- The oceanic fishing activities occurring on the high seas neighboring the waters of some PICs are managed collectively by the **Western and Central Pacific Fisheries Commission** established under the United Nations Fish Stocks Agreement.

Caution should be exercised however, when considering the fisheries regime as a model for cooperation on DSM because of several, important differences between DSM and fisheries. First, the fisheries regime under the Nauru Agreement aims to optimize revenue and benefits to PICs from an activity that is already fully developed. Second, as a shared renewable resource, fish provide a greater incentive to cooperate since one country's unsustainable actions damaging the stock would affect all other countries. Therefore, a common position in negotiations benefits all.

Possible Cooperation Arrangements

Current Situation

As detailed in Tables 14.1 and 14.2 below, under the Current Situation, the PICs cooperate with SPC on general regulatory functions (items 1-3 on Table 14.1); however, PIC governments carry out all specific project-related measures (items 4-6). The latter include scoping, reviewing and approving environmental and social assessments; selecting an appropriate Precautionary Approach option, including possibly 'no development'; supervising and enforcing the agreed environmental management regime under the selected option. However, given their current capacity and resources, most PICs are not in a position to perform most of the project-specific regulatory functions. SPC has provided technical assistance or to national regulators in some areas. Specifically, SPC provides technical and legal advice on the pros and cons of each option, while the decision of the appropriate Precautionary Approach option rests with sovereign states.

Table 14.1. Regional Cooperation under the Current Situation and Possible Alternatives - Overview

	Current		Possible Alternatives	
	PIC Gov't	SPC	Regional Technical Service Provider	Regional Regulator
ONGOING and GENERAL				
1) Ongoing data collection and management				
a. Collect, compile and evaluate baseline data		X	X	X
b. Regional / sub-regional strategic impact assessment		X	X	X
c. Manage independent scientific research program	X	X	X	X
2) Maintain specialized EIA and monitoring consultants list		X	X	X
3) Ongoing stakeholder consultations	X	X	X	X
PROJECT SPECIFIC				
4) Environmental and social assessments				
a. Determine scope	X		X	X
b. Review	X		X	X
c. Approve	X		Advice	X
5) Select Precautionary Approach option	X	Advice	Advice	X
6) Environmental management under chosen option (details in Table 14.2)	X		See Table 13.2	X

Source: Authors in consulation with SPC.

Possible Alternative Scenarios

Two scenarios replacing the Current Situation have been identified. The first alternative may be the establishment of a Regional Technical Service Provider which would build on and expand SPC's current function. More concretely, as detailed in Table 14.2, the Regional Technical Service Provider would manage or supervise all technical activities and provide advice to the national authorities on the choice of the appropriate Precautionary Approach option, on enforcement decisions in case of transgressions in the chosen option, and on questions regarding conversion of a mining proxy or trial operation to a full-scale (adaptive management). The decision making authority on these questions would rest with PIC national governments. Shifting the technical aspects of DSM regulation to a competent regional body, would drastically reduce the demands on national institutions. The Regional Technical Service Provider may also engage in capacity building capacity on DSM issues among decision makers.

The second alternative may entail a regional regulator, which would have not only the technical competency to carry out all technical functions listed above, but also the authority to make and implement decisions on enforcement matters, and choice of Precautionary Approach option, including conversion from proxy or trial to adaptive management or termination of an operation. The regional regulator would act on behalf of the sovereign states and be supervised by an advisory council.

The specific mandate and terms of reference of this regional body would be determined by the Pacific Leaders within the existing regional cooperation structure. The regional body, should Pacific Leaders decide to establish it, would need to be in operation for at least a decade for continuity in services. It is also important to note that regardless of the mandate chosen, a national DSM position needs to be in-build to work closely with the agency responsible for DSM in-country to ensure effective implementation of activities, or otherwise current capacity limitations within ministries can cause prolonged delays due to possible divergent priorities and staff movement.

While the establishment of a regional body, whether a technical service provider or regulator, would be much more efficient and effective, than individual PICs building up regulatory capacity, a critical question concerns the source of funding. It would seem natural and consistent with the polluter pays principle to suggest that the regional body be funded by companies licensed to carry out prospecting and to larger degree by companies licensed for exploration and exploitation. The "taxing" of companies at the exploration stage makes sense given that a large number of critical regulatory functions, including the social and environmental assessments and decisions on the Precautionary Approach option take place during the exploration phase, as discussed before.

Caution needs to be exercised on possible conflict of interest regarding a regional body, in particular and a regional regulator. If the *raison d'etre* of such a regulator is to help develop DSM and if it is funded through fees paid by mining companies, it may find itself torn between two motivations, one to make a mining operation happen on the one hand and to exercise the Precautionary Approach to its fullest extent, including not going ahead with / terminating a DSM exploitation project.

Table 14.2 Regional Cooperation under the Current Situation and Possible Alternatives – by Option

	Current		Possible Alternatives	
	PIC Gov't	SPC	Reg. Technical Service Provider	Reg.Regulator
ENVIRONMENTAL MANAGEMENT BY CHOSEN OPTION				
a. No development				
If decision is made "for the time being, until more information on the risks become available", continue to collect and assess risk data	X	X	X	X
b. Set-asides				
· Determine most suitable set-asides	X	X	X	X
· Demarcate set-asides	X		X	X
· Monitor impact of DSM on set-asides	X		X	X
· Monitor impact in other areas	X		X	X
· Monitor transboundary effects	??		X	X
· Continue public consultations; grievance mechanism	X	X	X	X
· Monitoring data compilation, analysis, interpretation	X	X	X	X
· Enforcement in case of transgressions	X		Advice	X
· Emergency preparedness and response	X		X	X
c. Use technological innovation to minimize impacts				
Define limits on impacts	X		X	X
Supervision and independent verification of company's monitoring activities.	X		X	X
Monitoring of transboundary effects	X		X	X
Continued public consultations; grievance mechanism	X		X	X
Monitoring data compilation, analysis and interpretation	X		X	X
Enforcement in case of transgressions	X		Advice	X
Decision to cancel operation in case of significant risk or impact	X		Advice	X
Emergency preparedness and response	X		X	X
d. Mining proxy				
· Monitor impact	X		X	X
· Monitoring of transboundary effects	X		X	X
· Continued public consultations; grievance mechanism	X		X	X
· Monitoring data compilation, analysis, interpretation	X		X	X
· Enforcement in case of transgressions	X		Advice	X
· Emergency preparedness and response	X		X	X
· Determine whether full-scale operation (adaptive management) is warranted	X		Advice	X
e. Pilot or trial mining on a small scale				

	Current		Possible Alternatives	
	PIC Gov't	SPC	Reg. Technical Service Provider	Reg.Regulator
· Monitoring of impact	X		X	X
· Monitor transboundary effects	X		X	X
· Continued public consultations; grievance mechanism	X		X	
· Monitoring data compilation, analysis, interpretation	X		X	X
· Enforcement in case of transgressions	X		Advice	X
· Emergency preparedness and response	X		X	X
· Determine if trial may be converted to full-scale operation (adaptive management)	X		Advice	X
f. Adaptive management				
· Monitoring of impact	X		X	X
· Monitoring of transboundary effects	X		X	X
· Continued public consultations; grievance mechanism	X		X	X
· Monitoring data compilation, analysis, interpretation	X		X	X
· Updating of ESMP plan based on monitoring data	X		X	X
· Enforcement in case of transgressions	X		Advice	X
· Emergency preparedness and response	X		X	X
· Cancel operation in case of significant risk or impact	X		Advice	X

Source: Authors

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Annex 1. Offshore Impacts by Mineral Deposit Type

