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ABSTRACT

Mining companies’ corporate social responsibility programs represent their projects as sustainable. However, "sustainable mining" and the mitigation of social and environmental impacts remains an elusive goal. Numerous studies have documented how terrestrial mining industries disenfranchise and endanger local communities and destroy ecosystems. This paper tracks “sustainability” into seabed mining, a nascent, boutique mining industry which has garnered increasing commercial and political attention in part because corporate scientists represent seabed mining as a benign and profitable alternative to terrestrial mining. Empirically grounded in three months of participant observation on a Nautilus Minerals exploratory vessel in the Solomon Islands, I use actor network theory and critical discourse analysis to investigate how corporate scientists and technicians on the ship saw sustainability as a natural feature of seabed mining extraction aside from corporate social responsibility programs. The scientists used remote sensing oceanographic devices, echosounding equipment, mapmaking software, and cameras to see the seabed at the mining sites as lifeless and empty and to render the ocean invisible and unproblematic, and drew on a rich range of agricultural and pillaging metaphors and comparisons with other disastrous mining projects to reveal sustainability as a relational quality of seabed mining. Visualizing the extraction regime as sustainable is a new strategy seabed mining companies use to co-opt NGO criticisms. This work raises important questions about the limits of sustainable development and technoscientific vision and the future relationship between telemining projects and environmental and indigenous rights groups.
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CHAPTER 1

In this thesis, I analyze the way that geoscientists on an exploratory seabed mining cruise visualized and represented the seabed and the ocean in particular ways. The seabed was understood as solid, vast and empty while the ocean was similarly conceptualized as “liquid rock.” These visions of the seabed materialized through acoustic, benthic map making and interpretation, thematic metaphors, and comparisons. Despite the array of remote sensing equipment the scientists and technicians used to see the seabed, their uncertainty about what was there seemed to haunt them. One engineer quipped, “What really gets me, is you don’t know, you can’t see. I have a little girlish feeling that I will run into the seabed. I don’t like to not see what’s happening when I do things like this, I can’t see what’s happening. It’s unscientific” (Harris, field notes, 07/2015). Despite concerns about risk and the limits of expertise, the technicians, who were well-experienced in the offshore oil and gas industry, but prior to boarding, had only but distantly heard of seabed mining, came to conceptualize seabed mining as sustainable. I will demonstrate the ways that the geologists and technicians on the ship constructed and naturalized extraction of a nonrenewable resource as sustainable by mobilizing remote sensing equipment, thematic metaphors, and comparisons with other, disastrous mining projects. Understanding that seabed mining does not inherently beget sustainability, but only approaches it, I conclude with a call for more cross-disciplinary and multi-sited research on corporate geoscience, national and international policymaking, burgeoning NGOs, and mobilizing local communities as commercial seabed mining continues to unfold.
Seabed Illegibility

The seabed and the ocean are bedeviling places that resist analytical and interpretive purchase (Helmreich 2012, 15-18). Diagrams of the landscape often show three-quarters of them comprising of uninterrupted blue ocean, sometimes gradated to black shading. This is abruptly interrupted by a stark line that indicates the seabed. Through a closer look at this environment, the seabed’s qualities quickly overflow these representations. The seabed is sometimes paved over with nodules packed so tightly together, that the seabed looks like a twilit, cobbled street in London. Sometimes, the pelagic ooze begins meters above where a surveyor’s lines would indicate where the seabed began and where the frigid, benthic waters permeate the rocks and sediment. The distinctions between rocky and watery spaces and materialities blur, complicating any claims of a hard, clear boundary.

Legal bodies have just as difficult a time seeing the seabed. States became concerned about the seabeds under their jurisdictions and those lying in international waters when underwater mineral deposits were identified as economically interesting. Concern about what was seabed and how much of it belonged to a state became important when underwater mineral deposits, especially gas, were identified and became economical to extract. Many states were concerned about rights to their own seabeds as well as those lying in international waters. Who was to benefit from this kind of seabed? How would intergovernmental groups ensure that international seabeds were not utilized for war or other destructive ends? It was Malta, a small, European state,
that first petitioned the seabeds as an item of imminent importance to the United Nations General Assembly (United Nations Conference on the Law of the Sea 1975, United Nations Office for Ocean Affairs and the Law of the Sea 1997). The concern over the High Seas, and the seabeds in international waters, the latter called the Area, resulted in the 1973 to 1982 United Nations Convention on the Law of the Sea, UNCLOS (United Nations Conference on the Law of the Sea 1975, United Nations Office for Ocean Affairs and the Law of the Sea 1997). Previous to this Convention, states loosely adhered to the cannon shot rule of three nautical miles to measure a state’s territorial waters and seabeds. After Guyana became the 60th nation to sign the treaty, UNCLOS came into force in 1994 (United Nations Office for Ocean Affairs and the Law of the Sea 1997). Since then, 166 countries and the European Union have joined the Convention. Much of the Convention codifies, has already or is likely to become customary law (United Nations Conference on the Law of the Sea 1975, United Nations Office for Ocean Affairs and the Law of the Sea 1997). The UNCLOS treaty delineates the territorial waters as 12 nautical miles off the coast (United Nations Conference on the Law of the Sea 1975, 23). This extension of ocean and seabed can be defended and regulated by the state in question and secures safe passage for vessels so long as they seek “innocent passage” (26). 12 nautical miles out from the territorial waters is the contiguous zone, a stretch of ocean where a state can continue to enforce laws concerning customs, taxation, immigration, or pollution (31). 200 nautical miles from the edge of the territorial sea marks the boundary of the state’s exclusive economic zone (EEZ), a band of ocean where a state maintains its rights to solely exploit the resources therein
EEZs are highly contestable, especially amongst close-lying states and disputed seascapes. For example, states may extend their continental shelf, but the extension does not apply to the overlying water. Moreover, questions of ownership and infringement have been raised with offshore, lateral drilling in which rigs within a state’s EEZ extract ore from another state’s EEZ by laying pipe at angles.

In 2001, the International Seabed Authority or ISA, an agency set up under the United Nations Convention of the Law of the Sea to administer the seaboards lying outside of national jurisdictions, has granted 26 countries exploratory licenses to map, collect soil and water samples, and even trial drill to ascertain indicated mineral resources. Of 26 permits, 18 were granted within the last five years due to increasing commodities demands, depleting terrestrial metal reserves, and growing, multi-scalar environmentalist movements opposing terrestrial mining (Steiner 2015).

Companies and stakeholder groups also contest what communities will be impacted by seabed mining. Although no one lives on the seabed, seabed mining companies have identified local communities located in “impact zones,” habitable places that could experience negative environmental impacts from seabed mining. Non-governmental organizations, and many local communities believe the seabed mining will externalize social and environmental risk onto local communities. For Example, the Ocean Foundation’s association of NGOs concerned about seabed mining’s impact on Pacific communities is the Deep Seabed Mining: Out of Our Depth campaign provides numerous testimonies from professors at the University of Papua New Guinea, senior
members of the Lutheran Church in Madang and Morobe, and Madang community members (Deep Sea Mining, 2015).

NGOs have also raised concern about the impact seabed mining will have on local ecologies. According to statements on the Deep Sea Mining: Out of Our Depth Campaign website, seabed mining in the Pacific will strongly influence how it is conducted in other parts of the world. However, mining activity is “occurring in the absence of regulatory regimes of conservation areas to protect the unique and little known ecosystems of the deep sea” (2015). The campaign’s mission statement takes mining corporations such as Nautilus and Lockheed Martin to task for not creating adequate inputs for local communities to voice their concerns about seabed mining, secure just compensation, and actualize measures to protect the environment (2015). The lack of regulatory regimes and the lack of precautionary research into seabed mining’s impacts have led many organizations and academics to call for a moratorium on seabed mining. A spokesperson for the DSM campaign noted that, “there is insufficient scientific data about the impacts of seabed mining, no regulatory frameworks in place to govern mining operations and the capacity to enforce such frameworks does not yet exist”. Some states have successfully established moratoriums on seabed mining within their national jurisdictions, including Canada, New Zealand, Australia, and Namibia (Michaud 2013). While a moratorium has not been put into effect on the Area by the ISA, the DSM campaign, MiningWatch Canada, Oasis Earth, and the Mineral Policy Institute collaborated to draft and submit a regulatory framework for deep seabed mining to the ISA. However, Marine Protected Areas that act like nature reserves on the seabed
have been established within states’ EEZ, including the Kermadec Ocean Sanctuary in New Zealand. In the Area, the ISA has established Areas of Particular Environmental Interest, APEIs, in the Clarion Clipperton Zone of the Area (Steiner 2015)

A History of Seabed Mining

Seabed mining is mineral extraction from the deep seabed: including abyssal plains, underwater mountains, plateaus, hillsides, and chimneys, typically no deeper than 6,000 meters below sea level. Seabed mining is an umbrella term that covers different methods of extraction, depths, and minerals of interest. There are currently three kinds of seabed mining under commercial consideration. First, mining companies are interested in mining manganese nodules that occur on abyssal plains and ferromanganese crusts that accumulate on the sides and on top of seamounts (Schmidt 2015, Verlaan, 2016, Wiltshire & McMurtry 2015). Crust mining would require bulk-head cutter vehicles, operating on steep slopes, to chisel layers of crust off the submerged mountains (Schmidt 2015, Verlaan 2016, Wiltshire & McMurtry 2015). Underwater engineers have yet to design a machine that will incise as little of the host rock as possible, while maximizing the amount of collected crusts recovered from the seamounts (Verlaan 2016). Secondly, and more imminent, is the extraction of ferromanganese nodules from the abyssal plains. These deposits form over millions of years in the sediments on the surface of the deep seabed. These nodules, first discovered on ancient, uplifted oceanic crust in the Swiss Alps in the 1700s, must be “vacuumed up” by autonomous collection vehicles (Wiltshire & McMurtry 2015). These nodules are the easiest to mine and have economic grades of nickel, manganese, copper, cobalt, and rare earth metals (Wiltshire & McMurtry
Finally, and most relevant to this thesis, seabed mining companies are interested in seafloor massive sulfides that form around underwater, hydrothermal vents. These vents release a super-heated metal-rich solution from the Earth’s mantle into the icy benthic waters. The temperature gradient causes gold, silver, zinc, copper, cobalt, and other minerals to precipitate into chimneys (Schmidt 2015, Verlaan 2016, Wiltshire & McMurtry 2015). Over time, hydrothermal activity shifts, leaving ore-rich chimneys and near-surface deposits in its wake (Schmidt 2015, Verlaan 2016, Wiltshire & McMurtry 2015). Hydrothermal activity is unpredictable, and the time it takes for chimneys to develop and cool varies (Wiltshire & McMurtry 2015). The inactive chimney fields are mineable using bulk-head cutters, an attached pulverizer, and a series of hydraulic pumps that transport the slurry of water and sediment to a vessel positioned above the site (Verlaan 2016, Wiltshire & McMurtry 2015).

It is important to note that these crusts, nodules, and chimneys are not considered renewable resources since they do not “have the potential of being maintained, improved in quantity or quality, or both” (Panel on Natural Resource Science Commission on Education in Agriculture and Natural Resources, Agricultural Board, Division of Biology and Agriculture, National Research Council 1967) within a human lifetime (Nysten-Haarala 2012).

Despite its technological feasibility, seabed mining has yet to be commercially practiced. Seabed mining was technically feasible when it was first proposed by John Mero in the 1959 and 1965, but it was economically inefficient, and commodity market fluctuations deterred commercial exploitation of seabed minerals until the early 2000s.
(Mero 1959, 1965, Barkenbus 1979). During that time, the offshore oil industry developed technology that could be more mobile and obtain oil in deeper waters, and other offshore mining industries, such as “wet diamonds” and nearshore gravel or sand extraction, developed autonomous mining technology that could cut crusts and suck up sediment layers (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2010, Garnett 1995).

Concerns about peak oil and commodities and the terrestrial mining industry’s negative, global, public image articulated with their increased operating costs and thinning profit margins, began to rekindle interest in seabed mining as an alternative to, though not a replacement of, terrestrial mining. However, to complicate this trend and to explain why commercial seabed mining has been delayed and why different seabed mining projects leapfrog in terms of profitability, commodities are subject to different, yet interrelated market cycles. Simulations have shown that in homeostatic economic conditions, such as a stable price of oil, US real interest rate and real effective exchange rate of the USD, and other markers, changes in cobalt anticipates a decrease in the cost of nickel while the price of oil raises the cost of nickel (Merrie et al. 2014). Despite and because of these dynamic markets and technological advances, deep seabed mining has gained commercial and political attention again along and within the Pacific Ring of Fire in particular. Thus, NGOs, local communities, and mining corporations “re/present” the Pacific through the old adage of the-Pacific-as-laboratory, where the conditions and consequences of seabed mining can be studied at a safe distance (Kabutaulaka 2015, Kirch 2000)
**Nautilus Minerals: Solomon Islands**

Nautilus Minerals is one a growing group of companies and government agencies vying to be the first commercial seabed mining outfits. The Canadian-based company buys licenses to explore tenements within the EEZs of mostly small island states in the Pacific, including Tonga, Solomon Islands, Fiji, Vanuatu, and Papua New Guinea. In 2005, Nautilus announced the discovery of Solwara 1 off of the New Ireland province in Papua New Guinea. The deposit is about the size of New York’s Central Park and sits at 1,200 meters below the ocean’s surface. Solwara 1 boasts an indicated reserve of 1,030,000 tons of ore with 7.2% copper and 5.0% tons of gold as compared to the average copper grade in the world’s largest copper mine, Escondida, which operates with ore grades below 1.0%. (189) Nautilus has reported that the three major tools to mine seafloor massive sulfides off of inactive hydrothermal vent systems have been built, and that it will begin mining operations in 2018 (Ferris 2015).

Currently, Nautilus is attempting to find more viable deposits, increase shareholder value, and attract more investors. The corporate activity was a context for the 2015 Solomon Islands Campaign. In order to maintain their licenses to explore certain tenements, the company must visit and conduct research on them. Nautilus’ tenements in Solomon Islands will expire in late 2016. The objective of the research cruise was to first, find plumes of mantle-derived fluids and gases released by underwater volcanoes and collect samples. These plumes indicated active hydrothermal systems, and although these were not areas of extraction interest due to high temperatures and corrosive acidity, the active systems are tell-tale indicators of nearby, potentially
mineable inactive hydrothermal systems. Secondly, they intended to visit all of the geological formations of greatest potential interest. All significant geological formations, such as ridges or underwater volcanoes, were graded from the most likely (A) to least likely (D) demonstrate volcanic activity. This systematization allowed the geoscientists to prioritize different formations and routes. Thirdly, the campaign was to produce up-to-date maps of the seabed using echosounding equipment. Next, the geoscientists eliminated tenements that did not demonstrate hydrothermal activity, thus reducing Nautilus’s operational costs.

Nautilus contracted with Gardline CGG, a marine geotechnical services company to rent 60 days on board the offshore surveying vessel, the MV Duke, formerly the MV Polar Duke. Due to severe mechanical malfunctions, the cruise had two stints, each about a month long. The personnel changed slightly between stints. The exploratory team comprised five geologists, a geotechnical engineer, a government observer, and myself. The exploratory team shared the lab and collaborated with the Gardline technical team. The technical team was itself composed of underwater engineers and surveyors. The underwater engineers were in charge of deploying, recovering, and controlling the sled. The surveyors were in charge of generating and processing the mapping data. The technical team included five surveyors and four engineers. Finally, the ship was operated by a 16-person marine crew, including the ship’s officers, party chief, ship doctor, electricians, able-bodied seamen, cooks, stewards, oilers, and boatswain. The three teams had between four to six women and twenty-six men from around the world, including Australia, the UK, the Philippines, the United States, Papua
New Guinea, and Croatia. The exploratory and technical crews collaborated to safely and effectively operate the remote sensing equipment and interpret the information. To achieve these goals, the primary procedures for the exploratory crew included towing the sled up and down in the water column anywhere from two hundred to twenty meters above the seabed. The sled was a two-ton cage of steel, weighted with lead. Mounted towards the nose of the sled was an array of remote sensing equipment attached to the ship through the cable that dragged it through the water. The remote sensing equipment included a GoPro housed in a pressurized, steel housing and a bike light. The sled also housed a Conductivity, Temperature and Depth package (CTD), a long, steel cylinder that measured the important physical qualities of the water of its namesake with high accuracy at depths of thousands of meters. The sled also held a rosette-shaped “carousel” of twelve, 2-liter “water bottles” wired to the CTD. When triggered, each water bottle could open, capturing a water sample. Clamped along the reinforced steel cable that attached the sled to the ship were Mini Autonomous Plume Recorders, MAPRs. These were essentially smaller versions of the CTD, but included instruments that recorded light-backscattering, or water turbidity, and oxidation-reduction potential, ORP. These sensors would be able to detect a hydrothermal vent plume, a gaseous cloud of hydrothermal vent water with dissolved and undissolved particulates in solution. The ship’s lab, where the technical and exploratory teams worked closely, housed an impressive array of sonic equipment controls, including the controls of the Robertson Winch, the large winch bolted onto the top of the back deck that paid the cable in and out, various echosounders and deeper, seismic acoustic equipment. The far-end of the room
was covered with monitors depicting the ship’s course, position in relation to the seabed, and speed, as well as the position of the sled, its depth, and proximity to the seabed, the hardness of the seabed under the ship, streams of incoming data to be “swathed” by surveyors and transformed into detailed maps of the seabed.