<table>
<tr><th rowspan="2">Impacts</th><th colspan="3">Effects</th></tr>
<tr><th>SMS</th><th>MN</th><th>CRC</th></tr>
<tr><td>Duration of individual mining effort</td><td>2-4 years</td><td>15 – 30 years</td><td>1-2 years</td></tr>
<tr><td>Approximate footprint of mine site</td><td>Direct impact: <0.4 km² per year
Indirect impact: <10 km²</td><td>Direct impact: 300 - 600 km² per year
Indirect impact: 1,500- 6,000 km² over multiple years</td><td>Direct impact: 100-300 km² per year
Indirect impact: Currently unknown</td></tr>
<tr><td rowspan="2">Seafloor operations to remove mineralised material</td><td>Complete removal of chimney structures and associated organisms. Removal and disruption of sediments.
Seafloor topography will change from being raised to being flattened or depressed. Excavation of seafloor to access chimney/mound deposits, and deposition of this material.
Active sites: Potential for alteration of fluid flow and potential for transient (unknown duration) changes in fluid properties, thereby altering the environmental conditions for any recovering vent ecosystems.
'No longer active' sites: Potential at some sites to reinitiate low-temperature fluid flow.
Direct physical effects localised, chemical effects more wide spread.</td><td>Complete removal of nodules and attached organisms, and removal or complete disruption of the top ~10 – 30 cm of sediments underlying removed nodules.
Seafloor topography unlikely to change, but sediments will be compacted by weight of machines.
Hard-substrate (nodules) will be removed or buried, changing the habitat to be largely soft sediment and the sediment-water layer chemistry will be affected.
Direct physical and chemical effects over very large areas for extended time periods.</td><td>Removal of the layer of crust from the seamount in strips or patches. Various depths of removal. Removal of all attached organisms.
Seamount will remain largely intact with minimum change to overall topography. Reduction in habitat complexity of impacted strips/patches.
Resultant habitat will remain mainly hard-substrate.
Direct effects may be localised or cover a wider combined area of multiple seamounts. Chemical effects more widespread.</td></tr>
<tr><td colspan="3">Lights attached to the machines on the seafloor will introduce light into an environment that is otherwise without light except for bioluminescence, if present. These lights may repel or attract some organisms, and could blind some species, if they have the ability to see (which may not be the case in an environment which is perpetually dark). In particular, lighting will interfere with biotic communications / interactions mediated by bioluminescence, if that method of communication is used.
Noise and vibration may also attract or repel some organisms and, if significant enough, could cause masking effects on marine mammals that use similar frequencies for communication, / navigation, prey detection and predator avoidance. Vibration may cause responses in other faunal types.</td></tr>
</table>

<table>
<tr><th rowspan="2">Impacts</th><th colspan="3">Effects</th></tr>
<tr><th>SMS</th><th>MN</th><th>CRC</th></tr>
<tr><td rowspan="2">Operational plume and sediment resuspension at the seafloor by machines</td><td colspan="3">Plumes of suspended sediment may smother/bury seabed organisms and hard substrates, disorient and choke motile organisms and suspension feeders, and dilute the layers of organic matter at the sediment-water interface (food for deposit feeders). Resuspended sediments have a low nutritional quality for sediment feeders and may clog the filtering apparatus of pelagic organisms. Additional sedimentation may impact the ability of larvae to feed in the water column or to settle on hard or soft substrates (e.g., by burying substrates and obscuring chemical settling cues). Metals, if they are associated with plumes, may become bioavailable – the potential for toxicity and bioaccumulation needs to be assessed and will likely vary with mineral type.
Plumes may spread to areas outside the direct mining site, and will have a gradient of impact, reducing with distance from the activity. The extent of plumes will depend on the mineral type, the amount of sediment that is disturbed during the mining process, the mining process used and water current speed and direction.</td></tr>
<tr><td>This will be of particular concern if side-casting or removal of sediment is required for machines to access the underlying SMS deposits.
Plumes could reach horizontally up to kilometres from the mine site.</td><td>Due to extremely low natural rates of sedimentation in MN areas, settlement of sediment from mining plumes may greatly exceed background sedimentation rates.
Plumes could reach tens of kilometres horizontally due to the large aerial extent of the mined area and the abundance of fine (silt and clay) slow-sinking particles in the sediments.
The long-time scales of plume persistence (for the duration of the mining effort) may increase the impacts of plumes. Sediment concentrations will accumulate over time and extend over larger areas.</td><td>Plumes and settling sediments might flow down the flanks of seamounts depending on localised current dynamics and eddies.
Ocean currents may transport sediment and other particulates to wider areas.</td></tr>
<tr><td>Returned seawater plume</td><td colspan="3">The seawater that is recovered with the mineralised material will need to be returned to the ocean. The volume returned seawater plume will be dependent on the recovery technology and is unlikely to be as heavily loaded with suspended sediments as the operational plume. Compared to the surrounding water it is released into, it is likely to contain different characteristics such as: temperature, dissolved minerals (including heavy metals), salinity, suspended sediment etc.
Due to the removal of the mineralised material from the seawater, surface water may need to be used to ‘make up’ the appropriate volume to be returned - this could further change the characteristics of the return water and subsequent plume.
Some settlement of sediment is expected, though if the water is filtered to remove suspended sediments as far as practicable, it may not be significantly greater than background sedimentation rates. However, the nature of settling sediment from plumes may differ from naturally settling sediment.
If the returned seawater is released in the surface waters (Photic Zone) it could: reduce light penetration, reduce plankton growth, inhibit feeding of zooplankton, over stimulate primary production if rich in nutrients (and of different species than those normally occurring in the area), reduce localised dissolved oxygen, increase heavy metal burdens, etc., and increase the footprint of the mining operation even further. They could also reduce water clarity, affecting visual predators. Toxicity and bioaccumulation would also need to be addressed.
Plumes could reach kilometres to up to tens of kilometres from the mine site. Plumes will have a gradient of impact, reducing with distance from the discharge location. Discharge and return of seawater to the seafloor (from where it came) should be encouraged, where practicable (it may not be for deeper projects). A higher discharge point may lead to a more extensive plume in the water column.</td></tr>
</table>

Impacts	Effects		
	SMS	MN	CRC
Standard vessel operation and discharges	It is likely that ocean-going vessels engaged in DSM activities will make routine operational discharges of ballast water, treated sewage, grey water, macerated food waste, and highly salinated water from desalination plants. Such vessels will also make atmospheric discharges from engine and incinerator exhausts. The nature of such discharges will, however, vary, depending on the location of the vessels from the shore and existing marine protected areas (as stipulated in Marine pollution Convention (MARPOL) 73/78). As mining vessels will be somewhat stationary, it is expected that the discharges may dilute less effectively and present other risks to the environment. There may also be concerns over the type of anti-fouling paints used as some of these may be toxic to an array of organisms. Surface-dwelling organisms (i.e., marine mammals) may be affected by noise and vibrations produced by the mining vessels, impeding their communication/navigation. The mining vessel could act as a 'fish aggregating device'. Organisms such as fish, sharks, cephalopods, seabirds, whales, dolphins and turtles may be attracted to the vessel. Associated additional traffic between site and supply areas may increase the chance of shipstrikes on mammals and turtles.		
Potential for recovery	Active SMS sites in some circumstances are expected to be able to recover, as mining operations will not 'turn off' the underlying 'plumbing' of the hydrothermal system. The fluid chemistry may change in the absence of a fluid-reaction path through the deposit itself. The dominant species may recover in tens of years; it is envisaged the community may not recover its original species pool until much later. The creation of substantial SMS deposits will take thousands to millions of years. 'No longer active' SMS sites are unlikely to fully recover. Mining may potentially open up new vents, changing the nature of the environment. Background sites affected by indirect impacts may take decades to centuries to recover.	MN sites will not be able to recover to their prior environmental condition for millions of years. The removal of the nodules will prevent repopulation by organisms requiring hard substrate. Depending on the physical and chemical changes to the sediments, the mined areas may be repopulated by stress-resistant species from nearby un-impacted areas within decades. The other organisms living in and on the sediments, which are not stress- resistant, are unlikely to recover within decadalcentury time scales.	Mining will only remove patches of the seamount's surface layer and might not significantly change the substrate. Hence, sessile communities may be able to repopulate the site, unless they require the crust substrate. Recovery of the same species will require that the texture, geochemistry and composition of the substrate remain the same, which is unlikely. The recovery of slow-growing organisms such as cold water corals could take 100s of years, and 1000s of years to reach maximal (pre-mining) size. The pelagic fauna may be impacted from the ongoing mining and any changes in seamount topography affecting current patterns.
Accidental, nonroutine incidents	Accidental events and natural hazards could induce spills (i.e., of recovered mineralised material) and oil leaks from the vessel, which then enter the sea, and leaks from the lifting system or mining equipment (i.e. hydraulic oil leaks). Vessel collisions or capsizing, though unlikely, could also occur. Such accidental and non-routine incidents would add to the environmental impacts caused by the mining operations, but are unlikely to be higher in severity than the mining impacts themselves.		