Roles on the ship were distinct, particularly between the technical and exploratory team. Surveyors on the Duke both coordinated navigation with the ship’s captain and first and second mates using single and multi beam acoustic echosounding devices to map the ship’s course, position, and transits. The surveyors also worked closely with the geoscientists to generate more accurate maps of the seabed. Technology facilitated personnel coordination and allowed teams to coordinate on the identification of potential sites of volcanic activity, navigation, and cartography. The acoustic and mapping technologies in the lab and the range of instruments mounted onto the sled interpreted the strength and time it took for sonic pulses to bounce off of the seabed and onto sensors protruding from the bottom of the ship. In the lab, computers amassed these “noisy” measurements. Surveying software allowed the surveyors to comb through the tangled and warped strands that represented distances from the seabed back to the sensor. Through a process called “swathing” the surveyors used their experience on other surveying jobs, old maps of the seabed, logic, and their intuition to generate cleaned up profiles of the seabed’s topography. The engineers operated the winches as the ship towed the sled through the water. They calculated and tuned the echosounders and the interpreting software to improve the incoming graphs of rebounding sound waves. The engineers handled the deployment and recovery of the sled, and coordinated with the
surveyors and bridge officer on duty to ensure that these procedures were done safely. The geoscientists on the ship interpreted incoming data from the sled and decided when the data looked promising enough to “fire” the bottles, and collect a water sample. They also were in charge of final quality control of the surveyor's’ maps before they were sent back to the Nautilus office and used to select and plot the next “lines” or routes that the sled would be towed along. The geoscientists collected water samples, packaged them, and set them aside for a lab in the United States to analyze for particulate composition and quantities.

As experienced team members knew and first timers would quickly discover, no cruise is perfect, and this cruise was certainly no exception. The ship’s operations were impeded by cyclones and high seas, mechanical failure, medical emergencies. The geologists frequently commented to me on the unusualness of the cruise. They stated in casual conversation and throughout the interviews that normally, they would be “running like a well-oiled machine” or “hardly a dull moment.” However, on this cruise, the poor conditions and mechanical issues often hampered the teams’ ability to collect data or tow the sled. Thus, some parts of the seabed that Nautilus intended to cover remained inscrutable and for all intensive purposes, invisible.

Access is an important and complicating aspect of “studying up” institutions of power such as mining corporations. Critics point out that the “embedded anthropologist” raises ethical questions concerning conflicts of interest and the misuse of anthropological skills. In the same way that NGOs have their discourses co-opted by the companies they critique, anthropologists working too closely with corporations run the risk of having
their work used towards purposes they do not want or intend. As Coumans (2011) pointed out, embedded anthropologists may not be at liberty to speak about certain insights (Coumans 2011). However, like Welker (2014), I believe that crucial insight into how corporations enact and how they mobilize networks can only be seen while participating in their everyday practices and my fieldwork constituted a “fuzzier” kind of embeddedness than what Coumans explored (Welker 2014).

I stood out on the ship and made a conscious effort to do so: I brought my field notes with me everywhere, I took notes in front of the teams in the lab, in the messroom, and in the lounges, and I widely distributed summaries of my research and questions on the ship. At the same time, the teams also came to see me as a regular, albeit odd part of life on ship. On one hand, although I was definitely a supernumerary, the marine and technical teams did not consider me the same as the “academics” on the exploratory team, because I was interested in and happily participated in doing the more physical and “dirtier” work of running the ship and working with the sled. On the other hand, the exploratory team did not wholly consider me one of them, since I had not completed my advanced degree and was not corporate. In general, the more I was willing to learn from and work with the teams, the more accepted I felt, despite their ribbing about my being the only American on the ship. I knew I had successfully staked out this position when I was repeatedly and jokingly referred to as the “ship chief anthropologist” and more than one person on the marine and technical teams commented that I was the strangest academic they knew. Thus, to see these everyday practices and understand the rationale the actors use to make them make sense and produce incisive and theoretically powerful
work, ethnographers that study up corporations and industries, especially those that have not completely enclosed as a black box, must get closer in the most visible way possible.

I initially gained access when I took two Ocean Resource Engineering courses at the University of Hawai‘i at Mānoa taught by Dr. John Wiltshire and Dr. Gary McMurry. Dr. Wiltshire connected me with Nautilus Minerals when the company solicited graduate students to volunteer on an exploratory cruise. I submitted my resume and was offered the Solomon Islands cruise. Nautilus paid for my flights and provided boarding and accommodation. I flew to Brisbane where I participated in a two-week offshore safety course with the exploratory team and then met the ship in Honiara, Solomon Islands. Before boarding the ship at the pre-departure orientation, I signed an indemnity agreement that prevents me from libel and describing coordinates, the number of dives, the number of samples, etc. As a precaution, I have had this thesis reviewed for libel by two environmental lawyers. I also made the thesis available to Nautilus Minerals.

My research was collected over the course of both stints in the Solomon Islands’ EEZs. I collected 15 interviews that spanned the marine, technical, and exploratory teams, genders, ages, corporate affiliations, and nationalities. The majority of these interviews were audio recorded, but some interviewees requested that their interviews not be recorded. I did not give Nautilus a pseudonym. The number of seabed mining companies doing work in the Pacific is so limited that it is virtually impossible to make the company unidentifiable. However, I gave pseudonyms to everyone on the ship and
removed identifiable information. Along with these interviews, I collected extensive, daily field notes, which I cite throughout this thesis. Like the technical and exploratory team, I was also assigned a 12-hour shift, noon to midnight, where I was on duty in the lab. I regularly participated in both pre-deployment and pre-recovery toolbox meetings on the ship’s bridge. I assisted the engineers on the back deck by attaching the MAPRs to the cable and navigating the sled through the water and around obstacles in the lab. I helped to prep and clean the sled, “dumped” the data collected by the MAPRs after recover and calibrated them before deployment. I learned to swathe incoming acoustic data and produce maps of the seabed from the surveyors, to take environmental samples, and the conduct initial processing of incoming CTD, ORP, and MAPR data. I also did small tasks around the ship, making signs, running errands, cutting copper pipe and making sample holders, organizing samples, reinforcing the cable, monitoring the winch system. I also helped collect water samples and package them appropriately for shipping and analysis. Besides working with the different teams, I also lived with them, mourning over the last bit of butter and lack of eggs, suffering through seasickness, sharing gym time, sunning on the top deck when it wasn’t raining, watching flying fish, beetles, and birds and countless romantic comedies.

I used discourse analysis to identify and interpret patterns of representation across the interviews I collected and fieldnotes. I transcribed all of the interviews and coded each of these with increasing specificity. I first open coded for key terms such as metaphor, ocean, science, seabed, economics, future, etc. I sorted these by term and coded again for kinds of metaphors, such as agriculture, past mining projects, Pacific
Ocean, etc. I used James Paul Gee’s (2005) building tasks to begin analyzing what activities the teams’ discourses accomplished and what connections they made to represent seabed mining. When I grouped these quotes by how and what they accomplished, they polarized into the ethnographically rich chapters three and four. Finally, I drew from my fieldnotes to compose four ethnographic vignettes. Each one described an event I witnessed on the ship that raised issues of representation. I participated in an ethnographic workshop with Kirin Narayan through the Center for South East Asia Studies where I refined the ethnographic vignettes I include in this thesis.

In this thesis, I approach the corporate field geoscience conducted on the exploratory vessel as an emergent structure of commercial seabed mining throughout the Pacific. Although I was present and participated in many of the ship’s procedures and duties, this was only the exploratory phase. Much more testing and lease applications will be necessary before Nautilus can proceed with extracting minerals from states’ EEZs. In this thesis I ask, what are the emergent structures of seabed mining? How the geologists on the ship construct truth claims about the ocean and the seabed? How do the geologists and technicians construe seabed mining as sustainable, despite the fact that none of the minerals they will extract are considered renewable? How do seabed mining companies address the history of mining, especially in the Pacific? How do geologists’ ontologies of meaning impact the way that they see the seabed, interpret it, and then translate their findings to other geologists and technicians on the ship, corporate persons on shore at the Brisbane Nautilus office, NGOs, political bodies, and local peoples?
In Chapter Two, I consider the discursive space between scientific practice and sustainability in mining corporations. I consider different technologies scientists, NGOs, states, and local community members use to make truth claims about the environment, mobilize networks, and enact the corporation in particular ways.

These theories and their purchase in seabed mining begin to be teased out in Chapter Three. I demonstrate the articulation between technological and discursively mediated sight that enables scientists to see the seabed as vast, empty and the ocean as a invisible, negligible, or a kind of “liquid rock.” I pay attention to swathing and comparisons between the seabed and agriculture.

In Chapter Four, I analyze the ways that these images of the seabed and ocean are compared through thematic metaphors, especially agriculture, in disparate ways. I also focus on the ways that seabed mining is positioned vis-à-vis previous, disastrous mining projects in the Pacific in particular. In effect, these discursive moves construe seabed mining as sustainable, despite the nonrenewable quality of the minerals deposits and .

Lastly, in Chapter Five, I ask how seeing seabed mining as sustainable will impact on local communities and shape critics’ and corporations’ forthcoming discourse. I call for deeper, lateral engagement in corporate field science but also in other sites of emergent features of seabed mining, including international policymaking and corporately defined “impact zones”, which are communities that seabed mining companies have identified as the groups nearest to and most directly affected by seabed mining activities.
CHAPTER TWO
In this chapter, I consider the state of the conversation around offshore practices, mining, extraction, scientific visualization, and corporate sustainability. I identify some currents in Science and Technology Studies (STS), with particular emphasis on Bruno Latour’s (1987) actor network theory and Andrew Pickering’s (1993) work on the mangle of practice. I examine how scientific practice gains traction in natural resources and different kinds of scapes through instrumentation. I then explore three proxy cases where technoscientific practice and truth claims alter the environment and people’s lives. I begin with Cymene Howe’s (2014) ethnography about contested truth claims and the environmental impacts of a nearshore wind farm. Secondly, I explore Veronica Davidov’s (2013) ethnography on the alliances within anti-mining and anti-oil activists in Ecuador and their connections or lack thereof with environmental NGOs. Next, I explore Hannah Appel’s (2012) account of modular, offshore oilrigs and their pervasive socializing techniques both on and offshore Equatorial Guinea. Finally, I briefly discuss mining companies’ relationship with sustainability and the growing visibility of the seabed mining industry in the Pacific. Through this constellation of scholarship, I aim to illustrate the conversations my research enters, the gap it fills, and its timeliness as an analysis of emergent structural features of seabed mining.

Scientific practice has rapidly diversified over the last forty years, generating novel technologies and gaining wider public access and use. Thus, scientific practice continues to be an unsettled object requiring more research (Woolgar et al. 2014, 2). Science and technology studies (STS) gained momentum in the 1980s in the wake of the post-structuralist and introspective turns in social scientific thought when scholars
reconsidered their approach to indigenous anthropology, institutions, ethnography, science, and corporations. Since then, STS has shifted its attention from challenging monolithic, ahistorical understandings of science towards ontology (Ingold 2011, Kohn 2013, Helmreich 2004), materiality (Bennett 2010, Helmreich 2013, Kockelman 2015), and embodiment (Haraway 1994, Vertesi 2015). STS frequently decenters the human and considers her in dynamic relationship with other actors. This rich dimensionality requires scholars to blur distinctions between natural and social sciences and subject and object through multi-sited (Tsing 2011) and multi-species ethnography (Haraway 2008, Choy et al. 2009).

Multi-modal ethnography began in large part with Latour’s (1987) Actor Network Theory, a set of theoretical tools and positions on material agency and conflict settlement. Actor network theory gave researchers the interpretive methods to trace the construction of scientific knowledge across many actors and spaces. For Latour, matters of fact are always made by mobilizing networks of actors (14, 173). Both Latour (1987) and Callon (1984) noted that scientists compete to enroll actors and actants into their networks by aligning their prospective allies’ interests with their own and establishing themselves as gatekeepers of knowledge through which all other actors and their claims must pass (Latour 1987, 205; Callon 1984, 65-66). However, actors may defect or resist the scientist’s enrollment (Latour 1987, 13, 80; Callon 1984, 66). Resisting enrollment and mobilizing networks against each other posed a trial of strength (Latour 1987, 78). If a network’s claim withstood a trial of strength, that defending scientists’ claims would be harder to usurp in future attacks, and the offensive scientists’ claims would be dismissed.
as less objective or untrue (78-79). Thus, a claim that withstood numerous networks’
trials of strength settled a dispute and effectively established a matter of fact (86).

Scientists’ battles to establish fact are not exclusive to human actors. Rather,
scientists’ networks include technology and the natural phenomena they observe. In his
reading of Donald Glaser’s bubble chamber, Pickering (1993) focused on the ways that
cosmic rays, xenon, the size of the bubble chamber, “triggers”, and “big science” resisted
his efforts to realize his goals. He also examined the ways that Glaser accommodated
these obstacles with new techniques (559, 561). The dialectical relationship between
resistances and accommodations made up what Pickering called the mangle of
practice. Social scientists must keep in mind the “temporal emergence” of scientists’
goals and practices, and second, the “tuning” of their methods and equipment to bring
those goals to fruition (564). Doing so, she would see that “science is a field of
performative material devices,” that “the trajectories of emergence of human and material
agency are constitutively enmeshed in practice by dialectic means of resistance and
accommodation,” and finally that “material and human agencies are mutually and
emergently productive of one another” (567).

The dialectical relationship between materiality and sociality plays out in the way
that humans and the environment interact. Ingold (2011) explored how materiality
animates our perceptions of the environment. Weather and the atmosphere condition our
experience of land and ocean. Ingold demonstrated this by describing how mistiness
upsets our perceptions of a static, striated landscape (132). Mistiness disrupts
the “homogenous and volumetric” perception of the landscape (132). However, the
ocean is seen as smooth space: “a patchwork of continuous variation, extending without limit in all directions” (132). Even outside of our perceptions of it, the landscape has never been static. Rather, it pitches and heaves across geological time and in minute ways. In this way the land is much more like the ocean, disrupting our perception of littoral space as the interface between ocean and land as distinct mediums (131-32). Thus, Ingold concluded that the “body is enlightened, ensounded, and enraptured” by the dynamic world in which she dwells (135). Through this reading, both the environment and perception of it are dynamic. Moreover, perception is not just sight projected onto material; rather, materiality impresses upon senses conditioned to see only a few of the myriad of ways.

Ingold (2011) challenged factual representations of the land by turning to the sea, but Helmreich (2009) did the inverse. Compared to the stability and familiarity of terrestrial metaphors and spaces, the ocean and dependent interest groups are slippery. In “Blue-Green Capitalism: Marine Biotechnology in Hawai‘i”, the ocean was a medium submerged in multiple currents of meaning that come to a head in capitalist, marine biotechnology. To marine biologists, the ocean is a veritable “frontier”, a “treasure chest” of “immense --and largely undiscovered” capital-generating and world-making microbes (108, 110). These meanings transformed the ocean and the microbes that comprised it, into profit. The ocean as a profitable and largely un(der)regulated resource needed protection and “political and economic representation” (111). As “promissory capital” the microbial ocean become of interest to Native Hawaiians as a statement of sovereignty recognition and self-determination (137, 139, 141). Corporate interests and
technoscientific practices and issues of sovereignty and self-determination inundate Pacific seascapes and its resources with related, but differently weighted symbolic loads. These symbolic loads position the microbial ocean as a profitable medium to control and a site of heated contestation. At the same time, the different meanings coursing through the microbial ocean articulate with each other in productive ways: Hawaiian wayfinding projects such as the Hokule’a are platforms where young people can learn about marine biology, and marine biology can leverage Hawaiians’ legal claim to the ocean and its resources.

Scientific visualization is mediated through discursive and material tools. Nystrom’s (2007) dissertation visualization tools developed in tandem with the mining industry. In the mining industry, improving corporate scientists’ ability to see underground allowed them “to represent underground spaces to different audiences” and to increase mining projects’ efficiency and profitability (6, 10). Although Nystrom analyzes many kinds of visualization tools, maps, models, and photographs were especially important to mining development in America during the 1920s and continue to be important rhetorical tools in seabed mining. Maps were “technical representations” that revealed underground geological formations, facilitated information processing, shifted expertise from local miners to rapidly professionalizing engineers and technologists, and represented new kinds of data (23-24, 67-68). Models, especially three-dimensional ones, best revealed qualities of invisible spaces to viewers. Nystrom added that models, “transformed arguments into facts which were then used to support arguments about geology and the law” (222). Finally, Nystrom claimed that photographs
allowed project managers “to keep records of physical progress on mine maps” and to produce evidence that mining conditions were safe, but miners who got injured on the job were at fault (275). Thus these visualization tools shaped the engineers’ professionalization and the trajectory of the mining industry.

Visualization tools not only shape scientists’ experience of the phenomena in question. The tools shape the ways that scientists relate to each other. In Vertesi’s (2012) ethnographic account of the Mars Rover teams, the rovers became totems that symbolized and coordinated team members and labs across the world and acted as gatekeepers that facilitated the scientists’ sight and daily projects on the Mars surface. Vertesi (2014) stated:

Seeing like a rover…also involves learning to see like a member of the rover team in the context of a particular social organization, and to account for robotic and human relations in particularly intimate, totem-like terms. It therefore draws a yet closer association between visualization regimes and local practices of sense-making on the one hand, and the imperatives of social order on the other (397).

The team members shared embodied movements and positions to mimic the rover’s movements and apparatuses, thus mapping the rovers’ technological features onto their own bodies (399). By overlaying technical features of embodied ones, the team member’s body became the rover’s body, creating a sense of collectivity between the team members and empathetic bonds with the rovers themselves (404, 406). Team members also anthropomorphized the rovers by giving them complex personalities and life spans. Preserving the lifespan of the rover and dealing with “rover death” highlighted the ways that the rover and the embodied practices that related the rover to the teams socialized the team members (408). Thus, Vertesi pointed out that “both
imaged objects and subjects are disciplined in the process of scientific seeing and representing these subjects are organizationally disciplined, too” (409).

**STS and Natural Resource Management and Extraction**

STS accelerated due to increasing use of science and anti-science in political rhetoric and concerns about climate change (Woolgar et al. 2014, Dove & Kammen 2015). This movement became visible in many arenas, but particularly in debates about natural resource management and extraction. Recent ethnographies on the relationships between mineral extraction and energy corporations, activist groups, governments, and local communities trace these processes by turning their attention to the ways technoscience, environmentalism, and corporations produce unexpected polarities within and between groups, organize everyday social life, and legitimize truth claims about the environment.

Global and local environmentalisms can result in different truth claims about the same environment. Howe (2014) demonstrated global and local environmentalists’ ability to make valid and compelling truth claims about the environment through the construction of a nearshore wind farm in Oaxaca, Mexico. Local community members believed the energy company, the state, and western environmentalists privileged green energy over preserving local fish stocks. Meanwhile, the Mexican government viewed the wind farm as a national project contributing to its image as an environmentally progressive state in the global forum. These two perspectives result in divergent ontologies of nature and contradictory truth claims (385). Howe called “these distinct
divergences [that] indicate distinct ways of imagining and articulating” the environment, “anthropocentric ecoauthority” (383). Verifying whose claims are true or will become true is difficult. Howe stated, “the unique geographic conditions of the Mareña Park make its environmental impacts difficult to fully estimate” and while the proponents have submitted an environmental impact statement, the long-term effects have not been addressed. Howe claims that the Mareña Renouvables project “is a case that illustrates several tensions that condition every transition, from sovereignty claims to dreams of sustainability” (397). Howe’s portrayal of two, conflicting nature ontologies about the same place gives social scientists a tractable theoretical tool, “ecoauthority”, to label and track the disparate claims that interest groups make about the environment. Moreover, it demonstrates that local people can generate compelling claims about indigeneity and connection to environmental spaces that strongly challenge scientific and corporate claims about the environment.

Natural resource management and use polarized people with similar environmental interests and concerns. Davidov (2013) traced the complex and multiple “environmental and political subjectivities” that characterize the divergent networks of anti-mining and anti-oil NGOs and the Ecuadorian government. Anti-mining groups backgrounded their alliances with other mining groups because of ethnic differences and foregrounded their alliances with INGOS to appeal to international ecotourists and lawyers (495, 501-02). Intag Valley anti-mining groups did not make alliances with anti-oil groups because anti-oil is so strongly associated with indigenous peoples and more visible in global consciousness (499). These anti-oil NGOs aligned with Ecuadorian
President Rafael Correra’s “new nationalism” which advocated mining as an alternative to oil (488). The fundamental difference between oil and copper is their symbolic load, which counter-intuitively polarized groups. These differences generated new rhetoric, polities, and narratives:

The difference between mining and oil extraction is an ongoing semiotic process that is simultaneously a strategic party line in Ecuador’s governmentality repertoire. It constitutes a generative force of divergent environmental subjectivities around natural resources, and an ontological truth about the ways in which fields of activity around those resources have been organized for and by the involved actors (502).

Finally, I turn to an industry that is heavily borrowed from and invoked among corporate seabed mining geologists and technicians. The mining industry goes to great lengths to manage risk and ensure safety. In her appraisal of offshore oilrigs off of Equatorial Guinea, Appell (2012) described offshore mining as a process of creating expertise and fantasy. The fantasy is the notion that profit is: “untouched by the site of production. Here the rig must seem as far as possible from the deep complicity between the operating companies and the Equatoguinean state, as far as possible from communities who might make claims on companies for environmental degradation or gainful employment” (698). The fantasy depends on what Appell called, modularity, “the use of mobile compliant, and self-contained infrastructures, labor set ups, forms of expertise, and legal guidelines to enable offshore work in Equatorial Guinea to function ‘just like’ offshore work in Ghana, Brazil, or the North Sea” (693). Modularity, she posited, also depended on understanding offshore oil sites as “spaces where the production of profit can evade or minimize contestation” (693). She highlighted that the rigs are far from the politics of landowners, local governments, and environmental harm
Thus, “the entire commodity chain, from exploration to processing to export can take place in the middle of the ocean, without ever touching land, seems to at least partially remove oil and gas companies from the most visible and most controversial consequences of their industry” (698). Since there are fewer people who can directly witness offshore oil drilling, there is less of a “call for action or regulation…a noticeable attenuation of public and government attention, facilitating unimpeded production” (2012). Bodies, time, social organization, and financial assets both on and offshore were shaped by these strict, and from Appel’s perspective, dehumanizing practices. Appel concluded that corporations aspire to modularity, divorcing frictionless profit from sticky entanglements with people’s lives and the environment; however, as she demonstrated, these entanglements are only get stickier as they move further afield from public view (2012).

**Sustainable Mining**

When I wrote my proposal for this research and until I finished writing the first draft of the thesis, I considered risk and uncertainty to be central to my ethnography and research question. While my research and many other ethnographies on mining demonstrated the importance of those topics and their impact on scientific and corporate practices, I found my data pointing me in a different direction. As I processed my interviews and field notes, sustainability appeared over and over again across the interviews, and it became clear that the geoscientists and technicians on the ship were more interested in the future of commercial seabed mining and its implications for the
offshore mining industry, commodity markets, and Pacific communities. In order to understand the features and significance of my findings that geoscientists and technicians saw seabed mining as sustainable through a techno-scientifically mediated vision of geological processes, metaphor, and strategic comparisons, I outline a brief summary of the emergence of corporate social responsibility programs in mining companies and the strategies they previously used to affect sustainability.

Sustainability has played an integral role in connecting natural resource management and social and environmental impacts. Paradoxes between natural resource management and sustainability generate counterintuitive and even detrimental effects: tension between global and local streams of environmentalism, polarizing dynamics within and between environmental groups and corporations, and risk externalization onto vulnerable communities. In the same way that social scientists demystified the construction of scientific knowledge, they must also demystify the corporations and NGOs to investigate how individuals come to personify these black boxes and track the implications these personifications have on local and global political ecologies. As Golub (2014) claimed in *Leviathans at the Gold Mine: Creating Indigenous and Corporate Actors in Papua New Guinea*, it is only by personifying black boxes that actors can effectively negotiate legal and corporate frameworks, claim landownership, and maintain bureaucracy (72, 111, 159, 198). Golub traced the genealogy that would eventually lead to black boxes such as “the mine” and “the Ipili.” However, both black boxes functioned by maintaining semiotic ambiguity, which each mobilized to secure benefits from the mine in the case of “the Ipili” and absolve the company of
responsibility in the case of “the Mine” (7). The ambiguity was productive for certain
landowners because “the Mine” did not understand the dynamic kith and kinship
networks in the Porgera Valley. The mine set about to identify Big Men and landowners,
but because of the ethnic and complicated kinship networks at play, personating “the
Ipili” was up in the air. Thus, men in the community could and did make a play at being
representative gatekeepers that spoke for “the Ipili.” (115).

Welker (2014) stated that the dynamic relationship between mining corporations
and local communities shapes the ways companies enact corporate social responsibility
through “descriptive and prescriptive dimensions and offering accounts of what is and
what ought to be” (4). Corporate social responsibility (CSR) is a nebulous and
heterogeneous term to describe a movement and an industry concerned with “developing
voluntary, regulatory principles and practices that tend to serve as surrogates for state
regulations” and "justify[ing] CSR interventions as being in the interest of the corporate
bottom line” (13). These practices play out in everyday decisions made by
“organizational actors” and come in the guise of “modernity” and self-sufficiency for
local communities (28, 16). In Welker’s ethnography, male village elites enrolled
unemployed male youths into their efforts to forestall mine operations while middle
managers enrolled them into their networks in support of the mining project. Middle
managers and by extension, the company, used community outreach and conservation
projects to enact responsibility and citizenship. Thus, CSR enables mining corporations
to personify themselves as moral, even as they cause severe environmental and social
harm. Through these mobilizing networks and practices, Welker concluded that the
“environmentally friendly mine” and CSR is continually enacted by corporate actors in tandem with downstream environmental and social impacts and mobilizing networks of governmental, citizen, and NGO actors (32).

However, as Kirsch noted, sustainability has not always been a concern for companies, and is, in fact, a relatively recent accommodation. Growing global public consciousness of and commitments for mitigating climate change and recognizing indigenous people’s rights to self-determination and sovereignty coalesced into influential NGO and INGOs dedicated to advocating for state and corporate recognition of these concerns (Kirsch 2013). These groups criticized mining companies’ dangerous practices and exposed the social and environmental damage they caused so effectively that shareholder value and public confidence in the extraction industry dropped. In response, mining companies combatted these claims by establishing CSR programs and highlighting their due diligence in social and environmental impact statements. These programs and texts became standard practice, emphasizing sustainable mining practices, enhanced education, infrastructure, and medical care, environmental catastrophe contingency plans, and economic development (2013).

Kirsch described the degrees by which mining companies accommodated their detractors’ critiques as three phases. First, mining companies “avoid engagement with externalities that have the potential to erode profitability and raise questions about legitimacy that may threaten the corporation or industry’s ability to continue operating” (2013). In the second phase, mining companies acknowledge an issue, but remedy the problem with largely “symbolic gestures of accommodation, such as the payment of
compensation or small-scale improvements” (2013). Finally, mining companies move into the third phase when they assess that “the problems facing the corporations or industry will become financially and socially too great to manage. In response, they create a new status quo of operation by “shaping...politics that lead to the regulation and management of industry-related problems” (2013). Sustainability is salient in all three phases of response to critique as a co-opted term to describe natural resource development as a project and the keystone of “sustainable mining”, what Benson and Kirsch (2013) called a corporate oxymoron where “harmful practice or commodity is camouflaged by a positive cover term...intended to reassure the public that the mining industry shares its environmental values” (Benson & Kirsch 2013).

**Seabed Mining Scholarship**

As Ballard and Banks (2003) noted, mining projects have increased in technological sophistication, novel resources, and dynamic relationships with critics and indigenous communities. In order to take these complexities seriously and do them justice, the authors stated that economic and sociological trends must be studied ethnographically. However, “an adequate ethnography of contemporary resource industries such as large-scale mining will require work at multiple sites and over a sustained period, and the ethics of engagement will vary considerably from one mine site to another, over time at the same site, and from one perspective to the next within a project” (306). Ethnographies of globalization and globalized institutions have proliferated since Ballard and Banks’s survey of the anthropology of mining and the mining industry. While this scholarship has offered innovative methods and provided
more theory to interpret meaning, trace conditions, and expose effects, the relationships and consequences of mining have continued to puzzle researchers. Seabed mining is a nascent industry, and as such, ethnographic study can evaluate it as it attempts to become modular. Research on corporate geoscientific practice during the exploratory phase of seabed mining is a place to begin the multi-sited, multi-community study Ballard and Banks and other social scientists have since advocated.

When I first began to study seabed mining in 2013, there was little anthropological work on seabed mining. The most pertinent materials related to international policy summaries and analyses of “the common heritage of mankind” clause in the United Nations Convention on the Law of the Sea (Noyes 2011, Guntrip 2003), geotechnical engineering manuals, ethnographies of ship life and ships as technoscientific networks (Hawkins 2015, Symes 2012) and economic predictions (Barkenbus 1979, Martino & Parson 2013). However, seabed mining has rapidly grown in global consciousness over the last three years alone. Weekly, I receive articles and blog posts from friends all over the world about seabed mining companies’ deals and plans, new international policy, scientists’ endorsements and warnings about benthic biology, and protests across Pacific communities. Scholars have dedicated papers on the ways that traditional ecological knowledge can inform policies concerning the management of the foreshore and the seabed (D’Arcy 2013) and the dialectical relationship between seabed mining and commodity markets (Martino & Parson 2013). My own previous research considers texts on seabed mining across many genres to consider the slippage between their various representations of seabed mining (Harris 2014). While writing this thesis at
the University of Hawai‘i at Mānoa, I have attended six presentations by visiting and guest lecturers about legal, technical, environmental, and social aspects of seabed mining in both international and national waters and courses in the Pacific Islands Studies, Geology, and Law departments have dedicated significant time to teaching on the subject.

Despite interest in this topic of research, more scholarship must be done to survey the emergent structural features and relationships within seabed mining. Academic scientists have called for a moratorium in light of the precautionary principle, stating that more research must be done to understand the natural systems within which this industry operates. Furthermore, environmental and indigenous rights groups have demanded more robust policy to effectively and justly compensate communities and protect marine species and their habitats. Scholars can only advise the International Seabed Authority to halt seabed mining in the Area and within states’ EEZs, but they cannot directly impede mining. Time is of the essence, and research on seabed mining, its features, representations, and consequences, must begin both while it emerges and before environmental or social catastrophe occurs.
CHAPTER THREE

William noted that part of the fun and the responsibility of an exploratory geoscientist is being the first person the community interacts with and the “first person on the scene.”

He stated:

“One of the things [about] being an explorer is that you are the first person to meet those people. So you go into the jungles in New Guinea, I’m [one of] the first people. You go and talk to the people up in the mountain and explain to them all what’s going on. You’re at the front! The exploration geologist is the first person on the farmer’s property or the town, and everyone is asking, and you’ve got to get the story across, not being patronizing, but not too detailed and try to make it [so]...they can understand it... I really enjoy getting that story across because people can then understand what we are doing and feel.”

The geologists on the ship were keenly aware of their position as spokespersons for seabed mining and the company. Hence, the instrumental and discursive technologies they employed to communicate among themselves and with other people on the ship did not stay there. The scientists knew that they would talk about the trip and their findings to community members and corporate persons afterwards.

In this chapter, I claim that the corporate geoscientists on the ship mobilized different technologies to render the ocean as invisible and unproblematic and the seabed as empty of irreplaceable life. However, scientists were not always able to enroll technology, the ocean, and the seabed into their networks. Thus, making these claims about the seabed and ocean required the scientists to accommodate these actants by turning their equipment, metaphors, and comparisons. The discursive and physical tools the scientists used were mutually constitutive. The relevance and productivity of the metaphors and comparisons depended on empirical qualities of the seabed and the ocean that was only visible through technologically mediated sight. Conversely, graphic
representations were interpreted through metaphors and comparisons that highlighted singular qualities of the seabed and ocean.

Despite the risks and the challenges of access, scientific visualization was essential to prove that what was on the seabed was economically viable. Without this visualization, questions about whether or not a deposit was there, whether a deposit was mineable, how long could it be mined, and which minerals were present became unanswerable. Moreover, corporate decisions about the feasibility of a project became insupportably tenuous. Scientists used comparison, metaphor, and instrumentation to make traces of the seabed and ocean visible to substantiate Nautilus’ claims about the commercial viability of seabed mining. As one technician noted:

“We are not actually seeing the seabed, are we? We’re getting hints of indications of it in there, indicators. That’s it. Change in water conductivity, oxygen reduction, and turbidity: that’s what we’re seeing. We’re not really seeing what’s there. We’re seeing those things that indicate that there’s something there.”

Thus, on this trip, the seabed was not actually seen, but was virtually assembled by relating physical traces of the seabed: plumes, water conductivity, and acoustic maps, by which comparisons and metaphors imagined the ocean as negligible and invisible and the seabed as a vast and empty field. These diverse images struggled to achieve a gestalt quality and there was always variance between the model and the actual seabed. As I will show, some things that were seen may not have been there, as in the case of map making and swathing, and yet others were there, but went unseen. As I claim in this chapter, visualization is mediated through remote sensing equipment and metaphor, and gives the exploratory and technical teams on vessel the ability to experience a remote
environment, interpret complex and fragmentary information, offer evidence of truth claims about the seabed, and make decisions about later extraction practices.