Source: SPC, 2016b

Annex 2. Elements of Stakeholder Engagement (Adapted from IFC Performance Standard 1)

Stakeholder Analysis and Engagement Planning

Project proponents should identify the range of stakeholders that may be interested in their actions and consider how external communications might facilitate a dialog with all stakeholders. Where projects involve specifically identified physical elements, aspects and/or facilities that are likely to generate adverse environmental and social impacts on Affected Communities the project proponent will identify the Affected Communities and will meet the relevant requirements described below.

The project proponent will develop and implement a Stakeholder Engagement Plan that is scaled to the project risks and impacts and development stage, and be tailored to the characteristics and interests of the Affected Communities. Where applicable, the Stakeholder Engagement Plan will include differentiated measures to allow the effective participation of those identified as disadvantaged or vulnerable. When the stakeholder engagement process depends substantially on community representatives[57] the project proponent will make every reasonable effort to verify that such persons do in fact represent the views of Affected Communities and that they can be relied upon to faithfully communicate the results of consultations to their constituents.

Disclosure of Information

Disclosure of relevant project information helps Affected Communities and other stakeholders understand the risks, impacts and opportunities of the project. The project proponent will provide Affected Communities with access to relevant information[58] on: (i) the purpose, nature, and scale of the project; (ii) the duration of proposed project activities; (iii) any risks to and potential impacts on such communities and relevant mitigation measures; (iv) the envisaged stakeholder engagement process; and (v) the grievance mechanism.

Consultation

When Affected Communities are subject to identified risks and adverse impacts from a project, the project proponent will undertake a process of consultation in a manner that provides the Affected Communities with opportunities to express their views on project risks, impacts and mitigation measures, and allows the project proponent to consider and respond to them. The extent and degree of engagement required by the consultation process should be commensurate with the project's risks and adverse impacts and

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[57] For example, community and religious leaders, local government representatives, civil society representatives, politicians, school teachers, and/or others representing one or more affected stakeholder groups.

[58] Depending on the scale of the project and significance of the risks and impacts, relevant document(s) could range from full Environmental and Social Assessments and Action Plans to easy-to-understand summaries of key issues and commitments. These documents could also include the project proponent's environmental and social policy and any supplemental measures and actions defined as a result of independent due diligence conducted by financiers.

with the concerns raised by the Affected Communities. Effective consultation is a two-way process that should: (i) begin early in the process of identification of environmental and social risks and impacts and continue on an ongoing basis as risks and impacts arise; (ii) be based on the prior disclosure and dissemination of relevant, transparent, objective, meaningful and easily accessible information which is in a culturally appropriate local language(s) and format and is understandable to Affected Communities; (iii) focus inclusive[59] engagement on those directly affected as opposed to those not directly affected; (iv) be free of external manipulation, interference, coercion, or intimidation; (v) enable meaningful participation, where applicable; and (vi) be documented. The project proponent will tailor its consultation process to the language preferences of the Affected Communities, their decision-making process, and the needs of disadvantaged or vulnerable groups.

Informed Consultation and Participation

For projects with potentially significant adverse impacts on Affected Communities, the project proponent will conduct an Informed Consultation and Participation (ICP) process that will build upon the steps outlined above in Consultation and will result in the Affected Communities' informed participation. ICP involves a more in-depth exchange of views and information, and an organized and iterative consultation, leading to the project proponent's incorporating into their decision-making process the views of the Affected Communities on matters that affect them directly, such as the proposed mitigation measures, the sharing of development benefits and opportunities, and implementation issues. The consultation process should (i) capture both men's and women's views, if necessary through separate forums or engagements, and (ii) reflect men's and women's different concerns and priorities about impacts, mitigation mechanisms, and benefits, where appropriate. The project proponent will document the process, in particular the measures taken to avoid or minimize risks to and adverse impacts on the Affected Communities, and will inform those affected about how their concerns have been considered.

Indigenous Peoples

For projects with adverse impacts on Indigenous Peoples, the project sponsor is required to engage them in a process of ICP and in certain circumstances the project proponent is required to obtain their Free, Prior, and Informed Consent (FPIC). The requirements related to Indigenous Peoples and the definition of the special circumstances requiring FPIC are described in IFC Performance Standard 7.[60]

External Communications and Grievance Mechanisms

External Communications. Project proponents will implement and maintain a procedure for external communications that includes methods to (i) receive and register external communications from the public; (ii) screen and assess the issues raised and determine how to address them; (iii) provide, track, and document responses, if any; and (iv) adjust the management program, as appropriate. In addition, project

[59] Such as men, women, the elderly, youth, displaced persons, and vulnerable and disadvantaged persons or groups.

[60] http://www.ifc.org/wps/wcm/connect/1ee7038049a79139b845faa8c6a8312a/PS7_English_2012.pdf?MOD=AJPERES

proponents are encouraged to make publicly available periodic reports on their environmental and social sustainability.

Grievance Mechanism for Affected Communities. Where there are Affected Communities, the project proponent will establish a grievance mechanism to receive and facilitate resolution of Affected Communities' concerns and grievances about the project proponent's environmental and social performance. The grievance mechanism should be scaled to the risks and adverse impacts of the project and have Affected Communities as its primary user. It should seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate and readily accessible, and at no cost and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The project proponent will inform the Affected Communities about the mechanism in the course of the stakeholder engagement process.

Ongoing Reporting to Affected Communities

The project proponent will provide periodic reports to the Affected Communities that describe progress with implementation of the project Action Plans on issues that involve ongoing risk to or impacts on Affected Communities and on issues that the consultation process or grievance mechanism have identified as a concern to those Communities. If the management program results in material changes in or additions to the mitigation measures or actions described in the Action Plans on issues of concern to the Affected Communities, the updated relevant mitigation measures or actions will be communicated to them. The frequency of these reports will be proportionate to the concerns of Affected Communities but not less than annually.

Annex 3. Key Issues in Solwara 1 EIS, Supporting Studies, and Independent Publications[61]

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
Seafloor operations to remove mineralised material	South Su, located about 2 kilometres up current from Solwara 1, is proposed to remain as a reference area until the completion of production operations and confirmation that the rehabilitation techniques are effective at Solwara 1. It is expected to provide a source of recruitment to excavated areas and provide a reference location to monitor natural variation in vent activity and communities over time. Biological comparisons of the two areas have shown that the samples taken from the active sites at both Solwara 1 and South Su share the same biomass-dominant species and generally similar indices of diversity and community structures. Where there are significant differences, South Su generally has higher abundances of secondary species and higher dominance of some groups. Some recruitment may also come from North Su (active subsea volcano), where extraction is not currently planned. However, because of the continuous active conditions and sediment-occluded visibility at North Su at the times of survey, it has not been possible to characterise its vent communities to the same extent as at Solwara 1 and South Su. Temporary refuge areas with Solwara 1: Not all of the resources can be extracted simultaneously. Some of the areas which will be excavated at later stages of the mine plan may function as temporary refuge sites for fauna that may assist with early recolonisation. Detailed hydrodynamic modelling was completed in 2014 to identify potential refuge locations at different stages of the mine plan.	• The exact species composition of the to-be-mined vent site is not fully known. This is true for meio fauna[64] and rare species. Lack of prior experience on effective mitigation and restoration of the mining site eco-system by recruiting specimens of common species from the reserve site. (Rosenbaum, 2011; IUCN Pacific Center for Environmental Governance, personal communication). Van Dover (2011) acknowledges the critical assumptions and difficulties associated with the mitigation strategy.