The Ship: The MV Duke

The most obvious and most indispensable piece of equipment that the technical and exploratory teams depended on was the ship that they lived and worked on. The Polar Duke, renamed and outfitted as the MV Duke, made travelling to potential sites, collecting samples, and mapmaking possible. The importance of the ship is best illustrated through a comparison with terrestrial exploration. In land-based mining, a small team, even a pair of scientists or technicians, could drive out to a tenement and systematically collect samples across the area in a grid pattern. However, as one scientist pointed out, the ocean and the nature of the indicators of a likely deposit are more nebulous and less accessible in the ocean than those on land.

“In Papua New Guinea] Terrestrial mining is so much easier...You would just have to pick up a rock and find something...it’s only a one- or two-man show. We would begin by driving to the mouths of the rivers and test the water and soil around there for gold. If we found gold, then we followed that river upstream to the confluence of that river and another, where we would test again. We would just keep doing that until we found the location of the gold deposit. It was all on land. But here, to pick up one thing, you need twenty guys. You need a boat to do this sort of work, and if the boat doesn’t deliver, then you’re kind of stranded in a sense. So you have to hunt around, you have to look through so much water.”

As the scientist observed, the boat allows for two kinds of analogies: In the first, the distance and the materiality of the ocean separates the exploratory geologist from both the terrain and the deposits in different ways than terrestrial mining. The geologist
talked first about the process of exploring tenements for gold deposits in Papua New Guinea, where samples were more readily accessible. It was easier to shuttle manpower, equipment, and samples back and forth from one place to another on land. Moreover, the diagnostics can be much more localized, since the source of the gold effluent in the river water can be deduced following the rivers upstream.

The scientist’s comparison between terrestrial and seabed mining also highlighted a second crucial difference: the billions of gallons of saltwater that separates the exploratory geologists from the seabed do not need to be displaced, whereas rock overburden, the material with no commercial value covering the ore deposit, and host material must be removed to mine terrestrially. For example, in strip mines such as the largest strip mine in the world, Escondida, overburden must be systematically removed and relocated before companies can exploit deposits. Sam noted that this process could take years before the company reaches the viable ore. In same way that field geologists could stand atop stratified layers of commercially useless dirt and search for alluvial gold, the exploratory team stood on a boat, atop billions of gallons of saltwater. The saltwater cannot be removed and relocated. Instead, seabed mining projects will always have to work through the ocean and contend with extreme cold, multiple atmospheres of pressure, salt water, shifting currents, and meteorological events. Hence, ships, remote sensing, and remote control will always be a necessary feature of extraction, since the ocean cannot be removed to expose the seabed. However, despite these technological and physical differences between seabed mining and terrestrial mining, William explained that industry application of structure tectonics, a branch of geology concerned
with the behavior and features of the earth’s crust over time and useful in the industry, does not take into account the ocean as a factor:

    W: I only looked at tectonics and geology…
    L: As if there wasn’t any water.
    W: Yeah it doesn’t matter…[It’s] the planet…it [the water] doesn’t matter. The water’s irrelevant.

Whereas Sam’s discourse presents a different set of challenges for geoscientists, William backgrounded the ocean to the point that it disappeared as a difficult or even important feature of seabed mining, and did not take into account oceanic traces such as water turbidity. What he did highlight was the geological processes that formed plate boundaries and impact plate movement, phenomena that happened with and without the ocean covering the deposit. These two visions of the seabed do not necessarily conflict, even if they are different. Both suggest that the ocean is a technical problem that can be solved through manpower and engineering. In the first case, seabed mining may require more powerful remote sensing equipment and manpower to make the seabed visible for even the exploratory phase of seabed mining. In the second case, field and discipline boundaries isolate the ocean as a separate phenomenon and remove it from its vision of the seabed. The seabed is defined by its structural tectonics, and not by its location under the ocean.

    The ocean also disappeared in the translations that the geoscientists used to explain seabed mining to local communities. Both Sam and Jordan, another scientist on the ship, identified translating technical knowledge of seabed mining into a coherent narrative that communities and people outside of the mining industry would understand as one of the most important parts of the scientists’ work. Jordan compared the seabed to
a garden and the resources as vegetables. Seabed mining was going to the garden to pick a carrot or a potato. “You don’t go in and destroy the entire garden in order to harvest the carrot,” Jordan explained. “You just lift it directly out of the soil, you go directly to it.” In this comparison it is not clear what the soil or the garden fully represents. Does the garden include the ocean? If so, what in the garden represents the target domain of ocean? Could the soil in the garden metaphor include the ocean or only the seabed out of which the resource is removed? Regardless, the soil over the carrot or the potato is not displaced. Pulling the potato or carrot out of the soil would only momentarily and trivially disturb it.

This metaphor makes two important claims: First, it compares the time frames involved in harvesting the vegetables and extracting sulfides (or nodules). Jordan and Ryan, also a member of the exploratory team, explained that relative to terrestrial mining projects which could take years before investors see a return on their investment, seabed mining’s temporality is much shorter. In this comparison, seabed mining is like pulling out root vegetables because the dormant hydrothermal chimneys that Nautilus is interested in mining form much faster than the mineral deposits on land form and then are pushed up enough in the earth’s crust to be mined. Secondly, Jordan’s representation of seabed mining as going to a garden to pull out a carrot highlights the minimal time the mine site will be open. Terrestrial mines can have decades-long lifespans. However, seabed mining sites for seafloor massive sulfides will be open for up to three years, because the deposits are smaller, but higher grade. After the company has extracted the sulfides from the site, the ship and the other autonomous mining equipment will be
moved to the next site. Similarly, Jordan’s metaphor emphasized the minimal time and effort it takes to go into a garden and pull out a carrot.

The geoscientists also represented how non-invasive seabed mining would be as a function of the minimal time and effort it would take to mine seafloor massive sulfides. Jordan used laser surgery to illustrate seabed mining to communities within the impact zone that Nautilus delineated. “In laser surgery, you know exactly where the bad is, and you take the bad out, while leaving everything else behind.” I pointed out that the opposite might be true: the ship would travel to the deposit, deploy the bulkhead cutter, and then remove “the good”, leaving “the bad” behind, whereas laser surgery would remove “the bad” and leave “the good.” Jordan responded that this metaphor would describe the technology best. Like laser surgery, the technology makes it so that Nautilus could extract minerals without harming the surrounding area. As an afterthought, she added that terrestrial mining is much more invasive. “You have to destroy so much in order to get to the mineral, but with seabed mining, you only take out the resource because you know exactly where it is.”

Jordan’s metaphor obfuscated the ocean. In this case, mining technology was so advanced that it could do finer or more precise mining, eliminating the ocean as a concern. The precision Jordan described is an important feature of seabed mining, because it underscores the negligible environmental disturbance flowing from this kind of mining. In comparison, local communities in Papua New Guinea and throughout the Pacific are familiar with terrestrial mines that removed entire mountains. As in the first metaphor Jordan proposed, the distinction Jordan made between the seabed and ocean in
the metaphor was unclear. Were the layers of flesh that the laser and the surgeon would work through be the ocean and the tissue that the (benign) tumor was affixed to be the seabed? Regardless, the sulfides can be extracted from the seabed with as much precision and with as little disruption as laser procedures on a human body. Thus, the ocean again disappears in the geoscientists’ representations of seabed mining.

Thus, seabed mining appears to be a technologically and environmentally unproblematic resource extraction regime. Unlike other mining projects, the scientists represented seabed mining as environmentally non-invasive, since the mining sites were small, but high grade and the new technology made seabed mining faster and more precise. Moreover, it is important to notice that in all representations, except for Sam’s representation of the ocean as a ponderous medium, the ocean disappears, exposing the seabed as a resource-laden area. Jordan’s metaphors reveal a fruiting garden ripe for picking, and a body made healthy and functional after some extracellular growth is removed.

Despite the technologies deployed to visualize commercial seabed mining as technologically and economically frictionless, the equipment’s limitations constantly jeopardized the metaphors and comparisons. The MV Duke was laden with high-powered sonic equipment, mostly meant for offshore oil and gas surveying. However, less detailed seismic equipment was all that was necessary on this project.

The ship posed important challenges that constrained visualization. First, the ship did not have dynamic positioning, a system that allowed the ship to move along a curve or even diagonally. A ship with dynamic positioning could easily reverse,
circumnavigate, or follow an arc without cross-towing. Sam articulated the frustration the scientists had with the boat:

“You come up with something and you have people like Drew who say, “Alright, since you guys are happy, I’ll plot that line, right? Since you said 60 kilometers, let’s just do 60 kilometers.” It was frustrating because you have geological features that you want to tow, but the boat can’t handle the curve. So you have to just go straight there and later, straight down this way. You’re missing something and you know, working on a vessel is time, is money…if you’re cross towing, it would have to be for a really good reason.”

The scientists accommodated the ship's limited positioning systems by plotting straight lines across or along a given feature or towing tangentially to an arc formation. They also covered more area by towing the sled up and down in the water column, increasing the likelihood that the equipment would detect a hydrothermal vent plume.

Secondly, other ships Nautilus had contracted with in the past had gated platforms on a side and the bow of the ship. This increased the number of angles the sled could be deployed in relative to currents, crosscurrents, and the ship’s heading. However, the MV Duke had only one gated platform and appropriate winch system to maneuver the sled.

The restricted degrees of freedom made visualizing the seabed and traces of hydrothermal activity more difficult. This challenge was heightened by the aggressive weather systems that battered the MV Duke during the trip, inhibiting the technicians’ ability to deploy and recover the sled in the rough seas. The cyclones and storms challenged the scientists’ representations of an invisible and negligible ocean. Although, the comparisons and metaphors some of the scientists shared were intended for local community members who had likely never been on an offshore mining vessel in rough seas and the scientists were quick to point out that this weather and trip were atypical.
William and Drew had gone to bed hours ago, and Adam, Katie, Isaac, and I were up late in the lab. Feeling bored, I tipped back in my chair and spun around. Isaac clicked away at the surveyor station, patiently trimming down some of the multibeam data that had come in earlier in the evening. I walked over and squatted next to his elbow, watching him meticulously sift through profile after profile of data. Finally, he turned and raised an eyebrow at me. “Would you…like to try swathing?”

Swathing is one the main objectives of the surveyors. As the ship slows down to 1-2 knots, the surveyors manually lower a giant antenna on the bottom of the ship into the water. The antenna emits a regular series of electrical pulses, which hit the seabed and bounce back to a receiver. The time between emission and reception, the strength, and angle of the data were received and plotted on a graph as a colorful scatter of points. Not all points were relevant or accurate, however: some bursts were altered by the density and content of the seabed, so the signal came back weaker or stronger. Some bursts scattered, like a pebble skipped across water, leaving multiple points. Some pulses didn’t come back at all. To process a clear image of the seabed’s topography, one surveyor on every shift was responsible for “cleaning up” “holey” or “noisy” data. After every line, the surveyor would edit the data, removing the outliers and producing a cleaner version and submitting it to one of the scientists. The product was a more detailed and updated topographical map of the seabed.

He settled me into his chair and pulled up another profile: a scattered plot of bright green dots that make an undulating ribbon across the screen. “You just take off the
bits that don’t make sense,” he said gently. With the mouse, he traced a loop around a handful of data points that seemed to fall outside of the general curve of the profile, and clicked. The points disappeared, leaving a refined arch. “Just remove the outliers.”

I tried while he watched; it was more like swatting at a few points that were radically outside of the curve. “A little bit more, like here and here.” He encouraged, pointing.

I made loops increasingly close to the curve and slowly, so I wouldn’t nick the data. “Gah! No!”

“It’s okay,” He laughed, seeing my hesitation. “Look,” he showed me the undo button, and how to manipulate the data, to see it from different angles, at different scales, three-dimensionally, and in relation to other overlapping profiles.

It took ten minutes for me to do one profile. Isaac and Katie leaned on the island in the center of the lab, watching my progress. I scowled at the monitor, wracked with a growing anxiety that I was removing something that was actually there and worried that I was leaving something that was not.

“You can’t go that slow,” Isaac said. “The data from the next line will come through soon.” I grunted a response, and tried to pick up my pace, but I was so focused on creating the perfect curve…

“Not that,” Isaac said calmly and he undid my last move. The points sprang back. “Watch this, see?” He clicked ahead and the profile shifted. “You are seeing a sagittal view of the seabed. That little bit you took out there, that was the beginning of another incline. Or watch,” Isaac returned my recent erasure and then skipped backwards
and forwards between profiles. “If we kept what you did, you would have created a hole in the data.”

“But I don’t know what actually is or isn’t there. What if I am cutting off some hill or something or what if I am leaving in a bit that isn’t there in reality?” I complained.

“You just get a feel for it after a while,” Katie offered from behind me.

I sighed heavily and continued my painstaking swathing effort until the ship reached the end of the multibeam line. Isaac needed to catch up on the time that I had lost, so I gave up my seat again. I stayed watching him rapidly make decisions and erase extraneous data.

Scientists had access to a myriad of remote sensing equipment that located, prioritized, and navigated obfuscated geological formations. Where visual light failed to penetrate layers of ocean and expose the seabed, the exploratory and technical team used sound frequencies to piece together topographical maps. Although the ship was endowed with a range of seismic equipment that could penetrate deep into the earth’s mantle, this phase of seabed sulfide extraction only required images of the lay of the seafloor and a few meters below its surface. The surveyors alternated between two kinds of seismic equipment, multibeam and single beam echosounders. In both cases, the systems would transmit high frequency beams to bounce off the seafloor. Computers on the ship calculated the distance from the ship to a particular point on the seabed based on the receive angle, travel time, the position and movement of the ship, and the speed of sound through saltwater. The surveyors put together not only a high-resolution image of the
seabed’s topography but also the content and lay of its shallowest layers. The main difference between these two types of sonar was the shape of the acoustic pulses. A multibeam survey indicates a fan of beams to create a broad, high-resolution profile. On the other hand, single beam surveys indicate a single beam, the product being a deeper image of a smaller area of the seabed.

My anecdotal story highlights many important features of swathing, the process of trimming down the noisy data into the neat profiles that software would knit together into a topographical map that scientists would use to select and plot the next Tow-Yo lines. Mariah, a technician, described the data collection and editing and calculating variables and using the product to make sense of the data.

“You take the things that you can measure and apply them to the data. You know, there’s certain variables such as the position of the ship in the water relative to the tenements. You know a ship, if you imagine the sea surface, isn’t going to change significantly...You’re heavier so a whole mounted equipment moves in relation to the sea surface, so that’s one thing you can measure. The speed of sound through water, which obviously we’re talking acoustic systems here, you know, that’s going to affect the data. That’s going be something you can measure and GPS satellite signal. That’s something that we continuously input into the system so we can track how we get there.”

Adam expanded on this in one of my interviews with him where he explained the importance of the surveyors’ work, saying:

“I mean, the way it works usually is that our client companies, if they want to get the raw data and process themselves, they can...we’re looking for the best initial quality we can get so that clients have the ability to make those decisions...come to certain conclusions more quickly than others.”

The raw data collected by the surveyors was never clean. Sometimes, if the Duke was towing over a strip of seabed that was harder, the return time on the pulse was shorter and stronger. On one hand, this created a clear profile, but on the other hand, the strong
reverberation could make the sound bounce multiple times as a spray of “noise”. When the surveyors showed me the raw data mapped, it looked like a rainbow, saw-toothed landscape with high, jagged peaks. The surveyors spent hours clicking through screen after screen of undulating seabed profiles in neon colors, manipulating mostly sagittal cuts of the seabed in space and slowly piecing them together. After swathing, the maps showed smoothed peaks, plateaus, ranges, and even dome volcanoes.

Secondly, the theory behind swathing is complex, but I was reassured by many of the surveyors that I could learn to manipulate the software quickly. However, fast and accurate swathing required years of experience of interpreting the seafloor. The ability to manipulate the software and visualize a two-dimensional model in three dimensions came with time. When pressed about how they knew what data to take out as outliers and what to leave when cleaning up the data, surveyors on both stints stated that they “just had a sense” or “just got the feel” of the seabed after a while. On both legs of the trip, the surveyors identified Isaac as a genius and the standard of expertise, because he had extensive experience with the surveying equipment and different benthic topographies.

During the trip, I asked some of the technicians about how they knew what data points to take out and what ones should be left. Isaac shrugged, and said in his quiet, laconic voice. “You just know.” Philip scratched his head looking at the array of monitors before him, saying that “you just get the hang of it after a while”. Rachel shook her head, “You just get a sense of it.” I did not find this comforting while I was swathing, and began anxiously calling over my shoulder for Isaac’s input. Patiently, he altered the software to put more of the seabed profiles together, so that I saw a longer
stretch of seabed, side-on. I created holes in the data by taking away clusters of data points and created sharpened peaks where I had left outliers in. He patiently corrected my swathing, by taking out small clusters, and adding back others that I had cut away.