[61] This annex is not intended to be a thorough review / critique of the Solwara 1 EIS, but to highlight the key issues identified in the EIS and by critics

[62] Impact classification follows that in SPC (2016b)

[63] http://nusc.live.irmau.com/IRM/Company/ShowPage.aspx?CategoryId=190&CPID=1176&EID=83153213. Accessed September 27, 2016.

[64] The term "*Meiofauna*" is related to microscopically small benthic invertebrates that live in both marine and fresh water environments. Source: Marine Biodiversity Wiki, http://www.marbef.org/wiki/Meiofauna_of_Sandy_Beaches.

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
	Progress against criteria will be examined through monitoring to determine if the major community elements (i.e. the three biomass-dominant species) have re-established at active chimneys in the earliest mined area. Transplant of animals: The loss of animals in the path of the Seafloor Production Tools can be minimised. Where feasible, an ROV will be used to remove large clumps of rock substrates with biology intact and relocated them to appropriate areas within Solwara 1 that have been excavated, or to temporary refuge areas. These clumps will be targeted to maximise the biomass-dominant species and any other associated attached or sessile fauna. Monitoring will be undertaken to confirm the successful of this strategy. Artificial substrates: Hard substrate animals (e.g. coral) and their associated fauna in inactive areas away from the vent ecosystems are expected to recover more slowly (compared with animals located in active vent areas). The same mitigation strategies employed for vent fauna will also be employed for hard substrate fauna where it is feasible to do so. Where feasible, animals will also be removed from the path of operations and repositioned in structures such as crates, where they might reform attached colonies. The survival and growth of such transplants will be monitored, with continued relocation if successful.	
Operational plume and sediment resuspension at the seafloor by machines	The mine design and production methodology has been used to complete detailed hydrodynamic modelling of the plume that is likely to be generated by the seafloor mining tools. This modelling indicates that the major impacts associated with the plume (that is, significantly increased sedimentation rates) will be restricted to the mining area. Sedimentation above background rates will continue outside of the mining area, and studies planned for 2015 will confirm the extent of this impact in relation to the natural variation in sedimentation rates caused by the adjacent North Su volcano. The hydrodynamic modelling also allows Nautilus to fix a boundary of impacts, outside of which it commits to have no impact on water quality, which will be monitored in real time under the EMMP and reported to the Conservation and Environment Protection Authority. In addition, the	Rosenbaum (2011) points out the likelihood of highly concentrated dewatering plumes extending to the South Su reference area and ending the chance of ecological rehabilitation. The EIS does not preclude the possibility of sediment settling on the South Su reference area, but states that the "maximum depositional thicknesses will not exceed 0.1mm and rates of settling are less than existing deep-sea sedimentation rates as measured at Solwara 1 and South Su. (EIS Executive Summary p.33). It is not clear whether the hydrodynamic modelling study planned for 2015 has been carried out and if so, what the findings are.[66]

[66] As of January 19, 2017, neither of two Nautilus websites "http://www.nautilusminerals.com/irm/content/environment-reports2.aspx?RID=413" and http://cares.nautilusminerals.com/irm/content/solwara-1-project.aspx?RID=339" featured such studies.

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
	modelling confirms that the South Su reference area will not be impacted by mine derived plumes. [65]	Deep Sea Mining Campaign (2012) assessed "the Nautilus EIS on physical oceanographic water properties and currents for accuracy and completeness, with emphasis on the presentation and analysis of the field data and computer modelling contained in the EIS." (p.6).. "Of particular concern is whether upwelling (vertical water movement) and currents could carry pollutants up out of the deep see or from spills and leakages into marine food chains where they may poison marine species and the humans that eat them. Two key sources of pollution are a focus: the settlement and dispersion of waste material removed pre-mining; and the spread of the plume created by the discharge of return water." (p.7) The report concluded that there were "serious omissions and flaws in information presented in the EIS about surface currents, the speed and direction of currents at different depths, and about tides. These deficiencies mean that several important risks to the marine environment and to local communities cannot be determined. These include the risks of pollution from spills from vessels at the surface, leakage from the riser or discharge pipes, and of upwelling dispersing from the mining activity or from the discharge water. The implications of these risks – especially for the people of New Ireland and possibly also East New Britain Province – demands that a thorough and independently verified analysis of currents be conducted as a basis for a comprehensive risk assessment."(p.9-10) Nautilus informed the authors that at any time the maximum amount of returned seawater (or of the mineralized materials) in the riser would be 11m3 and the riser was designed in such a way that it would stop operating in case of a break. Thus, the maximum amount of a spill would be 11m3. Nautilus also informed the authors that the company had commissioned a new oceanographic study, which supported the findings presented in the EIS and Nautilus would likely release the study in late 2016.[67] (Authors' communication with Nautilus Co. Sustainability Manager Renee Grogan in June 2016). The Solwara 1 EIS (Appendices 10, 11, 12 and 13) contains information about the Solwara 1 Project that is relevant to the fisheries industry. In addition to this data, Nautilus has updated its sediment plume modelling to reflect updated baseline information on the naturally occurring sedimentation processes (associated with the North Su volcano), as well as some amendments to the project design, engineering, and
Returned seawater plume	Dewatering discharge: Return water (water generated as part of the ore dewatering process) will be filtered to 8 microns prior to return to the seafloor. This is expected to significantly reduce the quantities of sediment lost in the dewater discharge. Discharging of filtered return water will occur at depths between 25 to 50 metres above the seafloor to confine all impacts to the bottom zones from where the water/sediment originated. Hydrodynamic modelling investigated the most appropriate direction for discharge in order to minimise the resultant plume, and this directional discharge will be implemented at all times. The exposure time of the return water to surface temperatures and oxygenation will be limited, thereby reducing potential for geochemical changes. The pipes used to transport the return water to the seafloor will allow for cooling to minimize the temperature differential between the return water and the water on the seafloor.	

[65] Source: Nautilus Minerals, http://nusc.live.irmau.com/IRM/Company/ShowPage.aspx?CategoryId=190&CPID=1176&EID=83153213. Accessed September 27, 2016.

[67] As of January 19, 2017, neither of two Nautilus websites "http://www.nautilusminerals.com/irm/content/environment-reports2.aspx?RID=413" and http://cares.nautilusminerals.com/irm/content/solwara-1-project.aspx?RID=339" featured such a study.

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
		mine design. This updated modelling will be finalised in mid 2016 and will be made public at that stage. Nautilus remains confident that it will have no impact on fisheries industries or any nearshore environments, including coral reefs (Authors' communication with Nautilus).
Standard vessel operation and discharges	As a result of the closed ore transfer system between the seafloor and the Production Support Vessel, and the return of dewatered ore to the seafloor, there are limited impacts in the mid-ocean and surface areas. Mitigation strategies include: - Compliance with the International Convention for the Prevention of Pollution From Ships (MARPOL) and a commitment to limit surface water discharges to treated sewage (in compliance with MARPOL treatment limits); - Limiting launch and recovery of seafloor production tools when there are whales or large cetaceans in the vicinity, including the use of observers to determine the presence of these species during such operations; - Directional lighting on the Production Support Vessel, and the restriction of engagement of lighting on seafloor production tools until the tools reach the vicinity of the seafloor, to ensure marine animals such as tuna are not attracted by artificial light in the surface and mid-water column; - Speed limits for support barges to minimize the risk of collisions with whales, turtles and other marine mammals; - Implementation of a detailed emergency response and spill management plan to minimize the impact of any spills from the Production Support Vessel. Published literature on turtle migratory pathways indicates there are no major routes between New Ireland and New Britain. Although it is expected that most species may migrate between these islands, the operations present no threat or obstacle to normal migration that would be materially different from normal shipping and commercial fishing activities.	

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
	The result of these strategies is that the Solwara 1 Project will cause no harm to fisheries, coral reefs, whales, turtles or other pelagic animals. ***Noise*** Noise from ship thrusters will be audible underwater for several hundreds of kilometres, as is the case for most large ships and other man-made and natural sources. However, noise at levels that may cause harm is limited to within tens of metres of the Production Support Vessel. Some behavioural avoidance and attraction (by some proportion of whales) is likely to happen within 15 kilometres of the vessel, but once established, familiarization with this new 'landmark' is likely to occur. The annual humpback whale migrations have continued off the east and west coasts of Australia notwithstanding the extensive shipping and oil and gas activities. Further noise modelling of surface and seafloor noise is planned for 2015, in order to determine the impact of natural noisy features (such as the North Su volcano), and mitigation strategies required (if any) on the seafloor.	
Potential for recovery	See entry in row on "Seafloor operations to remove mineralised material"	Deep Sea Mining Campaign (2012) critical of EIS for having "poorly addressed" the risk associated with "the destruction of unique and endemic ecosystems at hydrothermal vents. This is of particular concern as limited information exists about the capacity of, or timescale, for hydrothermal vent systems to re-establish following widespread vent field destruction, and whether any new vent systems will be biologically diverse.
Accidental, nonroutine incidents	EIS Volume A Chapter 11 covers extreme weather; seismicity,volcanism and tsunamis; hazardous material leakage or spillage; fire and explosion; and collisions under the heading "accidental events and natural hazards". With regard to possible impacts and risks associated with the Mining Support Vessel (MSV) and ore transfer, the EIS proposed "an exclusion zone of 500m around to MSV at all times to avoid risks of collisions." It further states that "this is a minor area of fishing exclusion for mainly commercial tuna fishing, but the Project area is not one from which catch return statistics indicate there would be any significant impact. Normal maritime navigational and communications procedures will apply for all shipping in the area to maintain safe distances. Being so far offshore, the recorded frequency of inshore vessels such as canoes and small vessels occurring at Solwara 1 is low." (p.31)	Regarding leaks of recovered mineralized materials or returned seawater refer to inserts above on "Operational plume and sediment resuspension at the seafloor by machines" and "returned seawater plume". Steiner (2009) pointed out that "[r]egarding impacts to the *nearshore* ecosystem, one of the greatest risks from the project is the potential loss of tow or power of an ore shuttle barge in route to Rabaul (the EIS projects 3-9 barge trips per week, with 6,000 tons of toxic ore onboard each transit), or of one of the 25,000 ton bulk ore freighters (3-6 trips per month from Rabaul), and the barge or freighter then drifting ashore spilling its toxic cargo and fuel onto the coastal reef system. Yet, this risk was not considered at all in the EIS."

Impacts[62]	Solwara 1 impacts and Proposed Mitigation Measures as per the EIS (Source: Coffey Natural Systems, 2008 and Nautilus Minerals[63])	Reactions to and Follow-up on the EIS (an incomplete list based on a partial literature review)
	The EIS stated that "the risks of major losses of equipment or spills of ore or fuel oils (during operational and abnormal conditions) will be extremely low with the implementation of best practice vessel and equipment maintenance procedures, navigational procedures, safety plans, environmental management plans, and emergency response plans."(p.31)	

List of Scientific Studies Supporting the Solwara 1 EIS (Volume 3 of the EIS)

Appendix Number	Supporting Study Title	Author
1	Baseline Environmental Study Eastern Manus Basin, Papua New Guinea – Module 1 Preliminary Scoping Study	CSIRO Division of Exploration and Mining
2	Baseline Environmental Study Eastern Manus Basin, Papua New Guinea – Module 2 Detailed Scoping Study	CSIRO Division of Exploration and Mining
3	Oceanography at Solwara 1	Coffey Natural Systems
4	Characterization and comparison of macrofauna at inactive and active sulphide mounds at Solwara 1 and South Su (Manus Basin)	Duke University Marine Laboratory
5	Macroinfauna of Active and Inactive Hydrothermal Sediments From Solwara 1 and South Su, Manus Basin, Papua New Guinea	Integrative Oceanography Division – Scripps Institution of Oceanography
6	Quality Including Trace Elements of Sediments from the SuSu Knolls, Manus Basin, Bismarck Sea, Papua New Guinea	Department of Geology, University of Toronto
7	Water and Sediment Characterisation and Toxicity Assessment for the Solwara 1 Project	CSIRO Land and Water Science
8	Juvenile Amphipod Whole Sediment Test Report	CSIRO Land and Water Science
9	Elutriate Testing Report Solwara 1 Project, Incorporating Phase 1: Effect of Holding Time; Phase 2: Effect of Temperature	Charles Darwin University
10	Biomass, Biodiversity and Bioaccumulation Desktop Study	Hydrobiology Pty Ltd
11	Modelling the Dispersion and Settlement of Sediment Removal Operation Prior to Mining at the Solwara 1 Mining Lease, Papua New Guinea	Asia-Pacific ASA
12	Modelling the Dispersion of the Returned Water Discharge Plume from the Solwara 1 Seabed Mining Project Manus Basin, Papua New Guinea	Asia-Pacific ASA
13	Prediction of underwater noise associated with a proposed deep-sea mining operation in the Bismarck Sea	Curtin University of Technology – Centre for Marine Science and Technology
14	The Potential for Natural Disasters being Triggered by Mineral Extraction at the Solwara 1 Seafloor Hydrothermal Vent Site	Rabaul Volcanological Observatory
15	Stakeholder Consultation	Coffey Natural Systems

Source: Nautilus Minerals by email (May 31, 2016)

List of Independent Studies

Report Title	Citation
A biological survey method applied to Seafloor Massive Sulphides with contiguously distributed hydrothermal vent fauna	Collins P.C., Kennedy R., Van Dover C.L. (2012) A biological survey method applied to seafloor massive sulphides (SMS) with contagiously distributed hydrothermal-vent fauna, *Marine Ecology Progress Series*, vol. 452, pp. 89-107.
Application of biological studies to deep-sea governance and management of deep-sea resources	Van Dover, C. L., Arnaud-Haond, S., Clark M., Smith, S., Thaler, A. D., Van den Hove, S. (2011) Application of biological studies to deep-sea governance and management of deep-sea resources. Biological Sampling in the Deep Sea, Wiley-Blackwell Publishing, 488pp.
Biogeography Ecology and Vulnerability of Chemosynthetic Ecosystems in the Deep Sea	Baker, M. C., Ramirez-Llodra, E. Z., Tyler, P. A., German, C. R., Boetius, A., Cordes, E., E., Dubilier, N., Fisher, C., R., Levin, L., A., Metaxas, A., Rowden, A. A., Santos, R. S., Shank, T. M., Van Dover, C. L., Young, C. M., Waren, A. (2010). Biogeography, Ecology and Vulnerability of Chemosynthetic Ecosystems in the