Having an intuitive sense of the seabed and producing high-resolution acoustic maps of the seabed does not meet stereotyped notions of objectivity. According to the technicians, scientists’ roles were defined by interpretation and this developed intuition. Alternately, the technicians viewed their work was a mix of the intuitive, experiential sense of the seabed and computation. Mariah both distinguished between science and technical work and the exploratory, marine, and technical teams roles by how each group interacted with the scientific equipment and a difference between process and interpretation.

M: I mean on a survey, you have us, to make sure we are in the right place and you know that’s certainly not a scientific job. The engineers they’re pretty much…the same, you know they have their fair share of computer stuff but they have to handle the deployment, the recovery, and then on especially the seismic jobs they have like the guns and the remote processing data there’s far more…they are scientists you know…They will study and process data and um…so they’re interpretive laughs
L: do you think that you do any interpretation in your work?
M: no. We’re doing the processing we don’t interpret
L: interpreting is what makes the scientist?
M: I would say so, yeah, because you’re studying the data and drawing conclusions from it…We just, its simply processing things very roughly. Um, so we acquire it we accumulate it, we process it, and we hand it over to them and then they do what they do with it that’s um, the black art.

On the first stint, Philip explained that there was software that could do initial data processing, but that human processing tended to be more accurate, albeit slower. The software relied on probabilistic algorithms that measured the incoming data against best-fit models. However, people were better at picking up anomalous geological formations

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where the algorithms reasoned that there should be none. He also noted that the
subjectivity of this process was useful and sensitive, despite the slowness and concerns
about human error.

Ryan pointed out the usefulness of subjective science when he indicated that
unlike in a shipboard fire, where smoke was an “absolute indicator”, the surveyors were
interpreting the seabed by analyzing the data, but making decisions about what was or
was not there based on subjective experience. Since verifying the accuracy of the maps
with cross tows was not often feasible, there was little chance of being able to validate
their findings until Nautilus towed over the area again. Ryan explained:

“But when it comes to what Rachel and what Michael and what Philip are doing,
there’s not an absolute indicator. I also sort of disagree with what they’re doing
because they’re creating an image of what they perceive to be there, Or they want
to find, or they expect to find or what they’ve been told, "You’ll find this,” so
they message the information to create. What I’d like to see, and I’ll ask them, I
said, “You know when you start modeling this in three dimensions…?” [They
say] “We can do it, but otherwise, you know, I prefer just…” This is Rachel’s
response: when I said, “when you start modeling this bathymetry into three
dimensions so when we see it…?” [She says] “Oh you know, could do it, but I
prefer looking at it this way, it makes more sense to me.” She prefers it two-
dimensional. I like seeing it three dimensional, and I said to you why. Because
there are, when there are all these little outliers, these random spikes, this
information that they go, ah that shouldn’t be there. That could be a chimney
field. You know if you had all these little spikes, that could be a chimney field
and we’re discounting it, because somebody goes, ‘I don’t feel right about that.’”

The geoscientists on the ship were also aware of the issues raised by subjectivity. For
William, the chance that the exploratory team could pass over a deposit was the nature of
exploratory mining and added to the excitement and adventure of the job.

“You can explore a hundred prospects and not one of them will turn into a
mine. The risk is massive. One of the greatest economists of all time that wrote
the book on it said, the worst business to ever get into is mining. One of the
biggest zinc deposits in Australia, for example, was passed over 5 times before it
was discovered…that’s what makes it adventurous because the people that are
into it love the high risk. They know it and they get a bit of gold dust in their eyes and go, “Oh, I can get a deposit,” because, if you can strike it, you could make billions. It is like dice. You can be really smart and I know guys who can go and just find a deposit.”

Drew concurred and explained that missing deposits was part of the nature of exploration.

D: Yeah and sometimes when we that’s happened in the past when we’ve done really detailed stuff more like high resolution mapping than we’re doing here and the guys have processed out stuff that…that they didn’t want to because a lot of them had been working in uh…um…say the oil industry and they’re not looking at rocks so they’re going all over the place they’re looking at flat seabed, so they map it as smooth as they can. In our case, we don’t want that and so that’s, so that’s part of what I do and that’s make sure…
L: And you check on all their data
D: Yeah
L: It’s also a little about what I want to find, like what I expect...
D: Expect, yeah
L: Is that just part of the nature of it also
D: Yes
L: You’re going to miss something?
D: Oh yeah, oh! Oh yeah sure! There’s always that
L: Does that ever frustrate you?
D: It’s part of the job! It frustrates you more if someone comes along five years later on the same ground and then they find that. That happens all the time in exploration. There’s ground that I’ve worked on in in the past, during the 1990s…and there’s people back there now. Because technology gets better and methods get better. [They are] getting better results than we got in the, you know in the same ground…that’s exploration.

In this exchange, Drew provided one example of the how uncertainty arose in exploration in general and mapmaking more specifically, and as such has resulted in outstanding consequences, and affected how scientists and technicians have managed their attitudes and conducted their science as a result. Drew noted that surveyors’ subjectivity can remove data points from the map, thus removing features from the landscape, as well as maintain data points that add features to the landscape. Their previous experiences, in this case, could impact the kind of data that they are producing, namely, surveys in the Mediterranean or the North Sea, where the geology and topography are much different,
and certainly much flatter. The subjective nature of modeling the seabed and the relative poverty and then later development of remote sensing equipment nullify any frustration about missing a deposit. Success is the product of technical skill, expertise, and educated risks, while failure is accounted as a lack of instrument sensitivity and human error. In either case, the scientists’ success or failure to produce accurate images of the seabed and materialize proof of that instantiation is equivocated as the nature of exploration.

The geoscientists used old maps created by l’Institut Francais de Recherche au Fond du Mer (IFREMER) from the early 2000s to identify and grade targets. These maps were low-resolution and the graphics cards in the CPUs could not handle much more detail at the time. Since then, remote sensing technology advanced and surveyors’ methods became more refined. Sam explained the difference between the early and later maps of the seabed:

“We were dealing with some old data before and so we are already have...A priorities followed by Bs and Cs so we can plan that all in, but when you come to do your Tow-Yo and your multibeam at the same time, you tend to find out that this area tends to be very interesting, because the old data we have never saw the volcanoes. And then, all of sudden, it's like Tow-Yo 008, and they have to save the sled! It was not a high ranking area when we started, but then you found something!”

The scientists on the MV Duke based their conclusions about what was actually on the seabed and which geological formations would be economical to study closer on their scientifically mediated vision. However, since the equipment was constrained by its hardware, the maps lacked fine details, and could even miss geological formations of interest, even larger hydrothermal systems. The maps did lead the scientists to hydrothermal vent systems. However, the maps’ representations both accommodated and
resisted the scientists’ experience of the seabed. In fact, the technology made other qualities of the seabed and its traces visible, such as the mineral composition of the seabed.

Furthermore, Sam’s exclamation, “We never saw the volcanoes” foregrounds the fallibility of technologically mediated sight. Things that were physically present were not virtually represented, and within this slippage, scientists did not act otherwise. The stakes in this case are high: scientists could miss a sizable deposit. Conversely, imagining that a chimney field was there when it was not is also costly. Operating the ship cost around $33,600 USD per day and transmitting to a line, towing a line, and cross towing if necessary could take days (Nautilus Minerals Inc., 2015, 13). Time was so often of the essence, that the scientists constantly reminded the ship officers that only a one-kilometer approach to a line was necessary, because their standard two-kilometer approach added on too much time. If the ship spent time, energy, and money towing a line over a geological feature that did not actually exist or even was even not exactly where the geoscientists thought, then the company was effectively wasting its time. It is no wonder then that the surveyors noted that reduced discrepancies in their initial data processing was the hallmark of high quality data.

These maps made the seabed visually available to scientists, even if they could not travel down to the seabed and walk the geological features themselves. Through these images, the scientists were able to experience the seabed whereas before, it was largely invisible because of how economically and technically difficult it was to put a human on the seabed. These representations of the seabed and ocean conditioned the
scientists’ interpretation of earlier maps of what was there, the technicians’ experience of what the seabed looked like in other places, what they expected to find, and careful editing. The maps were the scientists’ vision of the seabed, a vision that was constantly being refined not just by technology, but also intuitions of their own.

The Sled Equipment:

Mapmaking was integral to plotting and navigating towlines, but the primary objective was plume hunting. There are multiple ways to sense a plume and the sled was equipped with remote sensing equipment designed to pick up subtle traces of them in the water column. The most important when as the CTD, a package of instruments that monitors water Conductivity, Temperature, and Depth of the seawater, hence, CTD. The CTD was a long, cylindrical, almost a foot in diameter mounted onto the back of the sled. Smaller versions of the CTD called Mini Autonomous Plume Sensors, MAPRS, were attached at 50, 100, and 200 meters of cable out from the sled. This way, if the sled went through a plume, more information about the dimensions of the plume could be calculated. The CTD is attached to the ship via conducting cable and real-time data on these properties are relayed directly to the engineers’ station in the lab. These properties were plotted on a scrolling screen in green, orange, blue, and pink. If the temperature suddenly rose and corresponded with a spike in water conductivity and particulate matter passing before a light-sensing diode, then it was highly likely that the sled was passing through a hydrothermal vent plume. However, the indicators were not infallible: if the sled flew too close to the seabed and kicked up some pelagic sediment, this could trigger a false positive spike in the CTD data. When the colored lines on the screen suddenly
spiked, the geoscientists would quickly “fire” the water bottles loaded onto a carousel on the sled. This meant the CTD would trigger the cocked bottles, closing any number of the twelve, two-gallon, heavy-duty plastic bottles arranged in a rosette on the carousel to collect a water sample. In the case of a confirmed plume, the ship could make a wide loop and cross tow again to gain more information on the dimensions of the plume. Based on the size of the plume and the acceleration of the current, the geoscientists could infer the size of the active hydrothermal system that produced it. Hence, finding a plume on the cruise was a noteworthy event. William expressed his excitement during an interview after finding a plume earlier on during his shift:

W: Well we did find a plume today. I am going to send a report to them [the Brisbane Nautilus headquarters], I’m just finishing it. What was exciting for me was Drew plotted it up and it’s a three dimensional movie! Have you seen it?
L: No! I need to see the movie!
W: Yeah! Drew didn’t know that he could make a movie! I said, “Oh, Anthony [another scientist not on the ship] used to make movies out of it [the data]. And he said, “Aww really?” So he went in, and he figured it out, and he got a fly through movie so I showed Christian, and I showed Aaron, and I showed everybody on [shift]. It was really great to give them a concept of what we have been doing because people have just been doing their jobs and people who have been on many ships sometimes don’t understand. I got excited today to be able to show them some stuff so I can show them a two and three-dimensional movie to look at! That’ll give poor Christian a boost. We found a plume! That is definitely a KPI.

In this exchange, the seabed is made visible in many layers, between each one; the seabed is abstracted and translated into a complex of signs. Since the sled passed through the plume, the MAPRS and the CTD picked up on a change in turbidity, water conductivity, and temperature. The extent that these changes occur in the water column indicates the dimensions of the plume. By triangulating the ranges of these measurements, the
Fledermaus, software that graphically represented the sled and its location relative to the seafloor in real time, was able to create a best-fit model of the plume’s shape, size, and position. As these indicators dissipate and change over time depending on the ambient temperature of the water, the sea state, and the composition of the particulate matter, Drew was able to show that first, there was a plume, and second, that the scientists could trace its movement back to the hydrothermal system that made it. Making a movie, animating it, amasses the indicators, orders them, and then charts their change and movements as a collective, thus creating a plume, the form of an effluent fluid running through another.

This first translation from disparate data points into a three-dimensional movie of a plume was the first time on the cruise where the indicators were not just sensed, plotted on a graph, and sampled, but modeled, made visible on the ship. Logically, a confirmed plume is an absolute indicator of an active hydrothermal system. From this conclusion, the scientists are able to reasonably deduce that the active hydrothermal system has left a trail of inactive, mineable chimney fields in its wake. Thus, Drew’s three-dimensional movie represented the movement of a hydrothermal vent plume. By tracing its movement through the water column, the scientists could infer the location of the active chimney field and follow the chain of chimneys to previously active fields.

William was quick to translate this image into leverage both on and off the ship. He followed his exclamation about the movie with a list of people that he showed it to, namely the surveyors and the engineers. In both this interview and interviews with the technical team, the surveyors and engineers are often “just doing their job” and
“falling into a routine”. They often cited how sincerely they wanted to help the exploratory team, deliver the deliverables, and do a good job; however, they also noted that they would get paid to do their job whether or not a viable deposit was found. They often added that they were far-removed from the end product, namely profitable commercial seabed mining, since they would only be involved in this first, exploratory stage of mining. Finally, interviewees on both the technical and marine crew stated that before this cruise, and even while on it, they knew very little if anything about seabed mining for any kind of ore beyond offshore oil and gas. Detachment, routine, and tedium on the ship threw the novelty of the three-dimensional movie into sharp relief. The movie raised the technicians’ morale by making the technicians’ work visible and reminded them that their maps would produce tangible and useful outcomes. Lastly, more than substantiating the culmination of their work, the movie lifted morale on the ship, making a cruise impeded by many serious meteorological events and technical malfunctions more meaningful. Lastly, William’s referenced an important final translation: the plume becomes profit. KPI, or key performance indicator, is a unit that assigns value to an employee’s achievement or progress towards a specific, corporate goal. While KPI can be used to evaluate an agency or organization, William is referring to a personal KPI.

The sled was occasionally equipped with one more piece of remote sensing technology: a GoPro mounted below a bright bike light and housed in a small, steel case just below the CTD at the nose of the sled. The front of the housing featured a thick, Plexiglas plate through which the GoPro would take a picture every thirty seconds. A
battery with a 4-hour lifespan powered the camera, while the light had a 3.5-hour lifespan. However, deploying the sled and paying out the cable to depth, 20 meters above the seabed, often took two hours, while the average towline could take the better part of a 12-hour shift, and the hour or more to recover the sled. Ryan summed up the problem this posed in an interview:

“It’s been a high definition camera, in super powerful lights, that can show that there is either something there or nothing there. They’ve been pennywise and pound foolish with this they’ve saved themselves a little money because they haven’t had to hire high definition cameras, they haven’t had to hire powerful LED lights they have a go pro and a bicycle light...they turn around and say we’re going to show people the ocean floor by sticking a GoPro in a pause a housing you know uh, submersible housing down 6000 meters whatever, but you and I, we both completely understand that when the GoPro has batteries for four to five hours and the light runs out after 2.5 hours and it takes us an hour and half to get to the ocean floor pause after two and a half hour the light dies pause so the GoPro will get maybe 3.5 or four hours of nothing. It’s generally caught black, because there is no light source down there. It’s just black… We’ve done however many hours of video or footage of video and we have caught nothing. You’ve pretty much just engineered your way out of photographing anything that might actually be down in there. Why? We had high definition cameras and lights that we can run because there’s a power source on the CTD. We could run it and the entire time that it’s down there it could be filming the ocean floor, sending the images back up through the camera where we could be monitoring on the monitors and recording. We could be doing it, but we are choosing not to.”

Ryan identified an instance where the hardware shaped visualization, foregrounding certain properties of the seabed and the ocean, while backgrounding others. In this case, the battery life on the light and the GoPro camera framed sight in two ways: first, the light did not have enough power to last the entire tow. This meant that the time that the camera could take picture exceeded the amount of time there was light to expose any phenomena. Secondly, Ryan highlighted the significant difference in the degree of technological sensitivity and power. On previous stints, Nautilus rented
high-powered lights and high definition cameras that could penetrate the darkness thousands of meters below the surface of the ocean and last the duration of the dive.

These two constraints raised important questions about what is seen and what is obfuscated by these technological capacities. When the light and the camera were both running after the sled deployed, the GoPro collected hundreds of photos of increasingly dark seawater. This appeared in the photos as increasingly darker shades of blue then black. It is worth mentioning briefly that neither the high definition camera, nor the GoPro were strong enough to depict any of the microbes or plankton in the water, but they were theoretically able to take pictures of larger flora and fauna. However, when the camera was still taking pictures after the light had run out of battery power, it was taking pictures of dark ocean water, that appeared as blackness or whiteness, the light reflecting off the glass window. Regardless, as Ryan pointed out, this constraint was productive in that it permitted Nautilus to take pictures and materially substantiate their claims that there was little to nothing to disturb on the seabed with seabed mining. Eventually, the engineers stopped mounting the camera onto the sled before deployment.

William, on the other hand, was unfazed by the GoPro’s performance on this stint. He stated:

“We’ve got thousands of hours of video footage of the seafloor. We could fill this whole room with ROV footage. You know we’ve been exploring. I did a calculation once. We have been exploring a lot in the Bismarck Sea and if you see this large area. Everywhere we’ve gone and seen on the seafloor and sampled some for years and years and years we’re only barely finding barely .7 percent of the area. Facts and perspective must get right before they go. People just jump to conclusions…everything that has been found on the seafloor is extremely small and extremely high grade; it's barely a kilometer and a half long, rather than massive, massive amounts of area. And it's barely a scratch; it's a bump on the seafloor. If we finish, everything is working okay and we have a ship up there we
would mine that hole in two, two three years and be gone and no one would even know that we were there. Yeah, I mean, the damages are so minimal.”

Williams’s statement contrasted the depth of scientific vision at a particular site, in this case, Solwara 1, with the breadth of seabed unexplored. William’s proposition concerning the seabed at Solwara 1 highlighted the company’s documentation of the seabed and their due diligence collecting baseline data about a potential mining site. William’s frustration came from incontrovertible statistics about what had been seen and made visible of the seabed thus far in relation to the amount of seafloor yet unseen. What little is down there, he concluded, was small and replaceable given the vastness of what else was there.

The nothingness, emptiness, and vastness of the seabed and benthic waters were echoed in interviews as well as informal conversations where the ocean was referred to as “liquid rock” or that there was “nothing there, empty.” However, these properties were not always uniform and depended on the topic the ocean was in relation to and the geoscientists oscillated between “nothing being there” on the dormant hydrothermal vent systems that were of commercial interest or little environmental impact and “something is there, but minor and expendable.” In relation to the technical issues and advances in retrieving the ore, the ocean was spoken of as overburden. The geologists did not consider the ocean as anything other than an obstacle to seeing the seabed or something to be moved through. However, as noted above in the metaphors used to translate these engineering processes to community members, they used the language of CSR and environmental impact to say that the seabed was more or less empty, but full of potential. There were organisms that could be harmed by drilling regimes and pollution,
but they were small and unimportant to environmental processes that would impact cultural practices such as shark calling or important food sources such as fishing. Moreover, drilling and pollution would be minimal, compared to the terrestrial mines that Papua New Guineans were accustomed to. The geoscientists felt a responsibility, both personal and professional, to alleviate concerns about what was and was not on the seabed, describe seabed mining, and articulate how seabed mining would impact those things, local economies, and the people’s daily life. As Sam pointed out in his interview:

S: If Nautilus stated that there would be no environmental impact, it would not be believed by local people, the Papua New Guinean government, third party academics, or NGOs. There’s virtually three things. First up, the people they want to make sure, they want to feel comfortable that what we’re doing will…certainly not impact the environment they have…when you go talk to them they are a bit concerned because…they think that our impact will do that [negative impact] and we’re saying yes, it will impact. Any human activities that work on this planet earth have [impacts]; they’re always going to have an impact on the environment, and we know that we’re going to impact the environment but we are also continued to place and reduce the impacts here…So we’ve made it very clear to them that we identified to them this potential impacts: it’s the boat, it’s the lights and the engine sound that may affect the fish, and so forth. So we have done studies there and we’ve got riser on the boat right? So the potential, what if it breaks? There or tear or leaks? What do you need to do to protect the environment from the tailings?

L: And have you found that people were satisfied?

S: Yeah, they were satisfied that we, they needed to know that there are potential impacts because otherwise, if something went wrong, then we would be lying.

In short, there was so much potential for something to live on the seabed. Work had to be done to show that there were things down there, but not much, or not anything that could not be replaced, and that the area and the species could recover after the drill program. For Sam, any photographs and video footage of the seabed allowed local community members to “draw conclusions for themselves” as to whether or not they
agreed with seabed mining or felt that Nautilus adequately protected the environment from damage.

The scientists often complained that the public was misinformed about seabed mining, namely that charismatic species could be impacted by seabed mining pollution. This was not the case, they argued, since those species lived largely in and around active hydrothermal vents, while the inactive sites were much more sparsely populated. The impact to these species was negligible, because the duration of the actual exploitation was so short, relative to that of terrestrial mining. Furthermore, since so much of the Bismarck Sea was unexplored, there seemed to be a reasonable probability that any endemic species in the 1.5 square kilometer deposit site could exist elsewhere or could be readily re-established post hoc. Thus, it is difficult to prove that something is there when nothing is visible, unless there are other visualizing techniques such as sonar (which is not sensitive enough to detect organic from non-organic material) and metaphor.

**Conclusion:**

Visibility and interpretive clarity about the seabed and benthic ocean, and by extension about seabed mining is more than producing a material image of this environment. Rather than a self-evident holism, images of the seabed are gestalts of experience, expectation, technology, discourse, and interest. Phenomena are made visible is an assemblage of traces, abstraction, and models that represent the seabed and the ocean in particular ways. In this case, the seabed oscillated between empty, barren, potential, inert, and resource-laden. On the other hand, the ocean was understood as
nothing, empty, liquid rock, and overburden. Whether or not these representations are True or not, they have political implications, since how scientists understand these entities affects how they do their science, and influence how seabed mining will be carried out. Moreover, it impacts the ways in the scientists, as gatekeepers of knowledge about the seabed and the ocean, represent these phenomena to corporate persons, academics, to technical and marine crews, policy making bodies, local communities, and NGOs. Visualizing equipment such as the CTD, the multibeam echosounders, and GoPro cameras are not separate, but are cybernetic and shape the ways that the seabed and the ocean were described, understood, and translated. Furthermore, these phenomena were made visible in particular ways, in a dialectical relationship with the corporation that invested in exploration and local communities, and shaped by techno-discursive devices and subject to the speaker and audience.

Answering the question: “What is made visible and how” is not an old question, nor is scientific visualization of remote and minute phenomena to political ends innovative. However, these representations of the seabed and the ocean form the base of the implications and forecasts surround the environmental and social impacts of commercial seabed mining. As I will demonstrate in the next chapter, comparisons between seabed mining and other terrestrial mining projects generate a crucial, secondary representation of seabed mining: that it is sustainable. The slippage between these metaphors productively visualize commercial mining as sustainable, even to people that have been in the offshore mining industry for years.
CHAPTER FOUR

One of the engineers explained how he imagined the role seabed mining could play in global development and progress in an interview:

“People that also depend on us to make the car run? For instance: metal mining the seafloor here, comes to Japan, to make this that and the other, and this is sold throughout the world. I drive one in the UK and maybe somebody that’s got a job in the Solomon Islands, drives one here. He goes to work at say…And I’m being very stereotypical here, and I’m not racist. He goes to work at a company that desiccates coconuts to export to the rest of the world. I, in the UK, buy that. I in the UK, work at this job that helps in some small way to keep the flow of oil and gas consistent so that that man can put petrol in his car. My point being that we are already in some way, as a planet, getting towards being all interconnected. I’m not saying we’re there yet, and I’m not saying that we are utopian, but because we all share a common personal ambition for whatever makes you happy in your mind and most of us willing to work for it. Seeing as there are so many ways we are already on the same page, maybe every time we take a step forward in technology or in another field, maybe we draw closer to seeing each other’s common[ality]…I think that the more steps we take forward, the more we’ll get to each other’s common goals. And that’s what I think about the energy industry: [the] more steps forward we take in renewables…No one wants to live next to a country or a factory that spews out toxic waste like it’s going out of fashion…so maybe seabed mining allows us to take a little step forward. There could be derogatory effects, places like Tonga, Samoa, Solomon Islands, PNG... but maybe there comes another step, that you know, allows us to move beyond it.”

From Adam’s perspective, seabed mining is socially and environmentally justified compared to other mining projects. The technicians on the ship, most of whom had only just heard of seabed mining, developed this perspective over the course of the trip based on the qualities of the seabed and the ocean, their past experience in the offshore oil industry, and comparisons between seabed mining and other more problematic mining projects, such as Escondida, Ok Tedi, and Deep Water Horizon. By comparison, seabed mining was sustainable because it avoided many of the causes for negative environmental
and economic damage, duration and extensiveness. Despite the technicians’ optimism, they suspected that were “gaps in knowledge,” conditions, features, and consequences of seabed mining that required more scientific visualization to fill. However, overall, they viewed seabed mining as progressive. Seabed mining was an improvement over terrestrial and offshore oil projects because it was presented as less environmentally and socially damaging, technologically mobile and non-invasive, and short-lived. This shift in the technicians’ perspective exemplified the scientists’ strengthening position as knowledge gatekeepers and highlighted their expanding network within the mining industry. Therefore, the scientists successfully represented sustainability as a quality of seabed mining, rather than a consequence of CSR programs or macroeconomic trends in the global commodity market. Scientific visualization of sustainability as a quality of mining is a new way mining companies deter criticism. Moreover, it is a way to recommend seabed mining as a progressive alternative to traditional mining projects.

**Differences between Exploratory Seabed Geologists and Conventional Mining Geologists:**

Comparisons between the seabed mining and the traditional mining industries began with the differences between the geologists involved. When speaking to terrestrial geologists, seabed mining geologists felt alienated by the mining industry. Terrestrial mining geologists did not think that seabed mining was economically viable, or that seabed mining could compete with terrestrial projects. William stated:
“We’re very isolated by what we do, so at the end of the day, you don’t want to be too out of touch, but my membership [in the geological institute] helped me stay in touch with mining. It’s good to be up with it. You have got to be very clear. When we tell them that it is exploration, it is very different to normal mining.”

The distance between seabed and terrestrial exploration increased, because the differences between them are at the individual level, at the classification of kinds of geologists, and external from the differences in methods or resources of interest. However, many of the geologists on the ship did not pursue theses related to seabed mining at all, but focused on terrestrial geology. Moreover, the geologists indicated that the mining industry no longer focused on exploration and focused instead on development, extraction, and mine closure. Seabed mining, on the other hand, is in the early phases of development. Thus, their work in seabed mining exploration does not translate easily to the mining industry. The seabed mining geologists also stated that the terrestrial geologists viewed the seabed mining industry as speculative, with little commercial viability and a short life span. In response, the seabed mining geologists defended their projects by saying that oil was running out and that strip mines were operating with such low ore grades that they had to expand. Since the strip and pit mines had to expand the sizes of their sites, they were more socially and environmentally harmful. The seabed mining geologists saw the terrestrial geologists’ perspectives and methods as backward. William stated:

“The mining industry doesn't feel like we are a part of them. Every company is going: "Oh, you're a novelty act." The old school miners [are] really stuck in their ways and fine, I don't care. But that's, well they keep digging away but you know, the statistics are pretty damning in the fact that local copper mines are becoming bigger because the grade is becoming lower. So, there’s going to be a time when that is not viable anymore and they are going to need to wake up and smell the roses. So, maybe we’re ahead of the curve, possibly this won’t work.”
William’s story highlighted how the terrestrial geologists patronized the seabed geologists. From his perspective, the terrestrial geologists portrayed seabed exploration as a peripheral fad since seabed mining less technologically, legally, environmentally, and socially documented and established. Deep seabed mining has been theoretical for decades, and the geologists on the ship identified on many occasions that their job and Nautilus’s first priority was to prove that seabed mining had commercial value. On the other hand, terrestrial projects have already been profitable. However, seabed geologists pointed out how obsolete the “old school miners” were since they continued backward regimes that perpetuated negative environmental and social impact even as these projects economically declined. Finally, William’s statement demonstrates that the separation between seabed and terrestrial mining is mutually reinforced. Conventional mining companies are suspicious of a project that has yet to prove lucrative. By the same token, William’s disavowal is emphatic because seabed mining companies represent its extraction as a departure from terrestrial mining’s troubled history and old school mind set.

The damaging impact mining has had on the Pacific is still visible and remembered. However, if the seabed is seen as devoid of important and non-replaceable life and if the ocean is unproblematic and invisible, then seabed mining will minimize many of the issues that arose from other problematic mining projects. With this in mind, the geologists on the ship distanced themselves from past projects: the largest copper mine in operation, Minera Escondida in the Chilean Atacama Desert, Deep Water Horizon for offshore oil in the Gulf of Mexico, and Ok Tedi, a copper and gold mine on
Mount Fubilan in Papua New Guinea. By comparison, seabed mining appears as progressive and sustainable, that is, frictionlessly profitable and yet without significant damage to the environment or nearby communities.

**Mining Project Metaphors: Escondida, Ok Tedi, and Deep Water Horizon**

The geologists distinguished between seabed mining and other mining projects in regard to its environmental and social impact. First, many terrestrial mines and offshore mining projects for oil and gas were described as “dirty”, “disgraceful”, and “out of control”. Second, a “reasonable” person would see that her way of life depended on minerals such as copper and cobalt. These could be extracted more ethically, if they were extracted from the seabed than from the terrestrial strip mines. Third, western environmentalists do not understand that communities on mine sites in the Pacific fought to have mines on their land and for mining benefits to extend to them (Golub 2013). Environmentalists refused to acknowledge the benefits local people received from mines and undermined local people’s right to develop. William concluded:

> “The Philippines and China…there’s dirty mining everywhere! It’s illegal, it’s a disaster, and it’s pollution! It is just out of control, but that’s people’s desperation making money in poor countries and lots of things going on and I’m not saying it’s not terrible but a company that’s listed under very strict rules in Canadian law and everything [like Nautilus], I feel comfortable working in a company like that.”

William’s statement highlighted the moral difference between seabed mining and other mining projects in the Pacific. Some projects in the Philippines and China were unethical because they exploited people and illegal because they do not meet governmental standards and in some cases, work outside of legal frameworks all together. However,
Nautilus complies with strict and well-established laws that do not permit such a degree of risk externalization onto the environment or vulnerable populations. Moreover, this ethical distinction becomes personal, since William’s statement tied his own reputation to his claim that seabed mining is more ethical than dirty mining projects. The statement aligned the company’s ethos with his self-representation as respectful, responsible person. If the company’s ethos did not include these qualities, he would not have worked for it.

William first compared seabed mining with Escondida, a terrestrial mine also exploiting copper. This comparison highlights both the environmental impact and Escondida’s diminishing returns from operating the largest copper mine in the world. He highlighted that the low-grade ore body in Escondida required a large area to process increasingly large amounts of raw material to be economically viable. The environmental impacts of the pit mine and plans to expand it have been met with much resistance: local farmers compete with the mine for scarce freshwater supply in the arid region and local fishermen in nearby Antofagasta claim that spills of copper concentrate into Coloso Bay have poisoned fish and severely impacted local ecosystems (BHP Billiton Watch, 2009). The environmental impacts have also attracted international attention as well, specifically to repeated spills and effluent discharge into the Bay and habitat destruction of charismatic, endangered species in the Atacama Desert where the mine operates (2009). William stated:

“Escondida, so mass producing, need to build bigger and bigger pits...In Chile, I went to go to Escondida. It's one of the biggest pits in the world. Escondida is huge, huge sunken pit in Chile. Copper. It's a very low grade. So there's going to be a time where that is not viable anymore and they are going to need to wake up
and smell the roses. So, maybe we're ahead of the curve, possibly this won't work.”

For William, ore grades in the terrestrial mines are depleting and will only continue to do so. Expanding the mine highlights the demand for copper and the low ore grades are visible because the more accessible and best ores have already been exploited. However, terrestrial geologists and companies continue to pursue terrestrial deposits with 1 percent or lower concentrations of copper per millions of tons of ore. William’s digression allows for the unforeseeable and highlights his sense of risk. Seabed mining companies bet that terrestrial mines will not be able to meet the demand for copper at low reputational and financial cost. Moreover, his position made allowances for unforeseen problems with the economic and technical feasibility of seabed mining.

Geologists also emphasize that seabed mining has far less environmental impact than terrestrial mining. As previously stated by geologists on the ship, Escondida and other terrestrial mines must remove more overburden, dig deeper and wider pits, and process more raw material to operate at business as usual. Geologists on the ship named one such mine, Ok Tedi, as an environmental antithesis to seabed mining. Ok Tedi is an open pit mine that leveled a mountain in pursuit of gold and copper, but is most well known for the Ok Tedi environmental consequences from 1984 to 2013 in which some 90 million tons of mine waste was annually discharged into the Fly River, decimating fisheries, poisoning the riparian and forest habitats of fish and wildlife, and contaminating local peoples’ freshwater and food sources (Kirsch 2013). By invoking Ok Tedi and the Ok Tedi environmental impact and highlighting the emptiness and vastness of the ocean, the geologists made the environmental damage from seabed
mining visible as negligible compared to Ok Tedi and other terrestrial mines. William emphatically stated:

“You know, we're not going to rape and pillage. I can scour thousands of kilometers in the ocean and not find a single mine or find one little pimple of a mine. It's barely a dot and people will go: this is dangerous. Farmers rape and pillage our land at a massive rate. I think, everybody thinks when they say mine they think of events and disastrous mines like Ok Tedi and stuff that we are going to cause mass pollution and mass destruction and kill off this wildlife and that's just you know, about know what's going on that's what people think.”