Report Title	Citation
	Deep Sea, Life in the World's Oceans: Diversity, Distribution, and Abundance, McIntyre, A, D. (Ed), Chapter 9, pp. 161-182, Blackwell Publishing Limited.
Bone-eating marine worms- habitat specialists or generalists?	Vrijenhoek, R. C., Collins, P, and Van Dover, C. L. (2008). Bone-eating worms: habitat specialists or generalists? Proceedings of the Royal Society, doi:10.1098/3sbp.2008.0350.
Characterisation of 9 polymorphic microsatellite loci in Chorocaris sp. (Crustacea, Caridea, Alvinocarididae) from deep-sea hydrothermal vents	Zelnio, K. Z., Thaler, A D., Jones, R. E., Saleu, W., Schultz, T. F., Van Dover, C. L., Carlsson, J. (2010). Characterisation of nine polymorphic microsatellite loci in Chorocaris sp. (Crustacea, Caridea, Alvinocarididae) from deep-sea hydrothermal vents, Conservation Genetic Resources, vol 2, no. 1, pp. 223-226.
Characterization of 10 polymorphic microsatellite loci in Munidopsis lauensis, a squat-lobster from the southwestern Pacific	Boyle, E. A., Thaler, A. D., Jacobson, A., Plouviez, S., Van Dover, C. L. (2013). Characterization of 10 polymorphic microsatellite loci in Munidopsis lauensis, a squat-lobster from the southwestern Pacific, Conservation Genetic Resources, vol. 4, no. 4, doi 10.1007/s12686-013-9872-1.
Characterization of 12 polymorphic microsatellite loci in Ifremeria	Thaler, A. D., Zelnio, K. A, Jones, R. E., Carlsson, J., Van Dover, C. L., Schultz, T. F. (2010). Characterization of 12 polymorphic microsatellite loci in Ifremeria nautilei, a chemoautotrophic gastropod from deep-sea hydrothermal vents. Conservation Genetic Resources, vol. 2, pp. 101-103.
Characterization of 18 polymorphic microsatellite loci from the deep-sea hydrothermal vent mussel Bathymodiolus manusensis	Schultz., T., F., Hsing, P., Eng, A., Zelnio, K., A., Thaler, A. D., Carlsson, J., Van Dover, C. L. (2010). Characterization of 18 polymorphic microsatellite loci from Bathymodiolus manusensis (Bivalvia, Mytilidae) from deep-sea hydrothermal vents, Conservation Genetic Resources, vol. 3, no. 1, pp. 25-27.
Characterization of host-symbiont relationships in hydrothermal vent gastropods of hte genus Alviniconcha from the Southwest Pacific	Suzuki, Y, Kojima, S, Sasaki, T, Suzuki, M, Utsumi, T, Watanabe, H, Urakawa, H, Tsuchida, S, Nunoura, T, Hirayama, H, Takai, K, Nealson, K. H, Horikoshi, K. (2006). Host-symbiont relationships in hydrothermal vent gastropods of the genus Alviniconcha from the southwest Pacific, Applied and Environmental Microbiology, vol. 72, no. 2, pp. 1388-1393.
Macrobenthos community structure and trophic relationships within active and inactive Pacific hydrothermal sediments	Levin, L. A., Mendoza, G. F., Konotchick, T, and Lee, R. (2009). Macrobenthos community structure and trophic relationships within active and inactive Pacific hydrothermal sediments, Journal of Deep Sea Research II, doi: 10.1016/j.dsr2.2009.05.010.
Comparative population genetics of two hydrothermal-vent-endemic species, Chorocaris spp. and Olgasolaris tollmanni from southwest Pacific back arc basins	Thaler, A., Plouviez, S., Zelnio, K. A., Jacobson, A., Jollivet, D., Carlsson, J., Schultz, T., Van Dover, C. L. (2012). Comparative population genetics of two hydrothermal-vent-endemic species, Chorocaris spp. and Olgasolaris tollmanni from southwest Pacific back arc basins, Poster from 13th International Deep-Sea Biology Symposium.
Designating networks of chemosynthetic ecosystem reserves in the deep sea	Van Dover, C. L., Smith, C. R., Ardron, J., Dunn, D., Gjerde, K., Levin, S., Smith, S. (2011). Designating networks of chemosynthetic ecosystem reserves in the deep sea, Marine Policy, vol. 36, pp. 378-381.
Distribution and Sources of Trace Metals in Volcaniclastic Sediments of the SuSu Knolls Hydrothermal Field, Manus Basin, Papua New Guinea	Hrischeva, E. H., and S. D. Scott. (2007). Distribution and Sources of Trace Metals in Volcaniclastic Sediments of the SuSu Knolls Hydrothermal Field, Eastern Manus Basin, Papua New Guinea. American Geophysical Union Fall Meeting Abstracts, vol. 1, p. 0750.
Host-Symbiont Relationships in Hydrothermal Vent Gastropods of the Genus Alviniconcha from the Southwest Pacific	Suzuki, Y., Kojima, S., Sasaki, T., Suzuki, M., Utsumi, T., Watanabe, H., Urakawa, H., Tsuchida, S., Nunoura, T., Hirayama, H., Takai, K., Nealson, K. H., and Horikoshi, K. (2006). Host-Symbiont Relationships in Hydrothermal Vent Gastropods of the Genus Alviniconcha from the Southwest Pacific, Applied and Environmental Microbiology, vol. 72., no. 2, pp. 1388-1393.

Report Title	**Citation**
Evidence for a chemoautotrophically based food web at inactive hydrothermal vents	Erikson, K. L., Macko, S. A. and Van Dover, C. L. (2009) Evidence for a chemoautotrophically based food web at inactive hydrothermal vents (Manus Basin), Deep Sea Research II, vol. 56, pp. 1577-1585.
Evolution of the Metallothionein gene family in bathymodiolin mussels	Hsing, P., Carlsson, J., Jones, R., Sobel, A., THaler, A., Van Dover, C. L., Schultz., T. (2014). Evolution of the Metallothionein gene family in bathymodiolin mussels, Poster for *VentBase Workshop*, Wellington, 2014.
Facilitating fine-scale population genetic studies at Manus Basin hydrothermal fields	Carlsson, J., Jones, R., Schultz., T., Sobel, A., Thaler, A., Zelnio, K., Van Dover, C. L. (2014). Facilitating fine-scale population genetic studies at Manus Basin hydrothermal vent fields, Post for *VentBase Workshop*, Wellington, 2014.
Food Web Structure at Manus Basin Hydrothermal Vents	Honig, D. L., Hsing, P., Jones, R., Schultz, T., Sobel, A., Thaler, A., Van Dover, C. L. (2008). *American Geophysical Union Fall Meeting Abstracts*, no. 12.
Comparative Population Structure of Two Deep-Sea Hydrothermal-Vent-Associated Decapods (*Chorocaris* sp. 2 and *Munidopsis lauensis*) from Southwestern Pacific Back-Arc Basins	Thaler, A. D., Plouviez, S., Saleu, W, Alei, F, Jacobson, A., Boyle, E. A, Schultz, T. F., Carlson, J., Van Dover, C. L. (2014). Comparative Population Structure of Two Deep-Sea Hydrothermal-Vent-Associated Decapods (*Chorocaris* sp. 2 and *Munidopsis lauensis*) from Southwestern Pacific Back-Arc Basins, PLOS ONE, vol. 9, no. 7, e101345.
A biogeographical perspective of the deep-sea hydrothermal vent fauna	Tunnicliffe, V., McArthur, A. G., and McHugh, D. (1998). A biogeographical perspective of the deep-sea hydrothermal vent fauna*, Advances in Marine Biology*, vol. 34, pp. 354-442.
Genetic differentiation of populations of a hydrothermal vent-endemic gastropod, *Ifremeria nautilei*, between the North Fiji Basin and the Manus Basin revealed by nucleotide sequences of mitochondrial DNA	Kojima, S., Segawa, R., Fujiwara, Y., Hashimoto, J., Ohta, S. (2000). Genetic differentiation of populations of a hydrothermal vent-endemic gastropod, *Ifremeria nautilei*, between the North Fiji Basin and the Manus Basin revealed by nucleotide sequences of mitochondrial DNA, *Zoological Science*, vol. 17, pp. 1167-1174.
The SuSu Knolls hydrothermal field, Eastern Manus Basin, Papua New Guinea: An active submarine high sulfidation copper-gold system	Yeats, C. J., Parr, J. M., Binns, R. A., Gemmell, J. B., Scott, S. D. (2014). The SuSu Knolls hydrothermal field, Eastern Manus Basin, Papua New Guinea: An active submarine high sulfidation copper-gold system, *Economic Geology*, vol. 109, pp. 2207-2226.
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Mining seafloor massive sulphides and biodiversity – what is at risk	Van Dover, C. L. (2010). Mining seafloor massive sulphides and biodiversity: what is at risk?, *ICES Journal of Marine Science*; doi:10.1093/icejms/fsq086.
Molecular phylogenetic analysis of a known and a new hydrothermal vent octopod: their relationship with the genus *Benthoctopus* (Cephalapoda: Octopodidae)	Strugnell, J., Voight, J. R., Collins, P. C., Allcock, A. L. (2009). Molecular phylogenetic analysis of a known and a new hydrothermal vent octopod: their relationship with the genus *Benthoctopus* (Cephalapoda: Octopodidae), *Zootaxa*, vol. 2096, pp. 442-459.

Report Title	**Citation**
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Genetic diversity and connectivity of deep-sea hydrothermal vent metapopulations	Vrijenhoek, R. C. (2010). Genetic diversity and connectivity of deep-sea hydrothermal vent metapopulations, Molecular Ecology, vol. 19, pp. 4391-4411.