William’s statement ends with an acknowledgement of the importance of mining projects in public, and more specifically, the history of mining in the Pacific, and how these collective narratives frame future extraction regimes in the region. His statement begins, however, with a potent and colorful analogy that represents Ok Tedi’s environmental impact as invasive and harmful. “Raping and pillaging” as an analogy highlights despoilment of passivized and feminized environment. William represented this narrative as a foil that seabed mining defeats by its less invasive environmental impact. Seabed mining is foregrounded as just and conscientious. Thus, raping and pillaging people and settlements is connected to other mining projects’ ruinous harm to the environment. The sense of sudden and violent harm to the environment is reflected later in his statement, when he referred to “dangerous” mining, “disastrous mines”, “pollution”, “destruction”, and “killing off” wildlife as well as in his emphasis of a large scale. However, William’s comparison removes seabed mining from histories of mining impacts, because the deposits are so small and isolated, the seabed and the ocean surrounding the old chimneys are largely “empty” and unpopulated, and the technologies involved in seabed mining are much more advanced and safe than those in terrestrial mining.
William’s quote also extended the comparison outside of the mining industry and indexed another aspect of land and resource management: agricultural farming. In the past, I have argued that the metaphor of agriculture was used to communicate what the seabed and seabed mining is to policy makers, community members, and other interest groups identified that industrial agriculture was a prevalent source domain across genres (Harris 2014). This theme continued in both interviews and conversations with geologists on the ship and corporate persons at the Brisbane-based Nautilus office. Authors used “field”, “champs”, or “harvest” to visualize the seabed as full of mineable resources in news articles, international conventions, and corporate gray material, the geologists used agriculture to represent the negation of seabed mining’s methods and impact. In William’s comparison, some industrial farmers decimate soil nutrients, over-fertilize their crops, and tax freshwater resources beyond their capacity. He represented agriculture as more invasive than seabed mining. His comparison highlighted seabed mining as self-contained, and mobile, and localized. Thus, seabed mining would not re-work and tax a deposit to the detriment of the surrounding, dependent ecosystems: a single deposit could be mined in under three years, the ship and equipment could relocate to another deposit, and the benthic environment would be left to slowly recover.

Sam conceded that any mining activity would have an environmental impact; however, seabed mining incidents would not be as environmentally problematic as terrestrial mines, such as Ok Tedi. He indicated that where a leak or a malfunctioning riser in an offshore oil rig could cause a cataclysmic blowout, a leak in a hydraulic pipe
moving slurries of water and crushed, seafloor massive sulfides would only disperse rocks. The different qualities of the materials being moved: crude tailings, or a sediment slurry dispersed in water would behave differently, the latter, comprising of water and rock that was already there, would have little, negative, long-term impact on the environment, since the rocks and sediment would sink back to the seafloor. He explained:

“If the pipe breaks, the oil disperses. This is rock we’re dealing with, so if the pipe breaks, there might be a cloud but [in seabed mining] the rocks will just go back where they were.”

Sam claimed that although seabed mining would borrow technologies, such as detachable pipes, from offshore oil and gas extraction, it would not engender danger of the same magnitude, since the nature of the seabed debris is not one that goes on “lurking” and spreading in the same way that oil in salt water currents would (Juhasz 2010). People outside the mining industry understand terrestrial mining better than they understand seabed mining. This visibility helps interest groups understand seabed mining, but, at the same time, offshore mining is accused of destroying the planet in pursuit of profit. In his interview, William noted that Nautilus was transparent, sometimes to a fault. He referenced the 2008 Deep Water Horizon spill as a foil to illustrate the antithesis of this feature of seabed mining:

“I think it’s good that more people are corporately responsible for the company. It’s great. You need that kind of balance. But sometimes I worry that it is going the other way that companies are completely bending over backwards, and having too much liability on them that they can’t actually operate. But then, BP, what they did was incomprehensible and disgraceful. That’s greed and corporate arrogance to an extreme level. It makes me sick. [Nautilus’s smaller size] is controllable in so many ways…companies now just churning people over fairly quickly, wanting quick results and stuff, they lost that ethos…they went that way because their new boss was a new, ex-corporate banker who got too
greedy. People get fever pitch…Everybody tries to outdo each other and the gold prices go up and the mines cost more and more and they just escalate and it goes out and then it free falls. [BP in regard to the Deep Water Horizon blowout] went that way because their new boss was a new, ex-corporate banker who got too greedy. People get fever pitch…. everybody tries to outdo each other and the gold prices go up and the mine costs more and more and it goes out and then it free falls.”

Corporate greed and arrogance within a mining corporation pressures people to work longer hours, to not speak up about dangerous work conditions, and encourages people to push equipment past their capacity. This techno-bureaucratic pressure and short cuts result in catastrophes such as the Deep Water Horizon blowout, which devastated and continues to disrupt ecological processes, fisheries, and local economies around the Gulf of Mexico. William noted that although there are geologists conducting good science and best practices at BP, the large size of the company and steep competition means that the company’s ethos is backgrounded in favor of profit. Nautilus, by comparison, is much smaller than BP and has not lost its ethos; it balances profit and sustainability, and even overemphasizes sustainability to its own detriment. Moreover, the deep seabed mining projects proposed by Nautilus would cherry-pick the most profitable and most accessible, highest grade ore in the calmest waters. Since Nautilus represents progressive extraction regimes, encourages transparency making practices, and utilizes minimally invasive extraction techniques and equipment, seafloor mining both minimizes environmental harm through technical innovation and benefits from being early on the scene of a greenfield exploitation.

Like offshore oil and gas projects, seafloor mining takes place thousands of meters below the surface of the ocean. Since there are no communities who live on the seabed, seafloor mining companies avoid negotiating with landowners. In Papua New Guinea,
landownership is opaque, and claimants creatively establish ownership by any and all means possible, much to the consternation and dismay of geologists and other corporate persons. Rather than dealing with a cacophony of claimants, seabed mining companies operating within the EEZs only have to work with government agencies. Nautilus and other companies apportion royalties to the government and leave compensation and royalty allocation at the discretion of the government’s agencies. Thus, seabed mining streamlines the company’s interaction with communities and their reimbursement. Sam noted that the lack of landowners was one of the features of seabed mining that originally drew him from terrestrial mining in Papua New Guinea, to the seabed mining industry. He stated:

“I took the way forward, to decide, because I was tired of dealing with land miners and other issues as well. I said, “I want to be involved in something we can still pursue,” you know? My career? I’ve been dealing with them for the last thirty years and I said, “When it comes to seabed mining, there are no landowners...that you have to deal with. Maybe you can only deal with the government.” It's you can say, technically, they are the landowners, if you like.”

Weeks before the trip, Sam visited education centers and communities throughout the impact zone. He reported that students thought seabed mining would have a positive social impact on local communities, since the projects and CSR programs would provide vocational training and job opportunities.

“When you go to the community, the universities, high schools, you go to the schools, oh they’re excited! “I want to get into this new environment! Now you guys are telling me that this is a new area to venture!” They don’t care if there’s going to be environmental damage, no. To them, it’s a new industry; it’s another kind of opportunity for them. Hire the kids from school! They want to understand what we are doing. They’re excited! Then you come and go to the provincial government, they are decision makers and they will tell you, “We do according to what the people want.”
Sam noted that local community members were excited about seabed mining, since the new industry would need skilled workers, particularly people trained to operate the AUVs and ROVs during the exploratory phase of seabed mining, ship crew, and fresh produce from nearby farms.

**Sustainable Seabed Mining Among the Technical Crew:**

As Lakoff and Johnson (1980) have detailed, metaphors draw from existing cultural and linguistics reservoirs and become the frames of reference for experience (Lakoff & Johnson 1980). In this section, I will show that seabed mining metaphors came to frame technicians’ understandings of seabed mining. Although the technicians did not have experience or much prior knowledge about seabed mining before the trip, they had years of experience doing seismic surveys for offshore oil or national defense. They drew upon these experiences and also adopted the language used by the geologists on the ship to visualize seabed mining and its consequences. From these visions of seabed mining, they concluded that seabed mining was socially, economically, and environmentally just.

Although the technical team was experienced in offshore oil and gas, the technical team was largely unfamiliar with seabed mining for deep sea minerals. Many of them acknowledged that seabed mining and topography of this kind was novel, interesting, and unknown to them, despite having been on multiple surveys around the world, including the North Sea, the Mediterranean, and the Middle East. Many of the surveyors and engineers on the ship stated that they learned that they were going on a cruise with very little time. For the most part, the technologists had heard very little about seabed mining
before this stint, if at all. When I asked what they knew about seabed mining before this
cruise, the technical team’s response was that their knowledge and time were limited.

Mariah noted:

“I only got told I was going on the ship three days before my flight so, I didn’t
have a lot of time and it was very difficult already to accommodate that.”

Similarly, Aaron made time to conduct an abbreviated Internet search before he
boarded the ship. Aaron reported that he had heard of seabed mining before, but had not
looked into it until he was notified that he would be on this cruise. While on the ship and
during his shift, Aaron perused Nautilus’s environmental impact statement and other
online news and blog articles online. He stated:

“Oh, it’s Google! All you need to do is Google and all these things come up and
in ten minutes you know a lot more. That’s what I did before I came out here. It
was literally the day before I flew, I spent ten minutes looking at them, obviously
knowing that Nautilus would be in PNG area.”

The surveyors and engineers had years of experience working with sounding equipment,
mostly in oil and gas surveys of stratified layers of sediment tens of meters below the
surface of the seabed and for defense purposes. Although they did not have first-hand
experience with seabed mining and the end product was different, they did not feel like
they were at a loss, since much of the technological processes and social structures on the
ship were the same. The team’s skillset seemed to readily translate into topographical
surveys of the seabed.

The technical team also used metaphors to illustrate their opinion on seabed
mining by triangulating it with their experience with offshore oil and gas and contrasting
it with their perception of renewable energy. The surveyors and engineers had not
worked on an offshore wind or tidal energy project before, but many aspired to do so in
the future. Although these sources are materially and conceptually different from the seabed and its resources, Adam identified two similarities between these industries: First, technicians’ comparisons foregrounded terrestrial and other offshore oil and gas projects as operations that use less environmentally friendly technologies than those in wind and tidal energy projects and seabed mining. By the same comparison, like tidal and wind projects, seabed mining will capitalize on a plentiful resource with the potential to optimize to the point where there is both no environmental or social harm, and corporations and consumers have access to an unlimited power, or in this case, a commodity source. He stated:

“In my view renewable energies isn’t just a cleaner type of technology. It’ll probably be more sustainable income as an industry. Wind doesn't run out, wind devalues, and that's the same with tidal energy, you know, the sea's not going anywhere. Those things are not subject to the commodity chains like coal and gold are. From the little I've begun to understand about seabed mining on this trip, it does seem renewable and sustainable… I might be quite naïve of my understanding about it, but as long as there are places where we are not leaving anything nasty behind after we have done it, you know, then I think it's fine, so I think it falls into the same vein as renewable energy and technology.”

Adam's comparison groups seabed mining, tidal, and offshore wind energy industries together, despite the ontologically different materials involved. The technicians claimed that the equipment and concepts in offshore wind were more similar to those involved in seabed mining. He compared seabed mining to wind and tidal energy projects and pointed out that they both rely on a “cleaner type of technology” as opposed to terrestrial and other offshore mines. These latter two kinds of mining have powerful, negative, and dangerous connotations for mining’s public image. From this standpoint, seabed mining is superior, because it involves less invasive and more mobile technologies. Moreover, Adam stated seabed mining for sulfides fell into the same category as renewable energy.
since it did not harm the environment by “leaving anything nasty behind.” Adam and
Sam both asserted that a seabed mining pipe leak would be magnitudes less disastrous
than those in offshore oil and gas projects, such as Deep Water Horizon, since the
material in the seabed mining pipes would just re-disperse the materials back over the
area that they originated from. Finally, Adam highlighted that neither wind, tidal, nor
hydrothermal vent activity would deplete. In fact, the inactive chimneys that Nautilus
was interested in mining could rapidly rejuvenate, though the ore bodies underneath them
would take much longer to recover. In this sense, seabed mining for sulfides works with
a quickly rejuvenating resource that behaved more like wind or tides than like oil or
gas. So long as there was hydrothermal vent activity, mining companies interested in
seafloor massive sulfides could expect to exploit copper, cobalt, silver, gold, zinc, and
other important commodities fairly indefinitely.

The technicians continued to emphasize how little harm seabed mining would do
to the environment by using agricultural metaphors, the same metaphor geologists used to
dismiss detractors’ accusations that Nautilus would “rape and pillage” the seabed, to
highlight how quickly the hydrothermal vent systems could replenish the chimneys. In
the same way that categorizing seabed mining for sulfides as renewable like offshore
wind and tidal energy, the agricultural metaphor foregrounded the seabed as a field, a
space where resources could grow, be harvested, left to fallow, and then harvested
again. So long as the fields were take care of, and nothing polluted the field or the
surrounding area, then the hydrothermal chimneys, like a crop, would quickly
rejuvenate. Adam stated:
“Seabed mining is essential, is harvesting a crop. The earth is always going to be, as I understand it, is always going to be producing these [hydrothermal vent fields]. We only need to find a really more easier way, or at least these chucks of metal that are culled from volcanic eruptions…it’s always going to be producing these, and to come up and simply slide them off, as long as we’re not putting massive amounts of pollutant into the water…that’s fine. I’m sure it can’t be done in an area of environmental interests, but where protected everything, or specific [species]...the nice thing is: the sea actually regenerates itself...life’s been disturbed, but life’s starting to come back. I think that’s quite nice if you can find a sustainable way to do it that doesn’t harm anything...cause it does get to the point where you think maybe, we need to be a little bit more responsible.”

In this passage, Adam related seabed mining to harvesting a crop. In the same way that sown crops will continue to produce yields so long as ambient natural processes, such as nitrogen cycles or photosynthesis, continue. In the same way, Adam compared the reliable, replenishing productivity that he associated with agricultural fields with the productivity of hydrothermal vent activity. In this metaphor, the crop is the metallic ore seabed mining companies will cut from the seabed and pump to a vessel. Adam said that the ocean would absorb the impacts of seabed mining as long as mining did not take place near endemic species, and miners used the best available equipment and minimized the amount of pollution they produced. Thus, seabed mining becomes environmentally ethical and corporately profitable when it does no harm. However, whether or not there were organisms or ecosystems that could be harmed was questionable and deserved more attention. Adam doubted whether or not species were present or significantly impacted by seabed mining. He stated:

“I don’t want to be one of those human beings that say, just because I can’t see it, and I’ll never be aware of it, that it doesn’t matter, you know, and I would always say that...if you can harvest something without...creating...a long term environmental disaster or have a long term impact on something then you find that that is renewable, then isn’t it? If on the other hand, these...species these environments are being wiped out and that’s the end, then...I think probably that probably that needs to be looked at again... Somebody needs to do an
experiment. Somebody needs to say right, we’re going, this is, this is our experiment right, this is what we’re going to mine, for however long and then we’re going to leave it and then we’re going to study the after effects.”

Concern for pre-existing life on the seabed and ambient ecological processes on one hand and the role of scientific expertise and visualization on the other was also significant to others on the technical team. Aaron stated:

“Look on the baseline work that has gone out and inspected the data and stuff they hadn’t done enough work. They still need to do more, cause there are gaps in the knowledge…we need the academics. They’re the ones that understand the best about what you need to look into. We need those ups on the side which Nautilus probably have had and they need to conduct experiments.”

In these statements, Adam and Aaron identified a “gap in knowledge,” revealing a skepticism about what life could be on the seabed and how these organisms could be impacted by seabed mining. Furthermore, both comments represent scientific vision as a means to confirm the seabed and the ocean’s pre-existing conditions and the outstanding impacts of seabed mining after the fact. Scientists have the technological equipment, time, money, and expertise to see and hold forth on what is and is not there and the impacts associated with seabed mining. Undergirding these statements is a belief that the seabed’s nature is stable, discoverable, and not subject to construction.

Finally, the technicians pointed out that global population growth and the corresponding rise in demand for technology and infrastructure would depend on commodities such as copper, gold, silver, etc. Adam’s metaphor compares the need for seabed mining with the need for agriculture and dependence on metal commodities with dependence on food. Nautilus was interested in copper, a necessary component in technological devices and infrastructure. Population growth and a growing middle class meant that the demand for computers, phones, homes, roads, etc. would also increase,
hence, the demand for copper would also rise. By the same token, growth and development also correlate with an increasing demand for foodstuffs and agriculture. Hence, increases in agriculture and mining were necessary; however, expanding conventional mining and industrial agricultural schemes would occupy space and drain resources that would be necessary to support the burgeoning population. So both industries would need to innovate. In mining, seabed mining was just such an innovation where technology in offshore oil and gas and terrestrial mines could be adapted to mine a greenfield, far from communities, with little environmental impact, for a short period of time.

Aaron positioned extraction on “a large area of land” on one hand and “on a small area on the seabed” on another. They both felt that people were dependent on metals and unwilling to decouple growth and consumption, if it meant that they would have to sacrifice their technological conveniences or drastically change their lifestyle.

“I personally find alarming but sigh the problem is, I like my smartphone, a laptop I have all these things: You need the seabed mining to happen. You need the commodities, which is the problem. Do you take these minerals from this small area on the seabed or do you take from a large area on land? The problem is there's billions of billions of people but there are too many of us. I mean, each person has such a large footprint…The only hope is that our technology gets to the point where we can curb our impact and try to become a lot more sustainable.”