Source: Nautilus Minerals by email (May 31, 2016). (It is possible that there are additional studies that have been published since this list was compiled – Nautilus relies on scientists to notify it ahead of publishing, but this does not always occur.)

Annex 4. Cook Islands Manganese Nodules

Manganese Nodules are polymetallic concretions formed in deep sea beds usually at a depth of 4 to 5 km. These nodules contain manganese and smaller amounts of nickel, copper, titanium, cobalt and rare earth elements. They are potato like shaped and size ranges from 2 to 10 cm in diameters. The nodules are found lying loosely on the sediment covered abyssal plains of the world's deep sea basin. Manganese nodules are formed when dissolved metal compounds in the sea are deposited in solid form around a core. This process is extremely slow and can take millions of years (SPC, 2013). During the formation of the nodules several metals are collected from the seafloor but the majority of the metals are found in very low concentrations for economic recovery (Imperial College London Consultants, 2010).

There are four main locations where manganese nodules can be found at a density that is commercially attractive: (1) the Clarion Clippertone Zone; (2) the Peru basin; (3) the Penrhyn basin in the Cook Islands; and (4) the Indian Ocean. The reason for the high nodule density in these areas is similar environmental conditions. The manganese nodules in Penrhyn basin in the Cook Islands have been know for over a century. These deposits are known to have a high concentration over a very large area with concentrations varying but sometimes greater than 25kg/m^2 covering approximately 124,000 km^2 containing 3.6 billion tons in wet nodules (Hein at al. 2015, SPC, 2016a). Considering that the commercially interesting density for such deposits is 5kg/m^2 the Cook Islands resources are among the most commercially attractive.

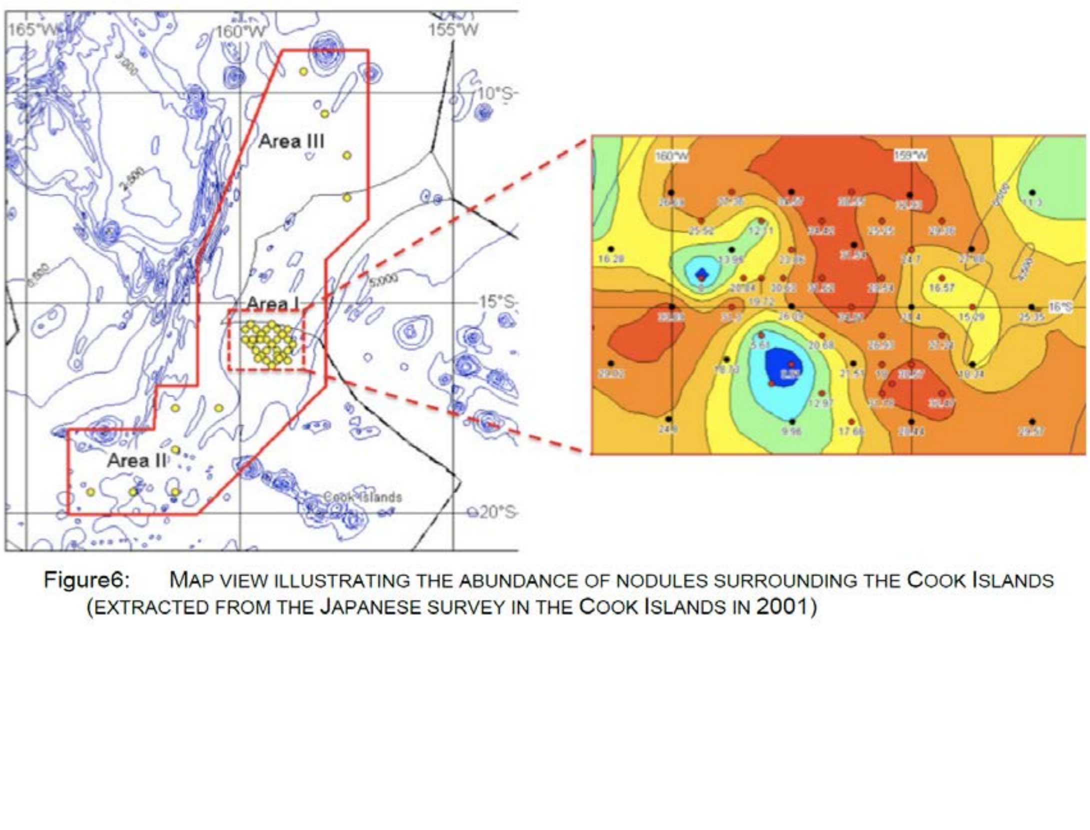


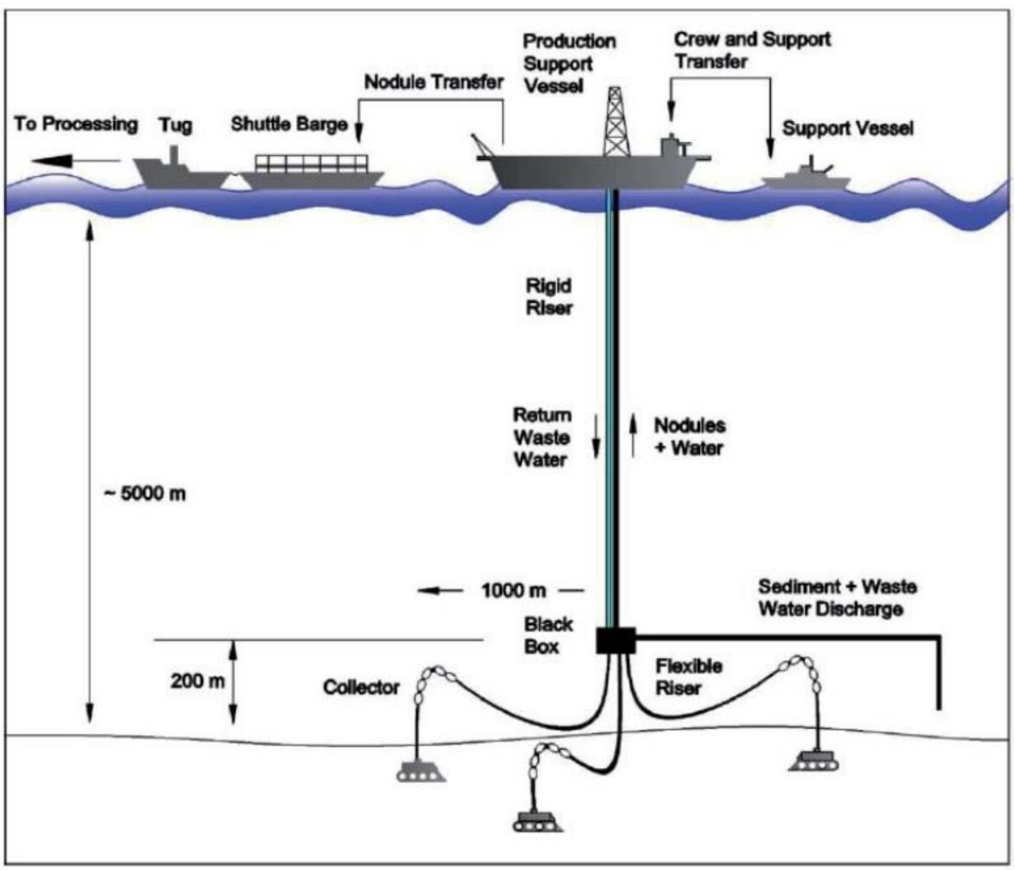
Figure6: MAP VIEW ILLUSTRATING THE ABUNDANCE OF NODULES SURROUNDING THE COOK ISLANDS (EXTRACTED FROM THE JAPANESE SURVEY IN THE COOK ISLANDS IN 2001)

Table A1. Basic Assumptions used in Cook Islands Mining Scenario

Table 4-5 Basic Assumptions used in Cook Islands Mining Scenario

Category	Assumptions Used
Total mineable area	2,705 km^2
Distance from nearest island	>300 km
Nearest processing facility[1]	Mexico (8,000 km)
Total estimated resource potential (dry tons)	50,000,000
Annual estimated resource potential (dry tons)	2,500,000
Duration of mining operation	20 years
Area mined per year	135 km^2
Collection efficiency	80%
Metallurgic Processing	Assume both three-metal and four-metal extraction technologies available
Note 1: The CBA assumes the nearest existing processing facility is in Mexico based on conversations with Cook Islands Seabed Mineral Authority. It is possible that a suitable processing facility could also be located in China or Korea.	