Ultimately, for some of the technicians, seabed mining was part of their hope that humans were progressing. They hoped that resource management optimized to do minimal harm to the environment while also meeting the rising demand for commodities. Adam came to the same conclusion that Aaron did, and added his belief that humans were becoming less environmentally destructive. Although seabed mining could not guarantee neutral environmental impact, the technical team juxtaposed it with agriculture, terrestrial mines,
offshore oil and gas, and wind and tidal energy projects in ways that imagined seabed mining as less environmentally and socially damaging because of technological innovation and the \textit{terra nullius} seabed and the \textit{mare nullius} ocean. Adam expressed aspirations for seabed mining as opposed to terrestrial mines for copper when he concluded:

“I like to think the human race is getting cleaner. I like to think, you know, we’re getting to a stage where, we’re a little bit more aware of our impact. Maybe we can’t do everything to stop it but we can certainly draw down on it…so seabed mining, maybe it’s not the step that uh, that produces our resources in a totally environmentally neutral way but it certainly seems far cleaner than strip mining or shaft mining on land.”

\textbf{Images Challenged and Sustainable Skepticism}

Both the technical team and the exploratory team spoke about seabed mining to each other and others off the ship as sustainable because the deposits had high metal contents, equipment was mobile, and sites were temporary and devoid of human communities. Both teams constructed seabed mining in opposition to offshore mining for oil and gas and terrestrial strip or shaft mines. These comparisons imagined seabed mining as less environmentally invasive and socially destructive, while generating more commodities and profit than the two former types of mining. However, the technical team did have some reservations and called for more baseline and impact studies to clarify concerns for endemic and migratory species, slow-recovering ecosystems, and economic development in host countries. Aaron recognized that seabed mining could have adverse effects on organisms, and identified that more research and study was
necessary in order to document any changes and evaluate environmental recovery. He stated:

“Look at the baseline work that has gone on and inspect the data. They hadn't done enough work. They still need to do more, cause there are gaps in the knowledge. The process is there, it just needs to be expended, but that's money and time and financial risk for them because they are putting in money to support something that will stop them from doing what they are doing, it doesn't work to their benefit.”

Ultimately, the technicians expressed both concern and hopeful optimism that seabed mining would have minimal, negative impact on benthic ecosystems. While the loss of any life and the disturbance of any ecosystem were regrettable, they judged that these minimal environmental impacts were less than the land loss, environmental degradation, and displaced communities that would occur if terrestrial mines were expanded to meet global demand for commodities.

Environmental concerns were not the only issues the technologists worried about, but also the social impact or lack thereof flowing from seabed mining. Although some technicians pointed out that seabed mining-related jobs and infrastructure could improve local communities, Ryan speculated otherwise:

“It’s a vessel that sitting in the middle of the ocean. You know, you don’t need vehicles travelling in and out to take people to and from the ship. If you have a look at a mine structure, there’s everything associated with it. A culmination: there’s maybe landing strip, hauling roads, there’s vehicles…you need mechanics, you need cooks, and everything, all that stuff will be self-contained on the vessel. Sure you’re going to need cooks in that kind of business but there’s so little people there, that the benefit doesn’t flow onto the community. There is no community immediately in the area. You know, if you are in a traditional land based mine, you would be able to employ the local people to do laboring jobs, you train them you train them to be welders, to be hydraulic engineers, all that kind of stuff. There are all these kinds of jobs that go along with it. This is autonomous. When you start doing autonomous mining, which they’re doing in Australia, remote tele-mining, where they have a mine site in the middle of the Pilbra or something and then people operating the vehicles in Perth. They’re
doing it by a satellite link. That’s taking all those people out of the link. There’s no truck drivers no haul road attendants it’s somebody flying a truck, like a computer game, in an office, where they don’t get dirty, where they can rock up in jeans and t-shirt and that’s them going to work. They say that’s a positive impact but then it’s a negative impact because instead of having those people on the mine site doing those jobs, it’s less and less people. This is almost no people on a mine site, so there’s no infrastructure that needs to be there to support a mine.”

Ryan highlighted that in terrestrial mines, costs are externalized onto local communities, but then, so too are the benefits: local people could be trained to operate machinery, workers would be needed to build roads and lay cable for telecommunication and transportation, even local farmers could benefit from the demand for local, fresh produce. However, Ryan claimed that there would be fewer individuals to witness and benefit from the mining because of depopulating mining through drones, remotely operated vehicles, autonomously operated vehicles, and other remotely controlled mining equipment. Remotely operated mining would cut costs by reallocating royalties, compensation, and dislocating many of the direct job opportunities and local market benefits flowing from seabed mining to government agencies. In this view, sustainability would become a darker black box by further limiting the kinds of personation individuals could invoke to fight for benefit from seabed mining, such as tribes or traditional landowners.

Finally, much anthropological work has considered how environmental and indigenous rights NGOs have pressured mining companies to consider CSR and environmental departments as standard practice. However, these studies have been critical of the efficacy of these programs by raising questions about greenwashing and encouraging economic dependency on corporate programs (Ferguson 1990). These questions are often raised by Pacific communities and states, whose waters and seabed
are billed as the first examples of commercial seabed mining and who have long and painful histories of exploitation (Kirsch 2013, Kahn 2011, Connell 2013). Sam noted that he had to visit communities multiple times, each time re-explaining the technology, programs, projected impacts, and future benefits associated with seabed mining.

“I went down and we went with this one guy in the army who speaks very good Tok Pisin, loud mouthed, he just went and said something, and when we went down and we were confronted again, same group of people who were turned our way, but now they changed their minds. They are not so educated, they tend to get convinced by any educated person that comes, if someone is anti- uh seabed mining and goes and says something they can be they can easily convince the villagers. It just gets so chaotic because they are confused about what is true and what isn’t. So that’s really the thing, to go back and repeat the same thing. I’ve been on the other little islands where we have tried to explain it because it’s the guys, like in PNG, they stay on the land, they are cooking their fish and in the village and they are looking out and they see Nautilus. They say, “What are these guys doing?” And the next year we go and do the more every fish that comes on shore is dead and dirty. “There must be someone that is causing all of this dead fish.”

**Analogical Knowledge and Ways of Seeing**

In this chapter, I have shown that both the exploratory and the technical team viewed seabed mining in ways that were not natural, but rather, fundamentally structured by past experience, culturally embedded metaphor, mining projects on land and in water, instrumentation on the ship, and other re/presentations of the seabed, ocean, and seabed mining. Without these technologies, the seabed, the ocean, and the extraction of their resources would both invisible and unintelligible. The analogies that they constructed and layered upon one another cobbled together an image of the ocean as “liquid rock”, a virtual extension of the seabed, itself imagined as a barren and yet pristine field. The geologists compared seabed mining to other, impactful mining incidents, some past and others on going, to highlight how environmentally non-invasive seabed mining
equipment, methods would be and how transparent and responsible their environmental and social programs would be.

While I do not claim that the technical team consciously borrowed from geologists’ representations of the seabed, the technical team did develop a sophisticated array of metaphors and comparisons that overlapped those used by the geologists and reported in gray material online. The technicians, who had little to no exposure to seabed mining for deep seabed minerals, used these comparisons and metaphors to make sense of and talk about seabed mining and its prospects. They used agricultural metaphors and compared seabed mining to renewable energy sources and their experiences in “dirtier” industries like offshore oil and gas. Ultimately, the teams on the ship imagined seabed mining as progress, an innovative and more ethical way to mine resources. Despite many “gaps of knowledge” and qualms about social impact, seabed mining was a compromise, if not a win-win situation in which the environment and local people benefitted and the company and consumers acquired resources.

My findings show that the geologists on the ship, often unconsciously imagined the seabed mining to be sustainable through technoscientific visualization. Flowing from premises of emptiness, vastness, and invisibility and comparisons to other mining projects, sustainability appeared to be natural, a measurable, a priori quality of the enterprise. However, as Sam noted, all mining activities will have environmental and social impacts. The quality and scale of these impacts are minimal compared to previous technicians’ and the geologists’ images of terrestrial mining and offshore oil and gas projects. Terrestrial mining and offshore oil and gas extraction were associated with
disaster, backwardness, and a lack of ethics. Seabed mining stood in sharp contrast: mobile, short-term, no displaced communities, and little environmental damage, through metaphor and technological innovation and creative adaptation.

The exploratory and technical teams ultimately imagine sustainability as a natural quality of seabed mining. However, the construction of seabed mining is anything but natural, and is a gestalt of memory, history, instrument, and metaphor. Moreover, its productivity has yet to be proven and vetted commercially. At last, seabed mining appears as an extraction regime struggling to become modular, frictionlessly profitable, and sustainable.

Previous ethnographies on mining emphasized the need for a “new politics of time” where the mining industry, companies, and their projects should be analyzed before a disaster through theories that measured corporations’ levels of response to criticism (Kirsch 2013). My thesis begins by analyzing the emergent structures of seabed mining in the corporate geoscience upon which later practices and policy decisions will be based. Furthermore, the seabed mining industry has not yet closed the lid on itself as a black box. As such, seabed mining companies are already mobilizing their networks to resist critics’ counterclaims about the profitability and of seabed mining. Where mining companies have established CSR programs to make their projects seem sustainable, my thesis articulates new way that seabed mining companies assert themselves above other mining projects and forestall criticism: Geologists used scientific visualization practices, including: maps, videos, comparisons to other mine projects, and metaphors to make sustainability appear as a naturally occurring quality of mining itself, rather than
dependent on additional programing. This raises important questions about how indigenous rights and environmentalist groups will accommodate scientific visualization of sustainability? (Adger 2011, Auge 1995). Moreover, how will these move changes in how companies approach, use, and practice sustainability, if at all?
Chapter Five

As I write, seabed mining has yet to be commercially practiced, so seabed mining companies like Nautilus must continue to mobilize their networks of support. A successful example of actor alignment was handed to me by one of the Nautilus scientists during my last interview in Brisbane. Earlier in the year, Nautilus Minerals commissioned Earth Economics, a non-profit organization that is “dedicated to researching and applying the economic solutions of tomorrow today” (Bakter & Schmidt 2015, ix; Earth Economics, 1). According to their mission statement, their goal is “to help communities shift away from the failed economic policies of the past, towards an approach that is both economically viable and environmentally sustainable. Everything we do can be measured in millions of dollars of investment shifted towards sustainability and by physical changes on the landscape” (Earth Economics, 1). Nautilus submitted to a rigorous internal review with the stipulation that the company could read and review the NGO’s findings.

The result of their analysis was the *Environmental and Social Benchmarking Analysis of Nautilus Minerals Inc. Solwara 1 Project*. In 104 pages, the report compared Solwara 1 against two existing terrestrial mines, Prominent Hill and Bingham Canyon, and a proposed terrestrial mine in the Intag Valley. The report identified a set of categories, including magnitude of annual damages, impact per ton of copper, and the value of each of ecosystems the mine operated in, and then rated and ranked the projects by profitability and sustainability. The authors concluded with a glowing recommendation of seabed mining as an industry and the Solwara 1 project, because it...
could recover more copper with less social and environmental impacts than the other
three mines and would expand mining to meet rising demand (Bakter & Schmidt 2015,
103). The report stated:

What sets Solwara 1, Nautilus, and the PNG Government apart is the implementation of
deep seabed mining. Copper mining has been exclusively terrestrial for 7,000
years. Expanding metal mining to the deep seabed opens most of the earth’s solid surface
to mining for the first time. The technological transformation associated with the mining
technology, machinery, and production vessel is remarkable. History records few
technological developments with such capacity for change, economic advancement, and
transformation toward greater sustainability (102)

This report is important because it showed that some of visualization techniques I
witnessed on the ship carried across platforms. In fact, the Earth Economics report was a
systematic comparison between mining projects, similar to the casual comparisons the
scientists and technicians made on the ship. The report did mention other mining sites,
including the Ok Tedi mine in Papua New Guinea, the Holden Mine in the United States,
and the Marcopper mine in Marinduque, the Philippines, to emphasize the impact of
these mines on local environments (14-15). However, this opened into a discussion about
the need for responsible copper mining alternatives. The focus of this report was not
other Pacific mining projects or offshore mining projects, but other terrestrial copper
mines. This move highlighted increasing copper demands and a niche in the commodity
market that seabed mining for sulfides could fill while backgroundering. It also de-
emphasized the Pacific’s history of mining and narrated a break from terrestrial mining.

Pacific communities, however, have not forgotten the impact mining has had on
local environments, economies, or politics, and their opinions and concerns about seabed
mining reflect these histories. While I was writing this thesis, colleagues sent me many
blog posts and news articles that narrated the dynamics between seabed mining
companies, their shareholders, and their critics. Some were hopeful and called seabed mining an opportunity to “open up a wealth of new resources to Pacific nations” so long as the Pacific Community developed a strong legal framework that included the rights of indigenous communities and provided guidance on trans-boundary issues (Razak 2016). Other authors were damning and pointed out the irony of Pacific states renting out their seabeds, despite Pacific Islands’ experience with mining. Interestingly, some of these blog posts featured comparisons that the scientists and technicians used on the ship. One blog post, titled: “Foreign Companies Lining Up to Rape the Pacific Seafloor,” covered the International Seabed Authority’s first exploration contract for 2016. In 2015, five contracts were signed, and five more permits are expected to be granted by July 2016, despite many scientists’ calls for a moratorium on seabed mining until more research has been done on benthic ecosystems (Laursen 2016).

Some authors have proposed that well-established, multilateral models of ocean resource management should be used to mitigate pollution and negative economic effects of seabed mining. In “The Nourishing Sea: Partnered Guardianship of Fishery and Seabed Mineral Resources for the Economic Viability of Small Pacific Island Nations,” D’Arcy (2013) argued that policies and corporate practice should combine place-based management schemas, western science, government and corporate interests, and environmentalism to establish sustainable development. D’Arcy suggested fisheries as a proxy for effective legal pluralism that could be applied to seabed mining. Pacific Island nations have successfully managed their tuna fisheries through a combination of governmental policing and local, cultural practices, such as rahui (D’Arcy 2013, Cinner
2005, a.2007, b.2007, c.2007, McClanahan 2014, Bambridge et al. 2016) and as leverage for more stringent protection from pollution (D’Arcy 2013). He concluded:

The destinies of both Pacific island MIRAB economies and resource rent economies in this era of heightened, human-induced climate change are not even further linked to processes beyond its area over which they have no influence...Now, more aware of influence looming just over the horizon, the region’s inhabitants must, nevertheless, still generally modify the impact of these external forces rather than hope to shape them (3362)

Although multilateral models have successfully preserved and regulated other Pacific resources, D’Arcy argued that mitigation strategies offer the best protection for the environment and establish sustainable development. Place-based values do not easily, if at all, enter scientific or corporate practice beyond CSR programs. While place-based management practices have improved the ways tuna are fished, D’Arcy is skeptical that these practices could be applied to mining practices beyond CSR.

Some Pacific communities share D’Arcy’s skepticism, but advocate for indigenous peoples’ complete control over the seabed. For example, delegates across Melanesia met to complete the Buala Declaration. The document reaffirmed Melanesian communities’ right to “unite and organize as a region to defend the continued control of Melanesian communities over our land, sea, water, air, and ancestral heritage. We re-assert that the customary land and sea systems are the basis of life and community in Melanesia” (Cullwick 2016). The Buala Declaration is significant because of its definition of land. The Declaration stated that land is “a collection and inclusive which includes the sea. Land has and always will be of the highest values to the lives of our peoples, and so it will be for generations to come” (Cullwick 2016). Since the ocean and the land underneath it are part of the Melanesian concept of land, they opposed seabed
mining within their EEZs, because renting the seabed would take away Melanesians’ rights to their land and would not align with Melanesian Ways. Seabed mining would therefore “take away the right to self-determination over our lands, reflective in Article 3 of the United Nations Declaration on the Rights of Indigenous Peoples, including customary land registration, foreign land and sea (ocean) grabbing, and extractive industries in Melanesia” (Cullwick 2016).

Seabed mining is a polemical issue that is not only concerned with best practices and good science. It is an extractive regime that raises important questions about the limits of self-determination, sustainable resource management, and diverging environmentalisms. Should scientific practice be abandoned as an input for place-based values and is sustainability only applicable in a mitigation strategy? Could mining companies incorporate their interests and place-based values in scientific practice, extraction, and mine closure? Would the corporations, communities, and seascapes be better off? How should the seabed be regulated, and how will stakeholders’ interests be represented and reconciled in corporate practice, policy, and protest? My thesis demonstrates that scientific visualization practices made sustainability appear as a natural feature of seabed mining. Clearly, this claim changed the conditions of the relationship between mining companies and their critics, but the implications of this shift requires further analysis. As commercial extraction begins, future research should track whether seabed mining companies convince people within and without the industry that seabed mining decouples sustainability from fantasies of limitless growth, their methods of visualization, and their critics’ responses and means of effecting the changes they wish to
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