Figure A1. Proposed Nodule Mining System



Source: Agarwal et al., 2012

Source: SPC 2016a, derived from Agarwal et al., 2012

SPC (2016a) provides the annual employment, income and value added (GDP) estimates for a DSM operation in the Cook Islands. It is estimated that a total of 80 local jobs will be directly supported by DSM operations. Overall, considering other indirect economic activities, a total of 147 jobs would be supported by the DSM operations each year. In total, it is also estimated that DSM operations will support $3.4 million in local income and a total of $43.2 million of GDP each year of operation (SPC, 2016a).

Table A2. Annual Mine Operating Impacts for Cook Islands DSM Mining (in millions USD)

Impact Type	Direct	Indirect	Induced	Total
Employment	80	65	2	147
Income	$2.4	$0.9	$0.1	$3.4
Value Added (GDP)	$39.3	$3.7	$0.2	$43.2
Totals may not sum due to rounding Monetary values are in 2015 dollars Note 1: Based on the average value added per US ‘other metal ore’ mining employee from IMPLAN model				

Source: SPC, 2016a

Annex 5. The SPC-EU Deep Sea Minerals Project. Objectives and Outputs[68]

With financial support from the EU, the SPC Geoscience[69] Division implemented the Deep Sea Minerals Project from 2011-2016 in 15 Pacific Island Countries[70]. The project's specific objective was to strengthen the system of governance and capacity of Pacific ACP States in the management of deep-sea minerals through the development and implementation of sound and regionally integrated legal frameworks, improved human and technical capacity and effective monitoring systems.

The project's produced the following outputs under its four Key Result Areas:

1. Regional legislative and regulatory framework (RLRF) for offshore minerals exploration and mining

- Held regional deep sea mineral consultation workshops to share deep sea minerals information with all stakeholders (representatives of government, civil society, private sector, local communities) in the region. Renowned world deep sea mineral experts were in attendance.
- Fifteen national deep sea minerals stakeholder consultation workshops were held, one for each of the 15 Pacific ACP States.
- Developed, reviewed and finalised the "Pacific ACP States Regional Legislative and Regulatory Framework for Deep Sea Minerals Exploration and Exploitation" (RLRF). The RLRF was officially launched during the 43rd Forum Leaders Meeting in Rarotonga Cook Islands in August 2012.
- In consultation with Pacific Island Countries and Territories, develop, review and finalise the "Regional Cooperation Agreement for Responsible Deep Seabed Minerals Management", and to table the Agreement to SPC Annual Session and subsequently to Pacific Forum Leaders for consideration.

2. National policy, legislation and regulations

- Fiji International Seabed Minerals Decree was promulgated in July 2013. The Mineral Bill and Seabed Minerals Policy are currently under review.
- Tonga National Seabed Minerals Act was enacted in August 2014. The Seabed Minerals regulations have been drafted and are currently under review.
- Tuvalu National Seabed Minerals Act was enacted in December 2014
- Niue National Seabed Minerals Policy and Legislation and Regulations have been drafted and sent to government and are currently under review.

[68] Source: SPC

[69] Formerly known as SOPAC

[70] These are: the Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Tuvalu and Vanuatu.

- Kiribati National Seabed Minerals Policy and Legislation have been drafted and sent to government for review and consultations.
- RMI National Seabed Minerals Policy and Legislation have been drafted and sent to government for review and consultations.
- FSM National Seabed Minerals Legislation has been drafted and sent to government. The Bill has been reviewed and presented to congress.
- Vanuatu National Seabed Minerals Policy has been drafted and is currently under review.
- Solomon Islands National Seabed Minerals Policy has been drafted and is currently under review.
- Nauru National Seabed Minerals Legislation has been drafted, reviewed, and finalised. The Legislation was recently passed by Parliament.
- Cook Islands Seabed Minerals Regulations has been developed, reviewed and finalised.

3. Building national capacities – supporting active participation of PICs nationals in the offshore mining industry

- In collaboration with the International Seabed Authority (ISA), "The International Workshop on Environmental Management Needs for Exploration and Exploitation of Deep Sea Minerals" was held in Nadi Fiji in late 2011.
- The 1st DSM Project Regional Training Workshop was convened in Nadi Fiji in August 2012. The theme of the workshop was "Geological, Technological, Biological and Environmental Aspects of Deep Sea Minerals".
- The 2nd DSM Project Regional Training Workshop was held in Nuku'alofa Tonga in March 2013. This theme of the workshop was "Deep Sea Minerals Law and Contract Negotiations".
- The 3rd DSM Project Regional Training Workshop was held in Port Vila Vanuatu in June 2013. The theme of the workshop was "Social Impacts of Deep Sea Mineral Activities and Stakeholder Participation".
- The 4th DSM Project Regional Training Workshop was held in Nadi Fiji in December 2013. The theme of the workshop was "Environmental Perspectives of Deep Sea Mineral Activities".
- The 5th DSM Project Regional Training Workshop was held in Rarotonga Cook Islands in May 2014. The theme of the workshop was "Financial Aspects of Deep Sea Minerals Development".
- The 6th DSM Project Regional Training Workshop was held in Apia Samoa in May 2015. The theme of the workshop was "Deep Sea Mineral Policy Formulation and Legislative Drafting".
- The 7th DSM Project Regional Training Workshop was held in Nadi Fiji in August 2015. The theme of the workshop was: Development of Appropriate Fiscal Regime and Revenue Management Options for Deep Sea Mining".
- The 8th DSM Project Regional Training Workshop was held in Nadi Fiji in October 2015. The theme of the workshop was "Environment Management of DSM Activities".
- A national Timor Leste deep sea Minerals workshop was held in Dili in November 2014.

- Financial support provided to selected PIC candidates to attend short term DSM courses, and international workshops and conferences.
- Provided funding and technical support to 11 Pacific ACP States to attend and participate in the International Seabed Authority (ISA) in the last three years.
- A legal internship programme was established in early 2012 as part of the project capacity building. A total of eighteen young Pacific lawyers have participated in the internship programme to date.
- A total of ten Pacific government lawyers trained on legal aspects of DSM and participated in the development of DSM policy and law.

4. Effective management and monitoring of offshore exploration and mining operations

- Archived manganese nodule samples from Cook Islands and Kiribati were sent to various research institutions [USGS, University of Leicester (UK), Victoria University (NZ)] for geochemical analyses and environmental studies.
- Technical assessment reports on manganese nodule potential within the EEZ of Cook Island and Kiribati have been completed and delivered.
- The assessment report on the state of knowledge of Pacific marine minerals has been completed by UNEP/GRID-Arendal. The report (comprising five booklets) was finalised and officially launched in December 2013 and has been distributed to the 15 Pacific ACP States and other stakeholders.
- Initiated and funded a Cost-Benefit Analysis (CBA) for deep sea mining in the Pacific. The final CBA report has been finalised and delivered to SPC.
- Develop, review and finalise the "Pacific-ACP States Regional Financial Framework for Deep Sea Minerals Exploration and Exploitation".
- Formulate, review and finalise the "Pacific-ACP States Regional Scientific Research Guidelines for Deep Sea Minerals".
- Prepare, review and finalise the "Pacific-ACP States Regional Environmental Management Framework for Deep Sea Minerals Exploration and Exploitation".
- Establish and maintain the Regional Marine Minerals Database (RMMD).

5. Other Activities

- As part of the stakeholder awareness and information sharing of the DSM Project, nineteen information brochures have been completed and distributed to stakeholders in the Pacific Islands region and beyond.
- A Communication Strategy for the Project has been developed and implemented resulting in increasing communication and stakeholder engagement.
- Three DSM documentaries prepared and completed, and distributed to stakeholders in the region and beyond.

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